The Target Seedling Concept: Implementing a Program

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INTRODUCTION

The Target Seedling Symposium in 1990 (Rose et al) covered a range of topics surrounding the target seedling concept. The usefulness of stock type designations was found to be less than worthy where there is a necessity to set criteria for reforestation success. Height and stem diameter were found to be useful target traits in seedlings, but these traditional measures of quality require support from other seedling traits in order to be useful. Root growth potential was not found to be quite as useful in pinpointing reforestation success as previously thought. Root system size was clearly shown to greatly enhance the ability to quantitatively assess quality. Mycorrhizae play an important role in reforestation success in some areas and their presence or absence can have subtle impacts on how seedlings perform. Bud dormancy and cold hardiness in temperate tree species can have profound impacts on seedling field performance Seedling moisture status is key to lifting seedlings in spring and ensuring their ability to survive the first few weeks after outplanting when new roots are being formed. And lastly, mineral nutrition is a vital link with reforestation success. Seedlings sent to the forest with nutrient imbalances are likely to suffer growth set backs even when environmental conditions are good. Seedling quality testing using the above mentioned traits is an integral part of all of this and forms the basis for discovering which traits will work best as successful reforestation criterion.

The purpose of this paper is to put the target seedling concept in the context of an on-going program coordinated between nursery activities and a reforestation planting program. Time and time again it has been learned that a reforestation program depends on the successful integration and coordination of all activities from seed collection to planting the seedling in the field. The purpose here is to discuss how to get a target seedling based reforestation program into existence.

DEFINITION

What is the target seedling concept? The concept is defined as targeting specific physiological and morphological seedling characteristics that can be quantitatively linked with reforestation success. There are two adjectives in this definition that carry a great deal of weight in terms of understanding the fundamental basis of the definition. The first adjective is 'specific', namely those characteristics at specific levels that are to be developed in seedlings to make them perform best on a given site. The second adjective is 'quantitative', namely those characteristics that can be statistically correlated with successful seedling performance on a given site. Overlooked, but implied, in this definition is the term, target site, which means that each target seedling is being cultured to grow under the known environmental

field conditions of a specific site, i.e. ecotype, slope, aspect, brush competition (Dr. Mike Newton, personal communication).

Carrying out the objective of the definition is a daunting task, especially when it is fully realized how little is known about how various species of differing characteristics perform. Few nursery operations are set up to deal with culturing more than a few stock types. Even within a single stock type designation seedling attributes such as height and stem diameter can occur over a wide range of values. It is common knowledge that one nursery's 2+0 stock can be much larger than the 2+0 stock of a nursery 50 miles away.

The reforestation industry long ago settled on height and caliper as grading criteria for seedlings because it was quick and easy. But, as costs have gone up, reforestation success has been mandated by law in some places and public responses have been negative regarding poor quality reforestation, and more attention has been shifted toward seedling quality. Every year private forestry operations strive to increase growth in the first few years, not only to improve long term economics, shorten rotations, and maintain sustainability, but to improve short term economic gain by capturing the site quicker in hopes of using fewer chemicals.

Running a target seedling program is less science than just good coordination and management. Where programs have been successful, such as at Weyerhaeuser Company and the Oregon Department of Forestry, upper management was in full support of the program. The seedling is seen as a product of the organization with a set of characteristics and quality control standards for manufacture. Quality control is maintained via the cultural practices such as genetics, seed quality, planting density, fertilization, irrigation, and storage. Wrenching and undercutting play a key role in some bareroot nurseries in developing the target root system.

LIST OF TARGET CHARACTERISTICS

To most nursery managers and reforestation supervisors there are a bewildering array of characteristics for seedlings. Over time it has been overwhelming for some operational managers to deal with the ever-increasing array of stock type designations. There are nurseries that advertise that they have over 160 seedling stock types. This is not hard to do if one is in the containerized seedling business with seed from 12 different species being sown to 12 different container sizes and shapes. This alone would make 144 stock types. Additionally, the cultural practices can be altered in 16 different ways (i.e. light regime, fertilization, hardening off schedule, nutrient levels). This could result in a huge factorial with seemingly endless combinations of stock types!

However, these stock type designations are unimportant if the actual characteristics of the seedlings do not yield predictable reforestation success under most circumstances. For all 160 stock types, however derived, it is still vital to ensure that they have enough roots to supply the top with water, sufficient cold hardiness to withstand long term storage and survive outplanting, and a workable nutrient balance.

There are many characteristics to examine. The point here is only to list them and briefly describe their usefulness. The target seedling concept uses all of these parameters in an

integrated way.

MORPHOLOGICAL PARAMETERS

Height. This parameter is the most common in use. Evidence has shown that height is not always a reliable indicator of success with out taking into account stem diameter and root volume. The height/diameter (mm/mm) ratio has been useful to understanding the ability of the plant to with stand stress. The higher the ratio the more out of balance it is (e.g. > 60) and the less it is able to compete with brush. Where herbicides are not allowed most managers prefer tall seedlings with big supporting root systems to outcompete the brush.

Stem Diameter. Diameter at ground line is also one of the most common characteristic looked at in seedlings. Some work has shown that there is a good correlation (r2 = .68) between stem diameter and root volume of newly lifted seedlings. However, depending on lifting techniques in the nursery a large diameter seedlings can go to the forest without a lot of roots Therefore, it is important to look beyond stem diameter when determining the target seedling.

Root volume. This characteristic is one of the newer traits to be linked with reforestation success. Unlike height and stem diameter this trait takes a little more time and effort to measure. The most common method of measuring trees for root volume is by water displacement on an electronic balance. It has been clearly shown that the greater the root volume the better the seedlings tend to survive and grow. Prior to the use of root volume, root length was sometimes used but length has little to do with root mass, although it can be important to get roots down to where the soil moisture is. Root volume says nothing about fibrosity. In some species the number of first order laterals can be quite important. Shoot volume can also be measured and used with root volume to calculate shoot:root ratio.

Other morphological characteristics like stem, needle or leaf, and root weights have been mostly looked at by researchers. Number of branches has been used. Bud size or appearance has been used in some species. Needle length may be useful if the seedlings transplant shocked in the nursery. Forking due to insect or disease is something to avoid. L-rooting of seedlings by undercutting or wrenching can create very undesirable characteristics.

By looking at these characteristics as part of a target seedling program it is possible to fully realize how close or how far a nursery manager is from producing optimal seedlings whether called target seedlings, ideal seedlings or archetype seedlings. The goal of the target seedling program is to seek the **optimization of all of these traits for the greatest** gain after outplanting (Figure 1).

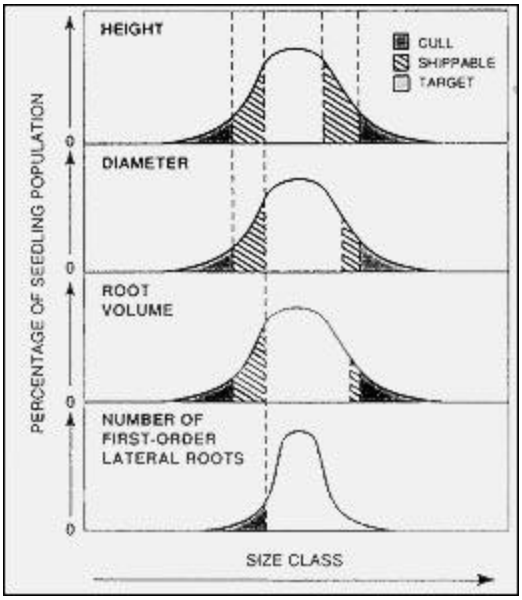


Figure 1. Normal population distributions for several morphological traits of tree seedlings.

PHYSIOLOGICAL PARAMETERS

Few if any physiological parameters are used by nursery managers and this needs to change if real progress is going to be made. Many known physiological or biochemical techniques are best suited for use by researchers, who then translate their findings into operational practices.

Plant Water Potential. The measurement of plant water potential or plant moisture stress using a pressure bomb has been used successfully in some nurseries for years to determine watering schedules to meet growth targets, to determine when best to lift, and to trouble shoot handling procedures between lifting and cooler Storage.

Cold hardiness. Some nurseries send their seedlings to a cold hardiness testing service to determine if their seedlings are ready to be lifted and long term freezer stored. It can be very surprising to learn that lots within the same species are no where near (-10 degrees C) as hardy as others (-20 degrees C).

Nutrients. Given the fact that there are so many labs able to do seedling foliage testing for nutrient levels, one would think more managers would avail themselves of this service. Few seem to bother at all and basically put on 'recommended' fertilizer rates and if the seedlings look green proceed from there, It is only when chlorosis shows up mysteriously do most nurseries want to run foliage tests. But then, they have nothing for data comparisons. Chlorotic foliage is yellow because it is missing nutrients and all the test will do is confirm that the nutrient levels are clearly wrong. Nutrition levels need to be tracked yearly in order to determine acceptable ranges at each nursery and for each species.

Other physiological techniques such as starch analysis, chlorophyll fluorescence, and photosynthesis belong to the domain of the researcher. The role of the researcher is to improve our understanding of how plant processes can be manipulated to best advantage. For instance, net photosynthesis (production of carbohydrates) Is known to be adversely impacted as plant water potential decreases beyond -15 bars. Knowing this aids the nursery manager in setting irrigation regimes, knowing if there is plant stress prior to storage, and knowing how best to harden seedlings off without doing physiological damage. This illustrates the fact that not all physiological characteristics can be used in a target seedling program, but a conceptual understanding of physiological mechanisms can greatly aid in the production of target seedlings.

IMPLEMENTING A PROGRAM

Starting a target seedling program is not particularly difficult, but it does take a high degree of commitment and in some instances a reallocation of resources. Some steps (Figure 2.) that might be followed to get started are as follows:

1) Inventory and Characterization

Set about finding out what kind of stock are currently grown. For each stock type collect information on height, stem diameter, shoot volume, root volume, and number of first order

laterals. From these data calculate height / diameter ratio and shoot /root ratio on a volume basis. These data on approximately 100 seedlings of each stock type should then be analyzed to produce means, standard deviations, range in values, and a coefficient of variation. Of added benefit is to break the data down into different stem diameter classes and look at the distribution. How many seedlings fall within each of the classes'? How many fall within a given root volume class? There are innumeral ways to look at these data and derive an operational understanding of what a particular stock type looks like based on a particular cultural regime. Some state and corporate operations have more than one nursery. In this case it can be eye opening to compare the same stock types from different nurseries. Physiological tests like root growth potential, cold hardiness, and nutrients can also be measured. Figure 2. Schematic diagram showing a generalized schedule for the coordination of a target seedling program between the nursery manager and the reforestation supervisor.

2) Field Testing

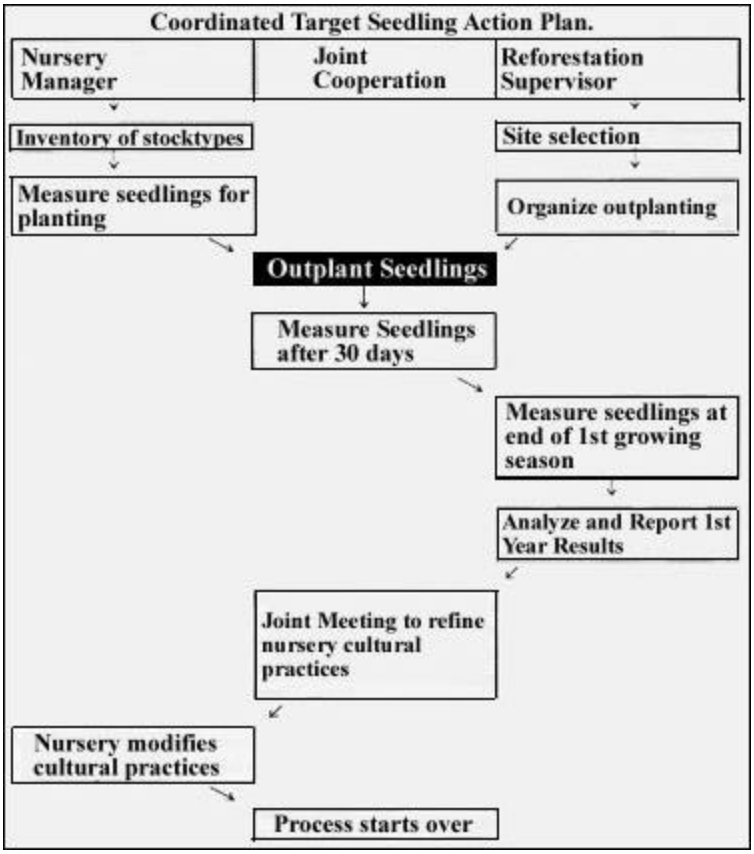
The non-destructive nature of this data collection is very useful toward the purpose of developing an on-going target seedling program. A minimum of three sites should be chosen representing an array of typical field conditions. A minimum of six replicated plots containing 10-15 seedlings of each stock type should be established. Single tree plots also work very well and a minimum of 100 seedlings should be used in this instance. Usually it is a good idea to test no more than six stock types in any one test so the experiment does not get too unwieldy to plant and measure.

This results in a replicated study where the initial height, stem diameter, shoot volume, and root volume are known along with the other values that can be calculated. Following planting the seedlings should be measured for field height and stem diameter within 30 days after planting and checked for signs of stress or mortality. At the end of the first growing season the seedlings should be measured again.

Some organizations with a real commitment to target seedling work repeat this same experiment with each year's nursery crop for two or more years, planting the seedlings in the same immediate area. In this way crop year is also a source of variation. There is great statistical power in doing this and it helps to confirm any other trends which may show up.

Why do the measurements and then plant the trees? Knowing the root volume, for instance, at planting allows a statistician to use this variable as a covariable, accounting for differences in growth attributable to initial root volume. A key to success is knowing what the seedlings actually look like prior to planting in a way that a stock type designation such as 2+0 never could.

Assuming the seedlings have been cultured, handled and planted correctly, trends in these planting trials are likely to show up within the first three years. It is critical to success that the handling and planting be the best ever done. It serves no purpose to handle and plant an expensive trial with inexperienced or poorly motivated planting crews. This is not a trial designed to study operational planting. It is a study to determining those characteristics that contribute the most to outplanting success, given that each seedling is well planted.



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SOME ESSENTIAL QUESTIONS

How can an operational target seedling program be initiated in a nursery or reforestation effort? Fundamental to success is commitment on the part of the organization at all levels. Attempts if 'a to create an artificial need for such a program is doomed to failure if various managers simply do not think it is necessary and that "things" are fine as they are. Too often what instigates a whole new look at reforestation are numerous unexplained failures that have many managers grasping for explanations. Eventually meetings are called and it becomes apparent that the nursery needs more funding to meet operational targets, weather has been less than optimal for planting, and the planting supervisors question the quality of the seedlings coming from the nursery. After all of the verbal exchanges are over everyone gets down to the fact that they have a problem and it is time to work more closely in order to improve reforestation success. This is where the target seedling program comes into play.

What are some of the common concerns? Initially there are often many concerns about funding and changing what seems successful now. Nursery managers often operate right at the margin of meager budgets so when it is suggested that they provide some labor and measure trees, set up meetings with field foresters, and visit plantations there is a lot of

concern about where the time and money are going to come from. Training people to do this kind of operational research is also a concern since most have no idea how to set up a crew to go forth and measure seedlings, much less know how to analyze and interpret the data. This is where upper management needs to step in and organize the support to make things happen with outside help.

What are some of the constraints? Money is a big constraint. The old adage that "it takes money to make money" is very true in this case. Money to buy small items of equipment and money to hire extra people is important, especially in those operations that depend a great deal on seasonal help. Money for extra travel is important so that communication among responsible parties can be maintained.

What are some of the important linkages that need to be made between the nursery and the field managers? It is surprising to some upper level supervisors how few of their nursery managers actually go into the field to see the results of their work. It is also surprising that reforestation supervisors seldom set foot inside of a nursery - most have seedlings delivered! These two entities form the most critical link in producing target seedlings because they must develop a trusting feedback mechanism to relay what is working and what is not working in the forest. Sometimes field foresters will want to see a particular type of seedling they think will do well, but soon discover it is impossible to grow in the nursery. On the other hand there are nursery managers who think their 6" seedlings are workable in high brush areas, having never actually seen or even heard that their seedlings die under such conditions. Upper management must be involved in this process from time to time in order to keep the goals realistic and keep everyone oriented toward functional outcomes, i.e. finding target seedling characteristics that work.

CONCLUSION

Implementing a target seedling program is really nothing more than an extension of the Job most managers are already paid to do. That job is to improve product quality in order to better meet customer needs and minimize costs. Nowhere has it been shown that planting failures save money. The primary objective of a reforestation program is to get the seedlings up and growing the first time, often to meet legal, environmental, and economic goals simultaneously. There is an old saying, "if you can not get it right the first time, when will you have time?" A target seedling program is a good step toward getting it right the first time.

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