

Strategies and Challenges for Nursery Production: Perspectives on Where We're Going and Where We've Been

Diane L Haase

Diane L Haase is Western Nursery Specialist, USDA Forest Service, PO Box 3623, Portland, OR 97208; Tel: 503.808.2349; E-mail: dlhaase@fs.fed.us.

Haase DL. 2010. Strategies and challenges for nursery production: perspectives on where we're going and where we've been. In: Riley LE, Pinto JR, Dumroese RK, technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—2009. Proc. RMRS-P-62. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 36-42. Online: http://www.fs.fed.us/rm/pubs/rmrs_p062.html.

Abstract: During the past century, seedling production has changed in accordance with technology and new knowledge. Many strategies have been developed to address challenges associated with pests, environmental conditions, and customer demands. Although the underlying concepts for growing seedlings have remained relatively constant, technological advances have enabled nurseries to improve stock quality significantly. As we move further into the 21st century, nurseries continue to face new challenges and develop new strategies with regard to pest management regulations, personnel shortages, demand for conservation species, economic hardships, and climate change.

Keywords: reforestation, native plants, nursery history, plant production

Introduction

During the past century, the world's land base has been subject to urban expansion, poor management practices, and increasing pressure to provide resources for a growing population. As a result, seedling production has become a fundamental tool for addressing reforestation, restoration, and conservation needs. Nursery practices for seedling production have evolved considerably over the past several decades in accordance with technological advances, increased understanding of seedling physiology and development, and changing customer demands (Dumroese and others 2005). Following is a broad overview of the past, present, and future strategies and challenges associated with several key areas within the nursery production process.

Growing Techniques

Considerable research into plant physiology and nursery culturing has led to a much greater understanding of seedling responses to environmental conditions, nursery treatments, and growing regimes over the past several decades (Rose and others 1990). For example, early nurseries had limited understanding about soil physical and chemical properties, as well as limited resources to improve them. Experimental trials resulted in guidelines and recommendations for amending soils to achieve maximal growth under specific soil conditions. Additionally, the manufacture of chemical fertilizers and other products, as well as the ability to transport materials over greater distances, have given growers more options for optimizing soil/media properties for seedling development.

Knowledge has also increased on the topic of seed preparation. Early nurseries often broadcast seeds onto seedbeds and then covered with a canvas tarp to allow the seeds to stratify in the soil (Figure 1). This could result in variable seed density and non-uniform germination. Much research into seed physiology has led to increased seed purity and viability, as well as stratification and sowing techniques for uniform crop production.

In addition to our better understanding of seedlings and the growing environment, technological advances in nursery equipment have greatly enabled nurseries to produce large volumes of high quality stock. Just about everything in early nurseries had to be done by horsepower and manpower, resulting in many hours of tedious labor to produce a seedling crop (Toumey 1916; Jones 1925; Olson 1930; Fleege 1995). For instance, transplanting seedlings was achieved by use of a transplant bar in which seedlings were aligned between two wooden boards and then, with a person on either end, the plants were suspended over a planting trench and transplanted (Figure 2a). This process was time-consuming and could result in desiccation of exposed seedling roots. Later, machines were developed to mechanically transplant individual seedling rows (Figure 2b); nowadays, multiple rows can be transplanted at once (Figure 2c). Lifting was also labor intensive and was accomplished slowly via horse and human labor (Figure 3). Today, there are custom machines for most nursery processes, from sowing to harvest, although smaller nurseries still rely on manual labor for many tasks. Additionally, most nurseries, small or large, must carry out much of their weed control via hand weeding.

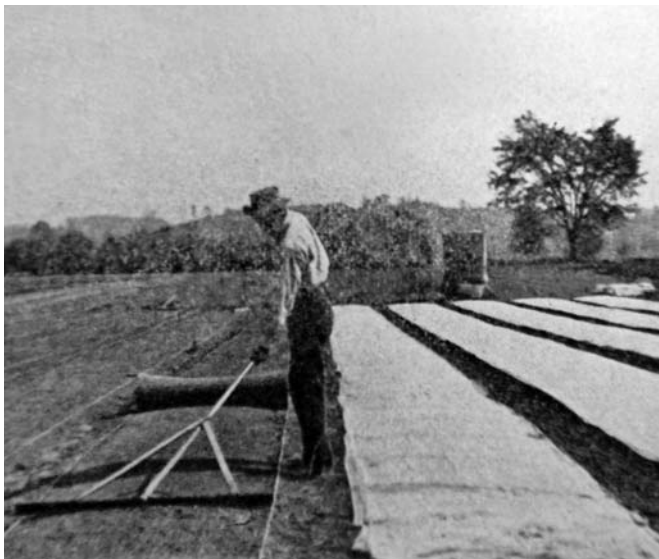


Figure 1. Covering seedbeds with burlap or cheesecloth following broadcast sowing was common practice in early bareroot nurseries to protect seeds from wind, sun, invasion of weed seeds, and predation from birds and rodents (Toumey 1916).

The basic concepts regarding density, fertility, irrigation, pruning, grading, storage, handling, and other seedling production practices have always been considered in nursery management. Whether it is 1909 or 2009, the underlying driving force is based on the Target Seedling Concept: “Targeting specific physiological and morphological characteristics that can be quantitatively linked to outplanting success” (Rose and others 1990). Seedling culturing is continually being fine-tuned to adapt to current needs and optimize seedling quality. Because nursery production is expanding more and more to encompass a larger variety of species, there is an accompanying need to develop and refine culturing techniques for many nontraditional native species.

Species

Until the past few decades, nursery production was primarily focused on commercial species for forest regeneration or horticultural cultivars for urban landscaping and gardens. Many indigenous plants were considered unwanted weed species, and control measures were developed to eradicate them, thereby reducing their competitive effect on desirable timber species. The rise of the environmental movement in the late 20th century, the explosion of invasive nonnative plants over the past century, and increased land degradation has led to much attention being directed toward propagation and restoration of native plants (Haase and Rose 2001).



Figure 2. Technology for transplanting has evolved over time from the labor-intensive manual transplanting using boards (A) (Savenac nursery photo archives), to mechanical planting of individual rows (B) (Savenac nursery photo archives), to modern transplanting in multiple rows (C).

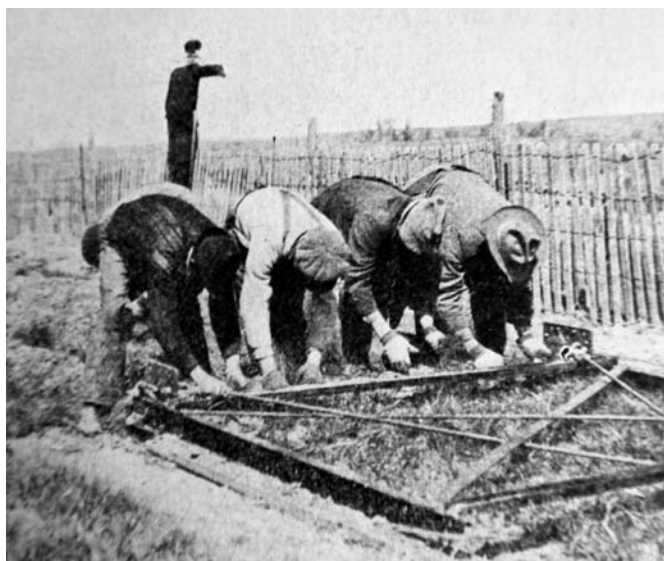


Figure 3. The Smith Tree Lifter consisted of a steel blade mounted in a slanted position on an iron frame. It was drawn over the bed using horse power and followed by a labor crew who removed the plants (Toumey 1916).

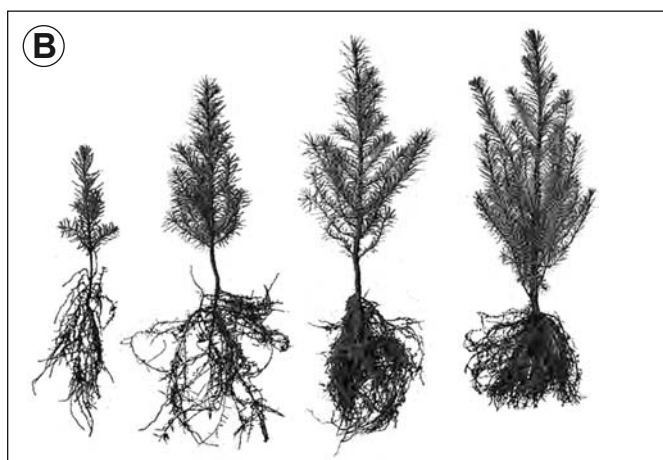
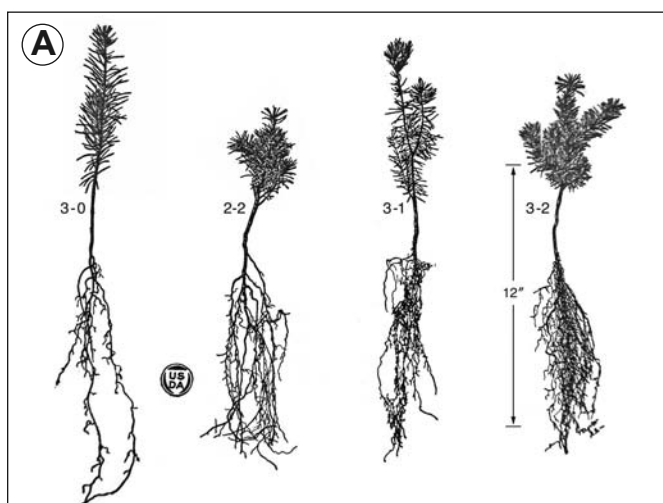


Figure 4. It could take 3 to 5 years to produce bareroot stock for out-planting in the early 20th century (A) (Douglas-fir seedlings, Korstian 1925); modern growing technology has resulted in production of quality bareroot seedlings in much less time (B) (left to right: 1+0, 1+1, 2+0, and plug+1 Douglas-fir, Rose and Haase 2006).

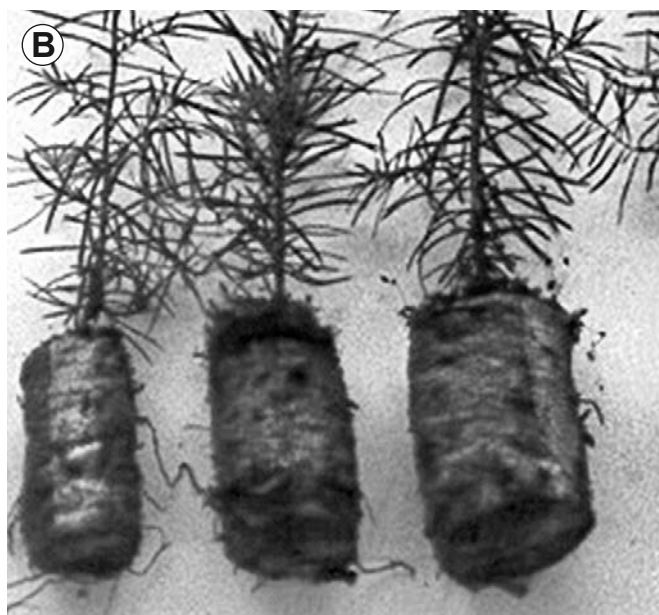


Figure 5. Many container growers in the US use Styroblock® containers (A). In addition, many other stocktypes are available, such as Jiffy® plugs (B) and large containers for restoration projects (C).

Shrubs and forbs provide erosion control, competitive exclusion of nonnative plants, and wildlife habitat. In addition, mixed plantings are important to avoid potential monoculture issues, such as was found in the 1990s with the onset of the Swiss needle cast epidemic (caused by the ascomycete fungus *Phaeocryptopus gaeumannii*) in the western United States (Hansen and others 2000).

Stocktypes

A century ago, it took 3 to 5 years to produce a bareroot seedling of adequate size and vigor for outplanting (Tillotson 1917; Korstian and Baker 1925; Show 1930) (Figure 4a). As growing practices improved, nursery growers modified stock specifications accordingly. Today, the same size (or better) can be produced in one or two growing seasons (Rose and Haase 2006) (Figure 4b). The 2+0 bareroot seedling was the standard stocktype for many years, but has been largely replaced by larger and better performing 1+1 and plug+1 transplant stocktypes.

The increase in automated processes and the transportation of peat over greater distances has also resulted in a significant proportion of plants now being grown as greenhouse container stock. In the past 25 years, container seedling specifications have changed considerably. In the forestry sector, container seedlings have gone from a typical 82- to 131-cm³ (5- to 8-in³) plug for outplanting to a 246- to 328-cm³ (15- to 20-in³) plug in the past 20 years. While most container growers in the US are using Styroblock[®] containers (Beaver Plastics, Acheson, AB Canada) for production (Figure 5a), many other container types have been developed to accommodate a wide range of seedling sizes and outplanting objectives (Figure 5b).

Genetics

Early seed collection for conifer species was accomplished primarily by raiding squirrel caches (Figure 6). In addition, few records were kept regarding the geographic location and elevation of the seed source. Variability in growth patterns and outplanting performance opened the door for the field of forest genetics and a wider understanding of species adaptation to ecotypes. Today, seeds are collected within specific seed



Figure 6. Early seed collection was accomplished by gathering cones from squirrel caches (Toumey 1916).

or breeding zones (Figure 7) and elevation bands to ensure that seedlings are best adapted to their designated outplanting site (Randall and Berrang 2002). Many seed orchards have been established that produce billions of seeds from parent plants of commercially valuable tree species with desirable growth and form traits. Furthermore, nursery culturing regimes have been developed to best simulate the natural seasonal climate for given ecotypes within a species. These culturing techniques are still being developed to address various issues with genetically selected seedlots. In conifer species, seeds from orchards can result in rapidly growing seedlings exhibiting “speed wobble” (stem sinuosity) as well as stem splits that are vulnerable to infection if disease is present. In addition, growers have difficulty getting these fast-growing seedlings to cease growth and harden off in a timely manner.

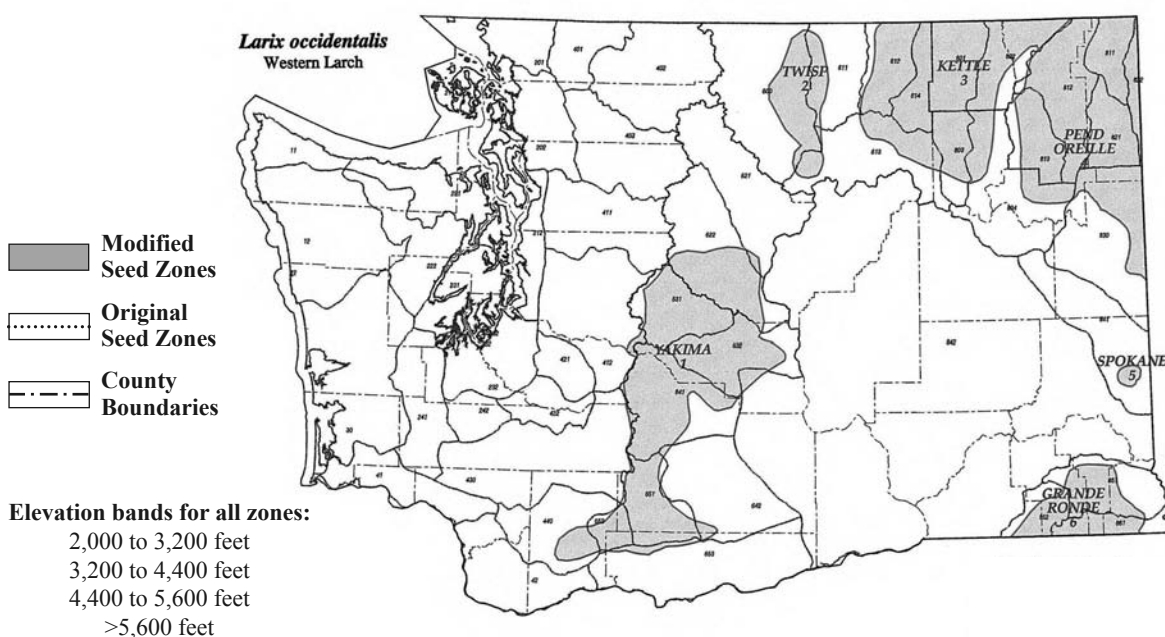


Figure 7. Seed zone maps, combined with elevational bands, are used for many tree species to determine appropriate geographic planting areas for seedlings. This is an example of a map for western larch (*Larix occidentalis*) in the state of Washington (Randall and Berrang 2002).

An understanding of genetics is lacking for most of the native species grown in nurseries for conservation and environmental restoration (Johnson and others 2004). There is still a need to develop a better understanding of the maximum distance many plant species can be established from the location of the original seed source (when seed production or sources are inadequate at a desired planting area), as well as how much growth can be gained by selection of seeds from parent plants with desirable traits. Additionally, climate change is likely to result in corresponding changes to plant geographic ranges (Gitay and others 2002) that will demand continued evaluation and development of seed zones and genetic families.

Products

As nursery practices have evolved over the past several decades, so too have the products that are manufactured to support seedling production. Specialized chemicals, fertilizers, equipment, tools, and supplies have been developed to improve seedling quality and to facilitate daily growing operations. Every year, new products abound for the nursery industry. There are root dips, foliar sprays, media amendments, technological gadgets, biological agents, and a wide range of others. Because most major nursery issues have already been addressed, many new products are based on some new twist of an old idea. These products are usually accompanied by a glossy flier and a slick company representative who promises a host of benefits that will cure just about any nursery ailment imaginable. While some products do have promise, too few are scientifically tested to statistically confirm the manufacturer's assertions. While many products are crucial to nursery processes, it's important for new products to undergo rigorous scrutiny to determine if they are a cost-effective and useful addition to seedling production.

Pest Management

Early seedling nurseries were often susceptible to decimation by disease or insects, or were overrun with weed species. This could result in huge annual crop losses. As these pests were studied more closely and various pesticides were developed in the mid 1900s, more and more control measures were available. In the chemical heyday, there was a toxic treatment for just about everything. However, as the US Environmental Protection Agency (EPA) revises and reviews its regulations based on national and international policies, more and more chemical treatments have been banned or heavily regulated to protect people, animals, and the environment. Most recently, soil fumigants that are commonly used in bareroot nurseries have been subject to Re-registration Eligibility Decisions (REDs) and will have greater restrictions for their use in the near future. Fortunately, most nurseries rely on an Integrated Pest Management (IPM) program that includes biological and cultural treatments in addition to chemical use. This reduces the need for chemical applications to some extent, although a complete loss of chemical options would be devastating to most nurseries. The past few decades have seen many private, academic, and governmental projects to evaluate potential pest control treatments in seedling nurseries and other agricultural crops. These projects are aimed towards providing alternative treatments in response to chemical regulations, thereby avoiding pest resistance to existing treatments.

Seedling Quality

Stock quality standards were once very forgiving (Figure 8). If it was alive and free of visible defects, then it was a quality plant worthy of outplanting. With limitations in technology and vulnerability to nursery pests, growers could lose half or more of their crop in a

season. The surviving stock was therefore subject to minimal scrutiny before being sent to the field for outplanting. Over time, standards were developed for minimal size specifications. Shoot height and stem diameter are still the main criteria used today (Mexal and Landis 1990; Jacobs and others 2005), although the minimum acceptable sizes for these parameters have increased greatly. Acceptable size categories from just 25 years ago would be considered culls under today's customer expectations. It's important to also pay attention to morphological parameters beyond the traditional shoot height and stem diameter. While these are very important measures, many other seedling morphological and physiological attributes contribute to overall plant quality, such as root mass, fertility, cold hardiness, xylem water potential, and shoot to root ratio (Haase 2008).



Figure 8. Monitoring seedling height of 2+0 Engelmann spruce seedlings in 1932 (Savenac Nursery photo archives).

One of the challenges for the future is to continue gaining an understanding of physiological quality in response to culturing practices, customer needs, and climate change. In addition, demand is always present to develop better, quicker tests for determining that quality. For example, seedling mortality is sometimes not visible following a stress event; it would be useful to refine testing procedures for early detection of plants that are damaged or killed. As with all other components of nursery production, expansion of the knowledge to include non-traditional native species is also an area deserving of further attention.

Outplanting Practices

By necessity, nursery practices must evolve along with outplanting practices. Research programs and technological advances have resulted in significant changes to outplanting techniques and treatments (Figure 9). As with any business, the end-user dictates the specifications for the product. As a result, nurseries must adjust their growing practices to accommodate their client's planting season, site environment, species needs, and requests for specific plant morphological/physiological conditions.

Too often, seedling growth in the nursery and its subsequent outplanting and establishment are treated as distinct, independent phases. Communication between the nursery and outplanting personnel is critical and contributes to ensuring the vigor and longevity of seedlings destined for specific outplanting sites.



Figure 9. A snapshot of 75 years of forest regeneration with nursery-grown seedlings: tree planters in 1930 (A) and 2005 (B).

People

People who work in nurseries generally love their jobs and stay in them for many years. Most consider it a very rewarding career and enjoy working with young plants destined for reforestation or conservation plantings. Early nursery managers were passionate about their crops as well. They were pioneers in an early effort to replant many thousands of acres of deforested land.

Currently, the nursery workforce is aging, with a paucity of “new blood” to fill critical positions as they become vacant. Even with unemployment rates climbing, professional nursery jobs can be difficult to fill. Young people rarely have nursery work as their career goal. This is especially true in the forestry sector in which college students are only introduced to seedling production during one term of reforestation silviculture and seldom go on to pursue a nursery position. A career as a professional grower or nursery manager is often not on their radar or is not quite as alluring as positions in ecology, climate change, or field forestry. Nonetheless, nursery careers are every bit as professional, rewarding, and vital as those in other disciplines.

Economy

During the past 100 years, the nursery industry has grown substantially. In the latter half of the 20th century, production rose to 1.5 billion seedlings annually. In recent years, the economy has had

a significant impact on nursery production. As timber prices fall, logging declines, funding for conservation projects decreases, and orders for nursery plants have waned.

Seedlings are always in demand regardless of the ups and downs in the economy. Although new construction and production of wood- and plant-based products has declined during the current economic downturn, the growing consumer population continues to need fiber resources such as printer paper, toilet paper, food packaging, housing, furniture, and other products which require harvesting and reforestation of the nation’s forests. Additionally, forest fires are a growing problem in the country and most necessitate replanting seedlings in order to establish new forests to provide long-term resources for wildlife, recreation, timber, and other uses within a reasonable time-frame. This is essential in areas where competing brush species become rapidly established following wildfire and can subsequently prevent growth of tree species for several decades.

Furthermore, awareness and concern regarding the environment is rising. The media and the public have placed a growing emphasis on the importance of being “green” in order to protect and improve the environment to mitigate climate change and conserve resources for future generations. As such, we now see unprecedented attention directed toward employing trees as carbon sinks and using woody and herbaceous native plant species to restore degraded lands. Seedling production will never cease to be important on this planet.

References

- Dumroese RK, Landis TD, Barnett JP, Burch F. 2005. Forest Service nurseries: 100 years of ecosystem restoration. *Journal of Forestry* 103: 241-247.
- Fleege C. 1995. History of Bessey Nursery. In: Landis TD, Cregg B, technical coordinators. National proceedings, forest and conservation nursery associations. Portland (OR): USDA Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-365. p 60-63.
- Gitay H, Suárez A, Watson RT, and 17 others. 2002. Climate change and biodiversity. Geneva (Switzerland): Intergovernmental Panel on Climate Change. IPCC Technical Paper V. 77 p.
- Haase DL. 2008. Understanding forest seedling quality: measurements and interpretation. *Tree Planters' Notes* 52(2):24-30.
- Haase DL, Rose R, editors. 2001. Conference proceedings, native plant propagation and restoration strategies; 2001 December 12-13; Eugene, OR. Corvallis (OR): Oregon State University, Nursery Technology Cooperative and Western Forestry Conservation Association. 142 p.
- Hansen EM, Stone JK, Capitano BR, Rosso P, Sutton W, Winton L, Kanaskie A, McWilliams MG. 2000. Incidence and impact of Swiss needle cast in forest plantations of Douglas-fir in coastal Oregon. *Plant Disease* 84:773-778.
- Jacobs DF, Salifu KF, Seifert JR. 2005. Relative contribution of initial root and shoot morphology in predicting field performance of hardwood seedlings. *New Forests* 30:235-251.
- Johnson GR, Sorenson FC, St Clair JB, Cronn RC. 2004. Pacific Northwest forest tree seed zones: a template for native plants? *Native Plants Journal* 5:131-140.
- Jones GW. 1925. Forest nursery working practice at Savenac Nursery. *Journal of Forestry* 10:635-644.
- Korstian CF, Baker FS. 1925. Forest planting in the intermountain area. Washington (DC): USDA Forest Service. Agriculture Bulletin 1264. 56 p.
- Mexal JG, Landis TD. 1990. Target seedling concepts: height and diameter. In: Rose R, Campbell SJ, Landis TD, editors. Proceedings, target seedling symposium, combined meeting of the western forest nursery associations. Fort Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-200. p 17-35.
- Olson DS. 1930. Growing trees for forest planting in Montana and Idaho. Washington (DC): USDA Forest Service. Circular Number 120. 166 p.
- Randall WK, Berrang P. 2002. Washington tree seed transfer zones. Olympia (WA): Washington Department of Natural Resources. 63 p.
- Rose R, Campbell SJ, Landis TD, editors. 1990. Proceedings, target seedling symposium, combined meeting of the western forest nursery associations. Fort Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-200.
- Rose R, Haase DL. 2006. Guide to reforestation in Oregon. Corvallis (OR): College of Forestry, Oregon State University. 48 p.
- Show SB. 1930. Forest nursery and planting practice in the California pine region. Washington (DC): USDA Forest Service. Circular Number 92. 75 p.
- Tillotson CR. 1917. Nursery practice on the national forests. Washington (DC): USDA Forest Service. Agriculture Bulletin 479. 86 p.
- Toumey JW. 1916. Seeding and planting: a manual for the guidance of forestry students, foresters, nurserymen, forest owners, and farmers. 1st ed. New York (NY): John Wiley and Sons. 455 p.