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Nursery Meetings

Note: Because FNN is only printed twice a year, the following information is necessarily dated. For the most up-to-date information on meetings about nurseries, reforestation, and restoration, visit the RNGR Website: www.rngr.net

The **17th Wildland Shrub Symposium** will be held **May 22 to 24, 2012** at the Las Cruces Convention Center in Las Cruces, NM. This year's theme will be Humans in Changing Landscapes and the program will include plenary sessions, oral and poster sessions, and field tours. You can register on-line or just get more information at:

Website:
http://jornada.nmsu.edu/wildland-shrub-symposium

The annual meeting of the **Westside Container Grower's** will be hosted by the Washington State DNR Webster Nursery in **June, 2012**. The exact date has not been determined and the agenda is still being developed, but if you'd like more information contact:

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This year's **Southern Forest Nursery Association** meeting will be held on **July 16 to 19, 2012** at the Sheraton Read House in Chattanooga, TN. The meeting will consist of technical presentations including one of the McMinnville, TN nursery industry. Nursery tours will visit the Native Forest Nursery in Chatsworth, GA as well as the East Tennessee Nursery, which is operated by the State of Tennessee in Delano. Chattanooga is known as Tennessee's Scenic City, and offers many options for vacations. The local contact is:

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Western Forest & Conservation Nursery Association

This coming September, a joint meeting of the **Intertribal Nursery Council**, the **Western Forestry and Conservation Nursery Association**, and the **Intermountain Container Seedling Growers' Association** will be held from September 11 to 13, 2012 in Bend, OR. Our host will be the USDA Forest Service, Bend Seed Extractory with the appropriate theme of Seeds. For the latest information, contact:

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The **Western Regional meeting of the International Plant Propagators' Society** meeting will be **September 19 to 22** at the Four Points Sheraton in Ventura, CA, For the latest information, go to the IPPS website (http://www.ippswr.org/), or contact Lee Dempsey:

E-mail: ippswrlee@sbcglobal.net

On **November 28 to 29, 2012**, a conference on the **Nutrition of Seedlings and Young Forests** will be held in Portland, OR. Exact details are still being developed and this meeting will possibly be sponsored by the International Union of Forest Research Organizations (IUFRO). **Diane Haase** is the meeting coordinator and can be reached at:

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Lammas Shoots in Nurseries and Plantations

by Thomas D. Landis

Lammas shoots are shoots that resume growth, or "flush", after budset in some woody temperate zone plants during the late summer. The name refers to Lammas day (August 1), which is the Celtic harvest festival (Wikipedia 2012a). This type of shoot growth is also known as second flushing (Kohnmann and Johnsen 1997), or summer shoots (Rikala 1992). Lammas growth was first documented by Theophrastus, a Greek contemporary of Artistotle who is considered to be the father of botany (Roth and Newton 1996).

Lammas growth is particularly relevent in nurseries and reforestation because it is most commonly observed on young plants under managed conditions, such as nurseries, plantations, provenance trials, and Christmas tree farms. In fact, one of the most extensive surveys on lammas growth was conducted because of the high incidence of these shoots in Douglas-fir (*Pseudotsuga menziesii*) plantations on the University of British Columbia (UBC) research forest (Walters and Soos 1961). They noted that seedlings of the same genetic source had a higher percentage of lammas shoots in the UBC forest nursery than in outplantings and, in these plantations, the occurrence of lammas shoots increased with site index. Curiously, seedlings with lammas shoots were not found in natural forest stands.

Concern about adverse effects of lammas growth in commercial forest plantations and genetic trials was considerable in the 1930s to 1970s. For example, a Journal of Forestry article (Carvell 1956) stated:

"Unless branches and double tops originating from lammas growth are removed, repeated formation of summer shoots . . . could eventually deform a sufficient number of stems to eliminate all possibility of future saw timber production from these plantations".

This concern seems to have tempered somewhat since then. After their survey of lammas growth in Douglas-fir plantations, Walters and Soos (1961) concluded that although common, lammas shoots usually only have a temporary influence on tree form. Likewise, an analysis of stem deformation in Scots pine (*Pinus sylvestris*) plantations found that trees with lammas shoots seemed to outgrow the apparent distortions and terminal forking (West and Rogers 1965). Other published

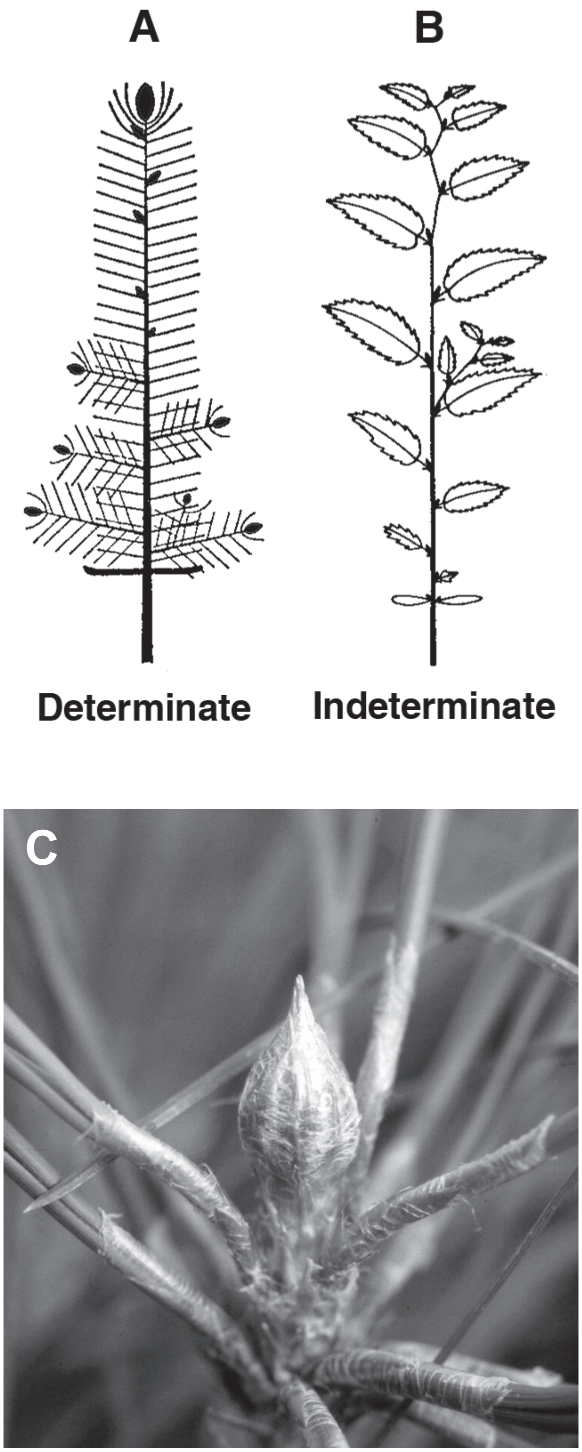


Figure 1 - Woody plants with determinate growth form firm buds (A), whereas those with indeterminate growth do not (B). Firm buds (C) have traditionally been a visible indication of dormancy, and therefore seedling quality.

reports conclude that lammas growth in plantations may actually be an asset. For example, lammas growth has been considered desirable when selecting for fast growth in tree improvement plantations. Lammas growth in genetically improved Sitka spruce (*Picea sitchensis*) plantations accounted for an average of 22% more height growth (Mboyi and Lee 1999). Lammas growth was also deemed beneficial in Douglas-fir plantations along the Pacific coast where deer browse is a problem (Roth and Newton 1996).

So, lets take a good luck at the phenomenon of lammas shoots and how they might affect nursery management and seedling quality. Before we can proceed however, we need to review some basic botany about how the shoots of woody plants grow. Two general types of shoot growth are recognized (Kozlowksi 1971; Wikipedia 2012b).

1. Determinate - Woody plants with a determinate growth habit exhibit a single growth flush in the spring from the elongation of pre-formed stem units in a dormant bud (Figure 1A&C). Species with determinate stem growth include many commercial conifers including pines and spruces, but also some hardwood species.

2. Indeterminate - With the indeterminate growth habit, the shoots of woody plants expand at regular intervals during the growing season and may or may not originate from a dormant bud. The shoots of some species, such as juniper (*Juniperus* spp.) or western redcedar (*Thuja plicata*), never form a dormant bud at the end of the growing season when shoot growth stops due to cold weather and short photoperiod (Figure 1B). In other species, the shoot beyond the last lateral bud dies back due to frost, and then that lateral bud acts as a terminal bud for the following season's growth.

Many scientists define lammas growth as only occurring from the terminal bud (Figure 2A). Other related terms include syllepsis, which has been defined as the flushing of lateral buds in the terminal cluster (Figure 2B), and prolepsis, the flushing of new buds from the lateral meristem after terminal budset. In one study, 73% of the second flushing came from lateral buds, 22% from terminal and lateral buds, and only 5% strictly from terminal buds (Rudolph 1964). I haven't taken any actual measurements but I have observed that container plants grown closely together in blocks tend to flush primarily from terminal buds; conversely, I have seen more flushing of lateral buds in more widely-spaced bareroot stock, especially in pines. For this discussion, however, we will define lammas as as any foliar growth that occurs after initial budset.

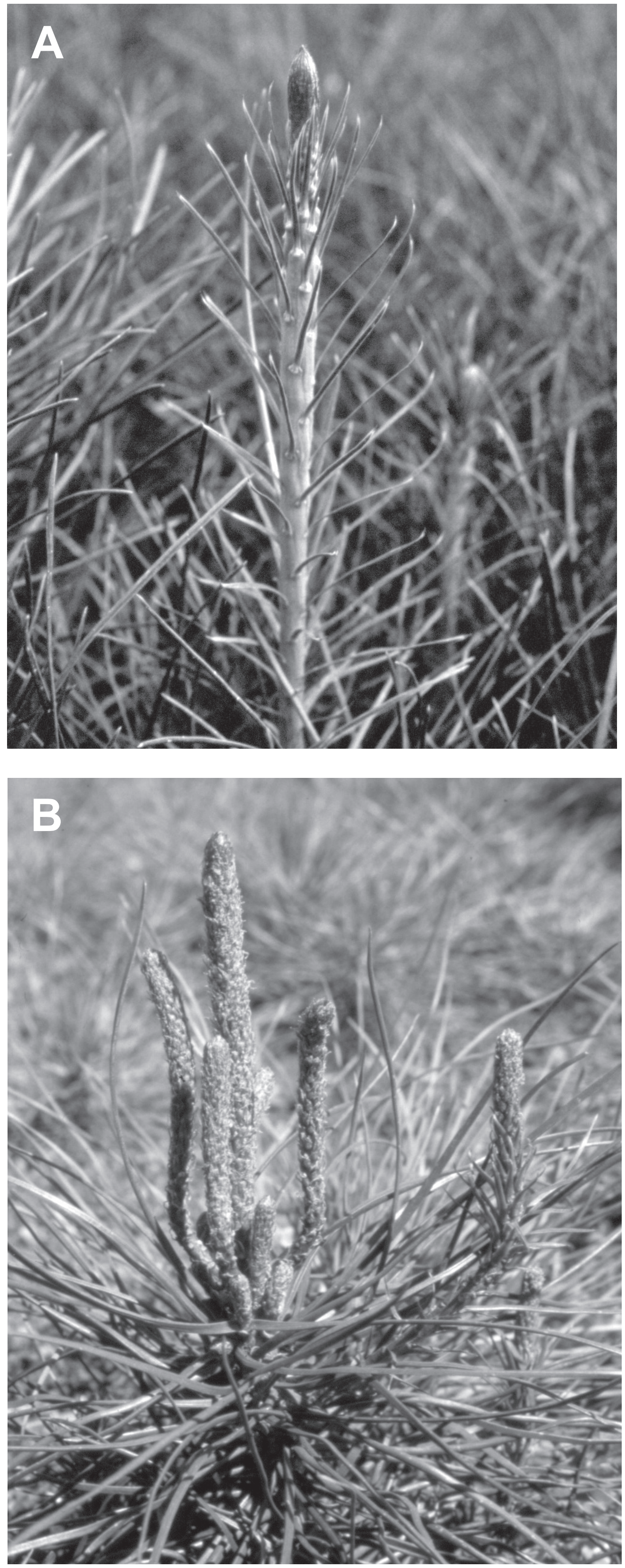


Figure 2 - Although some distinguish between growth flushes of the terminal (A) and lateral buds (B), we will consider any secondary flushing as lammas growth.

Another important distinction is that lammas growth is a juvenile trait because it rarely occurs in plants more than 10 to 15 years old (Adams and Bastien 1994).

Genetic and Environmental Factors Affecting Lammas Growth

Not all woody plants with the determinate growth habit exhibit lammas growth, although it has been documented in many conifers of commercial importance including true firs (*Abies* spp.), spruces (*Picea* spp.), pines (*Pinus* spp.), Douglas-fir and hemlocks (*Tsuga* spp.). Lammas growth also occurs in some broadleaved genera including oaks (*Quercus* spp.), beech (*Fagus* spp.) and maple (*Acer* spp.). Other genetic links have also been noted. Numerous studies (for example, Rudolph 1964) have shown that lammas shoots are much more common with certain seed sources. In a growth trial with Douglas-fir, seedlings from an interior seed source had significantly more lammas growth than those from a coastal source (Kaya and others 1994).

Nurseries and especially greenhouses optimize many environmental factors that can stimulate production of lammas shoots. Scots pine seedlings grown in a greenhouse produced more lammas growth than those grown outside. Of the cultural factors modified by the greenhouse environment, irrigation, fertilization, and carbon dioxide enhancement stimulated lammas growth (Alden 1971). Not surprisingly, the same 4 environmental factors that are used in nurseries to induce budset have been shown to stimulate the formation of lammas shoots (Figure 3A).

Warm Temperature - When dormant container seedlings of Japanese red pine (*Pinus densiflora)* were moved from outdoors into a heated greenhouse in mid to late winter, they developed lammas shoots. The earlier the seedlings were exposed to the warmer temperatures, the higher the percentage of plants with lammas growth and the earlier this second flush started (Kushida and others 1999).

Irrigation - The cultural practice of reducing irrigation to cause a moderate moisture stress has been used to induce budset in bareroot and container nursery stock. However, several nurseries have noticed that lammas shoots develop when normal irrigation is resumed. In a study with container Scots pine (Alden 1971), a strong relationship was shown between percentage of seedlings with lammas shoots and the moisture content of the growing medium (Figure 3B).

Fertilization - Fertilizer applications, especially nitrogen, are one of the most effective ways to stimulate additional shoot growth in bareroot and container nurseries (Landis and van Steenis 2003). Many growers are concerned that excessive fertilization, or fertilizer that is applied in late summer, may cause bud break and the development of lammas shoots. In one study, bareroot Scots pine received 3 top dressing applications of fertilizer containing nitrogen, phosphorus, and potassium and were then monitored for the development of lammas growth. Although lammas shoots were more prevalent in seedlings with higher foliar nitrogen concentration (Figure 3C), this study concluded that merely decreasing fertilizer concentration would not eliminate the occurrence of lammas shoots (Rikala 1992). Another study with Douglas-fir found that fertilization significantly increased the production of lammas shoots and that nitrogen was the nutrient responsible. Ammonium nitrate fertilizer had the greatest stimulating effect of all the fertilizers tested, whereas those containing only phosphorus or potassium had no effect on lammas shoot formation (Walters and Kozak 1967).

Many nursery managers are reluctant to fertilize later in the growing season because of concerns about stimulating lammas shoots. However, a review of late season nitrogen fertilization ("nutrient loading") of conifer seedlings in both bareroot and container nurseries concluded that such fertilization was beneficial as long as foliar nitrogen was kept in the ideal range of 1.5% to 2.5% with a moderate moisture stress to limit budbreak (Dumroese 2003).

Photoperiod - Manipulation of photoperiod, especially the timing and duration of blackout treatments, has also been shown to promote lammas growth. For example, when short blackout treatments was applied to Norway spruce (*Picea abies*) early in the summer, the plants were prone to break bud and develop lammas shoots (Kohmann and Johnsen 2007). In subsequent experiments with the same species, this stimulation of lammas growth was reduced by extending the blackout treatment for longer than 2 weeks (Luoranen and others 2009).

Lammas Shoots and Seedling Quality

Because of the large number of commercial conifers grown in nurseries, the occurrence of lammas growth is a source of serious concern by some managers and

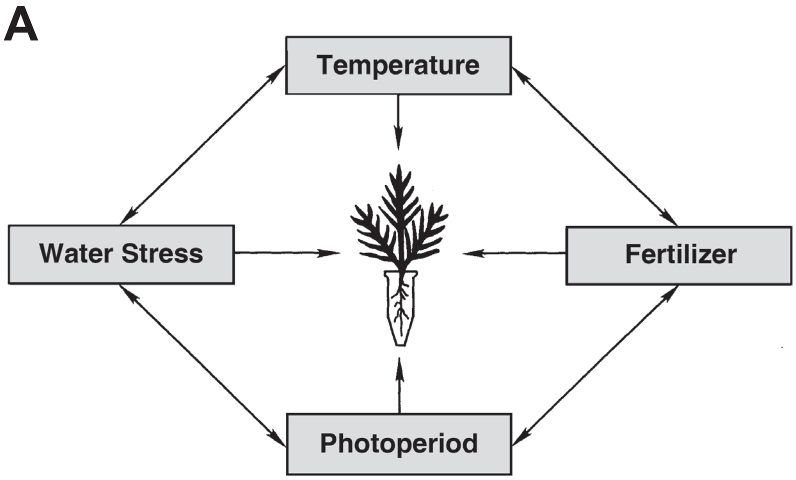
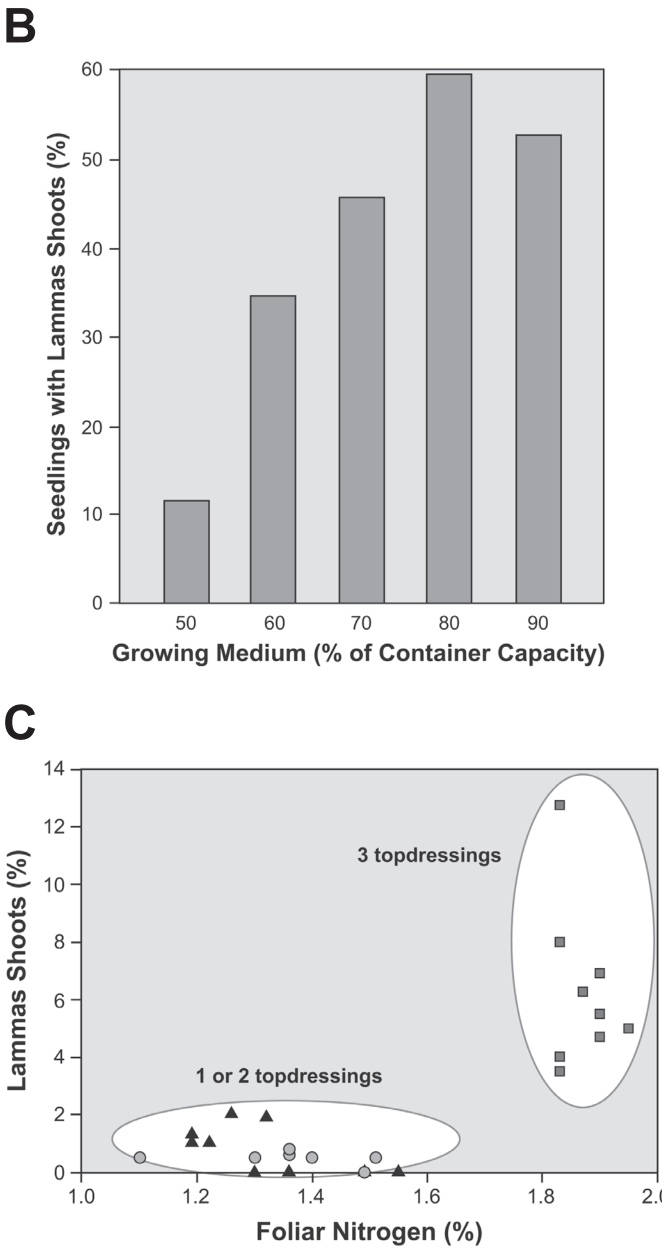


Figure 3 - The same 4 environmental factors used to induce bud dormancy in nurseries have been related to lammas growth (A). Applying irrigation after a period of drought stress stimulates lammas growth (B), as does nitrogen fertilization, especially later in the growing season (C). (A, from Landis and others 1999; B, modified from Alden 1971; C, modified from Rikala 1992).



particularly by nursery customers. Many foresters believe that a firm terminal bud is an indication of seedling quality, and lammas growth is considered undesirable. As we have just discussed, many woody plants with determinate growth habit will develop lammas shoots under a favorable nursery environment. These shoots may or may not develop a bud by the end of the growing season and the concern is that these plants are not dormant. Because the new growth occurs late in the growing season, seedlings with lammas growth are slower to develop cold hardiness and may be more susceptible to early fall frosts. I'm not aware of any published research that actually tested the dormancy or cold hardiness of plants with lammas growth, but these tests wouldn't be difficult and would provide some needed information. In outplanting trials with Sitka spruce, no evidence was found to suggest that lammas growth suffered increased frost damage (Mboyi and Lee 1999). A detailed study of the causes and effects of lammas growth on Scots pine in Finland determined that seedlings with lammas growth should not be culled (Rikala 1992), and I tend to agree with this conclusion.

Undoubtedly, foresters and other customers will occasionally express concern about nursery stock with lammas shoots, but most studies have found that forking and other growth deformations are temporary and seedlings will outgrow them. When you think of it, the very occurrence of lammas shoots shows that seedlings are well established and capable of rapid growth — a major expression of seedling quality.

Because lammas growth is strongly controlled by environment, nursery managers can at least partially control the development of lammas shoots by careful regulation of irrigation and fertilization, especially late in the growth season. Still, lammas shoots may develop as a result of late summer rains or after irrigation of transplanted plug+one stock so nurseries should inform and educate their customers about the causes and probable outcome of lammas growth.

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Seed Treatments for Container Seedling Production at the University of Idaho

by Olga A. Kildisheva, Donald J. Regan, and Anthony S. Davis

Introduction

Propagation from seeds is the most common method of plant production in forest and conservation nurseries (Landis and others 1999). Seed propagation is particularly widespread because this technique is relatively simple, inexpensive, and preserves genetic diversity in the crop – an important consideration in maintaining biodiversity and species persistence following outplanting. Other benefits of seed propagation include ease of shipping and long-term storage, especially for seeds with hard seed coats.

This article documents the techniques used to successfully propagate a wide variety of plants native to Idaho at the University of Idaho Franklin H. Pitkin Forest Nursery (UIPFN). Complete propagation protocols are being developed and will be posted on the Native Plant Network (www.nativeplantnetwork.org).

Disinfecting Seeds

Woody plant seeds, especially those with rough seed coats, harbor fungal and bacterial pathogens that can cause major problems during the seed treatment and germination process. This problem is acute for species that require several months of stratification; such seeds should be disinfected as a first step. One of the easiest and most effective treatments is a running water rinse (Figure 1) where seeds are placed under running water for 24 to 48 hours (James and Genz 1981). In addition to gently washing away pathogens, this treatment encourages full seed hydration, which is the first step in the germination process.

In cases when a water rinse is not sufficient, a solution of commercially available bleach and water can be used. Care should be taken with thin coated seeds, such as red alder (*Alnus rubra*), which can be damaged by prolonged exposure to concentrated bleach solutions. The most effective concentration (v:v) is species-dependent and can range from 1:8 to 2:3 (bleach:water) (Luna and others 2009). At the UIPFN, a 1:5 concentration is used to disinfect species particularly susceptible to fungal contamination, such as lodgepole, limber, and western white pines (*Pinus contorta, P. flexis, P. monticola, P. ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*).

Figure 1 – A running water rinse accomplishes 2 prerequisites for effective seed treatments: cleansing the seedcoat and imbibing the seed with water.

Seeds can be placed in sacks of tulle or mesh bags, submerged in a bleach solution, and swirled around in order to allow bleach to coat seeds evenly. After several minutes, seeds are thoroughly rinsed in running water. In extreme situations, fungicide can be used to reduce mold development, but should only be done when absolutely necessary due to possible phytotoxicity and health concerns (Finnerty and Hutton 1993).

Seed Treatment by Dormancy Type

Seed dormancy is an adaptation that ensures seeds will germinate only when environmental conditions are favorable for survival. Some seeds require no treatment and will germinate immediately in the proper environment whereas most native plants have seeds with some type of dormancy. Determining the type and degree of seed dormancy is critical to successful propagation, and keys are available to determine which type of dormancy is exhibited by seeds (Luna and others 2009).

External Dormancy

The term external dormancy is synonymous with physical dormancy and is caused by the presence of a lignified layer of cells in the seed coat that prevents a dormant seed from taking up water and gases. However, once the seed is made permeable it can complete its germination within 2 weeks, if no additional dormancy exists (Baskin and Baskin 1998; Luna and others 2009).

Scarification

Physical dormancy is alleviated by scarification of the seed coat, which can be done in a number of ways including piercing, filing, nicking, sanding, burning, acid scarification, or wet heat. At the UIPFN, a concentrated solution of sulfuric acid (H_2SO_4) is used to treat species with especially thick seed coats or stony endocarps such as black hawthorn (*Crataegus douglasii*), redstem ceanothus (*Ceanothus sanguineus*), and oakleaf sumac (*Rhus trilobata*), with treatment durations ranging from 20 to 45 minutes (Table 1). For this procedure, seeds are placed in a glass container and covered with concentrated sulfuric acid. The seeds are gently stirred and allowed to soak for a predetermined duration of time (dependent on the species, seed size, and seed coat thickness). Sulfuric acid reacts strongly with water, thus it is important to remember to never add acid to water, as it can result in a powerful reaction and cause severe chemical burns. In addition, sulfuric acid can damage the seed embryo; therefore seeds must be closely monitored during the treatment. If working with a new species for which treatment duration is not known, monitoring can be done by removing seeds from the acid bath at regular intervals and cutting them. Once the seeds can be cut easily but maintain a firm embryo they have been sufficiently scarified, at which point all seeds should be removed from the acid. Sulfuric acid can be potentially dangerous to the applicator and requires protective wear (gloves, goggles, and aprons) and must be disposed of properly (Luna and others 2009).

Internal Dormancy

Seeds with internal dormancy have embryos that are either underdeveloped or exhibit a low growth potential (Baskin and Baskin 1998). A number of different types of internal dormancy exist, but all respond to some combination of specific temperature and moisture treatments.

Stratification and Warm, Moist Treatment

Stratification can be described as the process that uses high moisture and temperature or a series of temperatures to overcome seed dormancy. According to Luna and others (2009) the term "stratification" refers to cold, moist conditions, while the term "warm, moist treatment" means exactly that. Several native plants require some combination of stratification and warm, moist treatment. Stratification temperatures usually range between 1 and 3 °C (34 to 38 °F), while warm, moist treatment temperatures fall between 18 and 30 °C (65 to 86 °F).

A number of different techniques can be used for stratification and for warm, moist treatment. Seeds can be placed in plastic bags and mixed with a moist medium, such as *Sphagnum* moss, or wet burlap to maintain high humidity. At the UIPFN seeds are placed in nylon tulle, which can be purchased at any fabric store in a variety of mesh sizes. The nylon tulle is tied, labeled, buried in a bucket filled with moist media, and placed in the appropriate temperature conditions (Figure 2). This is a particularly useful technique for species that are transplanted into containers as germinants, such as black hawthorn, red currant (*Ribes sanguineum*), Rocky Mountain juniper (*Juniperus scopulorum*), and several rose species (*Rosa nutkana* and *R. woodsii*) (Table 1). The germinant sowing procedures are well described in Landis and others (1999).

Figure 2 - At the Pitkin Forest Nursery seeds are placed in nylon tulle, which is buried in a bucket filled with moist media and placed in the appropriate temperature conditions for stratification or warm, moist treatment.

Another method, "naked" stratification, involves placing seeds in nylon tulle, which is positioned inside a plastic bag filled with a small amount of water in order to maintain high relative humidity (RH) inside each bag (Figure 3). The nylon tulle containing seeds should not come in contact with the water in the plastic bag. Bags can be tied and hung inside a cooler for the required duration of time. The seeds should be checked frequently to make sure there is no fungal presence and rinsed periodically to cleanse and aerate them. At the UIPFN, this method is used primarily for conifers, but is also suitable for the treatment of some native shrubs and hardwoods (Table 1).

Figure 3 - Naked stratification involves placing seeds in nylon tulle, which positioned inside a plastic bag above a supply of water, in order to maintain high relative humidity (RH) inside each bag. The nylon tulle containing seeds should not come in contact with the water in the plastic bag. Bags can be tied and hung inside a cooler for the required duration of time.

An alternative method involves stratifying seeds once they are in the growing containers. Dormant seeds are sown on the surface of the media and sometimes covered by a thin layer of media or grit that helps maintain constant conditions around the seed. Whether or not seeds are covered depends on their light requirement; for instance seeds of western syringa (*Philadelphus lewisii*) are stratified uncovered because they require light during germination. Once sown, containers are watered until the medium is brought to field capacity. Finally, the sown containers are placed into a cooler, or stored outside in a protected area during the winter (in areas where appropriate temperature conditions are met). If only a warm, moist treatment is required, seeds can be maintained under a moist cover in a greenhouse. It is important to note that the media moisture level should be maintained during the treatment period, which is of particular importance for warm, moist treatments. In addition, seeds treated in this manner must be protected against rodent predation.

At the UIPFN a number of native shrubs and hardwoods are stratified directly in containers (Table 1). This approach is especially useful for smaller seeds that are harder to transplant or those that are covered with mucilage [for example, serviceberry (*Amelanchier alnifolia*)] that prevents them from being effectively handled during naked or moist media stratification. In addition, container stratification allows for a quick transition from stratification into the greenhouse, thus saving the grower a substantial amount of time in the spring when time is limited. However, this approach requires considerably more area than other stratification methods and is not advisable when space constraints are an issue. To make certain that each container has a viable seed, several seeds are sown in each container and thinned after germination.

Some species require exceptionally humid conditions in order to germinate. For such species the use of a "foghouse" or another high humidity environment may be necessary to promote germination following stratification or warm, moist treatment. Mountain huckleberry (*Vaccinium membranaceum*) is an example of a species with this requirement. Although generally considered to be difficult to propagate, it has been successfully cultivated at the UIPFN. Seeds are sown directly into hydrated Jiffy J2865 (3.1 in^3) forestry peat pellets (Jiffy Products of America, Inc., Norwalk, OH), placed in corresponding trays, sealed in plastic bags to prevent moisture loss, and then stratified at 1.5 °C (35 °F) for 30 to 45 days. Following stratification, the trays are moved to the foghouse (at 85% RH) and placed on benches with heated-water circulation (21 °C [70 °F]). Germination occurs in 13 to 21 days. After 90 days seedlings are moved into a greenhouse and placed in front of moist cooling pads, where temperatures range between 26.5 °C (80 °F) and 10 °C (50 °F) (Regan and others 2012).

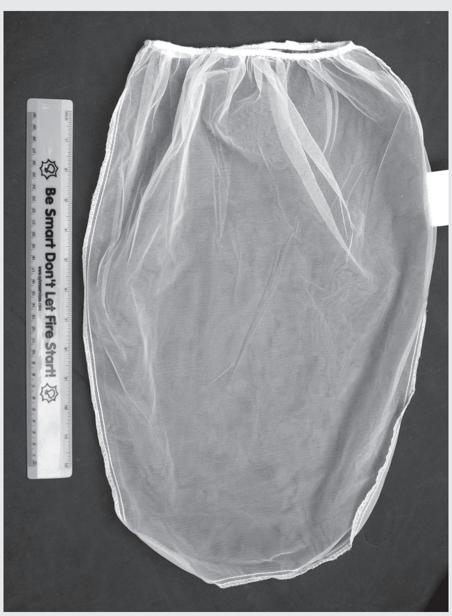
Scientific Name	Common Name	Sulfuric Acid	Gibberellic Acid	Running Water Soak	Warm Treatment	Stratification	Germinant Sowing	Running Water Rinse
Hardwoods								
Alnus incana	Thinleaf Alder	–	–	yes	–	180 d naked	–	yes
Betula occidentalis	Water Birch	–	–	–	–	–	–	–
Betula papyrifera	Paper Birch	–	–	–	–	–	–	–
Cornus sericea	Redosier Dogwood	–	–	yes	–	90 d naked	–	yes
Crataegus douglasii	Black Hawthorn	25 min	–	yes	30 d media	120 d media	yes	–
Prunus virginiana	Chokecherry	–	–	yes	–	140 d container	–	–
Sorbus scopulina	Mountain Ash	–	–	yes	–	150 d container	–	–
Shrubs								
Amelanchier alnifolia	Serviceberry	–	–	yes	–	120 d container	–	–
Ceanothus sanguineus	Redstem Ceanothus	20 min	–	yes	–	60 d naked	–	yes
Dasiphora fruticosa	Shrubby Cinquifoil	–	–	yes	–	60 d naked	–	yes
Philadelphus lewisii	Westem Syringa	–	–	yes	–	60 d container	–	–
Physocarpus malvaceus	Ninebark	–	–	yes	–	30 d naked	–	yes
Purshia tridentata	Antelope Bitterbrush	–	–	yes	–	60 d naked	–	yes
Rhamnus purshiana	Cascara	–	–	yes	–	115 d naked	–	yes
Rhus trilobata	Oakleaf Sumac	45 min	–	yes	–	60 d naked	–	yes
Ribes aureum	Golden Currant	–	–	yes	–	60 d container	–	–
Ribes sanguineum	Red Currant	–	–	yes	–	120 d media	yes	–
Rosa nutkana	Nootka Rose	–	–	yes	115 d media	115 d media	yes	–
Rosa woodsii	Woods' Rose	–	–	yes	30 d media	120 d media	yes	–
Salvia dorrii	Desert Purple Sage	–	–	yes	–	–	–	–
Sambucus nigra	Blue Elderberry	–	GA	yes	–	60 d tray	–	–
Vaccinium membranaceum	Mountain Huckleberry	–	–	yes	–	30 d Jiffy tray	–	–
Conifers								
Abies concolor	Concolor Fir	–	–	yes	–	28 d naked	–	yes
Abies grandis	Grand Fir	–	–	yes	–	28 d naked	–	yes
Abies lasiocarpa	Subalpine Fir	–	–	yes	–	28 d naked	–	yes
Juniperus scopulorum	Rocky Mountain Juniper	–	–	yes	120 d media	120 d media	yes	–
Larix occidentalis	Western Larch	–	–	yes	–	28 d naked	–	yes
Picea engelmannii	Engelmann Spruce	–	–	yes	–	28 d naked	–	yes
Picea pungens glauca	Blue Spruce	–	–	yes	–	28 d naked	–	yes
Pinus contorta	Lodgepole Pine	–	–	yes	–	28 d naked	–	yes
Pinus flexilis	Limber Pine	–	–	yes	–	40 d naked	–	yes
Pinus monticola	Western White Pine	–	–	yes	–	120 d naked	–	yes
Pinus ponderosa	Ponderosa Pine	–	–	yes	–	46 d naked	–	yes
Pseudotsuga menziesii	Douglas-fir	–	–	yes	–	28 d naked	–	yes
Thuja plicata	Westem Redcedar	–	–	yes	–	28 d naked	–	yes
Tsuga heterophylla	Western Hemlock	–	–	yes	–	45 d naked	–	yes

All water rinses are 24 hours and occur after stratification; all soaks are 48 hours and occur before stratificafion or sowing (if no stratification is required).

Table 1. Summary of seed treatment techniques used for native hardwoods, shrubs, and conifer species grown at the University of Idaho Pitkin Forest Nursery (Moscow, ID).

Gibberellic Acid

Gibberellic acid (GA_3) is a naturally occurring growth hormone that is often used to alleviate internal dormancy. It can be used alone or in combination with stratification and is sometimes substituted for a warm, moist treatment (Timson1966; Pinfield and others 1972; Luna and others 2009). GA_3 acts through increasing the growth potential of the embryo and by overcoming the mechanical constraints that prevent the emergence of the radicle (Hilhorst and Karssen 1992; Leubner-Metzger 2003). This chemical can be readily purchased from horticultural or chemical suppliers; however, the concentration of the effective GA_3 solution is species dependent, typically varying between 100 and 1000 ppm (Luna and others 2009). A treatment solution can be prepared by dissolving GA_3 in distilled water according to the concentration requirement. The UIPFN uses a 346 ppm solution to treat seeds of blue elderberry (*Sambucus nigra* spp. *cerulea*), which is prepared by mixing 51.9 mg of GA_3 with 0.15 L of water. GA_3 solutions can be applied by soaking seeds directly, thoroughly spraying them, or by placing seeds on germination paper saturated with the solution. With this latter technique, following treatment seeds are removed and then planted into growing containers (Figure 4). Because GA_3 is a powerful growth hormone, high concentrations can cause premature germination and poor seedling quality; when working with a new species, always start with dilute concentrations first (Luna and others 2009).



Editor's Note: Trimaco® Cone Paint Strainer bags come in 1 and 5 gallon sizes and are perfect for rinsing and stratifying seeds.

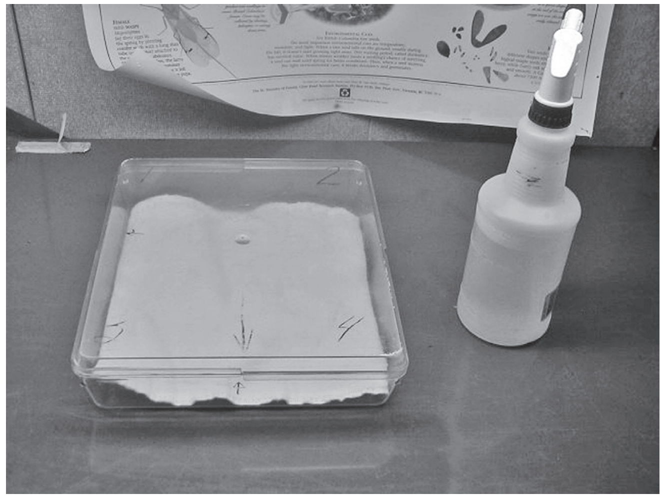


Figure 4 - The GA_3 solution can be applied with a spray bottle. This method requires seeds to be germinated in trays and then planted into growing containers.

Sowing Techniques in Container Nurseries

Direct Sowing

Direct sowing is a quick and economical method for sowing seeds because it minimizes handling and labor. It is by far the most common approach, especially for those seeds that require little to no pre-sowing treatment. Furthermore, direct sowing can be mechanized for larger scale operations, further expediting the process (Luna and others 2009). For this approach it is important for growers to have accurate germination information to set optimal sowing rates in order to insure adequate seedling emergence. If such information is not available, small-scale germination tests should be conducted in order to assess the germination rate of a particular seedlot (Luna and others 2009). Procedures for determining the optimal number of seeds necessary to obtain a target number of germinants are described in detail in Chapter 8 of the *Nursery Manual for Native Plants* (Luna and others 2009). However, many native plants have various dormancy requirements and often benefit from germinant sowing.

Germinant Sowing

Germinant sowing, sometimes referred to as planting "sprouts," is particularly useful for large seeds, seed lots of variable quality, or for those for which no germination test data are available (Landis and Simonich 1984; Finnerty and Hutton 1993). Germinant sowing is primarily used for seeds with internal dormancy that require stratification and/or warm, moist treatment, such as maples and junipers. The major advantage of this method is that it ensures a live seedling originates from each container (Landis and others 1999). At the UIPFN, this technique is used frequently, especially for seedlings planted into Jiffy forestry pellets.

Seeds that will be sown as germinants are place in stratification or warm, moist treatment and monitored every few days to gauge germination. Seeds with an emerged radicle are separated out and sown. Larger seeds can be planted by hand, but smaller ones require tweezers, although planting method is subject to preference (Landis and others 1999). For tap-rooted species such as some nut crops, the radicle of the dominant root is sometimes pruned to encourage the establishment of a more fibrous root system. However, the pruned amount should not exceed 3.0 mm (0.12 in) (Emery 1988).

One of the major drawbacks of germinant sowing is the need for precision in germinant placement. The seeds must be sown with the radicle extending downward as inadequately placed seeds will be deformed, brittle, or break when they become larger. Another disadvantage is that sowing may take several weeks or months, resulting in an uneven-aged crop and may not be beneficial when labor is an operational limitation. In order to reduce sowing time, seeds can be germinated and the germinants transplanted into containers. At the UIPFN, this technique is used for black hawthorn, red currant, Rocky Mountain juniper, and several rose species (Table 1). Because these species are stratified in moist media, the entire stratification bucket is moved from the cool into a warm environment (21 °C [70 °F]) and remains there for 3 to 5 days. During this process media moisture levels match those maintained during stratification. Germination is monitored daily. Seeds with an emerged radicle are separated out and sown. The major advantage of this treatment is that it requires little additional effort, but ensures more uniform and timely germination. However, not all species respond well to this technique so some experimentation is needed when working with new species. It is also important to note that sowing may sometimes take several weeks or months, which may not be beneficial when labor is an operational limitation.

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Problem Solving: A Creative and Systematic Approach

by Thomas D. Landis

We all experience problems in our daily lives and most people develop their own problem solving techniques through personal experience or their professional training. Because every problem is different, however, someone's "pet" problem solving technique may not be the best or the most efficient. Methods based on trial and error, for example, may be useless in a crisis situation when time is at a premium.

Problems are nothing new to nursery managers. Administrative constraints, site deficiencies, and equipment breakdowns are just a few of the problems that occur daily in tree or native plant nurseries. Good managers realize that problems are a natural part of any operation and must be dealt with directly, quickly, and effectively.

What constitutes a problem?

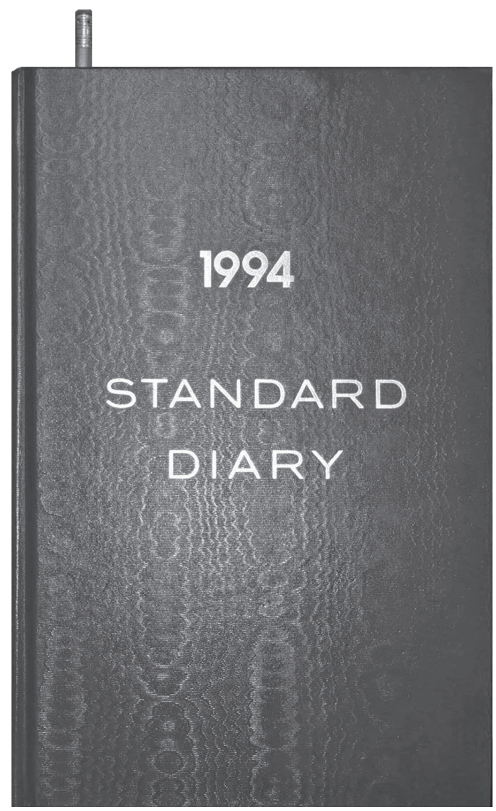
"Well, I tell you there's no problems, only solutions." — John Lennon

My favorite definition of a problem is any situation in which there is a difference between "what is" and "what what should be" (Van Gundy 1981). This definition emphasizes the relative nature of all problems. Defining problems always involves value judgments—what is a problem to one person may not be to another. The values or objectives of any organization will at least partially define the nature of its problems.

A complicating factor is that the differences between "what is" and "what should be" are frequently dynamic. In the case of seedling quality, the "what is" aspect changes with the physiological and developmental status of the seedling during the growing season or with short-term changes in weather. The "what should be" aspect of seedling specifications changes from year to year and from customer to customer. Because each crop and the weather each year is different, the best way to document daily activities is to have key nursery employees keep a daily log (Figure 1A). For example, the person doing the irrigation and fertilization should write down exactly what they do each day on a established data sheet. Then, if a problem with plant growth is observed, it's easy to go back and find out exactly what was applied.

Our objective in forest and native plant nurseries is to grow quality plants in a relatively short time frame. Whenever someone asks me to help evaluate a nursery program, the first thing that I ask is to see some growth

A



B

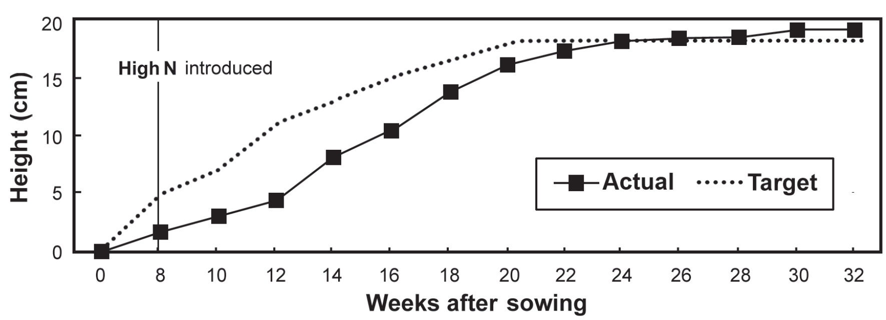


Figure 1 - One of the easiest ways to determine if a problem exists (the difference between "what is" and "what should be") is keep a daily diary (A), and to develop plant growth curves (B), which are based on past nursery records (Landis 2011).

data. It's difficult to notice and, more importantly, to quantify a nursery problem without good growth records (Figure 1B).

Traditional Approaches to Problem Solving

Managers must rely on their own experience and analytical skills to solve problems, and numerous techniques have been tried. Before investing a lot of time in problem solving, make sure that a real problem exists—some apparent problems can be resolved by merely taking a closer look at the situation or by readjusting expectations. Traditionally, problems have been solved in several ways.

The ostrich approach - These people ignore problems in the hope that they will eventually go away. Some problems do seem to solve themselves, or, if ignored long enough, may be solved for us. More often, however, problems that are ignored become even more serious or spawn a second generation of problems.

The panacea approach - This involves applying a "tried and true" solution without regard to its suitability for different problem situations (Van Gundy 1981). The panacea approach is a favorite of experienced managers who may have achieved positive results in the past but who overlook the variable nature of most problems or the advent of new technology.

The shotgun approach - People who use the shotgun approach believe that if enough solutions are tried, one of them should surely work (Van Gundy 1981). Many people, when confronted with a problem, feel that it is best to "do something" as quickly as possible; the danger is that some of these haphazard solutions may actually make the problem worse.

Roadblocks to Creativity

"Everyone is a prisoner of his own experiences. No one can eliminate prejudices, just recognize them." —Edward R. Murrow

Some people are naturally creative, but most of us have to work at it. Unfortunately, the human mind has several inherent processes that inhibit creative thinking.

Conditioned thinking - Most people develop a certain fixed way of thinking based on their previous knowledge and training (Beveridge 1957). Once a thought process is formed, it is usually very difficult to overcome. Most professional groups are guilty of such conditioned thinking, and nursery managers are no exception. Realizing this common pitfall is the first step in dealing with it.

Persistent errors - Having committed an error once, we often have an unconscious tendency to repeat the error again and again (Beveridge 1957). Apparently, the human mind is unable to detect these persistent errors. Often, getting a fresh perspective, such as having someone check your work, is effective.

Functional fixedness - This is the tendency to see only one use for an object. Unfortunately, the more highly specialized a person's field is, the more likely that person is to fall victim to this trait (Campbell 1977). One of my favorite quotes is: "People who are good with hammers see every problem as a nail".

Five Steps to Creative Problem Solving

Even novice nursery managers can become proficient problem solvers by following a systematic procedure based on creative thinking (Landis 1984). An effective problem solving procedures consists of five steps (Figure 2).

"Trouble that is easily recognized is half-cured." — St. Francis de Sales

Step 1. Identifying the problem - A problem has to be noticed and acknowledged before it can be solved. Problem identification requires knowledge and experience because a manager must know what is right before being able to recognize what is wrong: nursery managers must know what a healthy seedling looks like before they can identify a sick one. Managers must be observant and open minded, and think in terms of the differences between "what is" and "what should be". Because problems often develop gradually, these individual differences may go unnoticed until the situation reaches a critical level. Problem identification is also subject to changes in the state of knowledge about a specific operation. An increased understanding of a certain procedure can expose problems where they either did not exist before or lay unseen.

"Thinking a problem through is hard for the untrained mind." - Anonymous

Step 2. Analyzing the problem - Problem analysis begins with the development of a clear statement about

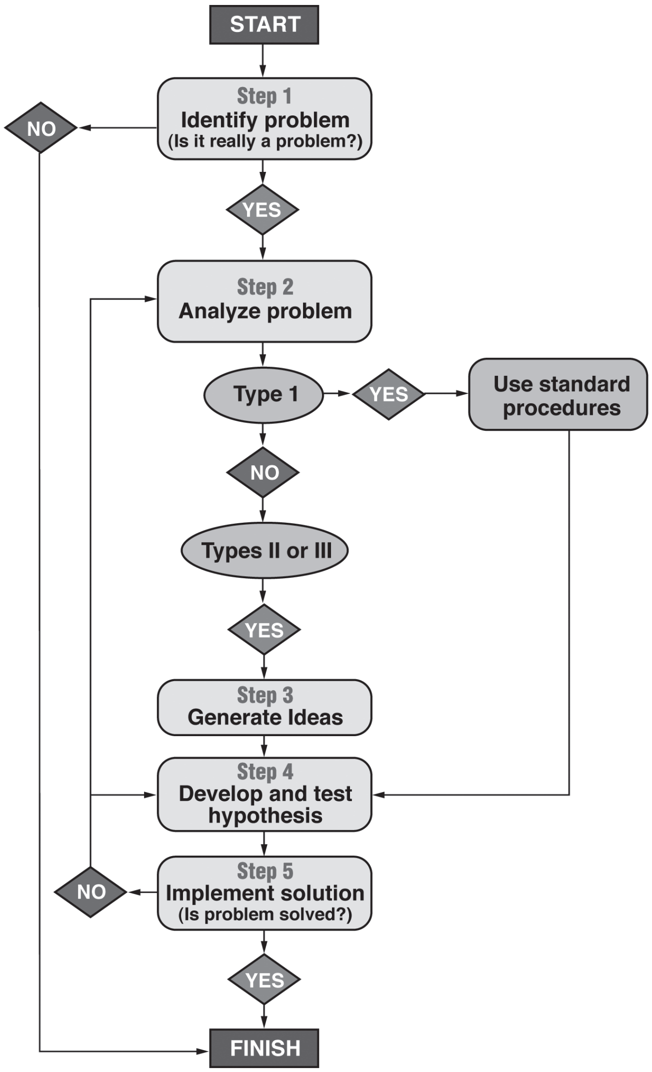


Figure 2 - This problem solving flow chart consists of 5 steps and can be used to solve a variety of nursery problems (Landis 1984).

the situation. Once identified, the problem should be described as accurately as possible; asking the questions ***what, when, where,*** and ***how much*** are often helpful. Make a list of knowns and unknowns to order your observational data in some way. The trick is to carefully delineate the boundaries of the problem before attempting to solve it.

Try to observe with an impartial, open mind and not to confuse symptoms with causes. Because it is impossible to observe everything closely, be discriminating—try to identify the significant characteristics. Often, the exceptional attribute of a problem is the critical element and can lead to the explanation of what happened (Beveridge 1957). Double check to be sure that the stated problem is the real problem; too often it is not. Furthermore, the real problem can be easier to solve than the stated one because it is almost impossible to solve a poorly defined problem (Furuta 1978).

Once the significant information has been gathered and organized, the problem should be ranked in terms of importance, urgency, and change (Rice 1981).

The ***importance*** of the problem will dictate whether it is worth solving, assuming it is solvable at all (Furuta 1978). Specify the available resources (money, personnel, time) that can be expended on the solution; some problems just cannot be solved economically.

The ***urgency*** of the situation will determine whether it must be dealt with immediately or can be postponed. Consider the amount of time that can be allotted to the given problem.

The ***change*** in nature, if any, of the problem also must be evaluated. Determine whether the problem is getting better or worse or remaining the same; a situation that is deteriorating will be more threatening than one that is improving.

"In every work of genius, we recognize our own rejected thoughts."—Ralph Waldo Emerson

Step 3. Generating ideas - A good knowledge base, which is the primary prerequisite for the creative process, can be obtained from nursery literature, staff discussions, and experts in the forest and native plant nursery field. Nursery literature includes manuals, technical books, and research publications. Publications in the fields of agronomy and horticulture or other related sciences can be valuable sources of new ideas; many of the cultural practices now used in tree nurseries were originally developed for other crops. Older nursery publications should not be ignored because many "outdated" ideas may be able to be modified for solving the problems of today. The Forest Nursery Notes database on the Reforestation, Nurseries, and Genetic Resources website (www.rngr.net) is an invaluable source of published information on nursery practices (Figure 3A). Not only does it contain all the articles from past issues of Forest Nursery Notes, but also the National Nursery Proceedings, Tree Planters' Notes, as well as valuable contact information.

The nursery staff is also a valuable source of information. Many of these people have accumulated a considerable amount of experience over the years. By presenting a problem at a staff meeting, nursery managers can benefit from a variety of different experiences and gain

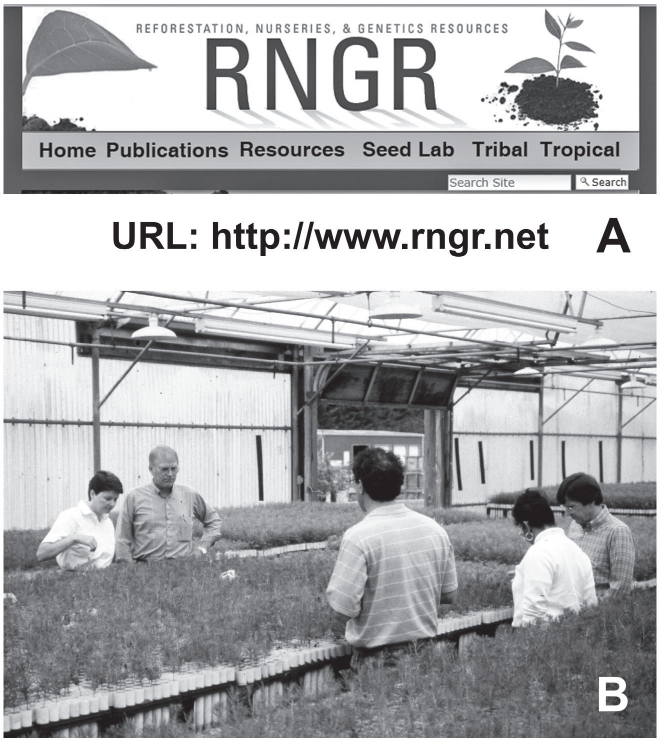


Figure 3 - It's easy to search for published information on nursery culture at the Forest Nursery Notes database (A); visiting other nurseries and talking with other growers can be a big help in problem solving (B).

valuable new perspectives about the problem. Attending nursery meetings and workshops is an excellent way to learn more about nursery practices, and meet other growers who can be an invaluable source of information. The old biblical proverb that "there's nothing new under the sun" certainly applies to nursery problem solving. It's very likely that other nurseries have faced similar situations, so visiting other nurseries during field trips can be eye opening (Figure 3B).

Ideas can be generated by either single individuals or groups. Group sessions have the benefit of a variety of people with different perspectives, and the interaction of experts and less well-educated individuals can sometimes result in innovative ideas (Hunt 1982). Groups that contain individuals of different status in an organization, however, can actually stifle creative expression because lower ranked employees may feel intimidated. So, the best approach is to use both private cosultations and group techniques during problem solving.

"One of the great tragedies of science is the slaying of beautiful hypotheses by ugly facts." - T. H. Huxley

Step 4. Developing and testing hypotheses - Once a list of possible solutions is developed, each must be evaluated and decisions made so that ideas can be converted into hypotheses. In most cases, the available information will not point clearly to one hypothetical solution, and managers will have to make decisions based on incomplete evidence. However, most decisions are made under some degree of uncertainty because all the facts will never be known (Furuta 1978). Another of my favorite quotes is: "Just because we don't know everything doesn't mean we don't know anything."

A manager must keep an open mind during the evaluation process and take time to consider all aspects of the situation. The most obvious solutions are not always the best, and once an opinion has been formed, it is more difficult to think of alternatives. Beware of ideas that seem obvious and are accepted without question. In evaluating various ideas, it is important to consider all possible consequences so that the solution to one problem does not generate a new one. Managers must accept the fact that some ideas simply are not practical operationally or economically. However, ideas that initially seem impractical may be able to be modified to a more practical form. Unfortunately, most people are inclined to judge in the light of their own experience, knowledge, and prejudices rather than on the actual evidence. Remember that hypothesis testing takes time. If a problem requires an immediate solution, implementing an short term solution may be best until adequate testing can be completed (Beveridge 1957).

"A man's legs must be long enough to reach the ground." - Abraham Lincoln

Step 5. Implementing a solution - The last step in the problem solving system is testing the hypothesis operationally. Some hypotheses may seem adequate in small scale tests, but may fail under operational conditions.

Once a hypothesis has been tested and implemented, a decision must be made as to whether the problem is completely solved. If the hypothesis provides an acceptable solution to the problem, then problem solving is complete. If not, then it is necessary to return to Step 4 to develop an alternative hypothesis or to Step 2 to reanalyze the problem (Figure 1). For complex problems, several different hypotheses may need to be tested before an acceptable solution is found.

Becoming Better Problem Solvers

"Nature never overlooks a mistake, or makes the smallest allowance for ignorance." - T. H. Huxley

Figure 4 - One of the best approaches to nursery problem solving is to use an experienced nursery worker as a scout who regularly walks through the crop and documents any potential problems.

The basic role of management is to achieve certain specified objectives. The objective in forest or native plant nurseries is obvious: to produce a specific number of healthy seedlings on a given date and at a reasonable cost. Most nursery problems arise when this objective is not met, either directly or indirectly. Nursery managers must realize that learning is a continuous process but that they can never learn enough about the technical aspects of their operation. New information is constantly being generated, and managers must attempt to stay abreast of new developments.

However, pure knowledge about nursery science is not enough; it must be tempered by actual field experience. Experts can take shortcuts in problem solving because their knowledge is functionally organized; this skill is the result of many years of practical experience (Hunt 1982). Experience can be acquired directly through time on the job, or indirectly, through visits to other nurseries and discussions with other nursery managers. Actual "eyes on the ground" are absolutely necessary in creative problem solving, so assigning one trusted employee to be a scout is an excellent approach (Simone 1996). Nursery managers and growers have their hands full with a wide variety of management activities so it's a good idea to assign an experienced worker as a scout who regularly inspects the crops and documents any potential problems (Figure 4). Ideally, the scout is the same person who measures seedlings and develops the nursery growth records. Nursery scouts should also receive additional training in pest management.

Although problems cannot always be avoided, their effect can be minimized if managers have a flexible plan. Develop "What If?" scenarios for each nursery operation. For example, lifting season is always demanding due to frequently changing weather, so be sure to inform your workers accordingly. If the soil is too wet or frozen early in the morning, having a phone tree will make sure that each member of the crew is informed without creating extra work for the nursery managers.

Realizing that problems are to be expected can make a manager's job much more enjoyable. Just remember that "Murphy's Law" applies in spades to nursery work.

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Nursery Safety: Publications and Training

by Thomas D. Landis

Safety is a year-round concern but winter is a great time to review nursery policies and schedule training. I'm always on the lookout for good safety information and wanted to make sure that nurseries were aware of the latest information.

Simple solutions: ergonomics for farm workers

Baron S, Estill CF, Steege A, Lalich N. 2001. eds.
DHHS (NIOSH) Publication No. 2001-111.
Cincinnati, OH: National Institute for Safety and Health. 46 p.

Backaches or pain in the shoulders, arms, and hands are occupational hazards when working in nurseries or tree planting. The technical term for these sprains and strains is "work-related musculoskeletal disorders" or WMSDs. One-third of all missed work injuries are sprains and strains, and one-fourth are back injuries. More importantly, they are also the most common causes for disability claims. Much of nursery work is done in a stooped position, and often in cool or damp weather. In addition, many nursery tasks require workers to carry heavy weights in awkward positions, kneel often, or move their hands and wrists repetitively. Equipment operators are subjected to repeated vibration. NIOSH (National Institute for Occupational Safety and Health) worked with specialists in the science of ergonomics to determine how nursery worker could be made safer. This pamphlet offeres some simple, practical, and inexpensive solutions. Although it deals with all types of farm work, nurseries should be able to modify some of these ideas to their own operations.

You can order Adobe PDF copies of this publication from the following website or contact NIOSH for hard copies:

NIOSH Publications Dissemination
4676 Columbia Parkway • Cincinnati, OH 45226-1998
Telephone: 1.800.356.4674 • FAX: 513.533.8573
E-mail: pubstaft@cdc.gov
Website: www.cdc.gov/niosh

Preventing noise-induced hearing loss

Beckley B. 2010.
Tech Tip 1067–2321P–MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service,
Missoula Technology and Development Center. 16 p.

Noise-induced hearing loss is almost always preventable and nursery workers can be exposed to loud noises for extended periods of time. The Occupational Safety and Health Administration mandates that employers supply personal protective equipment and provide training on how to use it correctly. This handy publication includes information about the causes of noise-induced hearing loss and provide practical ways to minimize exposure.

For hard copies of the pamplet, contact the Missoula Technology and Development Center, or you can download PDF files from their website:

USDA Forest Service
Missoula Technology and Development Center
5785 Hwy. 10 West • Missoula, MT 59808–9361
TEL: 406.329.3978 • FAX: 406.329.3719
E-mail: wo_mtdc_pubs@fs.fed.us
Website: http://www.fs.fed.us/eng/pubs

Increasing Nursery and Greenhouse Worker Safety

Langlois S, Coker CE, Posadas B, Knight P, Coker R.
Biloxi, MS: Mississippi State University, Coastal Research & Extension Center.
Website: http://coastal.msstate.edu/nurserytrainingvideos.html. Accessed 02-28-12.

On this website, you can access a series of DVDs called "The Three E's of Nursery and Greenhouse Safety."

Ergonomics - This relatively new science studies human capabilities in relation to work demands. Worker posture and position, lifting techniques, and repetitive motions are just a few areas of concern in the green industry. By understanding these risk factors, employers can develop processes and tasks to minimize the potential for worker injury while increasing productivity and morale.

Equipment - Maximizing the effectiveness of equipment while minimizing the chance for injury is important in the green industry. This video series offers examples of using common nursery equipment to develop good work behaviors among your nursery and greenhouse workforce.

Environment - Nursery and greenhouse workers are exposed to all types of environmental conditions. In this video series, learn practical tips for dealing with the heat, humidity, cold, and rain, as well as dangerous insects and reptiles.

These bilingual (English/Spanish) safety training videos can be the perfect complement to your new employee training program or can be used as refresher training material reviewed at routine safety or team meetings. They are available at no charge for online viewing (FLV) and download (MP4). Choose the FLV link to open a new browser window that will show a Flash Video file or choose MP4 to begin downloading a file viewable with many video players.

New Nursery Literature

Special Order Publications

National Proceedings: Forest and Conservation Nursery Associations—2010

Riley LE, Haase DL, Pinto JR, tech. coords. 2011
Proceedings RMRS-P-65. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station.183 p.

These proceedings are a compilation of 25 papers that were presented at the regional meetings of the forest and conservation nursery associations and the Intertribal Nursery Council meeting in the United States in 2010. The Joint Meeting of the Southern Forest Nursery Association and Northeastern Forest and Conservation Nursery Association was held at the Peabody Hotel in Little Rock, Arkansas on July 26 to 29, 2010. Subject matter for the technical sessions included marketing strategies, tree improvement programs, nursery certification, fumigation updates, and insect and disease management. The Joint Meeting of the Western Forest and Conservation Nursery Association and Forest Nursery Association of British Columbia: Target Seedling Symposium—2010 was held at the Sheraton Portland Airport Hotel in Portland, OR, on August 24 to 26, 2010. Subject matter for the technical sessions included the target seedling, seed handling, seedling nutrition, seedling culturing, pest management, nursery research and new technology, and general nursery topics. The Intertribal Nursery Council Meeting was held in Arlington, WA, on September 21 to 23, 2010. Subject matter for the technical sessions included native plant production for fisheries restoration, the use of small native plant nurseries in cultural and conservation education, energy conservation and alternative energy sources in nurseries, and the effects of climate change on nursery production.

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Bareroot Production

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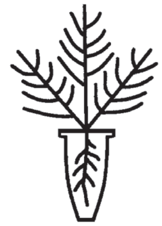

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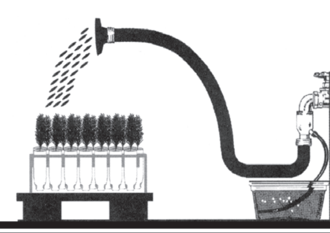

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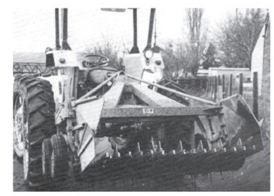

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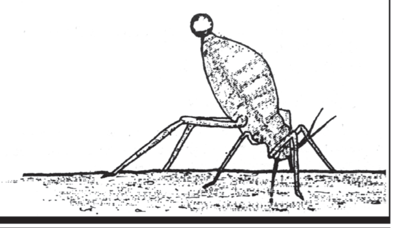

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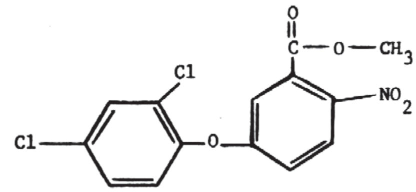

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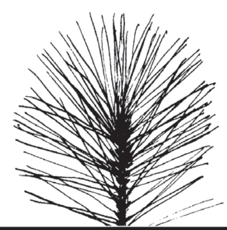

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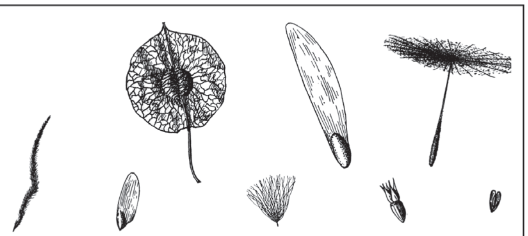

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