SALT-AFFECTED AREAS

In the eastern United States, problems with salt concentrations in the soil are somewhat isolated. Some affected areas may include:

- roadsides where winter salt is supplied
- runoff from DOT salt stockyards
- around oil and gas wells
- dredge disposal sites
- irrigation with saline water
- areas subject to coastal flooding

Natural adaptation to salt is common in coastal dune and tidal marsh/shoreline plants, both grasses and woody plants. Some of the native warm season grasses are more salt tolerant than the introduced cool season grasses. Little bluestem, switchgrass, coastal panicgrass, the cordgrasses, and eastern gamagrass have the most salt tolerance. 'Cape' American beachgrass is a native cool season grass that thrives in a salt-rich dune environment. Bayberry, beach plum, rugosa rose, shore juniper, seaside goldenrod, and beach pea just to name a few species, are all adapted to sandy soils and salt spray concentrations. See Table 2 for salt tolerances of coastal species.

High accumulations typically require the movement of salts, carried by water from adjacent areas, to markedly increase the salt concentration of a given site. Where the salt layer resides in the profile is important, since it influences whether a seeding verses a planting is appropriate, the type of site preparation needed, whether to use bare root or container planting stock, which corrective measures to implement, and the likelihood of success. Prolonged irrigation with salty water also increases soil saltiness. Infrequently, excessive fertilization can lead to localized increases in soil salinity in our region.

Before installing salt-tolerant plants or reclaiming a salt-affected site, it's important for landowners and managers to have good analytical information available in order to formulate a strong conservation plan. Professionals and landowners need to understand 1) the causes of salt-affected soils, 2) how to take a soil sample for the testing used to measure saltiness, and 3) plant species adapted to salt-affected soils.

Soil Test Procedures

To verify a potential salt problem, soil analyses are needed to determine the level of saltiness and the type of ions involved. Testing begins with a thorough sampling of the site. Obtain a representative soil sample from the upper 6 inches and another sample to represent the 6"-12"depth. There is often resistance to adequate soil testing because of the cost involved. Analytical costs represent a minimal percentage of the total cost of reclaiming a salty site.

There are several tests to quantify or qualify soil saltiness. It's important to understand the differences among these tests because each provides a specific type of information that may or may not help us determine best management. It's also valuable to be able to understand the results, although soils experts can assist with interpretation.

Electrical conductivity (EC) describes the amount of electrical current conducted by a saturated soil extract at a fixed temperature. The more salts in solution, the greater the EC reading, and the greater the toxicity to plants. This test does not distinguish between one type of salt and another; it simply provides an overall measure of water-soluble salts (see table 1). Units of measure include decisiemens per meter (dS/m or dS m^{-1}) and millimhos per centimeter (mmhos/cm or mmhos cm^{-1}), which are synonymous (1dS m^{-1} = 1mmhos cm^{-1}).

Total dissolved solids (TDS) provides similar information as EC, but is based on an evaporative test and has been largely replaced by the EC test. TDS results are expressed in milligrams per liter (mg/l or mg l^{-1}) or parts per million (ppm), the two units being equal. (You can approximate TDS by multiplying the EC[dS m^{-1}] of lesser saline samples by 640 or the EC of very saline samples by 800.)

Soil pH is another important soil measure even though it does not directly measure saltiness. It is a measure of the hydrogen ion concentration in soil solution - an important indication of the chemical status of the soil. Since soluble salts affect soil pH and vice versa, it is often included in evaluations and discussions of soil saltiness. A main implication of changing the soil pH is plant nutrient availability, which is often a secondary response to microbial activity levels responding to changing soil pH. As soil pH climbs, elements such as iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), cobalt (Co), phosphorus (P), and boron (B) become limiting. The soil pH scale ranges from 0 to 14, with <7 considered acidic, 7 neutral, and >7 alkaline or basic (see table 2). Each whole number represents a ten-fold change in both H concentration and OH, or a 100-fold change in the concentration of H relative to OH (since there is an inverse relationship between the two: as one increases the other proportionally decreases). Most arable soils in our region have a pH in the range of 6.0-7.0

Most soil analyses provide only absolute values for each test, with no indication of the significance of the measure. In some cases, unit conversion may be necessary. Landowners and managers will need correlation information to make sense of test results. As an example, a soil test indicating an EC of 8 dS m^{-1} is meaningless to the average cooperator or landowner. What is of value is data that correlates plant tolerances to various levels of salinity (Ecs).

Treatment Alternatives

Compare plant tolerances to electrical conductivity values from Table ?. Before making a selection, compare the conductivity values of the upper (0-6") and deeper (6-12") layers. If the upper layer is greater than the deeper layer, not much leaching has occurred and the plants must be selected to tolerate the top 6". However, if the upper value is considerably less than the deeper layer, leaching has taken place and the plants selected can have lower tolerances to salt concentration. If the salt concentration in the soil profile exceeds the tolerances of the least sensitive plant species, then the alternatives are to either allow natural rainfall to leach the salts below the root zone or to irrigate with non-saline water (frequency/volume).

Gypsum (calcium sulfate) or lime can be used to help leach salt from the soil. The calcium in these products replaces the sodium salt from the soil exchange sites and helps bring the salt into solution. Large concentrations of salt may be leached from a soil in this way. For a sandy loam soil, several tons of salt may be leached below the root zone within one growing season. For finer textured soils, it may take longer. Both work best when incorporated into the soil, however some positive effect is possible with surface broadcasting. Core or deep tine aerification can greatly improve infiltration and percolation of water & salts through the root zone if incorporation is not possible. Although gypsum is not very soluble, it is more soluble than limestone. After application of limestone or gypsum, irrigate with ¼ “to ½” of water per day. Continue irrigation for several days.

Use of Gypsum to Remove Soluble Salts

1. How gypsum works. Gypsum is used as an aid to hasten the removal of soluble salts (e.g., sodium) from soils. It is important to keep in mind that while the addition of gypsum makes it easier for soluble salts to be leached by water moving through the soil, only leaching can remove soluble salts from soil. The leaching process can be very slow, and may require several years.

2. Application. Where additions of gypsum are required to assist with the removal of soil soluble salts, gypsum shall be incorporated into the upper 4.0 to 6.0 inches of the soil surface. Gypsum used to reduce soil soluble salts shall not be left on the soil surface, and shall not be included in hydraulic seeding mixtures with seed. Gypsum application rates shall be based upon soil tests and standardized recommendations. Modifications to reduce excess soil soluble salts by incorporating gypsum into the soil shall be made according to the recommendations of the University of Maryland Soil Testing Laboratory, or another accredited soil testing laboratory, or the Maryland Cooperative Extension Service, or Table A, below. Gypsum shall be uniformly distributed over the soil surface with appropriate spreader equipment calibrated for use with gypsum.

Table C
Pounds of Gypsum to Add per 1000 ft^2
To Reduce Soluble Salts to Recommended Levels

Original Salts Level		Pounds Gypsum
millisiemens	**parts per million (ppm)**	**per 1000 ft^2**
8	2500	320
7	1800	230
6	1250	160
5	700	80
4.5	550	40

Recommended Amounts of Gypsum/Limestone for removing excess salts

Soil Type	Gypsum/Limestone (pounds/acre)
Loamy sand	1500
Sandy loam	2000
Loam	2500
Silt loam	3000

Additional Treatment Options

Deep Plowing: If the salt content is high only in the top 2”-3”of soil, plow as deeply as possible to turn this layer under and expose soil of low salt content on the surface. Plant a temporary cover of tolerant, short-lived species such as barley , tall fescue or perennial ryegrass to provide some erosion control cover in the interim as the salts leach or are diluted.

Existing Vegetative Cover: Salt and some other toxic polluted areas are easier to vegetate after a period of leaching has occurred. It can be important to avoid disturbing the site (for instance to grade it smooth). Disturbance can reverse whatever benefit hasoccurred from leaching since the last site disturbance took place. If a desirable permanent vegetative cover already exists before the area became salt affected, it may be best to leave the cover in place. A surface application of gypsum or limestone along with irrigation or natural rainfall should reduce the salt content in most soils within a 6 to 12 month time frame.

Table 1. Alkaline/Salt Tolerant Herbaceous Plants

PLANT SPECIES/CULTIVARS	UPPER pH LIMIT	SOIL SALT TOLERANCES [1/.]
Warm Season Grasses		Electrical Conductivity
Bermudagrass (*Cynodon dactylon*) **'Coastal', 'Tifway'**	8.0	12 (16-18)
Big Bluestem (*Andropogon gerardii*) **'Niagara','Kaw'**	8.0	Moderate
Coastal Panicgrass (*Panicum amarum var. amarulum*) **'Atlantic'**	7.6	Moderate
Indiangrass (*Sorghastrum nutans*) **all cultivars**	7.5-8.0	Moderate
Little Bluestem (*Schizachyrium scoparium*) **all cultivars**	8.4	Slight
Sideoats grama (*Bouteloua curtipendula*) **'El Reno'**	8.5	Slight-moderate
Switchgrass (*Panicum virgatum*) **all cultivars**	7.5	Moderate
Zoysiagrass (*Zoysia japonica*) **'Meyer', 'SR9100'**	8.5	Slight (6-10)
Cool Season Grasses		
Alkaligrass (*Puccinellia distans*) **'Fults'**, **'Salty'**	8.5	Strong (20-30)
Barley (*Hordum vulgare*) **'Seco'**	8.5	Strong (8)
Bentgrass, Creeping (*Agrostis palustris*) **'Seaside', 'Southshore'**	7.5	Moderate (6-10)
Fescue, Creeping Red (*Festuca rubra*) **'Dawson', 'Pennlawn'**	8.0	Moderate (6-10)
Fescue, Hard (*Festuca trachyphylla*) **'Durar', 'Warwick'**	8.5	None
Fescue, Sheep (*Festuca ovina*) **'Covar'**	8.0	None
Fescue, Tall (*Lolium arundinacea*) **'KY-31', 'Arid', 'Alta', 'Goar','Mohave'**	8.5	Moderate (8-10)
Foxtail, Creeping Meadow (*Alopecurus arundinaceus*) **'Garrison'**	8.4	Moderate
Oats (*Avena sativa)*	8.5	Moderate (4)
Ryegrass, Annual (*Lolium multiflorum*)	8.0	Strong
Ryegrass, Perennial (*Lolium perenne*) **'Blazer II', 'Pinnacle', 'Linn'**	7.5	Moderate (8-10)
Sweetgrass (*Hierochloe odorata*)	7.5	Moderate
Wheat *(Triticum aestivum*)	8.0	Slight
Wheatgrass, Crested (*Agropyron cristatum*) **'Ephraim'**	8.5	High
Wheatgrass, Intermediate (*Thinopyrum intermedium*) **all cultivars**	8.4	Moderate
Wildrye, Canada (*Elymus canadensis*) **'Mandan'**	8.0	Moderate
Legumes/Forbs		
Alfalfa (*Medicago sativa*)	8.5	Moderate (4)
Birdsfoot trefoil (*Lotus corniculatus*) **all cultivars**	7.5	Moderate (5)
Penstemon (Penstemon digitalis)?	7.0	Moderate
Sainfoin (*Onobrychis viciaefolia*)	8.0	Slight
Seaside goldenrod (*Solidago sempervirens*)	7.5	Strong
Wild Indigo (*Baptisia tinctoria*)		
Yellow sweetclover (*Melilotus officinalis*)	8.0	Moderate

1. Soil Salinity Classes

Salinity Class	EC (electrical conductivity)
	dS m^{-1} or mmhos cm^{-1}
Nonsaline	0-2
Very slightly saline	2-4
Slightly saline	4-8
Moderately saline	8-16
Strongly saline	>16

\ **2**. Soil pH Classes

pH Class	pH
Ultra acid	<3.5
Extremely acid	3.5-4.4
Very strongly acid	4.5-5.0
Strongly acid	5.1-5.5
Moderately acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral	6.6-7.3
Slightly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strongly alkaline	8.5-9.0
Very strongly alkaline	>9.0

Handy Unit Conversions:

Milligrams per liter (mg/l or mg l^{-1}) equals parts per million (ppm).
Example: 125 mg l^{-1} = 125 ppm.

Percentage multiplied by 10,000 equals parts per million (ppm) or conversely, parts per million (ppm) divided by 10,000 equals percentage (%).
Example: To convert 2% (0.02 x 100) to ppm, multiply 2 times 10,000 to get 20,000 ppm. Do not confuse the fraction 0.02 with 2 percent when converting. If, however, the percentage were actually 0.02% (0.02/100 or 0.0002), then the conversion would correctly be 0.02 x 10,000 = 100 ppm. Keep your fractions and percentages straight.

Milligrams per liter (mg l^{-1}) = parts per million (ppm).
Example: 20 mg l^{-1} = 20 ppm.

Electrical Conductivity (EC) x 640 = Total dissolved solids (TDS) of lesser saline soils
Electrical Conductivity (EC) x 800 = Total dissolved solids (TDS) of highly saline soils
Example: the TDS of a very slightly saline soil with an EC of 2.5 dS cm^{-1} can be approximated by multiplying 2.5 X 640 = 1,600 ppm or 0.16 percent or 0.0016.