# Nursery Inventory – Theory, Methods, and Practices

## Auburn University Cooperative Short Course

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# Presentation Outline

- Why do Nursery Inventories
- Bare Root Nursery
  - Following Sowing/Transplanting
  - History Plots
  - Spring Inventory
  - Fall Inventory
  - Packing/Shipping
  - Hardwood Seedling Inventory
- Container Nursery
  - Following Sowing/Transplanting
  - History Plots
  - Spring/Fall Inventory
  - Packing/Shipping
- QC/QA Program



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# Sowing VS Transplanting



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# Types of Inventories

- Seed Inventory
- Sowing/Transplant Inventory
- Seedling Inventory
  - Spring
  - Fall
- Mini-plug Inventory
  - Arrival at Nursery
  - Spring
  - Fall
- History Plots
- QC/QA
  - Field
  - Bag/Box

# Why Do a Seedling Inventory?

- Seed Inventory
  - Orchard Managers – Cone Collections
- Seedling are sold on a per hundred or per thousand basis
  - Procedures used to determine number of seedlings
- Inventory conducted twice yearly
  - Spring Inventory and Fall Inventory
- Help determine problem lots
  - Poor germination
  - Slow germination
- Assist in Management practices
  - Top-pruning
  - Fertilization
- History Plots
  - Historical Data
- QC/QA

# Determining Seedling Numbers

**Number of Seedling in the Field**

**Number of Seedling per Bag**




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# Determining Seedling Numbers

**Number of seedlings in the field**

**Number of seedlings per box**




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# Bare Root Nurseries



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# Following Sowing or Transplanting

- Inventory pounds of seed sown/mini-plugs transplanted
- Create a bed map
  - Family/Line ID
  - LBF
- Sowing inventory (sowing issues/poor germination)
- Transplant inventory – (Frame Counts)
  - Machine Problems
  - Mini-plug Issues
- Establish History Plots



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# History Plots – Bare Root Nursery

- Established to track survival and crop development
- Develop growth models
- Above Ground Measurements Include:
  - Survival
  - Height
  - RCD
  - Shoot dry weights
- Below Ground Measurements Include
  - Number of primary and secondary roots
  - Primary Root Length
  - Root dry weights
- Nutrition Analysis
- Root:Shoot Ratios
- QC/QA Program



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# History Plots


**<u>Right</u> -Established History Plots**

**<u>Below</u> – Height Measurements**




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# Establishing and Measuring History Plots

- Somatic Seedlings
  - Plot established every 300’
- Four foot x One foot plot established
- Plots established after sowing or transplanting
- Survival
  - Weekly the first four weeks following germination or transplant
  - Every four weeks following
- Height
  - Begin 6$^{th}$ week following germination or 4$^{th}$ week following transplant
- RCD
  - Begin measurement once base has lignified
- QC/QA measurements described earlier are taken during lifting season

- **EXAMPLE SPREAD SHEET**



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# SPRING INVENTORY



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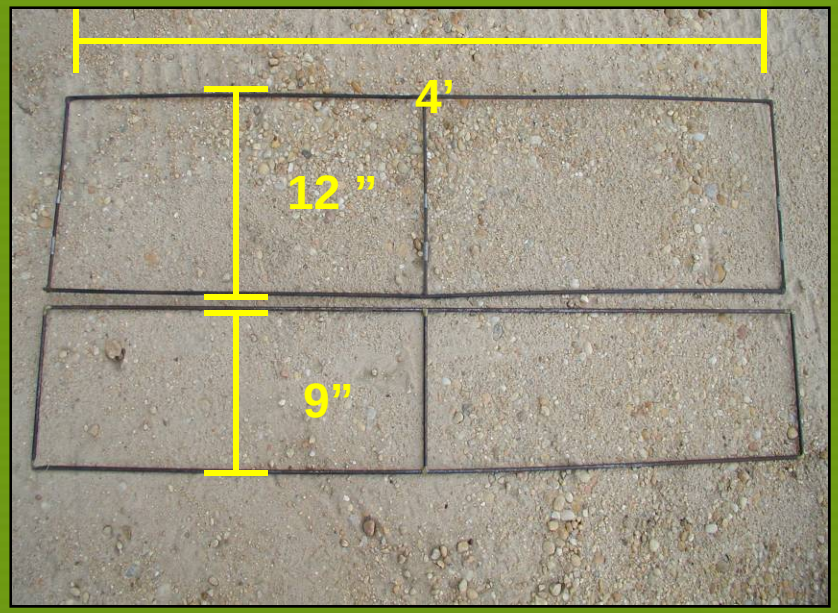
# Remember…..Planning is Critical

# Seedling Inventory Sampling Frame

Sampling frames

- 4 ft in length
- 6, 9, or 12 inches in width



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# Spring Inventory

- Conducted in June/July
- Determine seedbed density (seedling/linear bed ft)
- Determine total linear bed footage for each seedlot (changes since transplant inventory)
  - Washout
  - Fertilizer Burn
- Spring inventory
  - Determine germination rates
    - Some lots do better than others
  - Help determine number of seedlings for allocation
    - Internal use
    - Outside Sales

# Spring Inventory - Field Procedures

- Twenty-five (25) linear bed foot (4’ x 1’) plots should be sampled from each nursery seed source.
  - A rigid 4 foot by 1 foot sampling frame should be placed perpendicularly across the seedbed to define each sample plot.
- Sample plot locations should be evenly spaced across each nursery seedlot.
  - The precise spacing between plots should be determined by dividing the total seedlot bed footage by 25 (the total number of plots).
  - A plot should not be placed any closer than forty (40) feet and no further than two-hundred (200) feet from one another.
- The first plot placed in each seedlot should be randomly located in the first fifteen (15) feet of bed space occupied by that seedlot.
- **HANDOUT** – Random Number Generator

# Spring Inventory – Field Procedures

- Each sample plot location should be recorded and labeled using the nursery field (unit) number, the unit (section) number, the bed number (within the unit/section), and the location, in feet, along the bed.
- On each sample plot, the total number of seedlings should be counted and recorded for both the left and right half of the sampling frame.
- Since the inside dimension of the sampling frame should be 1 foot along the bed, any seedlings that are bent outward by the frame should not be counted. Seedlings that touch the frame, but are inside the frame, should be counted as in the plot.

# Inventory – Field Procedure



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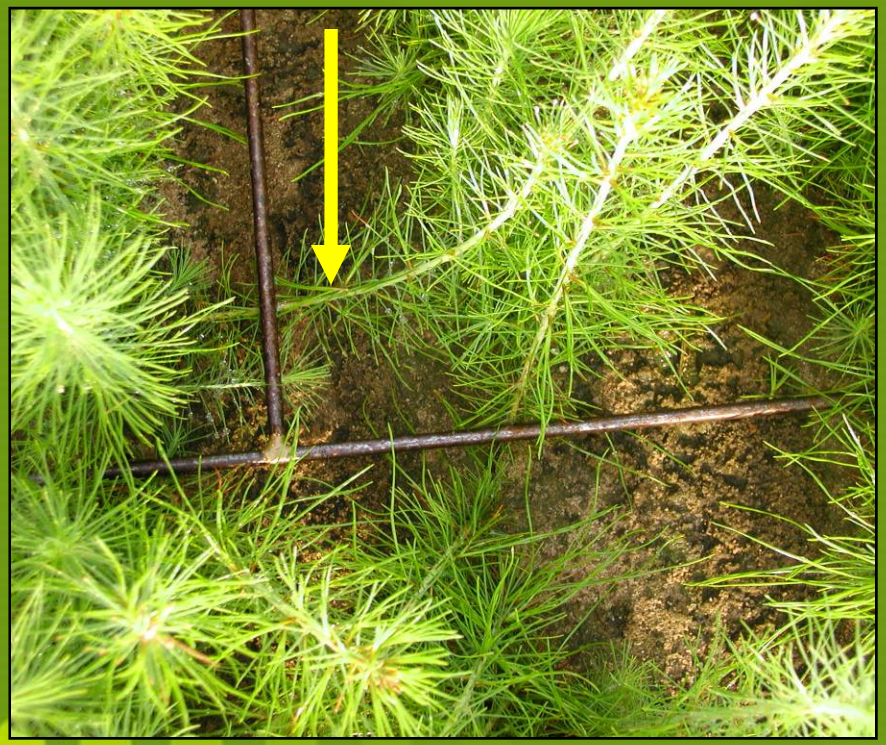
# Included in Inventory or Not?

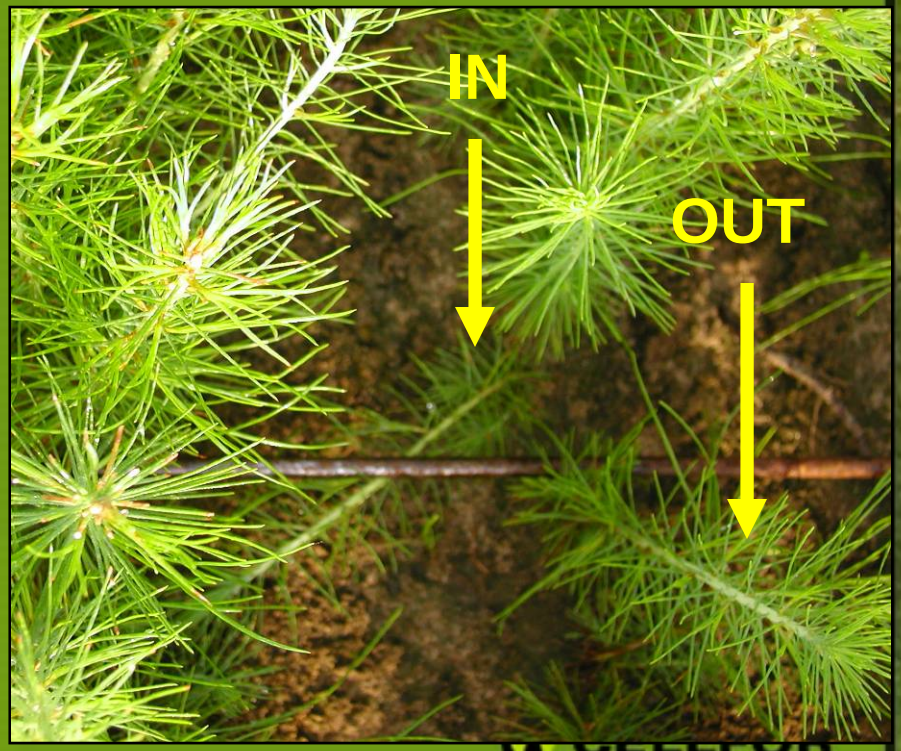
**Example 1:**

**Even thought this seedling appears to be in the right side of the frame it would be recorded as being on the left.**



**Example 2:**

**Even though a majority of the seedling on the left lies outside the frame, the base of the seedling originates inside the frame and therefore is counted.**



# Spring Inventory – Data Analysis

- **# Pure Live Seed**
  - Seed/lb x total lbs
- **Seedlings/LBP**
  - Average Plantable per frame (Left plot totals + Right plot totals)
- **Spring Inventory Totals**
  - Seedling/LBF * Total LBF
- **Approximate Germination**
  - Spring Inventory Totals/# Pure Live Seed
- **95% of Spring Inventory (estimated cull rate)**
  - Approximate Germination * 0.95

- **EXAMPLE SPREAD SHEET**



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# Fall Inventory



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# Fall Inventory

- **Nursery manager should survey the crop prior to designing the inventory and make any needed adjustments to nursery seedlot ID that are warranted**

- Designing the seedling inventory
  - MOST IMPORTANT PART OF THE INVENTORY
  - Done in the Spring inventory, but more important for the Fall Inventory

# Fall Inventory

- Conducted in September
- Goal is to provide estimates of the number of seedlings per linear bed foot for each seedlot
- Final estimates should have an allowable error (AE) of not more than $\pm$5% of the seedlot mean, calculated using an $\alpha$=0.05 probability level
- Any adjustments to the total number of bed feet in each seedlot should be noted at this time.

# Designing Seedling Inventory

**GOOD GERMINATION**

**POOR GERMINATION**

# Designing Seedling Inventory

- When germination is high and consistent across the entire seed lot:
  - Seedlot does not have to be divided
  - Observed precision should be low
  - No additional plots will be required

- When germination is poor or seedlots are inconsistent:
  - Seedlot will need to be divided up
  - Observed precision will most likely be > 5%
  - Additional plots may be requires

# Fall Inventory – Field Procedures

- Twenty-five (25) linear bed foot (4’ x 1’) plots should be sampled from each nursery seed source.
  - A rigid 4 foot by 1 foot sampling frame should be placed perpendicularly across the seedbed to define each sample plot.
- Sample plot locations should be evenly spaced across each nursery seedlot.
  - The precise spacing between plots should be determined by dividing the total seedlot bed footage by 25 (the total number of plots).
  - A plot should not be placed any closer than forty (40) feet and no further than two-hundred (200) feet from one another.
- The first plot placed in each seedlot should be randomly located in the first fifteen (15) feet of bed space occupied by that seedlot.

# Fall Inventory – Field Procedures

- Sample plot locations are recorded and labeled as with the Spring inventory
- On each sample plot, the total number of seedlings **and culls ( <3.2 MM RCD or Forked)** should be counted and recorded for both the left and right half of the sampling frame.
- Since the inside dimension of the sampling frame should be 1 foot along the bed, any seedlings that are bent outward by the frame should not be counted.  Seedlings that touch the frame, but are inside the frame, should be counted as in the plot.

# Fall Inventory – Data Analysis

- **Calculated the same as with the Spring inventory**
  - # Pure Live Seed, Seedlings/LBF, Fall Inventory Totals,
- **Cull percentage**
  - (Total Culls/Total Plantables) * 100
- **Total Plantables**
  - Mean Plantables * LBF
- **CV, Observed Precision, and Additional Plots can then be determined**

# Statistical Terms

- **Coefficient of Variation (CV)** – measures the variability in the values in a population relative to the magnitude of the population mean.
  - CV = ($\sigma$/|$\mu$|)*100
  - Where: $\sigma$ is the sample standard deviation and
    $\mu$ *is the sample mean*

Example:

1) 34,17,24,28,25,28,33,13, and 40; $\mu$ = 26.9
2) 24,27,26,28,27,29,26,26, and 28; $\mu$ = 26.8

# Statistical Terms

- **Observed precision of the mean:**
  - *Sqrt* of $[(4*CV^2)/n]$
  - Where n = the number of sample plots
- The result is the calculated percentage error estimate for the mean
- If the value calculated is less than 5 than no additional plots are needed
- If the value calculated  is greater than 5 additional plots will be required
- **To determine the number of additional plots solve for n,**
  - where n = $[(4*CV^2)/25]$

- **EXAMPLE SPREAD SHEET**



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# Additional Sample Plots

- Plots should be allocated and located in a manner similar to those used in the initial samples
- The data from the additional plots should be added to original data and re-analyzed
- If additional plots still don’t lower the observed precision below the 5% error than
  - Seedlot should be divided up and seedling inventory completed again
  - Additional plots may be required

# Pack in Field vs Packing Line

- Two types of packing in a bare root nursery
  - Field Packing
  - Packing Line
- Field Packing
  - Pack all seedlings in the field
  - Shippables vs Culls
- Packing Line
  - Seedlings lifted in field
  - Sorted in packing house
  - Shippables vs Culls

# Field Packing

**Seedlings are lifted on a LBF basis. The seedling inventory provides the nursery manger with an estimate of shippable and non-shippable (cull) seedlings; thus the manager knows the number of seedlings being shipped.**

# Packing Shed and Line

**As with field packing, seedlings are lifted in the field on a LBF basis. Seedlings are then brought to a packing shed and sorted with the culls being removed. Inventories allow managers to know culls in the field and culls missed on the line.**



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# Double Checking Your Numbers

- A pre-determined number of bags will be checked from each seedlot
- All the seedlings are removed from the bag and counted
- Numbers of physical counts are compared to estimated seedling inventory numbers
- If numbers are statistically different than seedling inventory will have to be re-done
- Very important for seedling sales and auditing purposes


**<u>Above</u>: Seedlings are being quality checked**



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# Hardwood Seedling Inventory

- Use the 9 inch sampling frames
- Samples collected every 40 ft
- A minimum of 10 samples is required
- Troubled areas are divided up
  - Deer browse
  - Poor Germination
- Analysis completed as with pine seedlings

# Hardwood Seedling Inventory

# Container Nurseries



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# Following Sowing or Transplanting

- Inventory pounds of seed sown/mini-plugs transplanted
- Create a bench/pivot map
  - Family/Line ID
  - Number of trays
- Sowing inventory (sowing issues/poor germination)
- Transplant inventory
- Establish History Plots

# History Plots – Container Nursery

- Established to track survival and crop development
- Develop growth models
- Above Measurements Include:
  - Survival
  - Height
  - RCD
  - Shoot dry weights
- Container Measurements Include
  - Number of primary and secondary roots
  - Primary Root Length
  - Root dry weights
- Root:Shoot Ratios
- QC/QA Program



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# History Plots

**<u>Left</u> – History Plots Established**

**<u>Below</u> – Height Measurements**




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# Establishing and Measuring History Plots

- Somatic Seedlings
  - Plot established every 6 rows
  - Third tray in from edge
  - Randomly select row
  - Every seedlings from some trays can be sampled
- Plots established after germination or transplanting
- Survival
  - Weekly the first four weeks following germination or transplant
  - Every four weeks following
- Height
  - Begin 6$^{th}$ week following germination or 4$^{th}$ week following transplant
- RCD
  - Begin measurement once base has lignified
- QC/QA measurements taken during lifting season

# Spring and Fall Inventory

- Spring Inventory conducted in June/July
- Fall Inventory conducted in late September
- Determine tray density
- Inventory
  - Determine germination/survival rates
    - Some lots do better than others
  - Help determine number of seedlings for allocation
    - Internal use
    - Outside Sales

# Inventory - Field Procedures

- Thirty (30) rows should be sampled from each nursery seed source.
  - Within each row 1 tray should be randomly selected
- Sample plot locations should be evenly spaced across each nursery seedlot.
  - The precise spacing between plots should be determined by dividing the total rows by 30 (the total number of plots).
  - A plot should not be placed any closer than four (4) rows and no further than ten (10) rows from one another.
- The first plot placed in each seedlot should be randomly located in the first five (5) rows of the seedlot.

# Inventory – Data Analysis

- **Assume that every cell is filled**
- **Total # of Trays**
- **Seedlings/Tray**
  - **Average of germinated/surviving seedlings**
- **Spring Inventory Totals**
  - Seedlings/Tray*Total # of trays
- **Calculate CV and Estimated Precision**

- **EXAMPLE SPREAD SHEET**



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# Packing and Shipping


- Same number of seedlings packed per box
- QC/QA packers is conducted as with bare root seedlings




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# QUESTIONS?

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