Seedling Performance Metrics: A Standardized Monitoring Approach

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Abstract

Planting seedlings is a significant investment. To assure success and minimize costs, the consumer needs to monitor seedling quality and field performance. A comprehensive monitoring program allows the consumer to identify issues in the nursery and the field and make adjustments as needed. PotlatchDeltic has established nursery inspections, root growth potential tests, box audits, garden plots, and field transects to evaluate seedling quality. The data generated from these monitoring activities is essential for assuring an efficient and successful reforestation program. This paper was presented at the Joint Annual Meeting of the Western Forest and Conservation Nursery Association and the Intermountain Container Seedling Growers Association (Coeur d'Alene, ID, October 25–26, 2018).

Introduction

Reforestation in the Inland Northwest is big business. Every year, industry, government, and private entities invest millions of dollars to grow and plant seedlings for reforestation and restoration. A common goal among them all is to plant high-quality seedlings that perform well in the field. There are several ways to ensure this goal, but the most important one is monitoring the crop.

It is important to monitor the production of seedlings from the time of ordering to establishment. The process involves several steps and without close monitoring, there is possibility of wasted seed, over production, and substandard seedlings. Each step allows the consumer to save money, but the consumer needs to be proactive.

PotlatchDeltic, headquartered in Spokane, WA, has an active container seedling-quality program that enables us to conserve our seed resources, monitor crop development, confirm that delivered seedlings meet contract specifications, and monitor seedling performance in the field. These basic principles may be customized to fit any consumer: industry, government, or private landowner.

Recommended Seedling Monitoring

Nursery Inspections

Nursery inspections are underutilized by the consumer, yet they are one of the most powerful tools available. PotlatchDeltic inspects nurseries twice a year. The purpose of the first inspection is to identify any seed issues, look for disease symptoms, and review the culturing regime with nursery personnel. Almost any issue with seed and early growth will show up as blank container cavities (figure 1). If there is an issue, the first inspection provides a good opportunity for a robust discussion with nursery personnel to determine if the problem is related to

Figure 1. Poor germination of lodgepole pine woods run seedlot (16 percent) resulted in blank container cavities and fewer net seedlings than ordered. (Photo by Abbie Acuff, 2013)

the seedlot or to nursery cultural practices, and if there is an opportunity to re-sow. By identifying an issue this early, the consumers have time to review potential impacts to their planting program and adjust accordingly. Also, a discussion regarding germination concerns can identify any seed issues and provide necessary information to adjust future seed calculations.

The purpose of the second inspection is to review seedling quality at the end of the growth cycle in the fall. At this time, the seedlings will have completed their active height growth, have lignified stems, have a good bud set, and should have roots filled out in the plug (figure 2). This is a good opportunity for the consumer to see the final product before it is packaged for cooler or freezer storage and to discuss cold hardiness, packing schedules, and anticipated shipping dates.

Root Growth Potential Tests

Root growth potential (RGP) tests are a quick, inexpensive way to evaluate the ability of seedlings to grow roots in an ideal environment. The idea is that the more roots seedlings grow in a test environment equates to better field performance. Some nurseries perform their own RGP tests. However, PotlatchDeltic works with Center for Forest Nursery and Seedling Research, Seedling Quality Lab at the University of Idaho (Moscow, ID) and has developed a consistent testing protocol and is participating in research to better understand the linkage between test results and field performance (figure 3). This allows for tests and research to be conducted on seedlings grown at all nurseries. PotlatchDeltic uses all available data to review seedling performance (table 1). If a potential issue is identified, then steps can be taken to minimize the impact on successful regeneration, such as block planting seedlings with lower RGP in one or two stands.

Box Audits

In too many cases, the first time consumers see their seedlings is on site when they are ready to plant. At this point, it is often too late to take a clinical look at seedlings or take measurements. To ensure delivered seedlings meet contract specifications and are of good quality, PotlatchDeltic instituted a box audit program several years ago. An independent auditor randomly measures height and stem diameter and assesses overall seedling quality shortly after delivery (table 2). By being proactive, foresters are made aware of any issues prior to planting and can adjust their planting program if necessary. Audit results are sent to nurseries weekly and any problems are addressed. For large seedlots, early notification of

Figure 2. Western larch seedlings grown in three different container sizes, all exhibiting roots that completely fill the plug. (Photo by Abbie Acuff, 2018)

Figure 3. Douglas-fir seedlings after 20 days in a root growth potential test at Center for Forest Nursery and Seedling Research, Seedling Quality Lab at the University of Idaho, spring 2018. (Photo courtesy of Center for Forest Nursery and Seedling Research, Seedling Quality Lab at the University of Idaho, 2018)

issues allows the nursery to review boxes still at its facility to determine if the problem is widespread or isolated. In addition, nurseries may be assessed penalties for poor audit results. Some of the issues identified by box audits include poor plug integrity, small-diameter seedlings, multiple tops, short seedlings, poor budset, disease, and active root or bud growth (figure 4).

Garden Plots

In 2013, PotlatchDeltic started planting samples of every seedlot and nursery combination in a garden plot at a common location (figure 5). The purpose of the garden plot is not to compare nurseries but to have one location to evaluate seedling performance in the field and to quickly identify issues.

Table 1. An example of root growth potential test results for seedlings planted in spring 2018. Seedlots with the same name were grown at different nurseries.

Seedlot	Size	Average height (cm)	Average RCD (mm)	Average root count	Average longest new root (cm)
DF-82-50 Blackwell Hump	8	35.87	3.79	57.2	7.1
DF-CL-Z1 Zone 1	8	28.45	3.85	32.9	7.7
DF-CL-Z1 Zone 1	8	37.36	4.86	47.1	7.5
DF-CL-Z2 Zone 2	8	34.89	4.77	39.9	10.4
DF-CL-Z2 Zone 2	8	41.65	5.03	59.6	8.2
DF-CL-Z4 Zone 4	8	33.93	3.89	21.4	7.2
DF-CL-Z4 Zone 4	8	42.94	4.74	61.7	7.4
DF-CL-Z5 Zone 5	8	39.71	4.69	60.4	6.7

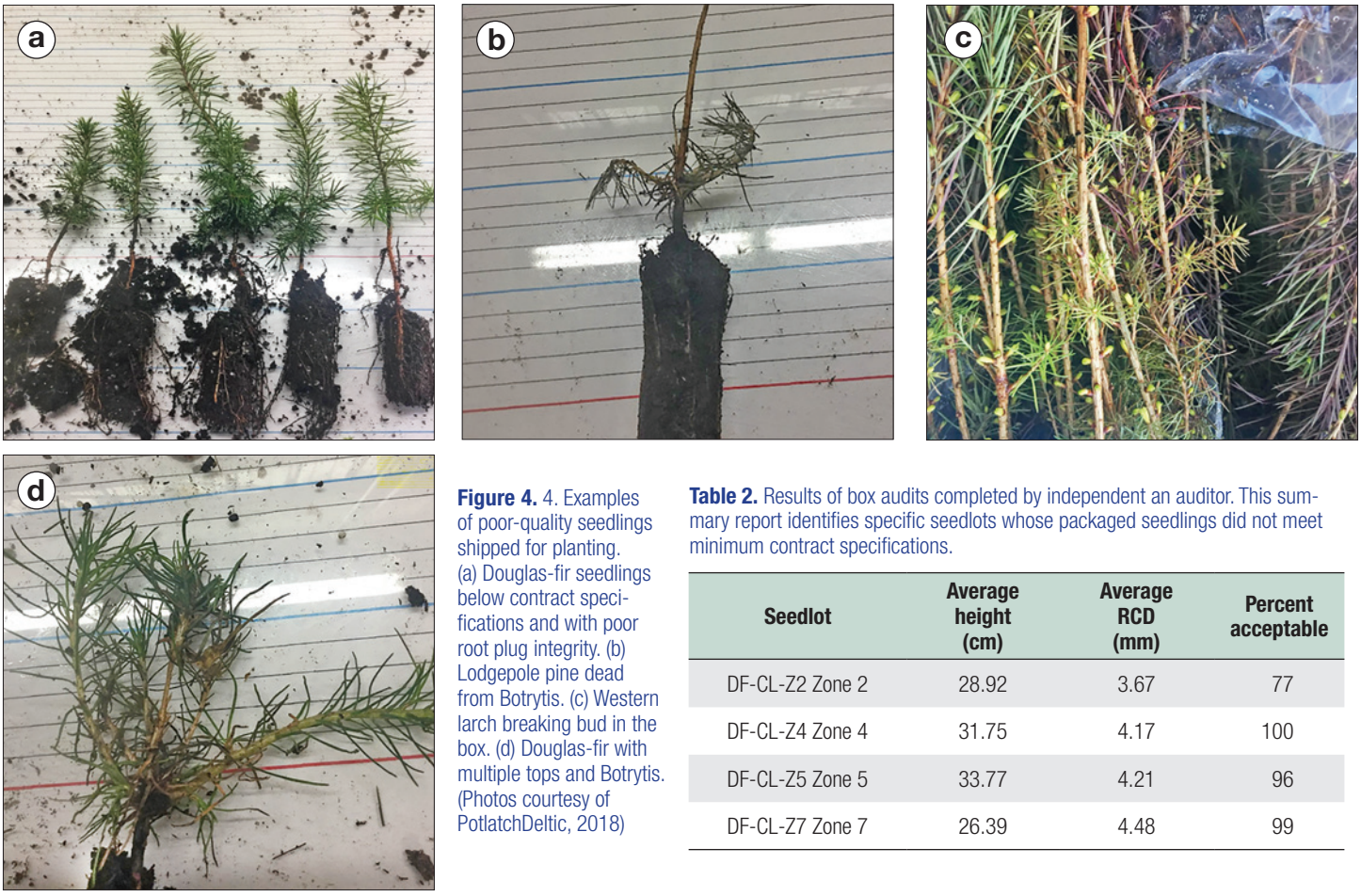

Figure 4. 4. Examples of poor-quality seedlings shipped for planting. (a) Douglas-fir seedlings below contract specifications and with poor root plug integrity. (b) Lodgepole pine dead from Botrytis. (c) Western larch breaking bud in the box. (d) Douglas-fir with multiple tops and Botrytis. (Photos courtesy of PotlatchDeltic, 2018)

Table 2. Results of box audits completed by independent an auditor. This summary report identifies specific seedlots whose packaged seedlings did not meet minimum contract specifications.

Seedlot	Average height (cm)	Average RCD (mm)	Percent acceptable
DF-CL-Z2 Zone 2	28.92	3.67	77
DF-CL-Z4 Zone 4	31.75	4.17	100
DF-CL-Z5 Zone 5	33.77	4.21	96
DF-CL-Z7 Zone 7	26.39	4.48	99

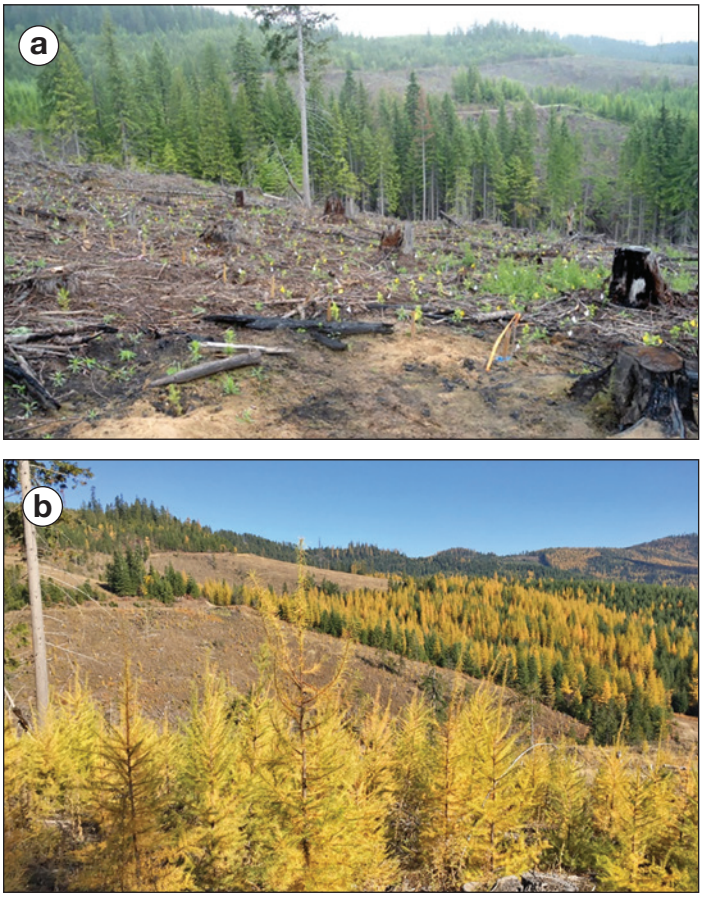

Figure 5. Garden plots are useful to evaluate field performance among seedlots and nurseries. (a) Staked rows of seedlings for garden plot. (b) Three-year old garden plot of western larch. (c) Labeled stake marking the end of a garden plot row and identifying the specific seedlot/nursery combination. (Photos by Abbie Acuff, 2017)

Figure 6. Sample of Douglas-fir root system at end of one growing season in a garden plot. (Photo by Abbie Acuff, 2017)

The rows of seedlot by nursery combinations are permanently marked at both ends and seedlings are flagged. Height and stem diameter measurements are taken at planting and the end of each growing season. Enough seedlings are planted so destructive sampling may be done to evaluate seedling growth (figure 6). The information garnered from garden plots not only alerts foresters to potential problems in the field but creates a database on early growth and survival of planted seedlings. The PotlatchDeltic program has evolved, and now each of the three Idaho Districts has a fenced site for planting and evaluating seedlings.

Transects

The purpose of the transect program is to quantify planted seedling mortality and associated causes within the first month of planting. The three main categories of cause are site conditions, site preparation, and seedling attributes. Evaluation of cause (figure 7) enables PotlatchDeltic to improve silviculture activities and

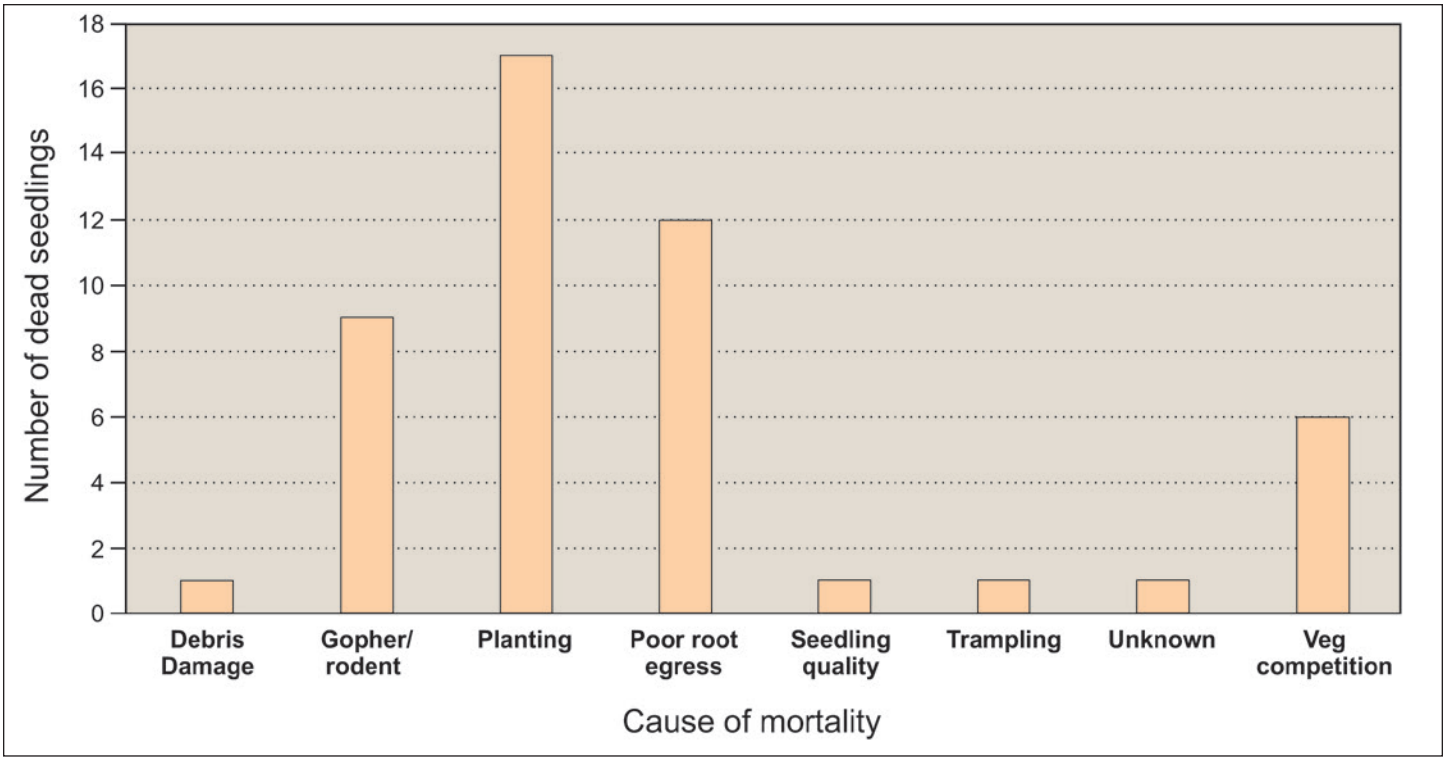

Figure 7. Example data showing causes of seedling mortality assessed using transects within 1 month of planting.

Table 3. Transect data collected as transect line is installed within 1 month after being planted.

Tree #	Species	Seedlot	Aspect (0-360)	Herbicide applied?	Vigor	Height (cm)	Caliper (mm)	Percent total vegetation cover	Dominant vegetation	Notes
1	DF	Mixed Z6, Z8	130	No	Average	27.0	4.7	<10	Grass	
2	DF	Mixed Z6, Z8	130	No	Average	30.0	4.1	10-19	Herbaceous	
3	DF	Mixed Z6, Z8	130	No	Average	29.0	4.5	10-19	Herbaceous	
4	DF	Mixed Z6, Z8	130	No	Average	20.0	4.0	10-19	Herbaceous	
5	DF	Mixed Z6, Z8	130	No	Average	22.0	3.0	10-19	Low shrub	
6	DF	Mixed Z6, Z8	130	No	Average	26.0	3.9	<10	Herbaceous	
7	DF	Mixed Z6, Z8	130	No	Average	19.0	3.2	20-29	Herbaceous	
8	DF	Mixed Z6, Z8	130	No	Average	28.0	4.0	10-19	High shrub	High shrub is natural regeneration
9	DF	Mixed Z6, Z8	130	No	Average	19.0	2.9	10-19	Grass	
10	DF	Mixed Z6, Z8	130	No	Average	32.0	4.8	<10	Low shrub	

fine-tune seedling specifications. Stands are semi-randomly selected to ensure major elevation bands, aspects, and districts are represented. Two transects per stand are permanently marked at each end and seedlings are flagged (figure 8). Each seedling's height, stem diameter, and health are recorded, as well as vegetation cover within 1 m2 (table 3). As the database increases with the addition of more transects, it will be used to confirm and drive future management decisions.

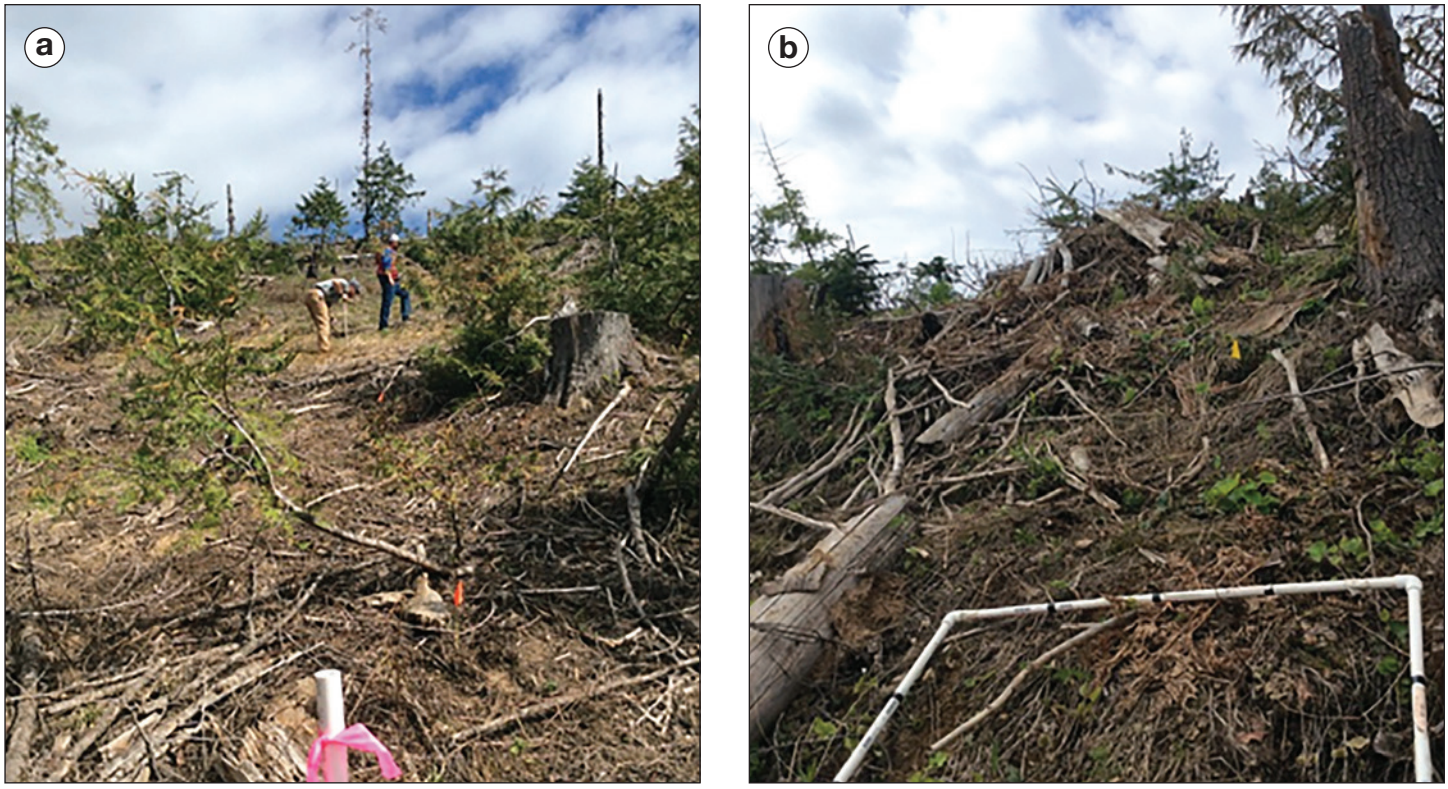

Figure 8. Transects can provide useful data in the early years after planting. (a) Data collecti on requires setting up transects, measuring seedlings, and (b) assessing vegetation cover. (Photos courtesy of Chance Brumley, Operations Manager, PotlatchDeltic, 2018)

Conclusions

Growing and planting seedlings is expensive (table 4). The best shot for minimizing costs is to have high survival the first time a unit is planted. To achieve this goal, care must be taken at each step to ensure the consumer is not wasting any resource, such as seed, seedlings, or site preparation. The consumer needs to be proactive and consistent with monitoring, otherwise any issues causing successes or failures will remain unknown. The consumer also needs to monitor every year to account for anomalies such as extreme weather. The monitoring systems outlined in this article are relatively inexpensive, easy to do, and provide a lot of valuable information to ensure a successful planting program the first time: one and done!

Table 4. Cost of planted seedlings shows how quickly costs increase with the planting program size. This table assumes 436 seedlings per acre (1,077 per ha), $350 per 1000 seedlings, and $100 for planting 1,000 seedlings.

Acres	Planted seedlings	Cost
500	218,000	$ 98,100
1,000	436,000	$ 196,200
2,500	1,090,000	$ 490,500
5,000	2,180,000	$ 981,000
10,000	4,360,000	$1,962,000
20,000	8,720,000	$3,924,000

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