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## PLANT MATERIALS TECHNICAL NOTE

# THE SALINITY TOLERANCE OF 18 TREES AND SHRUBS TESTED ON A HEAVY-TEXTURED SOIL IN SOUTH-CENTRAL MONTANA

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Figure 1. Tree and shrub salinity tolerance study, Bridger, Montana (NRCS photo).

## Abstract

Numerous acres of salt-affected soils across Montana and Wyoming are marginally productive, have low species diversity, and are prone to erosion. In some cases, vegetative practices such as Tree and Shrub Establishment (Code 612), Windbreak/Shelterbelt Establishment (Code 380), and Riparian Forest Buffer (Code 390) can be used to establish woody vegetation on such sites in order to improve site stability, species diversity, and productivity. To determine the adaptability of various woody plants to salt-affected soils, 18 species of woody plants were planted in a non-replicated study (MT-06-0005) across a salinity gradient at the Bridger Plant Materials Center, Bridger, Montana, on a sub-irrigated, salt-affected, silty clay loam site in 2006 (see Figure 1). Plant evaluation data was collected for several years, including survival, height, and vigor rating. Soil salinity data was collected using a Geonics® EM-38, as well as lab analysis of soil samples. Approximations of soil salinity tolerance of each species were determined by examining plant performance across USDA soil salinity categories over time. Study details will be reported in the project report for this study, available in October 2016. The following salinity tolerances are based on the results of this study alone, and given test site conditions.

**I. Tolerant to "Moderately Saline" soils (8 to <16 dS/M)**

Silver buffaloberry *Shepherdia argentea* (native)

**II. Tolerant to "Slightly Saline" soils (4 to <8 dS/M)**

Blueleaf honeysuckle *Lonicera korolkowii* (non-native)

Silverberry *Elaeagnus commutata* (native)

Golden currant *Ribes aureum* (native)

Siberian peashrub *Caragana arborescens* (non-native)

Snowberry *Symphoricarpos* species (native)

Skunkbush sumac *Rhus trilobata* (native)

Plains cottonwood *Populus deltoides* (native)

**III. Tolerant to "Very Slightly Saline soils (2 to <4 dS/M)**

Seaberry *hippophae rhamnoides* (non-native, restricted use)

**IV. Not well-adapted to "Non-Saline" (<2 dS/M) on heavy-textured soils**

American plum *Prunus americana* (native)

Ponderosa pine *Pinus ponderosa* (native)

Common chokecherry *Prunus virginiana* (native)

Colorado spruce *Picea pungens* (native to North America, not native to Montana)

Western sandcherry *Prunus besseyi* (native)

Nanking cherry *Prunus tomentosa* (non-native)

## Introduction

Sites dominated by salt-affected soils are often sparsely vegetated, or the existing plant community consists of weedy species and low ecological diversity. These site are prone to air and water erosion, and have low agricultural productivity. The establishment of trees and shrubs on these sites improves soil stability, reduces soil erosion, increases soil organic matter, and improves plant community function by creating vertical strata. Much of the available tree and shrub salinity tolerance information is based on observational and/or anecdotal information, or extrapolated from greenhouse studies conducted under ideal growing conditions. In many cases, site history or changes in management over time are unknown. Additionally, plant salinity tolerance is often reported in relative and undefined terms, such as "tolerant", "very tolerant", etc. This study attempted to demonstrate tree and shrub salinity tolerance under conditions similar to those encountered by conservation planners and to qualify tolerance in terms of the USDA soil salinity classification system.

## Study Design

A total of 30 seedlings of each of 18 species of woody plants were planted across a salinity gradient on a sub-irrigated, salt-affected site in 2006. Seedlings were planted on 5-foot, within-row spacing with 10 feet between rows. Herbaceous competition on 2 feet of either side of the seedlings was controlled for the length of the row with herbicide for most of the life of the study. The study was irrigated annually, 24 to 48 hours before using the soil salinity meter.

## Site Conditions

Bridger, Montana is located at an approximate elevation of 3,700 feet above sea level in a 10 to 11 inch annual precipitation zone. The site falls in USDA Winter Hardiness Zone 4b (-25° to -20° F). Average growing season (frost-free days) ranges from approximately 135 to 140 days. Soils at the test location are classified as Heldt silty clay loam, 0 to 2 percent and 0 to 6 percent slopes. Sodium Adsorption Ratio (SAR) can reach a ratio as high as 30 on the test site, but often ranges between 5 and 10.

## Results

Percent survival, relative plant vigor rating (1 through 9; 1 the best, 9 the worst), and stem height (feet) collected in 2014 were used as the basis for the results presented herein. The percentage survival listed in Table 1 represents the percentage of seedlings planted in a given soil salinity classification category that survived from 2006 to 2014. It is important to note that the number of seedlings planted in each salinity classification category was a function of the

Table 1. Percentage survival, tree and shrub salinity tolerance study, Bridger, Montana, 2014.

| | | Percentage Survival Non-Saline | Percentage Survival Very Slightly Saline | Percentage Survival Slightly Saline | Percentage Survival Moderately Saline | Percentage Survival Strongly Saline |
|---|---|---|---|---|---|---|
| | | *<2 dS/M* | *2 to ≤4 dS/M* | *4 to <8 dS/M* | *8 to <16 dS/M* | *≥16 dS/M* |
| *Elaeagnus angustifolia* | Russian olive | | | | 100 | |
| *Shepherdia argentea* | silver buffaloberry | | | | 60 | 24 |
| *Lonicera korolkowii* | blueleaf honeysuckle | | | 100 | 38 | |
| *Elaeagnus commutata* | silverberry | | | 100 | 43 | |
| *Fraxinus pennsylvanica* | green ash | | | 88 | 100* | |
| *Ribes aureum* | golden currant | | | 78 | 18 | |
| *Caragana arborescens* | Siberian peashrub | | | 50 | 20 | |
| *Ulmus pumilus* | Siberian elm | | | 100 | 20 | |
| *Symphoricarpos* species | snowberry | | | 58 | | |
| *Rhus trilobata* | skunkbush sumac | | | 57 | 22 | |
| *Populus deltoides* | plains cottonwood | | | 100 | | |
| *Hippophae rhamnoides* | seaberry | | 67 | 36 | 22 | |
| *Prunus americana* | American plum | 0 | 17 | | | |
| *Pinus ponderosa* | ponderosa pine | 0 | 7 | | | |
| *Prunus virginiana* | common chokecherry | 0 | | | | |
| *Picea pungens* | Colorado spruce | 0 | | | | |
| *Prunus besseyi* | western sandcherry | 0 | | | | |
| *Prunus tomentosa* | Nanking cherry | 0 | | | | |

indicates majority of seedlings should survive in this soil salinity category given test site conditions.

indicates only a relatively small percentage of seedlings should survive in this soil salinity category given test site conditions.

* Only 1 green ash seedling planted in this salinity category with extremely low vigor and height growth, so no projected tolerance assumed at this salinity level.

salinity level at their planting location in the row. This resulted in an unequal number of test seedlings planted in each salinity range. The soil salinity value at each plant was estimated by correlating soil conductivity readings generated by an EM-38 (to a depth of approximately 1.5 meters) with actual lab analysis of field samples. It is possible that soil salinity may be higher or lower in localized areas of the soil profile than reported. Percentage survival values are only provided in Table 1 for the highest salinity tolerance category(s) for each species.

The mean vigor rating listed in Table 2 represents the mean vigor of surviving seedlings planted in a given soil salinity classification category. The lower the rating number the better the seedling vigor. Vigor assessment was based on leaf color and condition, amount of leaf and stem necrosis, stem internode length, and other indices of plant condition. The mean vigor rating values presented in Table 2 are provided to demonstrate vigor trends across salinity gradients. Vigor is an important plant performance variable when selecting species for various conservation practices. Surviving, but low vigor plants may not provide the intended conservation benefit, such as food for wildlife, pollinator benefits, etc. Low vigor or stressed plants often do not reach functional size, produce abundant flowers or fruit, or are predisposed to insect and disease pathogens over time.

Table 2. Mean vigor rating, tree and shrub salinity tolerance study, Bridger, Montana, 2014.

| | | Mean Vigor Rating[1] Non-Saline | Mean Vigor Rating Very Slightly Saline | Mean Vigor Rating Slightly Saline | Mean Vigor Rating Moderately Saline | Mean Vigor Rating Strongly Saline |
|---|---|---|---|---|---|---|
| | | *<2 dS/M* | *2 to ≤4 dS/M* | *4 to <8 dS/M* | *8 to <16 dS/M* | *≥16 dS/M* |
| *Elaeagnus angustifolia* | Russian olive | 2.0 | 2.0 | 2.2 | 4.0 | |
| *Shepherdia argentea* | silver buffaloberry | | | 4.0 | 4.7 | 5.7 |
| *Lonicera korolkowii* | blueleaf honeysuckle | | 2.2 | 3.6 | 5.0 | |
| *Elaeagnus commutata* | silverberry | 4.2 | 3.5 | 4.4 | 5.5 | |
| *Fraxinus pennsylvanica* | green ash | 6.0 | 7.0 | 6.9 | 8.0 | |
| *Ribes aureum* | golden currant | | | 5.4 | 6.0 | |
| *Caragana arborescens* | Siberian peashrub | 3.3 | 4.0 | 4.1 | 6.0 | |
| *Ulmus pumilus* | Siberian elm | 5.5 | 5.2 | 4.4 | 5.0 | |
| *Symphoricarpos* species | snowberry | | | 5.0 | | |
| *Rhus trilobata* | skunkbush sumac | | | 5.5 | 7.0 | |
| *Populus deltoides* | plains cottonwood | | 6.4 | 5.9 | | |
| *Hippophae rhamnoides* | seaberry | | 3.8 | 5.0 | 7.5 | |
| *Prunus americana* | American plum | | | | | |
| *Pinus ponderosa* | ponderosa pine | | | | | |
| *Prunus virginiana* | common chokecherry | | | | | |
| *Picea pungens* | Colorado spruce | | | | | |
| *Prunus besseyi* | western sandcherry | | | | | |
| *Prunus tomentosa* | Nanking cherry | | | | | |

[1] Vigor rating 1 through 9; 1 = best; 4 = average; 9 = nearly dead

indicates a majority of seedlings should survive in this soil salinity category given test site conditions.

indicates only a relatively small percentage of seedlings should survive at this soil salinity category given test site conditions.

The mean plant heights listed in Table 3 represent the mean height in feet of surviving seedlings planted in a given soil salinity classification category. Mean height values are provided in Table 3 for the highest salinity tolerance category(s) for each species, and in limited cases, to demonstrate important trends in height. When selecting species for various conservation practices, it is important to consider whether height is an important conservation benefit and goal of the planting.

Table 3. Mean plant height, tree and shrub salinity tolerance study, Bridger, Montana, 2014.

| | | Mean Height (ft) Non-Saline | Mean Height (ft) Very Slightly Saline | Mean Height (ft) Slightly Saline | Mean Height (ft) Moderately Saline | Mean Height (ft) Strongly Saline |
|---|---|---|---|---|---|---|
| | | *<2 dS/M* | *2 to ≤4 dS/M* | *4 to <8 dS/M* | *8 to <16 dS/M* | *≥16 dS/M* |
| *Elaeagnus angustifolia* | Russian olive | | | | 14.9 | |
| *Shepherdia argentea* | silver buffaloberry | | | | 2.8 | 2.7 |
| *Lonicera korolkowii* | blueleaf honeysuckle | | | 8.1 | 6.0 | |
| *Elaeagnus commutata* | silverberry | | | 3.3 | 2.9 | |
| *Fraxinus pennsylvanica* | green ash | | | 2.2 | 1.3 | |
| *Ribes aureum* | golden currant | | | 1.8 | 1.5 | |
| *Caragana arborescens* | Siberian peashrub | 4.5 | 3.8 | 3.0 | 1.4 | |
| *Ulmus pumilus* | Siberian elm | | | 7.5 | 7.2 | |
| *Symphoricarpos* species | snowberry | | | 1.9 | | |
| *Rhus trilobata* | skunkbush sumac | | | 3.3 | 2.1 | |
| *Populus deltoides* | plains cottonwood | | | 10.6 | | |
| *Hippophae rhamnoides* | seaberry | | 4.4 | 2.2 | 1.3 | |
| *Prunus americana* | American plum | | | | | |
| *Pinus ponderosa* | ponderosa pine | | | | | |
| *Prunus virginiana* | common chokecherry | | | | | |
| *Picea pungens* | Colorado spruce | | | | | |
| *Prunus besseyi* | western sandcherry | | | | | |
| *Prunus tomentosa* | Nanking cherry | | | | | |

indicates a majority of seedlings should survive in this soil salinity category given test site conditions.

indicates only a relatively small percentage of seedlings should survive in this soil salinity category given test site conditions.

Table 4 lists the maximum soil salinity classification category recommended for each species tested. Russian olive is an invasive weed in riparian areas and is listed as a regulated plant in Montana and a noxious weed in Wyoming. It is therefore not recommended or allowed and was only included in this study as a standard of comparison. The other species are listed as “not recommended” for a given soil salinity classification category if survival was less than 50%, or there was only one test seedling planted in that salinity range. It should be noted, however, there may be situations where survival of less than 50% meets an intended conservation goal. Green ash was listed as “not recommended” because height and vigor were unacceptably low, despite adequate plant survival. Seaberry *Hippophae rhamnoides* is listed as “restricted use” and should only be planted under controlled and monitored conditions; since it is non-native and has not been extensively field tested in Montana and Wyoming. Species with a “conditional recommendation” should be planted in soils with salinity values in the lower end of the category range.

Table 4. Soil salinity tolerance recommendations for Montana and Wyoming by USDA soil salinity classification category, tree and shrub salinity tolerance study, Bridger, Montana, 2014.

| | | Percentage Survival Non-Saline | Percentage Survival Very Slightly Saline | Percentage Survival Slightly Saline | Percentage Survival Moderately Saline | Percentage Survival Strongly Saline |
|---|---|---|---|---|---|---|
| | | *<2 dS/M* | *2 to ≤4 dS/M* | *4 to <8 dS/M* | *8 to <16 dS/M* | *≥16 dS/M* |
| *Elaeagnus angustifolia* | Russian olive | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| *Shepherdia argentea* | silver buffaloberry | | | | √ | NR[2] |
| *Lonicera korolkowii* | blueleaf honeysuckle | | | √ | NR[2] | |
| *Elaeagnus commutata* | silverberry | | | √ | NR[2] | |
| *Fraxinus pennsylvanica* | green ash | | | NR[2] | NR[2] | |
| *Ribes aureum* | golden currant | | | CR[3] | NR[2] | |
| *Caragana arborescens* | Siberian peashrub | | | √ | NR[2] | |
| *Ulmus pumilus* | Siberian elm | | | √ | NR[2] | |
| *Symphoricarpos* species | snowberry | | | CR[3] | | |
| *Rhus trilobata* | skunkbush sumac | | | CR[3] | NR[2] | |
| *Populus deltoides* | plains cottonwood | | | CR[3] | | |
| *Hippophae rhamnoides* | seaberry | | RU[4] | NR[2] | NR[2] | |
| *Prunus americana* | American plum | NR[2] | | | | |
| *Pinus ponderosa* | ponderosa pine | NR[2] | | | | |
| *Prunus virginiana* | common chokecherry | NR[2] | | | | |
| *Picea pungens* | Colorado spruce | NR[2] | | | | |
| *Prunus besseyi* | western sandcherry | NR[2] | | | | |
| *Prunus tomentosa* | Nanking cherry | NR[2] | | | | |

√ indicates recommended for the salinity category given test site conditions.

[1] - NA "not applicable", invasive weed.

[2] - NR "not recommended".

[3] - CR "conditional recommendation", use only at low end of the salinity range for Slightly Saline soils.

[4] - RU "restricted use", untested non-native, use only under controlled conditions.

indicates majority of seedlings should survive this soil salinity category given test site conditions.

indicates only a relatively small percentage of seedlings should survive this soil salinity category given test site conditions

## Conclusion/Discussion

In general, the soil salinity tolerance of the test plants was lower than frequently reported in popular, web-based, and non-referenced sources. It is anticipated that most of the tested species will perform better on light-textured and well-drained soils under similar environmental and site conditions. The results of this study suggest many “salt-tolerant” woody plants may not provide the intended conservation benefits on saline soils. It is important to note the salinity tolerance recommendations in this report do not apply to all soil and climatic conditions, but are applicable to the site and climatic conditions comparable to Bridger, Montana. Planners should consider the goal of the conservation planting and the likelihood that plant performance will meet those goals, when selecting woody plant species for salt-affected sites.