# Appendix 6.1 Seed Characteristics of Some Common U.S. Plants

This appendix provides seed characteristics and treatments important for growing some common native plants of the United States. Information is provided by life form (conifer trees, deciduous trees, woody shrubs, forbs [wildflowers], grasses, and grass-like plants) and by very general distribution within the United States (eastern and western). Please consult local field guides to understand which plants are native to your area.

***Refer to explanations in sections 2.6 (Seed Storage), 2.7 (Seed Dormancy), and 2.8 (Seed Treatments) when using this appendix.***

## Sources:

Bonner, F.T.; Karrfalt, R.P. 2008. The woody plant seed manual. Agric. Handb. 727. Washington, DC: U.S. Department of Agriculture, Forest Service. 1223 p.

Cullina, W. 2000. The New England Wild Flower Society guide to growing and propragating wildflowers of the United States and Canada. Boston/New York: Houghton Mifflin Co. 322 p.

Lady Bird Johnson Wildflower Center. URL: http://www.wildflower.org/plants/ (accessed Jan 2012).

Native Plant Network. URL: http://www.nativeplantnetwork.org (accessed Jun 2011).

Schopmeyer, C.S. 1974. Seeds of woody plants in the United States. Agric. Handb. 450. Washington, DC: U.S. Department of Agriculture, Forest Service. 883 p.

U.S. Department of Agriculture, Natural Resources Conservation Service, Plant List of Accepted Taxonomy and Symbols (PLANTS) database. URL: http://plants.usda.gov (accessed Dec 2011).

**Appendix 6.1.1—Conifer Trees**

| Scientific name | Common name | Average seeds per pound | Seed treatment(s) |
|---|---|---|---|
| **Eastern** | | | |
| *Abies balsamea* | Balsam fir | 11,000 | 28 days stratification |
| *Larix laricina* | Tamarack | 250,000 | 60 days stratification |
| *Picea rubens* | Red spruce | 139,000 | None required |
| *Pinus banksiana* | Jack pine | 131,000 | 0 to 7 days stratification |
| *echinata* | Shortleaf pine | 46,000 | 60 days stratification |
| *palustris* | Longleaf pine | 4,900 | 0 to 30 days stratification |
| *resinosa* | Red pine | 52,000 | 0 to 30 days stratification |
| *rigida* | Pitch pine | 62,000 | None required |
| *strobus* | Eastern white pine | 26,000 | 60 days stratification |
| *taeda* | Loblolly pine | 18,200 | 30 to 60 days stratification |
| *virginiana* | Virginia pine | 55,000 | 30 days stratification |
| *Taxodium distichum* | Bald cypress | 5,000 | 30 days stratification |
| *Taxus canadensis* | Canada yew | 21,000 | 270 days of stratification |
| *Thuja occidentalis* | Arborvitae | 346,000 | 30 to 60 days stratification |

(continued)

**Appendix 6.1.1—(Continued)**

| Scientific name | Common name | Average seeds per pound | Seed treatment(s) |
|---|---|---|---|
| **Western** | | | |
| *Abies amabilis* | Pacific silver fir | 12,000 | 28 days stratification |
| *concolor* | Concolor fir | 11,000 | 28 to 60 days stratification |
| *grandis* | Grand fir | 19,000 | 21 to 42 days stratification |
| *lasiocarpa* | Subalpine fir | 34,000 | 28 to 42 days stratification |
| *magnifica* | California red fir | 7,000 | 28 to 42 days stratification |
| *procera* | Noble fir | 13,500 | 21 to 42 days stratification |
| *Chamaecyparis lawsoniana* | Port Orfordcedar | 210,000 | 0 to 14 days stratification |
| *nootkatensis* | Alaska yellowcedar | 108,000 | 30 to 90 days stratification |
| *Juniperus californica* | California juniper | | 30 to 120 days stratification |
| *communis* | Common juniper | 36,000 | 45 to 90 days moist, warm treatment then 90 to 120 days stratification |
| *occidentalis* | Western juniper | 12,000 | 45 to 90 days moist, warm treatment then 90 to 120 days stratification |
| *osteosperma* | Utah juniper | 5,000 | 45 to 90 days moist, warm treatment then 90 to 120 days stratification |
| *scopularum* | Rocky Mountain juniper | 27,000 | 45 to 90 days moist, warm treatment then 90 to 120 days stratification |
| *Larix lyallii* | Subalpine larch | 142,000 | 28 days stratification |
| *occidentalis* | Western larch (tamarack) | 137,000 | 28 days stratification |
| *Libocedrus decurrens* | Incense-cedar | 15,000 | 28 to 60 days stratification |
| *Picea breweriana* | Brewer spruce | 61,000 | 0 to 28 days stratification |
| *engelmannii* | Engelmann spruce | 135,000 | 0 to 28 days stratification |
| *pungens* | Blue (Colorado) spruce | 106,000 | 0 to 28 days stratification |
| *sitchensis* | Sitka spruce | 210,000 | None required |
| *Pinus albicaulis* | Whitebark pine | 2,600 | Tumble or sandpaper scarification, then 120 to 180 days stratification |
| *aristata* | Bristlecone pine | 18,000 | 0 to 28 days stratification |
| *attenuata* | Knobcone pine | 25,000 | 60 days stratification |
| *balfouriana* | Foxtail pine | 17,000 | 90 to 120 days stratification |
| *contorta* var. *contorta* | Shore pine (coastal) | 135,000 | 0 to 28 days stratification |
| *contorta* var. *latifolia* | Lodgepole pine (interior) | 94,000 | 0 to 28 days stratification |
| *edulis* | Pinyon pine | 1,900 | 0 to 60 days stratification |
| *flexilis* | Limber pine | 4,900 | 21 to 90 days stratification |
| *jeffreyi* | Jeffrey pine | 3,700 | 0 to 60 days stratification |
| *lambertiana* | Sugar pine | 2,100 | 60 to 120 days stratification |
| *monophylla* | Singleleaf pinyon | 1,110 | 28 to 90 days stratification |
| *monticola* | Western white pine | 27,000 | 30 to 150 days stratification (14 days of warm, moist treatment prior to stratification may help) |
| *ponderosa* | Ponderosa pine | 12,000 | 30 to 60 days stratification |
| *Pseudotsuga menziesii* | | | |
| var. *glauca* | Rocky Mountain Douglas-fir | 44,000 | 21 to 42 days stratification |
| *menziesii* var. *menziesii* | Coastal Douglas-fir | 39,000 | 14 to 21 days stratification |
| *Taxus brevifolia* | Pacific yew | 15,000 | 90 to 200 days moist, warm treatment, then 60 to 120 days stratification |
| *Thuja plicata* | Western redcedar | 414,000 | 0 to 21 days stratification |
| *Tsuga heterophylla* | Western hemlock | 280,000 | 21 to 90 days stratification |
| *mertensiana* | Mountain hemlock | 114,000 | 90 days stratification |

**Appendix 6.1.2—Deciduous Trees**

| Scientific name | Common name | Average seeds per pound | Seed treatment(s) |
|---|---|---|---|
| **Eastern** | | | |
| *Acer saccharinum* | Silver maple | 1,780 | 42 to 90 days stratification |
| *saccharum* | Sugar maple | 7,000 | 120 days stratification |
| *Aesculus glabra* | Ohio buckeye | 58 | 60+ days stratification |
| *Betula nigra* | River birch | 375,000 | 90 to 150 days stratification; sow seeds on the soil surface and kept moist during germination |
| *Carya ovata* | Shagbark hickory | 100 | 60 days stratification |
| *Cercis canadensis* | Eastern redbud | 18,000 | Scarification, then 120 days stratification |
| *Cornus florida* | Dogwood | 4,500 | 90 days stratification |
| *Fagus grandifolia* | Amrican beech | 1,600 | 210 days stratification |
| *Fraxinus pennsylvanica* | White ash | 19,000 | 60 days warm, moist treatment then 60 to 210 days stratification |
| *Gleditsia triacanthos* | Honey locust | 2,800 | Scarification |
| *Gymnocladus dioicus* | Kentucky coffee tree | 230 | Scarification, then 60 to 90 days stratification |
| *Liriodendron tulipifera* | Tuliptree | 12,250 | 30 days stratification |
| *Maclura pomifera* | Osage orange | 14,000 | 30 to 120 days stratification |
| *Morus rubra* | Red mulberry | 360,000 | 30 to 120 days stratification |
| *Nyssa sylvatica* | Blackgum | 2,500 | 30 to 120 days stratification |
| *Platanus occidentalis* | American sycamore | 160,000 | None required |
| *Populus deltoides* | Eastern cottonwood | 350,000 | None required; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Prunus serotina* | Black cherry | 2,400 | 120 to 180 days stratification (14 days warm, moist treatment before stratification may help) |
| *Quercus alba* | White oak | 215 | None required |
| *bicolor* | Swamp white oak | 120 | None required |
| *rubra* | Red oak | 105 | 30 to 60 days stratification |
| *velutina* | Black oak | 245 | 30 to 60 days stratification |
| *Robinia pseudoacacia* | Black locust | 24,000 | Scarification |
| *Sassafras albidum* | Sassafras | 5,500 | 120 days stratification |
| *Tilia americana* | American basswood | 3,000 | Scarification, then 120 to 150 days stratification |
| *Ulmus americana* | American elm | 70,000 | None required; sow seeds on the soil surface and keep them moist during germination |

(continued)

**Appendix 6.1.2—(Continued)**

| Scientific name | Common name | Average seeds per pound | Seed treatment(s) |
|---|---|---|---|
| **Western** | | | |
| *Acer glabrum* | Rocky Mountain maple | 13,430 | 90 to 180 days warm, moist treatment then 120 to 180 days stratification |
| *grandidentatum* | Bigtooth maple | 6,350 | 120 days stratification |
| *macrophyllum* | Bigleaf maple | 3,250 | 40 to 60 days stratification |
| *Alnus incana* | Thinleaf alder | 675,000 | 60 to 90 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *rubra* | Red alder | 776,000 | 0 to 30 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *viridis* | Sitka alder | 998,000 | 60 to 90 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Arbutus menziesii* | Pacific madrone | 258,500 | 42 to120 days stratification |
| *Betula papyrifera* | Paper birch | 1,380,000 | 60 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Chilopsis linearis* | Desert willow | 86,000 | 0 to 60 days stratification |
| *Cercis orbiculata* | California redbud | 27,460 | Scarification then 0 to 120 days stratification |
| *Cornus nuttallii* | Pacific dogwood | 4,700 | Scarification then 90 days stratification |
| *Corylus cornuta* var. *californica* | California hazelnut | 486 | 60 to 120 days stratification |
| *Frangula purshiana* | Cascara | 12,000 | Scarification then 30 to 140 days stratification |
| *Fraxinus latifolia* | Oregon ash | 12,000 | 30 to 90 days warm, moist treatment then 90 days stratification |
| *velutina* | Velvet leaf ash | 20,600 | 30 to 90 days stratification |
| *Populus balsamifera* | Black cottonwood | | None required; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *fremontii* | Fremont cottonwood | | None required; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *tremuloides* | Quaking aspen | 3,600,000 | None required; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Prosopis juliflora* | Mesquite | 12,500 | Scarification |
| *Quercus gambelii* | Gambel oak | 325 | 60 to 90 days stratification |
| *garryana* | Oregon white oak | 85 | None required |
| *kelloggii* | California black oak | 95 | 30 to 45 days stratification |
| *Robinia neomexicana* | New Mexico locust | 21,600 | Scarification |
| *Salix species* | Willow | Millions | None required; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Sorbus scopulina* | Cascade Mountain ash | 138,000 | 120 to 180 days stratification |

**Appendix 6.1.3—Woody Shrubs**

| Scientific name | Common name | Average seeds per pound | Seed treatment(s) |
|---|---|---|---|
| **Eastern** | | | |
| *Amelanchier laevis* | Serviceberry | 80,000 | 30 to 60 days stratification |
| *Asimina triloba* | Pawpaw | 700 | 60 days stratification |
| *Callicarpa americana* | Beautyberry | 272,000 | 60 days stratification |
| *Calycanthus floridus* | Eastern sweetshrub | 85,000 | 30 days stratification |
| *Cornus obliqua* | Silky dogwood | 12,000 | 100 to 120 days stratification |
| *sericea* | Redoiser dogwood | 18,500 | 90 days stratification (scarification before stratification may help) |
| *Corylus americana* | American hazelnut | 490 | 60 to 180 days stratification |
| *Euonymus americanus* | Bursting-heart | 35,000 | 140 days stratification |
| *Gaultheria hispidula* | Creeping snowberry | 3,000,000 | 83 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *procumbens* | Eastern teaberry | 3,000,000 | None required; seeds need light to germinate so sow on soil surface and keep them moist dur ing germination |
| *Hamamelis virginiana* | American witchhazel | 9,000 | 120 days stratification |
| *Juniperus communis* | Common juniper | 36,000 | 30 to 180 days stratification |
| *Lindera benzoin* | Northern spicebush | 4,500 | 90 days stratification |
| *Prunus americana* | American plum | 870 | 90 to 120 days stratification (may need to remove pit) |
| *virginiana* | Chokecherry | 4,800 | 90 to 120 days stratification |
| *Symphoricarpos albus* | Common snowberry | 140,000 | 60 to 90 days warm, moist treatment then 90 to 120 days stratification |
| *Vaccinium angustifolium* | Lowbush blueberry | 2,000,000 | 0 to 60 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *corymbosum* | Highbush blueberry | 1,000,000 | 0 to 60 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |

(continued)

**Appendix 6.1.3—(Continued)**

| Scientific name | Common name | Average seeds per pound | Seed treatment(s) |
|---|---|---|---|
| **Western** | | | |
| *Amelanchier alnifolia* | Serviceberry | 82,000 | 120 to 150 days stratification |
| *Arctostaphylos patula* | Manzanita | | Scarification (may need 90 days of warm, moist treatment before germination occurs) |
| *uva-ursi* | Bearberry | 58,000 | Scarification, then 60 to 90 days warm, moist treatment then 90 to 120 days stratification |
| *Artemisia cana* | Silver sagebrush | 1,300,000 | 60 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *tridentata* | Big sagebrush | 2,140,000 | 30 to 90 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Atriplex canescens* | Fourwing saltbush | 23,000 | After-ripen in dry storage for 90 days then 60 days stratification |
| *Ceanothus velutinus* | Snowbrush ceanothus | 94,000 | Scarification, then 90 days stratification |
| *Cercocarpus ledifolius* | Curlleaf mountain mahogany | 48,200 | 14 to 120 days stratification |
| *Cornus sericea* | Redoiser dogwood | 18,500 | 90 days stratification (scarification before stratification may help) |
| *Crataegus douglasii* | Black hawthorn | 22,600 | 90 to 120 90 days stratification (scarification before stratification may help) |
| *Ephedra species* | Mormon tea | 19,000 | 60 to 90 days stratification |
| *Ericameria nauseosa* | Rubber rabbitbrush | 600,000 | 60 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Holodiscus discolor* | Oceanspray | 5,000,000 | 120 days stratification |
| *Mahonia repens* | Creeping Oregon-grape | 51,000 | 90 to 120 days warm, moist treatment then 90 to 120 days stratification |
| *Philadelphus lewisii* | Lewis' mockorange | 5,300,000 | 21 to 75 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Physocarpus malvaceus* | Western ninebark | 748,800 | 90 to 120 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Prunus americana* | American plum | 870 | 90 to 120 days stratification (may need to remove pit) |
| *virginiana* | Chokecherry | 4,800 | 90 to 120 days stratification |
| *Purshia mexicana* | Mexican cliffrose | 75,000 | 60 to 90 days stratification |
| *tridentata* | Antelope bitterbrush | 15,400 | 60 to 90 days stratification |
| *Rhus trilobata* | Skunkbush sumac | 20,300 | Scarification, then 90 days stratification |
| *Rosa woodsii* | Woods' rose | 50,000 | 60 to 90 days warm, moist treatment then 90 days stratification |
| *Sambucus nigra* var. *cerulea* | Blue elderberry | 234,000 | 90 to 120 days stratification |
| *Shepherdia argentea* | Silver buffaloberry | 40,000 | 60 to 90 days stratification |
| *Symphoricarpos albus* | Common snowberry | 140,000 | 60 to 90 days warm, moist treatment then 90 to 120 days stratification |
| *Vaccinium* species | Huckleberry | 1,500,000 | 0 to 60 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |

**Appendix 6.1.4—Forbs (Wildflowers )**

| Scientific name | Common name | Average seeds per pound | Seed treatment(s) |
|---|---|---|---|
| **Eastern** | | | |
| *Aquilegia canadensis* | Eastern columbine | 504,000 | 90 days stratification |
| *Asclepias syriaca* | Common milkweed | 48,000 | 90 days stratification; sow seeds on the soil surface and keep them moist during germination |
| *tuberosa* | Butterfly milkweed | 70,000 | 90 days stratification; sow seeds on the soil surface and keep them moist during germination |
| *Aster novae-angliae* | New England Aster | 1,200,000 | 60 days stratification |
| *Baptisia australis* | Blue false indigo | 26,000 | Scarification (seeds may benefit from stratification after scarification) |
| *Bidens cernua* | Nodding bur marigold | 130,000 | 84 days stratification |
| *Coreopsis lanceolata* | Lance leaved coreopsis | 220,000 | 90 days stratification |
| *Dalea purpurea* | Purple prairie clover | 290,000 | Scarification |
| *Echinacea purpurea* | Eastern purple coneflower | 115,000 | 90 to 120 days stratification |
| *Eupatorium fistulosum* | Joe-pye weed | 2,000,000 | 90 days stratification |
| *Gaillardia pulchella* | Firewheel | 238,000 | None required |
| *Heliopsis helianthoides* | Smooth oxeye | 105,000 | None required |
| *Liatris spicata* | Blazing star | 100,000 | None required but 90 days stratification may help |
| *Lobelia cardinalis* | Cardinal flower | 1,000,000 | None required; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Monarda fistulosa* | Wild bergamot | 1,250,000 | 90 days stratification |
| *Oenothera speciosa* | Showy evening primrose | 3,000,000 | None required |
| *Penstemon digitalis* | Smooth beardtounge | 1,800,000 | 90 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Ratibida pinnata* | Grey headed coneflower | 1,000,000 | 30 days stratification |
| *Rudbeckia triloba* | Browneyed Susan | 500,000 | None required |
| *Senna marilandica* | Maryland senna | 20,500 | Scarification then 90 days stratification |
| *Solidago nemoralis* | Gray goldenrod | 1,000,000 | 90 days stratification |
| *Tephrosia virginiana* | Goats rue | 32,000 | 14 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Verbena hastata* | Blue vervain | 1,600,000 | None required; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Vernonia gigantea* | Giant ironweed | 300,000 | 90 to 140 days stratification |
| *Veronicastrum virginicum* | Culver's root | 7,750,000 | 21 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination; seeds do not tolerate any drying |

(continued)

**Appendix 6.1.4—(Continued)**

| Scientific name | Common name | Average seeds per pound | Seed treatment(s) |
|---|---|---|---|
| **Western** | | | |
| *Achillea millefolium* | Yarrow | 2,770,000 | 0 to 14 days stratification |
| *Aquilegia species* | Columbine | 432,000 | 60 to 90 days stratification |
| *Asclepias speciosa* | Showy milkweed | 245,000 | 30 to 60 days stratification; sow seeds on the soil surface and keep them moist during germination |
| *Aster laevis* | Smooth blue aster | 1,100,000 | 0 to 30 days stratification |
| *Balsamorhiza sagittata* | Arrowleaf balsamroot | 55,000 | 90 to 120 days stratification |
| *Dodecatheon species* | Shootingstar | 1,200,000 | 60 to 90 days stratification |
| *Castilleja linariifolia* | Wyoming Indian paintbrush | 4,915,000 | 60 to 90 days stratification |
| *miniata* | Giant red Indian paintbrush | 4,900,000 | 60 to 90 days stratification |
| *Echinacea angustifolia* | Blacksamson echinacea | 128,000 | 30 to 90 days stratification |
| *Eriogonum umbelllatum* | Sulfur buckwheat | 209,000 | 60 to 90 days stratification |
| *Gaillardia aristata* | Indian blanketflower | 132,000 | 0 to 30 days stratification |
| *Heuchera cylindrica* | Alumroot | 6,363,000 | 30 to 60 days stratification |
| *Iliamna rivularis* | Mountain hollyhock | 45,450 | Scarification then 60 days stratification |
| *Liatris punctata* | Dotted blazing star | 139,000 | 30 days stratification |
| *Lupinus sericeus* | Silky lupine | 12,900 | Scarification then 30 to 60 days stratification |
| *Monarda fistulosa* | Wild bergamot | 1,498,000 | 30 to 60 days stratification |
| *Oenothera pallida* | White evening primrose | 2,500,000 | 30 to 60 days stratification |
| *Oxytropis species* | Locoweed | 594,000 | Scarification then 0 to 60 days stratification |
| *Penstemon eatonii* | Firecracker penstemon | 600,000 | 60 days stratification |
| *nitidus* | Shining penstemon | 550,000 | 60 to 90 days stratification |
| *strictus* | Rocky Mountain penstemon | 592,000 | 60 to 90 days stratification |
| *Ratibida columnifera* | Prairie coneflower | 1,230,000 | 0 to 30 days stratification |
| *Rudbeckia hirta* | Blackeyed Susan | 1,710,000 | 0 to 30 days stratification |
| *Sphaeralcea coccinea* | Scarlet globe mallow | 500,000 | Scarification then 0 to 30 days stratification |
| *Wyethia amplexicaulis* | Mule ears | 24,625 | 0 to 60 days stratification |

**Appendix 6.1.5—Grasses and Grass-Like Plants**

| Scientific name | Common name | Average seeds per pound | Seed treatment(s) |
|---|---|---|---|
| **Eastern** | | | |
| *Agrostis perennans* | Upland bentgrass | 8,000,000 | None required |
| *Andropogon gerardii* | Big bluestem | 144,000 | 90 days stratification |
| *Bouteloua curtipendula* | Sideoats gamma | 710,000 | None required |
| *Calamagrostis canadensis* | Bluejoint | 3,300,000 | None required |
| *Carex scoparia* | Blunt broom sedge | 1,300,000 | 60 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Chasmanthium latifolium* | Indian woodoats | 90,000 | None required |
| *Danthonia spicata* | Poverty oatgrass | 448,000 | None required (tumble scarification may help) |
| *Elymus canadensis* | Canada wildrye | 114,000 | None required but 14 days stratification improves germination |
| *virginicus* | Virginia wild rye | 100,000 | None required |
| *Juncus effusus* | Common rush | 4,500,000 | 0 to 270 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Leersia oryzoides* | Rice cutgrass | 5,000,000 | None required |
| *Panicum virgatum* | Switchgrass | 259,000 | 14 days stratification |
| *Schizachyrium scoparium* | Little bluestem | 240,000 | 30 to 60 days stratification |
| *Scirpus cyperinus* | Wool bulrush | 9,000,000 | 30 to 120 days stratification; sow seeds on the soil surface and keep them moist during germination |
| *Sorghastrum nutans* | Indian grass | 175,000 | Dry, cool storage for 90 days; or, 90 days cold stratification |
| *Sporobolus compositus* | Tall dropseed | 750,000 | None required |
| *Tridens flavus* | Purpletop tridens | | 14 to 90 days stratification |

(continued)

**Appendix 6.1.5—(Continued)**

| Scientific name | Common name | Average seeds per pound | Seed treatment(s) |
|---|---|---|---|
| **Western** | | | |
| *Achnatherum hymenoides* | Indian ricegrass | 141,000 | Tumble or sandpaper scarification then 0 to 30 days stratification |
| *Bouteloua curtipendula* | Sideoats grama | 191,000 | 0 to 30 days stratification |
| *Carex aquatilis* | Water sedge | 485,000 | 30 to 90 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *microptera* | Small wing sedge | 847,000 | 60 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *nebrascensis* | Nebraska sedge | 534,100 | 60 to 90 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *urticulata* | Beaked sedge | 444,000 | 30 to 60 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Eleocharis palustris* | Common spikerush | 620,000 | 0 to 90 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Festuca idahoensis* | Idaho fescue | 450,000 | 0 to 30 days stratification |
| *Hesperostipa comata* | Needle and thread | 115,000 | 0 to 14 days stratification |
| *Juncus balticus* | Baltic rush | 10,900,000 | 60 to 90 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *torreyi* | Torrey rush | 12,300,000 | 30 to 90 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *Nassella viridula* | Green needlegrass | 181,000 | 0 to 30 days stratification |
| *Schoenoplectus acutus* | Hardstem bulrush | 377,600 | Tumble or sandpaper scarification then 30 to 60 days stratification |
| *americanus* | Chairmaker's bulrush | 179,800 | 30 to 60 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |
| *tabernaemontani* | Softstem bulrush | 550,000 | 30 to 60 days stratification; seeds need light to germinate so sow on soil surface and keep them moist during germination |

# Appendix 6.2. More Intensive Fertilization for Bareroot Seedlings: An Introduction

The percentage of N, P, and K in a bag of fertilizer is always given in the order of N:P:K. Well, that's not quite right. Because of some archaic convention, the percentages of P and K are really given as percentages of the oxides of P and K: $P_2O_5$ and $K_2O$. Therefore, a bag of 8:10:3 has 8% N, 10% $P_2O_5$, and 3% $K_2O$ by weight. To convert $P_2O_5$ to P, you'll need to multiply the percentage of P2O5 by 0.437. Similarly, to convert $K_2O$ to K, multiply $K_2O$ by 0.83. This process may sound confusing, but let's work through an example using this equation:

Let's say we want to use some 8:10:3 fertilizer, we want to apply 35 pounds of N per acre, and our nursery bed is 4 feet wide and 45 feet long (180 square feet).

First, divide 35 pounds of N by the percentage of N in the fertilizer (0.08):

$35 \div 0.08 = 438$ pounds of fertilizer per acre to get 35 pounds of N per acre.

Divide the 438 pounds of fertilizer by 43,560 (the number of square feet in an acre):

$438 \div 43{,}560 = 0.01$ pounds of fertilizer per square foot.

Multiply 0.01 pounds of fertilizer per square foot by the 180 square feet in the nursery bed:

$0.01 \times 180 = 1.8$ pounds of fertilizer should be applied to the nursery bed.

Okay, how much P and K were applied at the same time?

For P, multiply the 1.8 pounds of fertilizer by 0.1 (remember there's 10% $P_2O_5$ in the fertilizer):

$1.8 \times 0.1 = 0.18$ pounds of $P_2O_5$ were also applied to the nursery bed.

Convert that to P:

$0.18 \times 0.437 = 0.08$ pounds of P were applied to the nursery bed.

You may convert that back to a pounds-per-acre rate by dividing it by 180 (that gives you pounds of P per square foot) and then multiplying by 43,560:

$0.08 \div 180 = 0.000044$ and $0.000044 \times 43{,}560 = 19$ pounds of P per acre.

Similarly, to determine how much K was applied, take the 1.8 pounds of fertilizer and multiply it by 0.03 (3% $K_2O$ in the fertilizer); we applied 0.05 pounds of $K_2O$. Convert that to K by multiplying 0.05 pounds of $K_2O$ by 0.83; 0.04 pounds of K. Like P, you can convert back to pounds of K per acre by dividing by 180 and multiplying by 43,560; we applied 9.7 pounds of K per acre.

In commercial bareroot nurseries, commonly used fertilizers are ammonium phosphate (11:55:0), ammonium nitrate (33:0:0), ammonium sulfate (21:0:0), calcium superphosphate (0:20:0), triple superphosphate (0:45:0), and potassium sulfate (0:0:50). In general, if you have a soil with pH less than 6.0, your fertilizers of choice would be ammonium phosphate and ammonium nitrate. These fertilizers help maintain your pH around 5.0 to 6.0. However, if your soil pH is on the high side (over 6.0) use ammonium sulfate.

One advantage of using single element fertilizers is the ease of manipulating the amounts of each nutrient applied; only one nutrient is in each fertilizer formulation. Commercial operators have the luxury of using a particular fertilizer to apply a particular nutrient. Novice growers who wish to use an organic alternative may find that their choices for fertilizers usually include multiple nutrients per fertilizer formulations (for example, 9:1:1 or 0:3:1). This means more arithmetic for organic farmers because they may have to do some "tinkering" with their formulations and application amounts to achieve recommended fertilizer rates.

Regardless of your situation, right before the first growing season, plan on incorporating P and K into your nursery beds. If you have a good sandy soil, add some N as well. If your soil is too acidic (pH under 5) or too basic (pH over 6) for conifer seedlings, this is also the time to add lime to bring the pH back up or sulfur to lower pH. Use a whirly-bird-type spreader or drop-type spreader to apply fertilizer. You may have to mix it with sand to have enough material to fill your spreader and ensure an even application. Make sure it's applied evenly! Spade or rototill the fertilizer into the soil. Once your crop is growing, you'll need to topdress N and K over the top of your seedlings. If damping-off is a problem, avoid early applications of N during the first season.

**Appendix 6.2.1.—Intensive Bareroot Fertilization for Soil With Ph Less Than 6.0.**

| Year | Timing | Nutrient | Number of applications | Rate (pounds per acre) | Fertilizer (see footnote) | Ounces of fertilizer per 100 square feet |
|---|---|---|---|---|---|---|
| First Season | Pre-sow | N | 1 | 35 | 11:55:0 [A] | 12 |
| | | P | 1 | 120 | 0:20:0 | 18 |
| | | K | 1 | 45 | 0:0:62 | 3 |
| | Top-dress | N | 4 (mid-June, early and mid-July, & late September) | 20 | 33:0:0 | 2 |
| | | K | 1 (mid-summer) | 20 | 0:0:62 | 1.5 |
| Second Season | Top-dress | N | 1 (March) | 35 | 33:0:0 | 3.5 |
| | | K | 1 (March) | 20 | 0:0:62 | 1.5 |
| | | N | 4 (May, June, July, late September) | 20 | 33:0:0 | 2 |
| | | K | 2 (early and mid-summer) | 20 | 0:0:62 | 1.5 |
| Transplants | Pre-plant | P | 1 | 60 | 0:20:0 | 25 |
| | | K | 1 | 45 | 0:0:62 | 1.5 |
| | Top-dress | N | 4 (May, June, July, late September) | 40 | 33:0:0 | 4 |
| | | K | 2 (early and mid-summer) | 20 | 0:0:62 | 1.5 |

Fertilizers:
11:55:0 Ammonium phosphate
33:0:0 Ammonium nitrate
0:20:0 Calcium superphosphate
0:0:62 Potassium chloride

[A] Note the application of 12 oz of 11:55:0 supplies the necessary rate of N (35 lbs per acre) and 78 lbs of the suggested 120 lbs of P per acre. Therefore, the amount of 0:20:0 supplies only 42 lbs of P per acre (the difference between 120 and 78).

**Adapted from:** van den Driessche, R. 1984. Soil fertility in forest nurseries. In: Duryea, M.L.; Landis, T.D., eds. Forest nursery manual: production of bareroot seedlings. The Hague; Boston; Lancaster: Martinue Nijhoff/Dr. W. Junk Publishers. For Forest Research Laboratory, Oregon State University, Corvallis: 63-74.

**Appendix 6.2.2.—Intensive Bareroot Fertilization for Soil With Ph Greater Than 6.0.**

| Year | Timing | Nutrient | Number of applications | Rate (pounds per acre) | Fertilizer (see footnote) | Ounces of fertilizer per 100 square feet |
|---|---|---|---|---|---|---|
| First Season | Pre-sow | N | 1 | 35 | 11:55:0 [A] | 12 |
| | | P | 1 | 120 | 0:45:0 | 8 |
| | | K | 1 | 45 | 0:0:50 | 4 |
| | Top-dress | N | 4 (mid-June, early and mid-July, & late September) | 20 | 21:0:0 | 3.5 |
| | | K | 1 (mid-summer) | 20 | 0:0:50 | 2 |
| Second Season | Top-dress | N | 1 (March) | 35 | 21:0:0 | 6 |
| | | K | 1 (March) | 20 | 0:0:50 | 2 |
| | | N | 4 (May, June, July, late September) | 20 | 21:0:0 | 3.5 |
| | | K | 2 (early and mid-summer) | 20 | 0:0:50 | 2 |
| Transplants | Pre-plant | P | 1 | 60 | 0:45:0 | 11 |
| | | K | 1 | 45 | 0:0:50 | 2 |
| | Top-dress | N | 4 (May, June, July, late September) | 40 | 21:0:0 | 7 |
| | | K | 2 (early and mid-summer) | 20 | 0:0:50 | 2 |

Fertilizers:
11:55:0 Ammonium phosphate
21:0:0 Ammonium sulfate
0:45:0 Triple superphosphate
0:0:50 Potassium sulfate

[A] Note the application of 12 oz of 11:55:0 supplies the necessary amount of N (35 lbs per acre) and 78 lbs of the suggested 120 lbs of P per acre. Therefore, the amount of 0:45:0 supplies only 42 lbs of P per acre (the difference between 120 and 78).

**Adapted from:** van den Driessche, R. 1984. Soil fertility in forest nurseries. In: Duryea, M.L.; Landis, T.D., eds. Forest nursery manual: production of bareroot seedlings. The Hague; Boston; Lancaster: Martinue Nijhoff/Dr. W. Junk Publishers. For Forest Research Laboratory, Oregon State University, Corvallis: 63-74.

**Appendix 6.2.3.—Organic Fertilization of Bareroot Seedlings**

| Year | Timing | Nutrient | Number of applications | Rate (pounds per acre) | Fertilizer (see footnote) | Ounces of fertilizer per 100 square feet |
|---|---|---|---|---|---|---|
| First Season | Pre-sow | N | 1 | 35 | 9:1:1 [A] | 14 |
| | | P | 1 | 120 | 0:7:0 | 98 |
| | | K | 1 | 45 | 0:3:1 | 58 |
| | Top-dress | N | 4 (mid-June, early and mid-July, & late September) | 20 | 9:1:1 [B] | 8 |
| | | K | 1 (mid-summer) | 20 | 0:0:7 | 8 |
| Second Season | Top-dress | N | 1 (March) | 35 | 9:1:1 [C] | 14 |
| | | K | 1 (March) | 20 | | |
| | | N | 4 (May, June, July, late September) | 20 | 9:1:1 | 8 |
| | | K | 2 (early and mid-summer) | 20 | 0:0:7 | 10 |
| Transplants | Pre-plant | P | 1 | 60 | 0:3:1 [D] | 168 |
| | | K | 1 | 45 | 0:0:7 | 4 |
| | Top-dress | N | 4 (May, June, July, late September) | 40 | 9:1:1 [E] | 16 |
| | | K | 2 (early and mid-summer) | 20 | 0:0:7 | 8 |

Fertilizers:
9:1:1 Ocean Fresh Fish Powder
0:7:0 Budswel
0:3:1 Earth Juice Bloom
0:0:7 Greensand

[A] Applying 14 oz of 9:1:1 supplies 34 lbs of N, 16 lbs of P, and 32 lbs of K per acre. Applying 58 oz of 0:3:1 supplies the remaining 13 lbs of K (45 lbs total) and 21 more lbs of P Since we've only applied 37 lbs of P, apply 98 oz of 0:7:0 to supply the final 82 lbs of P suggested (120 lbs total).
[B] Four applications of 9:1:1 also supply 7.2 lbs of K (1.8 lbs per application). Therefore, we only need 8 oz of 0:0:7 (12.6 lbs of K) to achieve the suggested 20 lbs of K.
[C] Applying 14 oz of 9:1:1 supplies 34 lbs of N and 32 lbs of K per acre, which also satisfies our K requirement.
[D] Applying 168 oz of 0:3:1 provides 60 lbs of P and 38 lbs of K, so an additional 4 oz of 0:0:7 supplies 7 lbs of K to bring the total to the recommended rate of 45 lbs.
[E] Four applications of 9:1:1 also supply 14.4 lbs of K (3.6 lbs per application). Therefore, we only need 2 applications of 8 oz of 0:0:7 (12.6 lbs of K each application) to achieve the suggested 40 lbs of K.

**Adapted from:** van den Driessche, R. 1984. Soil fertility in forest nurseries. In: Duryea, M.L.; Landis, T.D., eds. Forest nursery manual: production of bareroot seedlings. The Hague; Boston; Lancaster: Martinue Nijhoff/Dr. W. Junk Publishers. For Forest Research Laboratory, Oregon State University, Corvallis: 63-74.

# Appendix 6.3. Calculating the Number of Seeds to Sow per Container Using a Hand-Held Calculator

The technique is based on the concept that a seed either grows or it doesn't (binomial probability). If "X" equals the probability of a seed germinating and "Y" equals the probability of it failing to germinate, a binomial expansion can be constructed that includes all possible occurrences. The following example shows the possibilities when 2 seeds are sown per container:

$$(X+Y)^2 = X^2 + 2XY + Y^2$$

where: $X^2$ = the probability of both seeds germinating
$2XY$ = the probability of only one germinating
$Y^2$ = the probability of neither seed germinating

So, as long as germination test data are known, the proper number of seeds to sow per container can be easily determined by entering the "germination failure" on a hand-held calculator with a universal power key ($Y^X$ , $X^Y$, $x^y$, or something similar). The procedure consists of keying in the decimal equivalent of the germination failure, pushing the universal power key, entering the number of seeds you might sow, and finally pushing the "equals" key. If your calculator doesn't have a universal power key, then just use repeated multiplication. For example, a seedlot with 78% germination has a 22% failure score:

| Seeds per container | Percentage of Empty Containers | |
|---|---|---|
| | Using $Y^X$ key | Using repeated multiplication |
| 1 | $(0.22)^1$ = 0.22 = 22% | 0.22 = 22% |
| 2 | $(0.22)^2$ = 0.0484 = 4.8% | 0.22 x 0.22 = 0.0484 = 4.8% |
| 3 | $(0.22)^3$ = 0.0106 = 1.1% | 0.22 x 0.22 x 0.22 = 0.0106 = 1.1% |
| 4 | $(0.22)^4$ = 0.0023 = 0.2% | 0.22 x 0.22 x 0.22 x 0.22 = 0.0023 = 0.2% |

You can see that the calculation becomes a "law of diminishing returns," and the best number of seeds to sow will depend on seed availability, seed cost, cost of thinning, and the reliability of the germination test. In this example, most nurseries would be satisfied with sowing 2 to 3 seeds per container.

**Source:** Schwartz, M. 1993. Germination math: calculating the number of seeds necessary per cavity for a given number of live seedlings. Tree Planters' Notes 44(1):19-20.

# Appendix 6.4. Soluble Fertilizer Chemicals that Provide Macronutrients for Custom Fertilizer Solutions for Container Seedlings

| Compound | Chemical formula | % of Nutrient Supplied | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | $NH_4$-N | $NO_3$-N | P | K | Ca | Mg | S |
| Ammonium nitrate | $NH_4NO_3$ | 17 | 17 | — | — | — | — | — |
| Ammonium sulfate | $(NH_4)_2SO_4$ | 21 | — | — | — | — | — | 24 |
| Calcium nitrate | $Ca(NO_3)_2$ | — | 15 | — | — | 17 | — | — |
| Diammonium phosphate | $(NH_4)_2HPO_4$ | 21 | — | 24 | — | — | — | — |
| Dipotassium phosphate | $K_2HPO_4$ | — | — | 18 | 45 | — | — | — |
| Magnesium sulfate | $MgSO_4$ | — | — | — | — | — | 10 | 13 |
| Monoammonium phosphate | $NH_4H_2PO_4$ | 11 | — | 21 | — | 1 | — | 3 |
| Monopotassium phosphate | $KH_2PO_4$ | — | — | 23 | 28 | — | — | — |
| Nitric acid | $HNO_3$ | — | 22 | — | — | — | — | — |
| Phosphoric acid | $H_3PO_4$ | — | — | 32 | — | — | — | — |
| Potassium carbonate | $K_2CO_3$ | — | — | — | 56 | — | — | — |
| Potassium chloride | KCl | — | — | — | 52 | — | — | — |
| Potassium nitrate | $KNO_3$ | — | 13 | — | 37 | — | — | — |
| Potassium sulfate | $K_2SO_4$ | — | — | — | 44 | — | — | 18 |
| Sodium nitrate | $NaNO_3$ | — | 16 | — | — | — | — | — |
| Sulfuric acid | $H_2SO_4$ | — | — | — | — | — | — | 33 |
| Urea | $CO(NH_2)_2$ | 45 | — | — | — | — | — | — |

**Adapted from:** Table 4.1.23—Soluble fertilizer chemicals that provide macronutrients for custom fertilizer solutions. Found in: Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1989. The container tree nursery manual. Volume 4, Seedling nutrition and irrigation.. Agric. Handb. 674. Washington, DC: U.S. Department of Agriculture, Forest Service. 119 p.

## Appendix 6.5. Calculating Parts Per Million and More Intensive Fertilization for Container Seedlings

If you use any other fertilizers than the ones listing in Table 3.8, you'll need to determine how much fertilizer to mix in a volume of water to get the suggested ppm. Before we calculate ppm, let's first review fertilizer in general. As discussed for bareroot seedlings, the percentage of N, P, and K in a bag of fertilizer is always given in the order of N:P:K. And as was the case for bareroot seedlings, that's not quite right. The percentages of P and K are really given as the percentages of the oxides of P and K: $P_2O_5$ and $K_2O$. Therefore, a bag of 30:10:10 has 30% N, 10% $P_2O_5$, and 10% $K_2O$ by weight. To convert $P_2O_5$ to P, you'll need to multiply the percentage of $P_2O_5$ by 0.437. Similarly, to convert $K_2O$ to K, multiply $K_2O$ by 0.83.

Fortunately, for fertilization of container seedlings more interest is on the rate of N. Many professional growers fertilize their crops with rates expressed in "some weight of fertilizer mixed in some volume of water" (ounces per 100 gallons, or pounds per 1,000 gallons). Some growers use some weight of N per volume of water. Finally, some growers fertilize using parts per million (ppm) or even milligrams of a nutrient per volume of water, both of which are just a more refined version of "some weight of fertilizer mixed in some volume of water."

Calculating ppm's isn't really that difficult. A good rule of thumb is that one ounce of granular fertilizer in 100 gallons of water equals about 75 ppm of fertilizer. If your fertilizer is 30% N, then the ppm N in that solution is 75 x 0.3 = 22.5 ppm N.

If you wanted 135 ppm N, you would have to divide 135 ppm N by the percentage of N in the fertilizer (30%) and divide that by 75:

135 ppm ÷ 0.3 ÷ 75 = 6 ounces of fertilizer in 100 gallons.

If your fertilizer is 10% $P_2O_5$, then the ppm $P_2O_5$ when you mix 1 ounce of fertilizer in 100 gallons of water is 75 x 0.1 = 7.5 ppm $P_2O_5$. Remember to multiply 7.5 by 0.437 to convert $P_2O_5$ to P (7.5 x 0.437 = 3 ppm P) and multiply 7.5 by 0.83 to convert $K_2O$ to K (7.5 x 0.83 = 6 ppm K).

Some professional growers strictly use premixed fertilizers (like Peters Conifer Grower®), some use a combination of premixed and custom-mixed fertilizers, and some only used custom-mixed. The discrepancy usually depends on the background of the grower. Growers using custom-mixed fertilizer feel they have better control over the growth of their seedlings, and can manipulate fertilizers to achieve particular growth responses in the crop. Customized fertilizers blend the "science" of growing seedlings with the "art" of growing seedlings, and usually experience is key. Most growers like to add calcium to their fertilizers (not found in Miracid or Miracle-Gro) to promote stem diameter development in their seedlings. Some growers like to reduce the rate of N while maintaining high levels of K to promote bud initiation and hardening; raising K levels can be easily done with a custom-mixed fertilizer. Commonly used fertilizers for growing container seedlings can be found in Appendix 6.4.

As mentioned earlier, the actual rates necessary vary from locale to locale, and the following example in Appendix 6.5.1 shows the tremendous variability found among four nurseries in the northern Rocky Mountains in regard to how they fertilize a crop of ponderosa pine seedlings. Amazingly, all four nurseries grow excellent seedlings that thrive once outplanted. So go ahead, experiment! Keep detailed notes so you can develop your own "art" in seedling production.

## Appendix 6.5.1. Fertilization of a Container Crop of Ponderosa Pine

Ratios of N:P:K:Ca (ppm) applied to ponderosa pine crops up to the time of bud initiation at four nurseries in the northern Rocky Mountains. Stock solution recipes for these ppm rates are provided below as amounts of fertilizer per 100 gallons of water. See Appendix 6.4 for fertilizer abbreviations.

| | Weeks after sowing | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Nursery** | **2** | **3** | **4** | **5** | **6** | **7 to 9** | **10** | **11 to 12** | **13** |
| 1 | 70:120:110:140 | | | 110:80:120:140 | 140:80:120:140 | 185:80:105:120 | 230:80:120:120 | | |
| 2 | 42:176:83:0 | | | | | 60:82:47:0 alternated with 81:0:0:42 | | 81:0:0:42 | |
| 3 | 59:134:49:0 | 92:0:0:101 alternated with 163:0:452:0 | | | | | | | |
| 4 | 30:69:172:0 | 44:30:51:31 | 88:30:102:62 | 179:30:136:149 alternated with 186:30:0:198 | | | | | |

| **Nursery #1** | **Nursery #2** | **Nursery #3** | **Nursery #4** |
|---|---|---|---|
| Weeks 2 to 4<br>3.5 fluid oz CAN-17<br>4 oz $KH_2PO_4$<br>1 oz $K_2SO_4$<br><br>Week 5<br>3 fluid oz CAN-17<br>1 oz $NH_4NO_3$<br>2 oz $KNO_3$<br>3.5 oz $CaCl_2$<br>1.5 oz $KH_2PO_4$<br>1 oz $K_2SO_4$<br><br>Week 6<br>3.5 fluid oz CAN-17<br>2 oz $NH_4NO_3$<br>2 oz $KNO_3$<br>3.5 oz $CaCl_2$<br>1.5 oz $KH_2PO_4$<br>1 oz $K_2SO_4$<br><br>Weeks 7 to 9<br>5.5 fluid oz CAN-17<br>2 oz $NH_4NO_3$<br>2 oz $KNO_3$<br>2 oz $CaCl_2$<br>1.5 oz $KH_2PO_4$<br>1 oz $K_2SO_4$<br><br>Weeks 10 to 12<br>6.5 fluid oz CAN-17<br>3 oz $NH_4NO_3$<br>2 oz $KNO_3$<br>1 oz $CaCl_2$<br>1.5 oz $K_3PO4_4$<br>1 oz $K_2SO_4$ | Weeks 2 to 6<br>8 oz Peters Conifer Starter (7:40:17)<br><br>Weeks 7 to 10<br>8 oz Peters Conifer Grower (20:17:19) alternated with 4 fluid oz CAN-17<br><br>Weeks 11 to 12<br>4 fluid oz CAN-17 | Week 2<br>8 oz 10:52:10<br><br>Weeks 3 to 13<br>8 oz $Ca(NO_3)_2$ alternated with 16 oz $KNO_3$ | Week 2<br>8 oz 5:15:35<br><br>Week 3<br>2.5 oz $Ca(NO_3)_2$<br>1.5 oz $KNO_3$<br><br>Week 4<br>5 oz $Ca(NO_3)_2$<br>3 oz $KNO_3$<br><br>Weeks 5 to 12<br>12 oz $Ca(NO_3)_2$<br>4 oz $KNO_3$ alternated with 16 oz $Ca(NO_3)_2$ |

| Nursery | Weeks after sowing | | | | | | |
|---|---|---|---|---|---|---|---|
| | 13 | 14 | 15 | 16 | 17 to 19 | 20 to 22 | 23 to extraction (30 to35) |
| 1 | 20:90:120:190 | | | | 60:90:120:185 | | |
| 2 | 81:0:0:42 | | | | 24:138:173:0 alternated with 162:0:0:84 | | |
| 3 | | 69:0:0:75 alternated 61:0:169:0 | | | | | |
| 4 | 0:30:94:106 alternated with 0:165:169:0 alternated with 0:30:314:0 | | 44:30:51:31 | | 88:30:102:62 | 133:30:136:99 | 179:30:136:149 alternated with 186:30:0:4198 |

| Nursery #1 | Nursery #2 | Nursery #3 | Nursery #4 |
|---|---|---|---|
| Weeks 13 to 16<br>1 fluid oz CAN-17<br>6.5 oz $CaCl_2$<br>2.5 oz $KH_2PO_4$<br>2 oz $K_2SO_4$<br><br>Weeks 17 to extraction<br>3 fluid oz CAN-17<br>1 oz $KNO_3$<br>5.5 oz $CaCl_2$<br>2.5 oz $KH_2PO_4$<br>1.5 oz $K_2SO_4$ | Weeks 13 to 16<br>4 fluid oz CAN-17<br><br>Weeks 17 to extraction<br>8 oz Peters Conifer Finisher (4:25:35) alternated with 8 fluid oz CAN-17 | Week 14 to extraction<br>6 oz $Ca(NO_3)_2$ alternated with 6 oz $KNO_3$ | Weeks 13 to 14<br>4 oz $CaCl_2$<br>2.4 oz KCl alternated with 8 oz $K_3PO_4$ alternated with 8 oz KCl<br><br>Weeks 15 to 16<br>2.5 oz $Ca(NO_3)_2$<br>1.5 oz $KNO_3$<br><br>Weeks 17 to 19<br>5 oz $Ca(NO_3)_2$<br>3 oz $KNO_3$<br><br>Weeks 20 to 22<br>8 oz $Ca(NO_3)_2$<br>4 oz $KNO_3$<br><br>Weeks 23 to extraction<br>12 oz $Ca(NO_3)_2$<br>4 oz $KNO_3$<br>alternated with<br>16 oz $Ca(NO_3)_2$ |

**Adapted from:** Dumroese, R.K.; Wenny, D.L. 1997. Fertilizer regimes for container-grown conifers of the Intermountain West. In: Haase, D.L.; Rose, R., coords. & eds. Symposium proceedings—Forest seedling nutrition from the nursery to the field; October 28-29, 1997; Corvallis, OR. Oregon State University, Nursery Technology Cooperative: 17-26.

# Appendix 6.6. Handy Conversions

| Multiply | By | To Obtain |
|---|---|---|
| Acres | 43,560 | square feet |
| Acres | 0.4047 | square hectares |
| Acres | 4,047 | square meters |
| Bed feet | 0.3716 | square meters |
| Bed foot | 4.0 | square feet |
| Bed meter | 13.12 | square feet |
| Bushels | 1.244 | cubic feet |
| Bushels | 0.03524 | cubic meters |
| Centimeters | 0.3937 | inches |
| Cubic feet | 0.8 | bushels |
| Cubic feet | 0.02832 | cubic meters |
| Cubic feet | 0.03704 | cubic yards |
| Cubic meters | 35.31 | cubic feet |
| Cups | 0.5 | pints |
| Cups | 0.25 | quarts |
| Cups | 16 | tablespoons |
| Cups | 48 | teaspoons |
| Feet | 30.48 | centimeters |
| Feet | 0.3048 | meters |
| Gallons | 3.785 | liters |
| Gallons | 128 | ounces (fluid) |
| Gallons | 8 | pints (fluid) |
| Gallons | 4 | quart (fluid) |
| Gallons of water | 8.3453 | pounds of water |
| Grams | 0.03527 | ounces |
| Grams | 0.002205 | pounds |
| Grams per liter | 1,000 | parts per million |
| Grams per liter | 0.1336 | ounces per gallon |
| Hectares | 2.471 | acres |
| Hectares | 107,000 | square feet |
| Inches | 2.540 | centimeters |
| Inches | 0.0254 | meters |
| Kilograms | 1,000 | grams |
| Kilograms | 35.27 | ounces |
| Kilograms | 2.2046 | pounds |
| Liters | 0.2642 | gallons |
| Liters | 2.113 | pints (fluid) |
| Liters | 1.057 | quarts (fluid) |
| Meters | 3.2808 | feet |
| Meters | 39.37 | inches |
| Ounces | 28.35 | grams |
| Ounces | 0.0625 | pounds |

| Multiply | By | To Obtain |
|---|---|---|
| Ounces | 3 | tablespoons (dry) |
| Ounces | 9 | teaspoons (dry) |
| Ounces (fluid) | 0.0078125 | gallons |
| Ounces (fluid) | 0.02957 | liters |
| Ounces (fluid) | 29.57 | milliliters |
| Ounces (fluid) | 2 | tablespoons (fluid) |
| Ounces (fluid) | 6 | teaspoons (fluid) |
| Ounces per gallon | 7.812 | milliliters per liter |
| Ounces per square foot | 2722 | pounds per acre |
| Parts per million | 1 | milligrams per kilo gram |
| Parts per million | 1 | milligrams per liter |
| Parts per million | 0.013 | ounces per 100 gallons |
| Parts per million | 0.0083 | pounds per 1000 gallons |
| Pints (fluid) | 0.125 | gallons |
| Pints (fluid) | 0.4732 | liters |
| Pints (fluid) | 16 | ounces (fluid) |
| Pints (fluid) | 0.5 | quarts (fluid) |
| Pounds | 453.594 | grams |
| Pounds | 0.453594 | kilograms |
| Pounds | 16 | ounces |
| Pounds of water | 0.1198 | gallons |
| Pounds per acre | 1.12 | kilograms per hectare |
| Pounds per acre | 0.000377 | ounces per square foot |
| Pounds per square foot | 4.882 | kilograms per square meter |
| Quarts (fluid) | 0.25 | gallons |
| Quarts (fluid) | 0.9463 | liters |
| Quarts (fluid) | 946.3 | milliliters |
| Quarts (fluid) | 32 | ounces (fluid) |
| Quarts (fluid) | 2 | pints (fluid) |
| Square feet | 0.000023 | acres |
| Square feet | 0.0929 | square meters |
| Square feet | 0.25 | bed feet |
| Square feet | 0.0762 | bed meters |
| Square meters | 0.000247 | acres |
| Square meters | 10.764 | square feet |
| Tablespoons (dry) | 0.0625 | cups (dry) |
| Tablespoons (dry) | 0.333 | ounces (dry) |
| Tablespoons (dry) | 3 | teaspoons (dry) |
| Tablespoons (fluid) | 0.0625 | cups (fluid) |
| Tablespoons (fluid) | 15 | milliliters |
| Tablespoons (fluid) | 0.5 | ounces (fluid) |
| Teaspoons (dry) | 0.111 | ounces (dry) |
| Teaspoons (dry) | 0.333 | tablespoons (dry) |
| Teaspoon (fluid) | 0.0208 | cups (fluid) |
| Teaspoon (fluid) | 5 | milliliters |
| Teaspoon (fluid) | 0.1666 | ounces (fluid) |
| Temperature (°C) +17.8 | 1.8 | temperature °F |
| Temperature (°F) -32 | 0.55 | temperature °C |

**Sources:**

Bonaminio, V.P. Extension Horticultural Specialist, The North Carolina Agricultural Extension Service.

Duryea, M.L.; Landis, T.D. eds. Production of bareroot seedlings. The Hague; Boston; Lancaster: Martinue Nijhoff/Dr. W. Junk Publishers. For Forest Research Laboratory, Oregon State University, Corvallis. 386 p.

The Rocky Mountain Research Station develops scientific information and technology to improve management, protection, and use of the forests and rangelands. Research is designed to meet the needs of the National Forest managers, Federal and State agencies, public and private organizations, academic institutions, industry, and individuals. Studies accelerate solutions to problems involving ecosystems, range, forests, water, recreation, fire, resource inventory, land reclamation, community sustainability, forest engineering technology, multiple use economics, wildlife and fish habitat, and forest insects and diseases. Studies are conducted cooperatively, and applications may be found worldwide.

**Station Headquarters**
Rocky Mountain Research Station
240 W Prospect Road
Fort Collins, CO 80526
(970) 498-1100

**Research Locations**

| | |
|---|---|
| Flagstaff, Arizona | Reno, Nevada |
| Fort Collins, Colorado | Albuquerque, New Mexico |
| Boise, Idaho | Rapid City, South Dakota |
| Moscow, Idaho | Logan, Utah |
| Bozeman, Montana | Ogden, Utah |
| Missoula, Montana | Provo, Utah |



**www.fs.fed.us/rmrs**