PLANT MATERIALS TECHNICAL NOTE

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Plant Materials and Techniques for Brine Site Reclamation

This technical note provides information regarding the reclamation of brine sites and was prepared to address a resource need identified in the Manhattan Plant Materials Center (PMC) Long Range Plan. This information was compiled from a literature review as well as from a brine site revegetation study completed in Graham County, Kansas by the Graham County Conservation District and the Manhattan Plant Materials Center.

Enclosure

PLANT MATERIALS AND TECHNIQUES FOR BRINE SITE RECLAMATION

Introduction

A large quantity of saltwater, also referred to as brine, is produced in the pumping of oil. Brine, which is high in salts, has been disposed of by various methods over the years. In the 1920's, brine was dumped indiscriminately across the landscape. Beginning in the 1930's, evaporation ponds were required by many states to help with disposal, and in the 1940's, salt-water disposal wells were required. Many of these early disposal methods were ineffective and resulting accidents with brine spills and pipeline leaks have led to the contamination of thousands of acres.

Brine affected sites are characterized by excessive salt concentration in the soil profile, loss of vegetative cover, and severe soil erosion. Any attempt to revegetate brine sites may be futile unless a thorough site investigation is undertaken. The severity of the salinity problem needs to be determined.

It must be realized that some sites have become so laden with salts there is no possible chance for revegetation. In these cases, the economics of attempting to reclaim the site must be considered.

To begin with, the amount and type of salt present in the soil needs to be determined. This can be best accomplished by taking a composite sample of several cores in the affected area, 6 to 8 inches deep. The samples can be sent to a soil-testing laboratory where the electrical conductivity (EC), pH, and exchangeable sodium percent (ESP) can be determined. These parameters will help determine the nature of the problem and if soil amendments should be recommended.

In addition to the soil test, plants growing on the site may be used as an indicator of the severity of the saline problem. Table 1 lists some of the more common plants that grow on salt affected sites.

Table 1. Native plants and introduced weeds found on salt affected sites.

SCIENTIFIC NAME	COMMON NAME	LEVEL OF SALINIZATION
Iva axillaris	poverty weed	
Kochia scoparia	kochia	moderate
Rumex crispus	curly dock	
Hordeum jubatum	foxtail barley	
Poa juncifolia	alkali bluegrass	high
Schedonnardus paniculatus	tumblegrass	
Sporobolus airoides	alkali sacaton	
Distichlis spicata var. stricta	inland saltgrass	
Puccinellia airoides	Nuttall's alkaligrass	very high
Tamarix pentandra	salt cedar	

Types of Salinized Soils

Salinized soils are classified as saline, saline-sodic, or sodic, depending on the kinds and amounts of salts present (see Table 2).

Saline Soils contain enough soluble salts in the upper root zone to reduce the yield of most cultivated crops. These are usually the easiest to reclaim if sufficient moisture is available and the soil has good permeability to allow the salts to be leached below the root zone. The addition of soil amendments such as sulfur, gypsum, or other calcium salt materials will not reclaim saline soils.

Saline-sodic soils are similar to saline soils in that the EC is greater than 4 mmhos/cm and the pH is less than 8.3. They differ by the fact that more than 15 percent of the exchangeable cations are sodium. Leaching of the soluble salts without the addition of a calcium product, such as gypsum, will result in a sodic soil.

Sodic soils are lower in soluble salts than saline or saline-sodic soils**.** The combination of high sodium, high pH, and low soluble salts results in the destruction of the soil structure. These soils have extremely low water intake rates. The addition of a calcium product, followed by sufficient leaching is required to reclaim these soils. Sodic soils are usually the most expensive soil type to reclaim.

Table 2. Chemical parameters defining saline and sodic soils.

Soil Condition	EC*	ESP	SAR	pH
Saline	> 4.0	< 15	< 13	< 8.3
Saline/Sodic	> 4.0	> 15	> 13	< 8.3
Sodic	< 4.0	> 15	> 13	> 8.5
Normal	< 4.0	< 15	< 13	< 8.3

EC = Electrical Conductivity (mmhos/cm)
ESP = Exchangeable Sodium Percentage
SAR = Sodium Absorption Ratio

Effects of Salinity on Plants

Soil salinity may negatively affect plant growth and survival by reducing soil water availability. As the salt content in soil increases, the amount of water available for plant uptake decreases. High concentrations of specific salts may also cause disruption in the uptake and utilization of other minerals needed by the plants.

Besides plant growth, salinity may also reduce seed germination, thereby affecting the ability to revegetate these sites. As the salt concentration increases, the ability of the seed to absorb the moisture necessary for germination is decreased. In addition, high salt concentrations may promote the entry of ions into the seed unit at toxic levels.

During the Graham County Brine Revegetation Study (Conway, 2000), packets of tall wheatgrass seeds were placed into a saline soil with an EC reading of 25 mmhos/cm in early fall. The packets, examined 2 months later, indicated that no germination had occurred. The same packets were then removed from the site and were taken to the Manhattan Plant Materials Center and placed under optimum growing conditions. Within a two-week period, 83 percent of the seed units germinated. This suggests that the high salinity levels restricted seed germination, but did not affect seed viability.

Management

Soil manipulation of brine sites varies with the nature of the soil. The reclamation of a saline soil is accomplished by leaching the salts from the soil. To accomplish this, sufficient moisture must be available and the soil must have good internal drainage. To improve the permeability, the incorporation of large amounts of organic matter is recommended. Organic matter may be in the form of clean straw, native prairie hay, sawdust, wood chips, or manure. This is particularly important where excessive soil loss has occurred. The organic matter improves soil structure, infiltration and percolation of moisture, thereby enhancing the salt leaching.

If the lack of sufficient precipitation restricts the ability to completely flush the salts, then proper plant selection may help minimize the salinity affect. If the saline levels are above the limits for salt tolerant species (see Figure 1), then a permanent seeding should be delayed until the levels can be lowered through the continual application of organic matter. This process may take several years to produce a site capable of supporting vegetation. If the site is capable of supporting vegetation, another option would be the planting of an adapted annual cover crop such as barley on the site. This practice could be performed for a number of years to build up the organic matter as well as providing erosion control prior to planting the permanent vegetation.

For saline-sodic or sodic soils, the excess sodium must first be replaced by adding a calcium - based product such as gypsum. Once the product has been applied and incorporated, sufficient moisture must be applied to leach the displaced sodium below the root zone. Reclamation of these type soils is usually slow because of the lack of soil structure. The incorporation of organic matter into the soil surface can help open up the sodic soil and along with planting salt tolerant species will enhance the reclamation process.

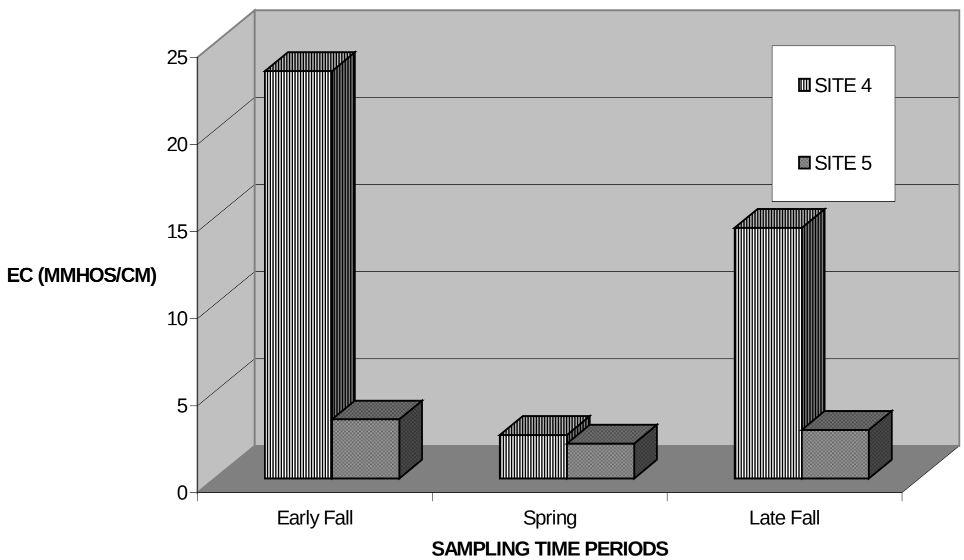
Plant selection is important as species have a wide variability in salt tolerance and thus may have high potential for use in reclamation of brine sites. Figure 2 provides a general guide for rating the relative salt tolerance of the more commonly used species. For information on adaptability of plant species listed in Figure 2, recommended varieties, and seeding rates, consult the appropriate sections within the Field Office Technical Guide.

The effects of high salinity levels on plant growth are more severe under dry and hot conditions than under cool and moist conditions. High soil temperature increases salt ion activity which may result in greater salt diffusion into the plant. The higher the diffusion rate, the greater the potential for toxicity. High temperatures and lower precipitation also increase surface evaporation rates. This results in increased salt concentration and reduces even further the amount of moisture available for plant uptake.

In consideration of these site factors, cool season plant species because of their germination and growth characteristics may have advantages over warm season species for use in brine site revegetation. Cool season species germinate and begin their growth early in the spring when temperature and moisture conditions are more conducive to establishment and growth. During the hot, dry periods, they enter into a semi-dormant state and then resume growth again during the cooler weather in the fall. Warm season species on the other hand germinate much later in the spring and achieve their maximum growth during the peak of the summer. Of the eleven different cool and warm season species seeded at the Graham County Study, only tall wheatgrass, Russian wildrye, and western wheatgrass, all cool season grass species, became established consistently across the area.

Seeding time may also be a critical factor in influencing establishment. Based on results from the Graham County Study, electrical conductivity readings were the lowest in the early spring compared to those taken in early (late August) and late fall (November) (see Figure 1). Winter and spring precipitation may dilute the surface salts and leach them below the surface. This suggest the optimum time for seeding to be late fall (dormant seeding), winter, or very early spring. These seeding times would allow the cool season species to germinate when the salinity levels are typically the lowest, thus increasing the probability of establishment. Having the plants germinate and establish under more favorable conditions in the early spring would allow them to become better equipped to survive the hot and dry conditions that follow.

Figure 1. EC readings over time for two sites in Graham County, Kansas

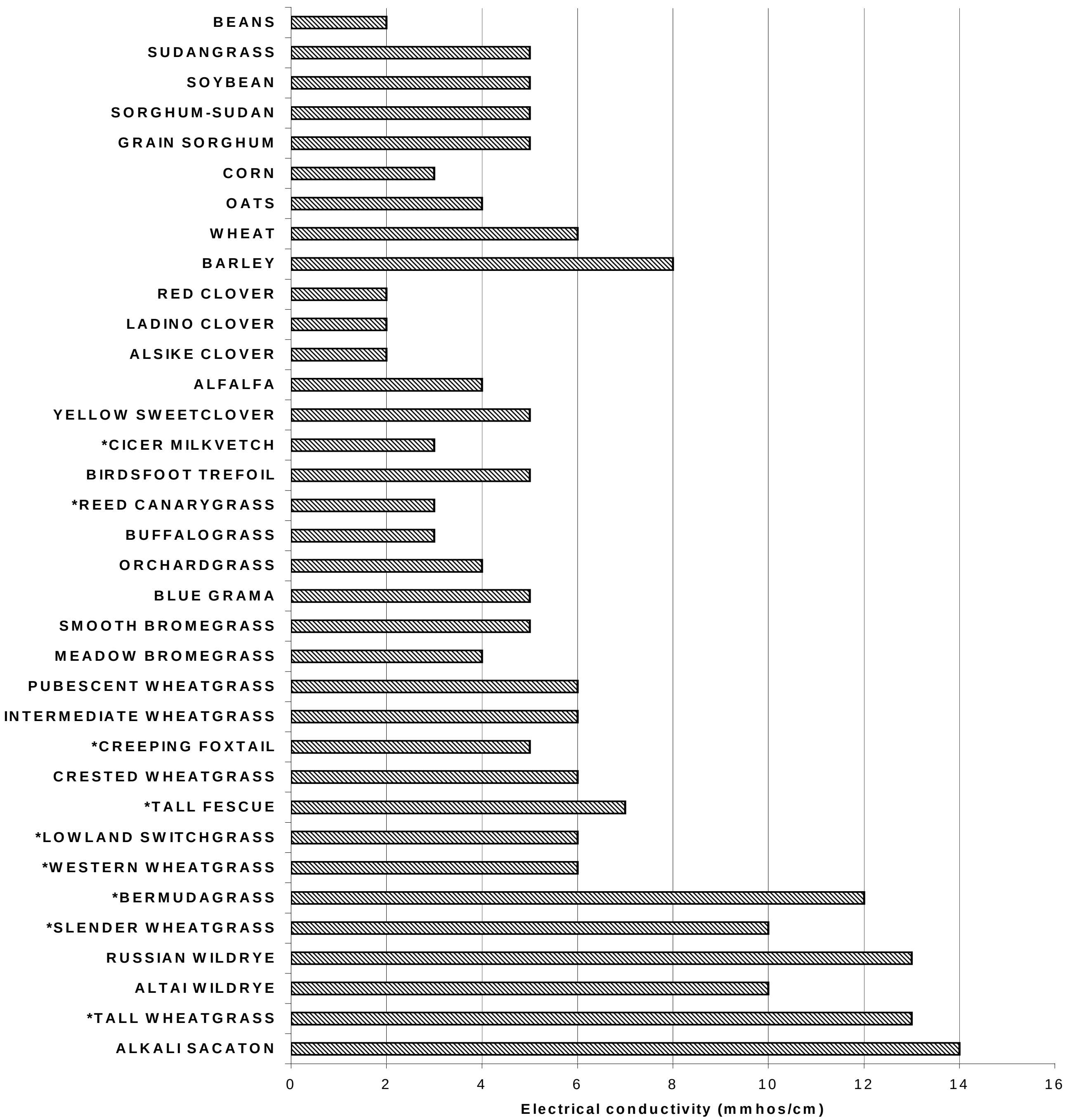


Following seeding, the area should receive an application of mulch such as native hay or clean straw applied at the rate of 3 to 5 tons / acre. A straight disc should be lightly run over the mulch to help crimp it into place. Mulch will help improve soil structure, retain soil moisture, reduce evaporation and salt movement to the surface, and help control runoff and erosion. The area should be protected from livestock grazing until the plants are well established.

Summary

High salinity levels, lack of vegetation, and excessive erosion typically characterize brine sites. The degree to which these sites can be reclaimed depend on specific site factors and landowners' objectives. Soil test can provide information as to the type and amount of salts present. This information can be used to determine the feasibility of reclaiming the site as well as management techniques to remove or minimize the salinity problem. Soil manipulation techniques, proper plant selection, and establishment methods may aid in site reclamation.

Figure 2. Salinity tolerance of various plant species. The upper limits indicate the salinity level at which productivity is initially affected.



** Plant species adapted to wet/saturated conditions.*

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