Seedling Inventory Procedures

Because tree seedlings are customarily sold and priced on a per hundred or thousand basis, it is crucial that the procedures used to determine the average number of seedlings in a bed or in a package be as accurate and precise as practical.

Spring Inventory

An initial inventory of all seedlots will be conducted eight weeks following sowing of each year. This inventory will result in an estimate of the seedbed density (seedlings per linear bed foot) and a measurement of the total number of linear bed feet for each distinct nursery seedlot. For inventory purposes, a nursery seedlot is defined as the smallest uniquely identifiable population of seedlings having a common genetic seed source. The Nursery Manager should carefully survey each seedlot prior to beginning the inventory process. Any noticeable patterns of density variation within a common genetic seed source should be used to subdivide that source into multiple, consistent nursery seedlots.

Once the seedling population has been subdivided into consistent nursery seed sources, each seed source should be sampled as follows:

1) Twenty-five (25) linear bed foot (4' x 1') plots should be sampled from each nursery seed source.
    a) A rigid 4 foot by 1 foot sampling frame should be placed perpendicularly across the seedbed to define each sample plot.
    b) 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.
    c) The first plot placed in each seedlot should be randomly located in the first fifteen (15) feet of bed space occupied by that seedlot. This can be readily accomplished by selecting random integers between one and fifteen for each seedlot prior to beginning the inventory.
    d) The location of each sample plot should be recorded and used as the sample plot identification number. This location identifier should consist of a concatenation of the nursery field (unit) number, the unit (section) number, the bed number (within the unit/section), and the location, in feet, along the bed. This within bed location measurement should be calculated from the same end of each bed within a nursery field (unit) and should be separated from the field, unit, bed information with a "-". As an example, if a plot falls 225 feet from the beginning of bed 3 in unit 5 of field 4, the appropriate plot ID number would be 453-225.
2) 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.
    a) Care should be taken to ensure that the sampling frame is placed firmly on the soil at a 90 degree angle to the direction of the bed.

b) 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.

3) Sample plot data should be entered into an MS Excel worksheet for analysis.
   a) Each row in the worksheet should contain the data from one sample plot.
   b) The first column in each row should contain the appropriate nursery seedlot identification code.
   c) The second column in each row should contain the sample plot identification code (concatenated field, unit, bed, distance).
   d) The third column of the worksheet should contain the number of seedlings counted in the left half of the sample frame.
   e) The fourth worksheet column should contain the number of seedlings counted in the right half of the sample frame.

4) The total linear bed footage for each nursery seedlot should be entered into a separate worksheet within the same MS Excel workbook.
   a) Each row in the worksheet should contain information about one nursery seedlot.
   b) The first column in each row should contain the appropriate nursery seedlot identification code. Care should be taken to ensure that this code exactly matches the code used on the inventory data worksheet.
   c) The second column in each row should contain the total linear bed footage, measured to the nearest foot, for the seedlot in question.

Fall Inventory

A second, independent inventory will be conducted in late September of each year. This inventory will consist of two phases and will have the stated goal of providing estimates of the number of seedlings per bed foot for each nursery seedlot. The 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 number of bed feet in each seedlot should be noted at this time. As in the spring inventory, the nursery manager should survey the crop prior to designing the inventory and make any needed adjustments to nursery seedlot ID that are warranted. The following specific procedures should be followed while conducting the inventory:

1) Twenty-five (25) linear bed foot (4’ x 1’) plots should be sampled from each nursery seed source.
   a) A rigid 4 foot by 1 foot sampling frame should be placed perpendicularly across the seedbed to define each sample plot.
   b) 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.

c) The first plot placed in each seedlot should be randomly located in the first fifteen (15) feet of bed space occupied by that seedlot. This can be readily accomplished by selecting random integers between one and fifteen for each seedlot prior to beginning the inventory.
d) The location of each sample plot should be recorded and used as the sample plot identification number. This location identifier should consist of a concatenation of the nursery field (unit) number, the unit (section) number, the bed number (within the unit/section), and the location, in feet, along the bed. This within bed location measurement should be calculated from the same end of each bed within a nursery field (unit) and should be separated from the field, unit, bed information with a "-". As an example, if a plot falls 225 feet from the beginning of bed 3 in unit 5 of field 4, the appropriate plot ID number would be 453-225.

2) On each sample plot, the total number of plantable and cull (<3.2 MM RCD or Forked) seedlings should be counted and recorded for both the left and right half of the sampling frame.
   a) Care should be taken to ensure that the sampling frame is placed firmly on the soil at a 90 degree angle to the direction of the bed.
   b) 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.

3) Sample plot data should be entered into an MS Excel worksheet for analysis.
   a) Each row in the worksheet should contain the data from one sample plot.
   b) The first column in each row should contain the appropriate nursery seedlot identification code.
   c) The second column in each row should contain the sample plot identification code (concatenated field, unit, bed, distance).
   d) The third column of the worksheet should contain the number of seedlings counted in the left half of the sample frame.
   e) The fourth worksheet column should contain the number of seedlings counted in the right half of the sample frame.
   f) The fifth column in each row should contain the number of culls counted in the left half of the plot. A zero should be entered when no culls are counted.
   g) The sixth worksheet column should contain the number of culls counted in the right half of the plot.

4) The total linear bed footage for each nursery seedlot should be entered into a separate worksheet within the same MS Excel workbook.
   a) Each row in the worksheet should contain information about one nursery seedlot.
   b) The first column in each row should contain the appropriate nursery seedlot identification code. Care should be taken to ensure that this code exactly matches the code used on the inventory data worksheet.

c) The second column in each row should contain the total linear bed footage, measured to the nearest foot, for the seedlot in question.

5) Summary statistics should be calculated for each seedlot. Prior to calculating these statistics, the left and right plot half values should be summed to obtain plot level values for plantable and cull seedlings. The following procedures should be used to determine if the desired level of precision has been obtained and, if not, how many additional sample plots will be required.
   a) An estimate of the mean number of plantable seedlings per linear bed foot should be calculated for each nursery seedlot. The appropriate estimator is obtained by dividing the sum of all plantable seedlings counted for each seedlot by the total number of plots counted in that seedlot.
   b) The coefficient of variation (CV) for each seedlot should be calculated by dividing the sample standard deviation into the sample mean and multiplying by 100.
   c) The observed precision of the mean estimate should be calculated by taking the square root of $\{(4*CV^2)/n)\}$, where n = the number of sample plots taken. The result is the calculated percentage error estimate for the mean.
   d) If the value calculated in 5(c) is less than or equal to 5, no additional plots are required. However, if the value calculated in 5(c) is greater than 5, additional plots will be needed. The estimated number of additional plots needed can be determined by solving the equation, $n = \{(4*CV^2)/25)$, for n where (25 is $\pm$5% squared).
   e) An estimate of the mean percentage of cull seedlings should be calculated for each nursery seedlot. The appropriate estimator is obtained by dividing the sum of all cull seedlings counted for each seedlot by the sum of all plantables and culls counted in that seedlot and multiplying the result by 100. It is not necessary to determine the precision of this estimate, since it is only used for informational purposes by the nursery manager.
6) Additional sample plots should be installed in those seedlots that do not meet the minimum precision requirements.
   a) These additional plots should be allocated and located in a manner similar to that used in the initial sample. Care should be taken to ensure that these extra plots do not fall in the same location as plots in the original sample.
   b) The data resulting from these additional samples should be combined with that from the initial sample and the statistical calculations and comparisons should be repeated as described in section 4.
   c) If additional plots are still indicated after these calculations have been completed, the magnitude of the potential error should be weighed against the cost of a third round of sampling. In very small or extremely variable nursery seedlots it may not be feasible to reach the desired level of precision. Large nursery seedlots that exhibit such high levels of variability should be re-examined to determine if they can be logically subdivided into more homogenous populations and resampled.
7) In an effort to verify and monitor the quality of the field data, a subset of nursery seedlots should be selected for auditing.
   a) The technical supervisor should randomly select two (2) of the larger nursery seedlots and two (2) of the smaller nursery seedlots to be audited at each nursery.

b) The nursery manager and a nursery technician not involved in the initial field counts should attempt to reconstruct all inventory plots in the nursery seedlots selected for audit. The recorded plot ID information should enable relocation of initial plots with a reasonable degree of accuracy.
c) Reconstructed sample plots should be counted using the same techniques that were used in the field inventory and the data should be recorded in a similar fashion.
d) The same statistical calculations that were applied to the field sample data should be applied to the audit data.
e) The upper and lower error bounds should be calculated for each nursery seedlot that was audited ([the square root of $\{(4*CV^2)/n)\}$]*the mean, added and subtracted from the mean).
f) If the estimate of the mean that was obtained from the field inventory falls between the upper and lower bounds on the audit mean, the original field estimate will be judged to be satisfactory.
g) If the estimate of the field inventory mean is not contained within the error bounds on the audit mean, the field inventory mean will be judged to be unreliable.
h) If all of the audited seedlot means are found to be satisfactory, the original field inventory will be accepted as accurate and will be used in the determination of seedling package contents.
i) If only one of the audited nursery seedlots is found to be unreliable, that estimate should be replaced by the audit estimate.
j) If more than one of the audited seedlot estimates is judged to be unreliable, the entire inventory will need to be repeated, with extreme care given to using proper field methodology.