

# Weyerhaeuser

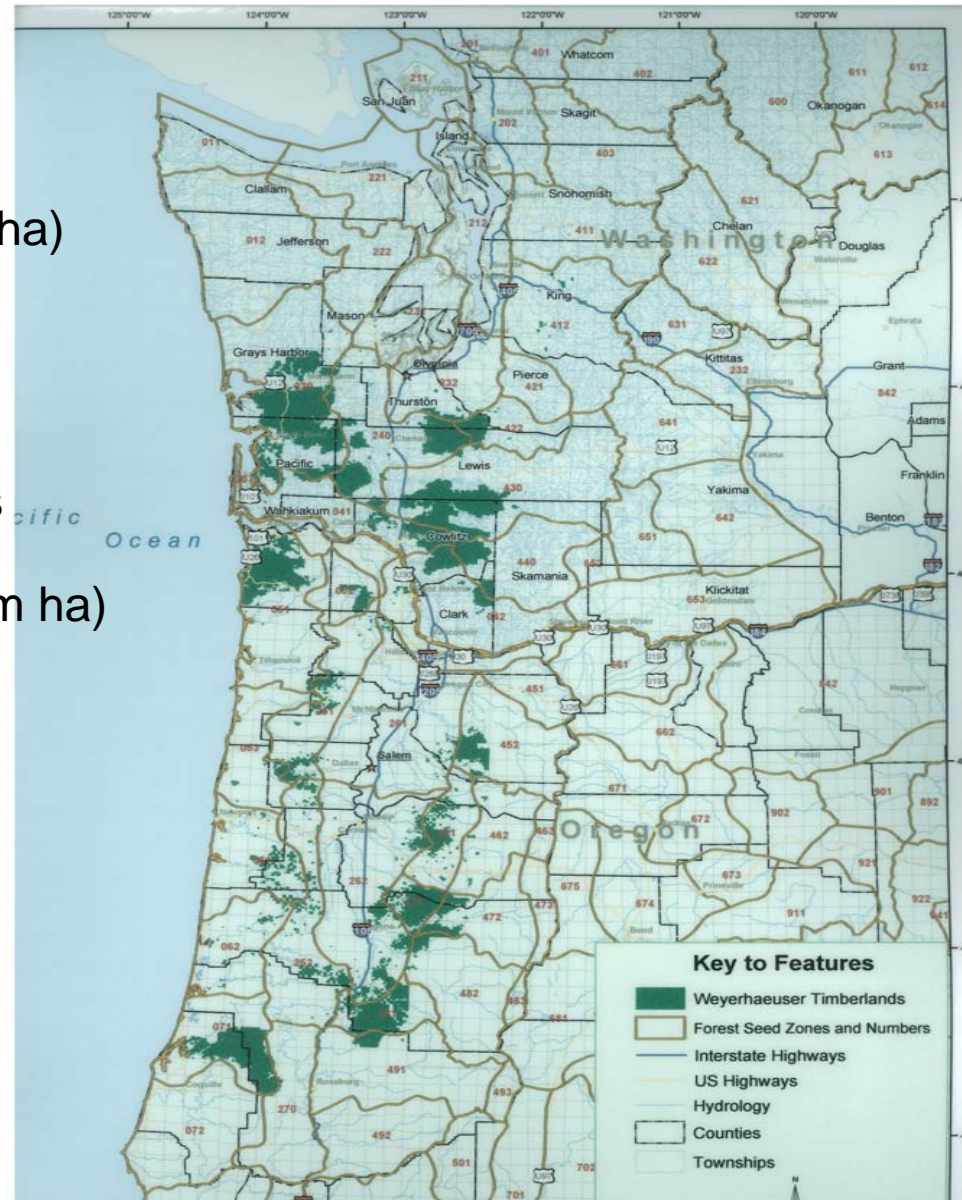
## An Integrated Seed-Seedling Supply System



Seed Use Efficiency  
MoF Tree Seed Centre  
July 30, 2008

# Western Timberlands Ownership

- 2.4 mm acres (971.3 ha)
  - WA – 1.2 mm acres
  - OR – 1.2 mm acres
- 12 Internal customers
- 45-50 m acres (19.2 m ha) regenerated annually



# Sow Order Volumes by Species (in ktrees)

2008	Improved Douglas fir					Other Species						GRAND TOTAL	
	low family	low mix	mid mix	high mix	TOTAL	W Hemlock	Noble fir	Grand fir	WR Cedar	Red Alder	WV-Pp		TOTAL
Washington	4810	4840	1235	490	11375	725	440	35	120	60		1380	12755
Oregon	1785	3570	1905	785	8045	195	350	25	15		10	595	8640
<b>TOTAL</b>	<b>6595</b>	<b>8410</b>	<b>3140</b>	<b>1275</b>	<b>19420</b>	<b>920</b>	<b>790</b>	<b>60</b>	<b>135</b>	<b>60</b>	<b>10</b>	<b>1975</b>	<b>21395</b>
	70%		15%	6%	<b>91%</b>	4.3%	3.7%	0.3%	0.6%	0.3%	0.0%	<b>9.2%</b>	

2006 - 2008	Improved Douglas fir					Other Species						GRAND TOTAL	
	low family	low mix	mid mix	high mix	TOTAL	W Hemlock	Noble fir	Grand fir	WR Cedar	Red Alder	WV-Pp		TOTAL
Washington	4627	4815	1197	520	11158								11158.3
Oregon	1927	3038	1947	520	7432								7431.67
<b>TOTAL</b>	<b>6553</b>	<b>7853</b>	<b>3143</b>	<b>1040</b>	<b>18590</b>	<b>868</b>	<b>475</b>	<b>320</b>	<b>430</b>	<b>240</b>	<b>25</b>	<b>2358.33</b>	<b>20948.3</b>
	69%		15%	5%	<b>89%</b>	4.1%	2.3%	1.5%	2.1%	1.1%	0.1%	<b>11.3%</b>	

# Sow Order Volumes by Stock Type (in ktrees)

2008	BAREROOT				P+1	CONTAINER					TOTAL
	1-0	2-0	1+1	TOTAL		415C	415D	515A	615A	TOTAL	
Total Douglas fir		895	15135	16030		675	1440	1115	160	3390	19420
		4.6%	77.9%	82.5%		3.5%	7.4%	5.7%	0.8%	17.5%	90.8%
Total Other	60	0	50	110	325	380	455	680	25	1540	1975
	3.0%	0.0%	2.5%	5.6%	16.5%	19.2%	23.0%	34.4%	1.3%	78.0%	9.2%
<b>TOTAL</b>	<b>60</b>	<b>895</b>	<b>15185</b>	<b>16140</b>	<b>325</b>	<b>1055</b>	<b>1895</b>	<b>1795</b>	<b>185</b>	<b>4930</b>	<b>21395</b>
	0.3%	4.2%	71.0%	75.4%	1.5%	4.9%	8.9%	8.4%	0.9%	23.0%	

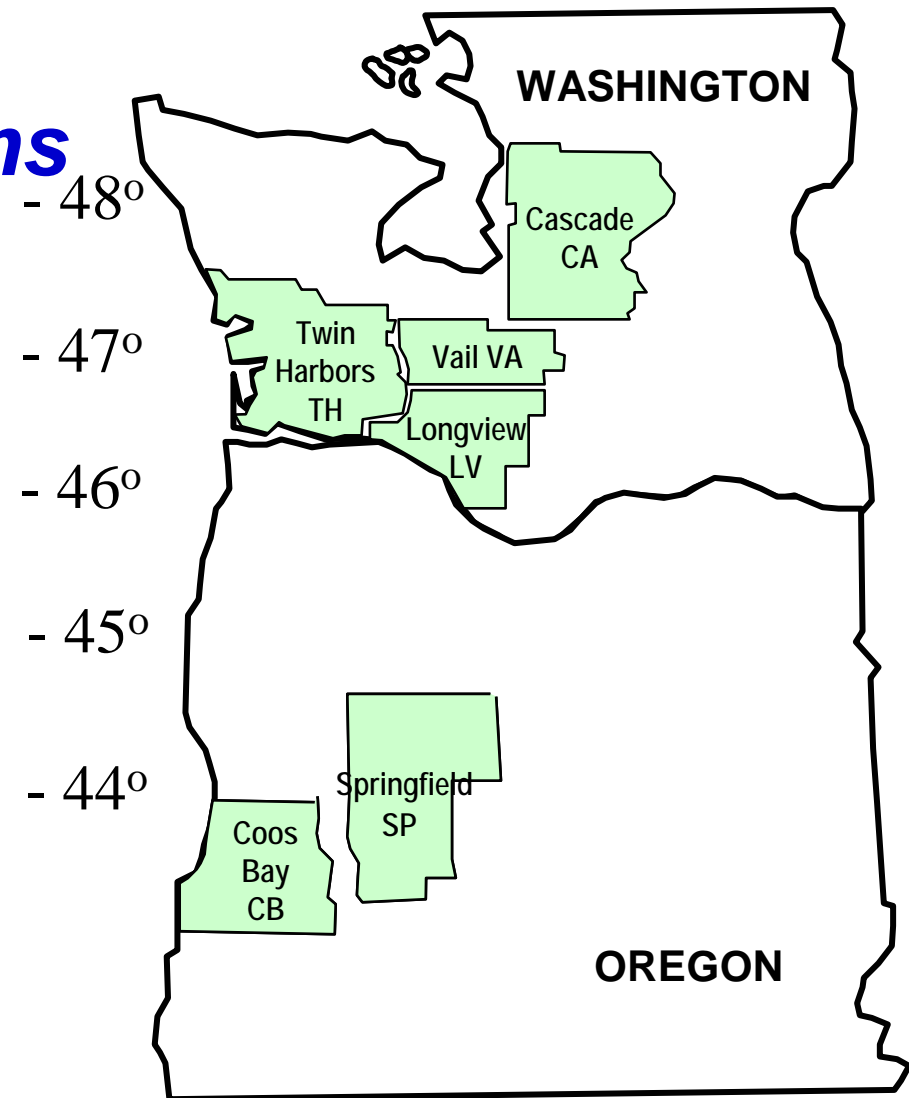
2006 - 2008	BAREROOT				P+1	CONTAINER					TOTAL
	1-0	2-0	1+1	TOTAL		415C	415D	515A	615A	TOTAL	
Total Douglas fir		842	15172	16013.3	158	373	928	1013.3	150	2465	18635.8
		4.5%	81.4%	85.9%	0.8%	2.0%	5.0%	5.4%	0.8%	13.2%	89.6%
Total Other	197	0	87	283	392	290	608	563	83	1545	2220
	8.9%	0.0%	3.9%	12.8%	17.6%	13.1%	27.4%	25.4%	3.8%	69.6%	10.7%
<b>TOTAL</b>	<b>196.67</b>	<b>841.67</b>	<b>15258</b>	<b>16296.7</b>	<b>496.67</b>	<b>663.33</b>	<b>1536.7</b>	<b>1576.7</b>	<b>233.33</b>	<b>4010</b>	<b>20803.3</b>
	0.9%	4.0%	73.3%	78.3%	2.4%	3.2%	7.4%	7.6%	1.1%	19.3%	

# ***Geographic sources of Breeding Programs***

Conservative tree seed zones used to control risk of maladaptation early on in absence of test data.

Breeding programs consolidated 2-6 seed zones for breeding and testing.

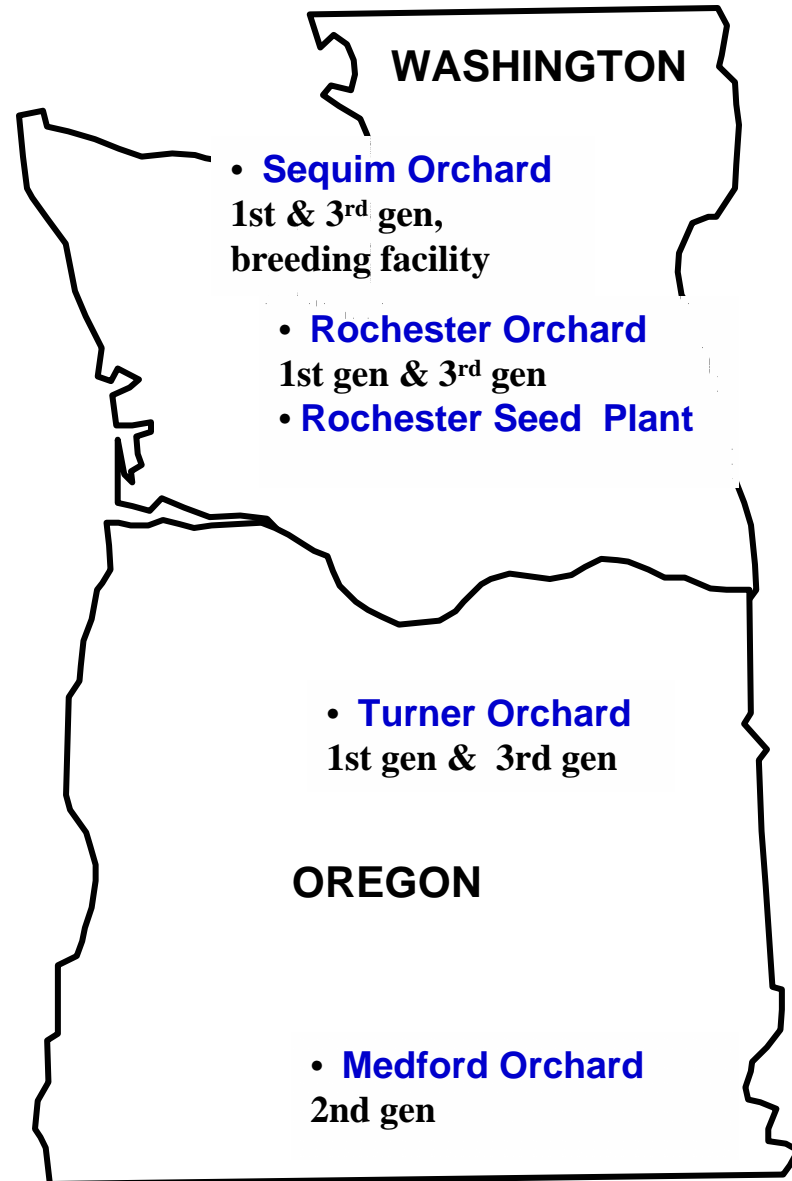
Further consolidation now underway after 2 generations of experience.



**Weyerhaeuser  
Douglas-fir Breeding Zones  
– Original Programs**



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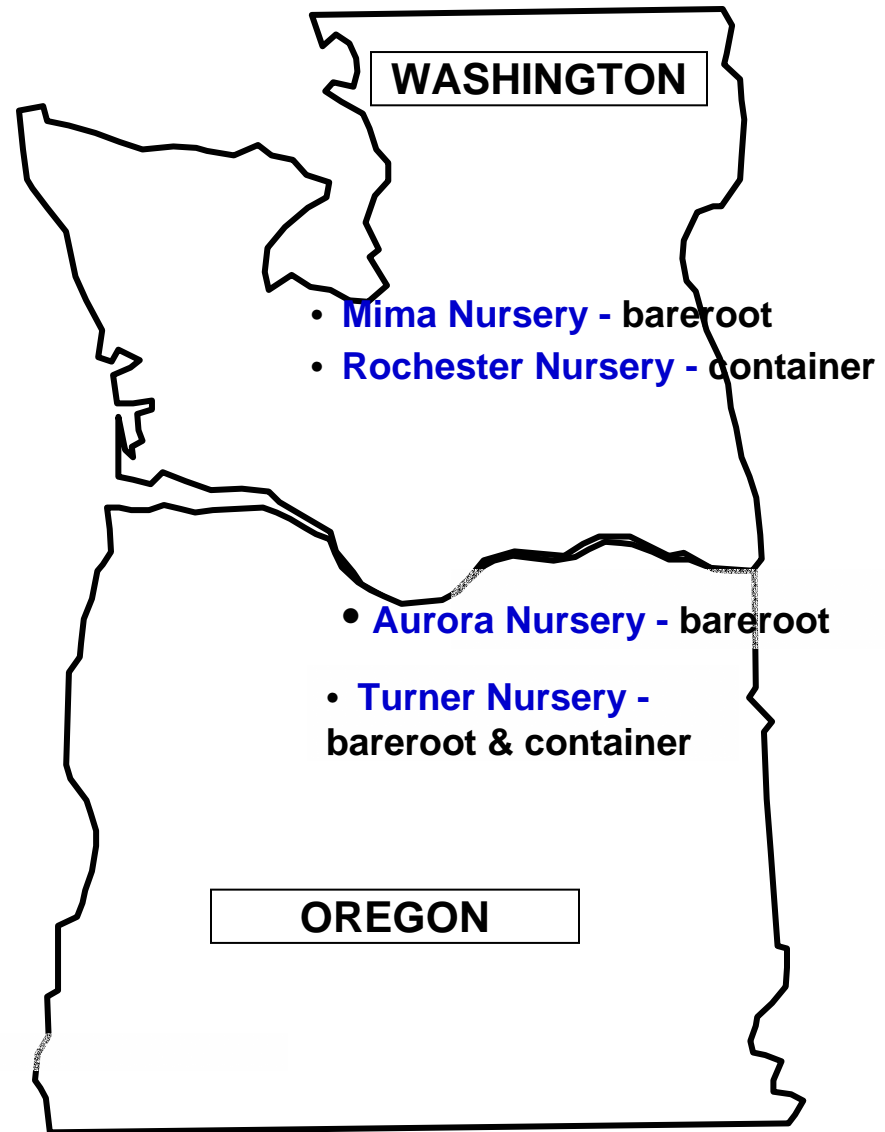


**Weyerhaeuser Company  
Seed Production Facilities**

# Douglas fir Production Seed Blocks

as of 9/2007	CASCADE LOW	LONGVIEW LOW	VAIL LOW	TWIN HARBORS LOW	COOS BAY LOW	SPRINGFLD LOW	CASCADE HIGH	LONGVIEW HIGH	SPRINGFLD HIGH
<b>ROCHESTER</b>	16 acres 35 yrs old 100% Tested 39 Parents	12.5 acres 37 yrs old 100% Tested 30 Parents	16 acres 35 yrs old 100% Tested 35 Parents	12.5 acres 37 yrs old 100% Tested 44 Parents					
<b>SEQUIM</b>	5.2 acres 33 yrs old 100% Tested 19 Parents	15.2 acres 33 yrs old 100% Tested 18 Parents	8.3 acres 33 yrs old 100% Tested 25 Parents	14.0 acres 33 yrs old 100% Tested 36 Parents		6.0 acres 33 yrs old 100% Tested 19 Parents	4 acres 31 yrs old 100% Tested 26 Parents	7.6 acres 31 yrs old 100% Tested 35 Parents	7.5 acres 31 yrs old 100% Tested 35 Parents
<b>TURNER</b>					14.5 acres 35 yrs old 100% Tested 30 parents	14.0 acres 37 yrs old 100% Tested 37 parents	2.1 + 9.0 acres 31 yrs old 100% Tested 21 Parents	9.5 acres 31 yrs old 100% Tested 18 Parents	5.3 acres 31 yrs old 100% Tested 20 parents
<b>TOTAL 1G</b>									
acres	21.2	27.7	24.3	26.5	14.5	20	15	17.1	12.8
original population	120	120	120	120	120	120	62	87	
current population	40	33	40	56	30	40	39	53	38
current ramets	380	542	473	814	262	415			
<b>MEDFORD 2G</b>	16.2 acres 18 yrs old 100% Tested	25.0 acres 18 yrs old 100% Tested	17.7 acres	42.0 acres 20 yrs old 100% Tested	14.0 acres 18 yrs old 100% Tested	13.0 acres 20 yrs old 100% Tested			
original population	50	66		50	63	80			
current population	25	49		29	31	55			
unrelated population	15	33		18	21	34			
current ramets	406	1230		1172	513	772			
<b>TOTAL ACRES</b>	<b>37.5</b>	<b>53</b>	<b>24</b>	<b>68.5</b>	<b>28.5</b>	<b>33</b>	<b>15</b>	<b>17</b>	<b>12.8</b>
<b>TOTAL 1G Ramets</b>	<b>380</b>	<b>542</b>	<b>473</b>	<b>814</b>	<b>262</b>	<b>415</b>			
<b>TOTAL 2G Ramets</b>	<b>406</b>	<b>1230</b>		<b>1172</b>	<b>513</b>	<b>772</b>			
<b>TOTAL RAMETS</b>	<b>786</b>	<b>1772</b>	<b>473</b>	<b>1986</b>	<b>775</b>	<b>1187</b>			

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## Weyerhaeuser Company Nursery Facilities



# Seedling Capacity

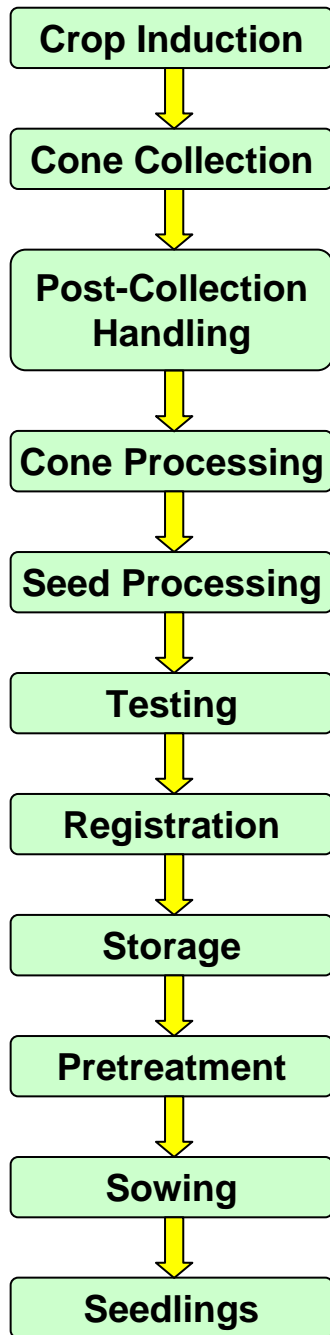
Average annual ship volume = 50mm

## BAREROOT

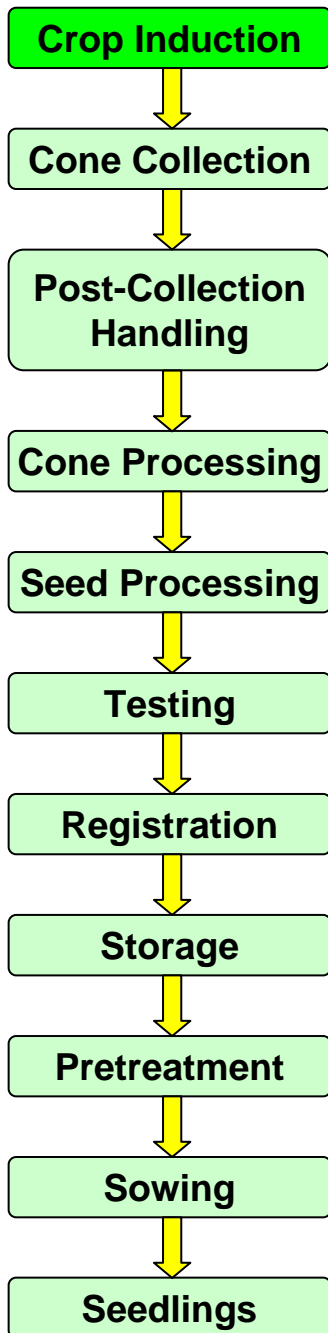
Facility	Total Acres	Growing Acres*	Pack Volume	
			Transplants	Outplant
Aurora	235	180	12 MM	18 MM
Mima	370	245	22 MM	18 MM
Turner	60	31	0.7 MM	2 MM
<b>TOTAL (acres)</b>	<b>665</b>	<b>456</b>	<b>34.7 MM</b>	<b>38 MM</b>
<b>TOTAL (ha)</b>	<b>270</b>	<b>185</b>	<b>34.7 MM</b>	<b>38 MM</b>

## CONTAINER

Facility	Growing Area (sq ft)				Pack Volume
	Indoor	Cold Frame	Outdoor	TOTAL	
Rochester	132,000	29,150	127,700	288,850	10-12 MM
Turner	110,000		109,000	219,000	4-5 MM
<b>TOTAL (sq ft)</b>	<b>242,000</b>	<b>29,150</b>	<b>236,700</b>	<b>507,850</b>	<b>14-18 MM</b>
<b>TOTAL (sq m)</b>	<b>22,482</b>	<b>2,708</b>	<b>21,989</b>	<b>47,179</b>	<b>14-18 MM</b>



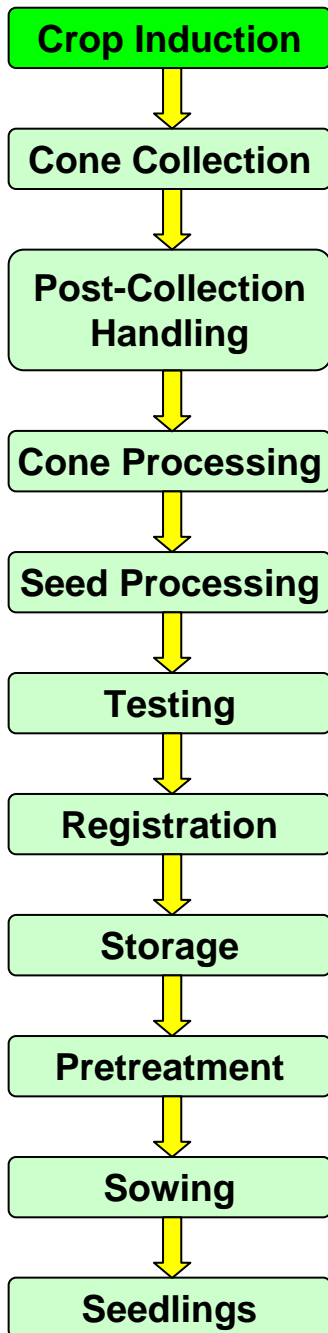
# Seed Production and Use



## Production Planning

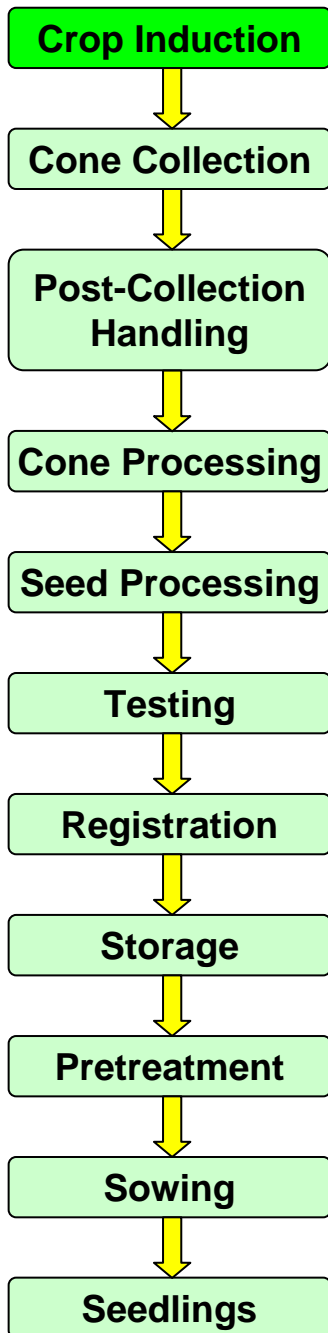
Define the following year production target as a function of current inventory and caps, in ktrees

- **Internal** inventory  
limited to 3 years of sow volume, current year sow + 2 years of reserve  
Internal use tracked on an annual basis by operation, charted as actual and 3 year average by breeding program for family and mix lots
- **Contract** customers factored in at specified contract quantities
- **Market** customers serviced from surplus internal inventory to the previous 3 yr sales average



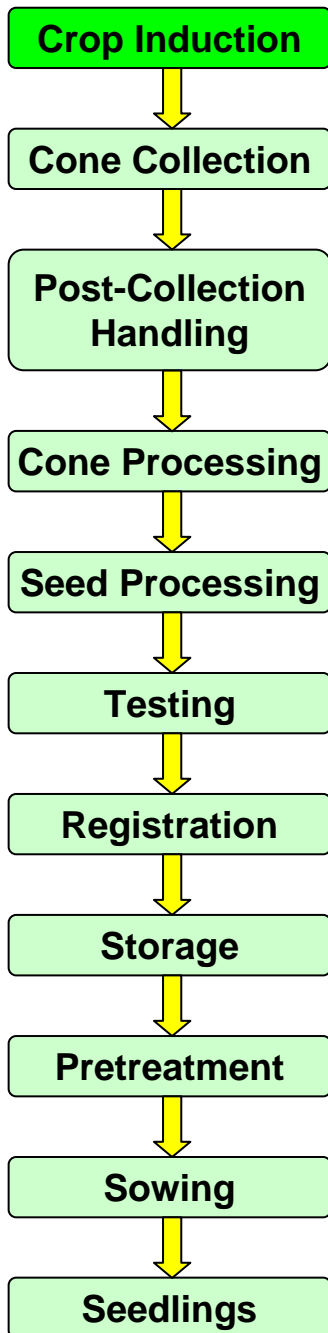
By breeding program, determine orchard location, parents and ramet counts to be stimulated.

- Stimulation plan utilizes the entire parent/ramet inventory of all 4 orchards in descending GV.
- Minimum parent stimulation = 20 by block.
- Determine seed production of the ramet count of initial 20 parents  
 $\text{ramets} * \text{average production volume} * \text{seed yield}$   
 converted to a 1+1 seedling yield  
 average production volume and seed yield are tracked by orchard site and breeding program
- Add parents/ramets if additional production is required
- Adjust ramet count down on initial 20 parents if less production is required.



**Stimulation** is conducted by the individual orchard staff

- Stimulation is achieved by the application of half circumferential, overlapping girdles and GA 4/7.
- Application of girdle is initiation of pollen bud swell  
A variety of girdle widths is used dependent on tree size and degree of desired wound
- Application of GA 4/7 is initiation of vegetative bud swell  
Direct injection into drilled ports  
Dosage rate is a function of stem diameter
- Both applications, timing and dosage, have been highly modified at each orchard site to adapt to specific site and program response conditions.
- >90% of cone production is a result of stimulation

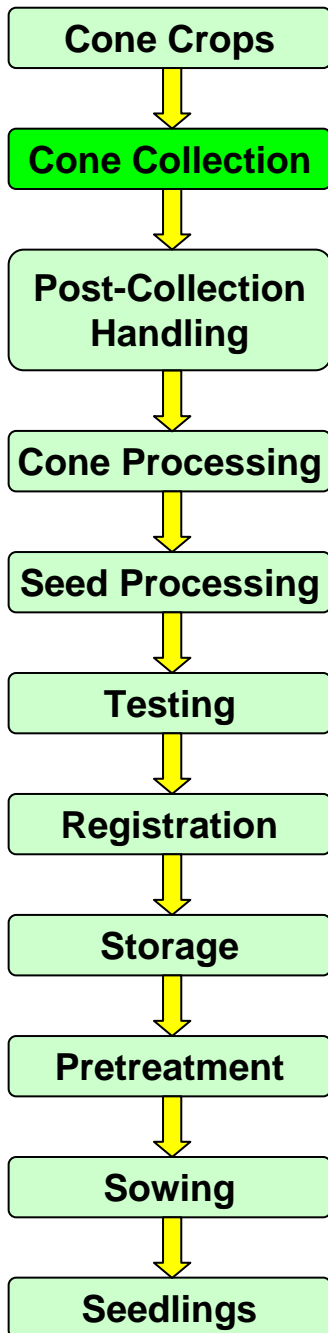


## Crop Protection

- We frost protect orchard crops thru the use of either under-crown irrigation or wind machines or in conjunction
- We chemically control for insect infestations of cone & seed insects. Primarily:
  - Midge (contarina) – all sites
  - Chalcid (megastigmus) – Turner, Medford
  - Cone Moth (barbara colifaxiana) – Medford
  - Cone Worm (dioryctria) – Medford, monitor Turner
  - Seed Bug (leptoglossus) – monitor

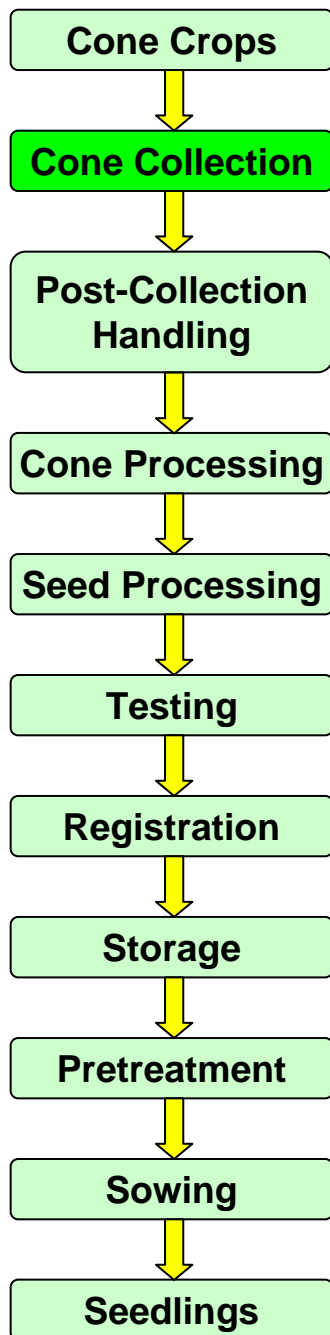
## Crop development

- Cone size has a dramatic impact on seed yield, germination and seed vigor. As a result we employ irrigation and fertilization programs to promote cone development, particularly in older orchards



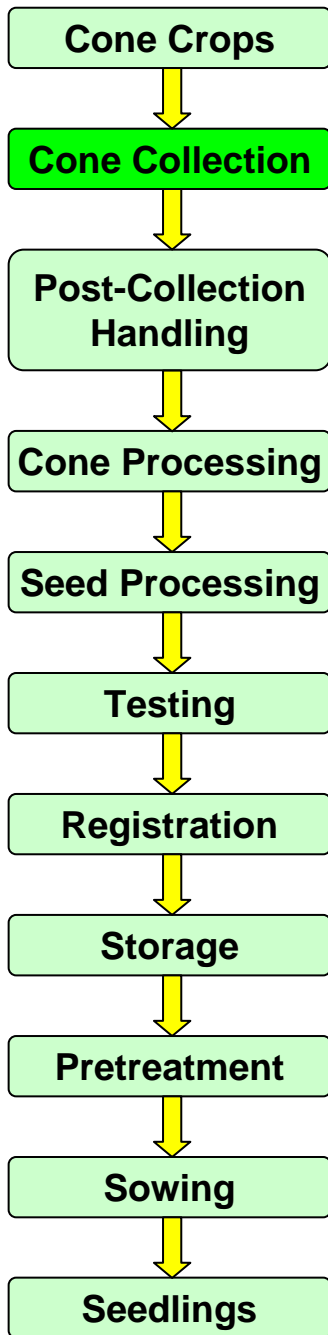
## Cone Collection

- Cone inventories are taken in early to mid July.
- A consolidated harvest plan is developed, based on current inventory and deviation from targets. Objective is to maximize the GV for internal use seed, provide contractual amounts and adjust market inventory.
- Cone harvest is initiated based on specific maturation criteria, which is consistently applied throughout the harvest on a parent/ramet basis.
- All harvest is from aerial lift equipment and cones are deposited directly into burlap bags. No cones are retrieved from the ground.
- Each bag is identified by parent and orchard position harvest date and picker.
- Bags are transported to the orchard cone storage facilities for processing.

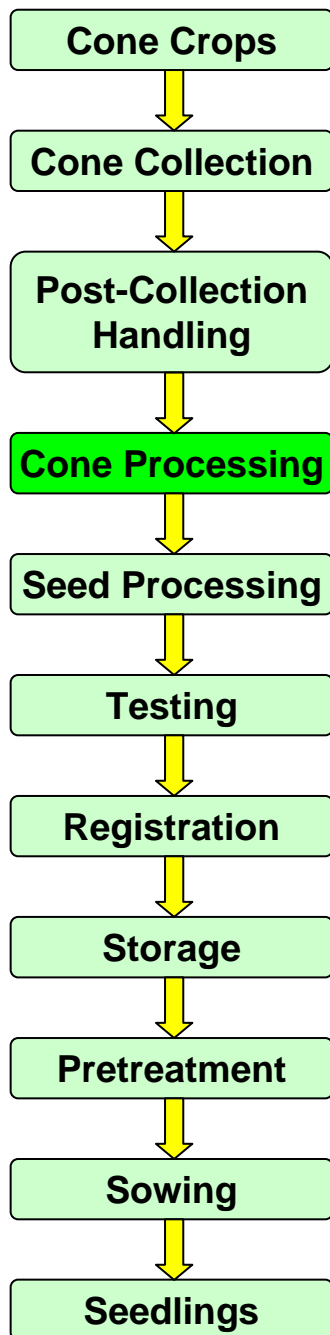


- Ramet Production Measurements  
All bags of a ramet are weighed for total weight and a random sample of 50 cones is weighed to determine cone production per ramet. A 20 cone sample is evaluated for maturation and cut count.
- Cone counts and maturation are registered to picker to assist in supervision, productivity and quality control of harvest crew.
- Ramet cone counts are utilized by orchard staff to monitor orchard productivity and ramet vigor issues.
- Aggregate of parent cone counts are utilized to build seedlots.
- Cones are racked for open air storage at the orchard.
- When cone moisture content is sufficiently low to avoid heating during transport, cones are sort by program and parent.
- All cones are inventoried, palletized and transported to Rochester Seed Plant for storage until processing.



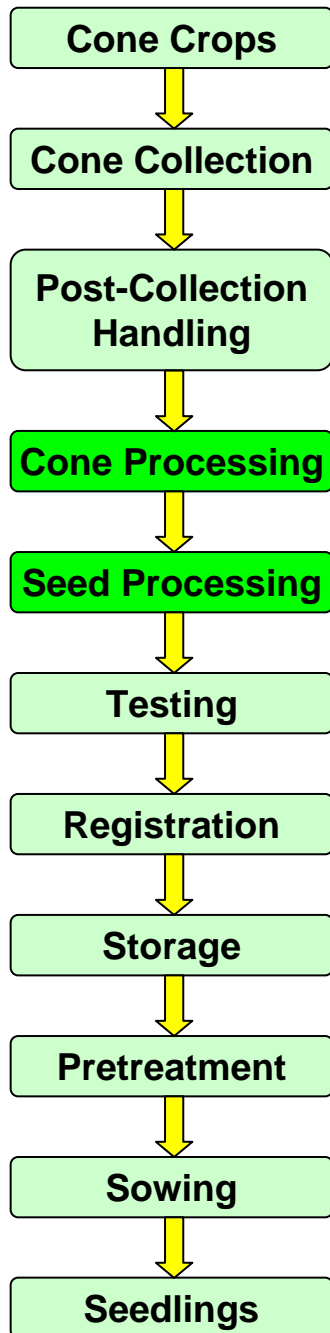


- Bushels and cone count data by ramet is transmitted to Rochester for consolidation.



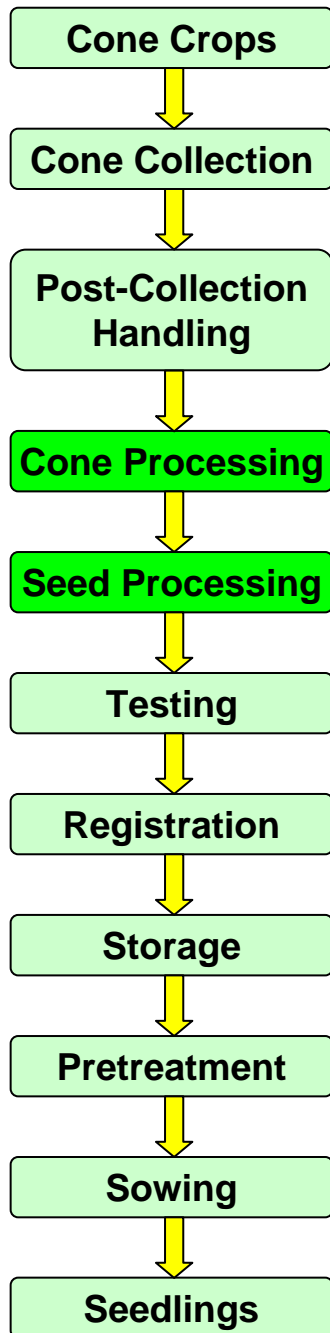
## Process Planning

- Harvest data is consolidated to breeding program, site, parent, GV (orchard lift), bushels and cone counts.  
\*orchard lift = (female BV + average male BV)/2
- Single family lots are identified  
≥ 10% GV over highest gain mixed lot  
must yield a minimum of 50 ktrees, truncate @ 1000 k
- Remaining cones are built into 1 to 3 mixed seedlots by program of varying GV.  
Component percentages are based on the sample weight basis cone counts derived at harvest.  
Objectives are to create 1 seedlot of maximum GV  
Minimum effective population of 10 (female component only)  
Limit spread of parental components to 10% orchard lift
- Priority order of processing established.  
Current year crop will be sown to bareroot in April.

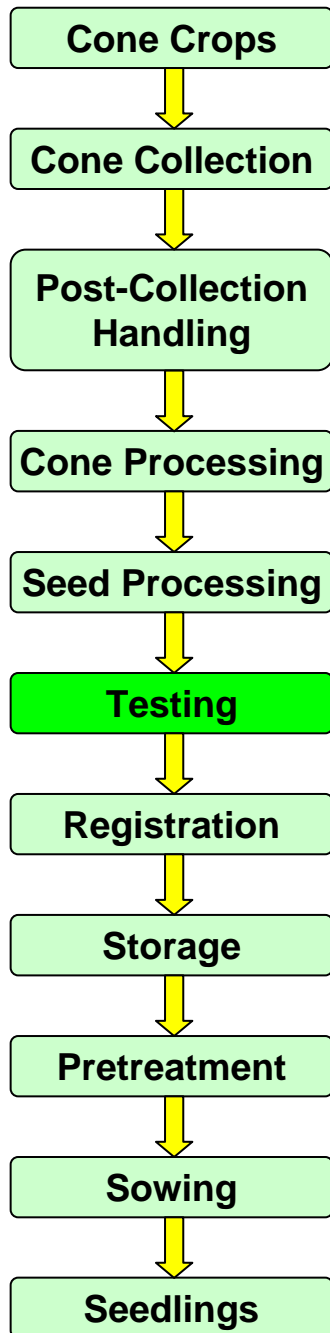


## Cone and Seed Processing

- Parents and specific bushel counts are located in the cone storage shed per seedlot recipe.
- Cones are soaked for uniform moisture content and to flex “hinge” for 12-14 hrs, then drained of free water.
- Kiln trays are loaded w/ 6 bu each. Kiln capacity = 144 bu (50 hl) /day
- Kiln trays are 6 high. Wet cones are loaded in the top 3 positions for 24 hr “pre-dry”, rotated to bottom 3 position for 24 hr final dry. Kiln operates at 100-110 F (40 C)
- After final dry cones are tumbled in a square tumbler to dislodge the seed.
- “Dirty” seed is then scalped on a 3 screen machine to remove large abrasive roughage and fine debris.
- Seed is dry dewinged
- Cleaning continues on oscillating screening machines until a uniformity of particle/seed size is achieved.
- Final cleaning is achieved on a pneumatic air column, removing light and heavy particles and empties from seed.
- Lot quality is determined by x-ray, re-cleaned as required.



- Small seed,  $\leq 7/64$  in, is removed prior to weighing and storage.
- Seed is tested for moisture content prior to storage, target = 6%, range 6-10%
- Seed is stored in our freezer at 0 F (-17 C)



- **Seed is tested for:**

Moisture content – target 6%, range = 6-10%

Purity - % seed vs non-seed particles, target = 99+%

Seed per lb - based on 500 seed weight

Germination – target 90%+

5 x 100 seed replicates

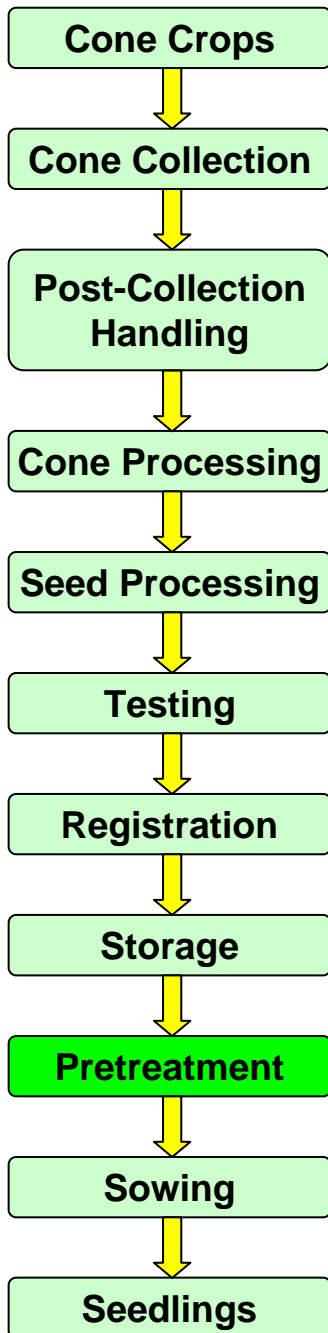
on moistened perlite

21 day chill at 3 C

germinated at:

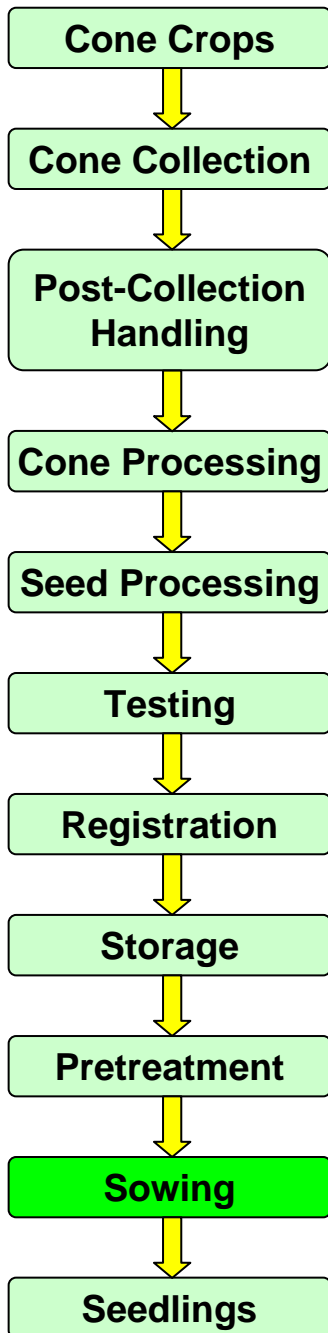
20 C for 16 hr - dark, 30 C for 8 hr - light

4 weekly counts



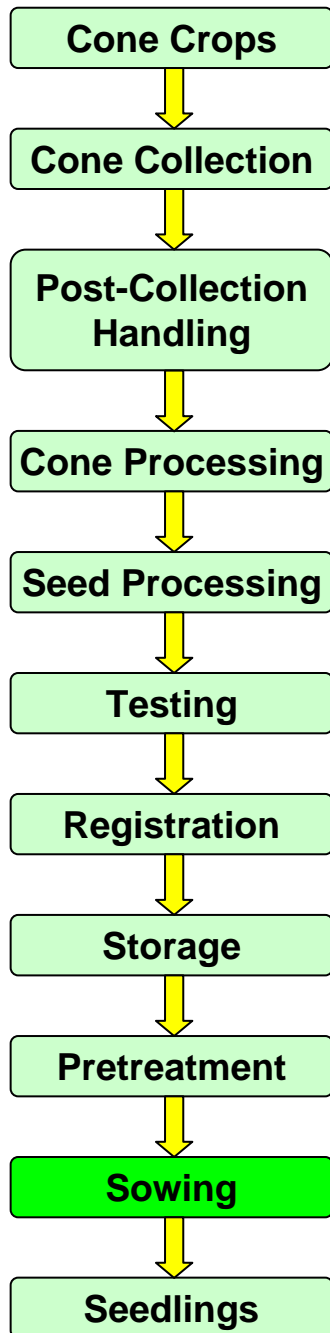
## Stratification

- Large seed species  
Aerated and/or continuous running water soak for 24 hr  
Individual 5 gallon containers, sanitized between lots  
Bagged in ~5 lb quantities  
Placed in stratifier at 1-2 C  
“Massaged” every other day
- Small seed species  
“Bucket” imbibed  
Individual plastic bag lined buckets  
Seed in mesh bag and soaked for 24 hr  
Bagged in .5 - 5 lb quantities  
Placed in stratifier at 1-2 C  
“Massaged” every other day
- Surfaced dried prior to delivery to growing facility.
- Fungicide treatment applied



## Sowing/Growing

- Sow order requests are received from each of the 12 internal foresters, defining species, stock type, seed type (family or mix), deployment elevation and order volume.  
Specific seed item and seedlot are assigned by seed mgr to maximize use and GV.
- Internal growing facilities get to set their own over-sow factors  
Seed/seedling utilization in the bareroot system is ~2:1  
Seed/seedling utilization in the container system is ~1.65:1
- Historical yield data is tracked by like seed groups or individual families to assist in determining over-sow
- Seed/cell (containers) is usually a function of species and germination rate and financial driver of fully utilizing greenhouse space. Some void cells can be tolerated when thinning cost exceeds common cost allocation based on trees /sq ft  
**exception** – ALL A-class Df is sown at 1 seed/cell
- All growing media in containers is pasteurized  
All sow fields in bareroot have been fumigated



- For orchard produced A-class seed, the driver for efficient seed utilization by the growing facilities is cost, which has become a significant proportion of seedling cost, not sufficient availability.