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Soil Atlas and Crop Production Guide for Northeastern South Dakota

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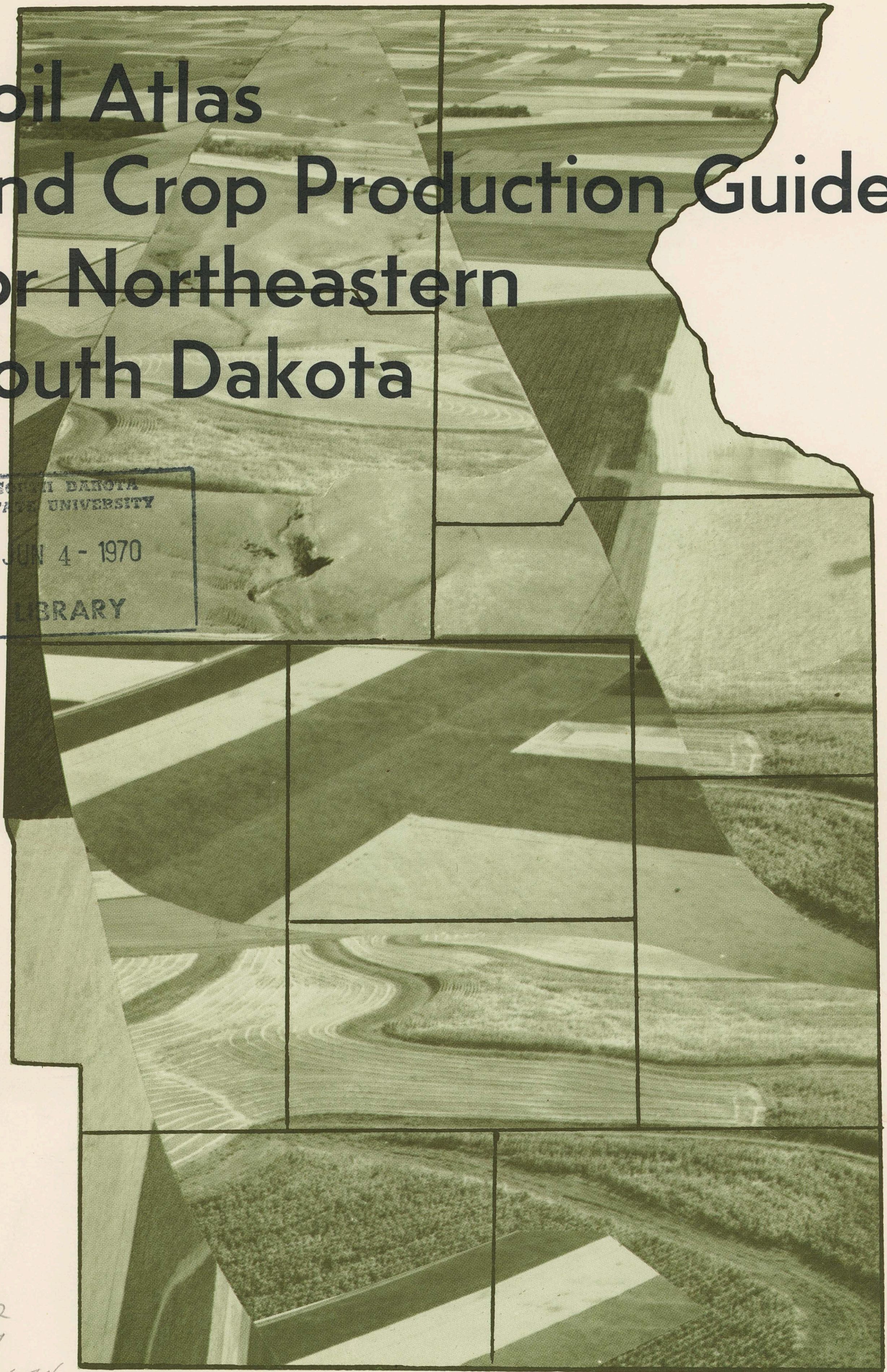

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Northeastern South Dakota

Soil Atlas and Crop Production Guide

CROPS COULD MAKE $30 3/4 MILLION MORE

Lyle A. Derscheid and Fred C. Westin*

Agricultural crop income in 10 northeastern South Dakota counties could be increased at least $30.75 million annually by applying up-to-date soil and crop management technology without increasing an acre of crops, irrigating or raising market prices.

The aim of this atlas and guide is to show how agriculture in the Northeastern Region of South Dakota can be improved and stabilized through development, use and conservation of existing land and water resources.

1 ENVIRONMENT OF THE REGION

The Northeastern Region includes Brookings, Clark, Codington, Day, Deuel, Grant, Hamlin, Kingsbury, Marshall and Roberts Counties (Figure 1). This region totals 5.2 million acres of which 4.9 million are farmland on 10,480 farms, representing 10.7% of the land area of the state or 10.8% of the farmland and 21% of the farms in South Dakota.

CLIMATE

Precipitation

The annual precipitation for the Northeastern Region ranges from about 19 inches in northwest Marshall County to 23 inches in southern Brookings County (Figure 2) and 24 inches in a small area around Clear Lake (Table 1). Approximately three-fourths of the yearly precipitation comes between March 1 and Sept. 5 (Table 2) – about half of it between March 1 and July 8. The area receives about 19% of its yearly total during June, the wettest month and about 12% during a four-week period between July 26 and Aug. 22, a period critical for corn production (precipitation summaries are given in Tables 1 and 2).

Temperature

Northeastern South Dakota has a typically continental climate with great temperature extremes, even from day to day. However, average yearly air temperatures vary only from about 44 degrees along the North Dakota line to 45 degrees (Figure 2) in the southern counties with a drop to about 42 degrees at higher elevations on the Prairie Coteau (Figure 4). Average weekly temperatures are shown in Table 3.

Spring and early summer generally are cool and moist, while later summer usually is warm and dry. The region's average frost-free period varies from about 120 days in northern Marshall and Roberts Counties and on higher parts of the Prairie Coteau to about 135 days in the southern half of the area and about 145 days in the Minnesota River-Red River Lowlands. The soil generally thaws the last week in March. It freezes in early November on the Prairie Coteau and about one week later at lower elevations, giving an average of 33 to 34 weeks when soil is not frozen. Average depth of frost penetration ranges from about 35 to 45 inches.

*Professors of agronomy—Leaders of Extension agronomy and soils survey groups, respectively.
†Based on 1963-67 prices.

Figure 1. The Northeast Region of South Dakota.

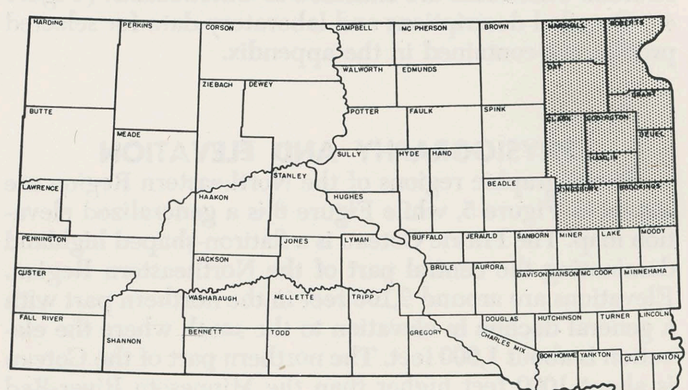


Table 1. Average Inches of Annual Precipitation During 13 Four-Week Periods in Northeastern South Dakota

Weather Station	3/1 to 3/28	3/29 to 4/25	4/26 to 5/23	5/24 to 6/20	6/21 to 7/18	7/19 to 8/15	8/16 to 9/12	9/13 to 10/10	10/11 to 11/7	11/8 to 12/5	12/6 to 1/2	1/3 to 1/30	1/31 to 2/29	Total
Clear Lake	1.05	1.84	3.25	3.55	3.78	2.36	3.35	1.86	1.21	0.68	0.56	0.29	0.54	24.24
Milbank	1.18	1.86	2.65	3.67	3.05	2.45	2.45	1.62	1.20	0.83	0.64	0.62	0.69	22.91
Clark	1.03	1.80	2.59	3.52	3.23	2.68	2.40	1.90	1.08	0.71	0.53	0.54	0.64	22.65
De Smet	1.08	1.69	2.71	3.63	3.12	2.70	2.19	1.67	1.13	0.74	0.48	0.54	0.62	22.30
Castlewood	0.80	1.76	2.52	3.89	3.07	2.84	2.41	1.57	1.02	0.69	0.36	0.38	0.45	21.76
Sisseton	0.96	1.71	2.60	3.84	3.61	2.32	1.97	1.38	0.96	0.68	0.45	0.45	0.62	21.55
Watertown	0.82	1.58	2.39	3.59	2.95	2.53	2.44	1.50	1.02	0.68	0.45	0.43	0.55	20.93
Webster	0.73	1.59	2.35	3.46	3.49	2.50	2.39	1.71	0.80	0.66	0.44	0.41	0.54	21.07
Britton	0.57	1.39	2.36	3.27	3.23	2.30	2.21	1.61	0.84	0.54	0.38	0.36	0.54	19.60

Precipitation Effectiveness

The precipitation effectiveness (PE) index is a function of both precipitation and temperature. It ranges from 40 in southern counties to 50 in eastern Grant County (Figure 3).

Growing Degree Days

There are 2,350 to 2,500 growing degree days at most locations for small grain and flax and 2,100 to 2,350 for corn and soybeans (Table 4).

Sunlight

Hours of sunlight received along the 44 degree and 46 degree latitudes range from 533 and 518, respectively, on Dec. 21 to 931 and 947 on June 21.

NATIVE VEGETATION

Although grass was the dominant native vegetation in the Northeast Region, there were several areas of native timber. One of these was the stream bottoms, and the other the protected north-facing slopes of the northern parts of the Prairie Coteau. The area covered by trees was small, however, and the soils of the Northeast Region owe their characteristics to the subhumid, grassland environment which predominated in the area. These characteristics include a nearly black surface, a very dark grayish-brown subsoil over a yellowish brown calcareous substratum. These soils are classified as Chernozems. (Figure 4). Detailed descriptions and laboratory data for selected profiles are contained in the appendix.

PHYSIOGRAPHY AND ELEVATION

Physiographic regions of the Northeastern Region are shown in Figure 5, while Figure 6 is a generalized elevation map. The Prairie Coteau is a flatiron-shaped highland dominating the central part of the Northeastern Region. Elevations are around 2,100 feet in the northern part with a general decline in elevation to the south where the elevation is about 1,600 feet. The northern part of the Coteau is about 1000 feet higher than the Minnesota River-Red River Lowland, and about 700 feet higher than the James Lowland on the west.

SOIL

Topography

The topography of the Northeast Area generally permits cultivation. However hilly or steeply sloping areas and closed depressions occur in the region and limit cultivation and affect management of the fields. Steeply slop-

Figure 2. Average mean temperature and precipitation, 1931-1960.

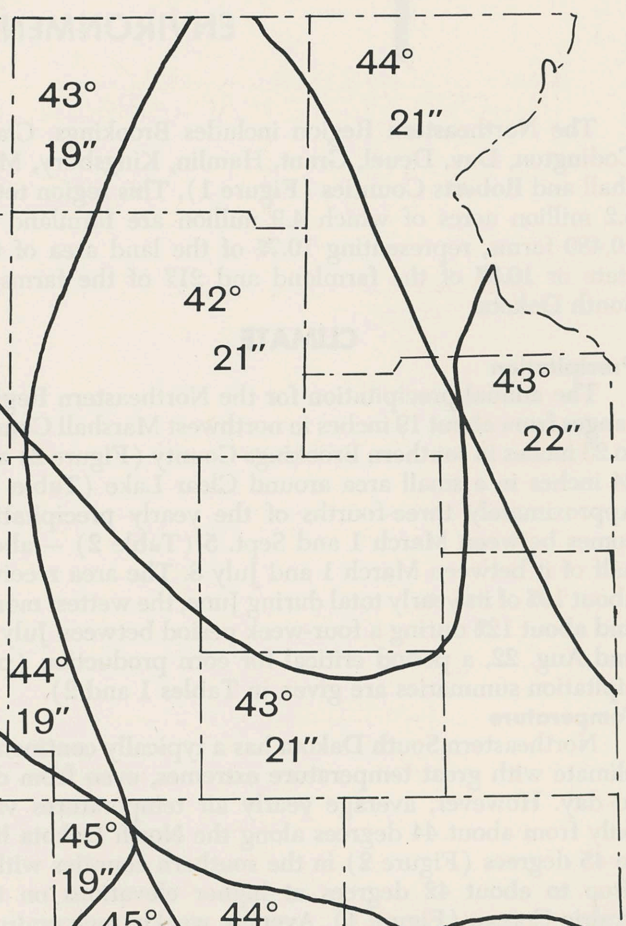


Figure 3. Precipitation effectiveness.

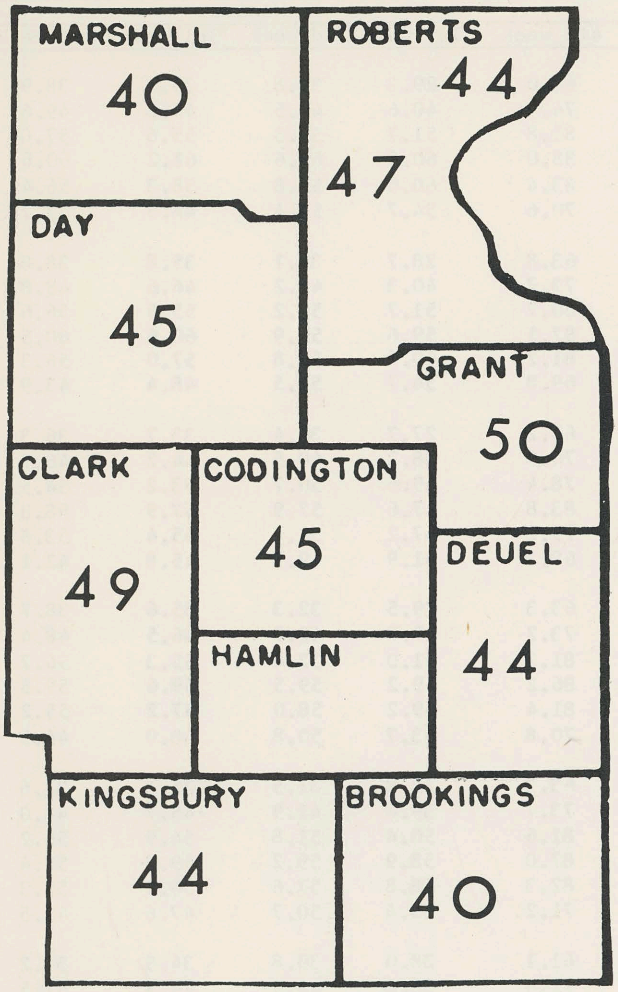


Figure 4. Classification of major soils.

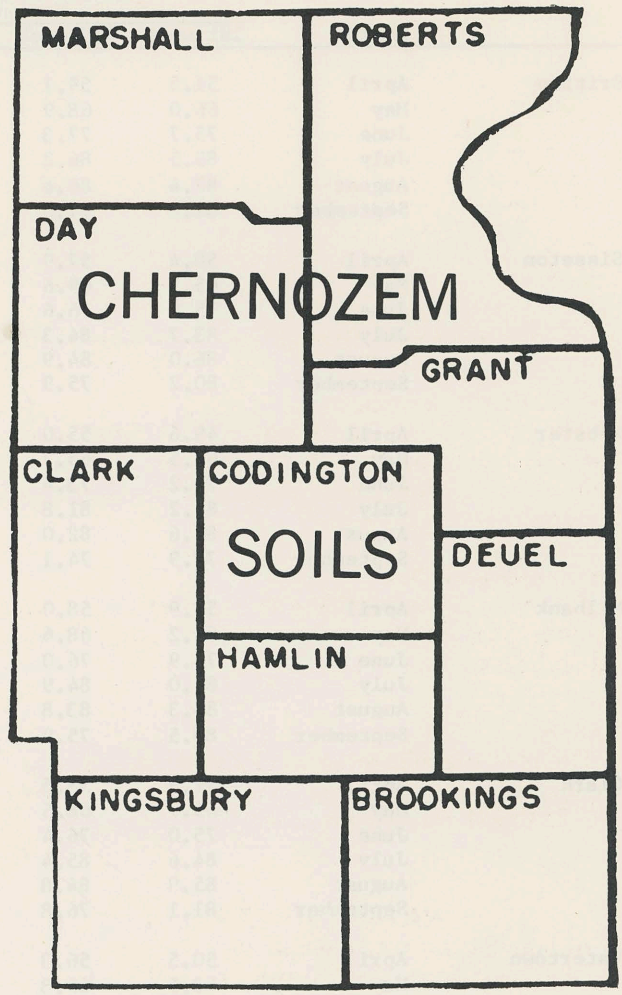


Table 2. Month and Day When Specified Amounts of Precipitation Are Received ("Weather Year" Starts March 1)

Percent precipitation	Clear Lake	Milbank	Clark	De Smet	Castlewood	Sisseton	Watertown	Webster	Britton
	Weather Station								
10	4/17	4/18	4/18	4/18	4/22	4/19	4/22	4/23	4/25
25	5/22	5/23	5/25	5/24	5/27	5/24	5/26	5/30	5/30
33	6/10	6/7	6/11	6/8	6/11	6/7	6/9	6/11	6/11
50	7/7	7/6	7/8	7/4	7/8	7/1	7/8	7/8	7/8
67	8/17	8/8	8/17	8/14	8/6	8/7	8/16	8/15	8/15
75	8/31	9/11	9/9	9/7	9/2	9/1	9/6	9/5	9/5

ing areas occur around the rim of the Prairie Coteau (Figure 5) and along the system of end moraines which occur west of, and roughly parallel to, the Sioux River. Closed depressions are common throughout the area except in a belt of land east of the Big Sioux River and running parallel to it from north of Watertown to the south boundary of the Northeast Region. Closed depressions are most common in the western part of the Prairie Coteau, especially in the northern portion.

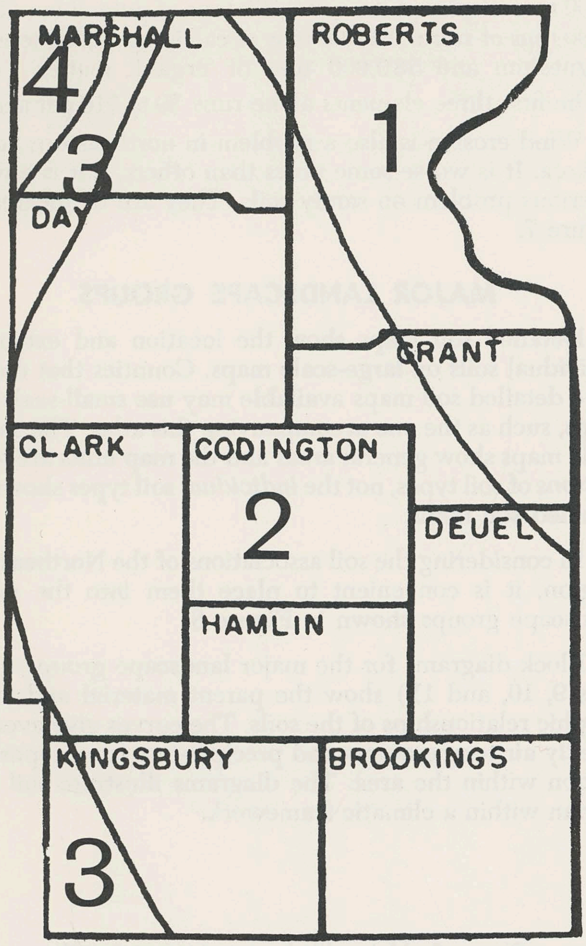
Parent Material

The most extensive soil parent material in the Northeastern Region is glacial till. Also present is loess, outwash, lacustrine materials and eolian sand. A few small areas of shale are exposed in some of the deeper stream-cut valleys draining the Prairie Coteau. For the most part these materials are medium textured, friable, calcareous and rich in primary minerals. Figures 7 and 8 show the areal extent and texture of the soil parent materials.

Table 3. Average Weekly Maximum and Minimum Temperatures in Selected Sites in Northeastern South Dakota

		Mean Weekly Temperature During Four Weeks of Month							
		Maximum				Minimum			
	Month	1st week	2nd week	3rd week	4th week	1st week	2nd week	3rd week	4th week
Britton	April	51.5	59.1	61.3	64.0	29.3	32.8	35.5	38.9
	May	66.0	68.9	72.0	74.9	40.6	42.5	45.8	49.6
	June	75.7	77.3	79.9	81.8	51.7	53.5	55.6	57.0
	July	85.5	86.2	88.1	88.0	60.8	60.6	61.2	60.6
	August	87.4	86.6	85.3	83.4	60.0	58.8	58.3	56.4
	September	81.9	77.0	74.8	70.6	54.7	51.4	48.5	43.7
Sisseton	April	50.4	57.9	61.1	63.8	28.7	32.1	35.8	38.8
	May	65.1	69.6	71.9	73.7	40.3	43.2	46.6	48.8
	June	75.2	76.6	78.9	80.7	51.7	53.2	55.5	56.6
	July	83.7	84.3	86.7	87.1	59.6	59.9	60.6	60.5
	August	86.0	84.9	83.2	81.2	60.6	58.8	57.0	56.3
	September	80.2	75.9	73.8	69.8	54.7	50.5	48.4	43.9
Webster	April	49.6	55.0	58.4	60.2	27.7	30.4	33.7	36.3
	May	62.5	65.7	69.1	70.9	38.2	40.5	44.2	46.7
	June	72.2	73.4	76.2	78.4	49.6	50.7	53.2	54.5
	July	81.2	81.8	83.4	83.8	57.6	57.9	57.9	58.3
	August	82.6	82.0	80.9	79.2	57.2	56.5	55.4	53.8
	September	77.9	74.1	71.5	68.3	51.9	49.1	45.8	42.1
Milbank	April	51.9	58.0	61.0	63.3	29.5	32.3	35.6	38.7
	May	66.2	68.6	71.5	73.2	40.8	42.7	46.5	48.4
	June	74.9	76.0	79.2	81.2	51.0	52.4	55.3	56.7
	July	84.0	84.9	86.2	86.2	59.2	59.5	59.6	59.5
	August	85.3	83.8	83.0	81.4	59.2	58.0	57.2	55.2
	September	80.5	75.9	73.3	70.8	53.7	50.8	48.0	44.5
Clark	April	52.9	58.5	61.7	63.3	28.8	31.5	35.3	37.6
	May	65.7	68.5	71.9	73.7	39.8	41.9	45.7	48.0
	June	75.0	76.4	79.3	81.6	50.4	51.8	54.9	56.2
	July	84.6	85.4	86.8	87.0	58.9	59.2	59.3	59.4
	August	85.9	84.8	84.1	82.3	58.8	57.6	56.6	55.3
	September	81.1	76.8	73.8	71.2	53.4	50.7	47.6	43.5
Watertown	April	50.5	56.3	59.5	61.1	28.0	30.8	34.5	37.2
	May	63.5	66.3	69.4	72.0	38.6	40.9	44.5	47.5
	June	73.2	74.5	77.2	79.6	50.1	51.0	54.0	55.3
	July	82.3	83.3	84.6	84.6	57.8	57.7	58.1	58.5
	August	83.6	82.6	81.9	80.1	57.4	56.8	56.0	54.1
	September	78.7	74.1	71.6	68.8	52.3	49.4	46.5	42.7
Castlewood	April	52.2	58.9	61.5	62.7	28.6	31.4	34.8	37.3
	May	65.5	68.9	71.7	74.0	39.1	41.1	44.9	47.9
	June	75.0	76.5	79.3	81.7	50.4	52.0	55.0	56.0
	July	84.5	84.9	86.7	86.9	58.5	58.2	58.8	59.0
	August	85.4	84.9	83.7	81.9	58.5	57.3	56.3	54.7
	September	81.2	76.9	74.4	69.8	53.2	51.0	48.0	42.5
Clear Lake	April	49.8	58.0	61.3	62.7	27.5	30.9	34.4	36.0
	May	67.1	70.9	69.9	72.8	42.4	44.0	46.0	48.4
	June	76.3	79.3	78.0	80.2	51.6	55.3	54.0	54.2
	July	82.2	82.9	85.6	84.7	57.1	58.4	59.6	58.8
	August	86.6	84.2	81.4	80.6	59.8	56.6	56.6	55.4
	September	77.0	75.1	68.9	67.4	52.7	48.9	45.1	42.9
De Smet	April	53.1	59.2	61.7	64.3	29.6	32.5	36.1	38.9
	May	65.9	68.7	72.0	74.5	40.9	42.5	46.6	49.1
	June	75.3	77.3	79.8	81.8	51.6	52.8	55.9	56.9
	July	85.1	86.4	88.0	87.8	59.8	60.1	60.5	60.2
	August	86.8	85.7	83.4	82.9	59.9	58.5	57.1	57.1
	September	81.5	77.3	74.8	70.4	54.6	51.4	49.0	43.8

Figure 5. Physiographic regions of northeast South Dakota.



1. Minnesota River-Red River Lowland
2. Coteau des Prairies
3. James River Lowland
4. Lake Dakota Plain

Table 4. Average Growing Degree Days (GDD) for Weather Stations in Northeastern South Dakota

Weather station	GDD T_b 40* April-July	GDD T_b 50** May-September
Britton	2485	2373
Sisseton	2549	2432
Webster	2275	2104
Milbank	2521	2410
Clark	2426	2279
Watertown	2353	2188
Castlewood	2387	2232
Clear Lake	2488	2310
De Smet	2605	2516
Brookings	2504	2349

* Growing Degree Days for small grain and flax.
** Growing Degree Days for corn and soybeans.

Soil Texture

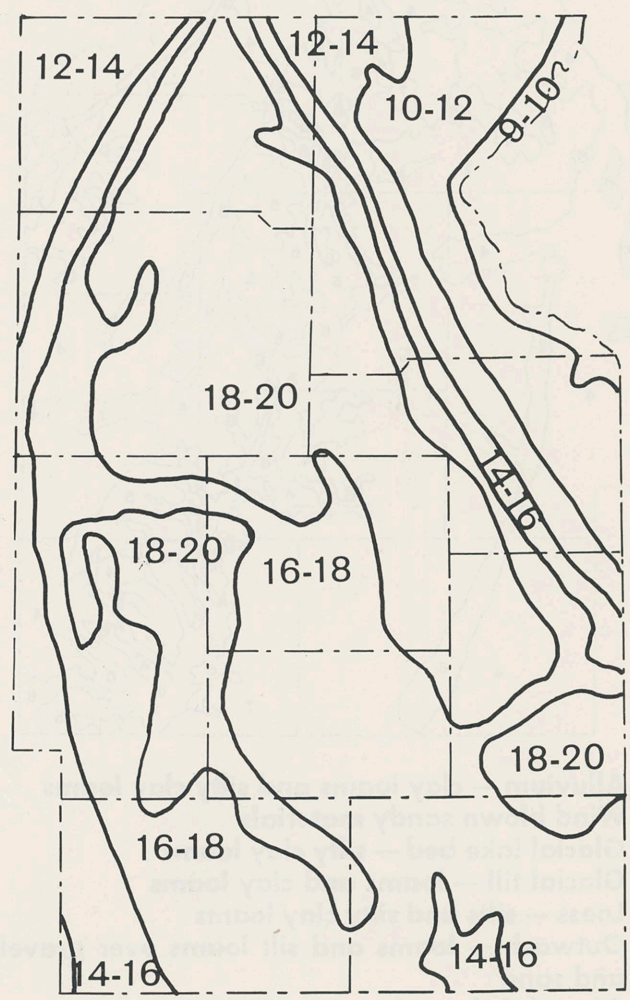
Soil texture for the Northeastern Region is shown in Figure 7. The areas of loess and lacustrine material are silty and stone-free. Glacial till soils have some stones throughout, but usually stoniness is a problem only on the steeper morainal areas. The Peever soils which occur mainly along the base of the Prairie Coteau are rather fine-textured. The reason for this is that the glacial till parent material in this area has a high percentage of shale present.

Soil Types

Soils can be sandy or clayey, or medium textured; occur on flats, hills, or undulating terrain or in closed depressions; be thin or thick or of moderate depth; be stony or stone-free; salty or non-salty; and well or poorly drained. These characteristics are used to classify soils, to catalog their properties, to predict best use and to determine special management requirements.

A group of soils having a defined range of soil characteristics is given a soil type name (for example the soil type Kranzburg silty clay loam refers to a deep, permeable, well-drained, stone-free silty soil occurring on un-

Figure 6. Elevations above sea level in hundreds of feet.



dulating uplands in the Northeastern Region. Buse loam is a thin, excessively drained loamy soil occurring on steep slopes).

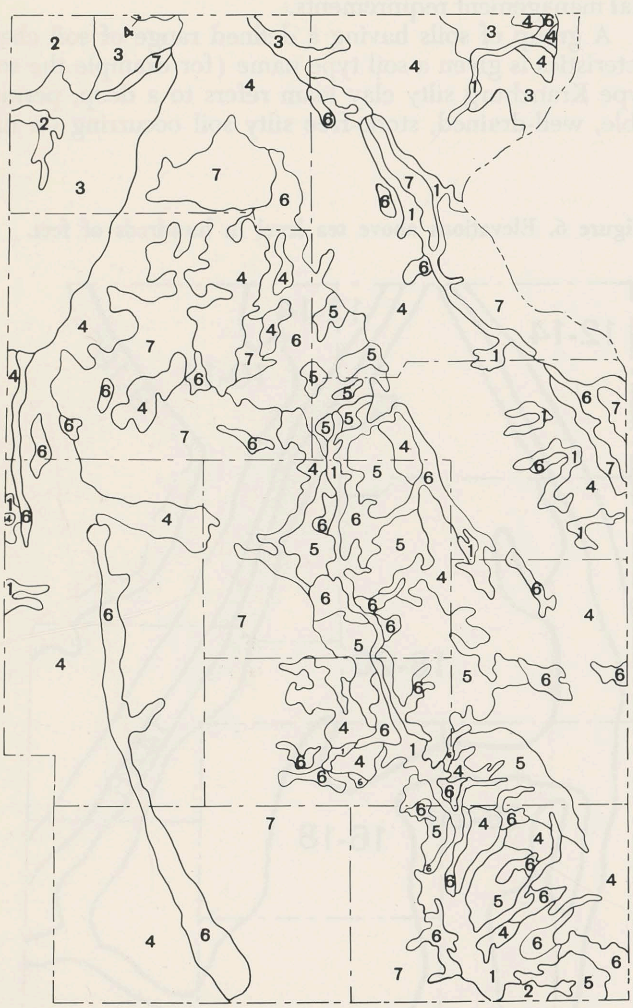
Since the characteristics of soils can be defined and the extent of soils can be shown on maps, it is possible to make predictions concerning soils. These predictions include crop adaptability, and crop yields. These predictions along with management requirements necessary to obtain these yields are presented in the following pages.

Soil Erosion

Considerable damage is caused by water erosion each year. It is estimated that numerous short but intense rain showers in 1967 caused almost $49 million worth of damage in the northeastern counties of South Dakota. In this estimation it was assumed that 25% of the 4.9 million acres of cropland lost 1/16 inch of topsoil through erosion. That much soil contains over 23,000 tons of nitrogen almost 7,000 tons of phosphorus, 289,000 tons of potassium, about 4,600 tons of sulfur, 86,900 tons of calcium, 34,750 tons of magnesium and 580,000 tons of organic matter (cost of the first three elements alone runs $9 to $10 per acre).

Wind erosion is also a problem in northeastern South Dakota. It is worse some years than others, but is always a serious problem on sandy soils. They are delineated in Figure 7.

Figure 7. General soil textures.



1. **Alluvium — clay loams and silty clay loams**
2. **Wind blown sandy materials**
3. **Glacial lake bed — silty clay loams**
4. **Glacial till — loams and clay loams**
5. **Loess — silts and silty clay loams**
6. **Outwash — loams and silt loams over gravel and sand**
7. **Glacial drift — silty**

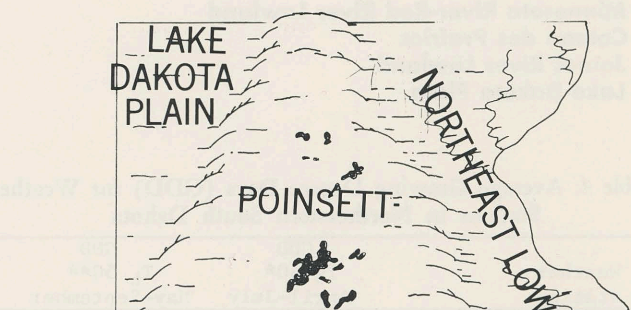
MAJOR LANDSCAPE GROUPS

Detailed soil maps show the location and extent of individual soils on large-scale maps. Counties that do not have detailed soil maps available may use small-scale soil maps, such as the one accompanying this atlas. The small-scale maps show general areas and the map units are *associations* of soil types, not the *individual* soil types shown on detailed soil maps.

In considering the soil associations of the Northeastern Region, it is convenient to place them into the major landscape groups shown in Figure 8.

Block diagrams for the major landscape groups (Figures 9, 10, and 11) show the parent material and topographic relationships of the soils. The curves give average weekly air temperatures and precipitation for a reporting station within the area. The diagrams illustrate soil and terrian within a climatic framework.

Figure 8. Major landscape groups of soils.



SOIL ASSOCIATIONS OF MAJOR LANDSCAPE GROUPS

The association of soils present in each major landscape group is given in the color map (pages 10-11).

Poinsett-Kranzburg Silty Prairie

1. **Flandreau-Egeland, undulating.** This is an association of sandy soils of minor extent occurring in the southeastern part of the region. The Flandreau soils are sandy loams while the Egeland soils are loamy sands.

2. **Fordville-Estelline, nearly level.** Both of these soils occur over outwash sand and gravel. The Estelline soils are silty and have deeper profiles than the loamier Fordville soils.

3. **Forman-Aastad-Parnell, strongly undulating.** These are clay loams developed from glacial till occurring mostly near the margins of the Prairie Coteau. The Forman soils are well drained upland soils, the Aastad occurs on flats while the Parnell are depressional soils.

4. **Forman-Buse-Aastad-Parnell, steep or rolling.** This association is similar to the Forman-Aastad-Parnell association except it occurs on steeper or more rolling topography. Here the thin Buse soils are found.

5. **Forman-Buse, sloping.** This association occurs on sloping topography having surface drainage which has eliminated the depressional sites where Parnell occurs.

6. **Forman, undulating.** This association consists principally of the deep, friable, clay loam soils.

7. **Kranzburg-Brookings-Vienna, nearly level.** This is an association principally of deep silty soils occurring on landscapes consisting of broad ridge tops and gentle side slopes.

8. **Lamoure, nearly level.** These are imperfectly drained, somewhat heavy alluvial soils of the Big Sioux River bottomlands and also of the bottomlands of smaller streams.

9. **Nutley, gently undulating.** These are clayey soils occurring on flat, steep-sided hills in Day and adjacent counties.

10. **Poinsett-Buse, strongly undulating.** These are silty and loamy soils of end moraines in the central part of the region.

11. **Poinsett-Heimdal, strongly undulating.** These are medium to coarse textured upland soils occurring in the northern part of the area.

12. **Poinsett-Waubay-Parnell, undulating.** This is an association of silty soils occurring in the western part of the area.

13. **Poinsett-Waubay, gently undulating.** This association is similar to the Poinsett-Waubay-Parnell association, but occurs on more gentle terrain.

14. **Renshaw-Fordville, gently undulating.** These are loams underlain by outwash with Renshaw having the sand and gravel at shallower depths than Fordville.

15. **Renshaw - Fordville - Divide, gently undulating.** This association is similar to Renshaw-Fordville, but includes Divide, an outwash soil having free carbonate at or near the surface.

16. **Renshaw-Fordville-Sioux, undulating to rolling.** This association resembles Renshaw-Fordville also, but occurs on hillier terrain and has more thin soils (Sioux).

17. **Sinai-Wentworth, gently undulating.** These are rather heavy soils occurring on uplands in the southwestern part of the area.

18. **Singsaas-Oaklake, undulating.** This association includes loam soils having worm-worked profiles.

19. **Vienna-Lismore, sloping.** These are loam soils of mature landscapes in the southeastern part of the region.

Northeast Lowland

20. **Antler-Parnell-Marsh, nearly level.** This is an area of poorly drained soils having some stones occurring in the extreme northeast corner of the state.

21. **Eckman-Gardena, gently undulating.** These are medium to moderately coarse textured soils occurring at the south end of glacial Lake Agassiz.

22. **Fargo-Grano-Lamoure, nearly level.** This is an association of heavy textured, imperfectly drained bottomland soils.

23. **Forman-Aastad-Parnell, gently undulating.** These are clay loams developed from glacial till.

24. **Forman, gently undulating.** This association consists mostly of well drained clay loam soils.

25. **Glyndon-Gardena, nearly level.** These are silty soils developed on the bed of Glacial Lake Agassiz.

26. **Heimdal-Fram, undulating.** This association occurs on a low ridge and consists of light calcareous and dark soils intermixed in a patchwork pattern.

27. **Heimdal-Sisseton, gently undulating.** These are loamy soils calcareous at or near the surface.

28. **Lamoure-Fargo, nearly level.** These are heavy soils along bottomlands.

29. **Peever, gently sloping.** This is a heavy soil developed from glacial till having a high component of shale.

30. **Peever-Tonka, gently undulating.** These heavy soils are on a plain pockmarked with shallow closed depressions where the Tonka soils occur.

31. **Sverdrup-Embden, gently undulating.** This is an association of sandy soils.

Lake Dakota Plain

32. **Beotia-Great Bend-Harmony, nearly level.** These are silty to moderately fine textured soils of Glacial Lake Dakota.

33. **Embden-Hecla-Ulen, undulating.** These are sandy loams well to poorly drained.

34. **Harmony-Aberdeen-Exline, nearly level.** These are moderately friable to heavy soils of Glacial Lake Dakota flats.

35. **Kranzburg, nearly level.** These silty soils are moderately deep over glacial till at margin of Glacial Lake Dakota.

36. **Maddock-Seroco, undulating.** This is an association of sandy to very sandy soils.

Houdek-Clarno Loamy Plain

37. **Beadle, gently undulating.** These moderately heavy soils are from glacial till.

38. **Beadle-Stickney-Dudley, nearly level.** This association is similar to Beadle, but contains moderate to heavy claypans in low or flat areas.

39. **Peever-Cavour, gently undulating.** This is an association of moderate to heavy soils some with claypans.

40. **Houdek-Ethan-Worthing, undulating.** These are friable loams associated with poorly drained soils in depressions.

41. **Houdek-Prosper, gently undulating.** These are friable, deep loams.

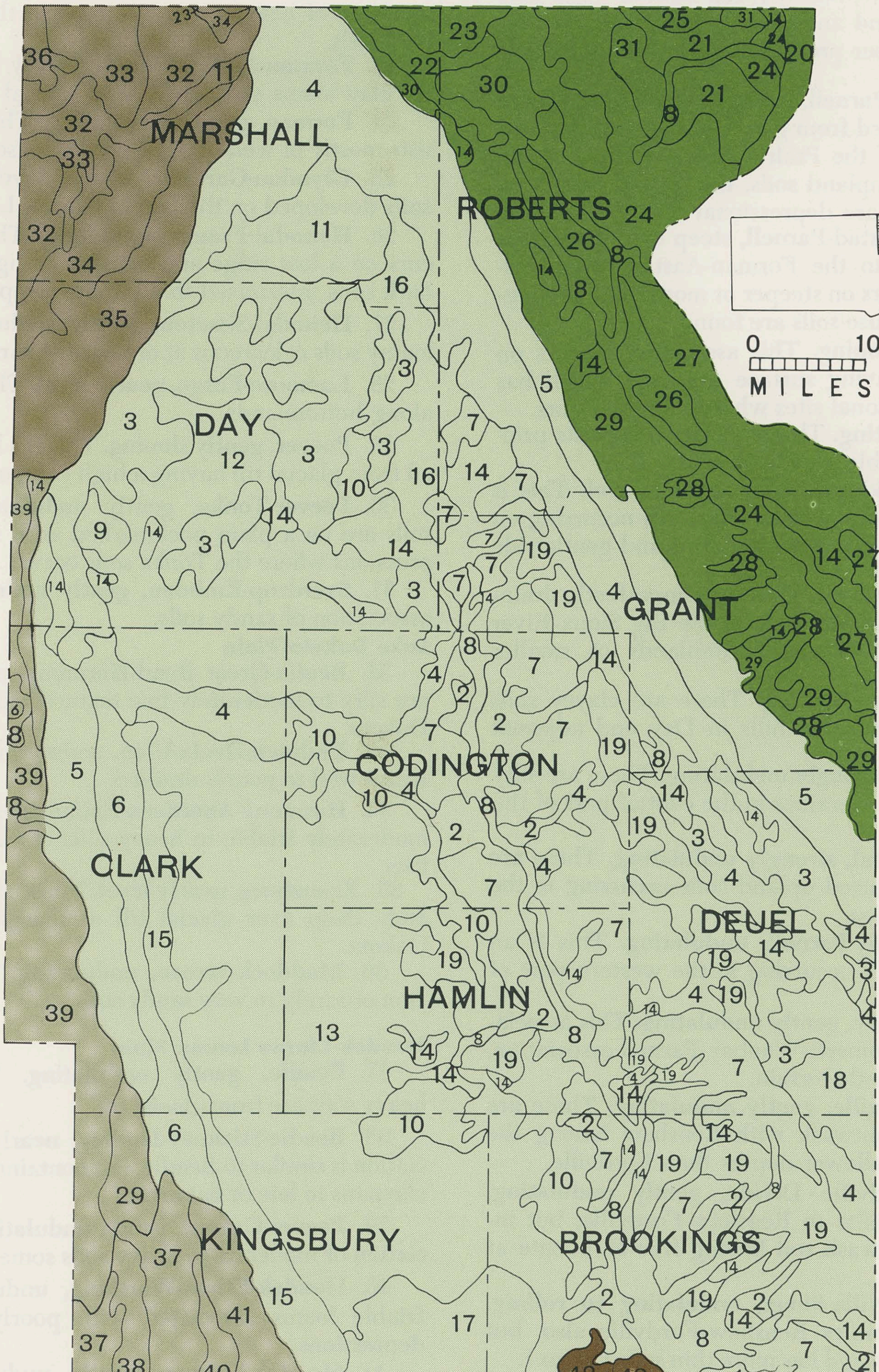
Moody Silty Prairie

42. **Wentworth - Egan - Clarno, strongly undulating.** These are friable silts and loams of uplands.

43. **Wentworth - Egan - Viborg, gently undulating.** These are deep friable silty soils.

SOIL MAP

Northeast South Dakota



U.S.G.S. Base Map Compiled in 1961

Agricultural Experiment Station and Extension Service, S.D.S.U., and Soil Conservation Service U.S.D.A. 1969

LEGEND

POINSETT-KRANZBURG SILTY PRAIRIE

- 1 Flandreau-Egeland, undulating
- 2 Fordville-Estelline, nearly level
- 3 Forman-Aastad-Parnell, strongly undulating
- 4 Forman-Buse-Aastad-Parnell, steep or rolling
- 5 Forman-Buse, sloping
- 6 Forman, undulating (Also on Houdek-Clarno Loamy Plain)
- 7 Kranzburg-Brookings-Vienna, undulating to nearly level
- 8 Lamoure, nearly level (Also on Northeast Lowland and Houdek-Clarno Loamy Plain)
- 9 Nutley, gently undulating
- 10 Poinsett-Buse, strongly undulating
- 11 Poinsett-Heimdal, strongly undulating (Also on Lake Dakota Plain)
- 12 Poinsett-Waubay-Parnell, undulating
- 13 Poinsett-Waubay, gently undulating
- 14 Renshaw-Fordville, gently undulating (Also on Northeast Lowland and Houdek-Clarno Loamy Plain)
- 15 Renshaw-Fordville-Divide, gently undulating
- 16 Renshaw-Fordville-Sioux, undulating to rolling
- 17 Sinai-Wentworth, gently undulating
- 18 Singsaas-Oaklake, undulating
- 19 Vienna-Lismore, sloping

NORTHEAST LOWLAND

- 20 Antler-Parnell-Marsh, nearly level
- 21 Eckman-Gardena, gently undulating
- 22 Fargo-Grano-Lamoure, nearly level
- 23 Forman-Aastad-Parnell, gently undulating (Also on Lake Dakota Plain)
- 24 Forman, gently undulating
- 25 Glyndon-Gardena, nearly level
- 26 Heimdal-Fram, undulating
- 27 Heimdal-Sisseton, gently undulating
- 28 Lamoure-Fargo, nearly level
- 29 Peever, gently sloping (Also on Houdek-Clarno Loamy Plain)
- 30 Peever-Tonka, gently undulating
- 31 Sverdrup-Embden, gently undulating

LAKE DAKOTA PLAIN

- 32 Beotia-Great Bend-Harmony, nearly level
- 33 Embden-Hecla-Ulen, undulating
- 34 Harmony-Aberdeen-Exline, nearly level
- 35 Kranzburg, nearly level
- 36 Maddock-Seroco, undulating

HOUDEK-CLARNO LOAMY PLAIN

- 37 Beadle, gently undulating
- 38 Beadle-Stickney-Dudley, nearly level
- 39 Peever-Cavour, gently undulating
- 40 Houdek-Ethan-Worthing, undulating
- 41 Houdek-Prosper, gently undulating

MOODY SILTY PRAIRIE

- 42 Wentworth-Egan-Clarno, strongly undulating
- 43 Wentworth-Egan-Viborg, gently undulating

Figure 9. Soil associations and climate for Poinsett-Kranzburg Silty Prairie.

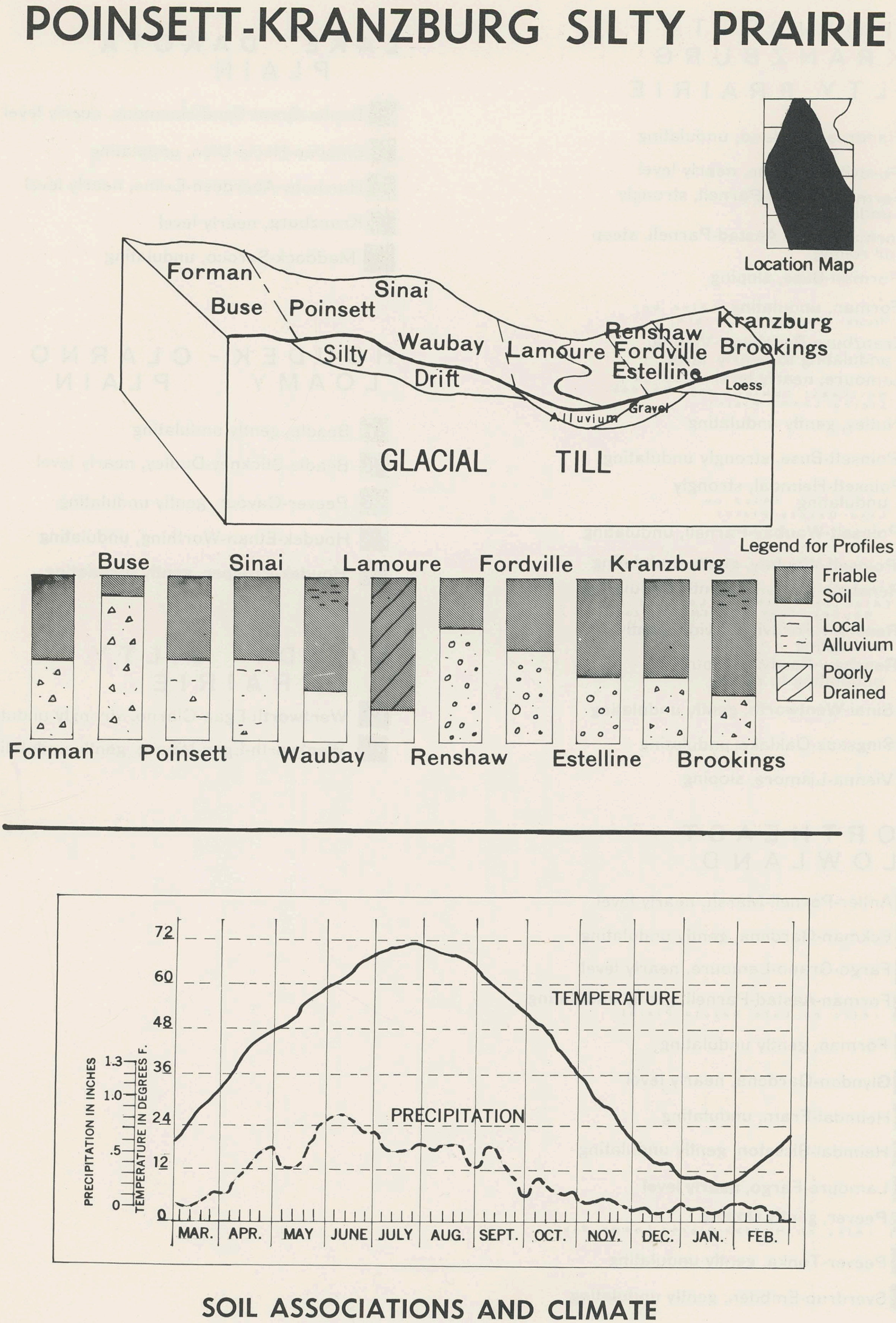
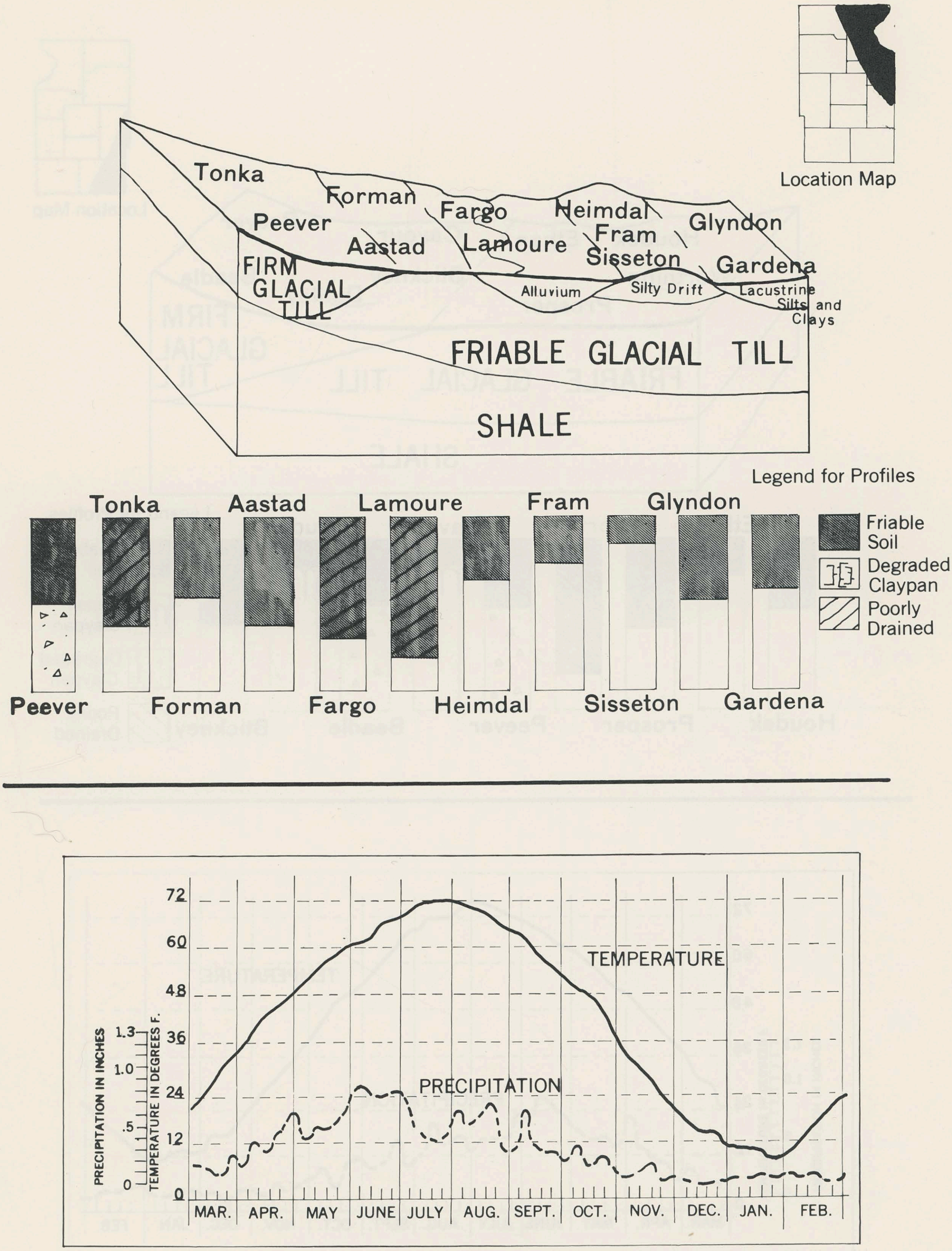


Figure 10. Soil associations and climate for the Northeast Lowland.

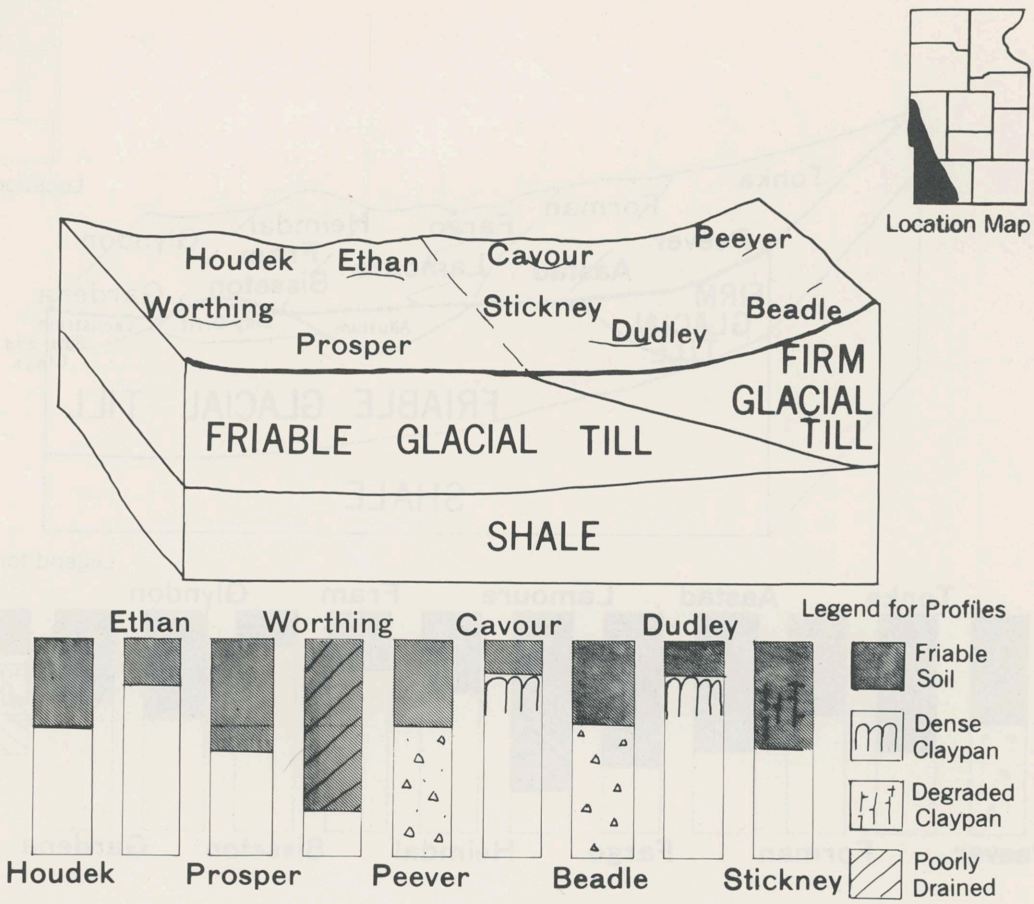
NORTHEAST LOWLAND

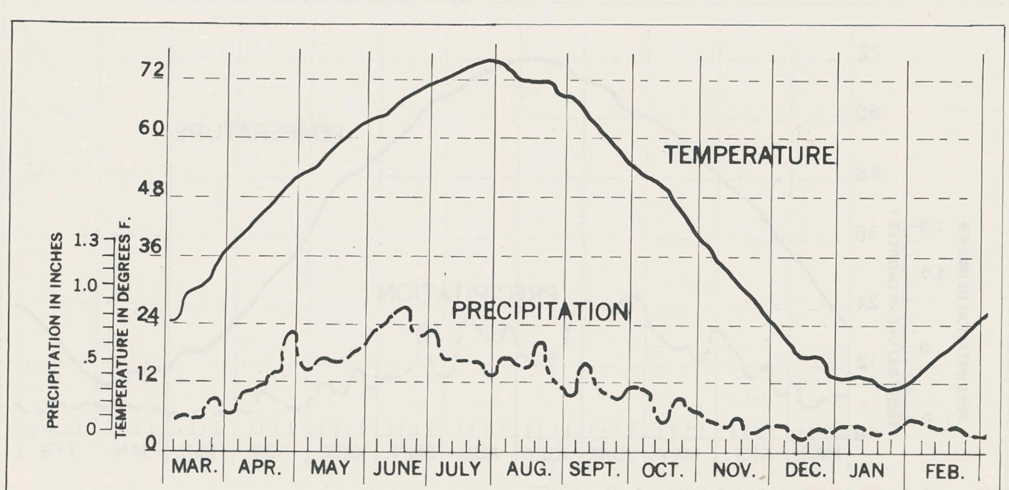


SOIL ASSOCIATIONS AND CLIMATE

Figure 11. Soil associations and climate for Houdek-Clarno Loamy Plain.

HOUDEK-CLARNO LOAMY PLAIN





SOIL ASSOCIATIONS AND CLIMATE

PRESENT LAND USE

Climatic environment of the Northeastern Region (cool-temperate with irregular and generally deficient rainfall and low relative-humidity) sets basic limits for kinds of crops which can be grown most successfully. Precipitation comes fairly early in the growing season, reaching its peak in June and tapering off about the last week in that month, although average weekly temperatures continue to rise for almost another month (Figure 12).

Generally the climatic environment on the Prairie Coteau favors the small grain crops — wheat, rye, barley and flax — and grasses and legumes. Corn, soybeans and sorghum, which require moisture coupled with higher temperatures and humidity during the summer, are not ideally suited. On the more permeable soils in the Northeast Lowlands, however, corn and soybeans are important crops. Corn also does well on the Lake Dakota Plain and the Moody Silty Plain.

Superimposed on climatic environment are the local crop controlling environments of topography and soil.

Present Crop Acreage

The acreage of each crop in each county (Table 5) represents the 1962-66 average number of planted acres of small grain, flax, corn, soybeans, and sorghum, harvested acres of wild hay and alfalfa hay and the 1964 acreage of tame grass hay, other hay, pasture, rangeland and total acres in farms. Per cent cropland is shown in Figure 13.

Present Crop Yield

The average yield of each crop in each county (Table 6) is the 1957-66 average for small grains, flax, corn, sorghum, soybeans, wild hay and alfalfa hay and the 1964 yield for tame grass hay.

Present Crop Production

The production of each crop in each county (Table 7) is the average yield (Table 5) multiplied by the average acreage (Table 6) for the crop.

Table 5. Average Acreage of Each Crop in the Counties of Northeastern South Dakota

	Corn*	Oats*	Barley*	Spring Wheat*	Durum Wheat*	Winter Rye*	Flax*	Soybeans*	Grain Sorghum*
Brookings	133,450	85,400	3,140	2,580	710	1,460	31,560	10,060	1,820
Clark	64,040	60,620	10,560	37,900	9,360	9,000	34,640	350	3,340
Codington	37,160	58,700	10,300	17,280	7,740	6,840	48,520	860	1,540
Day	37,260	67,360	24,840	40,960	18,940	10,960	55,740	210	1,440
Deuel	60,760	57,780	2,600	3,520	750	2,240	45,120	6,040	1,080
Grant	61,980	54,920	4,280	13,080	1,860	7,540	42,220	5,300	1,600
Hamlin	63,020	54,720	3,460	7,800	2,220	2,660	43,200	1,920	1,340
Kingsbury	100,960	57,800	6,040	13,780	7,540	4,820	35,360	1,960	3,780
Marshall	45,220	33,600	15,940	34,660	7,040	6,800	25,780	820	1,360
Roberts	78,780	78,160	5,640	35,640	4,720	8,900	67,780	22,720	1,680
Totals	682,640	609,060	86,800	207,200	60,880	61,220	429,920	50,240	18,980

	Alfalfa Hay*	Tame Grass Hay**	Native Hay*	Other Hay**	Pasture Cropland**	Pasture & Rangeland**	Other Farmland	Land in Farms**
Brookings	47,960	2,650	11,960	2,990	16,410	95,510	53,560	501,230
Clark	46,240	4,680	18,900	4,620	19,410	149,800	118,610	592,070
Codington	29,740	4,330	17,820	1,960	14,340	83,780	76,530	417,440
Day	35,040	6,160	39,200	2,020	17,590	124,080	139,250	621,050
Deuel	30,260	2,050	22,760	1,360	9,600	90,730	45,950	382,600
Grant	34,420	2,400	23,560	1,720	13,640	91,800	52,830	413,150
Hamlin	20,140	2,220	7,600	1,360	11,010	45,240	50,610	318,520
Kingsbury	43,520	5,280	10,740	2,990	24,250	94,930	84,840	498,590
Marshall	34,180	3,760	48,380	1,360	7,840	149,330	100,740	516,810
Roberts	38,500	5,400	57,940	1,890	12,060	142,820	101,360	663,990
Totals	360,000	38,930	258,860	22,270	146,150	1,068,020	824,280	4,925,450

* Average acreage reported by Crop and Livestock Reporting Service for years 1962-66, inc.
** Acreage reported by United States Census for 1964.

Table 6. Average Yield of Each Crop in the Counties of Northeastern South Dakota

	Corn*	Oats*	Barley*	Spring Wheat*	Durum Wheat*	Winter Rye*	Flax*	Grain Sorghum*	Soybeans*	Alf. Hay*	T. Grass Hay**	Native Hay*
Brookings	38.3	39.0	29.9	17.1	16.8	20.4	11.4	38.1	14.2	2.05	1.45	1.09
Clark	28.8	29.8	22.5	14.5	15.6	19.9	8.9	32.4	11.0	1.38	1.09	0.89
Codington	29.2	34.8	25.5	15.3	16.2	21.4	8.7	28.8	10.2	1.46	1.06	0.84
Day	28.0	32.4	26.6	17.1	18.4	21.5	8.5	25.3	11.2	1.38	1.08	0.88
Deuel	39.3	41.6	31.8	17.1	18.6	23.3	10.9	31.2	15.4	1.89	1.30	0.91
Grant	36.0	38.8	27.9	17.2	18.5	24.0	9.4	27.6	13.3	1.76	1.03	0.80
Hamlin	35.1	36.8	28.5	16.6	17.1	22.6	10.0	30.6	12.8	1.73	1.13	1.01
Kingsbury	35.5	35.9	27.1	16.2	15.6	20.6	11.5	29.8	14.4	1.76	1.26	1.00
Marshall	33.4	36.0	28.2	18.1	19.2	23.4	9.5	25.5	12.6	1.49	1.01	0.85
Roberts	34.6	38.2	30.0	17.3	18.4	24.5	7.0	28.6	13.4	1.60	0.99	0.82
Averages	33.8	36.3	27.8	16.7	17.4	22.2	9.6	29.8	12.9	1.65	1.14	0.91

* Average yield reported by Crop and Livestock Reporting Service for 10-year period 1957-1966, inc.
** Average yield reported by United States Census for 1964.

Table 7. Average Present Production of Each Crop in the Counties of Northeastern South Dakota*

	Corn	Oats	Barley	Spring Wheat	Durum Wheat	Winter Rye
Brookings	5,111,520	3,330,600	93,890	44,120	11,890	29,780
Clark	1,844,350	1,806,480	237,600	549,550	146,020	179,100
Codington	1,085,070	2,042,760	262,650	264,380	125,390	146,380
Day	1,043,280	2,182,460	660,740	700,420	348,500	235,640
Deuel	2,387,870	2,403,650	82,680	60,190	13,910	52,190
Grant	2,231,280	2,130,900	119,410	224,980	34,410	180,960
Hamlin	2,212,000	2,013,700	98,610	129,480	37,960	60,120
Kingsbury	3,584,080	2,075,020	163,680	223,240	117,620	97,850
Marshall	1,510,350	1,209,600	449,510	627,350	135,170	159,120
Roberts	2,725,790	2,985,710	169,200	616,570	86,850	218,050
Totals	23,735,590	22,180,880	2,337,970	3,440,280	1,057,720	1,359,190

	Flax	Soybeans	Grain Sorghum	Alfalfa Hay	Tame Grass Hay	Native Hay
Brookings	359,780	142,850	69,340	98,320	3,850	13,040
Clark	308,300	3,850	108,220	63,810	5,110	16,820
Codington	422,120	8,750	44,350	43,420	4,590	14,970
Day	473,790	2,350	--	48,360	6,650	34,500
Deuel	491,810	93,020	33,700	57,190	2,670	20,710
Grant	396,870	70,490	--	60,580	2,470	18,850
Hamlin	432,000	24,580	41,000	34,840	2,620	7,680
Kingsbury	406,640	28,220	112,640	76,600	6,650	10,740
Marshall	244,910	10,330	--	50,930	3,800	41,120
Roberts	474,460	304,450	--	61,600	5,350	47,510
Totals	4,010,680	688,890	409,250	595,650	43,760	225,940

* Present production equals 1962-1966 average yield times 1957-66 average acreage.

Figure 12. Weekly mean temperature, precipitation, Brookings.

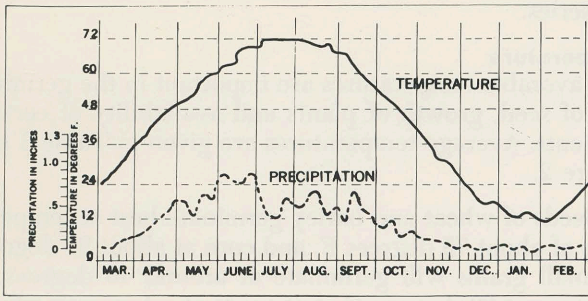
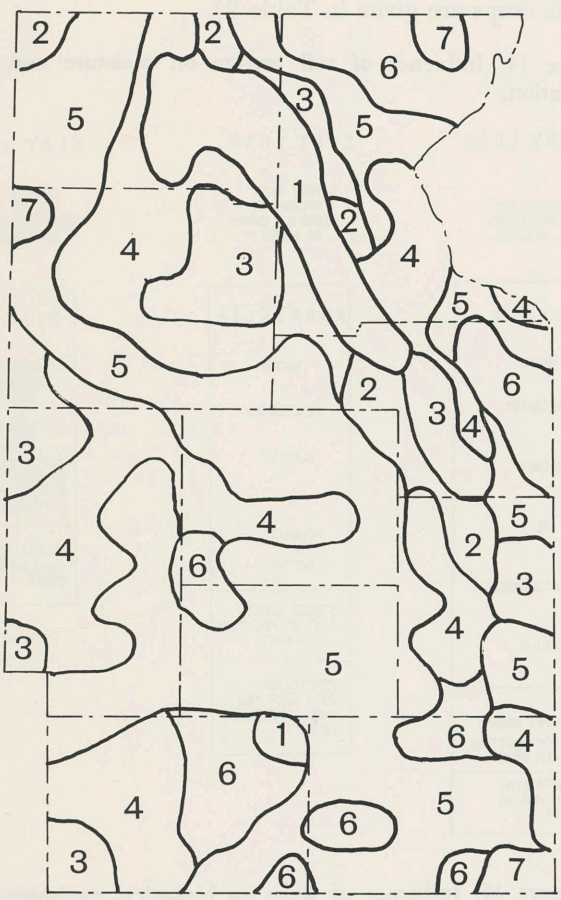


Figure 13. Per cent cropland.



1. Less than 35%
2. 35-45%
3. 45-55%
4. 55-65%
5. 65-75%
6. 75-80%
7. Over 80%

2 RELATIONSHIP BETWEEN ENVIRONMENT AND CROP PRODUCTION

Two important environmental factors – climate and soil – and three climatic factors – precipitation, temperature and sunlight–regulate the type of native vegetation produced in a region. Climate, native vegetation, topography and parent material regulate the formation of a soil.

Soils of northeastern South Dakota were formed under grass vegetation except for small local areas where trees grew. More humid areas of the region supported tall grass stands which left relatively large amounts of organic matter extending deeply into the soil profile. Short grasses were produced in the driest areas of the region which left lower amounts of organic matter and less nitrogen.

Although climate affects crop adaptation indirectly through its effect on soils, it may have an even greater direct effect. Climate generally causes regional differences in soils and governs crop adaptability over a large region. Local soil differences within the region are commonly due to differences in parent material and topography. Crop adaptation to local areas within the region are regulated by soil characteristics.

Table 8. Amount of Water Required by Crops and Weeds

Crop	Lbs. of water per lb. of dry matter	Weeds	Lbs. of water per lb. of dry matter
Millet	302	Tumble weed	227
Sorghum	322	Pigweed	297
Corn	368	Russian thistle	336
Wheat	513	Gumweed	432
Barley	534	Sunflower	705
Oats	597	Lamb's quarters	801
Flax	905	Western ragweed	948
Alfalfa	834		
Crested Wheatgrass	705		
Bromegrass	1016		

Crop	Acre-inch of water per ton or bushel*
Millet	2.3/T.
Corn	0.18/Bu.
Wheat	0.36/Bu.
Barley	0.25/Bu.
Oats	0.19/Bu.
Alfalfa	7/T.

* 1939 U. S. Yearbook of Agriculture

CLIMATIC FACTORS

Precipitation, temperature, radiation, number of frost-free days and relative humidity are important climatic factors.

Moisture

Crop production is influenced by the amount of precipitation, when it falls and by the quantity actually absorbed by the soil and available to crops. Most areas have adequate rainfall to produce good crops, but unfortunately much of it never becomes available to the growing plants.

Exact water amounts to produce a pound of dry matter vary with local weather conditions and crop types. But generally, something like 800 pounds of water is needed to produce 1 pound of dry alfalfa hay, 350 pounds produces 1 pound of dry matter for corn and 500 pounds produces 1 pound of small grain (water requirements for common crops and weeds are given in Table 8).

If straight-line relationships between yield and water requirements could be drawn, it would take about 5,000 gallons of water to produce a bushel of corn, 9,900 gallons to produce a bushel of wheat, 6,100 gallons to produce a bushel of oats, or 200,000 gallons to produce a ton of alfalfa. A 40-bushel corn crop, a 20-bushel wheat crop, 30-bushel oat crop, or a 1-ton alfalfa crop each would require 7 to 7.5 acre-inches of water. In experimental tests, 98 bushels of corn have been raised with 7 acre-inches and 5¾ tons of alfalfa have been raised with 22¼ acre-inches. In northeastern South Dakota, 20 to 22 inches of rainfall produce average yields of about 35 bushels of corn, 17 bushels of spring wheat, 36 bushels of oats, and 1.7 tons of alfalfa.

The time that moisture is available is also an important factor. The growing season for small grain is from around May 1 to around August 1. A good supply of moisture at the beginning of the growing season and some good rains in June or July will produce a successful small grain crop. Corn yield inversely correlates with the number of moisture stress days. This indicates that corn needs moisture all through the growing season for good yields. So corn in contrast to small grains, requires a good supply of moisture in August (Figure 12).

The amount of stored water in a soil profile has a decided effect upon crop yields. A good supply of stored water improves the chances of high yields. Silty soils can store more usable water than clayey soils which in turn can store more water than sandy soils. Estimates of the amount of stored water are possible before planting by examining the profile to a depth of 5 feet and noting the number of feet of moist soil. Every foot of moist sandy soil contains about 1 inch of water while silty soils contain 1.8 inches per foot and clayey soils contain 1.5 inches per foot (Figure 14).

Soil temperature is affected by the amount of water in the profile. It requires five times as much heat to raise the temperature of one pound of water one degree as it does for one pound of soil. Hence wet soils are cold soils. Sandy soils retain less moisture than medium- or fine-textured soils. Consequently they are warm soils. Drainage and texture are characteristics used in soil classification that can be used to estimate the relative temperature of a soil series.

Temperature

Favorable temperatures are important in the germination of seed, growth of plants and availability of certain nutrients. Average temperatures are given in Table 3 and Figure 2.

Seeds of wheat and barley germinate best at temperatures of about 75 degrees F. and corn at about 90 degrees F. Small grains will germinate at around 40 degrees F. and corn at 60 degrees F., but seeds of a few crop plants germinate at less than 40 degrees F.

Every living organism has its own set of cardinal temperatures — maximum, optimum and minimum (temperature ranges of metabolic activity of our agronomic crops are given in Table 9).

Figure 14. Influence of soil texture on moisture and crop adaptation.

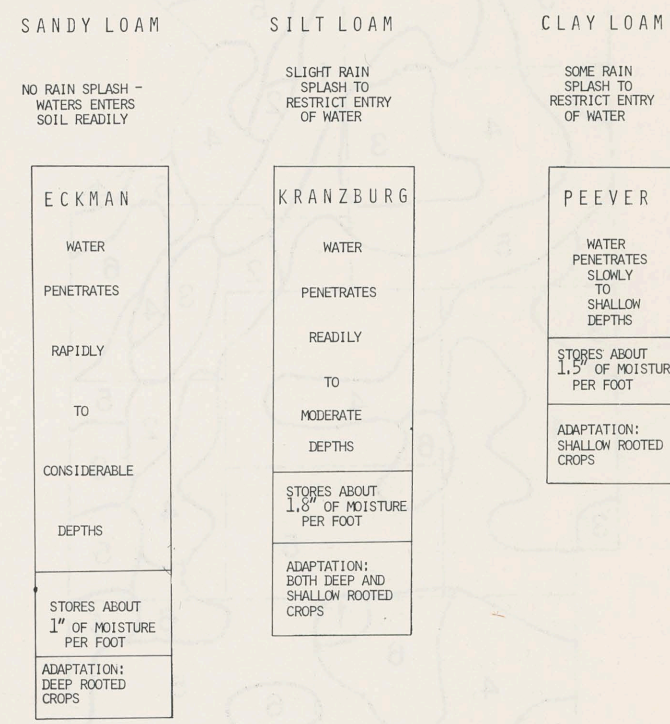


Figure 15. Influence of slope on biological environment.

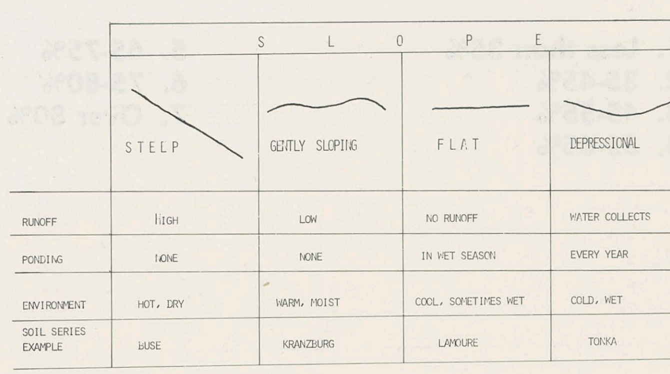


Table 9. Upper and Lower Air Temperature Limits for Growth of Four Agronomic Crops

Crop	Temperature° Maximum (°F)	Minimum (°F)
Barley	--	41
Corn	115	49
Peas	--	28
Wheat	104	41

Corn, for example, produces most of its growth at night. Daytime temperatures of 73 and 86 degrees F. have optimum night temperatures of 63 and 68 degrees F. Ears are not formed unless night-time temperatures are above 54 degrees F. Flax produces most seed with a 68 to 73 degree F. day temperature and a 50 degree F. night temperature.

Potatoes on the other hand, have better tuber production with day and night temperatures of 68 and 57 degrees F. Higher night temperatures greatly reduce yields. Sugar beets produce more sugar at lower temperatures – night temperature is more important than day temperature.

Each day is divided into two distinct periods for plants – one the photo-period or daylight when photosynthesis is dominant, the other the dark period (or night). In most plants, night temperature has more effect on flowering and plant growth than any other single factor.

Temperature has a decided effect on the activity of soil organisms which make available the nitrogen, phosphorus and sulfur in soil organic matter. High soil temperatures, if moisture is not limiting, favor the greatest activity and release of nutrients.

Average weekly maximum and minimum temperatures are given in Table 3 and average weekly temperatures for three stations are given in Figures 9, 10 and 11.

Growing Degree Days (GDD)

GDD is a statistic used for predicting plant development and adaptability. Base temperature (T_b) is the lowest temperature at which growth occurs. When daily temperature average is greater than the T_b figure, then growth, supposedly proportional to GDD, occurs within the plant. Within usually tolerable limits a certain number of GDD (Table 4) can be allotted to various stages of growth and development.

The number of growing degree days (GDD) required for production of crops common to northeastern South Dakota and minimum temperatures (T_b) at which growth occurs for these crops are given in Table 10.

Table 10. Values Frequently Assigned to Tb and the Total GDD Calculated for Various Crops in Northeastern South Dakota

Crop	T_b (°F)	Total GDD planting to harvesting
Corn	50-55	2,200 - 2,600*
Soybeans	50-55	2,000 - 2,400*
Barley	40-43	2,000 - 2,400**
Flax	40	1,900 - 2,200**
Oats	40-43	2,100 - 2,500**
Wheat	40-43	2,000 - 2,400**

* T_b = 50; ** T_b = 40

Precipitation Effectiveness

Effect of temperature upon available moisture can be assessed by a precipitation-effectiveness factor (PE) – the higher the PE, the more effective the precipitation. The PE formula provides climatological comparisons of various South Dakota areas.

Sunlight

Sunlight is essential for photosynthesis, the physiological activity that produces plant food (carbohydrates). In general, rate of photosynthesis increases as light intensity increases up to around 10,000 foot-candles and more hours of light provide more hours of photosynthesis. Lack of sunlight is seldom a worry in northeastern South Dakota, however.

SOIL FACTORS

Soil factors that affect crop adaptation include texture, thickness of solum (A + B horizons), profile drainage, salinity, alkalinity, and (if present) depth to claypan, sand, gravel, cobble or bedrock. Topographic factors most significant in crop adaptation include length, steepness, and aspect of slope and presence or absence of "potholes."

Topography

Steep slopes permit rainfall run-off, resulting in poor water absorption, soil erosion and a relatively dry soil. Slopes are best used for sod-forming grasses.

Soils on south-facing slopes receive the sun's rays more directly and hence receive more heat per unit area, so slope aspect also is important in assessing soil temperatures and can be a site selection factor for orchards and gardens.

Topography indirectly affects the activity of soil organisms and in turn affects soil fertility and crop adaptation. Since all the nitrogen and about half of the phosphorus in the soil are released from organic matter by soil organisms, soil fertility is affected by the activity of these organisms. They are most active in a moist, warm environment. Soil temperature is affected by soil moisture content and the amount of moisture is affected by topography.

Rain is absorbed on flat or gently sloping areas (Figure 15), resulting in a warm, moist environment. Soil organisms become active, decompose organic matter, liberate nitrogen and phosphorus and increase soil fertility. Water runs off a steep slope leaving it dry (and hot) and collects in depressions, leaving them wet (and cold). Soil organisms are not fully active and do not release a maximum amount of plant food.

Soils that warm-up early in the spring have nitrogen and phosphorus available early in the spring and are better adapted for early growing crops such as grass or small grains. Wet soils, on the other hand, do not warm up and nutrients are not readily available until later in the growing season. They are better adapted for the production of late-seeded crops, but sometimes can be used for early-seeded crops if plant food is provided in the form of commercial fertilizer.

Soil Texture

Soil texture and organic matter content affect the rate of water absorption and the depth of penetration. Sandy soils, for example, usually absorb more water than loams or clays. Depth of claypan, bedrock, cobble or gravel, if present, also affect the depth of penetration. Water is not absorbed readily and does not penetrate very deeply into a fine textured soil, such as a clay loam like Peever. Rain drops splash when they hit the surface, mix with fine soil particles and form a thin glue-like material that seals the pores between soil particles. This slows down absorption, resulting in large moisture losses through runoff and large soil erosion losses. Pores in the soil are small and do not allow water to penetrate very rapidly. Since rain water is on the surface a relatively short time, there is not enough time to penetrate very deeply. Although a clay loam will store about 1.5 inches of moisture per foot of soil, it is not well suited for the production of deep-rooted crops.

A silt loam like Kranzburg does not seal over as readily as a clay loam and has larger pores between soil particles. Therefore, water is absorbed more readily and penetrates more deeply in Kranzburg than in Peever. The silt loam will store about 1.8 inches of moisture per foot of soil so it is well suited to the production of all kinds of crops.

A sandy loam-like Eckman has larger soil particles and larger pores between particles than either a clay loam or silt loam. Therefore, raindrops do not splash on impact, do not form a glue to seal over the top or fill pores below the surface. Rain is readily absorbed, resulting in less runoff and less water erosion, and penetrates more deeply than in finer textured soils. A sandy loam will store about 1 inch of moisture for every foot of soil and is well suited for the production of deep-rooted crops. Sandy soils, however, have a severe wind erosion hazard and are low in nitrogen.

Humus (organic matter) tends to cement small soil particles together forming aggregates similar to the large soil particles in sandy soils. Consequently, organic matter helps increase the rate of absorption and depth of penetration. Since humus acts as a sponge, it also increases the storage capacity.

Mulches of crop residues on the soil surface tend to insulate and delay soil warm up time in the spring. They also cut down on evaporation but they reduce splashing of raindrops and improve water absorbing capacity. If mulches are used, the soil moisture situation will be improved but seed germination will be slower. Breakdown of organic matter also will be slower so nitrogen and phosphorus requirements in the early part of the growing season may have to be met with the use of commercial fertilizer.

Soil Thickness

Thin soils over claypan, sand, gravel or bedrock have relatively low water storing capacity. Since most of the rainfall in the region comes in the early part of the summer, soils with meager water storage are not adapted for the production of crops (such as corn) that require late season moisture. However, they may produce good small grain or grass.

Nutrient Elements

The surface horizon of a typical soil is composed of about 46% mineral material, 3% organic matter, 25% air and a small but significant percentage of soil organisms.

The mineral material of the soil is ground-up rock and consists of particles of sand, silt and clay. Only about 12% by weight of this material is involved directly in plant nutrition. The rest is inert and functions to support the growing plant.

Sixteen elements are considered essential for plant growth. Three of these – carbon, hydrogen and oxygen – come from carbon dioxide of the air and from water.

The remaining 13 elements come from soil mineral material and organic matter (listed in Table 11). Carbon, hydrogen and oxygen make up about 90 to 95% of plant tissue; nitrogen, sulfur and phosphorus make up 3 to 5%; while the remaining 7 elements make up less than .1% of plant tissue.

Nitrogen. Nitrogen present in the soil organic matter becomes available to plants through a decomposition process carried on by soil organisms (the amount needed for most crops is given in Table 12).

The soil organisms break down the protein to simpler forms called amino acids and these in turn are broken down to ammonia (NH_4) and to nitrate (NO_3).

Parts of the ammonia exist as positively charged ions and are electrically held both on the clay particles and on the humus. In this form the nitrogen is not subject to leaching loss but is readily available to plants and soil organisms. Another part of the ammonia – fixed ammonia – is held between the layers of micaceous minerals. It is only slowly available.

The nitrogen which changes to the nitrate form is available for direct use by plants and soil organisms. Since it is soluble, this form also is subject to leaching loss.

Table 11. Essential Plant Nutrients

Nutrient Elements	Total pounds per acre**	Available* pounds per acre
Major Nutrients		
Nitrogen#	4,000	1-50
Phosphorus*#	1,000	0.01-0.10
Potassium*	50,000	5-15
Sulfur#	800	1-10
Calcium*	15,000	10-100
Magnesium*	6,000	5-50
Minor Nutrients		
Iron*#	50,000	Trace
Manganese*	1,600	Trace
Boron*	100	Trace
Copper*	50	Trace
Zinc*	50	Trace
Molybdenum*	Trace	Trace
Chlorine*	Trace	Trace

* Located in minerals of soil
# Located in organic matter of soil
** Surface horizon

Conversion of nitrogen to the ammonia and nitrate form requires a warm, moist and well-aerated soil.

Thin, hilly soils and sandy soils are warm and well aerated but not moist. Flat, poorly-drained soils are moist but cool and poorly-aerated. Friable, well-drained, medium-textured soils are warm, moist and well aerated. Thus by knowing the soil series it is possible to predict the relative rate of nitrogen release.

When fresh organic matter is added to the soil, the number of microorganisms increases rapidly. They digest and oxidize the carbohydrates to obtain energy while releasing carbon dioxide. The nitrogen in the organic matter is incorporated into the tissue of the microorganisms. Although it is not lost while in this form, neither is it available to plants. As decomposition advances, the proportion of carbon to nitrogen becomes less or, in other words, the carbon/nitrogen (C/N) ratio becomes narrower. This continues until an equillibrium is reached when the organic matter is largely reduced to humus. At this time the activity of the microorganisms has decreased. They die because there is not enough carbohydrates for them to live on. The nitrogen of their bodies then becomes part of the soil humus.

Soils in the Northeastern Region of South Dakota have carbon to nitrogen ratios, in humus, of about 10 to 1. This ratio will remain fairly constant as long as no fresh organic material is added. One part of nitrogen will be released for plant growth for every 10 parts of carbon oxidized.

Phosphorus. The element phosphorus (P) is present in both the organic and the mineral portions of the soil (amounts needed for most crops are given in Table 12). About half of it is organic and half is mineral. In the surface horizons of these soils, the total amount of organic and mineral phosphorus present is around 1,000 pounds per acre or 0.05 per cent. Not only is the total amount of phosphorus in soils low, but so is the amount available at any given time.

Table 12. The Number of Pounds of Plant Food Elements Removed by Crops (Grain and Straw or Stover)

Crop	Lbs. of N*	Lbs. of P_2O_5*	Lbs. of K_2O*
Corn	1.5	0.5	1.0
Oats	0.8	0.4	0.8
Barley	1.2	0.5	1.0
Soybeans	5.5	1.2	1.8
Flax	4.0	1.1	1.8
Rye	1.6	0.8	1.4
Wheat	1.8	0.75	1.0
Alfalfa Hay	55.0	12.0	32.0
Bluegrass	30.0	11.0	42.0
Red Clover	43.0	10.0	35.0
Bromegrass	32.0	8.4	43.0
Potatoes	0.2	0.1	0.3
Estimated Number of Pounds of Plant Food			
Sorghum grain	1.5	0.5	1.0
Sorghum silage	6.0	2.0	4.0
Sorghum forage	18.0	6.0	12.0
Corn silage	7.5	2.5	5.0

* Plant food required for each pound of grain or ton of forage

Previous cropping has removed about 15% of the original supply of phosphorus. In the organic portion, a part of the phosphorus is tied up with humus and a part occurs as other compounds. Thus carbon and phosphorus do not form constant ratios in soils.

Most of the P in organic form becomes available to plants through decay of the organic materials in somewhat the same way nitrogen becomes available. A small part of the P in organic materials is "chelated," however. In this form it is not absorbed on the clay or precipitated, but remains soluble and available for plant use.

Since the release of most of the phosphorus from the organic form is dependent upon the activity of soil microorganisms which thrive best in warm, moist, well-aerated soils, knowledge of the soils series can aid in the prediction of this release.

The phosphorus in mineral form is released most probably by direct solution and by a substitution of other elements in solution for the phosphate of the minerals. At any one time only a very small concentration — several parts per million — of phosphorus is present in the soil solution. As plants use it, more is added by solution and substitution. If phosphate fertilizer is added to the soil it raises the concentration of phosphorus in the soil solution to some extent, but most of it reacts chemically with the soil to form compounds of iron and aluminum phosphate. An increase in these forms of phosphates, however, increases the chance of getting more phosphate into the soil solution by solution and substitution. Thus, at any one time there is not much phosphorus available for plants. Likewise, there is very little in a form that can be lost by leaching.

Potassium. Potassium is not a part of organic material and hence its release to plants is entirely a chemical matter (amounts needed by most crops are given in Table 12). It becomes available by weathering when the potassium goes into the soil solution or onto the clay particles as the potassium ion. It is in exchangeable form when electrically attached to the clay particles.

Transformation of potassium to an available form is a slow process and totals 5 or 10 pounds per year. However, the potassium in exchangeable form is a measure of the moderately-available form of potassium. Potassium added in plant residues, animal manures, or commercial fertilizer exists almost entirely as water soluble salts and when added to the soil, most of it will go to the exchangeable form.

Sandy soils generally have less available, exchangeable, and total potassium than medium- or fine-textured soils.

Other Elements. Calcium, magnesium and sulfur are called secondary elements. Boron, chlorine, copper, iron, manganese, molybdenum and zinc are known as trace or minor elements. These 10 elements are needed for plant growth. However, at present it appears that most soils in the northeastern region have sufficient quantities of most of these elements.

Organic Matter

Organic matter contains most of the nitrogen and about half of the phosphorus in the soil. Organic matter content of up to 3 or 4%, plus iron oxide, help impart a more favorable granular structure and make the granules more difficult to break-down. Humus itself, acts as a sponge to absorb water. It increases water intake, adds essential nutrient elements and reduces runoff, erosion and evaporation losses.

As long as no fresh organic material is added to the soil, there will be a steady release of nitrogen. Approximately 60 to 80 pounds of nitrogen is released each year. This may not be enough nitrogen for maximum crop production but there will be some available every year. If, however, fresh organic materials are added to the soil the carbonaceous material will encourage the growth of microorganisms which will use up all of the available nitrogen leaving very little or none for crops. If the fresh organic materials are high in carbonaceous material and low in nitrogen (like straw and corn stover) the soil will be critically low in available nitrogen. If, however, the organic materials added have a relatively low C/N ratio (like animal manures and legume green manure) then nitrogen availability in the soil will not be as critical as is the case with straw and stover.

Approximately half of the original supply of organic matter in the soils of northeastern South Dakota has been depleted by cropping. Under present farming systems, the organic matter content of soils will continue to decline. However, the rate of decline is slowing down as more resistant organic materials are encountered. Even though nitrogen losses can be made up by commercial products, the effect of lower organic matter levels will further aggravate an already serious moisture conservation problem.

Soil nitrogen and organic matter losses probably are more serious in the more humid soil regions. This is because relatively larger yields of crops in these areas have depleted the more humid soils, even though total amounts of nitrogen and organic matter in these soils still rank above the soils of the drier areas.

Water Erosion

Water erosion occurs when rain water falling on the soil surface runs off, carrying with it soil particles in suspension. This erosion is affected by soil, slope, texture, amount of organic matter, structure, and fertility status, factors which are more or less interrelated.

Type of crop raised affects the amount of soil lost by water erosion. In an experiment conducted near Madison, S. D., on a 5.8% slope 80 feet long, the 3-year average loss of soil under different cropping systems was 33.49 tons per acre under fallow, 10.32 tons under continuous corn, 9.15 tons under mulch tilled corn and 1.28 tons when oats was raised each year.

Wind Erosion Control

Wind erosion is a saltation process. Sand grains or sand-sized granules are blown several feet into the air during this process and then driven with a high velocity into the soil. The impact of the grains sprays soil up into the air. The fine individual silt and clay particles are taken up by the wind and blown out of the area. The sand-sized particles rise several feet into the air and, repeating the cycle, they again are driven back into the soil.

Susceptibility to erosion by wind depends largely upon soil texture. Soils with a large percentage of sand-sized particles (2-0.05 mm.) are most susceptible to blowing. These particles may be sand grains or clay or silt particles balled up into sand-sized grains.

Since wind erosion hazard depends so much on soil texture, it is fairly easy to delineate susceptible areas. They are shown accurately on county soil surveys — the sandy areas on the soil association map generally delineate the susceptible areas (Figure 7).

Aeration and Toxic Substances

Oxygen is essential for the life of the soil organisms which liberate nitrogen, phosphorus, sulfur and some minor elements from soil organic matter. Oxygen also is necessary for plant roots. Lack of oxygen (such as occurs in a poorly drained soil) not only restricts liberation of nutrient elements, but encourages growth of undesirable soil organisms which produce toxic substances. Some of these toxic substances are methane, hydrogen sulfide and iron salts. **Only in the very poorly drained soil are these toxic substances likely to form.** Lack of aeration resulting in low release rates of nutrients is most serious in the poorly drained soils.

In addition to toxic substances produced by soil organisms, other toxic substances such as excess soluble salts, and alkali may occur in soils. This is the result of having a soil parent material high in salts or alkali, or by having soil located where toxics are carried in the water.

Most of the soils of the Northeastern Region are not handicapped by salts or alkali within the rooting area, but may have excess salts or alkali in their lower horizons. Salts and alkali may be harmful if the soils are irrigated, unless drainage is provided.

LATITUDE AND ELEVATION

Latitude and elevation are directly associated with several climatic factors that affect adaptability of crops and crop varieties.

Maturity of corn is affected by several factors that affect growth and floral development.

Corn adapted to Mexico does not flower (tassel) in South Dakota, therefore does not produce grain. In contrast, corn from the Gaspe' Peninsula of Canada flowers and produces ears in August in South Dakota when not more than three feet tall. This reaction is generally attributed to the effects of photoperiod.

On the other hand, corn hybrids of different maturity are adapted to certain latitudes and elevations. As a rule, a movement of 120 to 150 miles northward or a 1,000-foot increase in elevation results in the need for a hybrid with 10 days shorter maturity. Reduced temperature may be the cause.

A corn hybrid classified as 110-day maturity, for example, at one latitude and elevation may be classified differently under other conditions. Irrigation improves growing conditions so that corn hybrids mature 5 to 15 days earlier than on dryland.

Late maturing oat varieties are better adapted to areas of higher elevation and northern latitude.

3 MANAGEMENT FOR POTENTIAL PRODUCTION

Four committees of crop production specialists listed under "Acknowledgments" helped estimate the potential yields and management practices needed to produce these yields for northeastern South Dakota.

POTENTIAL PRODUCTION

Potential yield of each crop on each of the soils in the region was estimated (soils are delineated in soils map and the yields shown in Table 13). These yields were weighed according to the present production in the county. An estimated potential yield for each county was obtained and recorded in Table 14.

Some farmers and ranchers produce yields above those shown in Table 14 on some of the more productive soils or during years of higher rainfall. The potential yields indicate producing capacity over a 10-year period of good and poor years for good and poor soil.

Estimated potential crop production for the region (Table 15) is the estimated potential yield multiplied by the present (1962-66 average) acreage of that crop in the county (Table 5).

MANAGEMENT FOR MAXIMUM PROFIT

Application of the best known crop and soil management practices and economic principles provides increased production and production efficiency. This means better profits.

These practices include crop rotation, use of best adapted crops, selection of proper variety, use of good quality seed, seed treatment, proper time, method and rate of planting, good fertility practices (including use of commercial fertilizer), weed control, insect control, proper time and method of harvesting, grazing management, better moisture utilization and soil and water conservation. Several committees of crop production, soils and pest control specialists (listed under "Acknowledgments") have made the management recommendations which follow.

Adapted Crops

Environmental factors of the area and environmental requirements were discussed in a previous section. Crops best adapted to soil associations of northeastern South Dakota are given in Tables 16 and 17.

Flax, oats, rye, spring wheat, barley and grasses are well adapted in the northern part of the area. Corn, soybeans, oats, barley, and flax are the best adapted crops in the Northeast Lowland and on the central and southern parts of the Poinsett-Kranzburg Silty Prairie. Alfalfa is adapted throughout the region on friable soils having gentle slopes. Hilly areas, poorly drained areas, and sandy or gravelly soils are best adapted for pasture. There are very few winter wheat varieties that possess enough winter hardiness to produce a good crop year after year.

There is an established market for malting barley, durum wheat and flax, making this area one of the best areas of South Dakota for producing these crops.

Table 13. Potential Crop Yields on the Soils of Northeastern South Dakota

	Bushels Per Acre										Tons Per Acre							Lb/A	
											Silage			Hay				Grazing	
Area[a]	Corn[b]	Corn	Oats	Barley	HRS Wheat	Durum Wheat	Winter Rye	Flax	Grain Sorg.	Soy-beans	Corn[b]	Corn	Sorghum	Alfal-fa[b]	Alfal-fa	Grass	Native	Pasture	Range
POINSETT-KRANZBURG SILTY LOAM																			
1.	90	58	55	48	28	29	37	20	50	22	12.0	9.7	14.5	4.7	2.9	1.9	1.4	2850	2100
2.	100	62	62	55	31	32	36	21	54	26	12.5	10.2	15.0	4.5	2.9	1.9	1.4	2850	2100
3.	--	48	56	49	28	30	30	17	40	--	--	8.4	12.5	--	2.1	1.6	1.2	2400	1800
4.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.2	0.8	1800	1200
5.	--	49	57	50	28	31	30	17	42	--	--	8.4	12.5	--	2.1	1.6	1.2	2400	1800
6.	85	48	45	40	23	24	28	15	41	16	12.0	8.4	12.5	4.5	2.0	1.3	1.0	1950	1500
7.	100	62	62	55	31	32	36	21	54	26	12.5	10.2	15.0	4.5	2.9	1.9	1.4	2850	2100
8.	85	55	53	47	32	33	37	16	47	20	12.0	9.3	14.0	4.7	2.9	1.8	1.4	2700	2100
9.	90	55	56	49	28	29	33	20	50	20	12.0	9.3	14.0	4.7	2.4	1.8	1.2	2700	1800
10.	--	40	50	44	25	27	27	15	35	--	--	7.2	11.0	--	1.9	1.3	1.0	1950	1500
11.	--	39	40	43	24	26	27	15	34	--	--	7.2	11.0	--	1.9	1.3	1.0	1950	1500
12.	--	48	56	49	28	30	30	21	40	16	12.0	9.3	14.0	4.7	2.4	1.8	1.2	2700	1800
13.	90	55	56	49	28	29	33	20	50	20	12.5	9.3	14.0	4.7	2.4	1.8	1.2	2700	1800
14.	85	48	45	40	23	24	28	15	41	16	12.0	8.4	12.5	4.5	2.0	1.3	1.0	1950	1500
15.	85	46	44	40	22	23	28	15	40	16	12.0	8.4	12.5	4.5	2.0	1.3	1.0	1950	1500
16.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.2	0.8	1800	1200
17.	95	57	58	51	29	30	35	21	52	22	12.5	9.4	15.0	4.7	2.5	1.9	1.4	2850	2100
18.	90	60	64	56	32	33	38	22	50	26	12.5	10.0	15.0	4.7	2.9	1.9	1.4	2850	2100
19.	90	55	59	52	29	30	35	19	47	22	12.0	9.3	14.0	4.7	2.6	1.7	1.3	2600	2000
NORTHEAST LOWLAND																			
20.	90	45	55	48	27	27	31	17	--	--	12.0	8.1	--	4.5	2.2	1.5	1.1	2250	1650
21.	110	62	62	55	31	31	35	21	--	24	14.0	10.2	--	5.3	3.0	2.0	1.5	3000	2250
22.	90	50	55	48	28	28	34	17	--	18	12.0	9.3	--	4.3	2.6	1.7	1.3	2600	2000
23.	100	60	60	53	30	30	33	19	--	21	12.5	10.0	--	4.5	3.0	2.0	1.5	3000	2250
24.	100	60	60	53	30	30	33	19	--	21	12.5	10.0	--	4.5	3.0	2.0	1.5	3000	2250
25.	110	62	62	55	31	31	35	20	--	24	14.0	10.2	--	5.3	3.0	2.0	1.5	3000	2250
26.	--	50	52	48	26	26	32	16	--	16	--	8.1	--	--	2.4	1.6	1.2	2400	1800
27.	85	55	56	50	28	28	31	17	--	18	12.0	10.0	--	4.5	2.6	1.7	1.4	2600	2000
28.	100	60	62	55	31	31	35	20	--	21	12.5	10.0	--	4.5	3.0	2.0	1.5	3000	2250
29.	90	58	59	52	30	30	36	19	--	20	12.0	9.7	--	4.5	2.6	1.7	1.3	2250	1950
30.	90	57	58	51	30	30	36	19	--	20	12.0	9.7	--	4.5	2.6	1.7	1.3	2250	1950
31.	100	54	45	40	23	23	27	16	--	17	14.0	8.7	--	5.0	2.7	1.8	1.3	2700	1950

	Bushels Per Acre										Tons Per Acre							Lb/A	
											Silage			Hay				Grazing	
Area[a]	Corn[b]	Corn	Oats	Barley	HRS Wheat	Durum Wheat	Winter Rye	Flax	Grain Sorg.	Soy-beans	Corn[b]	Corn	Sorghum	Alfal-fa[b]	Alfal-fa	Grass	Native	Pasture	Range
	LAKE DAKOTA PLAIN																		
32.	110	52	60	53	30	32	32	23	--	--	15.0	8.4	--	5.0	2.5	1.8	1.2	2700	1800
33.	100	46	45	40	22	24	24	17	--	--	15.0	8.0	--	5.0	2.0	1.6	1.1	2400	1650
34.	90	47	57	50	27	29	29	20	--	--	14.0	8.1	--	4.8	2.3	1.6	1.0	2500	1650
35.	110	52	60	53	30	32	32	23	--	--	15.0	8.4	--	5.0	2.5	1.8	1.2	2700	1800
36.	--	25	35	--	--	--	20	--	--	--	--	7.0	--	--	1.9	1.3	0.8	1800	1200
	HOUDEK-CLARNO LOAMY PLAIN																		
37.	90	45	53	46	26	27	26	17	47	16	12.0	8.1	12.0	4.7	2.1	1.4	1.1	2100	1650
38.	90	43	52	45	25	26	25	16	46	15	12.0	8.1	12.0	4.7	2.1	1.4	1.1	2100	1650
39.	90	41	50	44	23	24	25	15	45	15	12.0	8.0	11.0	4.5	2.0	1.3	1.0	2000	1650
40.	85	43	50	44	25	25	26	16	43	15	14.0	8.1	12.0	5.0	2.4	1.5	1.1	2500	1650
41.	95	52	49	43	24	25	30	19	62	16	15.0	8.9	11.5	5.5	2.2	1.6	1.1	2400	1650
	MOODY SILTY PRAIRIE																		
42.	120	65	60	53	30	32	38	20	55	27	15.0	10.5	15.8	5.5	3.2	2.1	1.6	3150	2400
43.	--	60	58	51	29	31	35	18	50	25	--	10.0	15.0	--	3.0	2.0	1.5	3000	2250

a Soil associations delineated in color center foldout map.
b Irrigated by either sprinkler or gravity system.

Adapted Varieties

Varieties should not only be selected for their high yielding ability, but also for quality and resistance to prevalent diseases and insects. Average yield can be increased by planting disease-resistant adapted varieties. If Vernal alfalfa were planted on all the alfalfa acreage in the state, yield would be increased about 7% or 0.12 ton per acre. In the northeastern counties the increase is greater.

The use of stem rust resistant varieties in South Dakota could have averted the $25 million loss in winter wheat during 1962 and the $8 million loss in durum during 1958. New races of rust and other diseases will develop in the future. It will be necessary to change varieties every 5 to 10 years in order to constantly have varieties that are resistant to the new diseases.

There are several varieties of each adapted crop that will do well in any area of northeastern South Dakota. For some crops the differences in elevation need to be taken into consideration when selecting a variety.

The established market for malting barley which frequently pays a premium of 25 to 30 cents a bushel, makes it impractical to grow a barley variety that has not been approved for malting. Leaf diseases, prevalent in the Red River Valley of North Dakota and Minnesota, sometimes become a problem in the Northeast Lowlands of eastern Roberts and Grant counties. Growers in this area should consider using barley varieties that are resistant to these diseases.

Only the most winter hardy winter wheat varieties should be grown. Also, some winter rye varieties will not overwinter in this area.

If flax is seeded late, there are certain varieties that will do better than others. Differences are less apparent when seeded early.

The Prairie Coteau is 700 to 1000 feet higher than many other parts of this Northeastern Region. Early maturing corn or soybean varieties normally produce better than medium to late maturing varieties at these higher elevations. On the other hand, late maturing oat varieties will do better on the Prairie Coteau than at lower elevations.

High Quality Seed

It is recommended that certified seed be bought for half the acreage of each small grain or soybean crop every 3 years. Home grown seed could be used on all the acres for 2 years and half the acres the third year. Seed produced in the other half of the acreage every third year should be used as the home grown seed the next 3 years.

Seeding

Crops specialists recommend that small grains and flax be seeded with a drill, preferably a press drill for spring-seeded crops and a deep-furrow drill for winter wheat. Winter wheat seems to overwinter better if seeded into a stubble-mulch. Recommended rates of seeding are 10 pecks per acre for oats, 5 for barley, hard red spring wheat, durum wheat or winter rye and 4 pecks for flax or winter wheat.

Early-seeded small grain generally outproduces later seeded crops. Seed spring wheat (including durum) and barley as soon as the soil is ready. Although the wheats are normally seeded first, this practice may change. Many research results indicate that early-seeded barley qualified for malting more often than late-seeded barley. Oats can be seeded later than barley or wheat, however, research results in Iowa indicate that oat yield in that state is decreased at least one bushel for every day that seeding is delayed past May 1. Most flax varieties produce better when seeded early, however, flax is less tolerant to frost than small grains. Plant flax during the last half of April; it may get frosted once in a while. For flax seeded later than May 10, use a variety that has proven that it will yield well when seeded late.

Seed winter rye during early September for a grain crop or spring pasture. Seed in July for a fall pasture.

Table 14. Estimated Potential Yield of Each Crop in the Counties of Northeastern South Dakota

	Corn	Oats	Barley	Spring Wheat	Durum Wheat	Winter Rye	Flax	Soybeans	Grain Sorghum	Alf. Hay(T)	T. Grass Hay(T)*	Native Hay(T)*	Corn Silage (T)
Brookings	60	60	51	30	31	36	20	22	52	2.8	1.9	1.4	10.0
Clark	45	50	46	25	26	30	16	--	42	2.2	1.6	1.1	9.0
Codington	50	54	50	29	29	33	17	--	43	2.5	1.7	1.3	9.0
Day	43	55	45	27	29	28	18	--	--	2.0	1.6	1.1	9.0
Deuel	61	63	54	30	31	36	17	21	47	2.7	1.8	1.3	10.0
Grant	54	60	52	29	29	37	16	18	--	2.6	1.7	1.3	9.5
Hamlin	55	56	49	29	30	35	17	17	45	2.5	1.8	1.3	9.5
Kingsbury	55	55	46	26	27	36	16	20	48	2.3	1.6	1.1	9.5
Marshall	52	56	49	28	30	31	18	--	--	2.2	1.5	1.1	9.5
Roberts	54	59	52	29	29	33	18	18	--	2.6	1.7	1.3	9.5
Averages	53.1	56.8	49.4	28.2	29.0	33.4	17.4	19.3	46.2	2.44	1.70	1.23	9.5

* Estimated potential yields for tame pasture and range are 75% of the estimated tame and native hay yields, respectively.

Table 15. Estimated Potential Production of Each Crop in the Counties of Northeastern South Dakota

	Corn	Oats	Barley	Spring Wheat	Durum Wheat	Winter Rye
Brookings	7,947,570	5,095,980	160,450	77,400	21,950	52,720
Clark	2,848,730	3,031,000	483,650	947,500	243,360	270,000
Codington	1,976,900	3,185,290	513,970	501,120	224,460	222,980
Day	1,610,900	3,724,680	1,127,740	1,092,200	541,680	304,690
Deuel	3,718,330	3,640,330	140,400	105,600	23,190	80,420
Grant	3,346,920	3,267,830	222,560	379,320	53,570	279,730
Hamlin	3,434,490	3,085,010	169,200	226,200	66,600	92,300
Kingsbury	5,591,680	3,153,570	278,440	352,770	203,580	171,590
Marshall	2,340,040	1,879,660	774,680	978,660	209,790	211,480
Roberts	4,229,240	4,611,440	292,720	1,033,600	134,990	293,700
Totals	37,044,800	34,674,790	4,163,810	5,694,370	1,723,170	1,979,610

	Flax	Soybeans	Grain Sorghum	Alfalfa Hay (T.)	Tame Grass Hay (T.)	Native Hay (T.)
Brookings	637,510	221,320	94,640	134,290	5040	16,740
Clark	554,240	--	140,280	101,730	7490	20,790
Codington	824,840	--	66,220	74,350	7360	23,170
Day	1,003,320	--	--	70,780	10,040	43,120
Deuel	767,040	129,860	50,760	82,940	3,690	29,590
Grant	683,960	98,050	--	87,790	4,080	30,630
Hamlin	751,680	34,180	60,300	50,490	3,970	9,880
Kingsbury	565,760	39,200	181,440	100,100	8,450	11,810
Marshall	471,770	--	--	73,830	5,750	53,220
Roberts	1,240,370	424,860	--	100,100	9,180	75,320
Totals	7,500,490	947,470	593,640	876,400	65,050	314,270

Table 16. Adapted Crops, Suggested Cropping Sequences, and Protective Measures for Soil Associations of Northeastern South Dakota

Landscape Groups and Soil Associations	Corn	Sorghum	Spring Wheat	Durum Wheat	Oats	Barley	Rye	Flax	Alfalfa	Sweet Clover	Alfalfa-Brome	Native Grass	Suggested Cropping Sequence[1]	Protective Measures
Poinsett - Kranzburg Silty Prairie														
1. Flandreau - Egeland, undulating	C	S	W	D	O	B			A	S	X	G	3,7,11	Contours
2. Fordville - Estelline, nearly level	C	S	W	D	O	B	R	F	A	S	X	G	3,7,2	Contours
3. Forman - Aastad - Parnell, strongly undulating		S	W	D	O	B	R	F	A	S	X	G	5,8,11,13	Terraces
4. Forman - Buse - Aastad - Parnell, steep or rolling												G	Native grass	Keep in grass
5. Forman - Buse, sloping		S	W	D	O	B	R	F	A	S	X	G	5,8,11,13	Terraces
6. Forman, undulating		S	W	D	O	B	R	F	A	S	X	G	5,8,11,13	Contours
7. Kranzburg - Brookings - Vienna, nearly level	C	S	W	D	O	B	R	F	A	S	X	G	1,2,6	Contours
8. Lamoure, nearly level	C	S	W		O	B	R	F	A	S	X	G	5,14	
9. Nutley, gently undulating	C	S	W	D	O	B	R	F	A	S	X	G	3,7,11	Contours
10. Poinsett - Buse, strongly undulating					O	B	R	F	A	S	X	G	10,11	Contours
11. Poinsett - Heimdel, strongly undulating					O	B	R	F	A	S	X	G	10,11	Contours
12. Poinsett - Waubay - Parnell, undulating	C	S	W	D	O	B	R	F	A	S	X	G	5,8,11,13	Terraces
13. Poinsett - Waubay, gently undulating	C	S	W	D	O	B	R	F	A	S	X	G	3,7,11	Contours
14. Renshaw - Fordville, gently undulating			W	D	O	B	R	F	A	S	X	G	4,8	
15. Renshaw - Fordville - Divide, gently undulating			W	D	O	B	R	F	A	S	X	G	4,8	
16. Renshaw - Fordville - Sioux, undulating to rolling							R		A	S	X	G	13	
17. Sinai - Wentworth, gently undulating	C	S	W	D	O	B	R	F	A	S	X	G	3,7,11	Contours
18. Singsaas - Oaklake, undulating	C	S	W	D	O	B	R	F	A	S	X	G	5,8,11,13	Terraces
19. Vienna - Lismore, sloping	C	S	W	D	O	B	R	F	A	S	X	G	5,8,11,13	
Northeast Lowland														
20. Antler - Parnell - Marsh, nearly level												G	14	Catch crops
21. Eckman - Gardena, gently undulating	C		W	D	O	B	R	F	A	S	X	G	1,2,6	Wind strips
22. Fargo - Grano - Lamoure, nearly level	C		W	D	O	B	R	F	A	S	X	G	3,7,11	
23. Forman - Aastad - Parnell, gently undulating	C		W	D	O	B	R	F	A	S	X	G	3,7,11	Contours
24. Forman, gently undulating	C		W	D	O	B	R	F	A	S	X	G	3,7,11	Contours
25. Glydon - Gardena, nearly level	C		W	D	O	B	R	F	A	S	X	G	1,2,6	
26. Heimdal - Fram, undulating			W	D	O	B	R	F	A	S	X	G	5,11,13	Contour
27. Heimdal - Sisseton, gently rolling			W	D	O	B	R	F	A	S	X	G	4,5,8,11,13	Terraces
28. Lamoure - Fargo, nearly level	C		W	D	O	B	R	F	A	S	X	G	5,14	
29. Peever, gently sloping	C		W	D	O	B	R	F	A	S	X	G	3,7	Contours
30. Peever, Tonka, gently undulating	C		W	D	O	B	R	F	A	S	X	G	3,7	
31. Sverdrup - Embden, gently undulating	C		W	D	O	B	R	F	A	S	X	G	4,5,8,11,13	Wind strip cropping

(TABLE 16 CONTINUED ON PAGE 28)

(TABLE 16—ADAPTED CROPS—CONTINUED)

Landscape Groups and Soil Associations	Corn	Sorghum	Spring Wheat	Durum Wheat	Oats	Barley	Rye	Flax	Alfalfa	Sweet Clover	Alfalfa-Brome	Native Grass	Suggested Cropping Sequence[1]	Protective Measures
Lake Dakota Plain														
32. Beotia - Great Bend - Harmony, nearly level	C		W	D	O	B	R	F	A	S	X	G	1,2,6	
33. Embden - Hecla - Ulen, undulating	C		W	D	O	B	R	F	A	S	X	G	3,7	
34. Harmony - Aberdeen - Exline, nearly level			W	D	O	B	R	F	A	S	X	G	3,7	
35. Kranzburg, nearly level	C		W	D	O	B	R	F	A	S	X	G	1,2,6	
36. Maddock - Seroco, undulating					O		R					G	1,2	Wind strip cropping
Houdek - Clarno Loamy Plain														
37. Beadle, gently undulating	C	S	W	D	O	B	R	F	A	S	X	G	3,7,11	Contours or terraces
38. Beadle - Stickney - Dudley, nearly level		S	W	D	O	R	B	F	A	S	X	G	3,7,11	Contours or terraces
39. Peever - Cavour, gently undulating		S	W	D	O	R	B	F	A	S	X	G	3,7	
40. Houdek - Ethan - Worthing, undulating	C	S	W	D	O	B	R	F	A	S	X	G	3,7,11	Contours
41. Houdek - Prosper, gently undulating	C	S	W	D	O	B	R	F	A	S	X	G	3,7,11	Contours or terraces
Moody Silty Prairie														
42. Wentworth - Egan - Clarno, strongly undulating	C	S	W	D	O	B	R	F	A	S	X	G	9,12	Terraces
43. Wentworth - Egan - Viborg, gently undulating	C	S	W	D	O	B	R	F	A	S	X	G	3,7,11	Contours or terraces

[1]1. Continuous corn (grain only)
2. 4 - 6 years R, GX
3. 3 - 6 years R, GX
4. R, R, GX
5. R, X
6. 4 - 6 years R, G, A, A
7. 3 years R, G, A, A
8. R, R, G, A, A
9. R, G, G, GX
10. R, G, (3 - 5 years)
11. R, G, Ag, Ag
12. R, G, Ag (3 years)
13. G, Ag (3 years of each)
14. R or suitable catch crop

R = Row Crop
G = Small Grain
GX = Small Grain w/legume for green manure
A = alfalfa or alfalfa and grass
Ag = Alfalfa and grass or grass alone

In the Northeast Lowlands plant corn in early May. Plant for a population of 10,000 to 12,000 plants per acre using hybrids that mature in 95 to 100 days in order to raise dry corn. Under high rainfall conditions 16,000 plants may produce higher yields, but under low rainfall conditions 8,000 plants will produce maximum yields. Using 30-inch row spacing may, in some years, result in slightly higher yields than 38- to 42-inch spacing, but generally not enough to warrent the expense of getting new equipment.

In the Poinsett-Kranzburg Silty Prairie, plant corn in mid-May. Plant for 8,000 to 10,000 plants per acre, using hybrids that mature in 90 to 100 days in order to raise dry corn. Use the higher planting rate and later maturing hybrids in the southern part of the area.

In the Lake Dakota Plain and the Houdek-Clarno Loamy Plain plant for about 10,000 plants, using hybrids that mature in about 100 days.

Under irrigation, plant a hybrid that matures 5 days later than those planted on dryland. Plant for a population of around 16,000 plants per acre. Use adequate amounts of fertilizer and irrigate properly. The use of 30-inch row spacings will help increase yields more on irrigation than on dryland. Plant corn on the contour if slopes exceed 3%.

Plant soybeans 1 to 1½ inches deep in warm moist soil right after planting corn. Plant 12 seeds per foot of row in 40-inch row spacings; 10 seeds per foot in 30-inch rows; or 8 seeds per foot in 20-inch row spacings. The narrower row spacings generally result in higher yields if weeds can

Table 17. General Crop Adaptability* of Soil Associations

Landscape Groups and Soil Associations	Cultivated Plants Deep**	Shallow***	Grass
Poinsett - Kransburg Silty Prairie			
1. Flandreau - Egeland, undulating	G	G-F	G
2. Fordville - Estelline, nearly level	G	G	G
3. Forman - Aastad - Parnell, strongly undulating	G	G	G
4. Forman - Buse - Aastad - Parnell, steep or rolling	P	F	F
5. Forman - Buse, Sloping	F	F	G
6. Forman, undulating	G	G	G
7. Kranzburg - Brookings - Vienna, nearly level	G	G	G
8. Lamoure, nearly level	G	G	G
9. Nutley, gently undulating	G-F	G	G
10. Poinsett - Buse, strongly undulating	G-F	G-F	G-F
11. Poinsett - Heimdal, strongly undulating	G-F	G-F	G-F
12. Poinsett - Waubay - Parnell, undulating	G	G	G
13. Poinsett - Waubay, gently undulating	G	G	G
14. Renshaw - Fordville, gently undulating	G-F	G-F	G-F
15. Renshaw - Fordville, divide, gently undulating	G-F	G-F	G-F
16. Renshaw - Fordville - Sioux, undulating to rolling	F-P	F-P	F-P
17. Sinai - Wentworth, gently undulating	G	G	G
18. Sinsaas - Oaklake, undulating	G	G	G
19. Vienna - Lismore, sloping	G	G	G
Northeast Lowland			
20. Antler - Parnell - Marsh, nearly level	F	F	G
21. Eckman - Gardena, gently undulating	G	G	G
22. Fargo - Grano - Lamoure, nearly level	G-F	G-F	G
23. Forman - Aastad - Parnell, gently undulating	G	G	G
24. Forman, gently undulating	G	G	G
25. Glyndon - Gardena, nearly level	G	G	G
26. Heimdal - Fram, undulating	G-F	G	G
27. Heimdal - Sisseton, gently undulating	G-F	G	G
28. Lamoure - Fargo, nearly level	G-F	G	G
29. Peever, gently sloping	G-F	G	G
30. Peever - Tonka, gently undulating	G-F	G	G
31. Sverdrup - Embden, gently undulating	G	G-F	G
Lake Dakota Plain			
32. Beotia - Great Bend - Harmony, nearly level	G	G	G
33. Embdon - Hecla - Ulen, undulating	G	G-F	G
34. Harmony - Aberdeen - Exline, nearly level	F	G-F	G
35. Kranzburg, nearly level	G	G	G
36. Maddock - Seroco, undulating	G	F-P	G-F

be controlled. A mechanical means of controlling weeds should be available, before attempting to use 20- or 30-inch row spacings, because herbicides sometimes do not control weeds satisfactorily. Plant on the contour if there is a slope of 2 to 6%; do not plant on slopes more than 6%.

Weed Control

Weed control specialists recommend the use of clean seed, proper seedbed preparations, good crop rotations and sound soil management practices to help eliminate annual weeds and prevent infestation by perennials. Generally, special cultivation, competitive crops and herbicides will be needed in the weed control program.

For the use of herbicides in northeastern South Dakota it is recommended that 25% of the spring wheat, durum wheat and barley acreage be sprayed annually to control wild oats; 35% should be sprayed for wild buckwheat control; and 60% be sprayed with 2,4-D to control other broad-leaved weeds.

For oats, the recommendations are 35% for wild buckwheat and 50% with 2,4-D or MCPA. Winter wheat and rye recommendations are 25% with 2,4-D. For flax the recommendations are 25% for wild oats; 35% for foxtail; and 50% with MCPA. Wild oats and wild buckwheat can be treated at one time, but 2,4-D, MCPA and dalapon should be applied at another time, making it necessary to make two applications of herbicide in most fields.

Recommendations for corn, soybeans and sorghum are that 75% of the acreage be treated preemergence with a herbicide such as atrazine, amiben, trifluralin, or propachlor or mixtures to control annual weeds and that 15% of the corn and sorghum acreage be treated with 2,4-D to control perennial weeds or annual broad-leaved weeds not controlled with the other herbicides.

The recommendations for grass hayland, pastureland and range is to spray 25% of the acreage with 2,4-D.

(TABLE 17 CONTINUED)

Landscape Groups and Soil Associations	Deep**	Shallow***	Grass
Houdek - Clarno Loamy Plain			
37. Beadle, gently undulating	G-F	G	G
38. Beadle - Stickney - Dudley, nearly level	F	G	G
39. Peever - Cavour, gently undulating	F	G	G
40. Houdek - Ethan - Worthing, undulating	G-F	G	G
41. Houdek - Prosper, gently undulating	G	G	G
Moody Silty Prairie			
42. Wentworth - Egan - Clarno, strongly undulating	G-F	G	G
43. Wentworth - Egan - Viborg, gently undulating	G	G	G

* G = Good; P = Poor; F = Fair
** Moderately deep or deep rooted crops
*** Shallow rooted crops

The estimated number of acres to be sprayed for various types of weed control is given in Table 18. The amount of herbicide needed can be determined by multiplying the average application rate for the herbicide by the number of acres of crops needing spray.

Insect Control

Entomologists recommend the use of insect resistant varieties whenever possible. However, insecticides will be needed to control several species of insects. Entomologists believe it will be necessary to spray for aphid control on 5% of the small grain acreage 1 year out of 10 and for pea aphid on all alfalfa every fifth year. Control of grasshoppers will be necessary 1 year out of 4 on 20% of the spring grain, 25% of the corn, soybeans and sorghum, 5% (field boundaries) of the winter wheat and rye acreage and about 5% of the hayland and grazing land each year. Spraying corn may be necessary about 1 year out of 5 on 30% of the acreage for corn borer control. All corn planted on corn ground should be treated for rootworm control. All corn and sorghum should receive a seed treatment for soil borne insect control. All corn or sorghum planted on alfalfa or grass sod should be treated with a soil applied insecticide for soil borne insect control and all other corn or sorghum should be treated every third time in the rotation for the control of soil borne insects. The estimated number of acres to be sprayed for various insects is given in Table 19. The amount of insecticide needed can be calculated by multiplying rate of application by acres of crop that need spraying.

Table 18. Average Acreage to be Sprayed Each Year for Weed Control in Crops Grown in Northeastern South Dakota*

Crop	Broad-leaved	Wild Buckwheat	Annual Grassy	Wild Oats
Corn	102,400	--	511,980	--
Oats	304,530	152,265	--	--
Barley	52,080	30,380	--	21,700
Spring Wheat	124,320	72,520	--	51,800
Durum Wheat	36,530	21,310	--	15,520
Winter Rye	15,300	--	--	--
Flax	214,960	--	150,470	107,480
Soybeans	--	--	37,680	--
Sorghum	2,850	--	14,235	--
Grass Hay	74,450	--	--	--
Grazing Land	267,000	--	--	--
Total	1,194,420	276,475	714,365	196,500

* Amount of herbicide needed can be calculated by multiplying rate of application per acre by number of acres.

Table 19. Average Annual Acreage to be Sprayed to Control Insects in Crops Grown in Northeastern South Dakota*

Crop	Grass-hoppers	Aphids	Corn Borer	Corn Rootworm	Soil Borne
Corn	42,665	--	40,960	136,530	227,320
Oats	30,450	3,045	--	--	--
Barley	4,340	435	--	--	--
Spring Wheat	10,360	1,035	--	--	--
Durum Wheat	3,045	305	--	--	--
Winter Rye	615	305	--	--	--
Flax	--	--	--	--	--
Soybeans	3,140	--	--	--	--
Sorghum	1,185	--	--	--	6,320
Alfalfa	22,500	72,000	--	--	--
Grass Hay	14,890	--	--	--	--
Grazing Land	53,400	--	--	--	--
Total	186,590	77,125	40,960	136,530	233,640

* Amount of insecticide needed can be calculated by multiplying rate of application per acre by the number of acres.

Use of Fertilizer

Each crop uses a certain amount of each plant food element. Amounts of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) needed to produce a bushel of grain or a ton of hay are given in Table 12 along with estimates for silage, sorghum grain and fodder.

Soils of northeastern South Dakota do not contain enough nitrogen or phosphorus to produce the predicted yields. Some plant food for these crops will come from the soil — the remainder must be applied as fertilizer.

The best way to determine the amount of fertilizer needed on any given field is a soil test, although percentage estimates have been figured (Table 20). By using this percentage with estimated potential yield (Tables 13 and 14) and amount of each element for each crop (Table 12), it is possible to estimate fertilizer needs.

Table 20. Estimated Rate of Fertilizer Application for Each Crop in Northeastern South Dakota

Crop	Nitrogen[a]		Phosphate[a]		Potash[a]	
	Pct.[b]	lbs[c]	Pct.[b]	lbs[c]	Pct[b]	lbs[c]
Corn	75	1.12	80	0.40	20	0.20
Oats	75	0.60	100	0.40	--	--
Barley	50	0.90	100	0.50	20	0.20
Wheat	50	0.90	100	0.75	--	--
Rye	75	1.20	100	0.80	--	--
Flax	d/	0.42	d/	0.28	--	--
Soybeans	10	0.55	50	0.60	50	0.54
Sorghum	75	1.12	80	0.40	20	0.20
Alfalfa Hay	0	0	80	9.6	10	3.2
Bromegrass	50	16.00	50	4.2	--	--
Native Hay	37.5	12.00	25	2.1	--	--

a/ Pounds of plant food removed by each bushel of grain or ton of forage given in table 12.
b/ Percent of plant food that will come from fertilizer - remainder will come from soil.
c/ Pounds of fertilizer needed for every bushel of grain or ton of forage that is produced in the area.
d/ 70% of that recommended for oats.

Average number of pounds of elemental nitrogen (N), actual phosphorus (P_2O_5), or actual potash (K_2O) required per acre for each crop in each county are given in Table 21. The thousands of pounds of each nutrient required for each crop in each county are given in Table 22.

Moisture Conservation

Moisture is lost mainly through runoff, deep percolation, evaporation, and transpiration by weeds. The amount varies with crop and degree of slope. For example, moisture losses through runoff and evaporation in northeastern South Dakota amounts to about 40% for alfalfa and 50 to 60% for corn and wheat. These losses are based on crop yields during the period 1961-66. It is assumed that approximately 7 acre-inches of moisture are necessary to produce 1 ton of alfalfa, 0.18 acre-inch to produce 1 bushel of corn, and 0.36 acre-inch to produce 1 bushel of wheat.

Terrace or contours help neutralize the slopes, improve water intake and reduce amount of runoff. Legumes and grasses in the rotation and addition of fertilizer, crop residue and manure increase the amount of organic matter and nutrient status; this improves the structure and hence the ability of the soil to absorb moisture.

A crop of weeds frequently uses 2 acre-inches of moisture (equivalent to 3 to 4 inches of rainfall). Weeds in the Northeastern Region annually use about ¾-million acre-feet of water. Moisture transpiration losses by weeds therefore are reduced by reducing weed numbers.

Evaporation results when water vapor in the soil moves to the surface and is removed by heat or air movement.

Table 21. Estimated Pounds per Acre of Fertilizer Needed to Give Estimated Potential Yields in Northeastern South Dakota

	Corn	Oats	Barley	Spring Wheat	Durum Wheat	Winter Rye	Flax	Soybeans	Grain Sorghum	Alf. Hay	Hay or Grazing Tame	Hay or Grazing Native
					Pounds of N per acre							
Brookings	66.8	36.0	45.9	27.0	27.9	43.2	25.1	12.1	58.2	--	30.4	16.8
Clark	50.4	30.0	41.4	22.5	23.4	36.0	21.0	--	47.0	--	25.6	13.2
Codington	59.4	32.4	45.0	26.1	26.1	39.6	22.8	--	48.2	--	27.2	15.6
Day	48.2	33.0	40.5	24.3	26.1	33.6	23.2	--	--	--	26.1	13.2
Deuel	68.3	37.8	48.6	27.0	27.9	43.2	26.5	11.6	52.6	--	28.8	15.6
Grant	60.5	36.0	46.8	26.1	26.0	44.4	25.0	9.9	--	--	27.2	15.6
Hamlin	61.6	33.6	44.1	26.1	27.0	42.0	23.7	9.4	50.4	--	28.6	15.6
Kingsbury	61.6	32.4	41.4	23.4	24.3	43.2	22.9	11.0	53.8	--	25.6	13.2
Marshall	58.2	33.6	44.1	25.2	27.0	37.2	23.5	--	--	--	24.5	13.2
Roberts	60.5	35.4	46.8	26.1	26.0	39.6	24.5	9.9	--	--	27.2	15.6
Averages	59.6	34.0	44.5	25.4	26.1	40.2	23.8	10.6	51.7	--	27.1	14.8
					Pounds of P_2O_5 per acre							
Brookings	24.0	24.0	25.5	22.5	23.3	28.8	16.7	13.2	20.8	26.9	8.0	2.9
Clark	18.0	20.0	23.0	19.4	19.5	24.0	14.0	--	16.8	21.1	6.7	2.3
Codington	21.2	21.6	25.0	21.8	21.8	26.4	15.2	--	17.2	24.0	7.1	2.7
Day	17.2	22.0	22.5	20.3	21.8	22.4	15.5	--	--	19.4	6.8	2.3
Deuel	24.4	25.2	27.0	22.5	23.3	28.8	17.6	12.6	18.8	26.3	7.6	2.7
Grant	21.6	24.0	26.0	21.8	21.8	29.6	16.7	10.8	--	24.5	7.1	2.7
Hamlin	22.0	22.4	24.5	21.8	22.5	28.0	15.8	10.2	18.0	24.1	7.5	2.7
Kingsbury	22.0	21.6	23.0	19.5	20.3	28.8	15.3	12.0	19.2	22.1	6.7	2.3
Marshall	20.8	22.4	24.5	21.2	22.5	24.8	15.7	--	--	20.7	6.4	2.3
Roberts	21.6	23.6	26.0	21.8	21.8	26.4	16.4	10.8	--	25.0	7.1	2.7
Averages	21.3	22.7	24.7	21.3	21.9	26.8	15.9	11.6	18.4	23.4	7.1	2.6
					Pounds of K_2O per acre							
Brookings	12.0	--	10.2	--	--	--	--	11.9	10.4	13.4	--	--
Clark	9.0	--	9.2	--	--	--	--	--	18.4	10.6	--	--
Codington	10.6	--	10.0	--	--	--	--	--	8.6	12.0	--	--
Day	8.6	--	9.0	--	--	--	--	--	--	9.7	--	--
Deuel	12.2	--	10.8	--	--	--	--	11.3	9.4	13.2	--	--
Grant	10.8	--	10.4	--	--	--	--	9.7	--	12.2	--	--
Hamlin	11.0	--	9.8	--	--	--	--	9.2	9.0	12.1	--	--
Kingsbury	11.0	--	9.2	--	--	--	--	10.8	9.6	11.0	--	--
Marshall	10.4	--	9.8	--	--	--	--	--	--	10.4	--	--
Roberts	10.8	--	10.4	--	--	--	--	9.7	--	12.5	--	--
Averages	10.6	--	9.9	--	--	--	--	10.4	10.9	11.7	--	--

Evaporation may be suppressed by reducing movement of vapor in the soil and by decreasing the transfer of water vapor into the air. A layer of plastic or other material, impermeable to water on the soil surface almost eliminates evaporation. Reduction of air movement by allowing stubble to stand or adding mulching material generally decreases the rate of evaporation.

All of these measures must be used in the Northeastern Region where moisture supplies sometimes are deficient. There actually is enough rainfall to raise about 3 tons of alfalfa, 60 bushels of wheat, 90 bushels of oats or 80 bushels of corn, if all the rainfall is absorbed by the soil and used by crop plants (not weeds). At present the average yield of alfalfa (1.7 tons per acre) uses about 13 inches of moisture, while the average yields of corn (35 bushels per acre) and oats (36 bushels per acre) use 5 to 7 inches of moisture.

Conservation of Organic Matter

Manures and crop residues returned to the soil are the only means of adding organic matter, although nitrogen can be added in commercial preparations. Alfalfa can return to the soil as much as 80 pounds of nitrogen per acre when the second cutting of a 3-year stand is plowed under. A 53-bushel crop of corn will remove 80 pounds of nitrogen from the soil. It is difficult to maintain soil nitrogen at present levels by this method of returning crop residues even when only one good crop of corn is raised for every 3 years of alfalfa.

Table 22. Estimated Pounds of Fertilizer Needed to Give Estimated Potential Production in Counties of Northeastern South Dakota

	Corn	Oats	Barley	Spring Wheat	Durum Wheat	Winter Rye	Flax	Soy-beans	Grain Sorghum	Alf. Hay	T. Grass Hay	Native Hay	Totals
Thousands of pounds of N													
Brookings	8,901	3,058	144	70	20	63	792	122	106	--	81	201	13,558
Clark	3,191	1,819	435	853	219	324	727	--	157	--	120	249	8,094
Codington	2,214	1,911	463	451	202	268	1,106	--	74	--	118	278	7,085
Day	1,304	2,235	1,015	983	488	366	1,293	--	--	--	161	517	8,862
Deuel	1,804	2,184	126	95	21	97	1,196	71	57	--	59	355	6,065
Grant	3,749	1,961	200	341	48	336	1,056	54	--	--	65	368	8,178
Hamlin	3,847	1,851	152	204	60	111	1,024	19	68	--	64	119	7,519
Kingsbury	6,263	1,892	251	317	183	206	810	22	203	--	135	142	10,424
Marshall	2,621	1,128	697	881	189	254	606	--	--	--	92	639	7,107
Roberts	4,737	2,767	263	930	121	352	1,661	234	--	--	147	904	12,116
Totals	39,131	20,806	3,746	5,125	1,551	2,377	10,271	522	665	--	1,042	3,772	89,008
Thousands of pounds of P_2O_5													
Brookings	3,179	2,038	80	58	16	42	427	133	38	129	21	35	6,296
Clark	1,139	1,212	242	711	183	216	485	--	56	977	31	44	5,296
Codington	791	1,274	257	376	168	178	738	--	26	714	31	49	4,602
Day	644	1,490	564	819	406	244	863	--	--	679	42	91	5,842
Deuel	1,487	1,456	70	79	17	64	794	78	20	796	16	62	4,939
Grant	1,339	1,307	111	284	40	244	705	59	--	843	17	64	4,993
Hamlin	1,374	1,234	85	170	50	74	713	21	24	485	17	21	4,268
Kingsbury	2,237	1,261	139	264	153	137	541	24	73	961	35	25	5,850
Marshall	936	752	387	734	157	169	405	--	--	709	24	112	4,385
Roberts	1,692	1,845	146	775	101	235	1,112	255	--	961	39	158	7,319
Totals	14,818	13,869	2,081	4,270	1,291	1,583	6,883	570	237	7,254	273	661	53,790
Thousands of pounds of K_2O													
Brookings	1,590	--	32	--	--	--	--	120	--	645	--	--	2,387
Clark	570	--	97	--	--	--	--	--	--	488	--	--	1,155
Codington	395	--	103	--	--	--	--	--	--	357	--	--	855
Day	322	--	226	--	--	--	--	--	--	340	--	--	888
Deuel	744	--	28	--	--	--	--	70	--	398	--	--	1,240
Grant	669	--	45	--	--	--	--	53	--	421	--	--	1,188
Hamlin	687	--	34	--	--	--	--	18	--	242	--	--	981
Kingsbury	1,118	--	56	--	--	--	--	21	--	480	--	--	1,675
Marshall	468	--	155	--	--	--	--	--	--	354	--	--	977
Roberts	846	--	59	--	--	--	--	229	--	480	--	--	1,614
Totals	7,409	--	835	--	--	--	--	511	--	4,205	--	--	12,960

Thus farmers may have three situations:

1. **No organic materials added.** For most soils of the Northeastern Region where total nitrogen levels are about 4,000 pounds per acre approximately 60-80 pounds per acre of nitrogen are released from the humus each year. Since maximum yields probably require more than this amount of nitrogen, commercial nitrogen could be added to raise it to the desired level.

2. **Fresh straw or corn stover added.** Since these materials are high in carbonaceous matter and low in nitrogen, most soil nitrogen and nitrogen present in straw or stover would be tied up by the microorganisms for at least the first year. In this case rather heavy applications of commercial nitrogen would be needed if maximum yields are to be expected.

3. **Legume green manure or barnyard manure are added.** These materials are high in both carbonaceous and nitrogenous materials. Here some nitrogen will become available both from the soil humus and the manure. Very little or no commercial nitrogen then would need to be added for maximum yields.

Water Erosion Control

Erosion control can be accomplished by increasing the percentage of legumes and grasses in the cropping sequence. The added organic matter will increase rate of water intake and decrease amount of water available to runoff and erode.

Since water erosion is serious on sloping lands, a good soil management program might involve terraces or contour cultivation and rotation that includes legumes and commercial fertilizer.

Terraces or contours tend to neutralize the slope factor, improve water intake and reduce the amount of water available for runoff and erosion. Legumes and grasses in the rotation and use of fertilizer, crop residue and manure, increase amount of organic matter and nutrient status. This improves the structure, hence the ability of the soil to absorb moisture. Less runoff means less erosion.

Certain soil associations lend themselves to contour erosion control measures. For example, soils of the Kranzburg-Brookings association have long, smooth slopes, while those of the till soil association, such as the Poinsett-Parnell association, have short, choppy slopes, difficult to farm on the contour.

Wind Erosion Control

Control measures for wind erosion depend on keeping a growing crop or crop residues on the land at all times. Because it is difficult to establish cover on sandy soils during dry periods when cover is needed most, it's safest to keep sandy soils in perennial vegetation. Should these soils be used for grains or row crops, residues ought to be returned and left on the soil surface or partly incorporated into the surface soil. If soils are bare when wind erosion starts, the soil surface may be roughened and thrown up into ridges by tillage implements as "last ditch" control measures. This may not be too effective, however.

Cover by growing crops or crop residues, ridging and strip cropping with solid-seeded crops in alternate strips are methods of reducing wind erosion. Width of the strips and amount of residue needed depends on texture of the soil and application of other control practices.

Amount of field crop residue can be estimated by figuring that spring wheat produces almost 100 pounds of straw for every bushel of grain, while oats produce about 50 pounds of straw for every bushel and corn produces about 60 pounds of stover for each bushel. More accurate estimates are made by determining the ounces of residue on three 1-square-yard areas and multiplying by 100 (for example: 16 ounces of residue times 100, equals 1,600 pounds of residue per acre).

Each tillage operation turns under a certain percentage of residue. A blade-type implement or rodweeder turns under about 10%, a tandem disk or one-way disk 50% and a blade and treader, duckfoot cultivator or flexible disk harrow 20 to 25% of the residue.

4 HIGHER PROFIT

"Net return" from harvested crops can be increased $30¾ million. This "increased net return" is income for labor, management, and net profit. The income can be increased even more by proper management of grazing land and by irrigation (several committees listed under "Acknowledgements" estimated the major production costs and the market value for the crops).

COSTS OF PRODUCTION

Machine Ownership

A range of estimates for machine ownership cost per acre are as follows: Corn—$4.30 to $5.30; soybeans—$4.50 to $5.50; spring wheat, flax, barley and oats — $3.70 to $5.00; rye — $3.50 to $4.00; stacked hay — $2.50 to $3.00; and baled hay — $3.40 to $4.00. Machine ownership includes capital investment and depreciation.

Machine Operation

Present machine operation costs per acre were calculated, using cost data on 3- to 4-plow tractors, while potential costs were figured using larger equipment (4- to 5-plow tractors). Machine operation includes oil, grease, fuel, repairs plus service for production and harvesting of all crops except corn and hay. Corn harvesting estimates were 4 cents per bushel for a 30-bushel yield (plus or minus 3 cents for each bushel above or below 30 bushels per acre). Cost of harvesting hay was estimated to be $1.90 per ton for alfalfa, $2 for tame grass hay, and $2.20 for native hay. Labor costs are not included.

Seed Costs

The value of home grown small grain seed was estimated to be market value (1963-67) plus additional costs for shrinkage losses, cleaning costs, trucking and seed treatment. It was assumed home grown seed now is being used exclusively. Yearly cost of high quality seed for potential yield was averaged for 3 years (cost of home grown grains for 2½ crops and certified seed for ½ crop). Costs of small grain seed are given in Table 23.

Corn and sorghum hybrids have been planted for several years and probably will be in the future, so cost for present and potential yields are about the same. At 1969 prices, cost for corn is 19 cents per 1,000 seeds planted (assuming that 25% of acreage is planted to single crosses, 35% to 3-way crosses and 40% to double crosses). Overplanting to allow for 15% mortality brings the cost to $2.40 per acre.

Grain sorghum seed costs about 10 cents a pound for 5 pounds per acre at a cost of 50 cents per acre.

Table 23. Cost of Small Grain Seed

Cost	Cert. Seed Cost*	Homegrown Seed Costs** Market Value	Shrink- age loss	Cleaning costs	Truck & Treat.	Total#
Oats	$1.40	0.58	0.06	0.07	0.05	0.76
Barley	2.00	0.88	0.09	0.08	0.05	1.10
S. Wheat	3.00	1.40	0.15	0.10	0.05	1.70
D. Wheat	3.00	1.75	0.20	0.10	0.05	2.10
W. Rye	1.75	0.95	0.10	0.10	0.05	1.15
Flax	4.50	2.89	0.44	0.12	0.05	3.50

	Oats	Barley	Wheat	Durum	Rye	Flax
Homegrown	$1.90	$1.38	$2.12	$2.62	$1.44	$3.50
High Quality	2.17	1.56	2.20	2.81	1.56	3.67

* Price of seed used for half the crop every third year.
** Price of seed used for all the crop for 2 years and half the crop the third year.
# Total for recommended seeding rates: oats - 10 pks, barley - 5, S. Wheat - 5, durum - 5, rye - 5 and flax - 4 pks/A

Fertilizer Costs

Cost of fertilizer needed for good management and potential yields is the rate of nitrogen recommended in Table 21, multiplied by 10 cents per pound, added to the rate of phosphate, multiplied by 9 cents per pound, and added to the rate of potash, multiplied by 5 cents per pound.

Present fertilizer use is estimated to be about 40% of that actually needed for good management of corn, 30% for small grain, and soybeans, and 25% for forage crops. Cost also is only about 40% for corn, 30% for small grain and soybeans and 25% for sorghum and forage crops.

Weed Control Costs

Present estimates are that about 25% of the spring grain acreage is sprayed with 2,4-D and 5% is sprayed for wild oats and wild buckwheat control at an average cost per acre planted of 35 cents for 2,4-D, 20 cents for wild oats and 10 cents for wild buckwheat. Estimates are 15% of the acreage at a cost of 20 cents per acre for winter grains. Estimates for flax are 25% now treated with 2,4-D or MCPA and 10% with dalapon, making an average per acre cost of 50 cents per acre planted (estimated costs under good management for potential yields are given in Table 24).

Estimates for corn and sorghum are that 25% of the acreage is being sprayed with 2,4-D at an average cost of 35 cents for each acre planted and that about 25% of the corn, sorghum and soybean acreage is treated preemergence at a cost of 75 cents per acre planted for corn and sorghum and $1.40 for soybeans.

Table 24. Estimated Costs of Chemical Weed Control in Northeastern South Dakota under Good Management

Crop	Cost of Herbicide per Acre Treated W. Oats	W. Buck.	Broad.	Foxtail	Total*
Oats	$ --	$ 1.00	.52	$ --	$ 1.26
Barley	4.00	1.00	.40	--	2.54
S. Wheat	4.00	1.00	.40	--	2.54
D. Wheat	4.00	1.00	.40	--	2.54
W. Wheat	--	--	.40	--	0.35
W. Rye	--	--	.40	--	0.35
Flax	4.00	--	.50	1.20	2.42
Corn	--	--	.40	2.70	2.40
Sorghum	--	--	.40	2.80	2.40
Soybeans	--	--	--	5.40	4.30
Grassland	--	--	.80	--	0.45

* Average cost for each acre planted -- includes cost of all herbicides and cost of two applications @ $1.00 per acre.

Insect Control Costs

Very little is spent for insect control, according to present estimates (estimated costs for best management, potential yield and highest income are given in Table 25).

Table 25. Cost of Insect Control in Northeastern South Dakota

Crop	Insect	Cost/A Treated	Cost/A Grown*
Small grain (not flax)	Aphids	$ 2.25	$ 0.01
Spring grain	Grasshoppers	2.00	0.10
Winter Grain	Grasshoppers	2.00	0.03
Corn, sorghum	Grasshoppers	2.00	0.13
Corn	Rootworm	2.80	0.56
Corn	Corn borer	3.50	0.21
Corn, sorghum	Soil borne	3.00	1.00
Corn, sorghum	Seed treat.	0.03	0.03
Alfalfa	Grasshoppers	2.75	0.36
Alfalfa	Pea aphid	2.25	0.45
Alfalfa seed	3.00	1.90	
Grassland	Grasshoppers	2.00	0.10

* Average cost of insecticide and cost of application for each acre planted.

INCREASED INVESTMENT

The use of improved practices required to give the estimated potential yield will cost more money than is now being spent for crop production. It is estimated that the difference will amount to an average annual increased investment of over $18 million. Subdivided, it amounts to an increase of about $⅓ million for seed, $10¼ million for fertilizer, $5¼ million for weed control, $1⅔ million for insect control and $1 million for increased harvesting costs.

For fertilizer, it would amount to an additional investment of about $3.5 million for row crops, $4.6 million for small grain and flax, $1.5 million for hay crops and $1 million for pasture and rangeland. Similar estimates for weed and insect control are $2.4 million and $1 million for row crops, $2 million and $106,000 respectively for small grain, $403,700 and $312,000 for hay crops and $450,000 and $200,000 for pasture. Seed costs would be increased $304,000 for small grain and $25,000 for soybeans, while harvesting costs would be increased $400,000 for corn and $565,000 for hay. Increased cost of harvesting other crops was not calculated.

INCREASED NET RETURN

In return for the increased investment, it is estimated that the producers would get enough higher yields to pay for the investment and yield an increased net return of $30¾ million to pay for labor, management and net profit (Table 26).

An estimate of "present net return" was obtained by calculating present production costs for "present yields" (Table 6) for the "present acreage" (Table 5) and using the average "market value" of crop for the years 1963-67. Any change in yield, production costs or market value of crops could change the "present income." However, "present net return" could be recalculated, using the new figures for yield, cost or market value.

Similarly, an estimate of "potential net return" was obtained by using "potential yields" (Table 14) for the "present acreage" (Table 5) and the 1963-67 average "market value" for the crops. "Increased net return" is that difference between "present net return" and the "potential net return." Any changes in cost of production or market value of crops can be used to calculate a new "potential net return" and a new "increased net return."

The increased net return amounts to about $8.9 million for corn, $4.6 million for oats, $8.1 million for flax, $3.6 million for alfalfa hay, $993,900 for hard red spring wheat, $873,500 for durum wheat, $330,400 for winter rye, $317,-800 for soybeans, $73,000 for sorghum, $227,100 for tame grass hay and $532,800 for native grass hay. Estimates were not made for grazing land, potatoes or specialty crops. Likewise, estimates were not made for irrigated crops.

The increased net return of $30¾ million is an average increase of $3 million per county or $2,900 per farm.

Table 26. Usual Costs and Returns for Present and Potential Yields of Crops of Northeastern South Dakota — Brookings, Clark, Codington, Day, Deuel, Grant, Hamlin, Kingsbury, Marshall, and Roberts Counties

	Corn		Oats		Barley		Spring Wheat	
	Present	Potential	Present	Potential	Present	Potential	Present	Potential
Acres Planted	682,640	682,640	609,060	609,060	86,800	86,800	207,200	207,200
Bushels per Acre	33.8	53.1	36.3	56.8	27.8	49.4	16.7	28.2
Area Production	23,735,590	37,044,800	22,180,880	34,674,790	2,337,970	4,163,810	3,440,280	5,694,370
COST PER ACRE (Dollars)								
Machine Ownership	4.80	4.80	4.00	4.00	4.00	4.00	4.00	4.00
" Operation (Prod.)	1.39	1.41	1.84	1.68	1.84	1.68	1.84	1.68
" " (Harvest)	1.31	1.89	--	--	--	--	--	--
Seed	2.40	2.40	1.90	2.20	1.38	1.56	2.12	2.20
Fertilizer	3.36	8.40	2.17	5.44	2.15	7.16	1.33	4.44
Weed Control	1.10	2.40	0.45	1.26	0.65	2.54	0.65	2.54
Insect Control	0.48	1.93	--	0.11	--	0.11	--	0.11
COST OF PRODUCTION (Dollars)								
Per Acre	14.84	23.23	10.36	14.69	10.02	17.05	9.94	14.97
Area	10,130,378	15,857,727	6,309,862	8,947,091	869,736	1,482,544	2,059,568	3,101,784
GROSS RETURN (Dollars)								
Per Acre	38,25	56.69	21.12	33.02	23.70	42.21	23.25	38.48
Per Bushel or Ton	1.10	1.10	0.58	0.58	0.88	0.88	1.40	1.40
Area	26,109,149	40,749,280	12,864,910	20,111,378	2,057,414	3,664,153	4,816,392	7,972,118
NET RETURN (Dollars)								
Per Acre	23.41	36.46	10.76	18.33	13.68	25.13	13.31	23.51
Area	15,978,771	24,891,553	6,555,048	11,164,287	1,187,678	2,181,609	2,756,824	4,870,334
Increased Net Return	8,912,782		4,609,239		993,931		2,113,510	

(TABLE 26 CONTINUED ON PAGE 36)

(TABLE 26—USUAL COSTS AND RETURNS— CONTINUED FROM PAGE 35)

	Durum Wheat		Winter Rye		Flax		Soybeans	
	Present	Potential	Present	Potential	Present	Potential	Present	Potential
Acres Planted	60,880	60,880	61,220	61,220	429,920	429,920	50,240	50,240
Bushels per Acre	17.4	29.0	22.2	33.4	9.6	17.4	12.9	19.8
Area Production	1,057,720	1,723,170	1,359,190	1,979,610	4,010,680	7,500,490	688,890	947,470
COST PER ACRE (Dollars)								
Machine Ownership	4.00	4.00	3.75	3.75	4.00	4.00	5.00	5.00
" Operation (Prod.)	1.84	1.68	2.59	2.71	2.27	2.12	2.92	2.62
" " (Harvest)	--	--	--	--	--	--	--	--
Seed	2.62	2.81	1.44	1.56	3.50	3.67	3.10	3.60
Fertilizer	1.82	4.57	2.56	6.40	1.14	3.81	0.70	2.70
Weed Control	0.65	2.54	0.20	0.35	0.50	2.42	1.40	4.30
Insect Control	0	0.11	0.04	0.04	--	--	--	--
COST OF PRODUCTION (Dollars)								
Per Acre	10.93	15.71	10.58	14.81	11.41	16.02	13.12	18.22
Area	665,418	956,425	647,708	906,668	4,905,387	6,887,318	659,149	915,373
GROSS RETURN (Dollars)								
Per Acre	30.40	49.53	21.09	30.72	27.05	50.59	30.44	41.87
Per Bushel or Ton	1.75	1.75	0.95	0.95	2.90	2.90	2.22	2.22
Area	1,851,010	3,015,547	1,291,231	1,880,630	11,630,972	21,751,421	1,529,336	2,103,383
NET RETURN (Dollars)								
Per Acre	19.47	33.84	10.51	15.91	15.64	35.57	17.32	23.65
Area	1,185,592	2,059,122	643,523	973,962	6,725,585	14,864,103	870,187	1,188,010
Increased Net Return	873,530		330,439		8,138,518		317,823	

	Grain Sorghum		Alfalfa Hay		Grass Hay		Native Hay	
	Present	Potential	Present	Potential	Present	Potential	Present	Potential
Acres Planted	18,980	18,980	360,000	360,000	22,270	22,270	258,860	258,860
Bushels per Acre	29.8	46.2	1.65	2.44	1.14	1.70	0.91	1.23
Area Production	409,250	593,640	595,650	876,400	43,760	65,050	225,940	314,270
COST PER ACRE (Dollars)								
Machine Ownership	4.50	4.50	4.00	4.00	2.00	2.00	2.00	2.00
" Operation (Prod.)	2.50	2.50	0.30	0.30	0.30	0.30	--	--
" " (Harvest)	--	--	3.13	4.63	2.28	3.40	2.00	2.00
Seed	0.50	0.50	0.80	0.80	0.75	0.75	--	--
Fertilizer	1.84	7.37	0.85	3.39	0.93	3.35	0	0.71
Weed Control	1.10	2.40	0	0.77	0	0.45	0	0.45
Insect Control	2.90	1.16	0	0.71	0	0.20	0	0.20
COST OF PRODUCTION (Dollars)								
Per Acre	13.34	18.43	9.08	14.60	6.26	10.45	4.00	7.06
Area	253,193	349,800	3,268,800	5,256,000	139,410	232,722	1,035,440	1,827,552
GROSS RETURN (Dollars)								
Per Acre	19.84	28.78	33.09	48.68	29.47	43.81	13.09	18.21
Per Bushel or Ton	0.92	0.92	20.00	20.00	15.00	15.00	15.00	15.00
Area	376,510	546,149	11,913,000	17,528,000	656,400	975,750	3,389,100	4,714,050
NET RETURN (Dollars)								
Per Acre	6.50	10.35	24.01	34.08	23.21	33.36	9.09	11.15
Area	123,317	196,349	8,644,200	12,272,000	516,990	744,170	2,353,660	2,886,498
Increased Net Return	73,032		3,627,800		227,180		532,838	
Total Increased Income								30,750,622

FACTORS AFFECTING SOIL VALUE

Basic soil and land characteristics used in classifying soil include (1) soil profile and texture, (2) depth to any gravel, cobble or sand layer present, (3) depth to any clay pan present, (4) depth to bedrock, if present, (5) depth to the carbonate horizon, (6) soil profile drainage, (7) salinity, (8) alkali, (9) topography and (10) climate.

Weight given these factors (discussed in this appendix) varies depending on intended use, for soils are also rated according to their specific purpose. Soils, for instance, may be rated for their desirability for irrigation or adaptability for growing wheat.

Thus soil and land characteristics are relatively constant factors, while usage may vary. For example, salinity in the substratum of a soil is important if irrigation is being planned, but not if the soil is to be used for growing wheat.

1. Soil Profile Texture

Texture refers to the coarseness or fineness of the soil. Although this characteristic differs some among horizons of a soil profile, a general texture usually can be given for a soil series.

Texture affects the amount of water a soil profile can hold and indicates how readily it gives up moisture to the growing plants. For example, a silt loam such as Agar can store about two inches of moisture for every foot of depth while a sandy loam like Hecla can store only about one inch of moisture for every foot.

Silty soils have the best rating, because they contain all three of the particle sizes—sand, silt and clay. If too much sand is present, soil does not hold enough water for good plant growth. The supply of plant nutrients also is rather low. If too much clay is present soils have low permeability, because pore spaces are too small. Clay soils cannot be worked when they are wet or they become hard and cloddy.

Silty soils, having excellent ratings, usually also have favorable structure, which refers to arrangement of the sand, silt and clay particles. When the structure is granular, as silty soil usually is, the soil takes in moisture readily. Granular soil is easy to till. It allows plant roots, moisture and air to move readily. This favorable structure is easier to maintain in silty and loamy soils. On the other hand, in clayey soils pores are too small for excess water to drain away and in sandy soils pores are too large to store much moisture.

Only the excess water drains away in a silty soil. The spaces it vacates fill with air, insuring oxygen for plant roots. This helps in organic matter decomposition and release of plant nutrients.

Even though clayey and sandy soils are not as well endowed as silty or loamy soils, farmers can do much to improve the plow layer structure. Soil structure is affected by tillage, freezing and thawing, wetting and drying, plant root action and influenced by organic matter. Thus the problem for the farmer is to obtain stable aggregates (granules) not easily broken by rain drops or by tillage.

Maintaining enough organic matter is the starting point. As organic matter decomposes, the soil releases products which bind the sand, silt and clay soil particles togther into stable aggregates.

The farmer can maintain the most favorable structure possible within limits of the texture by taking advantages of freezing and thawing and wetting and drying cycles and timely tillage.

Subsoil structure, discussed under the "Depth to Claypan" soil rating factor, also is important in crop production.

2. Depth to Sand, Gravel or Cobble

Coarse sand, gravel or cobble underlying a soil essentially cuts off the profile depth, because these materials form a plant root barrier. These materials are low in plant nutrients and water, so the barrier is not only physical, it also is a nutritional barrier. The nearer these coarse materials occur to the soil surfaces, the less desirable is the soil.

Fordville, Renshaw, and Sioux all are underlain by gravel. Although a gravel substratum may be detrimental in dry land farming the same structure could be desirable if the soil is used for irrigation, because of its good internal drainage.

3. Depth to Claypan

A Claypan is a dense subsoil horizon, usually occurring in soils having clayey textures. This phenomenon is caused by sodium action on the soil clay. The sodium causes the desirable soil aggregates to break down into smaller clay particles. They are dispersed and rearranged, reducing pore size and limiting pore space (this soil shrinkage is evidenced by cracks in the ground). Plant roots have difficulty penetrating the claypan and are poorly supplied with oxygen and nutrient elements. In many cases, the claypan soils are periodically waterlogged.

Claypan structure is difficult to improve economically. One method of improvement is to open a trench and blow organic residues into the exposed claypan. This improves aggregation of soil particles and increases the oxygen supply. Additional amounts of nitrogen, phosphorus and sulfur are released through decay of the added organic materials. Deep plowing, subsoiling and chiseling are used to increase the size and number of pores. These tillage methods usually have only a temporary effect, however, since clay particles tend to flow back together the next time they become wet.

If appreciable amounts of sodium are adsorbed on the clay particles, it is helpful to add gypsum ($CaSO_4$) to the soil. This replaces sodium with calcium, which encourages aggregation of the soil particles.

Claypan subsoils limit crop growth if they are within the root zone. They are expensive to improve, and are a factor in soil rating systems. Exline is a soil having a claypan near the soil surface while Aberdeen and Cavour have deeper lying claypans.

4. Depth to Bedrock

Most of the soils in the Northeast Region of South Dakota are developed from parent materials of glacial origin. These parent materials include the ground-up rock debris deposited by glaciers, wind or water. If the bedrock occurs within the soil profile, it effectively limits the profile to this depth. No series appear on the soil map which are shallow to bedrock.

5. Depth to Penetrable Carbonates

Soils having penetrable carbonates at shallow depths usually develop on fairly steep slopes where much of the precipitation runs off rather than soaks into the soil. Depth to penetrable carbonates simply is the depth of leaching. Moisture can penetrate into this zone of the soil, but rarely does. Some plant roots forage in the carbonate zone, but lack of moisture and low levels of many nutrients restrict much activity.

Most soils of northeastern South Dakota which occur on gently undulating landscapes are leached to depths ranging from 12 to 55 inches. Texture and structure, in addition to slope, influence the depth to penetrable carbonates. Sandy textures usually are leached more deeply than silts, but silts are leached more deeply than clays. Structure which is well-aggregated absorbs more rainfall than cloddy structure given the same texture (because it has larger pore size and greater pore space).

A penetrable carbonate horizon is not as serious an obstacle as bedrock since the carbonate horizon does support some plant growth. Betts, Zahl and Java soils have thin profiles over the carbonate zone.

6. Profile Drainage

The problem facing soils on steep slopes is that too little water enters the profile because they are excessively drained. Soils on flats or in depressions often suffer from too much moisture, especially following spring rains. These soils usually are poorly drained. Soils on gentle undulating landscapes, if the soil structure is good, absorb the precipitation they receive unless rain comes too fast. In this case, runoff occurs, but the soil does not erode if it is well aggregated. The soil is neither excessively drained nor ponded, thus is regarded as well or moderately well drained.

On the flats and in the depressions where excess water accumulates, several things occur which slow down or restrict plant growth. (1) The excess water uses up pore space excluding oxygen. Plant roots need oxygen and oxygen is necessary for desirable organic matter decomposition. (2) A wet soil is a cold soil in the spring. It takes 5 times as much heat to raise the temperature of a gram of water one degree farenheight as it does a gram of soil. This means seed germination is retarded and also the activity of the microorganisms which release nutrients from the organic matter is slowed down in poorly drained soils.

Moderately well drained soils usually are rated higher than well drained soils. Neither soil suffers from poor drainage, but moderately well drained profiles, being on less sloping topography, are thicker, have more organic matter and a better reservoir of moisture. Betts and Zahl are examples of excessively drained soils, Agar and Glenham well drained, and Hoven and Exline poorly drained.

7. Salinity

Very few soils in the Northeastern Region have saline surface or subsoil horizons. However, many of the soils, especially those developed from glacial till or lacustrine materials, have saline substrata. Having a saline substratum is not a serious consideration for dryland farming, but must be taken into account if irrigation is being considered.

Soil material is considered saline if harmful concentrations of salts, exceeding about .2 per cent are present. Common salts which contribute to the salinity of these soils include sodium and magnesium chlorides and sulfates.

Soils with saline surface and subsoil horizons occur on flats or in depressions. Usually the ground water is at or near the surface of these soils.

8. Alkali

While salinity refers to harmful concentrations of soluble salts, alkali deals with the activity of sodium and its effect on soils. A soil which has a moderate number (more than 15 per cent) of sodium ions attached electrically to the clay particles is considered an alkali soil. When a soil becomes alkali it loses its favorable structure, pore space is reduced and it becomes dense and hard. In this condition it often is referred to as "claypan" or "gumbo" or "Solonetz," and is a poor medium for plant growth.

This alkali condition is responsible for most claypan soils of the Northeastern Region. Alkali ratings are used principally to characterize substratum situation of soils and many of the good soils of this region do have alkali present in the substratum. This has very little effect on dryland farming operations, but must be considered if irrigation is contemplated.

Alkali condition can be determined by chemical analysis in a laboratory. A quick appraisal of alkali can be made, however, by determining soil pH (a measure of the acidity or alkalinity). Readings below pH 7 are acid, while those above 7 are due to alkalinity. If about 15% of the ions in the soils are sodium, the pH reading will be above 9.

9. Topography Ratings

Topography indirectly affects several soil rating factors, such as drainage and depth of leaching. However, topography also provides a tool to assess erosion hazard, runoff characteristics and ease of tillage of a soil. Topography can be moderately sloping without adverse effects. Ratings should be considered for both complex and simple slopes, because it makes a difference in farming operations if slopes are irregular and interrupted with depressions (complex or long and smooth (simple).

10. Climate Ratings

The total precipitation received by an area is only a general indicator of moisture available for crop production. High temperatures during wet periods result in high moisture losses by evaporation from soil and transpiration from plants.

Texture and structure soil factors influence the amount of water which soaks into or runs off of a soil. Slope also is a factor. Steep slopes always are droughty and low depressional areas usually are wet at some time during the spring rains.

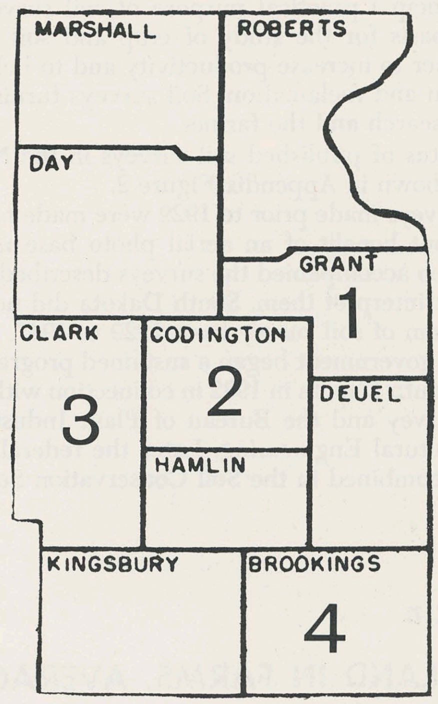
APPENDIX B

SOILS ON EXPERIMENT FIELDS

Location of the South Dakota agronomic experimental fields in the Northeastern Region is shown in Appendix Figure 1. Research is carried on at each location under a great variety of soil and weather conditions. **Appendix Table 1** lists dates of operation, location of each field, principal soils on each field and name of the soil association area, soil problems studied and the publication that summarizes experimental results.

In addition to these established fields, the South Dakota Agricultural Experiment Station maintains an "out state" program where agronomic research is carried out on farmers' fields.

Appendix Figure 1. Location of experiment fields in the Northeast Region.



1. Whetstone Valley Research Center, Milbank
2. Northeast Farm, Watertown
3. Northeast Farm, Garden City
4. Agronomy Farm, Brookings

Appendix Table 1. Soils and Kinds of Investigations on the Experiment Fields

Field or Station	Dates of Operation	Location (County)	Post Office	Dominant Soil on Field	Soil Map Number	Problems Studied	Recent Bulletin Summarizing Research
Whetstone Valley Crops Research Center	1969	Grant	Milbank	Peever	29	Rotation, tillage and residue	Annual Progress Reports
Northeast Farm Watertown	1956-Present	Codington	Watertown	Kranzburg	7	Plant breeding	Annual Progress Reports
Northeast Farm Garden City	1964-Present	Clark	Garden City	Poinsett	13	Rotations, legumes fertilizers	Annual Progress Reports
Agronomy Farm	1941-Present	Brookings	Brookings	Vienna	19	Rotations, fertilizers, plant breeding	Circ. 123

APPENDIX C

PROGRESS OF SOIL SURVEYS IN THE NORTHEAST REGION

A detailed soil survey made on a large-scale aerial photo base map is an essential part of agricultural planning and development. Argronomic research extends to farmers' fields through its use.

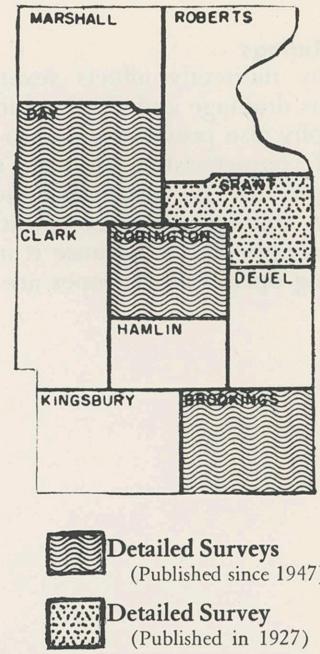
Such soil surveys are being made in South Dakota as cooperative projects by the South Dakota Agricultural Experiment Station, the U. S. Soil Conservation Service, the U. S. Bureau of Indian Affairs, the Bureau of Reclamation, and the Missouri River Basin Investigations Agency.

The principal practical purpose of soil surveys is to provide a basis for the study of crop and soil relationships in order to increase productivity and to help in soil conservation and reclamation. Soil surveys furnish a link between research and the farmer.

The status of published soil surveys in the Northeast Region is shown in Appendix Figure 2.

The surveys made prior to 1929 were made on a small scale without benefit of an aerial photo base map. The report which accompanied the surveys described the soils but did not interpret them. South Dakota did not have a state program of soil survey from 1929 to 1947, although the federal government began a sustained program of soil survey in South Dakota in 1932 in connection with the Soil Erosion Survey and the Bureau of Plant Industry, Soils and Agricultural Engineering. Later the federal soil surveys were combined in the Soil Conservation Service.

Appendix Figure 2. Published soil surveys in the Northeast Region.



The field mapping for surveys published since 1947 has been done on aerial photo base maps. Accompanying bulletins provide interpretations of the soils shown on the maps. Copies of these published soil surveys may be obtained from the South Dakota State University Agricultural Experiment Station at Brookings or by contacting your County Extension Agent or Soil Conservation Service Officer.

APPENDIX D

LAND IN FARMS, AVERAGE SIZE OF FARM AND AVERAGE VALUE PER ACRE AND PER FARM

The average size county (reported in Appendix Table 2) in the 10-county Northeast areas is 492,544 acres. Roberts is the largest county and Hamlin the smallest. Marshall County has the largest average size farm, about 673 acres in 1964, while the Brookings County farms were the smallest average size.

The average value per acre in the Northeast region increased, in the period 1954-1964, from about $62-$91. Among counties the lowest rise was in Brookings County while the highest rise was in Marshall County where the value per acre more than doubled.

The average value per farm in this region of South Dakota almost doubled in the 10-year period. Among counties the highest rise was in Marshall County where the value per farm increased more than two and one-half times during the period.

Appendix Table 2. Land in Farms, Average Size of Farms, Average Value per Acre of Land and Buildings*

County	Land in Farms Acres 1964	Average Size of Farms Acres 1964	Average Value Per Acre Lands and Buildings			Average Value Per Farm in Thousands of Dollars		
			Dollars 1954	Dollars 1964	Percent Increase	1954	1964	Percent Increase
						thousands		
Brookings	501,229	345.2	$114	$120	$105	$26.8	$42.0	$157
Codington	471,436	465.9	56	83	148	21.0	38.4	183
Clark	592,067	577.1	44	68	155	20.2	39.3	195
Day	621,049	505.7	45	70	156	18.0	34.8	193
Deuel	382,604	386.9	72	98	161	24.5	38.9	159
Grant	413,150	406.2	61	99	162	20.7	39.5	190
Hamlin	318,515	396.2	69	108	156	22.1	43.8	198
Kingsbury	498,589	476.7	60	102	170	23.3	49.2	211
Marshall	516,811	672.9	37	77	208	19.8	52.3	264
Roberts	663,994	427.3	58	86	148	21.4	37.3	174
Averages	492,544	466.0	62	91	157	21.8	41.6	192

* South Dakota Crop and Livestock Reporting Service data

APPENDIX E

SOIL CLASSIFICATION

When large numbers of objects, (such as soil types) are studied, it is necessary to classify them into some kind of a system.

There presently are two soil classification systems used in the United States. The oldest, proposed in 1938, is in the Yearbook of Agriculture "Soils and Men." This system has been revised slightly since 1938 and still is in use, but has one principal shortcoming—the criteria used to place soils are not quantitatively defined.

The second system, called the "Comprehensive System," a quantitative system in use since 1960, eventually will replace the old system entirely. The soils of the North Central Region are placed in the 1938 Yearbook system in Appendix Table 3.

Appendix Table 3. Classification of Soils

SOIL SERIES	Classification 1938 YEARBOOK REVISED (Great Soil Group)	SOIL SERIES	Classification 1938 YEARBOOK REVISED (Great Soil Group)
Aastad	Chernozem	Hecla	Chernozem
Aberdeen	solodized Solonetz	Heimdal	Chernozem
Antler	Calcium Carbonate Solonchak	Houdek	Chernozem
Beadle	Chernozem	Kranzburg	Chernozem
Beotia	Chernozem	Lamoure	Humic Gley
Brookings	Chernozem	Lismore	Chernozem
Buse	Regosol	Maddock	Chernozem
Cavour	solodized Solonetz	Nutley	Chernozem
Clarno	Chernozem	Oaklake	Chernozem
Divide	Calcium Carbonate Solonchak	Parnell	Humic Gley
Dudley	solodized Solonetz	Peever	Chernozem
Eckman	Chernozem	Poinsett	Chernozem
Egeland	Chernozem	Prosper	Chernozem
Embden	Chernozem	Renshaw	Chernozem
Estelline	Chernozem	Seroco	Regosol
Ethan	Chernozem	Sinai	Chernozem
Exline	solodized Solonetz	Singsaas	Chernozem
Fargo	Humic Gley	Sioux	Regosol
Flandreau	Chernozem	Sisseton	Resogol
Fordville	Chernozem	Stickney	solodized Solonetz
Forman	Chernozem	Sverdrup	Chernozem
Fram	Calcium Carbonate Solonchak	Tonka	Planosol
Gardena	Chernozem	Ulen	Calcium Carbonate Solonchak
Glyndon	Calcium Carbonate Solonchak	Viborg	Chernozem
Grano	Humic Gley	Vienna	Chernozem
Great Bend	Chernozem	Waubay	Chernozem
Harmony	solodized Solonetz	Wentworth	Chernozem

APPENDIX F

DETAILED SOIL DESCRIPTION AND LABORATORY DATA

The basic data of soil survey are the detailed soil descriptions and laboratory characteristics. From these materials most of the interpretations for agriculture are made. For readers desiring this additional information, descriptions and data are presented in Appendix Figures 3 through 8 for 6 soils of the Northeast Region: Estelline, Fordville, Kranzburg, Lamoure, Poinsett and Vienna.

Appendix Figure 3. Descriptions and Laboratory Data for Estelline Soil Series

Soil Type: Estelline silt loam, S-55-SD-6-11
Location: 100 yards S and 50 yards east of NW corner of Section 25, T110N, R49W, Brookings County
Vegetation: Corn
Parent Material: Loess over gravel
Physiographic position: Nearly level glacial outwash terrace
Climate: Average Annual Precipitation 22"; Average Annual Temperature 44° F.

A1p	0-9"	Very dark gray (10YR 3.5/1 dry) to black (10YR 2/1 moist), very friable, noncalcareous silt loam of cloddy to weakly developed fine granular structure. This changes clearly and smoothly to
B21	9-17"	Dark gray (10YR 4/1.5 dry) to very dark gray (10YR 3/1.5 moist), friable, noncalcareous silt loam of weakly to moderately developed prismatic breaking to moderately developed medium blocky breaking in turn to weakly developed fine granular structure. This changes clearly and smoothly to
B22	17-30"	Grayish-brown (1Y 5/2.5 dry) to dark grayish-brown (2.5Y 4/2.5 moist), friable, noncalcareous silt loam of weakly to moderately developed medium prismatic breaking to moderately developed medium blocky breaking in turn to weakly developed fine granular structure. Thin very patchy clay skins on structural peds. This changes clearly and smoothly to
Cca	30-45"	Light brownish-gray and white (2.5Y 6/2 and 8/0 dry) to grayish-brown and white (2.5Y 5/2.5 and 8/0 moist), friable, strongly calcareous silt loam of massive structure with common, hard lime concretions.
C-D	45-50"	Light gray (2.5Y 7/2.5 dry) to grayish-brown (2.5Y 5/2.5 moist), friable, strongly calcareous, massive loam with few, hard, lime concretions.
D	50-60"	Light brownish-gray (2.5Y 6/2.5 dry) to grayish-brown (2.5Y 5/2.5 moist), loose, strongly calcareous loamy sand of single grain structure.

Horizon	Depth (inches)	Particle Size Distribution (mm.) Very Coarse Sand 2-1	Coarse Sand 1-.5	Med. Sand .5-.25	Fine Sand .25-.1	Very Fine Sand .1-.05	Silt .05-.002	% Clay .002	pH 1-1	pH 1-10	Organic Matter %	N %
A1p	0-9	0.30	1.71	3.11	10.09	3.49	63.38	17.92	6.3	6.5	7.72	.2770
B21	9-17	0.60	0.76	1.55	4.73	10.96	60.24	21.16	6.3	6.6	3.91	.1920
B22	17-30	0.43	1.02	2.92	1.56	14.07	60.88	19.12	6.6	7.5	1.58	.0706
Cca	30-45	0.74	0.45	1.00	3.44	13.17	63.76	17.44	7.6	8.7	0.52	.0619
CD	45-50	1.36	3.43	9.66	14.10	16.15	40.70	14.60	7.2	8.8	0.32	.0606
D	50-60	2.47	11.10	23.57	28.73	15.73	10.56	7.84	7.5	9.0	0.11	.0502

Horizon	Depth (inches)	Elec. Conduct. Mmhos/cm 25° C	$CaCO_3$ Equiv. %	C.E.C NH_4Ac	Extractable cations Ca	Mg	H	Na	K
				milliequivalents per 100 g. soil					
A1p	0-9	0.30	3.23	32.02	15.29	8.18	-	.19	.12
B21	9-17	0.40	2.86	20.12	13.80	9.91	-	.25	.25
B22	17-30	0.50	3.02	24.72	12.46	10.90	-	.25	.15
Cca	30-45	0.40	18.04	19.74	-	-	-	.37	.14
CD	45-50	0.45	17.44	14.75	-	-	-	.35	.15
D	50-60	0.50	11.80	7.57	-	-	-	.24	.15

Profile Description by G.J. Buntley and F.C. Westin
Laboratory Data by S.D.S.U. Soils Laboratory, Brookings
Estelline Silt Loam S-55-SD-6-11

(-) Not determined

Appendix Figure 4. Descriptions and Laboratory Data for Fordville Soil Series

Soil Type: Fordville silt loam, S-58-SD-15-3
Location: 95' S and 165' W of the E¼ corner of Sec. 18, T118N, R52W, Codington County
Vegetation: Cropped, poor stand of alfalfa
Parent Material: Terrace alluvium over stratified sands and gravels
Physiography: Nearly level outwash plain
Climate: Average Annual Precipitation 21"; Average Annual Temperature 42° F.

Ap 0-6" Black (10YR 2/1 moist, 4/1.5 dry) crushing to very dark gray to dark gray (10YR 3.5/1 dry); silt loam; clods breaking to weak medium angular blocks and fine granules; very friable moist, soft dry; noncalcareous; false, plow depth boundary

B21 6-14" Black to very dark brown (10YR 2/1.5 moist, 3.5/1.5 dry); silt loam; moderate medium short vertical axis prisms breaking to moderate medium subangular-angular blocks; friable moist, slightly hard dry; noncalcareous; common fine pores; gradual, smooth boundary.

B22 14-18" Very dark brown to very dark grayish-brown (1Y 2.5/2 moist, 4/2 dry) with continuous very dark brown to very dark grayish-brown ped coats; silt loam; moderate medium short vertical axis prisms breaking to moderate medium subangular-angular blocks; friable to firm moist, slightly hard dry; noncalcareous; common fine pores; gradual, smooth boundary.

B23 18-25" Olive brown (2.5Y 3.5/3 moist, 1Y 4.5/3 dry) with continuous very dark gray to dark grayish-brown ped coats (1Y 3.5/1.5 moist, 4/1.5 dry); loam; moderate medium prisms breaking to weak to moderate medium subangular-angular blocks; firm moist, slightly hard dry; noncalcareous; common fine pores; smooth boundary

B3ca 25-30" Olive brown (2.5Y 3.5/3 moist, 4.5/3 dry) with continuous very dark gray to dark gray ped coats (2.5Y 3.5/1 moist, 5/1.5 dry); sandy loam weak to moderate medium prisms; firm moist, hard dry; differentially noncalcareous and moderately calcareous with common lime coats on gravels; few fine and few medium pores; clear, wavy boundary.

Dca 30-40" Very dark grayish-brown to olive brown (2.5Y 3.5/2.5 moist, 4.5/2.5 dry); coarse sandy loam; massive, slightly lime cemented single grains; friable moist, hard dry; strongly calcareous with common small and medium soft lime segregations and soft lime coats on gravels; clear, wavy boundary.

Dc1 40-54" Light olive brown (2.5Y 5/3 moist, 1Y 7/2 dry); loamy coarse sand with 15 to 20 % stones and gravels between 1 and 2" in diameter; partially cemented single grains; loose moist and dry; moderately calcareous; wavy boundary.

Dc2 54-60" Olive brown (2.5Y 4/4 moist, 1Y 5.5/3 dry); coarse gravelly sand, single grains; loose moist and dry; moderately calcareous.

Horizon	Depth (inches)	Particle Size Distribution (mm.) % Very Coarse Sand 2-1	Coarse Sand 1-.5	Med. Sand .5-.25	Fine Sand .25-.1	Very Fine Sand .1-.05	Silt .05-.002	Clay .002	pH 1-1	Organic C %	N %	C/N %	Moisture Tensions 1/3 Atm. %	15 Atm. %
Ap	0-6	2.4	5.1	4.6	5.9	3.8	53.8	24.4	6.2	3.99	0.318	12.5	31.6	13.3
B21	6-14	1.8	4.7	3.6	4.6	3.5	56.4	25.4	6.6	1.64	0.154	10.6	26.2	11.3
B22	14-18	2.8	4.9	3.7	4.6	3.9	56.9	23.2	6.8	1.23	0.112	11.0	26.7	10.1
B23	18-25	4.1	6.9	5.9	9.7	6.6	46.9	19.9	7.0	0.69	0.067	10.0	18.6	8.2
B3ca	25-30	12.7a	12.0a	10.3a	17.4a	10.2a	25.0	12.4	8.0	0.43	-	-	10.9	5.1
Dca	30-40	18.4a	17.7a	12.9a	14.9a	7.6a	19.6	8.9	8.2	0.10	-	-	8.3	3.1
Dc1	40-54	18.3a	23.8a	15.5a	23.3a	2.6a	12.4	4.1	8.5	0.01	-	-	4.7	2.5
Dc2	54-60	11.2a	20.6a	16.0a	32.6a	9.5a	7.2	2.9	8.5	0.01	-	-	3.8	2.3

Horizon	Depth (inches)	Elec. Conduct. Mmhos/cm 25° C	$CaCO_3$ Equiv. %	C.E.C. NH_4Ac	Extractable cations (Milliequivalents per 100 g. soil) Ca	Mg	H	Na	K
Ap	0-6	-	-	28.7	20.9	5.4	8.2	-	0.4
B21	6-14	-	*	24.5	17.6	5.6	4.9	-	0.4
B22	14-18	-	*	21.5	16.1	5.6	3.7	-	0.4
B23	18-25	-	*	17.1	12.4	4.8	2.4	-	0.3
B3ca	25-30	-	12	9.0	-	-	-	-	0.2
Dca	30-40	-	18	6.0	-	-	-	-	0.2
Dc1	40-54	-	20	3.1	-	-	-	-	0.1
Dc2	54-60	-	19	2.8	-	-	-	-	0.1

Profile Description by G.J. Buntley revised by F.C. Westin
Laboratory Data by U.S.D.A. Laboratory, Mandan
Fordville Silt Loam S-58-SD-15-3 (1-8)

(-) Not determined
(*) Less than one
(a) Trace smooth dark brown to black concr.

Appendix Figure 5. Descriptions and Laboratory Data for Kranzburg Soil Series

Soil Type: Kranzburg silty clay loam, S-57-SD-15-4
Location: .15 of a mile N of the SE corner of Sec. 8, and 115' W from the center of the road, T119N, R52 Reservation, Codington County
Vegetation: Cropped, soybeans
Parent Material: Loess over glacial till
Physiography: Nearly level convex ridge top
Climate: Average Annual Precipitation 21"; Average Annual Temperature 42° F.

A1p 0-8" Black (10YR 2/1 moist, 1Y 3.5/1.5 dry); black to very dark brown ped coats (10YR 2/1.5 moist, 3.5/1.5 dry); silty clay loam; clods breaking to weak fine granules; friable, soft to slightly hard; noncalcareous; false, plow depth boundary.

B21 8-11" Very dark grayish-brown to dark brown (1Y 3/2.5 moist, 4.5/2 dry); patchy very dark brown to very dark grayish-brown ped coats (1Y 2.5/1.5 moist, 4/1 dry); silty clay loam; moderate, medium and coarse, short vertical axis prisms breaking to weak, medium and fine, fragmentary blocks; friable, soft to slightly hard; noncalcareous; gradual, smooth boundary.

B22 11-19" Olive brown (2.5Y 3/4 moist, 4/4 dry); very dark gray to very dark grayish-brown ped coats (1Y 3/1.5 moist, 4/1.5 dry); silty clay loam; moderate, medium and coarse, short vertical axis prisms breaking to weak, medium and fine, fragmentary blocks; friable, slightly hard; noncalcareous; gradual, smooth boundary.

B23 19-25" Olive brown (2.5Y 4/3 moist, 5/3 dry); patchy dark grayish-brown ped coats (2.5Y 4/2 moist, 5/2 dry); silt loam; moderate, coarse prisms; friable, hard; noncalcareous; clear, smooth boundary.

B2ca 25-32" Olive brown to light olive brown (2.5Y 4.5/3 moist, 6/2 dry); silt loam; weak to moderate, coarse prisms; friable, hard; moderately calcareous; few, small, soft lime segregations; clear, smooth boundary.

B3ca 32-36" Olive brown to light olive brown (2.5Y 4.5/3 moist, 6/2 dry); silt loam; weak coarse prisms; friable, hard; moderately calcareous; few, small, soft lime segregations, lime coatings on the underside of rocks and pebbles; pebble lag at 36"; gradual, smooth boundary.

D-B3ca1 36-47" Light olive brown (2.5Y 5/3 moist, 7/2 dry); patchy olive brown to light olive brown ped coats (2.5Y 4.5/3 moist, 6/2 dry); loam; weak to moderate, very coarse prisms breaking to weak, medium horizontal blocks; firm, very hard; moderately to strongly calcareous; few, to common, medium and small, soft lime segregations, lime coats on undersides of gravels; gradual, smooth boundary.

D-B3ca2 47-60" Light olive brown (2.5Y 5/3 moist, 7/1 dry); patchy olive brown to light olive brown ped coats (2.5Y 4.5/3 moist, 6/2 dry); clay loam to loam; weak to moderate, very coarse prisms breaking to weak to moderate, medium, horizontal blocks; firm, very hard; moderately calcareous; very few, medium and small, soft lime segregations.

		Particle Size Distribution (mm.)							pH					Moisture Tensions	
Horizon	Depth (inches)	Very Coarse Sand 2-1	Coarse Sand 1-.5	Med. Sand .5-.25	Fine Sand .25-.1	Very Fine Sand .1-.05	Silt .05-.002	Clay .002 %	1-1	1-10	Organic C %	N %	C/N %	1/3 Atm. %	15 Atm. %
A1p	0-8	0.4	0.9	1.2	1.9	4.4	62.8	28.4	6.9	7.3	3.41	0.305	11.2	37.2	13.6
B21	8-11	-	0.3	0.5	0.8	3.8	64.8	29.8	7.1	7.5	1.74	0.164	10.6	26.2	13.0
B22	11-19	-	0.1	0.1	0.2	5.1	54.6	29.9	7.4	7.4	0.84	0.086	10.0	24.1	12.5
B23	19-25	-	0.1	0.1	0.3	7.1	67.5	24.9	7.9	8.2	0.59	0.063	9.0	21.1	10.4
B2ca	25-32	-	0.2	0.4	0.7	7.2	71.8	19.7	8.3	8.9	0.30	-	-	19.1	8.1
B3ca	32-36	2.5	4.6	4.6	6.5	7.9	54.1	19.8	8.5	9.1	0.22	-	-	17.8	7.9
D-B3ca$_1$	36-47	3.2	7.8	9.5	13.8	6.8	36.8	22.1	8.7	9.2	0.01	-	-	16.6	7.7
D-B3ca$_2$	47-60	4.8	6.2	6.1	9.3	6.0	40.5	27.1	8.7	9.3	0.08	-	-	19.7	9.7

					Extractable cations				
Horizon	Depth (inches)	Elec. Conduct. Mmhos/cm 25° C	$CaCO_3$ Equiv. %	C.E.C. NH_4Ac	Ca	Mg	H	Na	K
				milliequivalents per 100 g. soil					
A1p	0-8	-	-	30.6	21.0	7.2	5.5	-	0.7
B21	8-11	-	-	25.7	16.1	8.5	4.2	0.1	0.3
B22	11-19	-	-	24.5	14.4	11.3	2.9	0.1	0.3
B23	19-25	-	4	20.4	13.8	11.0	1.2	0.1	0.3
B2ca	25-32	-	17	14.9	-	-	-	0.1	0.2
B3ca	32-36	-	15	14.1	-	-	-	0.2	0.2
D-B3ca$_1$	36-47	-	16	12.1	-	-	-	0.2	0.2
D-B3ca$_2$	47-60	-	17	14.2	-	-	-	0.4	0.2

Profile Description by G.J. Buntley revised by F.C. Westin
Laboratory Data by U.S.D.A. Laboratory, Lincoln, Nebr.
Kranzburg Silty Clay Loam S-57-SD-15-4

(-) Not determined

Appendix Figure 6. Descriptions and Laboratory Data for Lamoure Soil Series

Soil Type: Lamoure silty clay loam, S-57-SD-15-2
Location: 175' S of the NW corner of Sec. 9, 20' E from the center of trail, T116N, R52W, Codington County
Vegetation: Cropped, corn
Parent material; Medium-textured stream alluvium over stratified gravels and sands
Physiography: Nearly level second bottom position in the confluence area of Willow Creek and the Sioux River
Climate: Average Annual Precipitation 21"; Average Annual Temperature 42°F.

A1pc	0-6"	Black (10YR 2/0.5 moist, 3.5/0.5 dry); silty clay loam puddled clods; friable, hard; very weakly calcareous; false, plow depth boundary.
ABc	6-11"	Black (10YR 2/1 moist, 3.5/0.5 dry); silty clay loam weak, coarse and medium prisms breaking to weak to moderate, fine and very fine, subangular blocks; many worm casts and filled worm channels same color as matrix; friable, hard; weakly to moderately calcareous; clear, smooth but worm worked boundary.
B1gc1	11-17"	Very dark gray (2.5Y 3/0.5 moist, N 4.5/0 dry); black ped coats (1Y 2/0.5 moist, 2.5Y 3.5/0.5 dry); clay loam; weak, coarse prisms breaking to weak, fine granules; few worm casts and filled worm channels slightly darker than matrix; friable, soft to slightly hard; moderately to strongly calcareous; gradual, smooth boundary.
B1gc2	17-22"	Dark gray (2.5Y 4/1 moist, N 6.5/0 dry); black ped coats (1Y 2/0.5 moist, 2.5Y 4/0.5 dry); clay loam; weak, coarse prisms breaking to weak, fine granules; friable, soft to slightly hard; moderately to strongly calcareous; gradual, smooth boundary.
B2gc1	22-30"	Dark gray (2.5Y 4/1 moist, N 6.5/0 dry); very dark gray ped coats (2.5Y 3/1 moist, 5/1 dry); clay loam weak, coarse prisms breaking to weak, fine granules; friable, slightly hard; moderately to strongly calcareous; gradual, smooth boundary.
B2gc2	30-35"	Grayish-brown (2.5Y 5/2 moist, 5Y 5.5/1 dry); clay loam; weak, coarse prisms breaking to weak, fine granules; friable, slightly hard; moderately to strongly calcareous; gradual, smooth boundary.
B2c	35-40"	Very dark grayish-brown (2.5Y 3/2 moist, 5/1 dry); loam; weak, coarse prisms breaking to weak, fine granules; friable, soft to slightly hard; moderately to strongly calcareous; smooth boundary.
B3c	40-46"	Olive brown (2.5Y 4/4 moist, 5/3 dry); very dark grayish-brown ped coats (2.5Y 3/2 moist, 5/2 dry); sandy loam; weak, coarse prisms breaking to weak, fine granules and single grains; friable to loose, soft to slightly hard; weakly calcareous; clear, smooth boundary.
Dc1	46-57"	Multicolored sands and gravels; basic color dark grayish-brown (2.5Y 4/2 moist, 5/3 dry); loamy gravelly sand; single grain; loose; weakly calcareous; clear, smooth boundary.
Dc2	57-65"	Multicolored sands and gravels; basic color dark grayish-brown to grayish brown (2.5Y 4.5/2 moist, 5.5/2 dry); gravelly sand; single grain; loose; very weakly calcareous; temperature 59°F.

		Particle Size Distribution (mm.)						%	pH					Moisture Tensions	
Horizon	Depth (inches)	Very Coarse Sand 2-1	Coarse Sand 1-.5	Med. Sand .5-.25	Fine Sand .25-.1	Very Fine Sand .1-.05	Silt .05-.002	Clay .002	1-1	1-10	Organic C %	N %	C/N %	1/3 Atm. %	15 Atm. %
A1pc	0-6	0.9	3.5	3.5	5.2	7.3	50.6	29.0	7.9	8.3	4.54	0.398	11.4	34.2	17.2
ABc'	6-11	0.9	3.5	3.3	4.5	6.4	50.2	31.2	8.0	8.6	3.93	0.347	11.3	39.4	18.2
B1gc1	11-17	1.8	4.8	4.2	6.0	5.3	49.3	28.6	8.2	8.8	2.85	0.255	11.2	34.2	16.6
B1gc2	17-22	1.7	5.8	5.0	6.7	4.3	44.0	32.5	8.5	9.2	1.58	0.136	11.6	30.8	14.3
B2gc1	22-30	1.9	5.7	5.6	7.5	4.3	39.7	35.3	8.5	9.1	0.99	0.086	12.0	28.1	13.7
B2gc2	30-35	3.8	9.5	8.9	10.5	4.2	33.9	29.2	8.4	9.1	0.66	-	-	23.1	10.3
B2c	35-40	4.6	12.2	10.5	12.0	4.2	33.2	23.3	8.2	8.9	0.59	-	-	21.3	8.7
B3c	40-46	7.5	16.1	16.5	21.2	6.6	20.9	11.2	8.3	9.1	0.23	-	-	12.5	4.6
Dc1	46-57	17.3	23.1	21.2	19.7	5.9	7.9	4.9	8.6	9.2	0.06	-	-	6.0	2.3
Dc2	57-65	20.8	25.1	20.9	20.7	4.6	5.0	2.9	8.5	9.3	0.01	-	-	4.3	2.0

Horizon	Depth (inches)	$CaCO_3$ Equiv. %	Extractable cations: C.E.C NH_4Ac	Na	K
			milliequivalents per 100 g. soil		
A1pc	0-6	2	35.4	0.1	0.4
ABc	6-11	6	33.8	0.2	0.3
B1gc1	11-17	9	28.9	0.2	0.3
B1gc2	17-22	15	22.5	0.3	0.2
B2gc1	22-30	21	16.5	0.4	0.1
B2gc2	30-35	16	13.4	0.4	0.1
B2c	35-40	12	13.7	0.4	0.1
B3c	40-46	4	8.6	0.2	0.1
Dc1	46-57	14	3.9	0.1	0.1
Dc2	57-65	13	2.9	0.1	-

Profile Description by G.J. Buntley revised by F.C. Westin
Laboratory Data by U.S.D.A. Laboratory, Lincoln, Nebr.

Lamoure Silty Clay Loam S-57-SD-15-2
(-) Not determined

Appendix Figure 7. Descriptions and Laboratory Data for Vienna Soil Series

Soil Type: Vienna loam, S-58-SD-15-2
Location: 1000' S and 600' W of the E¼ corner of Sec. 23, T116N, R52W, Codington County
Vegetation: Cropped, soybeans
Parent Material: Glacial till of Iowan age, appears to be some loess on surface
Physiography: On a slightly convex, 2 percent shoulder slope near a rather deeply incised drain
Climate: Average Annual Precipitation 21"; Average Annual Temperature 42°F.

ABp 0-6" Black (10YR 2/1 moist, 3.5/1.5 dry) crushing to very dark gray to dark gray (10YR 3.5/1 dry, not readable moist); loam; clods breaking to weak fine granules; friable moist, slightly hard dry; noncalcareous; false, plow depth boundary.

B21 6-10" Very dark grayish-brown to dark grayish-brown (10YR 3.5 moist, 1Y 4/2 dry) with patchy very dark gray to very dark grayish-brown ped coats (10YR 3/1.5 moist 1Y 4/1.5 dry); loam; weak to moderate coarse prisms breaking to weak medium and fine granules and subangular blocks; friable moist, slightly hard to hard dry; noncalcareous; gradual, smooth boundary.

B22 10-13" Dark brown to brown (1Y 3.5/3 moist, 4.5/3 dry) with patchy very dark grayish-brown ped coats (1Y 3/2 moist, 4/2 dry); loam; weak to moderate coarse prisms breaking to weak medium and fine granules and subangular blocks; friable moist, slightly hard to hard dry; noncalcareous; clear, smooth boundary.

B2c 13-18" Olive brown (2.5Y 4/3 moist, 5/3 dry); sandy loam; weak coarse prisms; friable moist, hard dry; weakly to moderately calcareous; clear, wavy boundary.

B3ca 18-24" Light olive brown (2.5Y 5/3 moist, 6.5/2 dry); loam; very weak coarse and very coarse prisms breaking to very weak coarse horizontal blocks; friable moist, hard dry; moderately to strongly calcareous in ped interiors, common medium soft lime segregations and lime coats on gravels; clear, smooth boundary.

Cca1 24-31" Light olive brown (2.5Y 5/4 moist, 6.5/2 dry); loam; weak to moderate medium horizontal blocks; friable moist, hard dry; moderately to strongly calcareous on ped faces and strongly calcareous in ped interiors, common medium soft lime segregations and lime coats on gravels; gradual, smooth boundary.

Cca2 31-37" Light olive brown (2.5Y 5/4 moist, 6.5/2 dry); loam; weak to moderate medium horizontal blocks; friable moist, hard dry; strongly calcareous on ped faces and moderately to strongly calcareous in ped interiors wtih common small and medium soft lime segregations; gradual, smooth boundary.

Cca3 37-53" Olive brown to light olive brown (2.5Y 4.5/4 moist, 6.5/3 dry); loam; weak to moderate medium horizontal blocks breaking to fine horizontal blocks; friable moist, hard dry; strongly calcareous on ped faces, moderately to strongly calcareous in ped interiors, few small soft limesegregations; gradual, smooth boundary.

Cc 53-60"+ Light olive brown (2.5Y 5/4 moist, 6.5/2 dry) with a few fine faint dark yellowish-brown iron stains (10YR 4/4 moist, 5/4 dry); loam; moderate medium breaking to fine horizontal blocks; friable moist, slightly hard dry; moderately calcareous.

Horizon	Depth (inches)	Very Coarse Sand 2-1	Coarse Sand 1-.5	Med. Sand .5-.25	Fine Sand .25-.1	Very Fine Sand .1-.05	Silt .05-.002	Clay .002	pH 1-1	Organic C %	N %	C/N %	Moisture Tensions 1/3 Atm. %	Moisture Tensions 15Atm. %
		Particle Size Distribution (mm.) %												
ABp	0-6	1.7	6.7	6.6	10.2	5.3	46.7	22.8	6.4	2.54	0.224	11.3	23.8	10.8
B21	6-10	2.6	8.0	8.6	16.5	7.7	35.1	21.5	6.9	0.97	0.100	10.0	18.4	8.7
B22	10-13	2.9	8.7	10.1	19.0	8.8	30.8	19.7	7.6	0.67	0.079	8.0	16.4	7.6
B2c	13-18	5.2	10.8	11.0	24.2	10.2	26.2	12.4	8.0	0.35	0.038	9.0	11.0	4.6
B3ca	18-24	4.4	7.2	6.2	11.0	7.4	42.1	21.7	8.1	0.25	0.030	8.0	18.6	7.4
Cca1	24-31	4.5	8.0	6.4	10.2	6.8	42.3	21.8	8.3	0.16	-	-	19.3	7.9
Cca2	31-37	4.4	7.8	7.0	11.9	7.9	42.3	18.7	8.3	0.09	-	-	18.3	7.4
Cca3	37-53	6.2	8.5	7.0	11.8	7.6	42.1	16.8	8.4	0.06	-	-	18.2	7.2
Cc	53-60+	4.8	9.5	9.5	17.1	8.0	34.2	16.9	8.4	0.04	-	-	16.4	7.2

Horizon	Depth (inches)	$CaCO_3$ Equiv. %	C.E.C. NH_4Ac	Extractable cations Ca	Mg	H	K
			milliequivalents per 100 g. soil				
ABp	0-6	-	23.6	16.7	5.4	5.3	0.6
B21	6-10	*	17.2	12.4	4.8	3.3	0.3
B22	10-13	2	14.4	-	-	-	0.3
B2c	13-18	14	8.2	-	-	-	0.2
B3ca	18-24	30	9.4	-	-	-	0.2
Cca1	24-31	31	8.8	-	-	-	0.2
Cca2	31-37	28	8.3	-	-	-	0.2
Cca3	37-53	26	8.4	-	-	-	0.2
Cc	53-60+	21	8.8	-	-	-	0.2

Profile Description by G.J. Buntley revised by F. C. Westin
Laboratory Data by U. S. D. A. Laboratory, Lincoln, Nebr.
Vienna Loam S-58-SD-15-2

(-) Not determined
(*) Less than one

Appendix Figure 8. Descriptions and Laboratory Data for Poinsett Soil Series

Soil Type: Poinsett silt loam, S-57-SD-15-6
Location: .15 of a mile W of the NE corner of Sec. 32, and 95' S from the middle of the road, T116N, R55W, Codington County
Vegetation: Cropped, fallow
Parent Material: Silty glacial drift
Physiography: On the broad, nearly level top of a low gently rise in a landscape showing no integrated drainage pattern
Climate: Average Annual Precipitation 21"; Average Annual Temperature 42° F.

A1p	0-6"	Black (10YR 2/1 moist, 3.5/1 dry); no readable moist ped coats; very dark gray ped coats (10YR 3/1 dry); silt loam; clods breaking to weak, fine crumbs and granules; friable, soft to slightly hard; noncalcareous; false, plow depth boundary.
AB	6-13"	Black (10YR 2/1 moist, 1Y 3.5/1 dry); silty clay loam weak to moderate, medium, short vertical axis prisms breaking to weak, fine crumbs and granules; friable, soft to slightly hard; non-calcareous; gradual, smooth boundary.
B21	13-17"	Olive brown (2.5Y 3/3 moist, 4/2 dry); black ped coats and a few tongues (1Y 2/1 moist, 3.5/1 dry); silty clay loam; moderate, medium, short vertical axis prisms breaking to weak to moderate, fine, subangular blocks; friable, slightly hard; noncalcareous; gradual, smooth boundary.
B22	17-24"	Olive brown (2.5Y 4/3 moist, 5/3 dry); very dark grayish-brown ped coats (2.5Y 3/2 moist, 4.5/2 dry); silty clay loam; moderate, coarse, short vertical axis prisms breaking to medium, short vertical axis prisms in turn breaking to weak to moderate, fine, subangular blocks; friable, slightly hard; noncalcareous; clear, smooth boundary.
B2ca	24-41"	Olive brown (2.5Y 4/4 moist, 5.5/3 dry); few, fine, faint dark yellowish-brown iron stains (10YR 4/4 moist, 5/6 dry); patchy olive brown to light olive brown ped coats (2.5Y 4.5/3 moist, 5/3 dry); silt loam; weak to moderate, coarse, short vertical axis prisms breaking to very weak, medium and coarse, horizontal blocks; friable, slightly hard to hard; moderately to strongly calcareous; few to common, small and medium, soft lime segregations; clear, smooth boundary.
B3c3	41-62"	Olive gray (5Y 5/2 moist, 6/1 dry); many, medium distinct dark yellowish-brown concentric iron stained rings radiating away from vertical pipestem iron concretions (10YR 2/1 moist, 3/1 dry); silty clay loam; friable to firm, very hard; weakly to moderately calcareous; weak and weak to moderate, very coarse, short vertical axis prisms breaking to moderate to strong, medium and coarse, horizontal blocks in turn breaking to fine horizontal blocks.

Hori-zon	Depth (inches)	Particle Size Distribution (mm.) %: Very Coarse Sand 2-1	Coarse Sand 1-.5	Med. Sand .5-.25	Fine Sand .25-.1	Very Fine Sand .1-.05	Silt .05-.002	Clay .002	pH 1-1	pH 1-10	Or-ganic C %	N %	C/N %	Moisture Tensions 1/3 Atm. %	Moisture Tensions 15 Atm. %
A1p	0-6	0.2	0.8	1.6	5.3	8.4	56.9	26.8	6.8	7.2	3.79	0.309	12.3	28.1	14.8
AB	6-13	0.1	0.5	0.7	2.7	9.1	57.9	29.0	7.2	7.6	3.17	0.254	12.5	27.4	14.7
B21	13-17	-	0.2	0.4	1.8	12.6	55.5	29.5	7.4	7.7	1.32	0.126	10.5	28.2	12.9
B22	17-24	-	0.2	0.2	1.2	8.8	58.5	31.1	7.7	8.1	0.87	0.090	10.0	26.5	12.4
B2ca	24-33	-	0.1	0.2	2.1	16.0	60.9	20.7	8.3	9.0	0.38	-	-	20.8	8.0
B3c3	53-62	0.3	0.3	0.2	0.6	6.3	63.7	28.6	8.5	9.3	0.18	-	-	32.7	13.2

Horizon	Depth (inches)	$CaCO_3$ Equiv. %	C.E.C. NH_4Ac	Extractable cations: Ca	Mg	H	Na	K
			milliequivalents per 100 g. soil					
A1p	0-6	-	32.1	23.2	6.4	5.0	-	2.3
AB	6-13	-	30.3	23.1	6.6	3.8	-	1.2
B21	13-17	-	25.5	-	-	-	-	0.5
B22	17-24	1	23.3	-	-	-	0.1	0.4
B2ca	24-33	18	13.1	-	-	-	-	0.3
B3c3	53-62	19	17.5	-	-	-	0.7	0.3

Profile Description by G.J. Buntley revised by F.C. Westin
Laboratory Data by U.S.D.A. Laboratory, Lincoln, Nebr.
Poinsett Silt Loam S-57-SD-15-6

(-) Not determined

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W. F. Lytle, climatologist
W. S. Spuhler, climatologist

A local committee in each county reviewed the estimates for potential yield in their respective counties. The personnel on these committees included representatives from the Extension Service, ASCS, SCS, FHA and Voc. Ag.

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