HortNote No. 6

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SELECTING PLANT SPECIES FOR SALT-AFFECTED SOILS

In HortNote 5 we discussed salt accumulation in soils, the various tests used to measure saltiness, and the different classifications of salty soil. We discussed the importance of specific ions on plant survival and growth, and the importance of sodium in particular. Soil saltiness information in-hand, we can proceed with forming a management plan for the site. One tool for reclaiming salt-affected sites is the use of salt-tolerant plants. Keep in mind that site preparation prior to planting, as well as treatment and maintenance afterwards, is needed to assure success. We'll discuss management options beyond species selection in another issue.

There is good information on the salt tolerance of various agronomic crops and grasses, so we won't dwell on these plants here. The Natural Resources Conservation Service (NRCS) Field Office Technical Guide (FOTG) lists salt-tolerant crops in the Montana Conservation Practice Specification, *Soil Salinity Management – Nonirrigated*, Code 571. Important native and introduced plants, cereal grains, forages, and native grasses are listed. Another excellent source of information is Technical Notes, Plant Materials No. 26 (Revised), *Plant Materials for Saline-Alkaline Soils* by Mark Majerus. Technical Note No. 26 is available in the Montana FOTG and on the web at http://Plant-Materials.nrcs.usda.gov. This reference describes both threshold tolerance (at which point growth or yield is impaired) and maximum tolerance; above which large-scale mortality occurs, or performance is so abysmal as not to be worthy of mention. Threshold is an important and overlooked aspect of salt tolerance, especially for conservation plantings. Although survival is obviously important, it alone does not guarantee proper practice function. Another handy reference for plant salt tolerance is *Agricultural Salinity Assessment and Management* developed by the American Society of Civil Engineers. It contains extensive listings of the salt tolerance of various plant species.

Information on the relative salt tolerance of woody plants can be obtained from several sources. Soil Survey reports contain plant species adaptation data by soil type, including saline soils. Conservation Tree/Shrub Suitability Groups (CTSG) in Section II, Windbreak Interpretations of the Montana FOTG provides a list of species adapted to salt affected soils. *Windbreaks for Montana: a landowner's guide* (MSU Extension Bulletin-366) also provides a list of windbreak species adapted to saline soils. There are, however, literature gaps when it comes to quantitative data on the salt tolerance of woody plants that makes recommendations for the northern Great Plains and Rocky Mountains a risky proposition. There is often interpretation and extrapolation from one type of salt tolerance to another, e.g., inferring that the effects of roadside salts, ocean spray, and fertilizer salts are essentially the same as saline soils. Many of the listed tolerances are based on observational or anecdotal information, e.g., a certain species found growing on a site that presumably has a certain level of saltiness. One problem with inferring salt tolerance based on woody plant performance is that trees and shrubs are long lived, and environmental conditions change over time. In some cases, site history is unknown. It may be that the plant was established under less salty conditions and is better able to tolerate increasing saltiness than a new planting, now that the salinity is high. Saltiness may have been high at planting time, but has decreased over the years for any number of reasons. The plants may have been sown as seeds, planted as bareroot stock, or installed in various sizes as containerized plants - all factors influencing survival and

growth. To complicate things further, the ability of plants to tolerate salty soils varies with many factors including air temperature, relative humidity, air pollution, soil fertility, water stress, soil texture, site management, and more. These are important secondary factors that planners must consider when selecting species for a particular site. The salt tolerance of woody plants is further complicated by sensitivity to specific salt ions, particularly Cl^- and/or Na^+. Different cultivars and rootstocks absorb these ions at different rates, so each cultivar or rootstock must be considered individually. This is an important factor when selecting grafted ornamental or fruit cultivars, i.e., the demonstrated salt tolerance of one cultivar is not necessarily the same as another cultivar, even within the same species.

Another important factor that Bob Logar, Montana State Staff Forester, noted is the location of salts within the soil profile. High salts in the top 1 to 3 inches would be more detrimental to a seeding, than a planting with bareroot or container plants. Conversely, high salts from 6 to 30 inches deep would seriously impact the long-term growth of most woody plants. If the high salt concentration was about 36 inches below the surface, the impacts to a woody planting would be relatively minor, assuming that the salts did not migrate upward into the rooting zone. The value of adequate soil sampling should again be stressed, since the location of the salts within the soil profile may vary significantly on a project site, with time, and with management changes.

Many summaries of salt tolerance do not consider the effects of salt level on plant growth parameters such as size, form, rate, and reproduction, but merely report survival. The performance of plants in terms of rate of height growth, plant form, root spread, and shoot development are critical aspects of a successful conservation planting as they affect how well the practice functions. There are many lists in circulation, but the recommendations are sometimes contradictory. One of the more quantitative and pertinent studies for the northern Great Plains was conducted by Richard W. Tinus of the US Forest Service titled *Salt Tolerance of 10 Deciduous Shrub and Tree Species*. Under various salt levels, Dr. Tinus germinated seeds of honeysuckle (*Lonicera tatarica*), crabapple (*Malus baccata*), common lilac (*Syringa vulgaris*), American plum (*Prunus americana*), buffaloberry (*Shepherdia argentea*), Russian olive (*Elaeagnus angustifolia*), chokecherry (*Prunus virginiana*), green ash (*Fraxinus pennsylvanica*), serviceberry (*Amelanchier alnifolia*), and caragana (*Caragana arborescens*). This study is particularly valuable to the northern Great Plains because it tested species adapted to this region and identified the levels at which various growth parameters (height, leaf, survival) were impacted. It demonstrated that, although some woodies survive and grow at high Electrical Conductivity (EC), the highest salt level at which plant survival and growth remains normal is relatively low, generally not greater than 8 dS/m (mmhos/cm). The 8 dS/m (mmhos/cm) turns out to be a common denominator in several references, and I use it as a rule of thumb as the upper limit of salt tolerance for the most tolerant woody plants. Some degree of caution must be exercised when inferring the long-term survival and growth of bareroot and container plants under salty soil conditions from this study. Tinus looked at plants grown from seeds for a relatively short period of time under adequate moisture conditions. In a conservation planting, moisture stress and other factors may actually reduce salt tolerance. The study does provide a good indication of the salt tolerance of the tested species in a nursery or container production situation, and suggests which trees and shrubs may perform well in direct seeding practices, particularly if adequate moisture is available.

It is generally safe to say that most woody plants are less salt-tolerant than grasses. Several grass species withstand 16 or more dS/m (mmhos/cm) of electrical conductivity (Strongly Saline soil; EC $\geq$ 16), whereas, few trees and shrubs handle even 8 to 10 dS/m (mmhos/cm) without reduced growth (the low end of a Moderately Saline soil; EC 8 to <16). Based on this criterion, the only tall stature tree native to Montana that might grow on <u>some</u> Moderately Saline soils is green ash, and our experience is that it is better suited to Slightly Saline soils (EC 4 to <8). Most native woodies found growing on Moderately Saline soils are small to moderate stature shrubs such as silver buffaloberry, several saltbush species (*Atriplex*), and winterfat (*Krascheninnikovia lanata*). Two woody plants found growing in the northern Great Plains on Moderately Saline and some Strongly Saline soils are Russian olive and saltcedar (*Tamarix ramosissima*) – non-natives that are invasive on wet saline sites. It should be noted that various terms are used to describe the salt tolerance of trees and shrubs, such as “highly-tolerant,” that do not jibe with our Soil Classification system, and often mislead the reader into believing that they are more salt-tolerant than is actually the case.

Tables 1 through 3 list native and non-native woody plants adapted to or found growing in our region on salt affected sites. Included are some potentially weedy species for comparison. These tables are based on data from various sources. Keep in mind that quantitative data on this subject is scarce, and that the values presented here are based on both controlled experiments and field observations. Higher limits of salt tolerance are presented when data supported the claim, but I tended to "moderate" claims that could not be supported by research or field data. Although many references claim greater salt tolerance for the listed species, a distinction should be made between degrees of tolerance. "Full performance" indicates that the plant grows and survives to that saltiness level without significant effects on growth and survival. "Reduced performance" implies a reduced rate of growth, plant health, or survival of about 25 to 50 percent. I have not included a "Maximum reported tolerance" because plant growth and survival is so severely impacted above the "Reduced performance" level, that we would not recommend use given such poor performance. Table 1 plants should grow well on some Moderately Saline soils (EC 8 to <16) and all Slightly Saline soils (EC 4 to <8), based on full performance to an EC of 8 or 10 dS/m (mmhos/cm), depending on the species. Table 2 plants should grow well on some Slightly Saline soils (EC 4 to <8) based on full performance to an EC of 6 dS/m (mmhos/cm). Table 3 plants should grow well on Very Slightly Saline soils (EC 2 to <4), and may occasionally grow well on Slightly Saline Soils, based on full performance to an EC of 4 dS/m (mmhos/cm).

Some of the data surprised me. I do not consider green ash, serviceberry, or chokecherry particularly salt-tolerant, although all three performed well to an EC of 8 dS/m (mmhos/cm) in the Tinus study. I suspect that these species perform well to EC 8, under ideal conditions, but that their tolerance decreases to 6 dS/m (mmhos/cm) or less as moisture stress increases. As a result, they have been grouped with woody plants that grow well on Slightly Saline soils (Table 2). It is interesting to note that there is evidence of ecotypic variation in the salt tolerance of populations of the same species of *Atriplex*, which may explain why variation in salt tolerance is reported in this and other species of plants. It also suggests that there may be opportunity to select individual plants or seed sources that are more salt tolerant than others.

Table 1. Woodies that grow well on some Moderately Saline soils (full performance to 8 or 10 dS/m).

Common Name	**Latin Name**	**Full Performance**	**Reduced Performance[1]**	**Native Status (US)**	**Primary Uses**
		dS/m	***dS/m***		**(c, o, na)[2]**
saltbush, fourwing	*Atriplex canescens*	10	>10 to 18	native	c
saltbush, Nuttall's	*Atriplex nuttallii*	10	>10 to 18	native	c
saltbush, Gardner's	*Atriplex gardneri*	10	>10 to 18	native	c
winterfat	*Krascheninnikovia lanata*	10	>10 t o12	native	c
greasewood	*Sarcobatus vermiculatus*	10	>10 t o12	native	na
saltcedar (weed)	*Tamarix ramosissima*	10	no inform.	non-native	na
buffaloberry, silver	*Shepherdia argentea*	8	>8 to 12	native	c
Russian olive (weedy)	*Elaeagnus angustifolium*	8	>8 to 12	non-native	na
sea-buckthorn	*Hippophae rhamnoides*	8	>8 to 12	non-native	c, o
caragana	*Caragana arborescens*	8	>8 to 10	non-native	c
pine, mugo	*Pinus mugo*	8	no inform.	non-native	o

[1] - Anticipate increasingly poor performance with increasing EC above "Full Performance" level.
[2] – c=conservation; o=ornamental; na=not applicable.

Table 2. Woodies that grow well on Slightly Saline soils (full performance to 6 dS/m).

Common Name	Latin Name	Full Performance	Reduced Performance[1]	Native Status (US)	Primary Uses
		dS/m	*dS/m*		(c, o, na)[2]
ash, green	*Fraxinus pennsylvanica*	6	>6 to 12	native	c, o
serviceberry	*Amelanchier alnifolia*	6	>6 to 12	native	c, o
chokecherry	*Prunus virginiana*	6	>6 to 10	native	c, o
pine, ponderosa	*Pinus ponderosa*	6	>6 to 9	native	c, o
elm, Siberian	*Ulmus pumila*	6	>6 to 8	non-native	c
juniper, Pfitzer	*J. chinensis 'Pfitzeriana'*	6	>6 to 8	non-native	o
lilac, common	*Syringa vulgaris*	6	>6 to 8	non-native	c, o
sumac, skunkbush	*Rhus trilobata*	6	>6 to 8	native	c
yucca	*Yucca filamentosa*	6	>6 to 8	native	c, o
maple, Norway	*Acer platanoides*	6	>6 to 8	non-native	o
honeylocust	*Gleditsia triacanthos*	6	>6 to 8	native	c, o
cottonwood, white	*Populus alba*	6	>6 to 8	non-native	c
bur oak	*Quercus macrocarpa*	6	>6 to 8	native	c, o
black locust	*Robinia pseudoacacia*	6	>6 to 8	native	c
spruce, Black Hills	*Picea glauca var. densata*	6	>6 to 8	native	c, o
pine, Austrian	*Pinus nigra*	6	>6 to 8	non-native	o
silverberry	*Elaeagnus commutata*	6	>6 to 8	native	c
sumac, staghorn	*Rhus typhina*	6	>6 to 8	native	c
snowberry, common	*Symphoricapos albus*	6	>6 to 8	native	c
shrubby cinquefoil	*Dasiphora floribunda*	6	>6 to 8	native	c, o
Virginia creeper	*Parthenocissus quinquefolia*	6	>6 to 8	native	o
maple, amur	*Acer ginnala*	6	no inform.	non-native	c, o
willow, golden	*Salix alba*	6	no inform.	non-native	c
rubber rabbitbrush	*Ericameria nauseosa*	6	no inform.	native	c
sagebrush, basin big	*Artemisia tridentata*	6	no inform.	native	c
juniper, common	*Juniperus communis*	6	no inform.	native	c
arborvitae, American	*Thuja occidentalis*	6	no inform.	native	o

[1] - Anticipate increasingly poor performance with increasing EC above "Full Performance" level.
[2] – c=conservation; o=ornamental; na=not applicable.

Table 3. Woodies that grow well on Very Slightly and some Slightly Saline soils (full performance to 4 dS/m).

Common Name	Latin Name	Full Performance	Reduced Performance[1]	Native Status (US)	Primary Use
		dS/m	*dS/m*		(c, o, na)[2]
spirea, Van Houtte	*Spiraea x vanhouttei*	4	>4 to 8	non-native	o
lilac, late	*Syringa villosa*	4	>4 to 6.5	non-native	c, o
boxelder	*Acer negundo*	4	>4 to 6	native	c
aspen, quaking	*Populus tremuloides*	4	>4 to 6	native	c, o
fringed (prairie) sagewort	*Artemisia frigida*	4	>4 to 6	native	c
sagebrush, silver	*Artemisia cana*	4	>4 to 6	native	c
juniper, Rocky Mt.	*Juniperus scopulorum*	4	>4 to 6	native	c, o
birch, paper	*Betula papyrifera*	4	>4 to 6	native	o
plum, American	*Prunus americana*	4	>4 to 5	native	c
sandcherry, western	*Prunus pumila var. besseyi*	4	no inform.	native	c, o
cottonwood, plains	*Populus deltoides spp. monilifera*	4	no inform.	native	c, o
willow, laurel	*Salix pentandra*	4	no inform.	non-native	c
hackberry	*Celtis occidentalis*	4	no inform.	native	c
rose, Wood's	*Rosa woodsii*	4	no inform.	native	c

[1] - Anticipate increasingly poor performance with increasing EC above “Full Performance” level.
[2] – c=conservation; o=ornamental; na=not applicable.

With these results in mind, planners and landowners need to determine what, if any, reduced level of plant performance is acceptable when selecting species for a given soil salt level. When soil, environmental, or cultural conditions increase the likelihood of water stress, assume that salt tolerance decreases. For ECs above 8 dS/m (mmhos/cm), conservation applications emphasizing salt-tolerant grasses may be in order. Even in a landscape situation, reductions in ornamental appeal at certain saltiness thresholds may favor the use of one type of plant (grass, forb, shrub, tree) over another. That being said, a highly salty site may be greatly enhanced by the establishment of trees and shrubs, even if performance is substandard. Not sure what to recommend? Supplement reference data with field experiences in your area. Identify which species are growing well under conditions that are similar to those at the planned project site.

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