Using History Plots to Improve Seed Use Efficiency and Fine-Tune Cultural Practices

By Thomas D. Landis

Every nursery uses some sort of inventory procedure to estimate how many seedlings will develop into shippable plants. History plots are unique in that they are permanent monitoring plots that are established in sections of a seedbed or in a block of containers at the time of sowing. History plots are not a new concept, as many different aspects of the history plot procedure have been used in forest tree seedling nurseries for years. Belcher (1964) provided one of the first published procedures for monitoring bareroot tree seedlings with history plots.

Efficient nursery management involves producing the maximum number of high-quality seedlings with the least amount of seeds. Often, however, seed and seedling losses are hard to identify and harder yet to quantify. Because sown seeds are buried, preemergence losses are hidden from view and even postemergence mortality happens so quickly that it often goes unnoticed. With history plots, the nursery manager can measure these losses empirically and obtain objective data on their amount and timing (Landis and Karrfalt 1987).

Sowing Factors

The major sowing factors and the associated seed and seedling losses can be illustrated by the example in Figure 1 and are defined as follows:

Pure live seed - This describes the percentage of a quantity of seeds that are expected to germinate after sowing.

Nursery loss factors - This accounts for the seeds and germinants lost due to damping-off and other diseases, insect and bird predation, as well as other losses during the crop cycle. These can only be measured with history plots.

Crop inventory - This is the total count of live plants at the end of the crop cycle as measured during the final inventory prior to harvesting. Some nurseries just use gross inventories whereas others estimate culling losses to produce a net inventory.

Cull factors - These are the plants that are discarded during grading because they are outside of size

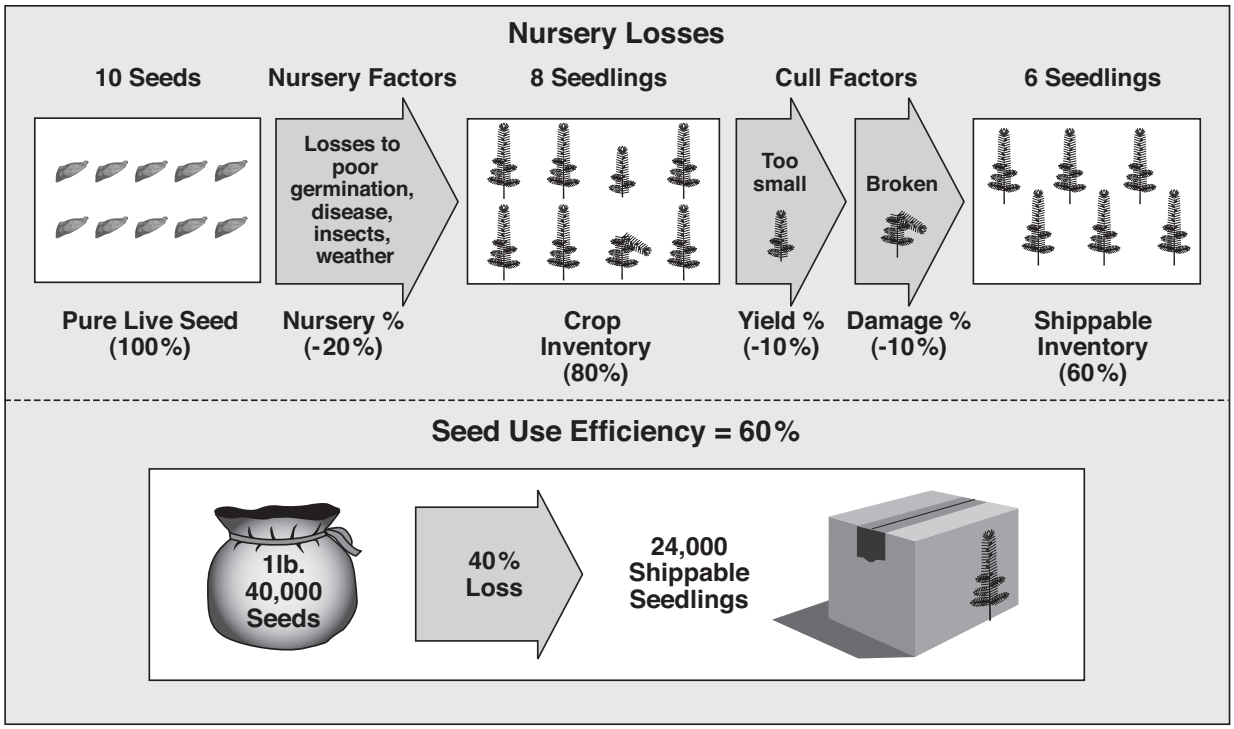

Figure 1 - History plots provide an accurate method of measuring losses that occur during the nursery crop cycle, and precisely calculate seed use efficiency.

specifications (Yield %) or damaged in some way (Damage %). These can be directly measured during grading or calculated by subtracting the shippable inventory from the crop inventory.

Shippable inventory - These are the plants that meet all specifications that will be packed and shipped to customers.

Seed use efficiency - The number of plants in the shippable inventory expressed as a percentage of the pure live seed.

In addition to supplying data on seed-use efficiency, history plots also provide several other immediate benefits to nursery management. Excavating sown seeds provides a check of seed drill or sowing equipment calibration and sowing depth.

Design and installation of history plots

The design of a history plot is unique in that it features a paired-plot design, which permits destructive sampling (Figure 2). Nondestructive, repetitive measurements such as live seedling counts and size measurements can be made throughout the crop cycle in Subplot 1, whereas one-time destructive measurements involving seed and seedling excavation are done in Subplot 2. In bareroot nurseries, history plots should be laid-out with the subplots side-by-side in the same seedbed with a narrow buffer zone between them. The subplots should extend across the full width of the seedbed to eliminate any possible variation between seed rows. The same concept can be applied to container nurseries; for example, one half of a Styroblock™ could be designated as for destructive sampling and the other used for long-term monitoring.

The ability to excavate and examine sown seeds is a unique feature of history plots. Although the approximate number of seeds that are sown per area of seedbed or container cavity can be estimated from sowing calculations, the only way to really know is to count them directly. Small seeds can be difficult to locate and separate from the soil in bareroot beds, but coloring the seed coat has made this job much easier. Fluorescent powders (Day-Glo 2010) are easy to apply to seeds and, because they are organic, do not interfere with germination (Landis 1976). Once the sown seeds are counted, they can be replanted in the container or seedbed. If they are carefully sown at the same depth, they will germinate and emerge normally. Container nurseries have a real advantage in that the sown seeds can more easily be extracted and resown in the destructive sampling subplot.

History plots should be monitored at regular intervals, at least one a month, beginning immediately after sowing and continuing until harvest. The fate of the sown seeds and emerged seedlings can be determined during each visit. After emergence is complete, the destructive plot can be sampled for ungerminated seeds, which can be bisected to determine if the seed is dormant or diseased. Decayed seeds give a direct and accurate measurement of pre-emergence damping-off, a statistic

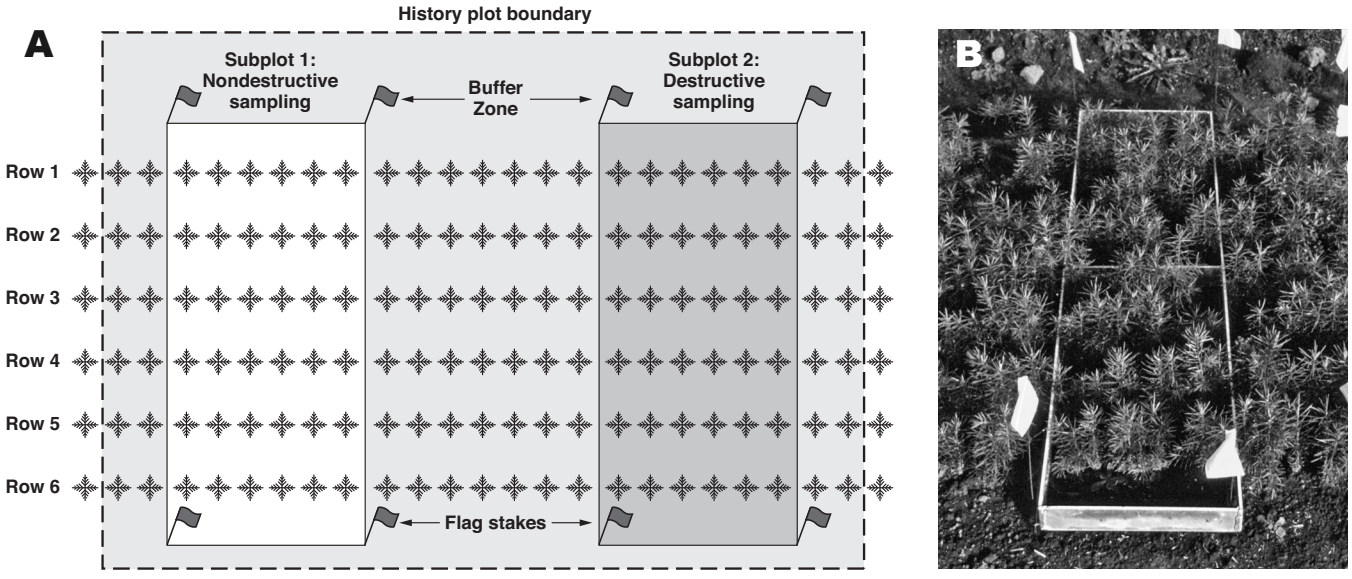

Figure 2 - History plots differ from normal inventory plots in that they feature a pair of subplots (A): destructive sampling is done in Subplot 2 immediately after sowing, whereas inventory plant counts and measurements are monitored in Subplot 1 through the growing season (B).

that could only be estimated by normal monitoring. Dead seedlings should be recorded and then removed during each visit to avoid possible confusion as to when the loss occurred. Damaged seedlings can be marked with colored toothpicks to see if they die between the monitoring visits. Close-up photographs during each visit will great aid in the diagnosis and, when viewed in sequence at the end of the growing season, present an excellent visual chronology of crop development. The history plot area can also be equipped with weather recording data which can be most useful in determining microsite conditions and diagnosing winter injury. Soil samples can be collected at the history plot locations during the growing season and analyzed for pathogen populations. This information can prove most useful in determining the efficacy of soil fumigation and other subsequent soil fungicide treatments later in the growing season.

Using History Plot Data in Nursery Management

Seed-use efficiency - A major benefit of history plots is that they can be used by nursery managers to develop or refine sowing calculations that govern sowing density and seed-use efficiency. Many nursery managers use sowing factors that were developed through years of experience but are not based on any actual measurements. Monitoring history plots yields specific information on the fate of sown seeds that can be used to adjust future sowing rates. The numerical data on seed and seedling losses have obvious applications the determination and refining nursery factors (Figure 1) that can be used in sowing rate calculations. Once the specific causes of the losses are identified, corrective actions can be taken to reduce or eliminate them completely. Although not often recognized, improving seed-use efficiency can have significant economic impacts, particularly with expensive seeds. South (1986) estimated that a southern forest nursery with an annual production of 30 million seedlings could realize a yearly savings of $15,000 by increasing seed-use efficiency from 50 to 55%.

Scheduling and evaluating cultural practices - The cost effectiveness of nursery cultural operations, such as seedbed fumigation that can cost well over $1,000 per acre, can also be critically examined through the use of history plots. When history plot data from Mt. Sopris Nursery in Colorado were analyzed, it was obvious that the greatest seed and seedling loss occurred during the germination and emergence period (Landis 1976). Direct observations during checks of the history plots and associated soil testing for pathogenic fungi identified the cause of the losses as damping-off and seed predation by birds. Consequently, regular seedbed fumigation was prescribed to reduce damping-off fungal populations, and early morning bird patrols were established to discourage bird predation.

Other cultural practices, like root pruning or top mow-

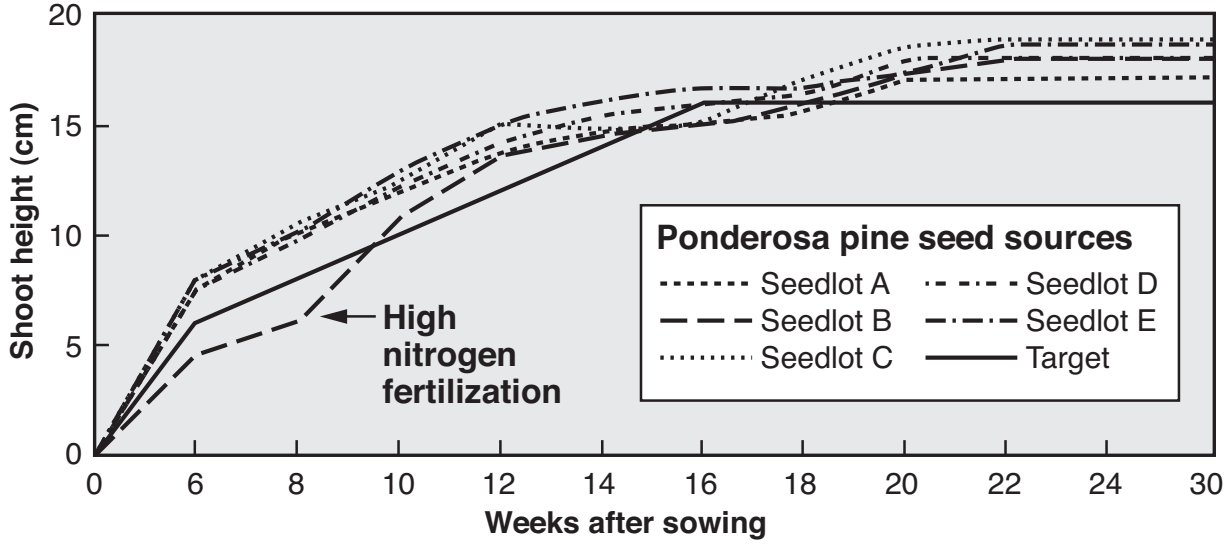

Figure 3 - Plant measurements taken during history plot monitoring can be used to construct detailed growth curves, which have many applications for nursery managers. In this example, a target height growth curve for ponderosa pine seedlings was developed using history plots from previous years. In this current crop, all seedlots performed well except seedlot B, so the nursery manager increased nitrogen fertilization to stimulate more height growth in those plants.

ing, have extremely narrow operational windows that must be carefully scheduled. Many nursery managers try to prune the roots of pine seedlings in the fall of the 1+0 year to sever the dominant tap root and stimulate a more fibrous root system. The timing of this operation is critical, however. If it is done too early, it may reduce shoot growth, but if it is done too late, the seedlings will not have time to reestablish a good root system and may undergo frost-heaving during the winter. The best time for root pruning, as determined from the history plot data, is a narrow time period after budset but before the fall root growth period.

Developing crop schedules - The plant height and stem diameter measurements made when monitoring history plots can be used to generate detailed seedling growth curves that illustrate the annual cycle of seedling growth (Figure 3). Not only do these growth curves provide an excellent visual representation of the timing of significant events, such as emergence, bud break, and bud set, but they can be used to help schedule cultural practices such as fertilizer applications. Nitrogen fertilizer should be applied early in the growing season, so that sufficient N is available during the rapid shoot growth period, but not so late that it could interfere with the onset of dormancy.

Problem solving - One of the most useful applications of the history plot procedure is for nursery problem solving. Installations of history plots in seedbeds of a particularly troublesome species or seed lot can provide invaluable information on the fate of the seed and seedlings during the crop cycle. Without the focused perspective provided by history plots, nursery managers often are unable to determine the specific causes of seed and seedling losses or poor growth (Figure 3).

Summary

The history plot technique has many applications in forest and conservation nurseries; it provides an excellent way to monitor seedling development and diagnose the true cause of injury and mortality. Although history plots often provide information to late for nursery managers to make any corrective treatment, this data can be used in future crops to improve seedling quality and nursery efficiency.

References

Belcher EW Jr. 1964. The use of history plots in the nursery. Tree Planters' Notes 64: 27-31.

Day-Glo. 2010. Day-Glo Color Corporation.Website. URL: http://www.dayglo.com (accessed 3 Aug 2010).

Landis TD. 1976. An analysis of seed and seedling losses at Mt. Sopris Tree Nursery. Lakewood (CO): USDA Forest Service, State and Private Forestry. Biological Evaluation R2-76-18. 7 p.

Landis TD; Karrfalt RP. 1987. Improving seed-use efficiency and seedling quality through the use of history plots. Tree Planters' Notes 38 (3): 9-15.

South DB. 1986. Economics of seed efficiency. Journal of Forestry 84(3):33-34.