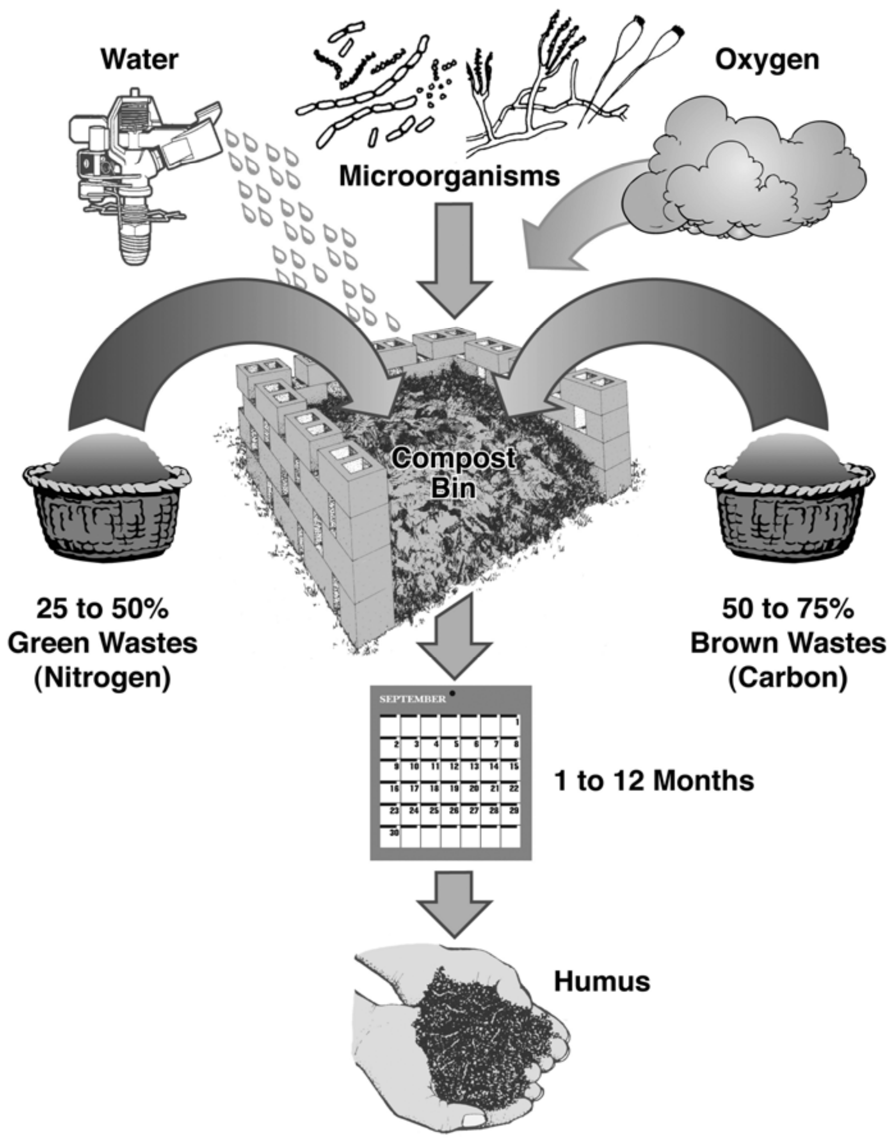
United States
Department of
Agriculture

Forest Service

Volume 28, Issue 2

Forest Nursery Notes

Summer 2008



Forest Nursery Notes Team

R. Kasten Dumroese, Editor-In-Chief
USDA Forest Service
Southern Research Station
1221 S. Main Street
Moscow, ID 83843-4211
TEL: 208.883.2324
FAX: 208.883.2318
E-Mail: kdumroese@fs.fed.us

Tom D. Landis, Lead Author and Editor
Forest Nursery Consultant
3248 Sycamore Way
Medford, OR 97504-9005
TEL: 541.210.8108
FAX: 541.858.6110
E-Mail: nurseries@aol.com

Rae Watson, Layout and Author
USDA Forest Service
2606 Old Stage Road
Central Point, OR 97502
TEL: 541.858.6131
FAX: 541.858.6110
E-Mail: rewatson@fs.fed.us

Laura Hutchinson, Library Services
USDA Forest Service
North Central Research Station
1992 Folwell Avenue
St. Paul, MN 55108
TEL: 651.649.5272
E-Mail: lhutchinson@fs.fed.us

Please send address changes to Rae Watson. You may use the Literature Order Form on page 36 to indicate changes.

This international technology transfer service is produced by the U.S. Department of Agriculture, Forest Service/Natural Resources Conservation Service, National Agroforestry Center, Nursery Technology and Restoration Team with funding from the Forest Service, State and Private Forestry, through the Center for Reforestation, Nurseries, and Genetics Resources.

Nursery Meetings

This section lists upcoming meetings and conferences that would be of interest to nursery, reforestation, and restoration personnel. Please send us any additions or corrections as soon as possible and we will get them into the next issue.

A special joint meeting of the Eastern and Western Regions of the International Plant Propagators' Society (IPPS) will be held at the Denver Marriott City Center in Denver, Colorado on September 14 to September 17, 2008. In addition to tours of local nurseries, the presentations will highlight propagation techniques, new plants, and plant breeding and selection with an emphasis on the Rocky Mountain region. For more information, check-out the IPPS website: www.ipps.org/WesternNA

The 29th Intermountain Container Seedling Growers' Association meeting is set for October 7 to October 9, 2008 in Coeur d'Alene, Idaho. Updates will be available at http://seedlings.uidaho.com as they become available. For more information contact:

Anthony Davis
University of Idaho
asdavis@uidaho.edu

The Western Forest and Conservation Nurseries (WFCNA) meeting will be combined with the Intermountain Container Growers Association meeting as well as the Intertribal Nursery Council meeting. These meetings will be held in Moscow, Idaho July 13 t0 July 15, 2009. For futher information please contact:

Gabriela Buamscha
Forest Service Western Nursery Specialist
333 SW First Ave.
Portland OR 97208
Tel: 503.808.2349
Fax: 503.808.2339
Email: gbuamscha@fs.fed.us

The Northeast Forest and Conservation Nursery Association Nursery Conference will be held the week of July 20, 2009 in Grand Rapids, Michigan at Amway Grand Hotel. For more information contact:

Ronald P. Overton
Area Regeneration Specialist
USDA Forest Service
Northeastern Area, State & Private Forestry
Purdue University
Dept. of Forestry and Natural Resources
715 W. State Street
West Lafayette, IN 47907-2061
Tel: 765.496.6417
Fax: 765.494-9461
E-mail: roverton@fs.fed.us

Plant Heat Stress and Its Management
by Thomas D. Landis

Temperature is one of the most critical of the growth-limiting environment factors in nurseries, because it controls all aspects of plant metabolism and growth. Plants have adapted to a discrete range of temperatures. For instance, 6 conifer and broadleaved tree seedlings grew best in the relatively narrow range of 66 to 73 ^{o}F (19 to 23 ^{o}C). During the sunny and hot days of summer, temperatures can often exceed these ideal temperatures. This article will identify the types of heat injuries that can occur to nursery stock, and discuss the most practical cultural methods for preventing them.

Stress physiologists recognize 2 types of heat injury (Levitt 1980):

- Direct heat injury occurs when plant tissues are harmed by excessive temperatures, causing cell membranes to rupture and walls to collapse. In the case of young plants and succulent tissue, direct heat injury can cause severe growth loss or even death. In nature, heat injury is limited to young first-year plants but can occur on much larger nursery stock due to their accelerated growth rates and propagation method.

- Indirect heat injury refers to a number of metabolic maladies such as the denaturation of proteins that occur at above optimum temperatures (Hermann 1990). The symptoms of indirect heat injury are less obvious and can vary considerably between plant species and growth stages. Succulent, actively growing plants are much more susceptible to indirect heat stress than dormant, hardy plants.

Heat injuries in forest and conservation nurseries.

In nurseries, excessive heat can occur during spring or summer when sunlight is most intense and young plants are germinating or actively growing. With proper irrigation, plant foliage is continually cooled by transpiration and so should not be subject to heat injury (Figure 1). This is true even on outplanting sites without the benefits of irrigation. For example, foliage temperatures of outplanted Douglas-fir seedlings were within 5 ^{o}F (3 ^{o}C) of surrounding air temperatures (Helgerson 1990).

Stems and roots are not so protected, however, and can suffer direct heat injury. Two different types of heat injury have been reported in nurseries:

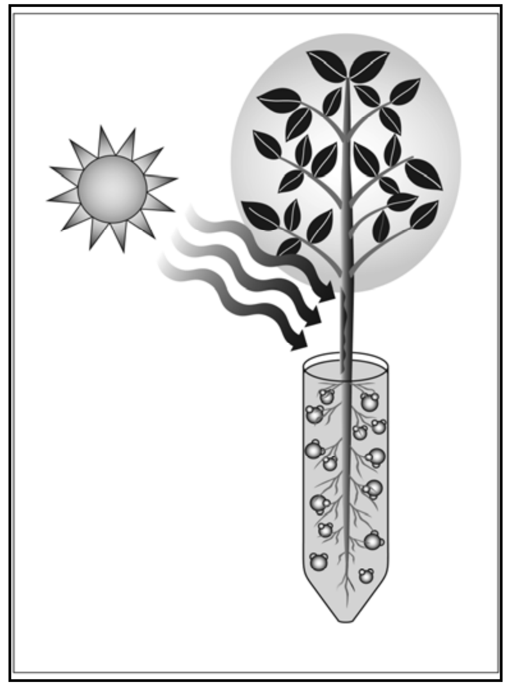


Figure 1 - Because of the frequent irrigation in nurseries, plant foliage is cooled by transpiration . However, stems of young plants can be damaged by intense sunlight because protective bark has not yet developed.

1. Solar heat injury to stems of young plants - Because it takes time to develop protective bark layers, the stems of young plants can be damaged by intense sunlight (Figure 1). The problem was first reported with conifer germinants in both natural regeneration and in nurseries (Hartley 1918, Baker 1929).

Symptoms - Injury usually occurs on the stem just above the soil surface where the buildup of heat is greatest (Figure 2A). Numerous studies found that injury typically occurs at temperatures between 117 to 151 ^{o}F (47 to 66 ^{o}C) which have been documented in nurseries (Helgerson 1990). With young germinants just emerging through the soil or seed covering, injured seedlings appear constricted (Figure 2B) due to the collapse and rupturing of the stem cells. On older seedlings, a white spot may develop on the south or southwestern side of the stem (Figure 2C). In greenhouse experiments using heat lamps, seedlings were able to recover if the cellular damage did not reach the vascular tissues (Smith and Silen 1963).

Note that germinants can be killed before or just after emerging from the soil, and these losses are often misdiagnosed as damping-off. True damping-off is a fungal disease which can be distinguished from heat injury

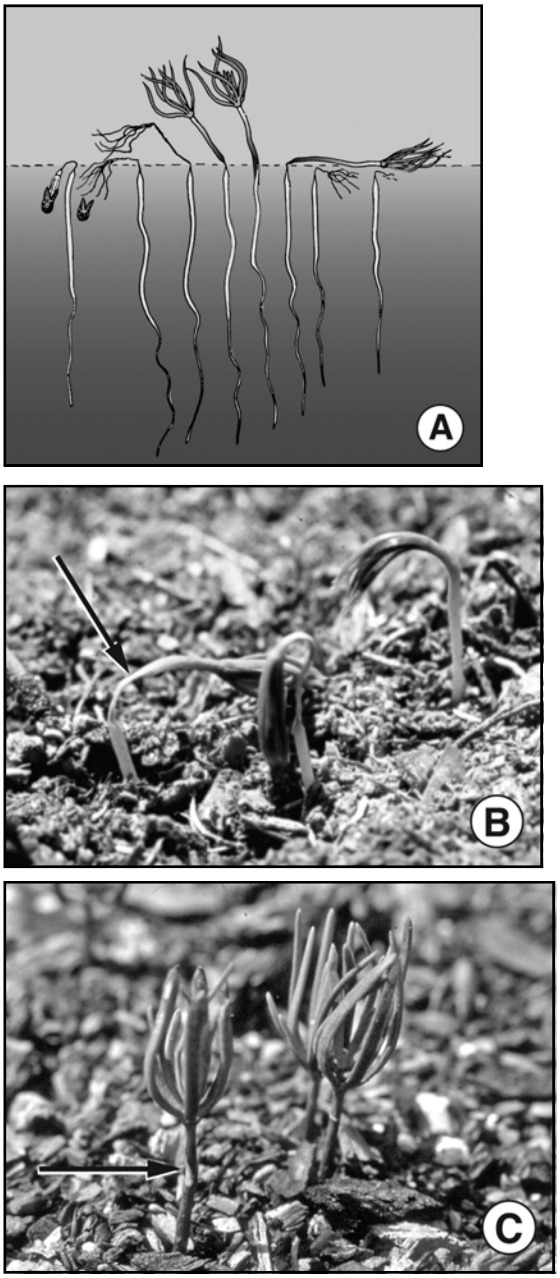


Figure 2 - Intense sunlight can cause damaging surface soil temperatures resulting in "heat damping-off" (A). Dark organic seed mulches build-up heat rapidly and the heat can kill young germinants (B), and cause white lesions on older seedlings (C).

because the roots of affected seedlings are brown or black and decayed. Roots of heat injured seedlings remain white below the constricted area (Figure 2A).

Management - Because water has the highest latent heat of vaporization of any liquid, heat injury can be prevented by keeping the surface of seedbeds and containers moist with frequent light irrigations.

Container nursery managers should schedule short bursts ("mists") of irrigation during the hottest time of day. This "water shading" is particularly effective during the establishment phase, when the young, succulent germinants can be easily damaged by high temperatures at the surface of the growing medium. Mist cooling can also supply the young seedlings with enough water without saturating the medium. Some container nurseries have outfitted their moveable irrigation booms (Figure 3A) with multiple-position nozzles that contain a mist head in addition to the standard irrigation nozzle. Older seedlings can also be cooled with irrigation, but this is usually done on a periodic basis to supplement the standard greenhouse cooling system during unusually hot weather.

In bareroot nurseries, the decision of when to irrigate and for how long will depend on the plant species and soil type. Some nurseries irrigate 5 to 10 minutes during every hour the temperature is above that considered critical; others water for an hour; and still others water until the soil temperature drops below a fixed, safe temperature [for instance, 77 °F (25 °C)]. Some bareroot nurseries use air temperature as a guide for determining the need for cooling, but the majority use soil surface temperature, usually measured 0.5 to 1 cm below the surface (Table 1).

Covering seeds with light-colored mulches can be effective in reflecting sunlight (Figure 3B). Dark mulches can increase damage because they absorb solar energy but are also poor conductors which allows heat to build up at the soil surface. When surface temperatures were monitored under dark-colored forest sand and light-colored granite grit (Peterson and Tuller 1987), the highest temperatures were recorded under dark mulch at 108 °F (42.5 °C). Unfortunately, I can vouch for this by personal experience because once we covered Engelmann spruce (*Picea engelmannii*) seeds at Mt. Sopris Nursery with a dark mulch thinking that the dark color would speed germination. Instead, the intense sunlight at 6,400 feet of elevation damaged many of the germinating seedlings (Figure 2B**)**. As the old saying goes: "we get too soon old, and too late smart".

Heat tolerance of nursery stock can be increased by prior exposure to hot but non-lethal temperatures. Black spruce (*Picea mariana*) container seedlings that were preconditioned to 100 °F (38 °C) for only 3 hours per day for 6 days were significantly more heat tolerant than non-conditioned stock (Colombo and Timmer 1992). This relatively brief heat treatment reduced both direct

Table 1 - Guidelines for When to Irrigate Seedbeds to Prevent Heat Injury*		
Time Period	**Do Not Exceed Surface Soil Temperature**	
Before July 1	90 °F	32 °C
July 1 to August 1	95 °F	35 °C
August 1 to September 1	100 °F	38 °C
After September 1	105 °F	41 °C
*modified from Thompson (1984)		

and indirect heat injury (Figure 4). This reinforces the need to gradually expose nursery stock to hot temperatures before the "dog days" of summer, and especially to include a period of heat exposure when hardening plants before harvest and outplanting.

2. Solar heat injury to roots of container stock - The roots of container plants grow best just inside the walls where both water and air are most readily available. Unfortunately, this also makes them susceptible to heat injury. Roots have adapted to the buffered temperatures of native soil and therefore cannot tolerate excessive heat.

Symptoms - Heat injury to container plant roots can occur anywhere during clear weather because the damage comes from solar radiation, not air temperatures (Figure 5A). Because of their solar exposure, plants along the southern and western edge of container blocks are most susceptible. In standard black plastic containers, growing medium temperatures can easily reach temperatures high enough to cause injury (Newman 1987). Growing medium temperatures as high as 138 ^oF (59 ^oC) have been recorded in southern nurseries and even in Ohio. Even in the relatively mild Pacific Northwest, container media temperatures of 122 ^oF (50 ^oC) have been observed (Mathers 2001). Note that these studies were done on larger volume containers where the heat can be better dissipated by the greater amount of growing media. Although little research has been done, the risk of heat injury would be much higher on smaller containers (Figure 5B).

One of the real risks of high growing medium temperatures is increased damage from root pathogens. Temperature affects both the incidence and severity of conifer seedling root rot from *Fusarium oxysporum*. Mortality of Douglas-fir container seedlings was four times greater when growing medium temperatures exceeded only 74 ^oF (23 ^oC) (Strobel and Sinclair 1991). In an-

Figure 3 - Cooling the surface of containers is easier with irrigation booms equipped with a mist nozzle (A). Light-colored seed coverings (B) also help reflect solar radiation.

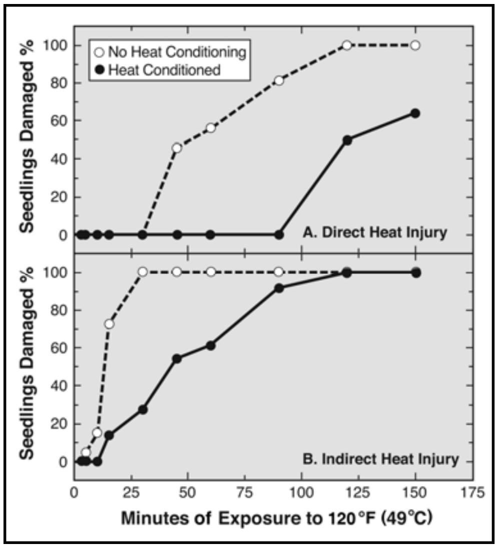


Figure 4 - Seedlings that were preconditioned to hot temperatures were better able to tolerate damaging heat levels (modified from Colombo and Timmer 1992).

other study with *Eucalyptus* spp. seedlings, the pathogenic root fungus *Phytophthora cinnamomi* was most damaging at temperatures of 64 to 72 °F (18 to 22 °C) where large numbers of highly infectious zoospores are produced (Halsall and Willams 1984).

Management - The best way to prevent solar heat injury to container plant roots is to always keep the growing media wet. In container nurseries, shading is also recommended especially during seed germination and emergence before plant canopies develop and provide self shading (Newman and Davies 1988).

Container type and color must also be considered. Black plastic absorbs the most sunlight resulting in growing medium temperatures high enough to cause root injury or even death (Whitcomb 1980). The growing medium in white containers has been shown to be cooler than black ones, which can be especially important in small volume plug trays (Faust and others 1997). Container composition can also help protect against heat injury. Styroblock® containers are ideal because the white color reflects light and the styrofoam walls provide good insulation. Jiffy containers or fiber pots keep root systems cool because evaporation is continually cooling the outside of the container (Mathers 2001).

Sources:

Baker FS. 1929. Effect of excessively high temperatures on coniferous reproduction. Journal of Forestry 27:949-975.

Colombo SJ, Timmer VR.1992. Limits of tolerance to high temperatures causing direct and indirect damage to black spruce. Tree Physiology 11(1):95-104.

Faust JE, Heins RD, Shimizu H. 1997. Quantifying the effect of plug-flat color on medium-surface temperatures. HortTechnology 7(4):387-389.

Halsall DM, Williams JD. 1984. Effect of root temperature on the development of *Phytophthora cinnamomi* root rot in Eucalyptus seedlings. Australian Journal of Botany 32:521-528.

Hartley C.1918. Stem lesions caused by excessive heat. Journal of Agricultural Research 14:595-604.
Hermann RK. 1990. Heat injury. IN: Hamm PB, Camp-

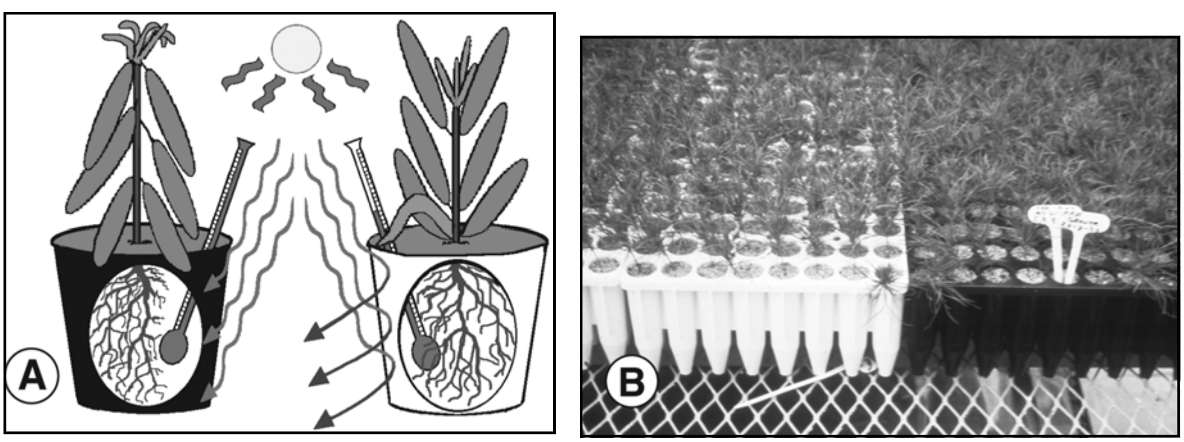


Figure 5 - The growing media in containers exposed to direct sunlight can quickly reach damaging temperatures and black absorbs more radiation than white (A). The risk of injury is even greater in smaller volume containers especially during seed germination (B).

bell SJ, Hansen EM, editors. Growing healthy seedlings: identification and management of pests in northwest forest nurseries. Corvallis (OR): Oregon State University, Forest Research Laboratory. Special Publication 19. 110 p.

Levitt J. 1980. Responses of plants to environmental stresses, volume 1. Chilling, freezing, and high temperature stresses. New York (NY): Academic Press. 497 p.

Mathers H. 2001. Tackling heat stress. Nursery Management and Production 17(3):73-74, 76, 78.

Newman SE. 1987. Root stress in containers. International Plant Propagators' Society, Combined Proceedings 36:384-390.

Newman SE, Davies FT Jr. 1988. Influence of field bed position, ground surface color, mycorrhizal fungi and high root zone temperature in woody plant container production. Plant and Soil 112(1):29-35.

Peterson MJ, Tuller SE. 1987. Die-back of container-grown Douglas-fir seedlings: associated microclimate. Victoria (BC): Canadian Forestry Service and British Columbia Ministry of Forests and Lands, Economic and Regional Development Agreement. FRDA Report 035. 43 p.

Strobel NE, Sinclair WA.1991. Influence of temperature and pathogen aggressiveness on biological control of Fusarium root rot by *Laccaria bicolor* in Douglas-fir. Phytopathology 81(4):415-420.

Whitcomb CE. 1980. The effects of containers and production bed color on root temperatures. American Nurseryman 151: 65-67.

Composting Applications in Forest & Conservation Nurseries
by Thomas D. Landis & Nabil Khadduri

What is composting?

Composting can be defined as the biological decomposition of organic matter under controlled aerobic conditions (Epstein 1997). The microorganisms that breakdown organic matter require carbon for an energy source and nitrogen for growth and reproduction, so organic materials for composting ("feedstocks") must contain a balance of carbon and nitrogen. This balance is known at the carbon-to-nitrogen ratio (C:N), which we'll discuss in more detail a little later. The other essential requirements for successfully making compost are water and air (Figure 1A). Because it requires either periodic mixing or active aeration, oxygen is the limiting factor in most compost piles. Simply making a pile of organic matter and waiting is not composting (Figure 1B).

"Compost", like "organic", is one of those words that are generally assumed to be beneficial. However, as I always do before starting an article, I did a comprehensive search of the published literature in the FNN database. Several days of perusing convinced me that, while composts are being widely used in horticulture, it is almost impossible to come to any conclusions. Each article uses a different type of compost from different source materials for different purposes. Other problems in interpreting the published research are that composting is a progressive process, and there are no widely-accepted standards for compost maturity or quality. Having said that, I still believe that composts have wide application in both bareroot and container nurseries:

1. Soil amendment in bareroot nurseries - Composts are an excellent nursery soil amendment because they encourage the formation of soil particle aggregates which improve tilth, and also stimulate the microbial component of the soil.

2. Organic component in growing media in container nurseries - Composts are being tested and used in a wide variety of artificial growing media as substitutes for peat moss.

3. Pest management - Some composts have shown "suppressive" effects on pathogens in both bareroot soil and container growing media. At a reforestation nursery in northern Mexico, pine bark is composted on-site and inoculated with benefical microorganisms. Not only does this compost grow good seedlings but it was found to suppress root rot fungi and therefore reduce the use of fungicides (Castillo 2004).

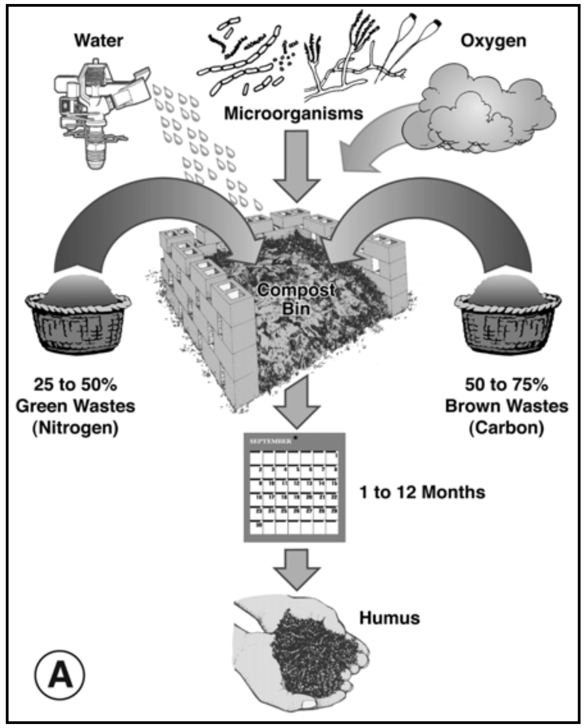


Figure 1 – Effective composting require supplying all the necessary elements so that none become limiting to the process (A). Merely piling organic wastes and waiting is not composting (B).

4. Compost "teas" - Compost teas can be made by aerated and non-aerated processes, and have been used to grow plants for hundreds of years. Compost extracts and teas have been shown to prevent or control a wide range of foliar diseases, including *Botrytis cinerea*, and have been used as a seed treatment against soilborne pathogens. Other horticultural applications include increasing the rootability of cuttings (Summers 2007). The principal active agents are bacteria in the genera *Bacillus* and *Serratia* and fungi in genera *Penicillium* and *Trichoderma.* It is thought that compost teas work in 3 ways: inhibition of spore germination, antagonism and competition with pathogens, and through induced host resistance. Considerable work is required to ensure predictable disease suppression and control but operational studies on a wide variety of crops have shown promising anecdotal evidence (Litterick and others 2005).

5. Mulches for weed control - Composted organic mulches were an important method of weed control prior to the development of herbicides. Their herbicidal effectiveness is due to the physical presence of the materials on the soil surface, and the chemical action of phytotoxic compounds generated by microbes in the composting process. Physical weed control improves with the thickness of the organic mulch layer but the degree of weed control is dependent on type of mulch, weed species, and environmental conditions. Generally, a 4 to 6 inch (10 to 15 cm) mulch layer is most effective. The herbicidal effects of raw compost mulches is due to several organic acids, the most effective of which is acetic acid which has been shown to inhibit weed seed germination. Because they must be applied and maintained, compost mulches would be most effective in older bareroot seedlings, transplants, and very large container stock (Ozores-Hampton 1998). As with any new cultural practice, install trials before beginning operational use.

Types of composts that could be used in nurseries.

Any organic waste can be composed and a wide variety of feedstocks have been used (Martin and Gershuny 1992). Because of high transportation costs, it just makes sense to use local materials. Many municipalities and industries are prohibited from disposing of their wastes and so have developed an active program of composting. Composting regulations in the United States are mainly concerned with protecting public safety and limiting environmental hazards rather than producing high-quality compost (Mecklenburg 1993).

Yard waste - Up to 40% of the volume in a municipal solid waste stream is yard waste, but tests have shown considerable variation between composted yard waste (CYW) sources. Mature, biologically stable compost may require 9 months or more but one study found that typical yard waste in California has been composted for 4 months or less with no curing time. They concluded that at least 9 to 12 weeks of composting was necessary (Hartz and Gianni 1998). Compared to industrial feedstock, CYW is low in potentially toxic heavy metals and pesticides were not found to be a problem. Chemical analyses of CYW have found pesticide levels to be well below US Environmental Protection Agency (EPA) guidelines, which proves that these chemicals degrade during composting (Mecklenburg 1993). These composts are excellent soil amendments for bareroot nurseries or can be used as peat substitute in growing media. Quality will vary with the season, however, so periodic testing is recommended.

Municipal or industrial sewage sludge and biosolids - Sludge is defined as a solid, semi-solid, or liquid residue generated during the treatment of domestic or industrial sewage. Biosolids are a primarily organic solid product produced by municipal wastewater treatment processes (EPA 2008). Activated sludge is the product of vigorous areation of sewage whereas digested sludge is produced when the sewage processed without agitation. A major concern about municipal or industrial feedstock has been heavy metal levels. The EPA sets limits for heavy metals contamination in sewage-sludge compost., and all biosolids are required to be tested by the producer and these test results are available upon request (Gage 2008). Municipal or industrial sludge and biosolids are an excellent source of organic matter for bareroot nurseries, and are also being used in growing media (Bettinski 1996a).

Wood waste - Sawdust and wood chips have traditionally been waste products from mills but are now being burned for fuel or sold as mulches for landscaping and agriculture. Wood wastes have a high carbon-to-nitrogen (C:N) ratio and compost best when mixed with a high nitrogen material like manure. When used in composts, wood wastes are valuable not only for a carbon source but as a bulking agent that increases air movement in the pile. Wood chips can be superior to sawdust because they contain bark (Martin and Gershuny 1992). When conifer seedlings were grown in sewage sludge or mixes of sludge and woodwaste, they were inferior to those grown in peat-vermiculite media but the authors thought that adjusting fertilization regimes could resolve the differences (Simpson 1985). The C:N of tree bark is considerably lower than sawdust and so has become a preferred material for horticultural composts. Composted pine bark (CPB) has become the standard growing media components for horticultural nurseries, especially in the southern states where the cost of *Sphagnum* peat moss is prohibitive (Pokorny 1979).

Pulp and paper sludge - Sludges from pulp and paper mills are mainly cellulose fiber generated at the end of the pulping process prior to entering the paper machines. They are composed essentially of fibrous fines and some inorganics such as kaolin clay, calcium carbonate, titanium dioxide and other chemicals used in the specific manufacturing process. Over 70% of the recyclable organic solid wastes produced by the US pulp and paper industry are presently landfilled. A single mill in Georgia produces about 100,000 dry tons of solid waste a year. Pulp and paper sludge has a high C:N and must be composted with a high nitrogen feedstock; in one study, mixing with chicken litter produced a superior compost (Das and others 2008). Before using pulp and paper sludge, however, all feedstocks should be tested because some materials like bleached sludge can contain high salt levels.

Spent mushroom compost - This is the residual organic compost waste generated by mushroom farms. The exact composition of mushroom compost varies from location to location depending on available organic material. Analysis of one facility in Pennsylvania revealed 40% straw bedded horse manure, 25% hay and small amounts of cottonseed hulls, gypsum, and chicken manure. Mushroom compost has good potential as an organic soil amendment or a component of growing medium, especially when mixed with peat moss and wood or bark chips. A chemical analysis found that both soluble salts and nitrate-nitrogen far exceeded the recommended ranges but both can easily be corrected by leaching with water. The pH levels were mildly alkaline but this could be easily adjusted by mixing with more acid components such as peat moss. The compost showed good levels of other mineral nutrients. Porosity measurements were favorable and a mixture of 1 part mushroom compost: 2 parts peat drained comparably to other growing media (Dallon 1989).

Vermicompost - This is earthworm-processed organic wastes and contains finely-divided peat-like particles with high porosity, aeration, drainage. There are 2 main methods of large-scale vermiculture. The first uses a windrow containing bedding materials for the earthworms to live in and acts as a large bin. The second is the raised bed or flow-through system in which the worms are fed across the top of the bed while castings are harvested from below (Wikipedia 2008). Although it is undoubtedly the highest quality compost, the relatively small volumes produced make land application impractical but vermicompost is an excellent growing media component.

Nursery wastes - Cull seedlings and weeds can generate a substantial volume of waste in nurseries. One recent trial in Finland compared the growth of Norway spruce (*Picea abies)* in the traditional media of 100% *Sphagnum* peat moss versus mixes of peat with composted nursery waste. The nursery waste compost consisted of cull container and bareroot seedlings and weeds, which had been composted for 4 years and then filtered through a 4 mm screen. Survival after outplanting was comparable but seedlings from the compost-amended media were still significantly shorter after 4 years. The authors concluded that changes in irrigation and fertilization could correct for these growth differences (Veijalainen and others 2007).

Evaluating composts.

So, we can see that composts can be used many ways in the culture of both bareroot and container nursery stock. Before making or purchasing any compost, however, nursery managers should ask the following questions:

1. What materials were used in this particular compost?

There is no such thing as standard or typical compost; instead, they are complex mixtures of humus-like constituents such as partially decomposed organic wastes, the decomposing organisms themselves, and their byproducts. A wide variety of feedstocks have gone into compost which contributes to the variability of the final product. Municipal and industrial composts have proven to be the most variable (Table 1). Some composts could even contain toxic contaminants that could harm seedlings. Other composts contain a high proportion of inert materials such as stones, glass, or plastic that may lower their horticultural value.

Chemical and physical analysis of 4 common composts used in growing media illustrate this variation (Table 1). Chemical properties were the most variable. Soluble salt levels, as measured by electrical conductivity (EC), were excessive for both total salts and sodium, which can cause serious problems with germinating seeds and young plants. Leaching these composts with fresh water before use can effectively lower soluble salts below damaging levels (Carrion and others 2006).

The physical properties of the composts in Table 1 were generally good as all measures of porosity met or exceeded the ideal ranges, but varied considerably with the feedstock. When composted green waste was mixed with peat moss in ratios from 10 to 50%, total porosity and water-holding capacity was reduced (Maher and Prasad 2005). Some municipal wastes containing tree leaves and lawn clippings have particles so small that they can seriously reduce aeration porosity (McCloud 1994). Composts should be screened to remove excessive fine particles before use; the percentage of fines passing through a 100 mesh screen should not exceed 15% of the total volume (Miller 2004).

2. What is the carbon-to-nitrogen ratio (C:N)?

The C:N is one of the most important characteristics to

Table 1 - Chemical and physical analysis of raw materials commonly used in composts (modified from Chong 2003 & Chong and Pervis 2006)

Characteristic tested	Ideal range	Mushroom waste	Turkey litter	Municipal waste	Paper mill sludge
pH	5.5 to 6.5	8.2	8.7	8.4	7.2
Electrical conductivity* (ds/m)	< 1.0	4.0	4.1	3.0	1.2
Ammonium nitrogen (ppm)	< 10	15	103	4	37
Nitrate nitrogen (ppm)	100 to 200	89	232	0.02	0.02
Phosphorus (ppm)	6 to 9	6	27	2	8
Sodium (ppm)	0 to 50	511	501	139	387
Total porosity (%)	> 50	71	73	66	72
Aeration porosity (%)	15 to 30	40	45	32	40
Water-holding porosity (%)	25 to 35	31	28	34	31

* EC measured as dilution of 1 part substrate to 2 parts water

measure in both raw materials and finished compost. One of the traditional concerns with composts and other organic matter sources in nurseries is whether the material will tie-up nitrogen after use (Rose and others 1995). Many composts that are made from wood wastes have a very high C:N ratio (Table 2) and the decomposing microorganisms will outcompete your seedlings for nitrogen and induce chlorosis and stunting. Bareroot nurseries that have added too much uncomposted sawdust to their seedbeds have learned this lesson all too well.

The higher the C:N, the higher the risk of nitrogen drawdown. The carbon in easily decomposed compounds such as sugars and cellulose are quickly used as an energy source for soil microorganisms which need also nitrogen for growth and reproduction. Because this nitrogen is stored in their cells, it is unavailable for plant uptake. As carbon sources become depleted, the high populations of soil microorganisms gradually die and nitrogen is released for plant growth. When C:N is greater than 15 to 20:1, available nitrogen is immobilized but, as ratios drop lower, nitrogen becomes available for plant uptake. A major problem of compost use in nurseries has been the variation in nitrogen drawdown between different products (Handreck 2005).

Wood wastes such as sawdust have been used in nurseries for decades. Because of their very high C:N ratios, these materials are often composted with manure or supplemented with fertilizer to supply the needed nitrogen. The C:N of tree bark can be considerably lower than wood (Table 2). As previously mentioned, composted pine bark has become the standard growing media components for horticultural nurseries. Bark of other tree species may also prove useful for composting, but tests should be conducted before beginning operational use.

3. What are the mineral nutrient levels and pH?

Although some sources recommend composts as a type of fertilizer, that's not a good idea: if you want to add fertilizer to your crop, buy fertilizer. You can get some added nutritional benefit from composts but nutritional value, as reflected by the nitrogen and phosphorus levels, showed extreme variation (Table 1). Animal wastes used for composting are often very high in nitrogen and phosphorus — note that the turkey litter is way above recommended rates. Composts with high ammonium levels can induce ammonium toxicity in growing media.

The EC test can be used as a good indication of nutrient content as composts that have a high EC are often high in mineral nutrients. The C:N also provides information on potential nutrient levels. Compost with C:N below 10:1 can provide a ready source of available mineral nutrients, are therefore considered fertilizers. Still, the overall nutrient composition of most composts is low compared to traditional fertilizers. Milorganite©, the composted municipal waste that has been used in bareroot forest nurseries for decades, has a fertilizer analysis of only 6-2-0. Vermicomposts have greater CEC, lower soluble salts, and they contain nutrients that are readily available for plant uptake (Atiyeh and others 2000). Nutrients in mature composts are slow-release and so compost application rates should be based both on nutri-

Table 2 - Carbon-to-Nitrogen Ratios of Common Organic Materials (Modified from Rose and others (1995)	
Organic Waste Materials	**Carbon-to-Nitrogen Ratio**
Wood (Ponderosa pine & Douglas-fir)	1200:1 to 1300:1
Bark (Ponderosa pine & Douglas-fir)	400:1 to 500:1
Wood (Red alder)	377:1
Paper	170:1
Pine needles	110:1
Wheat straw	80:1
Bark (Red alder)	71:1
Dry leaves	40:1 to 80:1
Dry hay	40:1
Yard clippings	25:1 to 30:1
Oat straw	24:1
Aged manure	20:1
Alfalfa hay	13:1

ent content and release rate.

Composts can also affect fertility indirectly through their effect on pH. Many composts have a neutral pH but others can as high as 8.7 (Table 1), which could cause serious nutrient availability problems.

4. What about the potential of toxic elements in municipal and industrial waste composts?

Some composts can contain high levels of heavy metals and other elements that can be toxic to plants and animals. These elements are naturally found in soils (Table 3) but become accumulated through human activities from fertilizer additions to industrial processes. In recent years, the Clean Air Act and other environmental legislation have limited industrial discharge into municipal wastewater facilities and so the level of toxic elements in biosolids has also decreased. High soluble salts, and sodium in particular, are another common problem, especially with composts containing a high proportion of manure or municipal sludge

Conifer seedlings were grown in bareroot beds supplemented with various amounts of 3:1 sawdust:composted municipal sludge from Seattle. Initial growth stimulation was followed by reduced growth, probably due to a high C:N. Of more concern, however, is that tests showed increased levels of toxic heavy metals such as cadium and zinc in seedlings (Coleman and others 1987). Municipal wastes containing glue and industrial wastes can contain high levels of boron. While small amounts of boron are needed by plants, toxicity is more of a concern so composts with more than 25 ppm of boron should be monitored closely (Rosen 2000).

So, although you should always request a complete chemical analysis of feedstocks or finished composts, professionally produced composts are safe because toxic element levels are constantly monitored. For example, chemical analyses of biosolids show that all toxic elements are well below legal standards and are often less than levels found in natural soils (Table 3).

5. How sensitive is my crop?

Forest and conservation plants can tolerate most composts if they are applied at the proper rate, in the proper manner, and at the proper time. Because of their restricted root volume, container stock will be more sensitive than bareroot plants and newly-sown seedlings will be much more sensitive than transplants.

Testing Feedstocks or Compost Products

Whether you are considering making your own compost or buy the finished product, it’s a good idea to consider testing. Before we discuss the various options, let’s define two terms that often cause confusion when evaluating composts—maturity and quality (Bettineski 1996b).

Table 3 - Toxic elements limits and ranges from common composts

Element	Range in natural soils (ppm) *	Legal lLimits for biosolids ** (ppm)	Concentrations in biosolids from US and Canada *
Arsenic	5 to 13	41	1.0 to 12.8
Cadmium	0.01 to 7.00	39	3.6 to 16.0
Copper	1 to 300	1,500	180 to 890
Lead	3 to 25	300	14 to 340
Mercury	------	17	0.01 to 3.50
Nickel	3 to 300	420	18 to 42
Selenium	0.00001 to 3.4	100	0.10 to 0.55
Zinc	10 to 2000	2,800	534 to 990

* (Epstein 1997) ** US EPA (2008)

1. **Compost maturity** tests evaluate whether the composting process has been completed, and that the C:N ratio has stabilized. The traditional way to evaluate compost maturity is to monitor temperature within the compost pile or in the finished product (Martin and Gershuny 1992). The activity of the decomposing microorganisms generates heat which follows a standard curve (Figure 2A). Long-stemmed compost thermometers can be inserted into the pile at regular intervals, and the temperatures used to monitor compost maturity (Figure 2B). While this monitoring system is simple and inexpensive, it does not provide a true picture of compost quality. The composting process might have stalled at some point because one of the essential factors became limiting—this often happens due to poor aeration.

2. **Compost quality** tests are more comprehensive; they reflect maturity but also reveal chemical properties, mineral nutrient content, and intended use. The traditional test of compost quality has been a bioassay using the germination ability of a quick growing plant. The original compost maturity test used cress (*Lepidium sativum*) germination as the bioassay (Zucconi and others 1981) but subsequent testing found this procedure has been difficult to replicate. A more recent study (Emino and Warman 2004) tested cress and a variety of other commonly-used indicator plants and found that none did a good job of predicting compost quality. Their tests showed that Joseph's coat, a cultivar of *Amaranthus tricolor*, did a good job in distinguishing between immature and mature compost. It appears that there is considerable variation between plant response but, if enough time were available, nurseries could do germination testing with their own specific crops. A high quality mature compost should be able to support earthworms and other soil fauna (Figure 2C).

Most states don't require compost producers to label their products with an analysis of quality (Mecklenburg 1993). So, growers either have to test it themselves or have a supplier do the testing (Bettineski 1996b).

In-House Testing - In addition to measuring compost temperature, a series of hands-on tests are available from Woods End Research® and numerous compost supply firms on-line (Table4):

* The Solvita Compost Maturity Test is a colorimetric test that takes only 4 hours, and costs about $14 per sample. The relative color is keyed to a numerical index from 1 to 8, which then describes the compost condition.

* The Dewar Self-heating Test Kit evaluates the stability of the compost by measuring residual heating ability by monitoring the temperature in a special reusable flask.

* The Compost Oxygen Probe is a kit containing a hand vacuum pump with a long probe for taking gas samples from within the compost pile. Some models also feature a thermometer.

Laboratory Testing - Several laboratories offer specialized compost analysis, and many different tests and services are available (Table 5). These tests are more expensive ($75 to $300), but give a more detailed picture of compost maturity and quality. Washington State University Extension provides excellent guidelines on how to sample composts and what to ask from a testing laboratory (Bary and others 2002):

<u>Sampling</u>. Without a good representative sampling procedure, compost analysis is a waste of time and money. To collect a representative sample of your compost, take

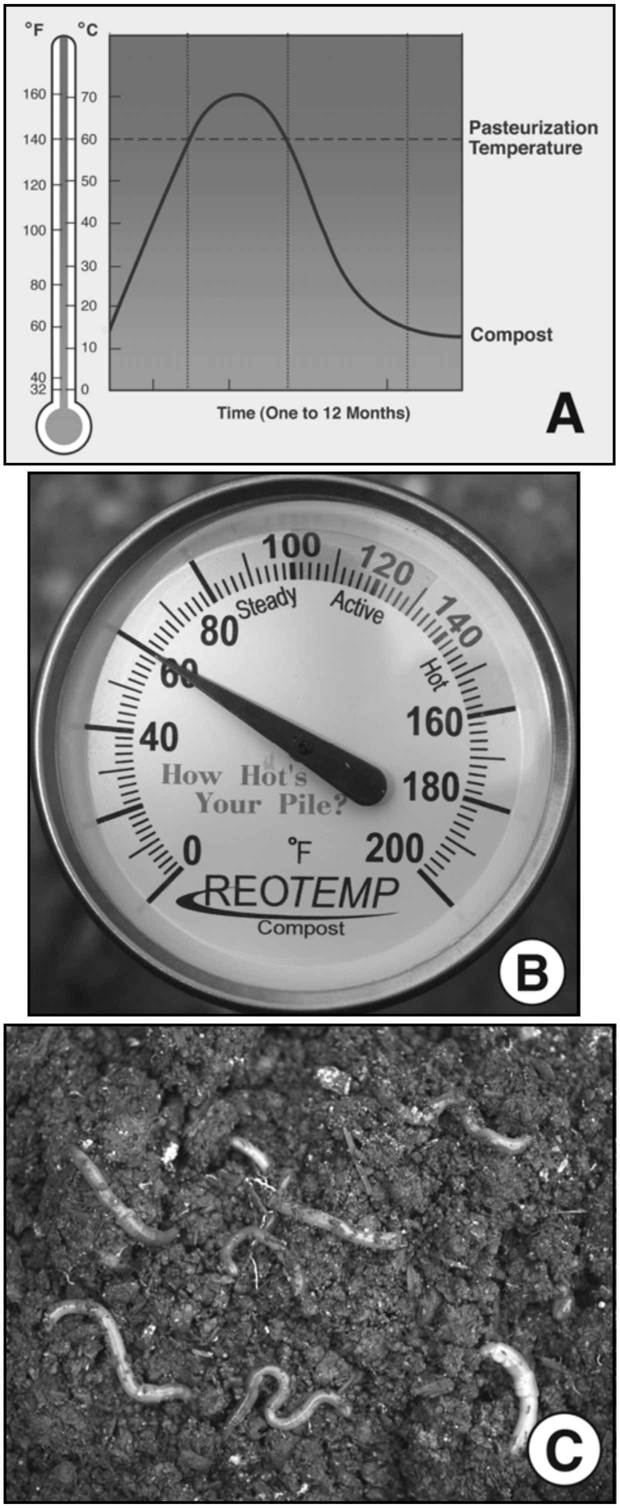


Figure 2 – The traditional way of monitoring the composting process has been to measure the temperature in the pile (A) with a long-stemmed thermometer (B). The ultimate measure of compost maturity and quality is a bioassay using a germination test or checking for earthworms and other microfauna (C).

15 to 20 samples from different parts of the pile and combine them together. Don't sample the surface of the pile; rather, break the pile open in several places and sample the exposed surfaces. Mix the sample thoroughly and take a 1 quart subsample to send to the lab. Cool or freeze the sample for shipment or pack with "blue ice". Contact the lab for specific handling and shipping instructions.

Laboratories. Use a laboratory that analyzes for compost on a regular basis. Ask for a copy of their report form to see if the results are presented in a manner that you can understand and in units that are useful. Ask what specific tests they do, and what are the costs of each? Inquire about handling and shipping requirements and when the results will be ready.

The United States Composting Council operates an approval system for composting facilities. The Seal of Testing Assurance (STA) is a program that requires compost manufacturers to regularly test their composts using an approved third-party testing facility. The procedures for sampling and testing are outlined in the Test Methods for the Examination of Composting and Compost protocols. The STA program takes the worry out of purchasing compost because you know that you can be assured that the company is reputable. Through this program, compost manufacturers are required to report test results to customers that request them as well as provide guidance on application rates and methods (Gale 2008). A current list of STA laboratories can be found at URL:<www.compostingcouncil.org>.

Woods End Research Labs performs more complicated tests that require specialized facilities. Compost conditions, such as decomposition rate, volatile organic acids, and phytotoxic compounds can be done on a fee basis. For more information, contact:

Woods End® Research Laboratories
PO Box 297
Mt. Vernon, ME 04352
TEL: 207.293.2457
FAX: 207.293.2488
E-mail: solvita@woodsend.org
Website: www.woodsend.org/

Summary and conclusions.

Both bareroot and container nurseries can use high-quality organic matter, and composts are a way to both meet that demand and also provide an eco-friendly source for organic wastes. Although the published literature is rife with articles on compost use in nurseries, the highly variable nature of the feedstocks and differ-

Table 4 - Measuring compost maturity with in-house testing kits and equipment				
Stage in Composting Process	**Solvita Maturity Test**	**Dewar Self-Heating Test**	**Oxygen Probe (mg/ gVS/hr)**	**Carbon Dioxide Evolution (%C/day)**
Fresh, raw compost - Extremely high rate of decomposition. High in volatile organic acids so very odiferous	1 Yellow	I	1.60	2.75
Moderately fresh compost - Very high respiration rate, requiring frequent turning & aeration	2 Orange-Yellow	II	1.40	2.25
Acitve compost - high respiration rate, requiring frequent turning & aeration	3 Light-Orange	III	1.00	2.00
Moderately Active Compost - still decomposing	4 Orange	III	0.50	0.75
Moderately Active Compost - beginning to cure	5 Reddish-orange	IV	0.75	1.25
Modertely Mature Compost - Curing phase	6 Maroon	IV	0.50	0.75
Well-matured and aged compost - **Ready for growing media & soil amendments**	7 Reddish-Purple	V	0.25	0.50
Highy-matured & aged compost - **Best for all uses**	8 Purple	V	0.00 to 0.10	0.00 to 0.25

ences in composting technique make interpretation difficult. Using composts as mulch is the most conservative use but incorporating a light 1 to 2 inch (2.5 to 5.1 cm) layer of compost into bareroot beds can also be recommended. As an added safety measure, do the incorporation at the beginning of the fallow year. Using composts as an organic substitute in growing media is a more critical application especially in the small volume containers used in forest and conservation nurseries. Always make sure that the compost has been tested and only use 20 to 30% until you are sure of the results.

As with all changes in cultural practices, always start with a small trial before using composts on an operational scale. Be aware that compost maturity and quality can vary from batch to batch and supplier to supplier, so always ask for test results or do them yourself.

References:

Atiyeh RM, Edwards CA, Subler S, Metzger JD. 2000. Earthworm-processed organic wastes as components of horticultural potting media for growing marigold and vegetable seedlings. Compost Science and Utilization 8 (3):215-223.

Bary A, Cogger C, Sullivan D. 2002. What does compost analysis tell you about your compost? URL: http://www.puyallup.wsu.edu/soilmgmt/Pubs/Poster_CompostAnalysis.pdf (accessed 22 Jul 2008).

Bettineski L. 1996a. How nurseries can benefit from composting. The Digger 40(4):19-23.

Bettineski L. 1996b. Compost standards: are you getting a reliable product? The Digger 40(5):23, 25-29.

Chong C, Purvis P. 2006. Use of paper-mill sludges and municipal compost in nursery substrates. International Plant Propagators' Society, Combined Proceedings 55:428-432.

Chong C. 2003. Use of waste and compost in propagation: challenges and constraints. International Plant Propagators' Society, Combined Proceedings 52:410-414.

Table 5 - What to request in a compost analysis & how to interpret results *

Analysis	Units	Target Range	Importance & Application
Carbon to Nitrogen Ratio (C:N)	None	12:1 to15:1	This is the range of stable compost & will not cause nitrogen availability problems
Electrical conductivity (EC)	dS/cm or mmhos/cm	0.0 to 4.0	This measures soluble salts which can burn sensitive plants
pH	Log Units	5.5 to 6.5	This measures acidity or alkalinity, and composts outside this range can lead to nutritional problems
Ammonium nitrogen	ppm	Less than 500	This fertilizer ion can damage plants at high levels
Nitrate nitrogen	ppm	200 to 500	Low levels of this fertilizer ion can reduce plant growth. High levels can cause water pollution.
Moisture content (MC)	% "as is" weight	40 to 60	Composts with high MC are hard to handle & spread; those with low MC are dusty
Organic matter (OM)	% dry weight	40 to 60	Low values (<30%) indicate composts mixed with sand or soil. High values (>60%) indicate fresh, uncomposted material.

* modifed from Bary and others (2002)

Coleman M, Dunlap J, Dutton D, Bledsoe C. 1987. Nursery and field evaluation of compost-grown conifer seedlings. Tree Planters' Notes 38(2):22-27.

Dallon J Jr. 1989. Physical and chemical characteristics of spent compost. International Plant Propagators' Society, Combined Proceedings 38:590-593.

Das KC, Tollner EW, Tomabene TC. 2008. Composting pulp and paper industry solid wastes: process design and product evaluation. URL: http://www.p2pays.org/ref/12/11563.pdf (accessed 23 Jul 2008).

Emino ER, Warman PR. 2004. Bioassay for compost quality. Compost Science and Utilization 12(4):342-348.

Epstein E. 1997. The science of composting. Boca Raton (FL): CRC Press LLC. 487 p.

Gage J. 2008. Personal communication. Longview (WA): Swanson Bark & Wood Products, Inc. E-mail: jeffg@swansonbark.com

Hartz TK, Giannini C. 1998. Duration of composting of yard wastes affects both physical and chemical characteristics of compost and plant growth. HortScience 33 (7):1192-1196.

Litterick A, Watson C, Wallace P, Wood M. 2005. Compost teas and crop quality in nursery stock. International Plant Propagators' Society, Combined Proceedings 54:174-177.

Martin DL, Gershuny G. 1992. Rodale book of composting. Emmaus (PA): RODALE Press. 278 p.

Mecklenburg RA.1993. Compost cues: how to evaluate and use urban waste compost for plant production. American Nurseryman 177(4):62-65, 67, 68, 70-71.

Ozores-Hampton M. 1998. Compost as an alternative weed control method. HortScience 33(6):938-940.

Pokorny FA. 1979. Pine bark container media—an overview. International Plant Propagators' Society, Combined Proceedings 29:484-495.

Rose R, Haase DL, Boyer D.1995. Organic matter management in forest nurseries: theory and practice. Corvallis (OR): Oregon State University, Nursery Technology Cooperative. 65 p.

Rosen CJ. 2000. Compost criteria. American Nurseryman 191(1):48-51.

Simpson DG. 1985. Growing conifer seedlings in woodwaste—sewage sludge compost. Victoria (BC): British Columbia Ministry of Forests. Research Note 98. 18 p.

Summers J. 2007. Suggestions for using compost tea in cutting propagation. International Plant Propagators' Society, Combined Proceedings 56:221.

[US EPA] US Environmental Protection Agency. 2008. A plain English guide to the EPA part 503 biosolids rule. http://www.epa.gov/owm/mtb/biosolids/503pe/ (accessed 21 Jul 2008).

Veijalainen A-M, Juntunen M-L, Heiskanen J, Lilja A. 2007. Growing *Picea abies* container seedlings in peat and composted forest-nursery waste mixtures for forest regeneration. Scandinavian Journal of Forest Research 22:390-397.

Wikipedia. 2008. Vermicomposts. URL: http://en.wikipedia.org/wiki/Vermicomposting (23 Jul 2008).

Zucconi F, Pera A, Forte M, de Bertoldi M. 1981. Evaluating toxicity of immature compost. BioCycle 2(2): 54-57.

Overwinter Mulches
by Thomas D. Landis

Mulches are one of the oldest and most widely-used cultural practices in nurseries because they offer so many benefits (Borland 1990):

- **Conserve soil moisture** - Fibrous mulches create a textural change at the soil surface, which stops water from moving upward through capillarity and evaporating (Figure 1).

- **Reduce soil erosion** - All types of mulches dissipate the energy of raindrops and wind which can dislodge soil particles and leave them vulnerable to wind and water erosion.

- **Increase water infiltration** - Mulches stop soil crusting and allow irrigation and rainfall to slowly soak into the soil.

- **Insulate surface soils from temperature extremes** - Thick mulches form an insulating layer that dissipates solar energy and prevents soils from reaching damaging levels. When applied over cold or frozen soils, mulches slow soil warming which can prevent loss of dormancy or premature germination of fall-sown crops.

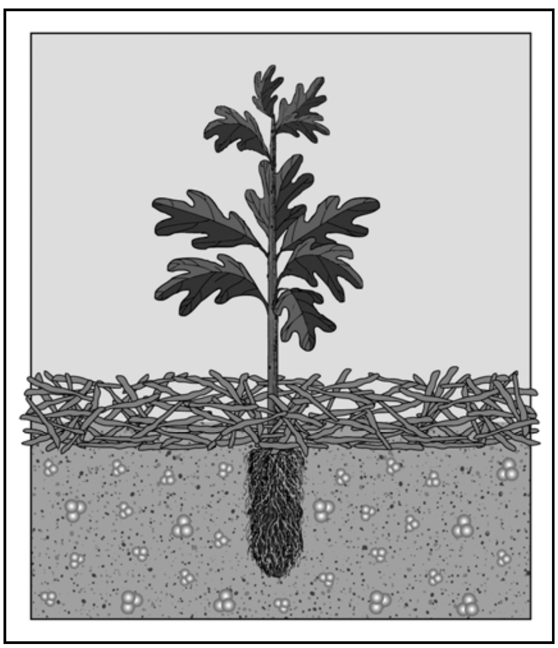


Figure 1 - Thick fibrous mulches prevent surface evaporation and wind and water erosion.

- **Stop wicking of salts** -A thick mulch can prevent soluble salts from moving upward as water is lost from the soil surface by evaporation.

- **Prevent frost heaving** - Because they insulate the soil surface, mulches prevent the recurring freeze and thaw cycles that cause frost heaving.

- **Reduce weed germination and growth** - Mulches control weeds in 2 ways: inhibition of weed seed germination by reducing light levels, and physical suppression (Mathers 2003).

Many growers use mulches after sowing or during the growing season but many people aren't aware of the benefits of using mulches during the winter season. Let's take a look at those last 2 benefits as they apply to overwintering.

Frost heaving.

At high latitudes and elevations, frost heaving can be a serious problem in bareroot nurseries and on outplanting sites. Frost heaving is a purely mechanical process whereby plants or other objects are slowly racheted out of the soil by repeated freezing and thawing (Goulet 1995). All types of nursery stock can be frost-heaved but small seedlings (Figure 2A). and recent transplants (Figure 2B) are particularly susceptible because they haven't developed a strong enough root system. Because of their smooth-walled root plugs, container plants are particularly susceptible after transplanting into bareroot beds or after fall outplanting. In fact, nurseries and foresters have avoided late summer or fall transplanting and outplanting because of concerns about frost heaving. Sites prone to frost heaving have high soil moisture and soil textures with good hydraulic conductivity (Bergsten and others 2001). The tendency to frost heave increases as pore size decreases, so silt and clay soils are most problematic. Southerly or southwesterly sites have more of a problem with frost heaving because the high solar exposure intensifies the freeze-thaw cycle.

Winter weed control.

Mulches are effective against weeds during the growing season but they can be especially valuable in controlling those pesky winter annuals. The seeds of winter annuals germinate in the fall, grow a strong tap root during the winter (Figure 3A), and then bloom and set seed very early in the spring. Winter annual weeds are difficult to control because they often go unnoticed during the winter and escape control in the spring when nurseries are very busy with other tasks like lifting and sowing.

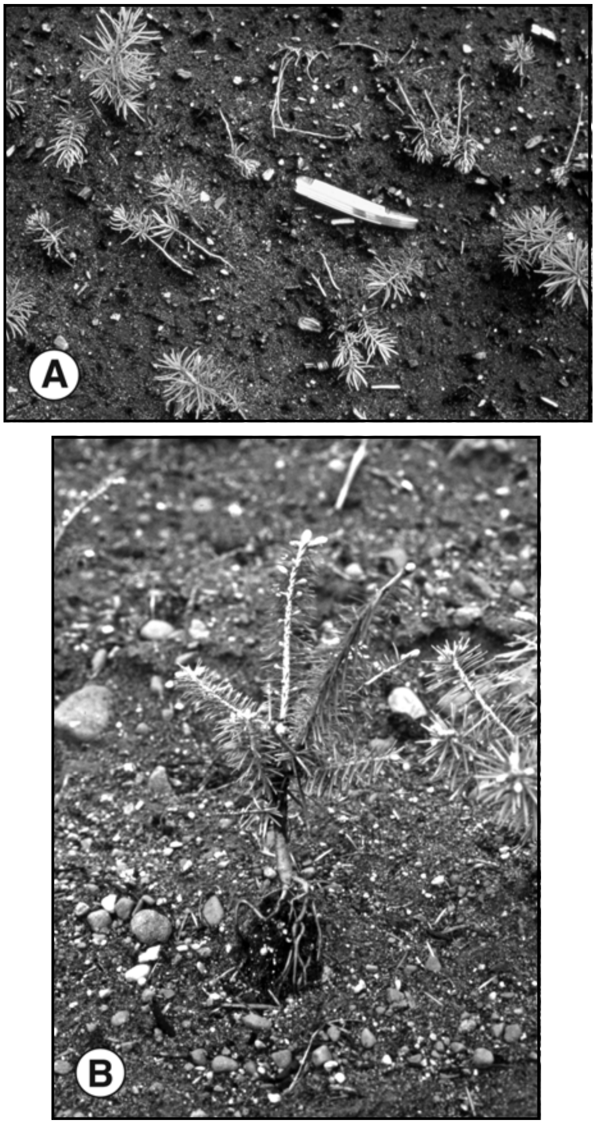


Figure 2 - Small seedlings (A) and recent transplants are particularly susceptible to frost heaving as are container plants due to the smooth walls of the plugs (B).

Some common examples of winter annual weeds include:

Purple deadnettle (*Lamium purpureum)*
Henbit (*Lamium amplexicaule*)
Field pennycress (*Thlaspi arvense*)
Shepherd's-purse (*Capsella bursa-pastoris*)
Small-flowered bittercress (*Cardamine parviflora*)
Common chickweed (*Stellaria media*)
Redstem filaree (*Erodium cicutarium*)

As previously mentioned, one way that mulches inhibit weed germination and growth is by physical inhibition. Most weed seeds need high light levels to germinate and dense or thick mulches keep weeds seeds in the dark and thereby stop germination. For example, mulberry weed (*Fatoua villosa*) is a new and invasive weed of bareroot and container nurseries the southeastern US, California, and Washington. When seed germination of this weed was measured under different mulches (Penny and Neal 2003), a mulch thickness of 2 inches (5 cm) was most effective (Figure 3B).

Mulches can also kill or inhibit weed growth through chemical means. Interestingly enough, mulches composed of immature municipal compost have shown better weed control than mature compost and other mulch types in ornamental container nurseries (Table 1). This herbicidal effect has been attributed to the buildup of organic acids, especially acetic acid, during the initial stages of composting. When they analyzed mulches of different ages, acetic acid levels were 2,474 ppm in the 3-day-old municipal compost, 1,776 ppm in an 8-week-old compost, and only 13 ppm in the mature (1-year-old) sample (Ozores-Hampton and others 2002). To avoid possible phytotoxicity to the crop plants, the authors recommend avoiding direct contact with crop plants and using them in tractor paths or in ground around containers.

Table 1 - Effect of different mulches on the germination and growth of Ivyleaf morningglory (*Ipomoea hederacea*) - modified from Ozores-Hampton and others (2002)

Type of Mulch	Emergence (%)	Shoot weight (g)	Root weight (g)
None	97	0.24	0.05
Sand	95	0.25	0.12
Immature municipal compost (3 days)	52	0.04	0.02
Mature municipal compost (1 year)	95	0.30	0.06

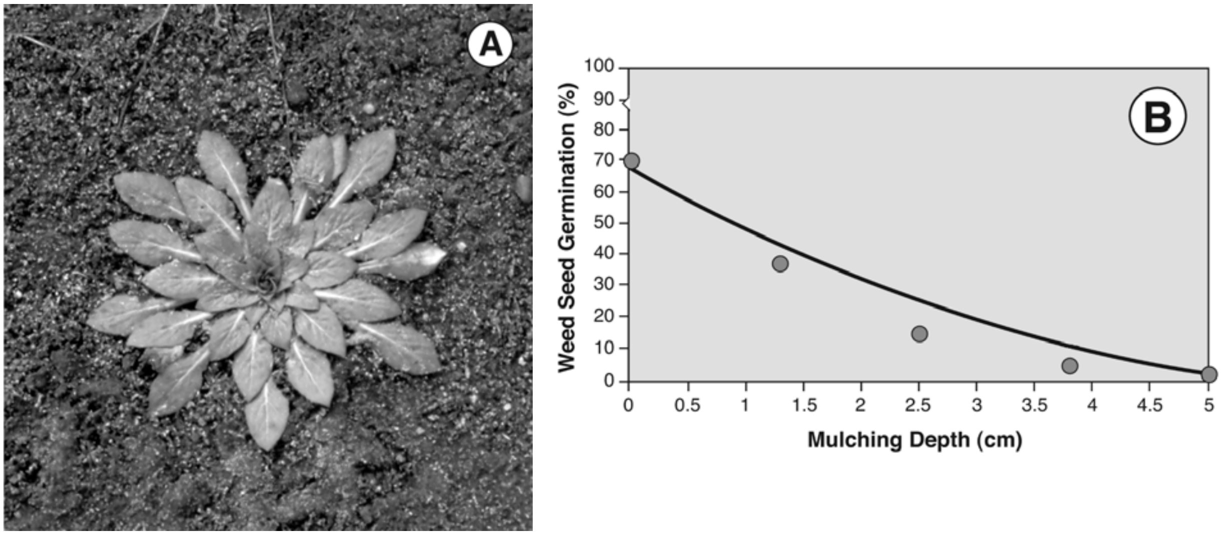


Figure 3 - Winter annuals develop a strong tap root and store energy over the winter (A) so that their shoots can grow rapidly and produce seeds early in the growing season. A 2 inch-thick mulch was most effective in preventing mulberry weed (Fatoua villosa) from germinating (B). B - modified from Penny and Neal (2003

Ornamental nurseries have also been experimenting with a novel approach to weed control in their large containers - mulches pretreated with preemergent herbicides. Bark nuggets treated with the herbicide oryzalin provided excellent weed control (Mathers 2003). I couldn't find any published information on herbicide-treated mulches in bareroot nurseries but the principle should be the same.

Summary.

Overwinter mulches can provide many benefits but preventing frost heaving and controlling winter annual weeds are especially effective. For controlling frost heaving, mulches must be thick enough to insulate and prevent repeated freezing and thawing throughout the winter. Mulches can prevent weed seed germination by physical exclusion of light and immature composts have also demonstrated chemical weed control. As always, these applications should be tested on your own crops on a small trial basis before full-scale operational use.

Sources:

Bergsten U, Goulet F, Lundmark T, Lofvenius MO. 2001. Frost heaving in a boreal soil in relation to soil scarification and snow cover. Canadian Journal of Forest Research 31(6):1084-1092.

Borland J. 1990. Mulch: Examining the facts and fallacies behind the uses and benefits of mulch. American Nurseryman 172(4):132-133, 135, 137, 138-141.

Goulet F. 1995. Frost heaving of forest tree seedlings: a review. New Forests 9(1): 67-94.

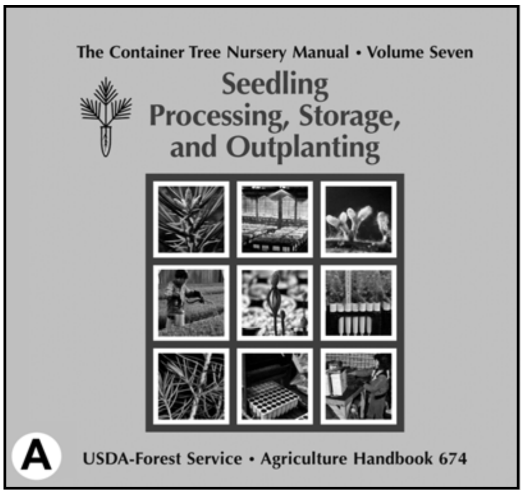
Mathers HM. 2003. Novel methods of weed control in containers. HortTechnology 13(1):28-34.

Ozores-Hampton M, Obreza TA, Stoffella PJ, Fitzpatrick G. 2002. Immature compost suppresses weed growth under greenhouse conditions. Compost Science and Utilization 10(2):105-113.

Penny GM, Neal JC. 2003. Light, temperature, seed burial, and mulch effects on mulberry weed (*Fatoua villosa*) seed germination. Weed Technology 17(2):213-218.

The Container Tree Nursery Manual - Volume Seven
by Thomas D. Landis

Yes, it's finally done! With the help of co-authors Kas Dumroese and Diane Haase, I was finally able to finish the last of the CTNM series entitled Seedling Processing, Storage and Outplanting (Figure 1A). This volume covers the time from when the crop is hardened-off and ready for harvest to when they go in the ground. If it seems like a long time since Volume Six was published, you are right - nine years in all (Figure 1B). Many things, including my retirement from the Forest Service in 2004, contributed to this long gestation period but hopefully you will think that it was worth the wait.



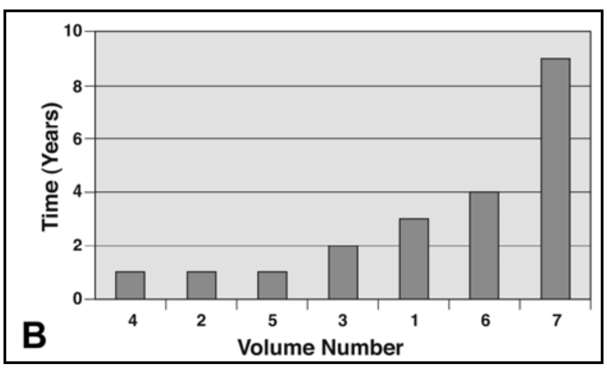


Figure 1A - Volume Seven of the Container Tree Nursery Manual series is finally finished (A). Many people were beginning to worry because each volume was taking longer to get published (B).

CTNM Seven is organized into six chapters:

1. The Target Plant Concept - This first chapter forms the conceptual basis for the rest of the book. The basic tenet is that nursery plant quality is determined by outplanting performance and cannot be described at the nursery. There is no such thing as an "all-purpose" plant because quality depends on how the plants will be used—"fitness for purpose" (Ritchie 1984). Using the six steps in the Target Plant Concept (Figure 2), nursery managers work with their customers to define and then produce nursery stock that will be well adapted to the specific outplanting site.

2. Assessing Plant Quality - How to define nursery stock quality has always been a challenge, so for this chapter I enlisted the help of Gary Ritchie, retired plant physiologist from Weyerhaeuser. Although many "seedling quality tests" have been proposed in the past 50 years, most failed to stand the test of time and were not operationally useful. So, in this chapter, we define the various morphological, physiological, and performance attributes of plant quality as well as discuss how this information can be used in nurseries and on the outplanting site.

3. Harvesting - Methods of harvesting container stock across North America are a function of nursery size and location, plant species, research input, and tradition. This chapter discusses ways to determine the "lifting window" as well as the procedures used to grade the stock and prepare it for outplanting or storage.

4. Storage - Storing nursery stock is an operational necessity, not a physiological requirement as some nurseries ship directly after harvesting. However, for larger nurseries and those far from the outplanting sites, well-designed storage facilities are an essential feature. This chapter discusses open, sheltered, and refrigerated storage practices including the latest information on frozen storage. Ways to monitor the quality of stored stock as well as how to identify causes of overwinter damage round-out the chapter.

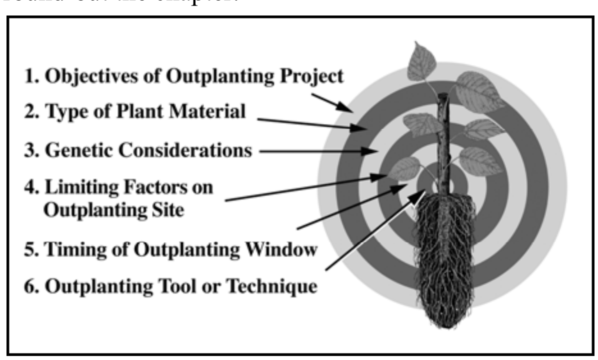


Figure 2 - The Target Plant Concept is crucial to outplanting success.

5. Handling & Shipping - Nursery plants are at their maximum quality immediately before they are harvested, but they then must pass through many hands before being outplanted. Nursery stock is subjected to a series of potential stresses from harvest through outplanting, including temperature extremes, desiccation, mechanical injuries, and storage molds. Each stage in the process represents a link in a chain, and overall plant quality is only as good as the weakest link. The effect of these stresses is also cumulative so that seemingly minor problems can add up to serious damage. Often, these sublethal injuries are not immediately apparent but the damage only becomes evident as decreased survival and growth weeks or months after outplanting.

6. Outplanting - The final three steps of the Target Plant Concept (Figure 2) are critical to outplanting success and must considered when planning and initiating outplanting projects. This chapter discusses preplanting procedures as well as site preparation treatments that help improve a plant's ability to survive and grow. How to determine the proper plant spacing and select the best planting spots are also discussed as well as proper handling and planting techniques. Sections on the various types of hand planting tools (Figure 3A) and planting machines (Figure 3B) will be useful to reforestation and restoration specialists, especially since there hasn't been a new book on planting for many years. The latest information on treatments to prevent animal damage and fertilization at the time of outplanting are also discussed. Lastly, the types of surveys to determine planting quality and track outplanting success over time are presented.

Publication Plans. Like the preceding volumes, CTNM Seven will be published as Agriculture Handbook 674 which means that it will have to go through the editorial processes of both the Forest Service and the Department of Agriculture. This will take up to a year and so, to get this information out as quickly as possible, we're going to publish it first as a electronic book ("E-Book"). If you are not familiar with this format, the entire volume will be contained on a compact disk in Adobe PDF format.

We're producing a limited number of copies at this time so that we can have the chapters reviewed by subject matter specialists. That process will take several months with a final deadline of November 1. Then, we'll incorporate any changes and print up more E-books for sale and send them draft back to Washington, DC to start the editorial process for the hard copy printing. Hopefully, I'll be able to announce the printing in the Summer 2009 issue of FNN.

How to Get a Copy.

If you would like to be a reviewer or have some information you would like included in CTNM Seven, you can order a CD containing the review PDF files by contacting Tom Landis at the address in the inside front cover. The review draft is also available on the RNGR website:
http://www.rngr.net/Pubications/ctnm/volume7

If you would like to advance order an E-book of CTNM Seven which will be ready in November, you can contact Richard Zabel at:

Western Forestry and Conservation Association
4033 SW Canyon Road
Portland, OR 97221
TEL: 503.226.4562
FAX: 503.226.2515
E-mail: richard@westernforestry.org
Website: www.westernforestry.org/

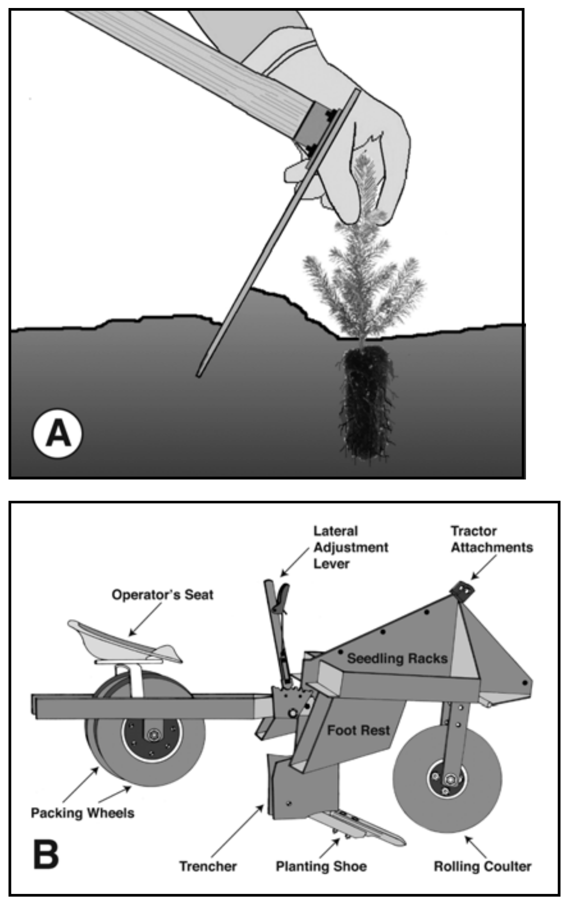


Figure 3 - CTNM Seven will be popular with both nursery workers and seedling users because it presents the very latest information on planting tools (A), machines (B), and techniques.

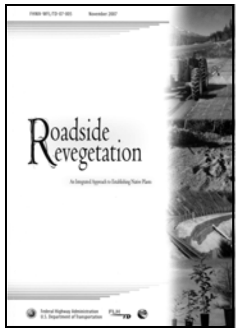
"What's this about your refusing to attend another meeting because you "want to get some work done"??

"The great thing about this Information Age is that **people** don't have to know **anything**"

Okay, everybody, we're having to recycle some "oldies but goodies". I'm sure that you have some favorite cartoons laying around, so send them in and we'll get them scanned and into future FNN issues.

Special Order Books

Roadside Revegetation: An Integrated Approach to Establishing Native Plants
by David E. Steinfeld, Scott A. Riley, Kim M. Wilkinson, Thomas D. Landis, Lee E. Riley
Publication Date: 2007



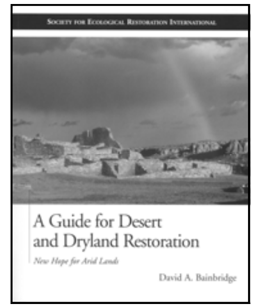
Abstract: Native plants are a foundation of ecological function, affecting soil conservation, wildlife habitat, plant communities, invasive species, and water quality. Establishing locally-adapted, self-sustaining plant communities can also support transportation goals for safety and efficiency. Past obstacles to establishing native plant communities on roadsides have been technical, informational, and organizational. Effective strategies and practical techniques for revegetating the disturbed conditions with limited resources must be made available to practitioners. Multiple disciplines, ranging from engineering to soil science, ecology, botany, and wildlife science, must be able to work cooperatively, not in isolation. This softbound book offers an integrated approach to facilitate the successful establishment of native plants along roadsides and other areas of disturbance associated with road modifications. It guides readers through a comprehensive process of: 1) initiating, 2) planning, 3) implementing, and 4) monitoring which will be useful for all types of wildland restoration.

Download Adobe PDF files at: http://www.wfl.fhwa.dot.gov/td/revegetation.htm

Request free softbound copies from:

Amit Armstrong, Ph.D., P.E.
Technology Deployment Engineer
Western Federal Lands Highway Division
Federal Highway Administration
610 East Fifth Street
Vancouver WA 98661
Phone: 360-619-7668
Fax: 360-619-7846
E-mail: amit.armstrong@fhwa.dot.gov

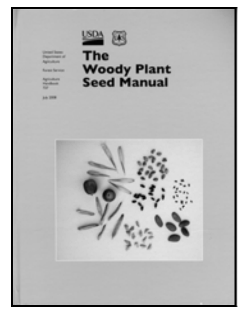
A Guide for Desert and Dryland Restoration: A New Hope for Arid Lands
by David A. Bainbridge
Publication Date: 2007



Abstract: Desert degradation and desertification now affect almost a billion people. This book provides an introduction to the ecology of desert plants, explores the causes of desert land abuse, and discusses the processes and procedures for evaluating sites, planning, implementing, and monitoring desert restoration projects.
Price: $100 Hardback or $50 Softcover

Order from: Island Press at website: www.islandpress.org

The Woody Plant Seed Manual
Edited By Bonner FT and Karrfalt RP, with editorial coordination by Nisley RG
Publication Date: 2008



Abstract: This is the long-awaited update of the classic Seeds of Woody Plants in the United States which was published back in 1974 and went through 5 reprintings. At 1,233 pages and a weight of over 9 pounds, this is a formidable reference. The Woody Plant Seed Manual, which has been issued as Agriculture Handbook 727, follows the organization of the previous versions. Part One consists of 7 chapters on general principles such as seed biology, harvesting, storage, testing as well as the instant classic on nursery practices. Part Two has been expanded to included 236 genera of native and introduced woody plants, many of which are tropical species or western natives which have become more widely-used. The information on each genus is presented in the following sections: growth habit; occurrence and use; flowering and fruiting; collection, extraction and storage of seeds; pregermination treatments; germination tests; and nursery practices.

Price: Hardbound for $103.00

Order from: US Government Bookstore at TEL: 202-512-2010 or Website: http://bookstore.gpo.gov. There are plans to issue a DVD version in the near future so stay tuned for more information.

Adobe PDF files can be downloaded at http://nsl.fs.fed.us/wpsm/

New Nursery Literature

NEW PROCEDURE—ELECTRONIC COPIES ONLY

A compact disk with all the following journal articles or publications in Adobe PDf format can be ordered using the Literature Order Form on the last page of this section. Note that there are a 2 restrictions:

1. Copyrighted Material. Items with © are copyrighted and require a fee for each copy, so only the title page and abstract will be provided through this service. If you want the entire article, please order a copy from a library service.

2. Special Orders (SO). Special orders are books or other publications that, because of their size or cost, require special handling. For some, the Forest Service has procured copies for free distribution, but others will have to be purchased. Prices and ordering instructions are given following each listing in the New Nursery Literature section.

Business Management

1. Growers can apply Lean to shipping and handling. Rogish, A. Greenhouse Management and Production 28 (3):31-35. 2008.

2. High-voltage electric safety. Tompkins, P. American Nurseryman 206(4):26-29. 2007.

3. How safe is your greenhouse? Mulhern, B. Greenhouse Grower 26(1):68, 70, 72. 2008.

4. Micro-organisms of human health importance in growing media. Carlile, W. R. and Hammonds, S. J. Acta Horticulturae 779:67-73. 2008.

5. Prepare yourself and your business for a disaster. Hudson, G. Greenhouse Management and Production 28 (6):38-40, 42. 2008.

Container Production

6. Diagnosing abiotic disorders in the greenhouse. Gibson, J., Whipker, B., and Nelson, P. V. American Nurseryman 207(3):12, 14, 16. 2008.

7. © Frost tolerance of two-year-old *Picea glauca* seedlings grown under different irrigation regimes in a forest nursery. Carles, S., Lamhamedi, M. S., Stowe, D. C., and Margolis, H. A. Scandinavian Journal of Forest Research 23:137-147. 2008.

8. © Influence of irrigation method and container type on northern red oak seedling growth and media electrical conductivity. Davis, A. S., Jacobs, D. F., Overton, R. P., and Dumroese, R. K. Native Plants Journal 9(1):4-13. 2008.

9. Leaching of pesticides through container peat medium in forest seedling production. Juntunen, M.-L. and Kitunen, V. Acta Horticulturae 779:221-229. 2008.

10. Pot production of pecan seedlings with 'Cynthiana' grape pomace. Stafne, E. T. and Carroll, B. L. Journal of Food, Agriculture & Environment 7 (1):89-91. 2008.

Diverse Species

11. © The 'Appar' flax release: origin, distinguishing characteristics, and use; and a native alternative. Pendleton, R. L., Kitchen, S. G., McArthur, E. D., and Mudge, J. E. Native Plants Journal 9(1):18-24. 2008.

12. © Canopy shade and the successional replacement of tamarisk by native box elder. Dewine, J. M. and Cooper, D. J. Journal of Applied Ecology 45:505-514. 2008.

13. © Comparison of the seed germination of native and non-native winter annual Apiaceae in North America, with particular focus on *Cyclospermum leptophyllum* naturalized from South America. Walck, J. L., Baskin, C. C., Hidayati, S. N., and Baskin, J. M. Plant Species Biology 23:33-42. 2008.

14. Effect of hot water, sulphuric acid and nitric acid on the germination of rose seeds. Younis, A., Riaz, A., Ahmed, R., and Raza, A. Acta Horticulturae 755:105-108. 2007.

15. © The germination characteristics of *Scrophularia marilandica* L. (Scrophulariaceae) seeds. Nurse, R. E. and Cavers, P. B. Plant Ecology 196:185-196. 2008.

16. The greening of public roadsides. Armstrong, A., Riley, S., Steinfeld, D., and Wilkinson, K. M. Public Roads 71(3):1-12. 2007.

17. Growth, nitrogen use efficiency, and leachate comparison of subirrigated and overhead irrigated pale purple coneflower seedlings. Pinto, J. R., Chandler, R. A., and Dumroese, R. K. HortScience 43 (3):897-901. 2008.

18. © Improving seed germination of saltgrass under saline conditions. Shahba, M. A., Qian, Y. L., and Lair, K. D. Crop Science 48:756-762. 2008.

19. © The influence of fertilization regime and mycorrhizal inoculum on outplanting success. Meikle, T. W. and Amaranthus, M. Native Plants Journal 9(2):107-116. 2008.

20. © An introduction to propagation of arbuscular mycorrhizal fungi in pot cultures for inoculation of native plant nursery stock. Corkidi, L., Evans, M., and Bohn, J. Native Plants Journal 9(1):29-38. 2008.

21. Methods for *Rosa* germination. Anderson, N. and Byrne, D. H. Acta Horticulturae 751:503-507. 2007.

22. Modeling the effects of temperature and gibberellic acid concentration on red huckleberry seed germination. Lopez, O. A., Barney, D. L., Shaffii, B., and Price, W. J. HortScience 43(1):223-228. 2008.

23. Native roadside perennial grasses persist a decade after planting in the Sacramento Valley. O'Dell, R. E., Young, S. L., and Claassen, V. P. California Agriculture 61(2):79-84. 2007.

24. © Portable refrigerator / freezer provides stable temperature for plant material collection. Davis, A. S. and Gauthier, M.-M. Native Plants Journal 9(1):41-44. 2008.

25. © Prairie turnip *Pediomelum esculentum* (Pursh) Rydb.: historical and modern use, propagation, and management of a new crop. Stahnke, A., Hayes, M., Meyer, K., and Witt, K. Native Plants Journal 9(1):46-58. 2008.

26. © Propagation protocol for giant trumpets (*Macromeria viridiflora* DC. [Boraginaceae]). Raiter, H. Native Plants Journal 9(1):15-16. 2008.

27. Response of seedlings of two hypogeal brush species to CO_2 enrichment. Tischler, C. R., Derner, J. D., Polley, H. W., and Johnson, H. B. IN: USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-47:104-106. Proceedings: Shrubland dynamics - fire and water. 2007.

28. © Sand verbenas (*Abronia* spp., Nyctaginaceae) germinate in response to ethylene. Drennan, P. M. Journal of Arid Environments 72:847-852. 2008.

29. Seed germination biology of intermountain populations of fourwing saltbush (*Atriplex canescens*: Chenopodiaceae). Meyer, S. E. and Carlson, S. L. IN: USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-47:153-162. Proceedings: Shrubland dynamics - fire and water. 2007.

30. Seed storage, germination and seedling emergence in *Rhamnus catharticus*. Tylkowski, T. Dendrobiology 58:67-72. 2007.

31. Small scale and large scale monitoring of vegetation changes in a restored wetland. Margoczi, K. and Takacs, G. University of Szeged, Department of Ecology, Hungary. W3M Conference for Wetlands: Monitoring, Modelling and Management, Sept. 22025, 2005. 55 p. 2005.

Fertilization and Nutrition

**32. Effect of fertiliser and water supply on the growth, nutrient status and photochemical efficiency of *Eucalyptus pilularis* seedlings in a phosphorus-

deficient soil. Weggler, K., Carney, C., and Stone, C. Australian Forestry 71(1):54-63. 2008.

33. Effects of phosphate uptake on root architecture of apple seedlings in water culture. Fan, W. and Yang, H. Acta Horticulturae 767:423-427. 2008.

34. © Growth and nutrient dynamics of Douglas-fir seedlings raised with exponential or conventional fertilization and planted with or without fertilizer. Everett, K. T., Hawkins, B. J., and Kiiskila, S. Canadian Journal of Forest Research 37:2552-2562. 2007.

35. Nitrogen-based fertilizers for trees. Werner, L. American Nurseryman 207(5):18-21. 2008.

36. Plants' essential chemical elements. Smith, K. T. American Nurseryman 206(10):10-11. 2007.

37. PourThru: a method for monitoring nutrition in the greenhouse. Cavins, T. J., Whipker, B. E., and Fonteno, W. C. Acta Horticulturae 779:289-297. 2008.

38. Release rates of soluble and controlled-release boron fertilizers. Broschat, T. K. HortTechnology 18 (3):471-474. 2008.

39. © Short-term nitrogen deprivation increases field performance in nursery seedlings of Mediterranean woody species. Trubat, R., Cortina, J., and Vilagrosa, A. Journal of Arid Environments 72:879-890. 2008.

40. Understanding plant nutrition: an introduction. Argo, B. and Fisher, P. Greenhouse Grower 26(1):34, 36, 38, 40, 42. 2008.

41. Understanding plant nutrition: fertilizers and media pH. Argo, B. and Fisher, P. Greenhouse Grower 26(8):54, 56, 58, 60. 2008.

42. Understanding plant nutrition: limestone and pH. Argo, B., Fisher, P., and Huang, J. Greenhouse Grower 26(3):44, 46, 48, 50. 2008.

43. Understanding plant nutrition: limestone, calcium and magnesium. Argo, B., Fisher, P., and Huang, J. Greenhouse Grower 26(4):38, 40, 42. 2008.

44. Understanding plant nutrition: nutrient sources: media cation exchange capacity. Argo, B. and Fisher, P. Greenhouse Grower 26(2):46, 48, 50, 52. 2008.

45. © Using mushroom farm and anaerobic digestion wastewaters as supplemental fertilizer sources for growing container nursery stock in a closed system. Chong, C., Purvis, P., Lumis, G., and Holbein, B. E. Bioresource Technology 99:2050-2060. 2008.

46. What's in your fertilizer toolbox? Robbins, J. OAN Digger 52(5):29-34. 2008.

General and Miscellaneous

47. © Burbot restoration in the Kootenai River Basin: using agency, tribal, and community collaboration to develop and implement a conservation strategy. Ireland, S. C. and Perry, P. N. American Fisheries Society Symposium 59:251-256. 2008.

48. Carbon sequestration and nitrogen status in arenosols following afforestation or following abandonment of arable land. Armolaitis, K., Aleinikoviene, J., Baniuniene, A., Lubyte, J., and Zekaite, V. Baltic Forestry 13(2):169-178. 2007.

49. Challenges and trade-offs in environmental and financial approaches of the afforestation of degraded lands. Blujdea, V. IN: Climate and land degradation, p. 405-420. Springer-Verlag, Berlin. 2007.

50. © A digital photography short course. Loeffler, K. Native Plants Journal 9(1):60-75. 2008.

51. © First Nations, forest lands, and "aboriginal forestry" in Canada: from exclusion to comanagement and beyond. Wyatt, S. Canadian Journal of Forest Research 38:171-180. 2008.

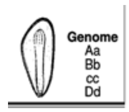
52. Friendly for fish: Salmon-Safe, Part 1. Stoops, R. OAN Digger 52(5):46-49. 2008.

53. © Opportunities for academic training in the science and practice of restoration within the United States and Canada. Nelson, C. R., Schoennagel, T., and Gregory, E. R. Restoration Ecology 16(2):225-230. 2008.

54. © Spontaneous revegetation of cutaway peatlands of North America. Graf, M. D., Rochefort, L., and Poulin, M. Wetlands 28(1):28-39. 2008.

55. © Using the LANDIS model to evaluate forest harvesting and planting strategies under possible warming climates in northeastern China. Bu, R., He, H. S., Hu, Y., Chang, Y., and Larsen, D. R. Forest Ecology and Management 254:407-419. 2008.

Genetics and Tree Improvement



56. © From horticultural plantings into wild populations: movement of pollen and genes in *Lobelia cardinalis*. Johnson, L. M. K. and Galloway, L. F. Plant Ecology 197:55-67. 2008.

57. © Genetic diversity of butternut (*Juglans cinerea*) and implications for conservation. Ross-Davis, A., Ostry, M., and Woeste, K. E. Canadian Journal of Forest Research 38:899-907. 2008.

58. © Geographical variation in phenology of *Quercus petraea* (Matt.) Liebl and *Quercus robur* L. oak grown in a greenhouse. Jensen, J. S. and Hansen, J. K. Scandinavian Journal of Forest Research 23:179-188. 2008.

59. © Screening of Sitka spruce genotypes for resistance to the white pine weevil using artificial infestations. Alfaro, R. I., King, J. N., Brown, R. G., and Buddingh, S. M. Forest Ecology and Management 255:1749-1758. 2008.

Nursery Structures And Equipment

60. Be prepared with standby power equipment. Bartok, J. W., Jr. Greenhouse Management and Production 28(7):90-91. 2008.

61. Burning wood may offer heating savings. Bartok, J. W., Jr. Greenhouse Management and Production 27 (8):65-66. 2007.

62. Comparison and analysis of pneumatic pressure and vacuum sowing machines. Mursec, B., Vindis, P., and Janzekovic, M. Annals of DAAAM for 2007, p. 491 -492. 2007.

63. Consider design with a new floor heating system. Both, A. J. and Reises, E. Greenhouse Management and Production 27(12):35-37. 2007.

64. Geothermal heat taps natural source. Bartok, J. W., Jr. Greenhouse Management and Production 27 (7):90-91. 2007.

65. Greenhouse cooling basics. Both, A. J. American Nurseryman 206(6):20-22, 24. 2007.

66. Greenhouses cuts fuel costs with free heat. Kuack, D. Greenhouse Management and Production 27(8):8-10. 2007.

67. Maintain ventilation equipment before warm weather starts. Both, A. J. Greenhouse Management and Production 28(4):21-24. 2008.

68. Pay closer attention to your electric bill. Bartok, J. W., Jr. Greenhouse Management and Production 28 (4):42-43. 2008.

69. Putting the "green" in greenhouses. Bramwell, J. American Nurseryman 207(12):14-19. 2008.

70. Reduce energy use for greenhouse heating. Sanford, S. Greenhouse Management and Production 28 (8):43, 45-47. 2008.

71. Solar heat is not an option, yet. Bartok, J. W., Jr. Greenhouse Management and Production 27(10):66. 2007.

72. Upgrade your heating systems now. Bartok, J. W., Jr. Greenhouse Management and Production 28(8):66-67. 2008.

73. Where conservation meets innovation. McCoy, M. Digger Farwest Edition, Aug. 2007:42-48. 2007.

Outplanting Performance

74. Achieving establishment success the first time. Talbert, C. Tree Planters' Notes 52(2):31-37. 2008.

75. © Effects of compaction and water content on lodgepole pine seedling growth. Blouin, V. M., Schmidt, M. G., Bulmer, C. E., and Krzic, M. Forest Ecology and Management 255:2444-2452. 2008.

© 76. Effects of overstory retention and site preparation on growth of planted white spruce seedlings in deciduous and coniferous dominated boreal plains mixedwoods. Gradowski, T., Sidders, D., Keddy, T., Lieffers, V. J., and Landhausser, S. M. Forest Ecology and Management 255:3744-3749. 2008.

77. Enrichment of natural regeneration through direct seeding and fill planting in logging trails of black spruce stands. Gauthier, M.-M. and Ruel, J.-C. Tree Planters' Notes 52(2):18-23. 2008.

78. © Establishing oak woodland on cutaway peatlands: effects of soil preparation and fertilization. Renou-Wilson, F., Keane, M., and Farrell, E. P. Forest Ecology and Management 255:728-737. 2008.

79. An evaluation and comparison of mechanised and manual tree planting on afforestation and reforestation sites in Ireland. Nieuwenhuis, M. and Egan, D. International Journal of Forest Engineering 13 (2):11-23. 2002.

80. Exclosure size affects young blue oak seedling growth. Phillips, R. L., McDougald, N. K., Atwill, E. R., and McCreary, D. California Agriculture 61(1):16 -19. 2008.

81. Fifteen-year response of weed control intensity and seedling type on Norway spruce survival and growth on arable land. Hytonen, J. and Jylha, P. Silva Fennica 42(3):355-368. 2008.

82. © Impact of standing vegetation on early establishment of willow cuttings in the flooded area of the Parana River Delta, (Argentina). Garau, A. M., Caccia, F. D., and Guarnaschelli, A. B. New Forests 36:79-91. 2008.

83. Influence of overstory density on understory light, soil moisture, and survival of two underplanted oak species in a Mediterranean montane Scots pine forest. Rodriguez-Calcerrada, J. , Mutke, S., Alonso, J., Gil, L., Pardos, J. A., and Aranda, I. Investigacion Agraria: Sistemas y Recursos Forestales 17(1):31-38. 2008.

84. The mechanism of frost heaving of tree seedlings. Schramm, J. R. Proceedings of the American Philosophical Society 102(4):333-350. 58.

85. © Mounding site preparation: a review of European and North American experience. Sutton, R. F. New Forests 7:151-192. 93.

86. © Relating the survival and growth of planted longleaf pine seedlings to microsite conditions altered by site preparation treatments. Knapp, B. O., Wang, G. G., and Walker, J. L. Forest Ecology and Management 255:3768-3777. 2008.

87. Results from four *Pinus patula* water planting trials in the summer rainfall region of South Africa. Rolando, C. A. and Little, K. M. Southern Hemisphere Forestry Journal 69(1):9-17. 2007.

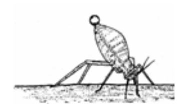
88. Root dip treatments affect fungal growth and survival of loblolly pine (*Pinus taeda*) seedlings following exposure. Starkey, T. and South, D. B. Auburn University, Southern Forest Nursery Management Cooperative, Research Report 07-04. 10 p. 2007.

89. © Summer planting performance of white spruce 1+0 container seedlings affected by nursery short-day treatment. Tan, W., Blanton, S., and Bielech, J. P. New Forests 35:187-205. 2008.

90. © Survival of longleaf and loblolly pines planted at two spacings in an East Texas bahiagrass silvopasture. Oswald, B. P., Farrish, K. W., and Beierle, M.-J. Southern Journal of Applied Forestry 32(1):44-45. 2008.

91. Time consumption of planting after partial harvests. Granhus, A. and Fjeld, D. Silva Fennica 42 (1):49-61. 2008.

Pest Management



92. All predatory mites are not created equal. Cloyd, R. Greenhouse Grower 26(1):48-49, 52, 54. 2008.

93. © Assessment of the control of *Phytophthora* root rot disease spread by Spin Out-treated fabrics in container-grown hardy nursery-stock. Pettitt, T. R., Monaghan, J. M., and Crawford, M. A. Crop Protection 27:198-207. 2008.

94. Choose the most effective aphid controls. Gilrein, D. Greenhouse Management and Production 28(5):51-53, 55. 2008.

95. Combating fungus gnats. Griffith, L. P. American Nurseryman 208(2):12-13. 2008.

96. Controlling four-legged pests in the nursery and landscape. Clark, B. American Nurseryman 207(11):8-9. 2008.

97. © Field management effects of damping-off and early season vigor of crops in a transitional organic cropping system. Baysal, F., Benitez, M. S., Kleinhenz, M. D., Miller, S. A., and Gardener, B. B. M. Phytopathology 98:562-570. 2008.

98. First report of the European lineage of *Phytophthora ramorum* on *Viburnum* and *Osmanthus*

spp. in a California nursery. Grunwald, N. J., Goss, E. M., Larsen, M. M., Press, C. M., McDonald, V. T., Blomquist, C. L., and Thomas, S. L. Plant Disease 92 (2):314. 2008.

99. Growers take another look at biocontrols. Murphy, G. Greenhouse Management and Production 28 (2):29, 31, 33-35. 2008.

100. Improving pesticide use in nurseries and greenhouses. Byrne, F. American Nurseryman 207 (7):10-11. 2008.

101. © Infection of Norway spruce container seedlings by *Gremmeniella abietina*. Petaisto, R. L. Forest Pathology 38:1-15. 2007.

102. Let beneficial insects work for you. Abbey, T. American Nurseryman 207(6):20-23. 2008.

103. Monitoring pathogens and algae in irrigation water. Fisher, P. and Smith, C. Greenhouse Grower 25 (11):8-10. 2007.

104. Natural enemies to the rescue. Raupp, M. and Shrewsbury, P. American Nurseryman 206(5):36-41. 2007.

105. © Observations on root disease of container whitebark pine seedlings treated with biological controls. Dumroese, R. K. Native Plants Journal 9(2):92 -97. 2008.

106. © Pathogenicity of *Fusarium verticillioides* and *Fusarium oxysporum* on *Pinus nigra* seedlings in northwest Spain. Martin-Pinto, P., Pajares, J., and Diez, J. Forest Pathology 38:78-82. 2008.

107. Pathogens and other fungi in growing media constituents. Waller, P. L., Thornton, C. R., Farley, D., and Groenhof, A. Acta Horticulturae 779:361-365. 2008.

108. Planning can reduce disease losses. Warfield, C. Greenhouse Management and Production 28(1):43-46. 2008.

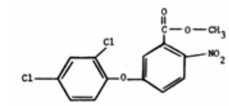
109. Proper planning can help to manage whitefly. Ludwig, S. and Osborne, L. Greenhouse Management and Production 27(8):53-54, 56. 2007.

110. © Recovery of *Phytophthora ramorum* following exposure to temperature extremes. Tooley, P. W., Browning, M., and Berner, D. Plant Disease 92:431-437. 2008.

111. Things that go munch in the night. Bubl, C. OAN Digger 51(11):26-31. 2007.

112. The use of compost in growing media as suppressive agent against soil-borne diseases. Raviv, M. Acta Horticulturae 779:39-47. 2008.

Pesticides



113. Mixed up about tank mixing? Cloyd, R. A. American Nurseryman 206(9):26-28. 2007.

114. Pesticide application tips: back to basics. Canas, L. American Nurseryman 206(5):10-11. 2007.

115. Providing protection from pesticide hazards. Bartaholomew, C. L. American Nurseryman 207(3):22-24, 26, 28-29. 2008.

Seedling Physiology And Morphology

116. © Appraisal of root leakage as a method for estimation of root viability. Radoglou, K., Cabral, R., Repo, T., Hasanagas, N., Sutinen, M. L., and Waisel, Y. Plant Biosystems 141(3):443-459. 2007.

117. © Carbon translocation patterns associated with new root proliferation during episodic growth of transplanted *Quercus rubra* seedlings. Sloan, J. L. and Jacobs, D. F. Tree Physiology 28:1121-1126. 2008.

118. Freeze injury to roots of southern pine seedlings in the USA. South, D. B. Southern Hemisphere Forestry Journal 69(3):151-156. 2007.

119. © Frost hardiness of nutrient-loaded two-year-old *Picea abies* seedlings in autumn and at the end of freezer storage. Luoranen, J., Lahti, M., and Rikala, R. New Forests 35:207-220. 2008.

120. Growth and frost hardening of *Picea abies* seedlings after various night length treatments. Konttinen, K., Luoranen, J., and Rikala, R. Baltic Forestry 13(2):140-148. 2007.

121.© Measuring water stress in *Eucalyptus grandis* Hill ex Maiden seedlings planted into pots. Rolando, C. A. and Little, K. M. South African Journal of Botany 74:133-138. 2008.

122. © Seedling cold hardiness, bud set, and bud break in nine provenances of *Pinus greggii* Engelm. Aldrete, A., Mexal, J. G., and Burr, K. E. Forest Ecology and Management 255:3672-3676. 2008.

123. Understanding forest seedling quality: measurements and interpretation. Haase, D. L. Tree Planters' Notes 52(2):24-30. 2008.

Seeds

124. © Deterioration of western redcedar (*Thuja plicata* Donn ex D. Don) seeds: protein oxidation and in vivo NMR monitoring of storage oils. Terskikh, V. V., Zeng, Y., Feurtado, J. A., Giblin, M., Abrams, S. R., and Kermode, A. R. Journal of Experimental Botany 59 (4):765-777. 2008.

125. Development of a sequential digital imaging system for evaluating seed germination. Geneve, R. L., Dutt, M., and Downie, A. B. IN: Seeds: biology, development and ecology, p. 315-323. S. Adkins, S. Ashmore and S.C. Navie, eds. CAB International. 2007.

126. Dormancy and germination in *Eucalyptus globulus* seeds. Nair, T. S., Wilson, S., and Spurr, C. IN: Seeds: biology, development and ecology, p. 262-268. S. Adkins, S. Ashmore and S.C. Navie, eds. CAB International. 2007.

127. © Drying and soaking pretreatments affect germination in pedunculate oak. Doody, C. N. and O'Reilly, C. Annals of Forest Science 65:509. 2008.

128. © Effects of seed water content and storage temperature on the germination parameters of white spruce, black spruce and lodgepole pine seed. Beardmore, T., Wang, B. S. P., Penner, M., and Scheer, G. New Forests 36:171-185. 2008.

129. Impact of storage on viability of white spruce seed. Simpson, D., Daigle, B., and Hayes, D. Tree Planters' Notes 52(2):4-8. 2008.

130. Low cost seed storage techniques for certain hardy indigenous pod vegetables. Doijode, S. D. Acta Horticulturae 752:589-591. 2007.

131. Overcoming dormancy of *Pinus pinceana* seeds. Ramirez-Herrera, C., Beardmore, T., and Loo, J. Seed Science and Technology 36:1-20. 2008.

132. Storage and germination response of recalcitrant seeds subjected to mild dehydration. Eggers, S., Erdey, D., Pammenter, N. W., and Berjak, P. IN: Seeds: biology, development and ecology, p. 85-92. S. Adkins, S. Ashmore and S.C. Navie, eds. CAB International. 2007.

133. © Upgrading germinability of ponderosa pine seeds from Patagonia, Argentina, by adjusting prechilling periods and applying the IDS technique. Pasquini, N. M., Defosse, G. E., and Del Longo, O. New Forests 36:93-102. 2008.

134. Using sequential digital images to study seed germination and dormancy. Geneve, R. L. and Dutt, M. Propagation of Ornamental Plants 8(1):13-16. 2008.

135. Vigor testing in small-seeded horticultural crops.. Geneve, R. L. Acta Horticulturae 782:77-82. 2008.

136. © Whitebark pine (*Pinus albicaulis* Engelm.) seed production in natural stands. Owens, J. N., Kittirat, T., and Mahalovich, M. F. Forest Ecology and Management 255:803-809. 2008.

Soil Management and Growing Media

137. Acidification of composts from agricultural waters to prepare nursery potting mixtures. Carrion, C., Abad, M., Fornes, F., and Noguera, V. Acta Horticulturae 779:333-340. 2008.

138. Analytical methods for growing media - challenges and perspectives. Baumgarten, A. Acta Horticulturae 779:97-104. 2008.

139. Barks' worsening bite. Kipp, C. OAN Digger 52 (3):24-25, 58-59. 2008.

140. © Biological assay for compost quality. Emino, E. R. and Warman, P. R. Compost Science & Utilization 12(4):342-348. 2004.

141. Classification of growing media on their environmental profile. Verhagen, J. B. G. M. and Boon, H. T. M. Acta Horticulturae 779:231-239. 2008.

142. Clean chip residual: a substrate component for growing annuals. Boyer, C. R., Fain, G. B., Gilliam, C. H., Gallagher, T. V., Torbert, H. A., and Sibley, J. L. HortTechnology 18(3):423-432. 2008.

143. A comparison of methods for the analysis of compost-based growing media. Frangi, P., Castelnuovo, M., Pozzi, A., Valagussa, M., Crippa, L., and Genevini, P. L. Acta Horticulturae 779:113-119. 2008.

144. Count down the most common growing media questions: part 1. Cavins, T. and Evans, M. Greenhouse Management and Production 28(2):15-16, 19. 2008.

145. Count down the most common growing media questions: Part 2. Cavins, T. and Evans, M. Greenhouse Management and Production 28(3):26-29. 2008.

146. Crushed rockwool as a component of growing substrates. Dubsky, M. and Sramek, F. Acta Horticulturae 779:491-495. 2008.

147. Effect of soil reclamation on afforestation of degraded areas in the Chocianow Forest District. Bacia, J. and Barzdajn, W. Sylwan 5:44-51. 2007.

148. Effects of enhanced APG surfactant on leaching and wettability of six bark substrates. Olszewski, M. W., Danan, S. J., and Boerth, T. J. HortTechnology 18 (2):295-300. 2008.

149. Evaluation of municipal solid waste compost as a growing media component for potted plant production. Cendon, Y., Moldes, A., and Barral, M. T. Acta Horticulturae 779:591-597. 2008.

150. Five factors controlling substrate pH. Taylor, M. and Nelson, P. American Nurseryman 206(8):36-40, 42-44. 2007.

151. Growing growing media: promises of *Sphagnum* biomass. Gaudig, G., Joosten, H., and Kamermann, D. Acta Horticulturae 779:165-171. 2008.

152. Improved water saving in nursery production using *Sphagnum* peat. Desbiens, M.-C., Bussieres, P., Caron, J. , Beeson, R., Haydu, J., and Elrick, D. Acta Horticulturae 779:407-413. 2009.

153. Interpret soil and tissue tests correctly. Fisher, P. R., Douglas, A. C., and Argo, W. R. Greenhouse Management and Production 27(11):47-49. 2007.

154. © Maturity and stability evaluation of composted yard trimmings. Brewer, L. J. and Sullivan, D. M. Compost Science & Utilization 11(2):96-112. 2003.

155. Micronutrient determination in water extracts of peat incubated with mineral fertilizers. Abreu, C. A. , Abreu, M. F., Bataglia, O. C., Furlani, A. M. C., Furlani, P. R., and Paz-Gonzalez, A. Acta Horticulturae 779:375-383. 2008.

156. A new substrate for container crops. Wright, R. D. and Jackson, B. E. American Nurseryman 208(2):26-30, 32. 2008.

157. Nurseries turn their waste materials into rich soil free of weeds and pathogens. Petersen, E. OAN Digger 52(6):47-49, 51. 2008.

158. Physical and micromorphological properties of organic and inorganic materials for preparing growing media. Anicua-Sanchez, R., Gutierrez-Castorena, M. C., and Sanchez-Garcia, P. Acta Horticulturae 779:577-582. 2008.

159. © The physical properties of compost. Agnew, J. M. and Leonard, J. J. Compost Science & Utilization 11 (3):238-264. 2000.

160. A practical and low cost microbiotest to assess the phytotoxic potential of growing media and soil. Blok, C., Persoone, G., and Wever, G. Acta Horticulturae 779:367-373. 2008.

161. Risk of phytotoxicity of sawdust substrates for greenhouse vegetables. Dorais, M., Menard, C., and Begin, G. Acta Horticulturae 761:589-594. 2007.

162. Soil construction: a step for ecological reclamation of derelict lands. Sere, G., Schwartz, C., Ouvrard, S., Sauvage, C., Renat, J.-C., and Morel, J. L. Journal of Soil Sediments 8(2):130-136. 2008.

163. © Subsoiling promotes native plant establishment on compacted forest sites. Archuleta, J. G. and Baxter, E. S. Native Plants Journal 9(2):117-122. 2008.

164. Temperature and salinity effects on measurements of growing media moisture content carried out with TDR and capacitance probes. Morel, P., Guillemain, G., and Michel, J.-C. Acta Horticulturae 779:393-399. 2008.

165. Tree-seedling compost as a component in *Sphagnum* peat-based growing media for conifer seedlings: physical and chemical properties. Veijalainen, A.-M., Heiskanen, J., Juntunen, M.-L., and Lilja, A. Acta Horticulturae 779:431-438. 2008.

166. The use of composted materials in growing media. Carlile, W. R. Acta Horticulturae 779:321-327. 2008.

167. Use of composted urban waste in the reforestation of a degraded calcic regosol in Central Spain. Garcia Lopez de Sa, M. E., Roman, R., and Fortun, C. Agrochimica 52(1):23-33. 2008.

168. Utilization of zeolite as a substrate for containerized oriental spruce (*Picea orientalis* L. (Link.)) seedlings propagation. Ayan, S., Yahyaoglu, Z., Gercek, V., and Sahin, A. Acta Horticulturae 779:583-590. 2008.

169. Variation in quality of composted green wastes of UK origin and their suitability for inclusion in growing media. Surrage, V. A. and Carlile, W. R. Acta Horticulturae 779:631-636. 2008.

170. Wood ash application and liming: effects on soil chemical properties and growth of Scots pine transplants. Saarsalmi, A. and Levula, T. Baltic Forestry 13(2):149-157. 2007.

171. You should be doing greenhouse soil tests. Smith, T. Greenhouse Management and Production 28 (8):64-65. 2008.

Tropical Forestry and Agroforestry

172. Effect of seed size on field survival and growth of *Eucalyptus* in KwaZulu-Natal, South Africa. Naidu, R. D. and Jones, N. B. Southern Hemisphere Forestry Journal 69(1):19-26. 2007.

173. Energy synthesis of intensive *Eucalyptus* cultivation in Sao Paolo, Brazil. Romanelli, T. L., Cohen, M. J., Milan, M., and Brown, M. T. Forest Science 54(2):228-241. 2008.

174. © Hydrogel applied to the root plug of subtropical eucalypt seedlings halves transplant death following planting. Thomas, D. S. Forest Ecology and Management 255:1305-1314. 2008.

175. © An improved method for breaking dormancy in seeds of *Sesbania sesban*. Wang, Y. R. and Hanson, J. Experimental Agriculture 44:185-195. 2008.

176. © Initial seedling morphological characteristics and field performance of two Sudanian savana species in relation to nursery production period and watering regimes. Zida, D., Tigabu, M., Sawadogo, L., and Oden, P. C. Forest Ecology and Management . 2008.

177. Mangrove conservation through community participation in Pakistan: the case of Sonmiani Bay. Shah, A. A. and Jusoff, K. International Journal of Systems Applications, Engineering & Development 4 (1):75-81. 2007.

178. Micronutrient deficiencies in teak (*Tectona grandis*) seedlings: foliar symptoms, growth performance and remedial measures. Sujatha, M. P. Journal of Tropical Forest Science 20(1):29-37. 2008.

179. © Nursery transplant practices determine seedling root quality of two subtropical eucalypts. Thomas, D. S., Heagney, G. A., and Harper, P. New Forests 36:125-134. 2008.

180. An overview of breadfruit (*Artocarpus altilis*) in the Caribbean. Roberts-Nkrumah, L. B. Acta Horticulturae 757:51-59. 2007.

181. © Planting mahogany in canopy gaps created by commercial harvesting. Lopes, J. do C. A., Jennings, S. B., and Matni, N. M. Forest Ecology and Management 255:300-307. 2008.

182. © Regeneration of mahogany and Spanish cedar in gaps created by railroad tie extraction in Quintana Roo, Mexico. Negreros-Castillo, P. and Mize, C. W. Forest Ecology and Management 255:308-312. 2008.

183. Response of seed treatments on seed germination in wild *Crotalaria* species. Kak, A., Devi, L. C., Gupta, V., and Singh, N. Acta Horticulturae 752:261-264. 2007.

184. © Restoration of mangrove plantations and colonisation by native species in Leizhou Bay, South China. Ren, H., Jian, S., Lu, H., and Zhang, Q. Ecological Research 23:401-407. 2008.

Vegetative Propagation and Tissue Culture

185. The effect of moisture content in the substrate on rooting of seedlings in plug trays. Blom, T. J., Kerec, D., and Al-Batal, N. Acta Horticulturae 782:305-310. 2008.

186. Enhancing the rooting of Canada yew stem cuttings with IBA treatments. Holloway, L., Krasowski, M., Smith, R. F., and Cameron, S. I. Propagation of Ornamental Plants 8(1):23-27. 2008.

187. Nursery performance of peach seedling rootstocks. Beckman, T. G. Journal of the American Pomological Society 62(2):46-51. 2008.

188. Rooting native azaleas and *Stewartia*. Jenkins, M. Y. American Nurseryman 207(7):22-25. 2008.

189. © Vegetative propagation of coastal redwood (*Sequoia sempervirens* (Lamb. ex D. Don) Endl.). Luna, T. Native Plants Journal 9(1):25-28. 2008.

Water Management and Irrigation

190. Defining critical capillary rise properties for growing media: model and methodology. Caron, J. and Elrick, D. E. Acta Horticulturae 779:149-153. 2008.

191. Detention and recycling basins for managing nutrient and pesticide runoff from nurseries. Mangiafico, S. S., Gan, J., Wu, L., and Lu, J. HortScience 43(2):393-398. 2008.

192. Drilled wells can be a reliable water source. Bartok, J. W., Jr. Greenhouse Management and Production 28(3):56-57. 2008.

© 193. Evaluation of hydrogel application on soil water retention characteristics. Abedi-Koupai, J., Sohrab, F., and Swarbrick, G. Journal of Plant Nutrition 31:317-331. 2008.

194. Groundwater nitrate contamination costs: a survey of private well owners. Lewandowski, A. M., Montgomery, B. R., Rosen, C. J., and Moncrief, J. F. Journal of Soil and Water Conservation 63(3):153-161. 2008.

195. Harvest rain to save money. Bartok, J. W., Jr. Greenhouse Management and Production 27(9):72. 2007.

196. Lower your pumping costs with better sprinkler spacing. Snell, D. OAN Digger 51(8):25, 27-28, 30-31, 33. 2007.

197. Sizing the greenhouse water system. Bartok, J. W., Jr. Greenhouse Management and Production 28 (6):78-79. 2008.

198. Treatment wetlands: cost-effective practice for intercepting nitrate before it reaches and adversely impacts surface waters. Iovanna, R., Hyberg, S., and Crumpton, W. Journal of Soil and Water Conservation 63(1):14A-15A. 2008.

199. Water treatment series: choose the best water-treatment method for your operation. Fisher, P., Argo, W., Fischer, R., and Konjoian, P. Greenhouse Management and Production 28(3):19, 21-24. 2008.

200. Water treatment series: gas chlorination can sanitize water. Majka, J. M., Argo, B., Fisher, P., and Hong, C. Greenhouse Management and Production 28 (8):17-19. 2008.

201. Water treatment series: sodium, calcium hypochlorite can treat irrigation water. Fisher, P., Argo, B., Hong, C., and Huang, J. Greenhouse Management and Production 28(6):21-22, 24-25. 2008.

202. Water treatment series: water sanitation using chlorine. Fisher, P., Huang, J., Looper, A., and Minsk, D. Greenhouse Management and Production 28(7):15-16, 19-20, 22. 2008.

203. Water treatment series: waterborne pathogens affect water treatment. Wick, R. L., Fisher, P. R., and Harmon, P. F. Greenhouse Management and Production 28(4):16-18. 2008.

204. What's your leaching fraction? A simple test can reduce irrigation inefficiencies. Owen, J. OAN Digger 51(12):40-43. 2007.

Weed Control

205. The challenges of specialty crop weed control, future direction. Fennimore, S. A. and Doohan, D. J. Weed Technology 22:364-372. 2008.

206. Flame weeding effects on several weed species. Cisneros, J. J. and Zandstra, B. H. Weed Technology 22:290-295. 2008.

207. Industry views on minor crop weed control. Gast, R. E. Weed Technology 22:385-388. 2008.

208. Ornamental weed control. Malinich, T. American Nurseryman 206(1):30-32, 34. 2007.

209. Pendimethalin movement through pine bark compared to field soil. Simmons, L. D. and Derr, J. F. Weed Technology 21:873-876. 2007.

210. Perennial crop nurseries treated with methyl bromide and alternative fumigants: effects on weed seed viability, weed densities, and time required for hand weeding. Shrestha, A., Browne, G. T., Lampinen, B. D., Schneider, S. M., Simon, L., and Trout, T. J. Weed Technology 22:267-274. 2008.

211. Southern redcedar and southern magnolia wood chip mulches for weed suppression in containerized woody ornamentals. Ferguson, J., Rathinasabapathi, B., and Warren, C. HortTechnology 18(2):266-. 2008.

212. Tolerance of three juniper species to glyphosate. Czarnota, M. A. HortTechnology 18(2):239-242. 2008.

213. Weeding out the options. Ahrens, J. F. American Nurseryman 206(7):43-44, 46-48, 50, 52. 2007.

Literature Order and Mailing List Update Form
Summer 2008

Please fill out a separate order form for each person receiving FNN. For items that require a copyright fee, you will receive the title page with abstract and ordering instructions if you want the entire article. Fax or mail this form to:

Forest Nursery Notes
J.H. Stone Nursery
2606 Old Stage Rd.
Central Point, OR 97502
TEL: 541.858.6166
FAX: 541.858.6110
E-mail: rewatson@fs.fed.us

Name: ____________________ **Position:** ____________________

Department: ____________________ **Nursery/Company:** ____________________

Mailing address: ____

Street Address: ____

City: ____________________ **State/Province:** ____________________

Country: ____________________ **Zip/Postal Code:** ____________________

Telephone: ____________________ **FAX:** ____________________

E-mail: ____________________ **Website:** ____________________

☐ **= Yes, please send me a CD with all the articles in the New Nursery Literature Section**

☐ **= Yes, please keep me listed on the FNN mailing list.**

Contact Information for Reforestation, Nurseries, and Genetic Resources (RNGR) Team http://www.rngr.net		
Technology Transfer Services	**Region of Responsibility**	**Who to Contact**
• National Nursery Specialist • Forest Nursery Notes • Container Tree Nursery Manual • Proceedings of Nursery Meetings • Native Plants Journal	US and International	Kas Dumroese USDA Forest Service 1221 S. Main Street Moscow, ID 83843 TEL: 208.883.2324 FAX: 208.885.2318 E-Mail: kdumroese@fs.fed.us
• Technical Assistance about Tree Improvement and Genetic Resources • Technical Assistance about Forest and Conservation Nurseries	Southeastern US	George Hernandez USDA Forest Service Cooperative Forestry 1720 Peachtree Road NW, Suite 811N Atlanta, GA 30367 TEL: 404.347.3554 FAX: 404.347.2776 E-Mail: ghernandez@fs.fed.us
• Technical Assistance about Tree Improvement and Genetic Resources • Tree Planters' Notes	Northeastern US and International	Ron Overton Regeneration Specialist USDA Forest Service, S&PF Purdue University 1159 Forestry Building West Lafayette, IN 47907-1159 TEL: 765.496.6417 FAX: 765.496.2422 E-Mail: roverton@fs.fed.us
Technical Assistance about Tree and Shrub Seed	US and International	Bob Karrfalt Director National Seed Laboratory 5675 Riggins Mill Road Dry Branch, GA 31020 TEL: 478.751.4134 FAX: 478.751.4135 E-Mail: rkarrfalt@fs.fed.us

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
J. HERBERT STONE NURSERY
2606 OLD STAGE ROAD
CENTRAL POINT, OR 97502

OFFICIAL BUSINESS
PENALTY FOR PRIVATE
USE TO AVOID PAYMENT
OF POSTAGE $300

FIRST CLASS MAIL
POSTAGE & FEES PAID
USDA
Permit No. G-40