Benefits and Techniques for Evaluating Outplanting Success

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Neumann, R. W.; Landis, T.D. 1995. Benefits and Techniques for Evaluating Outplanting Success. In: Landis, T.D.; Cregg, B., tech. coords. National proceedings, Forest and Conservation Nursery Associations. Gen. Tech. Rep. PNW-GTR-365. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 36-43. Available at: http://www.fcnanet.org/proceedings/1995/neumann.pdf

Abstract-Although outplanting information is essential to good nursery management, many nurseries do not have the time or funds to follow the survival and growth of their seedlings after they are outplanted. The benefits of evaluating outplantings are discussed along with types of sampling plots and an example of a survey form. It is concluded that, if they don't have one already, all forest and conservation nurseries should develop a system for monitoring outplanting performance. This should be considered a normal "cost of doing business" and that for state forest nurseries, federal cost-share funds could be used to insure that this essential information is collected.

INTRODUCTION

What exactly do we mean by "success" in forest and conservation nurseries - large, healthy seedlings in the seedbeds or in the greenhouse'? No, the true measure of success cannot be determined at the nursery itself but rather can only be evaluated after the seedlings are outplanted. The best-looking seedling at the nursery is worthless if it does not survive and grow after outplanting (Landis and others 1995). The goals of a nursery program should be to promote and maintain customer satisfaction, meet management objectives, and improve environmental quality. A good source of reliable information on seedling performance is essential to achieve these goals. The purpose of this paper, therefore, is to discuss the basic concepts related to the systematic and regular evaluation of outplanting success, and suggest some ways that nurseries can implement these procedures.

WHY EVALUATE OUTPLANTINGS?

There can be several reasons for wanting to conduct evaluations of outplanted seedling success:

1. To determine if the seedlings are surviving and growing.
2. To gain feedback information to help refine the nursery cultural practices used to produce the Target Seedling.
3. To monitor compliance of planting contracts.
4. To satisfy government or company performance evaluation requirements.

All nurseries should know how well their seedlings are performing after they are outplanted. Unfortunately, this phase of the process is often overlooked because of lack of time or funding. Within a forestry organization, the responsibility for performing outplanting evaluations is sometimes not well defined and so this vital task sometimes "falls between the

cracks". Unfortunately, nursery managers have their hands full just growing the seedlings and often cannot afford the time to travel around and talk to their customers.

For the purposes of this paper, we were interested in whether state forest nursery managers in the 17 western states were able to perform outplanting evaluations and so we sent out a short survey. The survey had two sections: 1) Satisfaction with seedling quality and nursery services, and 2) Outplanting performance. About one-half of the respondents reported that they regularly query their customers regarding satisfaction with the services and seedlings they provide. Only 40% of the nurseries, however, indicated that they check survival in any organized manner, and only two gather data on seedling growth and this was based on comments from customers. The establishment of long-term monitoring plots to monitor seedling survival and growth is simply not done.

The second objective of an outplanting survey involves the fine-tuning of the target seedling. As nursery managers strive to perfect their craft, good data about field performance is essential. Nurseries determined their target seedlings (what species and stock type that they should be growing) when they first got started, but many never go back to review their applicability in the current market. Because outplanting performance is the only true measure of success, growers must continually review their concept of the target seedling and change cultural practices accordingly (Figure 1). Without sound data regarding seedling survival and growth, it is difficult to decide how to improve nursery culture practices. "Sound data" does not include casual visual surveys of planted seedlings to determine success because such surveys are far too subjective and impossible to adequately evaluate and document.

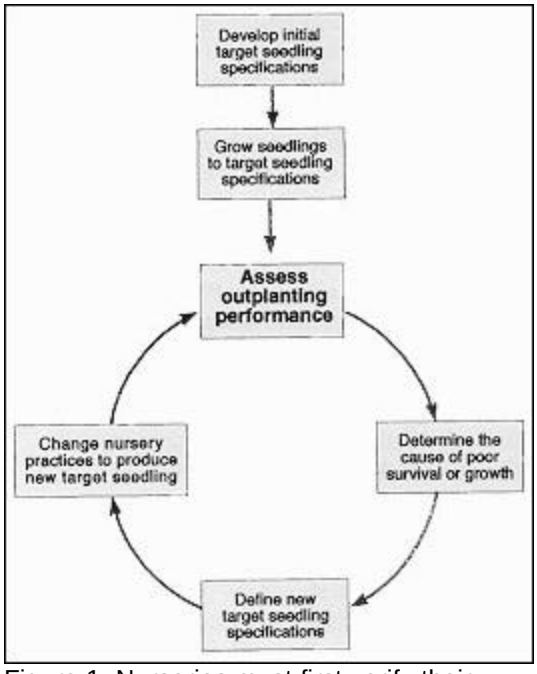

Figure 1. Nurseries must first verify their target seedling specifications and then continually revise them by monitoring performance on outplanting sites (modified from Burdett 1983)

The third reason for surveying seedling survival and growth is to check-up on how well contractors are planting the seedlings. Nurseries should be very interested in this because the performance of their seedlings critically depends on seedling planting techniques. In Texas, where they use a program of monitoring outplanting success to determine planting contract compliance, the incidence of plantation failure was more than cut in half (from 40% to about 16%) in the 10 years after an inspection program using established plots was initiated (Boggus 1994).

Finally, outplanting surveys are needed for completing government or company performance

reports. The USDA Forest Service provides cooperative funding and technical support to state forest and conservation nurseries through a program called Seedlings, Nurseries, and Tree Improvement (SNTI). A new accomplishment reporting system called the Performance Measurement Accountability System (PMAS) has just been instituted, and will significantly change the way that state forestry organizations report their accomplishments of the various cooperative programs. For the past several months, a national team in Washington, DC has been working on exactly how PMAS is going to work. Much of the PMAS discussions centered on "Outputs" vs. "Outcomes". Outputs are tangible things like "How many seedlings your nursery grew last year" and "How many acres were planted". Well, this isn't good enough anymore. The new trend in the PMAS System is to try and relate these easy-to-measure outputs to some broader "benefits" or "Impacts". For example, the PMAS team has proposed that the broad outcome for SNTI programs should be "To provide quality seedlings and establishment procedures to ensure a stand of trees within 3 years". So, instead of just reporting how many seedlings were produced at a nursery or how many acres were planted each year, state foresters will be asked to report on seedling performance after outplanting.

WHAT KIND OF SAMPLING IS BEST?

As to the best type of sampling design, we recommend systematic stratified sampling. Systematic samples are located at standard predetermined distances and because of this regular pattern, plots are easy to establish and relocate. Stratification means that the entire population of seedlings in the outplanting area is subdivided into homogeneous units before sampling begins. First, strata of uniform conditions are identified, and then sample plots are located systematically within these areas. These strata could be based on species, nursery of origin, planting crew, site type, or any number of other factors that can be identified as a source of variation in seedling performance. This system combines the reduced variability among plots within a stratum with the ease of systematic sampling (Pearce 1990).

Plot type - Staked, long-term plots are those in which individual seedlings are marked so that they can be monitored over time (Figure 2). We recommend that seedlings be individually staked because it is often difficult to locate planted seedlings after weeds and brush have grown in the plantation. Often, unstaked seedlings just seem to disappear after a few months or years especially when they are eaten by animals. When measuring seedling growth, staking is the only way to insure that the same seedling is being monitored over time. The USDA Forest Service uses a plantation evaluation system with staked row plots and monitors seedling survival and growth at one and three years after outplanting (Table 1). This procedure is detailed in the Forest Service Handbook (Section 2409), and copies can be obtained by contacting any Ranger District or Forest Supervisor's office.

Figure 2. Staking seedlings is a simple way to insure that they can be easily found for several years after weeds and other vegetation has overgrown the plantation.

Table 1. Survival of seedlings in staked row plots for National Forests in Colorado and Wyoming during 1978 to 1983

Species	Stock Type	Year Sampled	Staked Seedlings	No. of Live Seedlings	No. of Survival %	Range
Engelmann spruce	3+0 Bareroot	First	11,150	9,283	83	45 to 98
		Third	5,220	2,686	51	7 to 83
	Container	First	11,755	9,532	81	20 to 97
		Third	8,208	4,417	54	9 to 94
Lodgepole pine	2+0 Bareroot	First	8,496	6,094	71	50 to 99
		Third	5,549	3,681	66	12 to 93
	Container	First	7,100	5,408	76	19 to 99
		Third	3,719	1,932	52	11 to 83

Source: Jeffers (1985)

The actual plots can be one of two basic shapes: *linear* or *areal*.

Linear - This type of plot is established in a straight line, and is most appropriate for sampling in long, narrow plantings such as windbreaks or shelterbelts. Linear plots can also be used in large area plantings where trees are planted in very well defined rows. A systematic sample using line plots may dictate that a plot will be established every so many meters along the line of trees (Figure 3A).

Areal - As their name infers, these plots cover a discrete area and are generally circular or quadrilateral in shape. Areal plots are best for sampling large forest plantations. Circular plots are

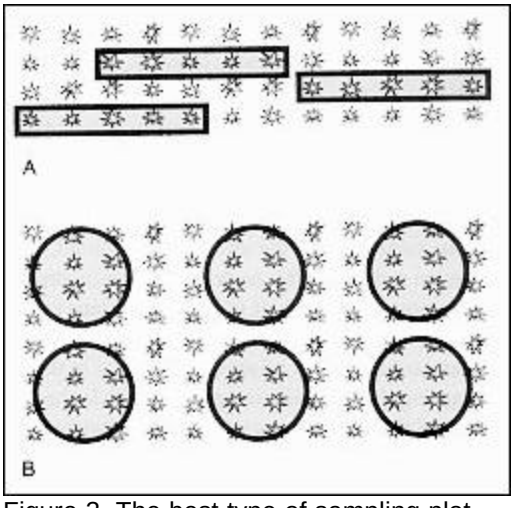

Figure 3. The best type of sampling plot will depend on whether the plantation is linear, such as a shelterbelt (A) or covers a

easy to establish using a known radius from the plot center (Figure 3B).

wide area such as a forest plantation (B).

HOW MANY PLOTS ARE NECESSARY?

The number of plots to establish is generally a function of two factors:

1) available resources (time and money)

2) variability of the attributes that will be measured.

Plantation evaluation is impossible without sufficient personnel and adequate funding. Based on our survey of western nurseries, however, lack of funds was the principal reason that most nurseries did not survey customers or evaluate outplantings. In the face of additional budget cuts, some creative use of existing resources will be required. If state forest nurseries do not have the staff or funds to monitor their seedlings after outplanting, then this may be an excellent use for some of the SNTI funds that are provided to State Foresters by the federal government. Some other suggestions:

* Work with others in your organization to see if outplanting evaluations can be combined with other field activities to reduce travel expenses.
* Use existing personnel like fire crews when they are in standby status.
* Require planting contractors to establish and monitor plots.
* Ask customers to help. Most nursery customers will be happy to assist when they realize that the survey information will help improve the quality of their seedlings.

The second factor affecting the proper number of plots, variability of the attributes measured, is somewhat more difficult to define. In calculating the appropriate number of plots, statisticians are interested in some measure of variability - such as the standard deviation of seedling heights in the outplanting. Using this example, if a quick check on the height of seedlings varies greatly within the plantation to be sampled, then more plots should be taken. On the other hand, if the heights appear to be very uniform, then fewer plots will be sufficient. Much will depend on the type of outplanting. Shelterbelts in the Great Plains are often machine planted which reduces planter-to-planter variation and site conditions are relatively uniform. On the other hand, there is often a wide amount of variation on mountainous outplanting sites because of differences in microclimate, soils, and planting quality. For example, seedling survival after the third year varied from as low as 9% to as high as 94% on National Forests in the Central Rocky Mountains (Table 1). To be statistically significant, there are rather complicated calculations to compute appropriate number of plots using an estimate of the variability of the attribute and the degree of statistical accuracy desired (Stein 1992).

Determining the number of plots based on variability is often a judgement call but, in most cases, a I to 2% sampling intensity will be sufficient. For example, if we were sampling a plantation where the seedlings were planted at a density of 2,000 per hectare (800/ac), then we would need to sample about 20 to 40 seedlings per hectare (8 to 16/ac). If we wanted the plots to contain approximately 10 seedlings each, they each would need to be about 1/200 ha (1/80

ac) in size, with a radius of about 4 meters (13.1 ft). Using these parameters, we could then specify a minimum of 2 to 4 plots per hectare (I to 2/ac) and a maximum of 10 to 20 plots for fairly homogeneous plantations.

WHAT TO MEASURE?

During the years following outplanting, most plantations are evaluated for only a few factors: survival, general seedling condition, and shoot and caliper growth. Before beginning the survey, it is helpful to construct a data form such as that in the Appendix to make sure that the evaluation is applied uniformly and that no information is left out. This is particularly important when more than one person is doing the evaluations because there can be significant differences in procedure unless everything is strictly defined. Developing standard codes for seedling condition and cause of mortality or injury helps to describe common situations. The sample form provides space for several evaluation dates of the same plot. A plot map makes it possible to identify the location of individual seedlings by azimuth and distance from the plot center. Starting with due North (which is 0") each seedling that falls within the plot radius can be numbered consecutively, staked, and the location noted on the form. Accurate plot mapping is important so that the seedlings can be relocated from year to year. If trees are particularly difficult to locate, it may be necessary to also tag each tree with a numbered metal tag around the base.

HOW OFTEN TO EVALUATE?

Many people think that the first evaluation should be scheduled one year after outplanting, but they are mistaken. It is extremely important to check the seedlings within a couple of months after they are planted because stock quality problems show up quickly. Mortality or poor growth due to substandard planting stock can often be identified by evaluating the outplanting within the first few months. Some of the common problems that can be identified at this time include seedlings that had unsatisfactory or damaged root systems, those that did not generate new roots, and those which were improperly planted. Poor planting technique often can be identified by the presence of "J" shaped tap roots when an examination hole is carefully dug next to the seedling. Other sources of mortality which are often identified at the two-month evaluation include improper storage, transportation, or handling. Desiccated seedlings on a site that had adequate soil moisture might indicate freezing during storage or excessive root exposure during on-site transportation and handling. On the other hand, it is almost impossible to do a postmortem on seedlings that have been dead for a year. Many surveys done on the one-year anniversary list the cause of death as "drought" because the seedlings appear totally desiccated. This sort of misleading information is worse than none at all.

Once the two month evaluation has been completed, the customer and nursery manager can backtrack through the sequence of events prior to outplanting and determine the true cause of the poor performance. The other advantage of an early evaluation is that plans can be made to replant quickly so that site preparation costs are not lost.

Outplanting performance plots should also be monitored at intervals of 1, 3 and 5 years. These long-term evaluations are recommended so that the effects of seasonal factors as well as site and genetic quality can be checked. The one-year measurements are useful for checking seedling tolerance to drought and frost, for example, as well as evaluating damage due to

animals, insects or disease. The measurements of survival and growth at 3 and 5 years give good indications of plant adaptability and productivity - useful information when choosing future species and seed sources. Long-term plant performance also helps to evaluate site quality.

CONCLUSIONS AND RECOMMENDATIONS

The establishment of long-term plots to monitor the outplanting performance of seedlings is an essential part of nursery management. Information on seedling survival and growth has several benefits to the nursery including a way to fine-tune the specifications of the target seedling. We believe that simple monitoring plots can be established with a minimum of effort and expense, yielding a maximum of informational benefit to nursery managers. Nurseries should include the cost of monitoring outplanting performance in their normal operating budget. If state forest nurseries do not have the staff or funds to monitor their seedlings after outplanting, then this may be an excellent use for some of the Seedling, Nursery, and Tree Improvement funds that are provided to State Foresters by the federal government.

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Appendix

Site: _____ Location: _____ Nursery: _____

Plot: _____ Species: _____

TREE	DATE 1: _____			DATE 2: _____			DATE 3: _____		
	HT (cm)	CAL (mm)	COND/ CAUSE	HT (cm)	CAL (mm)	COND/ CAUSE	HT (cm)	CAL (mm)	COND/ CAUSE

CONDITION/CAUSE CODES

CONDITION:

H	= healthy	U	= unhealthy
D	= dead	M	= missing

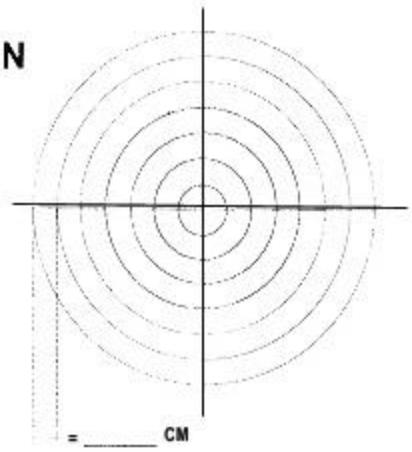
CAUSE:

1	= drought	7	= spiral root
2	= cattle/deer	8	= deep planted
3	= rodent	9	= "J" rooted
4	= insect	10	= small seedling
5	= loosely planted	11	= fire
6	= shallow planted	12	= vandalism

INCLUDE COMMENTS WITH THESE CAUSES

13	= shallow soil	15	= other
14	= poor site	16	= unknown

PLOT MAP



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