GROWTH AND DEVELOPMENT OF SALINE SEEPS

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The increase in dryland salinity or "saline seeps" in recent years has caused considerable concern to agriculturists in the Northern Great Plains. Aerial photography was used to show increases in salinity of five severely affected areas in Stark County, North Dakota.

Introduction

Saline seeps are ubiquitous to the Northern Great Plains. This is the major durum and hard red spring wheat producing region of the United States and Canada. The cropping sequence generally followed in this region is alternate crop-fallow. This system has been associated with recent increases in the number and size of saline seeps (4,7).

Saline seeps develop as a result of water percolating through the soil profile and below the rooting zone of crops in the upland recharge area. Then at some depth, depending on the stratigraphy and geology of the site, the water encounters either a less permeable layer which restricts further downward flow or a highly permeable layer which is conducive to lateral flow. The water, together with soluble salts dissolved from the conducting materials, moves laterally to a position where the layer is truncated by the landscape and a saline seep results (10). Continuous surface wetness and an accumulation of soluble salts sufficiently concentrated to restrict or eliminate crop growth usually results.

Saline seeps are associated with excess moisture and soluble salts. Other salt related problem soils exist throughout the region. Alkali soils with high sodium content, characterized by the presence of a dense, clay B horizon and columnar structure are fairly common. In many instances, these soils appear to have existed for a very long time. It is not uncommon for these alkali soils to also have high soluble salt content. These salts may have existed for a very long time or may be recent accumulations. The length of time the sodium or soluble salt has existed in the soil profile is difficult if not impossible to determine.

This paper is concerned primarily with problem soils which exhibit surface wetness and high soluble salt content: saline seeps. In most instances, these have either formed or visibly expanded within the memory of present land operators and as such are very recent.

The frequency of observation of saline seeps has increased in recent years and more land has become unproductive as a result (1, 6, 8, 10). In 25 eastern counties of Montana, saline seeps affect 33,000 hectares[1] with an annual growth rate estimated between 8 and 10 per cent (5). The materials in this area are identified as glacial till overlying thick sequences of marine shales of Late Cretaceous age. Geologic conditions of this type cover about 331,520 square km[2] in the United States and Canada and could be considered susceptible to saline seep development (9). Seeps also occur in non-glaciated areas where the Fort Union Formation exists (10).

It has been suggested that the small grain-summer fallow farming system is a major factor in the development of saline seeps. Climatic conditions are also major factors identified with respect to the recent increase in incidence of seeps (2, 3). The objectives of this paper are to document the frequency of occurrence of saline seeps in selected areas and to examine the climatic conditions and cultural practices associated with seep development.

Photo Interpretations and Growth

The changes in salt-affected areas in Stark County, North Dakota, were recorded on standard black and white aerial photography in 1950, 1957, 1965 and 1972. During the dry period of the year, August and September, saline seeps were identified on the aerial photographs by the following criteria:

1. Presence of a salt crust which appeared white on the photographs.

2. Changes in field patterns due to field areas becoming so wet as to alter normal farming operations.

3. Textural and tonal pattern changes resulting from shifts toward salt tolerant vegetative species (11).

Field surveying verified the photo interpretation procedures and provided current acreage figures for seep affected soils.

Figures 1a and 1b illustrate the changes which have occurred in saline seeps from 1950 to 1972. In 1950, the drainageway southeast of "A" exhibited some wetness and salinity. By 1972, the drainageway could no longer

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[1]*One Hectare = 2.47 Acres*

[2]*One Square km = 0.39 Square Miles*

be cultivated and the affected area had doubled in width. The upper end of the drainageway had become salinized and this salinity had encroached upon the backslope. In the area around "B," salinity had increased greatly to the north and south. The salt affected area in the cultivated field north of "B" was also moving up the backslope. The area south of "B" was partially associated with a drainageway and had become more severely affected in the cultivated areas. The stock dam east of "B" had aggravated this condition. New areas of salinity had developed at "C" and "D." These areas were in native pasture in 1950 but were brought under cultivation by 1957.

Five areas were selected for detailed temporal analysis. These areas are described in Table 1. Changes in the amount of wet, salt affected area are illustrated in Figure 2. The data showed a 6.6, 10.7 and 13.5-fold increase in salt affected areas over a 25-year period for sites 1, 3 and 5 respectively. Site 4, which was primarily pasture, showed a 2.5-fold increase. The ground survey of this site led to the conclusion that most of the salts had been transported over the surface by water through a drainageway common to site 1.

These areas represented some of the most severely salt affected areas in Stark County, with the loss of area due to salinity and wetness encompassing 15 per cent of the area at the five sites. A ground survey of the 22-section area surrounding the five study sites indicated that 4.1 per cent of that area is currently out of production because of saline seep associated wetness and salinity.

Cultural Practices

There are several factors which can be cited as being responsible for increases in saline seep areas. A higher percentage of the cultivated area in Stark County has been summer fallowed in recent years (Figure 3). From the mid-1950's to the early 1960's there were 2.5 to 2.8 hectares of cropped land per hectare of summer fallow. By the early 1970's this ratio has changed to 1.2 to 1.6 hectares of cropped land per hectare of summer fallow. Study sites 1, 2, 3 and 5 (Table 1) have a high proportion of the areas in crop-fallow culture and it can be assumed that the same trends in land use applied here. The land use ratio appeared to start changing in 1973, with a high percentage of cultivated areas devoted to crop production. Some species of vegetation in pasture land are actively growing and utilizing water during the entire growing season. As a result, less recharge occurs and fewer seeps are associated with pasture.

Climatic Conditions

There has been a trend towards above long-term average precipitation in the 1960's and 1970's (Figure 4). Years of above average precipitation associated with very wet spring seasons are of special significance of saline seep development. These kinds of precipitation patterns occurred in 1965, 1970, 1971 and 1972, during the time period when seeps increased greatly in size and number. A moisture budget model was used by Brun and Worcester (2) to estimate water movement beyond the root zone which could contribute to seep formation. On the average, the quantities of water were quite small, ranging from about 1.5 to 4 cm per year. However, in some of the wet spring seasons, values up to 15 cm were obtained. Consequently, a number of wet springs could provide a large quantity of water that could contribute to seep formation under the stratigraphic conditions in the study area.

Conclusions

Photographic records indicated that saline seep affected areas have increased from 6.6 to 13.5 times in the past 25 years in cultivated areas. The increase has been much less, 2.5 times, in pasture areas. Three factors appear to have contributed to this rapid growth.

First, a shift towards more summer fallow in relation to cropped areas has occurred during the period of study. This has provided more opportunity for water movement below the root zone of annual crops.

Second, there has been an increase in precipitation above long-term average in recent yeras. This has been associated with extremely high precipitation amounts during the spring season when there is no plant growth in cultivated areas. Third, there has been a tendency toward more efficient summer-fallowing and subsequently greater water conservation during these years. The combination of these factors can explain the increased frequency of occurrence of saline seeps.

Literature Cited

1. Ballantyne, A. K. 1963. **Recent accumulation of salts in the soils of southeastern Saskatchewan.** Can. J. Soil. Sci. 43:52-58.
2. Brun, L. J. and B. K. Worcester. 1974. **Role of alfalfa in saline seep prevention.** North Dakota Farm Res. 31:9-14.
3. Brun, L. J. and B. K. Worcester. 1975. **Soil water extraction by alfalfa.** Agron. J. 67:586-588.
4. Black, A. L., F. H. Siddoway and P. L. Brown. 1974. **Summer fallow in the Northern Great Plains (winter wheat).** In Summer Fallow in the Western United States. U.S.D.A. Cons. Res. Report 17, p. 36-50.
5. Clark, C. 1971. **The mechanics of saline seep development on non-irrigated cropland.** In Saline Seep-Fallow Workshop Proceedings. Highwood Alkali Control Assoc., Highwood, Montana.
6. Greenlee, G. M., S. Pawluk and W. E. Bowser. 1968. **Occurrence of the soil salinity in drylands of southwestern Alberta.** Can. J. Soil Sci. 48:65-75.
7. Halvorson, A. D. and A. L. Black. 1974. **Saline seep development in dryland soils of northeastern Montana.** J. Soil and Water Cons. 29:77-81.
8. Luken, H. 1962. **Saline soils under dryland agriculture in southeastern Saskatchewan (Canada) and possibilities for their improvement.** Plant and Soil. 17:1-65.
9. Miller, M. 1971. **Hydrogeology of saline seep spots in dryland farm areas.** In Saline Seep-Fallow Workshop Proceedings. Highwood Alkali Control Assoc., Highwood, Montana.
10. Worcester, B. K., L. J. Brun and E. J. Doering. 1975. **Classification and management of saline seeps in western North Dakota.** North Dakota Farm Res. 32:3-7.
11. Worcester, B. K. and B. D. Seelig. 1976. **Plant indicators of saline seeps.** North Dakota Farm Res. 34:18-20.

TABLE 1. STUDY SITE DESCRIPTIONS.

Site	Location	Year	Hectares	
			Land Use*	Salt Affected
1	NE¼ Sec. 7, T140N, R97W	1950	26.5 P, 37.3 CF	1.86
		1957	13.0 P, 50.8 CF	2.19
		1965	13.0 P, 50.8 CF	2.40
		1972	13.0 P, 50.8 CF	7.53
		1975	13.0 P, 50.8 CF	12.34
2	SW¼ Sec. 12, T140N, R98W	1950	64.8 CF	0
		1957	64.8 CF	0
		1965	64.8 CF	0.53
		1972	64.8 CF	1.74
		1975	56.7 CF, 8.1 P	4.86
3	NE¼ Sec. 1, T140N, R98W	1950	42.5 P, 22.3 CF	0.61
		1957	64.8 CF	1.86
		1965	2.4 P, 62.4 CF	3.08
		1972	12.2 P, 52.6 CF	5.51
		1975	12.2 P, 52.6 CF	6.48
4	SE¼ Sec. 7, T140N, R97W	1950	64.8 P	3.20
		1957	58.3 P, 6.5 CF	4.05
		1965	64.8 P	3.81
		1972	64.8 P	5.47
		1975	64.8 P	8.14
5	NE¼ Sec. 19, T140N, R97W	1950	21.9 P, 42.9 CF	0.53
		1957	21.9 P, 42.9 CF	1.13
		1965	17.0 P, 47.8 CF	3.56
		1972	9.3 P, 55.5 CF	4.50
		1975	9.3 P, 55.5 CF	7.09

**CF – crop-fallow culture, P – pasture.*

Fig. 1 a. Aerial photograph of NE¼ Sec. 7, T140N, R97W taken August of 1950.

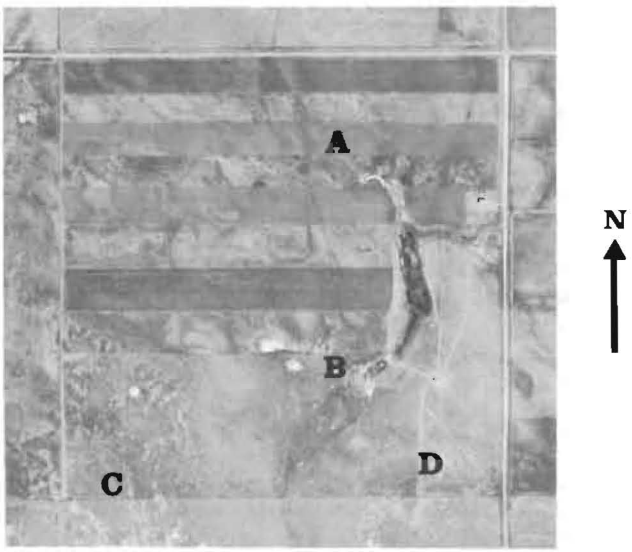

Fig. 1 b. Aerial photograph of NE¼ Sec. 7, T140N, R97W taken August of 1972.

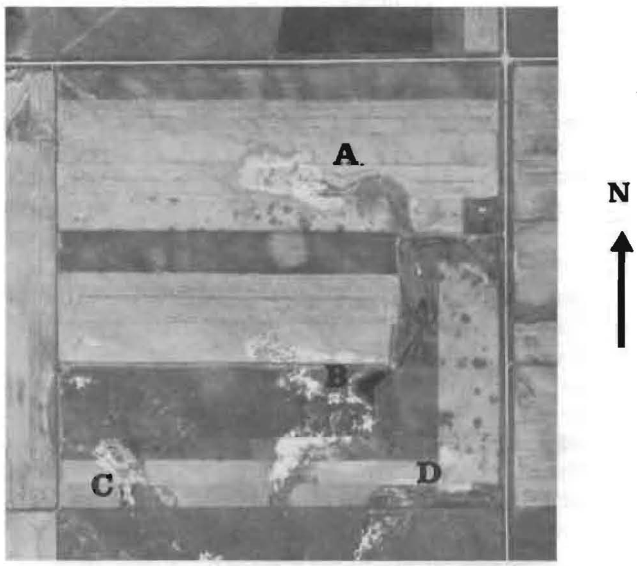

Fig. 2. Change in salt affected area of five 64.8 hectare study sites.

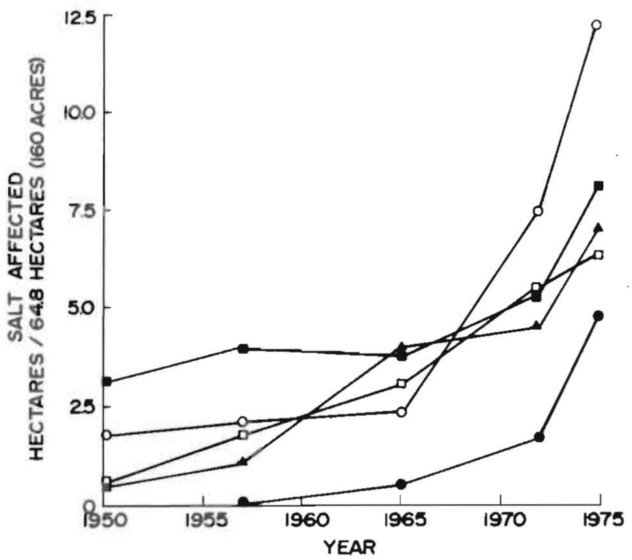

Fig. 3. Area and ratio of cropped fallow land in Stark County, North Dakota.

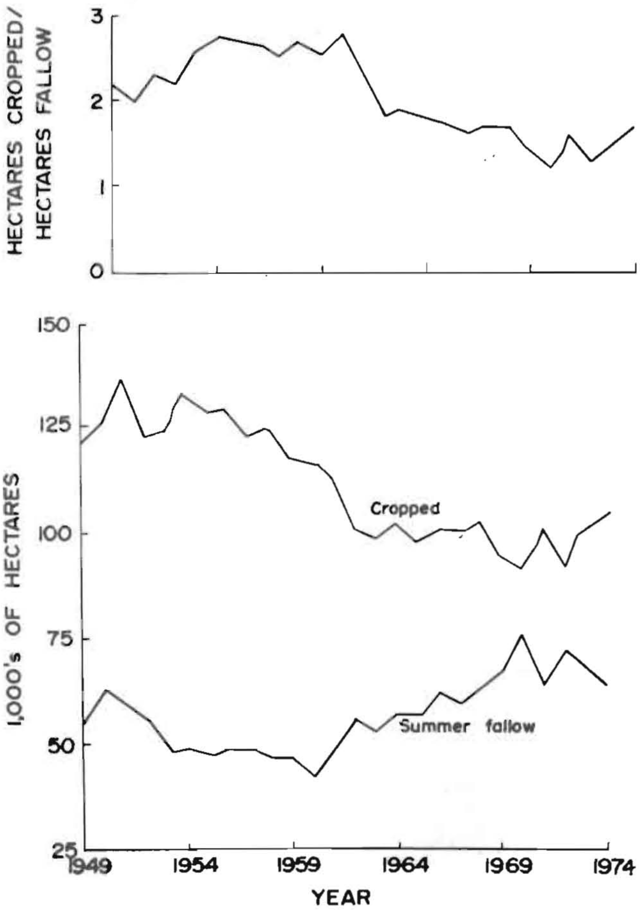

Fig. 4. Annual precipitation trend at Dickinson, North Dakota (PPT = precipitation, YR = year).