CHAPTER SIX

Appendices

APPENDIX 6.1

Seed Characteristics of Common Conifers of the Pacific Northwest

Common name	*Scientific name*	*Cone cycle (years)*	*Ounces of seeds per bushel of cones*	*Seeds per pound*	*Stratification (days)*
Firs					
Pacific silver fir	*Abies amabilis*	3-6	48	12,000	28
Concolor fir	*A. concolor*	2-4	17-32	11,000	28-60
Grand fir	*A. grandis*	2-3	24-32	19,000	21-42
Subalpine fir	*A. lasiocarpa*	2-4	22	34,000	28-42
California red fir	*A. magnifica*	2-3	18	7,000	28-42
Noble fir	*A. procera*	3-6	22-46	13,500	21-42
Larches					
Subalpine larch	*Larix lyallii*	1-10	-	142,000	28
Western larch (tamarack)	*L. occidentalis*	1-10	8	137,000	28
Spruces					
Brewer spruce	*Picea breweriana*	-	-	61,000	0-28
Engelmann spruce	*P. engelmannii*	2-3	6-16	135,000	0-28
Colorado (blue) spruce	*P. pungens*	1-3	12-20	106,000	0-28
Sitka spruce	*P. sitchensis*	3-4	6-20	210,000	0
Pines					
Whitebark pine	*Pinus albicaulis*	3-5	-	2,600	120-180
Bristlecone pine	*P. aristata*	1-2	17	18,000	0-30
Knobcone pine	*P. attenuata*	1	2	25,000	60
Foxtail pine	*P. balfouriana*	5-6	-	17,000	90-120
Shore pine (coastal)	*P. contorta* var. *contorta*	1	8-19	135,000	0-30
Lodgepole pine (interior)	*P. contorta* var. *latifolia*	1	3-13	94,000	0-30
Pinyon pine	*P. edulis*	2-5	52	1,900	0-60
Limber pine	*P. flexilis*	2-4	-	4,900	21-90
Jeffrey pine	*P. jeffreyi*	2-4	16-32	3,700	0-60
Sugar pine	*P. lambertiana*	3-5	24-32	2,100	60-120
Single-leaf pinyon	*P. monophylla*	1-2	27-75	1,110	28-90
Western white pine	*P. monticola*	3-7	5-13	27,000	30-150
Ponderosa pine	*P. ponderosa*	2-5	9-32	12,000	30-60

Common name	Scientific name	Cone cycle (years)	Ounces of seeds per bushel of cones	Seeds per pound	Stratification (days)
Douglas-firs					
Rocky Mountain Douglas-fir	*Pseudotsuga menziesii* var. *glauca*	2-11	8-13	44,000	21-42
Coast Douglas-fir	*P. menziesii* var. *menziesii*	3-11	4-13	39,000	14-28
Yew					
Pacific yew	*Taxus brevifolia*	-	-	15,500	*
Cedars					
Western redcedar	*Thuja plicata*	3-4	12	414,000	0-42
Incense-cedar	*Libocedrus decurrens*	-	16-48	15,000	28-60
Hemlocks					
Western hemlock	*Tsuga heterophylla*	2-8	-	260,000	21-90
Mountain hemlock	*T. mertensiana*	1-5	-	114,000	90
			Pounds of seeds per 100 pounds of fruits or cones		
White-cedars					
Port-orford-cedar	*Chamaecyparis lawsoniana*	-	20	210,000	0-14
Alaska yellow-cedar	*C. nootkatensis*	-	-	108,000	30-90
Junipers					
California juniper	*Juniperus californica*	-	-	-	*
Common juniper	*J. communis*	-	16	36,000	*
Western juniper	*J. occidentalis*	-	20	12,000	*
Utah juniper	*J. osteosperma*	2	25	5,000	*
Rocky Mountain juniper	*J. scopularum*	2-5	11-28	27,000	*

* See Section 2.2.3 (Warm Treatments Before Stratification) for details.

Source: Schopmeyer, C.S. 1974. Seeds of Woody Plants in the United States. Agricultural Handbook 450. Washington, D.C.: USDA Forest Service. 883 p. (see Appendix 6.6).

APPENDIX 6.2

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 P_2O_5 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:

$$\frac{\text{Amount of Nutrient Required (Pounds per Acre)}}{\text{\% Nutrient within Fertilizer}} \times \frac{\text{Square Feet Needing Fertilizer}}{\text{43,560 Square Feet per Acre}} = \text{Pounds of Fertilizer Needed}$$

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 ÷ 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 ÷ 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 x 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 x 0.1 = 0.18 pounds of P_2O_5 were also applied to the nursery bed.

Convert that to P:
0.18 x 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 ÷ 180 = 0.000044 and
0.000044 x 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), 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 Under 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. Pages 63-74 in Duryea, M.L.; Landis, T.D. (eds.) Forest Nursery Manual: Production of Bareroot Seedlings. Martinue Nijhoff.Dr W. Junk Publishers, The Hague/Boston/Lancaster, for Forest Research Laboratory, Oregon State University, Corvallis. 386 p. (see Appendix 6.6).

APPENDIX 6.2.2

Intensive Bareroot Fertilization for Soil With pH over 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	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. Pages 63-74 in Duryea, M.L.; Landis, T.D. (eds.) Forest Nursery Manual: Production of Bareroot Seedlings. Martinue Nijhoff.Dr W. Junk Publishers, The Hague/Boston/Lancaster, for Forest Research Laboratory, Oregon State University, Corvallis. 386 p. (see Appendix 6.6).

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. Pages 63-74 in Duryea, M.L.; Landis, T.D. (eds.) Forest Nursery Manual: Production of Bareroot Seedlings. Martinue Nijhoff.Dr W. Junk Publishers, The Hague/Boston/Lancaster, for Forest Research Laboratory, Oregon State University, Corvallis. 386 p. (see Appendix 6.6).

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. In this example, a seedlot with 78% germination has a 22% failure score.

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.

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%

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

Calculating Parts Per Million and More Intensive Fertilization for Container Seedlings

If you use any other fertilizers than the ones listed in Table 3.7, 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 Table 6.1.

As mentioned earlier, the actual rates necessary vary from locale to locale, and the following example in Appendix 6.4.1 shows the tremendous variability found among three 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.

TABLE 6.1

Soluble fertilizer chemicals that provide macronutrients for custom fertilizer solutions for container seedlings.

		% of Nutrient supplied						
Compound	Chemical formula	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 chloride	$CaCl_2$	-	-	-	-	36	-	-
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. Seedling Nutrition and Irrigation, Volume 4, The Container Tree Nursery Manual. Agriculture Handbook 674. Washington, D.C.: USDA Forest Service. 119 p.

APPENDIX 6.4.1

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 and Table 6.1 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

Weeks 2 to 4
3.5 fluid oz CAN-17®
4 oz KH_2PO_4
1 oz K_2SO_4

Week 5
3 fluid oz CAN-17
1 oz NH_4NO_3
2 oz KNO_3
3.5 oz $CaCl_2$
1.5 oz KH_2PO_4
1 oz K_2SO_4

Week 6
3.5 fluid oz CAN-17
2 oz NH_4NO_3
2 oz KNO_3
3.5 oz $CaCl_2$
1.5 oz KH_2PO_4
1 oz K_2SO_4

Weeks 7-9
5.5 fluid oz CAN-17
2 oz NH_4NO_3
2 oz KNO_3
2 oz $CaCl_2$
1.5 oz KH_2PO_4
1 oz K_2SO_4

Weeks 10 to 12
6.5 fluid oz CAN-17
3 oz NH_4NO_3
2 oz KNO_3
1 oz $CaCl_2$
1.5 oz K_3PO_4
1 oz K_2SO_4

Nursery #2

Weeks 2 to 6
8 oz Peters Conifer Starter® (7:40:17)

Weeks 7 to 10
8 oz Peters Conifer Grower® (20:17:19) alternated with 4 fluid oz CAN-17

Weeks 11 to 12
4 fluid oz CAN-17

Nursery #3

Week 2
8 oz 10:52:10

Weeks 3 to 13
8 oz $Ca(NO_3)_2$ alternated with 16 oz KNO_3

Nursery #4

Week 2
8 oz 5:15:35

Week 3
2.5 oz $Ca(NO_3)_2$
1.5 oz KNO_3

Week 4
5 oz $Ca(NO_3)_2$
3 oz KNO_3

Weeks 5 to 12
12 oz $Ca(NO_3)_2$
4 oz KNO_3 alternated with 16 oz $Ca(NO_3)_2$

APPENDIX 6.4.1 *(continued)*

Ratios of N:P:K:Ca (ppm) applied to ponderosa pine crops at four nurseries from bud initiation to extraction.

	Weeks after sowing						
Nursery	*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

Weeks 13 to 16
1 fluid oz CAN-17
6.5 oz $CaCl_2$
2.5 oz KH_2PO_4
2 oz K_2SO_4

Weeks 17 to extraction
3 fluid oz CAN-17
1 oz KNO_3
5.5 oz $CaCl_2$
2.5 oz KH_2PO_4
1.5 oz K_2SO_4

Nursery #2

Weeks 13 to 16
4 fluid oz CAN-17

Weeks 17 to extraction
8 oz Peters® Conifer Finisher (4:25:35) alternated with 8 fluid oz CAN-17

Nursery #3

Week 14 to extraction
6 oz $Ca(NO_3)_2$ alternated with 6 oz KNO_3

Nursery #4

Weeks 13 to 14
4 oz $CaCl_2$
2.4 oz KCl alternated with 8 oz K_3PO_4 alternated with 8 oz KCl

Weeks 15 to 16
2.5 oz $Ca(NO_3)_2$
1.5 oz KNO_3

Weeks 17 to 19
5 oz $Ca(NO_3)_2$
3 oz KNO_3

Weeks 20 to 22
8 oz $Ca(NO_3)_2$
4 oz KNO_3

Weeks 23 to extraction
12 oz $Ca(NO_3)_2$
4 oz KNO_3
alternated with 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; Oct. 28-29, 1997; Corvallis, OR. Corvallis, OR: Oregon State Univ. Nursery Technology Cooperative: 17-26

APPENDIX 6.5

Handy Conversions

Multiply	By	To Obtain
Acres	43,560.00	square feet
Acres	0.4047	square hectares
Acres	4,047.00	square meters
Bed feet	0.3716	square meters
Bed foot	4.00	square feet
Bed meter	13.12	square feet
Bushels	1.244	cubic feet
Bushels	0.03524	cubic meters
Centimeters	0.3937	inches
Cubic feet	0.80	bushels
Cubic feet	0.02832	cubic meters
Cubic feet	0.03704	cubic yards
Cubic meters	35.31	cubic feet
Cups	0.50	pints
Cups	0.25	quarts
Cups	16.00	tablespoons
Cups	48.00	teaspoons
Feet	30.48	centimeters
Feet	0.3048	meters
Gallons	3.785	liters
Gallons	128.00	ounces (fluid)
Gallons	8.00	pints (fluid)
Gallons	4.00	quart (fluid)
Gallons of water	8.3453	pounds of water
Grams	0.03527	ounces
Grams	0.002205	pounds
Grams per liter	1,000.00	parts per million
Grams per liter	0.1336	ounces per gallon
Hectares	2.471	acres
Hectares	107,000.00	square feet
Inches	2.540	centimeters
Inches	0.0254	meters
Kilograms	1,000.00	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

Multiply	By	To Obtain
Ounces	28.35	grams
Ounces	0.0625	pounds
Ounces	3.00	tablespoons (dry)
Ounces	9.00	teaspoons (dry)
Ounces (fluid)	0.0078125	gallons
Ounces (fluid)	0.02957	liters
Ounces (fluid)	29.57	milliliters
Ounces (fluid)	2.00	tablespoons (fluid)
Ounces (fluid)	6.00	teaspoons (fluid)
Ounces per gallon	7.812	milliliters per liter
Ounces per square foot	2722.00	pounds per acre
Parts per million	1.00	milligrams per kilogram
Parts per million	1.00	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)	16.00	ounces (fluid)
Pints (fluid)	0.50	quarts (fluid)
Pounds	453.594	grams
Pounds	0.453594	kilograms
Pounds	16.00	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)	32.00	ounces (fluid)
Quarts (fluid)	2.00	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)	3.00	teaspoons (dry)
Tablespoons (fluid)	0.0625	cups (fluid)
Tablespoons (fluid)	15.00	milliliters
Tablespoons (fluid)	0.50	ounces (fluid)
Teaspoons (dry)	0.111	ounces (dry)
Teaspoons (dry)	0.333	tablespoons (dry)
Teaspoon (fluid)	0.0208	cups (fluid)
Teaspoon (fluid)	5.00	milliliters
Teaspoon (fluid)	0.1666	ounces (fluid)
Temperature (°C) +17.8	1.8	temperature °F
Temperature (°F) -32	0.55	temperature °C

Sources:

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

Forest Nursery Manual: Production of Bareroot Seedlings. Duryea, M.L.; Landis, T.D. (eds.). Martinue Nijhoff.Dr W. Junk Publishers, The Hague/Boston/Lancaster, for Forest Research Laboratory, Oregon State University, Corvallis. 386 p. (see Appendix 6.6).

APPENDIX 6.6

Beyond the Basics—More References

Looking for more information? There are many excellent publications dealing with nursery management. The following publications contain good information on growing seedlings. If you plan on developing your hobby into a business, these publications should certainly be on your shelf.

The Container Tree Nursery Manual

Consisting of seven volumes, this USDA Forest Service manual contains all of the state-of-the-art information for growing seedlings. Although it contains technical information, the manuals are well written for both the professional and lay-person alike. As of 1998, only the first 5 volumes have been published:

1. Nursery Planning, Development, and Management
2. Containers and Growing Media
3. Atmospheric Environment
4. Seedling Nutrition and Irrigation
5. The Biological Component: Nursery Pests and Mycorrhizae
6. Seedling Propagation (expected 1999)
7. Seedling Processing, Storage, and Outplanting (expected 2000)

Available from:

Tom Landis
National Nursery Specialist
USDA Forest Service
PO Box 3623
Portland, OR 97208-3623

Complete citations:

Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1995. Nursery Planning, Development, and Mana]lume 1, The Container Tree Nursery Manual. Agriculture Handbook 674. Washington, D.C.: USDA Forest Service. 188 p.

Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1990. Containers and Growing Media, Volume 2, The Container Tree Nursery Manual. Agriculture Handbook 674. Washington, D.C.: USDA Forest Service. 88 p.

Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1992. Atmospheric Environment, Volume 3, The Container Tree Nursery Manual. Agriculture Handbook 674. Washington, D.C.: USDA Forest Service. 145 p.

Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1989. Seedling Nutrition and Irrigation, Volume 4, The Container Tree Nursery Manual. Agriculture Handbook 674. Washington, D.C.: USDA Forest Service. 119 p.

Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1990. The Biological Component: Nursery Pests and Mycorrhizae, Volume 5, The Container Tree Nursery Manual. Agriculture Handbook 674. Washington, D.C.: USDA Forest Service. 171 p.

Seeds of Woody Plants in the United States—Agriculture Handbook 450

The much anticipated revised version of this out-of-print classic, renamed *Woody-Plant Seed Manual*, is expected out in 2000. This USDA Forest Service agricultural handbook is packed with information on all aspects of seeds from trees and shrubs grown throughout the U.S. Information on seed collection, handling, seeds per bushel, seeds per pound, presowing treatments, nursery cultural practices, etc. is given for most woody plants grown for conservation and reforestation purposes in the United States.

Available in the year 2000 from:

U.S. Government Printing Office
Superintendent of Documents
Mail Stop SSOP
Washington, D.C. 20402-9328

Complete citation:

Schopmeyer, C.S. 1974. Seeds of Woody Plants in the United States. Agricultural Handbook 450. Washington, D.C.: USDA Forest Service. 883 p.

Seeds of Woody Plants in North America

This large-format hardbound book is an updated version of USDA Agricultural Handbook 450: *Seeds of Woody Plants in the United States* (described above). The main benefit of this new book is that many more plants have been added, although most of the new additions are relatively uncommon, introduced species. The authors also incorporated over 1,000 literature citations.

Available from:

Timber Press
9999 SW Wilshire, Suite 124
Portland, OR 97225-9962
Telephone: 800-327-5680
Price: $49.95 plus $3.75 S&H (U.S. and Canada)
or $6.00 (foreign)

Complete citation:

Young, J.A.; Young, C.G. 1992. Seeds of Woody Plants in North America. Portland, Oregon: Dioscorides Press. 407 p. ISBN 0-931146-21-6

Forest Nursery Manual

Tom Landis is probably biased, but as National Nursery Specialist for the USDA Forest Service he thinks that this is one of the most comprehensive publications on the subject. It contains 30 chapters on the full range of subjects from site development, through cultural practices, to harvesting and storage. It's expensive but required reading if you plan to start a bareroot nursery business.

Available from:

Kluwer Academic Publishers
PO Box 358
Accord Station
Hingham, MA 02018-0358
Telephone: 781-871-6600
http://www.wkap.nl
Price: $139.50

Complete citation:

Forest Nursery Manual: Production of Bareroot Seedlings. Duryea, M.L.; Landis, T.D. eds. 1984. Hingham, MA: Kluwer Academic Publishers. 384 p. ISBN 90-247-2913-0.

Western Fertilizer Handbook

The handbook has the following chapters: Soil—a Medium for Plant Growth; Water and Plant Growth; Principles of Plant Growth; Essential Plant Nutrients; Fertilizers—a Source of Plant Nutrients; Fertilizer Formulation, Storage and Handling; Correcting Problem Soils with Amendments; Soil Organic Matter; Soil and Tissue Testing; Methods of Applying Fertilizer; Growing Plants in Solution Culture; Benefits of Fertilizers to the Environment; Western Laws Relating to Fertilizing Materials; Amending the Physical Properties of Soils for Planting and Potting Purposes.

Available from:

Interstate Publishers Inc.
PO Box 50
Danville, IL 68134-0050

Complete citation:

California Fertilizer Association. 1990. Western Fertilizer Handbook. Danville, IL: Interstate Publishers, Inc. 279 p. ISBN 0-8134-2858-0

Growing Conifer Seedlings, Transplants, and Trees in an Outdoor Nursery—Book One and Book Two.

Both books are full of practical solutions and tips for growing bareroot seedlings. Written in 1992 by Donald B. Hilliker, Jr. and Joan M. Hilliker, owners of Treehaven Evergreen Nursery, both books, plus another entitled *Basics of Growing Christmas Trees*, can be obtained by writing them at:

Treehaven Evergreen Nursery
981 Jamison Road
Elma, NY 14059.

APPENDIX 6.7

Directory of Seed Dealers
(available on the Internet at: http://willow.ncfes.umn.edu/snti/snti.htm)

Better Forest Tree Seeds
Rd. 1, Box 27093
Petersburg PA 16696

Blue Ridge Evergreen Nursery
Rt. 4, Box 599
Boone NC 28607

Brown Seed Co.
PO Box 1792
Vancouver WA 98668

Callahan Seeds
6054 Foley Lane
Central Point OR 97502

Carter Seeds
475 Mar Vista Rd
Vista CA 92083

Cascade Forest Nursery
Rt. 2
Cascade IA 52033

Charles Inouye & Sons
Box 937
Gunnison UT 84634

Clyde Robin Seed Co., Inc.
3670 Enterprise Ave
Hayward CA 94545

Comstock Seed
8520 West 4th St
Reno NV 89523

Container Corp. of America
PO Box 626
Callahan FL 32011

Dean Swift Seed Co.
PO Box B
Jaroso CO 81138

Dow Seeds Hawaii Ltd.
PO Box 30144
Honolulu HI 96820

Early Bird Nursery
2875 Salem Rd
Parrottsville TN 37843

F.W. Schumacher Co., Inc.
36 Spring Hill Rd
Sandwich MA 02563

Federal Paper Board Co., Inc.
PO Box 1007
Lumberton, NC 28359

Forest Seeds of California
1100 Indian Hill Rd
Placerville CA 95667

Granite Seed Company
PO Box 177
Lehi UT 84043

Great Northern Seed Co.
1002 Hamilton St
Wausau WI 54401

Herbst Tree Seed Inc
307 Number 9 Rd
Fletcher NC 28732

Hicks Seed Company
Rt 2, Box 566
Willow Springs MI 65793

Indiana Propagation Co.
#3 Lyon Block
Salem IN 47167

Inter Ag Seed Co.
3720 64th St
Holland MI 49423

Intermountain Seed Co.
445 South 1st E., Box 62
Ephraim UT 84627

International Forest Seed Co.
PO Box 490, Simpson Rd
Odenville AL 35120

K & S Jeane Seed Inc.
PO Box 21
Quitman LA 71268

Lafara Tree Seed Co.
Rt 3, Box 172-1
Cloverdale IN 46120

Land of the Sky Nurseries
108 Lakewood Dr
Asheville NC 28803

Lawyer Nursery, Inc.
950 Highway 200 West
Plains MT 59859

Louisiana Forest Seed Co., Inc.
303 Forestry Rd
Lecompte LA 71346

Lovelace Seeds, Inc.
Browns Mill Rd
Elsberry MO 63343

Maple Leaf Industries, Inc.
Box 9-6, 480 South 50 East
Ephraim UT 84627

Mistletoe Sales
780 North Glen Annie Rd
Goleta CA 93117

Mortensen Landscaping, Inc.
N 7512 Bruce Rd
Spokane WA 99207

NORTHPLAN/Mountain Seed
PO Box 9107
Moscow ID 83843

Native Seed Foundation
Star Route
Moyie Springs ID 83845

Northwest Seed Co.
38050 Highway 228
Brownsville OR 97327

Pacific Forest Seeds
1075 Meridian Brownsboro Rd
Eagle Point OR 97524

Pakulak Seed and Nursery Co.
4293 West Hansen Rd
Ludington MI 49431

Pecoff Brothers Nursery & Seed
20220 Elfin Forest Rd
Escondido CA 92029

Plants of the Southwest
Rt 6, Box 11-A
Santa Fe NM 87501

Resource Mngt. Service, Inc.
PO Box 43388
Birmingham AL 35243

S & R Seed Dealers, Inc.
PO Box 1087
Cass Lake MN 56633

Sheffield's Seed Co., Inc.
273 Auburn Rd, Rt. 34
Locke NY 13092

Silvaseed Co.
PO Box 118
Roy WA 98580

Smith Nursery Co.
PO Box 515
Charles City IA 50616

Southern Seed Co.
PO Box 340
Baldwin GA 30511

Stevenson Intermountain Seed
PO Box 2
Ephraim UT 84627

Syverson Seed
PO Box 520
Ridgefield WA 98642

Timberline Tree Seed
9100 Abbey Rd
Pueblo CO 81004

Tree Improvement Enterprises
PO Box 630
Cottage Grove OR 97424

Vans Pines Inc.
7550 144th Ave
West Olive MI 49460

Wapumne Native Plant Nursery
3807 Mt. Pleasant Rd
Lincoln CA 95648

West Tennessee Forest Seed
720 Nancy Dr
Brownsville TN 38012

Western Native Seed
PO Box 1463
Salida CO 81201

Weyerhaeuser Co.
33405 8th Ave. South
Federal Way WA 98003

Wild Seed Inc.
2073 East ASU Circle
Tempe AZ 85284

Williams Tree Seeds
Rt 4, Box 275-B
Bemidji MN 5660l

Wind River Seed
Rt 1, Box 97
Manderson WY 82432

Source: Commercial Suppliers of Tree and Shrub Seed in the United States—December 1995. USDA Forest Service, Southern Region, State and Private Forestry, Cooperative Forestry Miscellaneous Report R8-MR 33. 102 pp.

APPENDIX 6.8

Distributors of Seedling Containers in the Western U.S. and Canada

Jiffy Products of America, Inc.
951 Swanson Drive
Batavia, Illinois 60510-4202
1-800-323-1047
http://www.jiffyproducts.com

Henry A. Spencer
Spencer-Lemaire Industries, Ltd.
11406—119 Street
Edmonton, AB T5G 2X6
1-800-668-8530

Stuewe & Sons, Inc.
2290 SE Kiger Island Drive
Corvallis, Oregon 97333-9461
1-800-553-5331
http://www.stuewe.com

Hummert International
4500 Earth City Expressway
Earth City, MO 63045
1-800-325-3055
http://www.hummert.com

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