TECHNICAL NOTE

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SALT TOLERANCE OF CONSERVATION TREES AND SHRUBS

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INTRODUCTION

When working with landowners to plan a windbreak; or evaluating the performance of an existing windbreak, one of the first things to consider is the soil. Determine if the soil is suitable for trees and shrubs, taking into account the climatic zone and annual precipitation received. Are there limitations to growth and survival of woody plantings inherent in the soil that should be considered, such as: depth to a restricting layer, soil texture, wetness, or slope?

Beyond easily observable features, something else may be going on in the soil that effects the growth and function of woody plants. In some portion of the planting site, the soil may be affected by a build up of salts. What are salts and how do they affect the choice of plants we recommend for conservation plantings?

SALTS IN THE SOIL

Salts occur in all soils as part of the natural weathering of the primary minerals. As water moves through the soil it dissolves the soluble primary minerals. The dissolved salts, called solutes, are either the positively charged cations or negatively charged anions that result. Commonly occurring cations include: Calcium (Ca^{+2}), Magnesium (Mg^{+2}), Sodium (Na^{+}), and Potassium (K^{+}). Negatively charged anions include: Sulfate (SO_4^{-2}), Bicarbonate (HCO_3^{-}), Carbonate (CO_3^{-2}), Nitrate (NO_3^{-}), and Chloride (Cl^{-}).

Salts are a common and necessary component of all soil, and many soluble salts, such as nitrates and potassium, are essential plant nutrients.

With adequate rainfall and good internal drainage, the salts that are not strongly attached to the surfaces of clay particles are moved down in the soil profile, below the root zone. In areas with arid and semi-arid climatic conditions, like the Northern Plains; limited rainfall results in minimal leaching of salts, so soils tend to have a large amount of soluble salts such as Ca^{+2}, Mg^{+2}, and Na^{+} present in the soil profile. Significant salt accumulation in the rooting zone is uncommon in areas where annual rainfall exceeds 20 inches per year.

SALINITY

A soil that has accumulated soluble salts in the rooting zone in sufficient quantity to adversely affect plant growth and performance is considered **saline**. The weathering of minerals in a localized site seldom results in a saline soil. Poor drainage is the most common cause of soil salinity. High enough accumulations to cause a salt problem in the rooting zone of a localized site typically require the movement of salts, carried in solution by water, from adjacent areas.

Gravity is always at work pulling water down through the soil profile; but a restrictive layer in the soil can retard the downward movement of water. Unbound water in the soil, such as a

perched water table, can then move laterally along a gradient or upwards into the rooting zone and to the surface by capillary action. In capillary flow, water moves from an area where the soil is saturated to drier soil, independent of gravity. The dissolved mineral salts move with the water. As plants absorb soil water or as water is evaporated off the surface, the salts are left behind in the soil. If this process is allowed to continue over time, salts are concentrated at or near the surface, and the soil becomes saline. A saline soil may develop a white surface crust when dry.

Soil salinity is a measure of the total amount of soluble salts in soil. Soil salinity is determined by measuring the electrical conductivity (EC) of a solution extracted from a water-saturated soil paste at 25° Celsius. Electrical conductivity does not identify or differentiate between the kinds of salts, just the total amount of salt. As the amount of total soluble salts increase the electrical conductivity of the solution increases. Units of EC are recorded in decisiemens per meter (dS/m) or millimhos per centimeter (mmhos/cm). Both units are equivalent; so a value of 3.8 dS/m is the same as 3.8 mmhos/cm. Soil testing labs can run this test to determine EC as well as run other tests to determine the kind and amount of different salts present.

FIELD ANALYSIS

In South Dakota, field office personnel use the one-to-one method in the field with a hand held EC tester to test for salinity. The results are given in millimhos per centimeter (mmhos/cm). The value on the hand held EC meter must be multiplied by a factor of 1.6 to give the equivalent laboratory EC reading of a solution extracted from a paste of water-saturated soil.

For example: Using 1 part soil to 1 part distilled water, the hand held EC tester gives a reading of 2.7 mmhos/cm. To find the equivalent laboratory EC value, you need to multiply the 2.7 reading by 1.6 to arrive at a value of 4.32 mmhos/cm. This is the same as 4.32 dS/m. The soil in question would be considered slightly saline. See **Table 1** below for classification of salinity levels.

Table 1 SALINE CLASSIFICATION

EC (dS/m) or (mmhos/cm)	**CLASSIFICATION**	**INTERPRETATION**
0 to <2	Non-saline	Very little injury to plants
2 to <4	Very slightly saline	Growth of sensitive plants may be restricted
4 to <8	Slightly saline	Growth of many plants is restricted
8 to <16	Moderately saline	Only salt tolerant plants grow satisfactory
= >16	Strongly saline	Only a few, very tolerant plants will grow

INJURY SYMPTOMS

Symptoms of salt injury in plants resemble drought. In woody species, high soil salinity may cause leaf burn and can lead to defoliation. Plants are stunted, may show nutrient deficiencies, wilting, and eventually death, if the salt level is excessive for the plant. When the soil has high salt concentrations, the roots have a harder time performing their osmotic activity and experience difficulty pulling water from the soil. They must expend more energy to obtain water; energy that otherwise would be used for growth, flowering, or fruiting. In extreme conditions, the roots may even lose water to the soil. High salt levels in the soil can also upset the nutrient balance in the plant or interfere with the uptake of some nutrients required for healthy growth.

As the soil dries, salts become concentrated in the soil solution, increasing salt stress conditions even more for plants. Salt problems are more severe under hot, dry conditions than under cool, humid conditions when plant transpiration demands are low.

In some cases, salinity also has a toxic effect on plants because of the high concentration of certain salts, such as sodium (Na^+) and chlorine (Cl^-), in the soil. High levels of sodium can be toxic to root tissues. Also, sodium will replace the calcium and magnesium adhered to the clay particles, which causes the soil to become dispersed, and destroys soil structure. Sodium can alter soil structure to the point that permeability (water movement thru a soil) will be greatly reduced. Soils with slow permeability have reduced oxygen penetration into the soil and reduced water drainage from the soil.

Since sodium toxicity to plants is severe, and the effects of sodium on soil pH and structure are significant, two tests have been devised to describe the relative amounts of sodium present in the soil. They are exchangeable sodium percentage (ESP) and sodium adsorption ratio (SAR).

The ESP provides a measure of the amount of exchangeable sodium (Na^+) relative to the total cation exchange capacity of the soil.

The SAR is the ratio of sodium ions (Na^+) relative to Calcium (Ca^{+2}) and Magnesium (Mg^{+2}) ions. If sodium levels are high or not balanced with the calcium and magnesium, the soil is sodic or saline-sodic. See **Table 2** below.

Table 2 SODIC CLASSIFICATION

Classification	EC	ESP	SAR
Saline soils	Greater than 4 dS/m	Less than 15%	0 - 13
Saline-Sodic	Greater than 4 dS/m	Greater than 15%	>13
Sodic soils	Less than 4 dS/m	Greater than 15%	>13

SOIL pH

Soil pH is another important soil measurement. It is a measure of acidity or alkalinity of the soil solution. Soil pH does not directly measure saltiness but soluble salts affect soil pH, and changing pH affects plant nutrient availability. As pH increases (the soil becomes more alkaline), plant nutrients such as iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), cobalt (Co), phosphorus (P), and boron (B) become limiting. A pH of 7.0 is neutral; any soil with a pH greater than 7 is alkaline. See **Table 3** below for soil classifications. As a point of reference, ground limestone ($CaCO_3$) has a pH of 8.3.

Table 3 SOIL pH

pH	Soil Classification
6.1 to 6.5	Slightly acidic
6.6 to 7.3	Neutral
7.4 to 7.8	Slightly alkaline
7.9 to 8.4	Moderately alkaline
8.5 to 9.0	Strongly alkaline

SALT TOLERANCE

The salt tolerance of a plant can be defined as the plant's capacity to endure the effects of excess salt in the rooting zone. Some plants will tolerate high levels of salinity while others can tolerate little or no salinity. Salt-tolerant plants are more able to absorb water from saline soils by

internally adjusting the osmodic effect. As a general rule, plants that have low drought tolerance will have low salinity tolerance. The salt tolerance of plants can also vary during different stages of growth and development. Generally trees are more sensitive to salinity at establishment, when their root systems are not very extensive.

Salinity tolerance is influenced by many plant, soil, and environmental factors and their interrelationships. When soil salinity exceeds a plants threshold tolerance, growth or yield is impaired. For windbreak trees and shrubs, the most likely effect of salinity is stunted growth. The threshold level is not very well established for most windbreak trees and shrubs, but it may not be important as long as the trees survive and the growth is adequate for the purpose for which the windbreak was planted. For fruit and nut production in an orchard, knowing the threshold value can be very important, as yields can be reduced at fairly low salt levels.

Tolerance values and salinity ratings should be used with caution. Many references have categorized most plants by degree of sensitivity or tolerance to salinity. They should be used as a guide to compare the expected performance of various species and not as an absolute value. Variety differences and environmental conditions may make plants more or less salt tolerant than indicated in their tables.

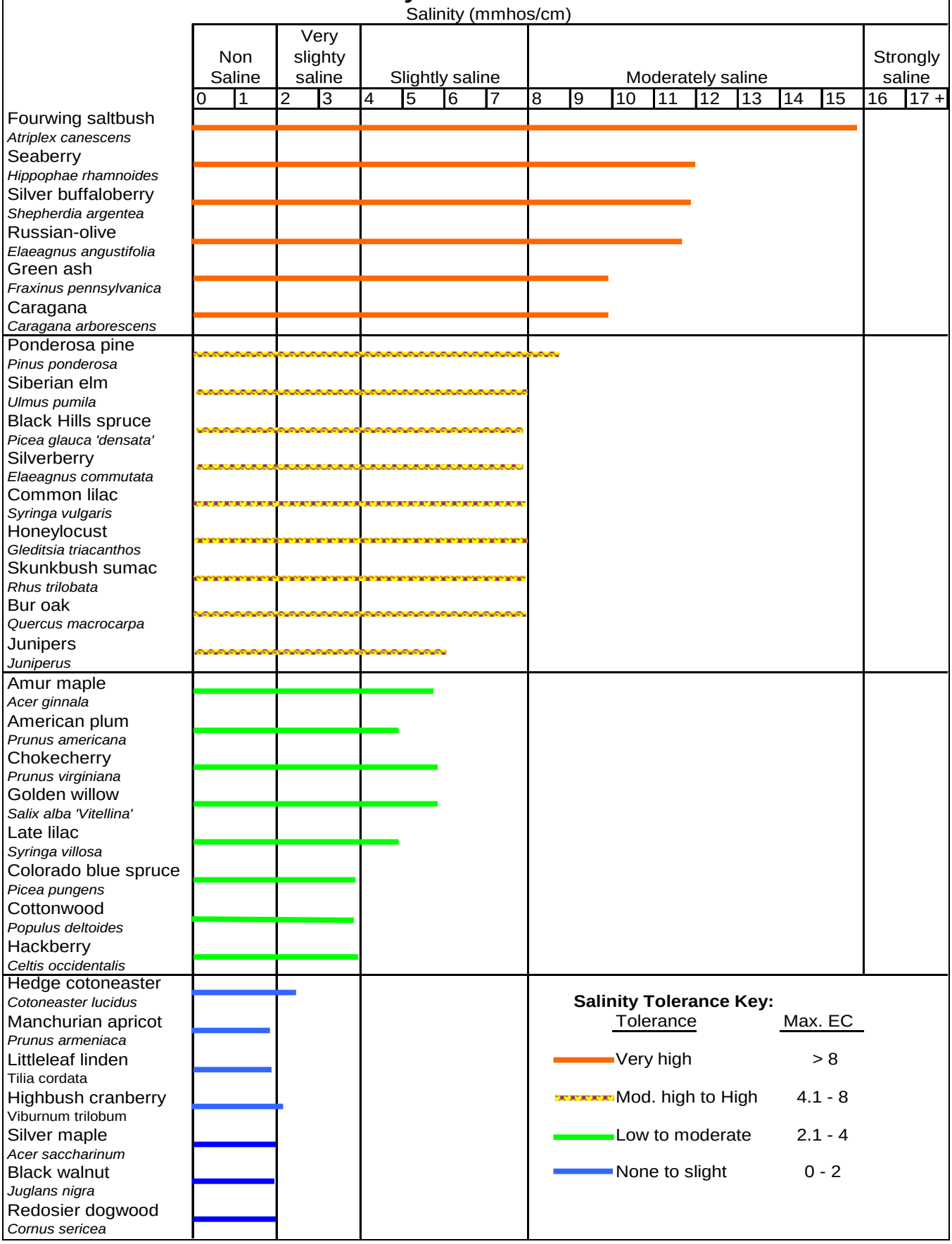
Information on the salt tolerance of woody plants for this report was obtained from several sources and not all use the same rating system. One source may classify a plant as having high tolerance to salinity if it can tolerate EC levels of 3 - 4 dS/m; while other sources rated the same plant as moderately sensitive. A plant would have to tolerate EC levels up to 8 dS/m, or even 10 dS/m to be considered highly tolerant in the other rating systems. Be careful of ratings that do not conform to our system, they often mislead the reader into believing that certain plants are more salt-tolerant than is actually the case.

SPECIES TOLERANCE

Trees and shrubs listed as suitable for planting on sites in Conservation Tree/Shrub Groups 9C and 9L are the most salt tolerant species. Consider an EC of 8 dS/m as the upper limit of salt tolerance for the most tolerant woody species. Though most of the highly tolerant plants will survive in moderately saline soils, their growth will be much slower than on better sites. If vegetative cover is needed on a very saline site, consider establishing some salt tolerant grasses, such as beardless wildrye, tall wheatgrass, or western wheatgrass, as trees and shrubs are more sensitive to salinity than grasses.

Table 4 included in this report should not be considered a comprehensive listing of all woody plants suitable for planting in South Dakota. The listed plants are representative of salt tolerance groupings. The colored line extending out from the species name indicates the maximum tolerance level as gleaned from several sources that were in agreement as to the plants tolerance. The maximum tolerance is the point above which large scale mortality occurs. The plants with a red line are the most salt tolerant species. If they cannot survive on a saline site, no tree or shrub will. Even if they can survive, the growth may be so poor that no benefit can be achieved by the planting and other vegetative cover should be considered. The next grouping of plants can tolerate levels up to 8 dS/m. They demonstrate moderately high to high salt tolerance and should be suitable for slightly saline soils. The plants with green lines are somewhat tolerant of salts and can be used on very slightly saline soils. The bottom grouping of trees and shrubs are examples of plants that are sensitive to saline soils and should only be used on non-saline sites.

Table 4 Salinity Tolerances of Trees and Shrubs



REFERENCES

"Salinity and Plant Tolerance," Jan Kotuby-Amacher, Rich Koenig, Boyd Kitchen, Utah State University Extension, July 1997

Plant Materials Program HortNote No. 5, Joe Scianna, Bridger, MT, 2002

Plant Materials Program HortNote No. 6, Joe Scianna, Bridger, MT, 2003

"Plant Materials for Saline-Alkaline Soils," USDA/NRCS, Technical Notes, Plant Materials No. 26 (Revised), 1996, Bridger, MT

"Salinity, Sodicity and Flooding Tolerance of Selected Plant Species of the Northern Cheyenne Reservation," Krista E. Pearson

Northland News, USDA-NRCS, Bismarck, ND PMC, 1997/98

"Salinity Tolerance of Ornamental Trees and Shrubs," Agriculture, Food and Rural Development; Government of Alberta, Canada, Feb. 2002

"Salt Tolerance of Plants," Agriculture, Food and Rural Development; Government of Alberta, Canada, Nov. 2001

"Managing Salt Affected Soils," unpublished paper by Jim Millar, NRCS Soil Scientist, Huron, SD

"Salt Tolerance of Various Temperate Zone Ornamental Plants," Curtis E. Swift, Colorado State University Cooperative Extension, Revised Aug. 2003.

"Soil Salinity, Salt Tolerance, and Growth Potential of Horticultural and Landscape Plants," Alan D. Blaylock, University of Wyoming, Cooperative Extension Service B-988, February 1994