Nursery Inventory – Theory, Methods, and Practices

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Presentation Outline

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

Why Do a Seedling Inventory?

- Seed Inventory
  - Preparation for sowing
- 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 or areas
  - Poor germination
  - Slow germination
  - Chemical damage
  - Pest damage
- Life History Plots
  - Assist in Management Practices
  - Historical Data
- Lifting/Packing Inventory
  - Box/Bag Counts

Determining Seedling Numbers

Types of Inventories

- Seed Inventory
- Sowing Inventory
- Seedling Inventory (Bareroot/Container)
  - Spring
  - Fall
- Shipping/Packing Inventories
  - Field
  - Bag/Box

Seed Inventory – Why It's Important

- Seed Size (XS, S, M, L, XL)
- Lbs of Seed
- Seed/lb
- Germination
- Purity
- Estimating Viable Seedlings Prior to Sowing:
  - Lbs*Seed/Lb*Germination*Purity
- Nursery Factor
  - Varies by Nursery and Seedlot (Typically 85%)
- Provides Estimate for Shippable Seedlings

Sowing Inventory

- Importance of Knowing
  - Seed Size
  - Seed/Lb
  - Germination
- Inventory Plots
  - Density Accuracy
  - Uniform Germination
- Used to generate nursery bed maps

SEEDLING INVENTORIES

Bare Root Nurseries

Following Sowing

- Confirm sowing inventory matches seed inventory
  - Keep good notes in the field
  - Find mistakes early
- Monument Field/Unit/Beds – Family Changes
- Create a bed map
  - Family ID
  - LBF
- Establish History Plots
  - Inventory (Sowing or Germination Issues)
  - Seedling Quality
- Update if needed following weather invents
  - Heavy Rains (washouts)
  - Hail Damage (Germination/Seedling Damage)

Life History Plots – Bare Root Nursery

- Established to track survival and crop development
- Above Ground Measurements Include:
  - Survival
  - Height
  - RCD
  - Shoot dry weights
- Below Ground Measurements Include
  - Number of primary and secondary roots
  - Tap root length
  - Primary root length
- Nutrition Analysis
- “Operational Research”
- Seedling Quality Program

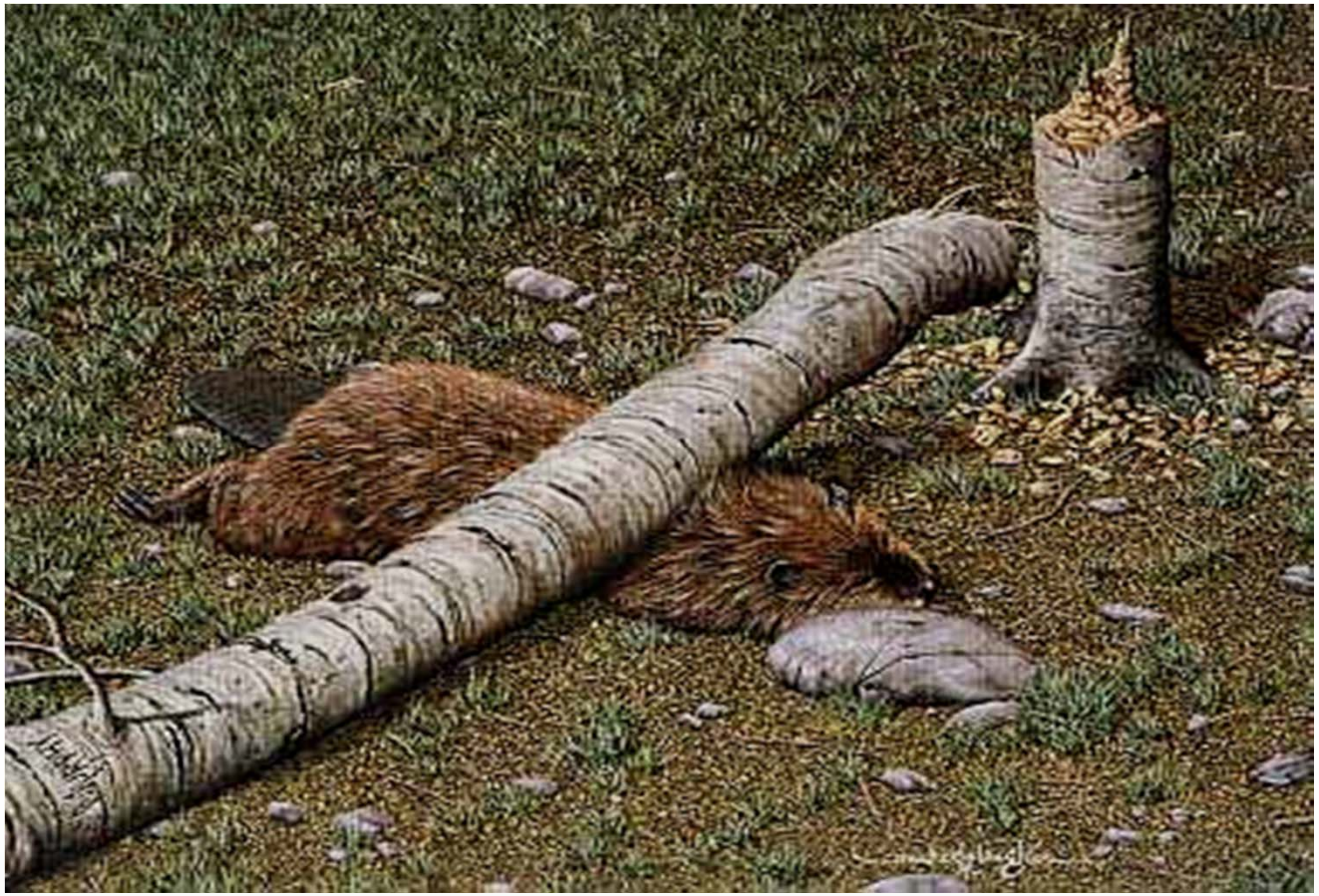
Life History Plots

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

<u>Below</u> – Height Measurements

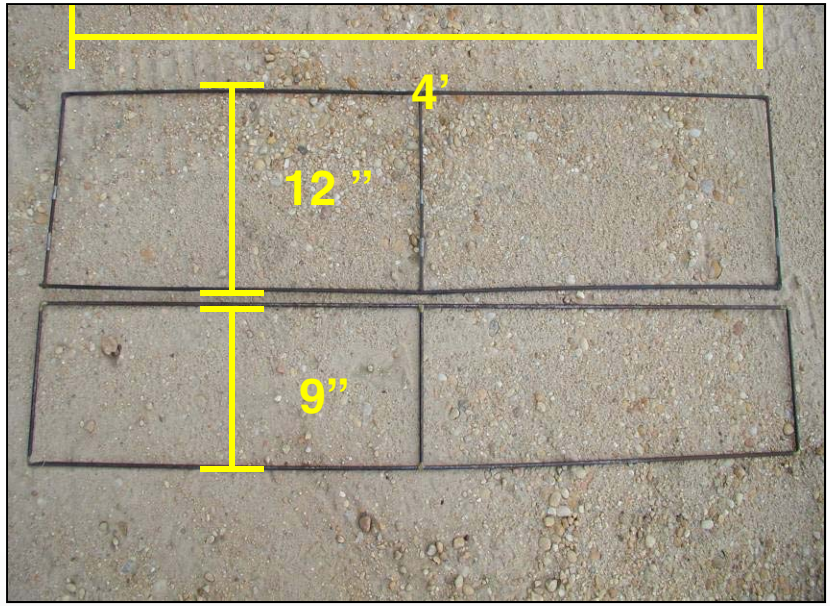
SPRING INVENTORY

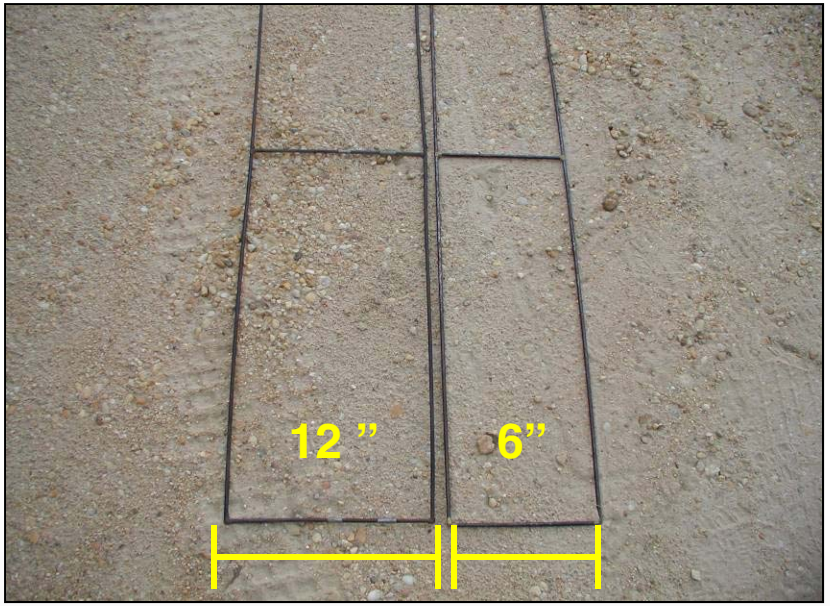
Remember.....Planning is Critical



Seedling Inventory Sampling Frame

- Sampling Frames
  - 4 ft in length (i.e. bed width)
  - 6, 9, or 12 inches
- Type of frame may vary depending on what's being sampled





Sampling Frames - Advantages/Disadvantages

6” or 9” Frame

- Advantages
  - Better on smaller lots
  - Allows you to put in more plots across the nursery
  - “Operational Research”
  - More useful in areas with lots of variation
  - Tends to provide a more accurate inventory
- Disadvantages
  - Can take longer compared to 12” frame

12” Frame

- Advantages
  - Better on larger lots
  - Allows you to put in less plots across the nursery
  - Faster then smaller frames
  - Typically provides more data points then smaller frames
- Disadvantages
  - Typically not as accurate as smaller frames
  - Not as useful in areas with lots of variation

Spring Inventory

- Conducted in June/July
- Confirm seedbed densities (seedling/linear bed ft)
- Update or confirm nursery bed footage
  - Washout
  - Mechanical damage
  - Pest/Disease
- Estimate germination rates
  - Do they match the germination tests
  - Family trends year to year
  - Slow or poor germination (genetics/stratification/weather)
- Improved inventory for seedling allocation and sales
- First assessment of crop development
  - Determine areas of concern

Spring Inventory - Field Procedures

- Refer to Handout
- 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 (i.e. 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
  - Need to account for beginning and end of beds
  - Avoid areas not representative of the crop

Spring Inventory – Field Procedures

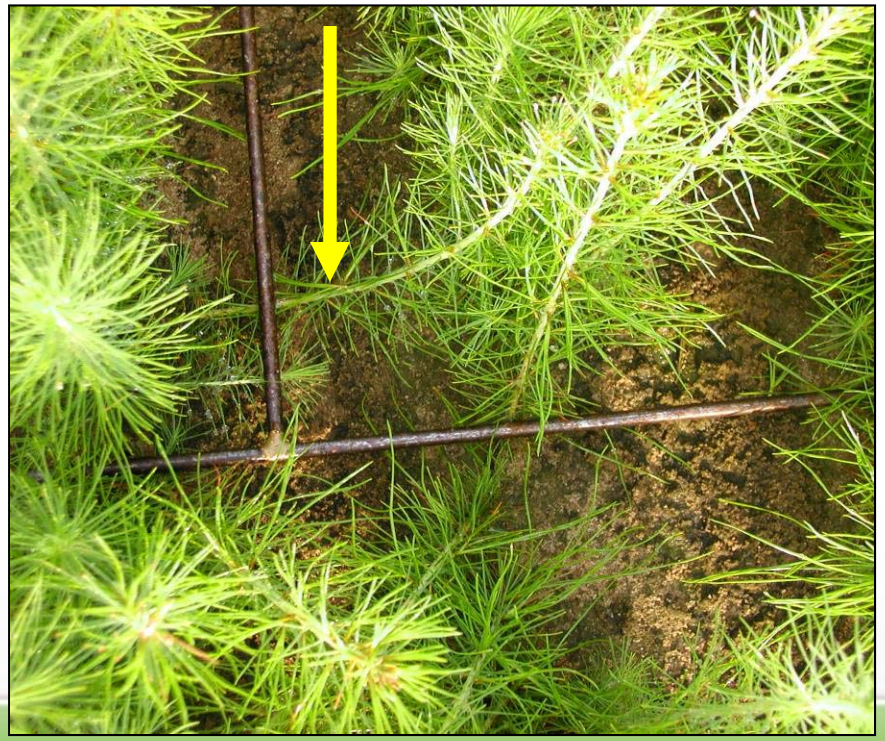
- Each sample plot location should be recorded using the nursery field, unit, bed numbers and the location, in feet, in the bed being sampled.
- On each sample plot, the total number of seedlings should be counted and recorded for both the left and right half of the sampling frame.
- Since the inside 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

Included in Inventory or Not?

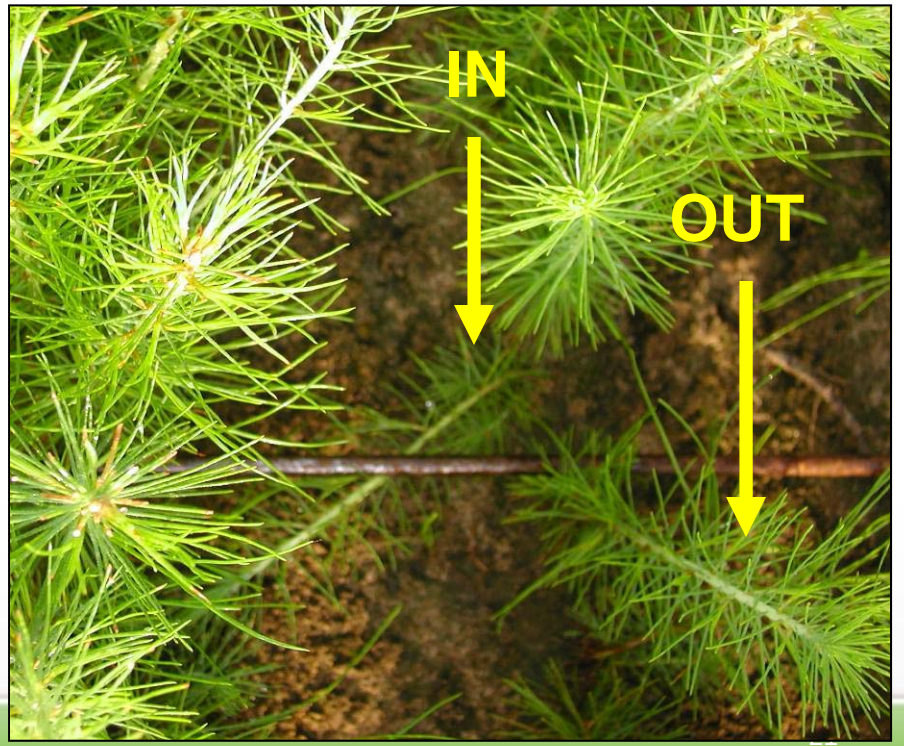
Example 1:

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)
- Actual LBF
- Spring Inventory Totals
  - Seedling/LBF * Total LBF
- Approximate Germination
  - Spring Inventory Totals ÷ Pure Live Seed
- 95% of Spring Inventory (estimated cull rate)
  - Spring Inventory Totals * 0.95

- Sample Spring Seedling Inventory.xlsx
  - Identifying an issue within a seedlot
  - Good germination
  - Poor germination

Fall Inventory

Fall Inventory

- **Nursery manager should survey the crop prior to designing the inventory and make any needed adjustments 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/October
- 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 α=0.05 probability level
- Any adjustments to the total bed footage for each seedlot should be updated 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
  - Need to account for beginning and end of beds
  - Avoid areas not representative of the crop

Fall Inventory – Field Procedures

- Sample plot locations are recorded and labeled the same way as the Spring Inventory

- On each sample plot, the total number of seedlings and the total number of culls 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

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: σ is the sample standard deviation and
    μ *is the sample mean*

- Does the sample mean tell the whole story?
  - 1) 34,17,24,28,25,28,33,13, and 40; $\mu = 26.9$; $|\mu| = 8.41$
  - 2) 24,27,26,28,27,29,26,26, and 28; $\mu = 26.8$; $|\mu| = 1.48$

- **Observed precision of the mean –** calculates the percent error around the sample mean
  - *Sqrt* of $[(4*CV^2)/n]$
  - Where n = the number of sample plots

Fall Inventory – Data Analysis

- Some variables are calculated the same as with the Spring Inventory
  - # Pure Live Seed, Seedlings/LBF, Actual LBF, Fall Inventory Totals
- Cull percentage
  - (Total Culls/Total Plantables) * 100
- Total Plantables
  - Seedling/LBF * Total LBF
- The Coefficient of Variation (CV) and Observed Precision can be calculated
  - If the observed precision is less than 5% than no additional plots are needed
  - If the observed precision is greater than 5% then additional plots will be required
- **To determine the number of additional plots solve for n,**
  - where n = $[(4*CV^2)/25]$

- Sample Fall Seedling Inventory.xlsx

Additional Sample Plots

- Once the number of plots is determined, they should be assigned in the same manner as the initial samples
- The data from the additional plots should be added to original data and re-analyzed
- If the additional plots still don't lower the observed precision below 5% then:
  - 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
  - Culls get packed
  - Additional bag counts needed to confirm inventory
  - 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.

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.

Double Checking Your Numbers

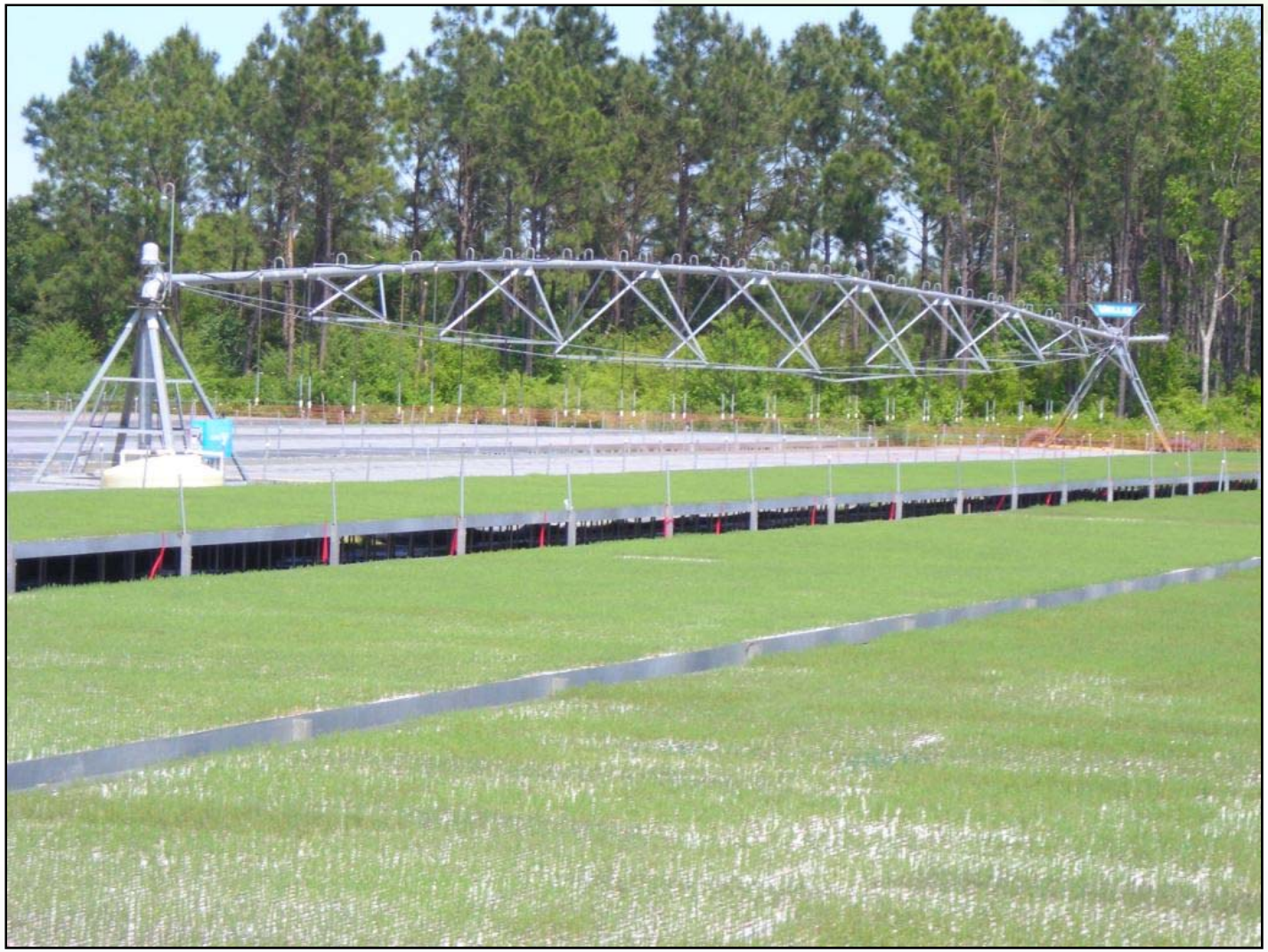
- A pre-determined number of bags will be checked from each seedlot
- All the seedlings are removed from the bag and counted
- Numbers of physical counts are compared to estimated seedling inventory numbers
- If numbers are statistically different than seedling inventory will need to be reassessed
-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

Hardwood Seedling Inventory

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

Hardwood Seedling Inventory

Container Nurseries



Following Sowing

- Confirm sowing inventory matches seed inventory
  - Keep good notes in the field
  - Find mistakes early
- Monument Pivots/Greenhouses/Benches – Family Changes
- Create Maps
  - Family ID
  - Total Number of Trays
- Establish History Plots
  - Inventory (Sowing or Germination Issues)
  - Seedling Quality
- Update if needed following weather invents
  - Heavy Rains (washouts)
  - Hail Damage (Germination/Seedling Damage)

History Plots – Container Nursery

- Established to track survival and crop development
- Above Ground Measurements Include:
  - Survival
  - Height
  - RCD
  - Shoot dry weights
- Container Measurements Include
  - Root development/Root Symmetry
  - Plug Fill
- Nutrition Analysis
- “Operational Research”
- Seedling Quality Program

History Plots

Left – History Plots Established

Below – Height Measurements

Spring and Fall Inventory

- Spring Inventory conducted in June/July
- Fall Inventory conducted in late September
  - Containers typically get shipped before bareroot
- Determine seedling density within the trays
- Estimate germination rates
  - Do they match the germination tests
  - Family trends year to year
  - Slow or poor germination (genetics/stratification/weather)
- First assessment of crop development
  - Determine areas of concern
- Improved inventory for seedling allocation and 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

- # Pure Live Seed
  - Assume that every cell is filled
- Total # of Trays
- Seedlings/Tray
  - Average of germinated seed
- Spring Inventory Totals
  - Seedlings/Tray*Total # of trays
  - Approximate germination
  - 95% of Spring Inventory (account for culls)
- Fall Inventory
  - Some variables are calculated the same as with the Spring Inventory
    - # Pure Live Seed, Seedlings/Tray, Actual Trays, Fall Inventory Totals
  - Cull percentage
    - (Total Culls/Total Plantables) * 100
  - Total Plantables
    - Seedling/LBF * Total LBF
  - Calculate CV and Estimated Precision
- Sample Fall Container Inventory.xls

Packing and Shipping

- Same number of seedlings packed per box
- Box counts for quality control are conducted in the same manners as bareroot seedlings in bags

QUESTIONS?