United States Department of Agriculture

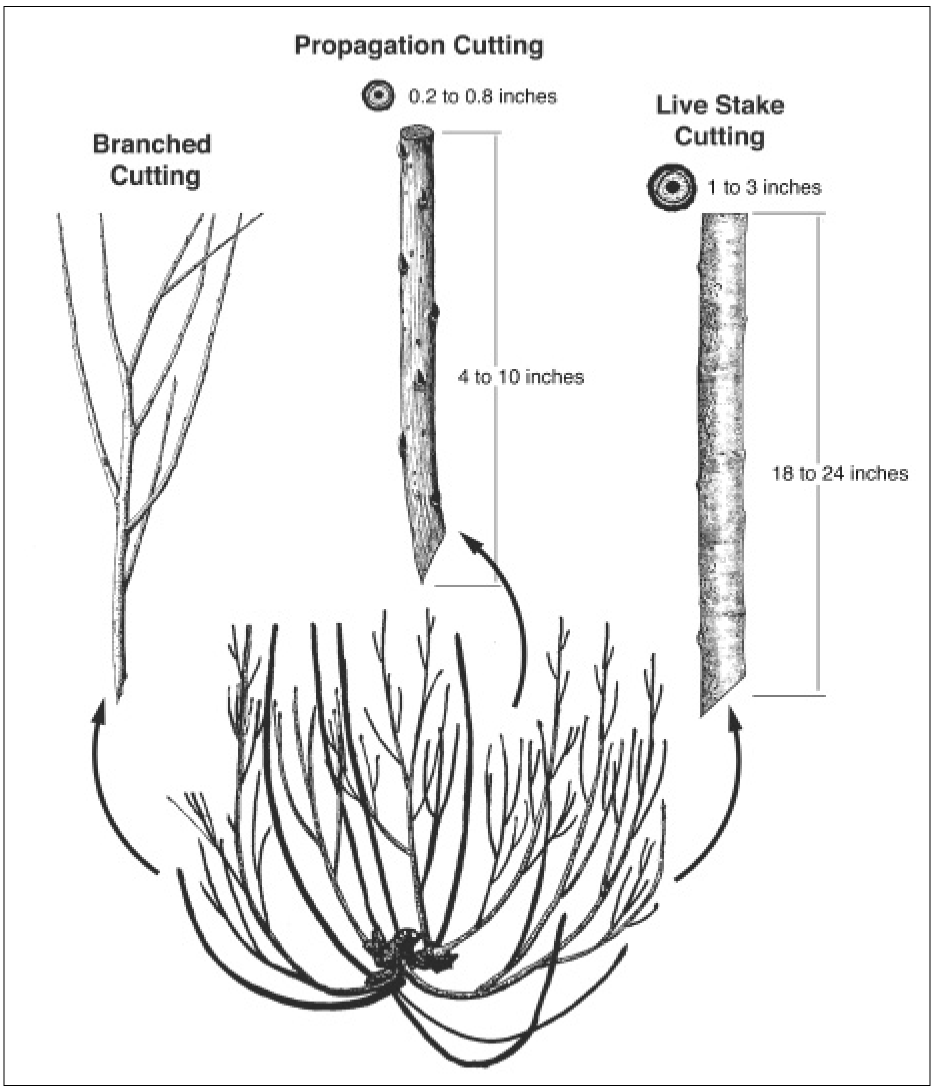
Forest Service

Pacific Northwest Region

R6-CP-TP-01-2007

# Forest Nursery Notes

## Winter 2007



**Please send address changes to Rae Watson. You may use the Literature Order Form on page 39 to indicate changes.**


## 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: 541.245.6892
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

**This technology transfer service is funded by:**
***USDA Forest Service, State and Private Forestry***

---

# 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.*

The 2007 **Northeastern Nursery Conference** will be held **July 16 to July 19, 2007** in Concord, New Hampshire at the Grappone Conference Center. For more information please contact:

Dan DeHart
Nursery Manager
New Hampshire State Nursery
Tel: 603.796.2323
E-Mail: ddehart@dred.state.nh.us

The Forest Nursery Association of British Columbia (FNABC) will host a joint conference with the Western Forest and Conservation Nursery Association (WFCNA) on **September 17 to September 19, 2007.** The conference will take place in Sydney, BC at the Mary Winspear Centre (http://www.sanscha.com). For more information please contact:

Evert Van Eerden
NewGen Forestry Ltd.
5635 Forest Hill Road
Victoria, BC V9E 2A8
CANADA
Tel: 250.479.4165
E-Mail: ev.newgen@shaw.ca

**The Society for Ecological Restoration Northwest Chapter (SERNW) and the Society for Wetland Scientists Pacific Northwest Chapter (SWS)** will be holding a joint Annual Meeting at the Yakima Convention Center, Yakima, WA on **September 25 to September 28, 2007**. Sessions will feature an array of topics pertinent to restoration of plant communities in the Pacific Northwest. For information on submission of titles for presentations or posters or for additional information about the meeting, contact:

Jim Hansen (SERNW)
TEL: 509.454.6573
Email: jimbobtoo@aol.com
or
Jim Wiggins (SWS)
Tel: 360.856.2139
E-Mail: atsi@fidalgo.net

The meeting agenda will be available at a later date on the web:
http://www.ser.org/sernw/calendar.asp

**Native Plant Materials Directory**
By R. Kasten Dumroese

This summer, Native Plants Journal Inc and the Indiana University Press will publish their annual Native Plant Materials Directory. Trying to build a coherent directory of producers of native plant materials is the US and Canada is daunting, especially because directories are out-of-date as soon as they are printed. This directory is the only one updated annually. The *Native Plants Journal* contacts everyone in the directory to ensure only the best data is printed and is published as the summer issue of *Native Plants Journal*.

The directory has three sections:

1. A "professional directory" that lists companies and universities that support anyone producing native plant materials.
2. An alphabetical listing of the more than 1200 entities that produce native plant materials, including private, not-for-profit, tribal, state, and federal organizations.
3. A robust listing of all of the producers by location, subdivided by product type (either plants or seeds).

Any organization that produces native plant materials can be listed. Three types of listings are included. A **basic listing** is free to anyone and includes the nursery name, address, contact person, contact information, and business type. A **standard listing** (Figure 1) is free to subscribers of *Native Plants Journal* and available for a modest fee to nonsubscribers. Besides these basics, additional information about product types, business hours, ordering, and other services can be included (Figure 1). This **enhanced advertisement**, available for a modest fee, also includes a bold listing of the nursery name, internet information, and a free paragraph of information about the business.

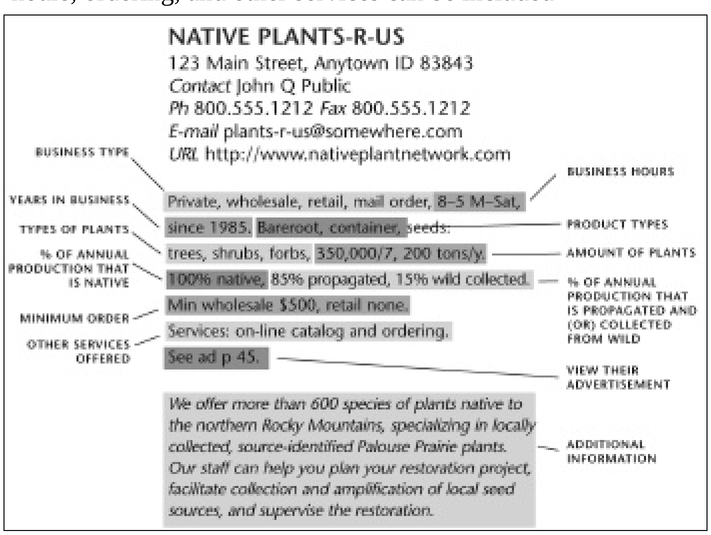



*Figure 1—The standard listing contains contact information as well as product types, business hours, ordering instructions, and other offered services.*

The USDA Forest Service Reforestation, Nurseries, and Genetics Resources team is working to make the basic directory available in a searchable on-line database at http://www.rngr.net. In addition to the directory, anonymous data collected from native plant materials producers will be used to generate the annual Tree Planting in the United States report. This report helps guide development and implementation of national programs dealing with native tree and shrub planting, such as the Conservation Research Program.

**To have your company included in the directory, please contact:**

Suzy Franko
Native Plant Materials Directory
PO Box 8232
Moscow, ID 83843-0732
Ph 208.882.2601
sfranko@moscow.com

**To purchase copies of Plant Materials Directory or subscribe to *Native Plants Journal*, please contact:**

Indiana University Press
Journals Department
601 North Morton Street
Bloomington, IN 47404-3797
800.842.6796

**You can also subscribe, purchase back issues, or purchase the directory on-line at http://iupjournals.org/npj**

## Miniplug Transplants: Producing Large Plants Quickly

by Thomas D. Landis


### Abstract

Miniplug transplants are a new nursery stocktype created when seedlings from very small containers are transplanted into bareroot nursery beds or larger containers. All miniplugs used in forest and conservation nurseries feature some sort of stabilized growing medium which allows transplanting before the plugs become rootbound. Miniplug transplants continue to grow in popularity because they are a quick way to produce large plants, they are very efficient in use of nursery production space, and have a very favorable seed-to-shippable plant ratio.


### Introduction

To begin, what do we mean by a "miniplug"? In nursery jargon, seedlings produced in containers are called "plugs" because of the firm root mass formed by the end of the growing season. In forest and conservation nurseries, container stock has traditionally been produced in multi-celled containers with volumes from 2 to 30 $in^3$ (33 to 492 $cm^3$). Miniplugs, therefore, are very small container plants grown in containers less than 2 $in^3$ (33 $cm^3$) in volume.

### Types of Miniplugs

In the ornamental and vegetable industry, plants have been grown in small plug containers for many years, but this practice is relatively new for forest trees and other native plants. The published literature is also rather sparse. Whereas there are whole books on plug culture for horticultural crops (for example, Styer and Koranski 1997), only a few articles have been published about miniplugs in forest and conservation nurseries.

**Miniplug stocktypes**. Bareroot plug transplants have a traditional stocktype nomenclature - "plug", followed by the number of years in the transplant bed. For example, container seedlings that will be in the transplant bed for one year are known as "Plug+1", whereas those that will remain another year are "Plug+2". There is no standard stock ype naming system for container miniplug transplants but, following this system, we can add whether they were transplanted to other containers (C) or bareroot beds (B):

- Miniplug+1C = Miniplugs that have been transplanted to larger containers and remain there for one year.
- Miniplug+1BR = Miniplugs that have been transplanted to bareroot beds and grow there for 1 year.

**Stabilized media**. All of the miniplugs used in forest and conservation nurseries feature stabilized growing media, which I define as any growing medium that holds the root system together when removed from the container. Stabilized media allow miniplugs to be extracted from their containers before a firm root plug has formed (Figure 1). This allows miniplugs to be transplanted weeks before the seedling root system would have formed a firm plug, and is one of the

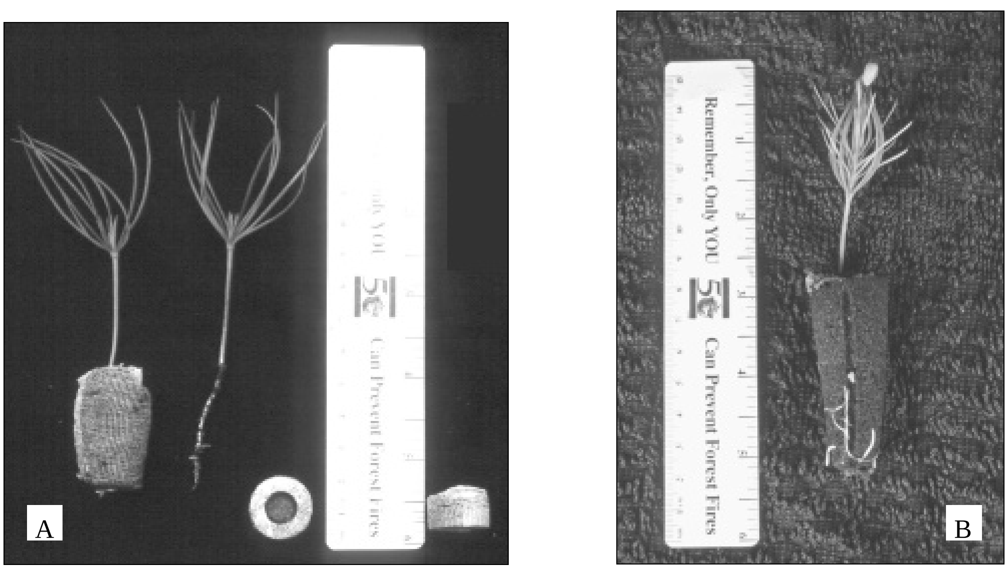



*Figure 1—All miniplugs used in forest and conservation nurseries featuer stablilized media which holds the root plug together and allows earlier transplanting: A) Jiffy-7® forestry pellet, B) Q Plug®.*

**Table 1—Types of miniplugs currently used for transplanting in forest and native plant nurseries**

| Brand Name | Manufacturer | Container | Growing Media | Plug Sizes |
|---|---|---|---|---|
| Q Plug® | International Horticultural Technologies Hollister, CA<br>Website: www.ihort.com<br>Email: info@ihort.com | Prefilled Styrofoam™ or plastic trays | Patented peat and bark mixture, or custom mixes | Wide range, from 0.22 $in^3$ (3.6 $cm^3$) to large sizes |
| Excel® | | Prefilled Styrofoam™ or plastic trays | Patented peat and bark mixture, or custom mixes | Wide range, from 0.22 $in^3$ (3.6 $cm^3$) to large sizes |
| Jiffy-7® Forestry Pellets | Jiffy Products<br>Norwalk, OH and Shippagan, NB, Canada<br>Website: www.jiffypot.com<br>Email: jiffy@vianet.ca | Compostable plastic net around plugs in plastic trays | Compressed peat mixture, or Carefree™ pellets | 0.7 in (18 mm) diameter pellet expands to 0.9 in (22 mm), with heights of 1.3 in (32 mm) or 1.6 in (42 mm) |
| Preforma® Plug | | Prefilled Styrofoam™ or plastic trays | Compressed peat mix with binding agent. Custom mixing available | Wide range, from 0.25 $in^3$ (3.6 $cm^3$) to large sizes |
| HortiPlug® | | Prefilled Styrofoam™ or plastic trays | Patented Coir-Bark blend with binding agent | Wide range, from 0.25 $in^3$ (3.6 $cm^3$) to large sizes |
| Ellepot® System | Purchase machine from Blackmore Co. Belleville, MI.<br>Website: www.ellepot.dk<br>Email:kmarlin@blackmoreco.com | 3 grades of porous biodegradable paper | Mixture of peat, vermiculite & perlite, or custom mix | 0.6 x 1.6 in (15 x 40 mm) plug that fits into a standard 338 horticulture tray |

system's primary advantages. In addition, roots in stabilized plugs haven't developed the deformities that characterize other root plugs, and often lead to structural defects in the transplants. There are two methods of stabilizing the media in miniplugs:

1. Physically Stabilized Plugs – This is the older method of keeping the growing medium together. Examples are Jiffy® Forestry Pellets which use plastic mesh (Figure 1A). and Ellepots® which feature treated paper (Table 1).

2. Chemically Stabilized Plugs - This newer system uses chemical binders to hold the growing media together (Figure 1B). All of the chemical binders are trade secrets but examples include Q Plugs®, Excel® plugs, Preforma® plugs and HortiPlugs® (Table 1).

**Types of Miniplug Transplants**

Although many miniplugs are on the market, only a relative few have been used for transplanting in forest and native plant nurseries (Table 1). Miniplugs are used in 2 distinct stocktypes: container-to-bareroot transplants, and container-to-container (plug-to-plug) transplants.

**Bareroot miniplug transplants.** Before we can discuss miniplug transplants, we need to look back at the whole concept of container plants transplanted to bareroot nurseries. The first published record of transplanting container seedlings was at the Ray Leach Nursery in Aurora, Oregon in 1971. Apparently, that first crop wasn't too successful, because it was four years until it was tried again. In the spring of 1975, Phil Hahn grew a small trial of Douglas-fir container seedlings at the Georgia-Pacific container facility in Cottage Grove, Oregon and then transplanted them to the Tyee Tree Nursery near Roseburg, Oregon. The following fall, the crop was harvested and showed good uniformity and yield. The plants looked quite different from a normal bareroot transplant, especially in the root systems, which were very busy with many fine roots. Of course, the true test is on the outplanting sites, and these first trials were encouraging in spite of a severe summer drought. This new "plug+one" stocktype was slow to catch-on, but by the time of a 1983 survey, plug transplants had reached about 2 % of total forest nursery production (Hahn 1984).

Miniplug transplants are an even newer phenomenon. The first miniplug transplants that I saw were grown in Techniculture© peat plugs in Thunder Bay, Ontario in the early 1980s. Although these early trials were very successful (Klapprat 1988), this technology was never adopted on a large scale. A few years later, the Weyerhaeuser Company purchased the rights to the MiniPlug™ Transplant System from Grower's Transplanting of Salinas, California (Hee and others 1988). Extensive field testing on a variety of outplanting sites in western Oregon and Washington showed that miniplug transplants survived and grew as well as or better than other bareroot stocktypes (Tanaka and others 1988). Their transplanter, which used pneumatic plant setters to push the miniplug from the

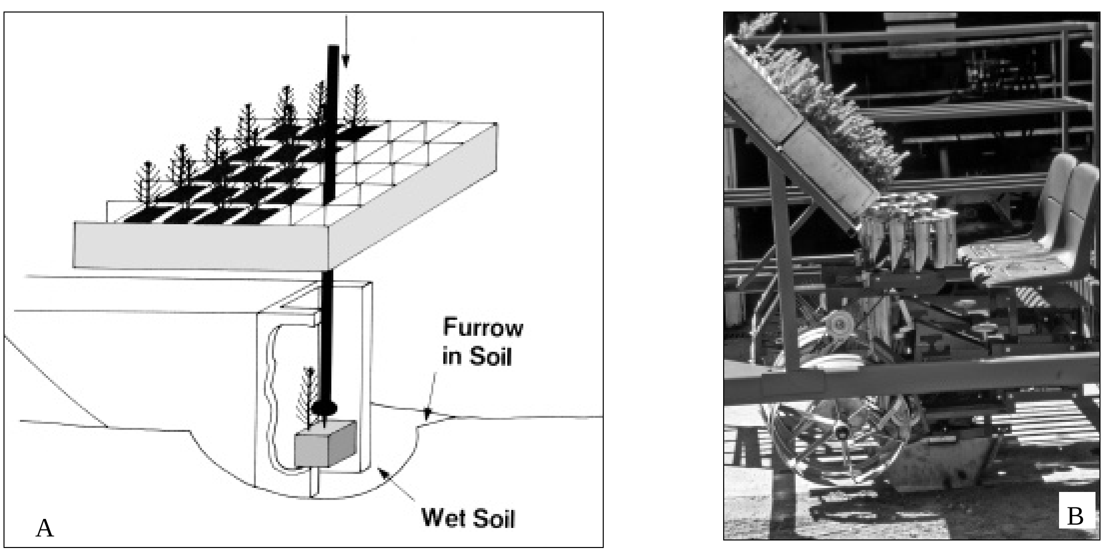
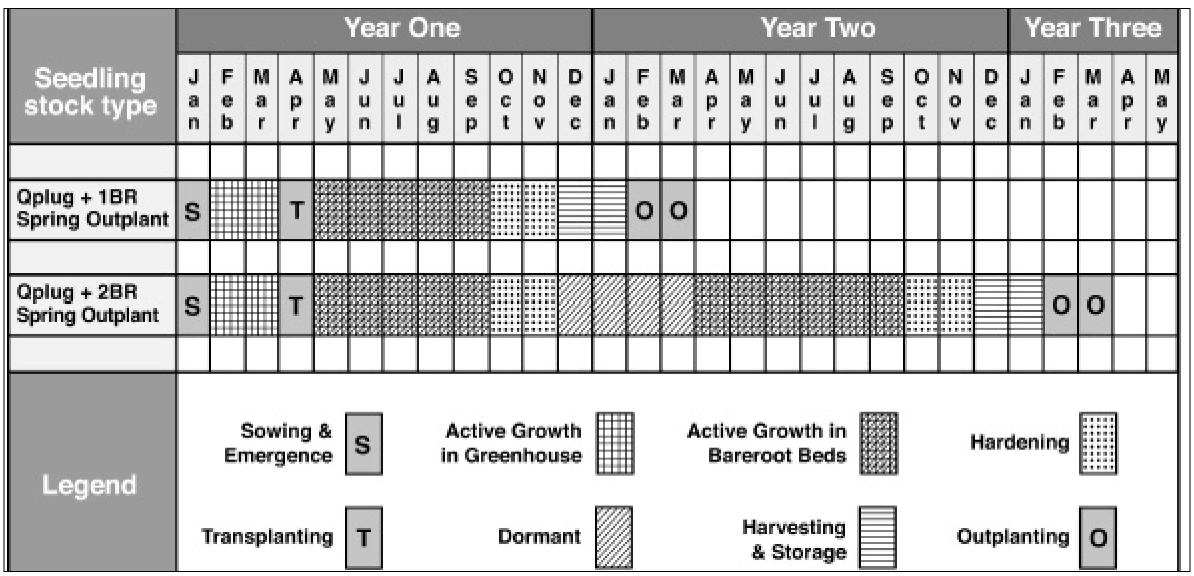
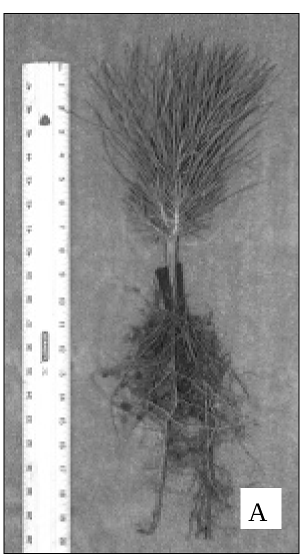



*Figure 2—Although the MiniPlug™ Transplant System (A) proved impractical, the carousel-type transplanter (B) revived the popularity of miniplug transplants.*

growth tray and into the soil, proved impractical (Figure 2A). Miniplugs were too small for standard clip-and-wheel type transplanters and so this new stocktype did not become popular until the development of the carousel-type transplanter (Figure 2B). The plants are dropped into the carousel tubes and so are not subject to the centrifugal forces that cause root sweep. The individual carousel transplanter units are ganged on a tool bar in a staggered array to produced row spacing as close as 12 in (31 cm) (Windell 2002).

Responding to the demand for large transplant stock produced in a short time, the JH Stone nursery in Central Point, Oregon decided to use Q Plugs® to produce miniplug transplants. They constructed an innovative 9-row transplanter can transplant an average of 25,000 miniplugs per hour (175,000/day) per machine at a density of 12 miniplugs per $ft^2$ ($130/m^2$) in a standard 4 ft (1.2 m) wide transplant bed (Wearstler 2006). Species trials showed that ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*P. jeffreyi)*, sugar pine (*P. lambertiana*), Douglas-fir *(Pseudotsuga menziesii*), western redcedar (*Thuja plicata*), incense cedar (*Calocedrus decurrens*), western larch (*Larix occidentalis*) and red alder (*Alnus rubra*) could be produced in one year. Slower growing species, including western white pine (*P. monticola*), western hemlock (*Tsuga heterophylla*), Engelmann spruce (*Picea engelmannii*) and noble fir (*Abies procera*) required an extra season in the transplant beds to reach shippable size (Figure 3A). The resultant plants have the thick stem diameter (Figure 3B) and extensive, fibrous root systems (Figure 3C). Outplanting trials have demonstrated their superior performance, especially on sites with heavy brush competition.



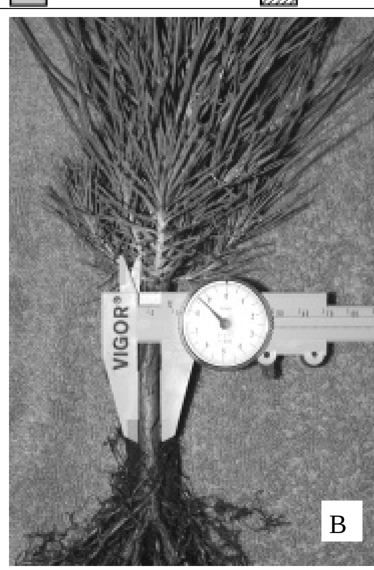




*Figure 3—Miniplug bareroot transplants using* Q Plugs® *can be produced in 1 to 2 seasons at the JH Stone Nursery (A). Their thick stem diameter (B) and fibrous root systems have proven popular with customers.*

**Miniplug container transplants (plug-to-plug).** Transplanting miniplug seedlings to other containers is a much newer phenomenon. The traditional practice of "pricking out" young seedlings from germination tray and transplanting them into a container has been done since container plants became popular in the 1970s. This practice has several operational drawbacks, especially root deformation and resultant stunting of the transplant.

Starting plants in miniplugs and transplanting them to containers has only become popular in forest and conservation nurseries in the last 10 to 15 years. Initially, all transplanting was done by hand and that is still the most popular technique. Mechanical transplanters are common in horticulture (Bartok 2003) and larger forest nurseries have experimented with the newest equipment, some of which use computer vision to deal with blank cells in the miniplug blocks (Pelton 2003). However, the high cost of the transplanters has limited their acceptance in most nurseries. Bartok (2003) estimates that a $60,000 automatic transplanter will take at least 3 years to pay for itself in labor savings. This estimate is based on large numbers of a uniform crop, however, which is rarely the case in forest and conservation nurseries who deal with smaller orders and many different species and seed sources. So, for the near future, hand transplanting will remain the method of choice.

Microseed Nursery of Ridgefield, Washington (Moreno 2006) has developed a successful miniplug container transplant system based on Excel® miniplugs going into Hiko V265 containers (16 $in^3$ [265 $cm^3$]). The miniplugs are sown in late summer, and their stock takes 16 to 20 weeks to produce, depending on whether the customer wants fall or spring outplanting (Figure 4A). After the miniplug seedlings become established they are overwintered in the greenhouse and then transplanted the following spring. Then, they grow to shippable size and are hardened in outdoor compounds. One unique innovation is that seedlings destined for fall outplanting are treated with blackout to haste the hardening process. This growing regime produces seedlings with hefty stem diameters (Figure 4B), and full, well-balanced shoots (Figure 4C).

**Benefits of Miniplug Transplants**

Several factors have contributed to the increasing attraction for this new stocktype by both nursery managers and customers.

**Demand for larger stocktypes.** Foresters and other native plant customers have been asking for larger and larger seedlings, and several things have contributed to this trend. New "Free-to-Grow" reforestation standards have created a demand for larger nursery stock that not only survive but will grow quickly. For example, reforestation laws in the State of Oregon require that trees outplanted on cutover lands must have grown above the competing vegetation in only 5 years. In addition, fewer mechanical and chemical site preparation options are available nowadays and larger plants with more buds seem better able to tolerate browsing (Landis 1999).

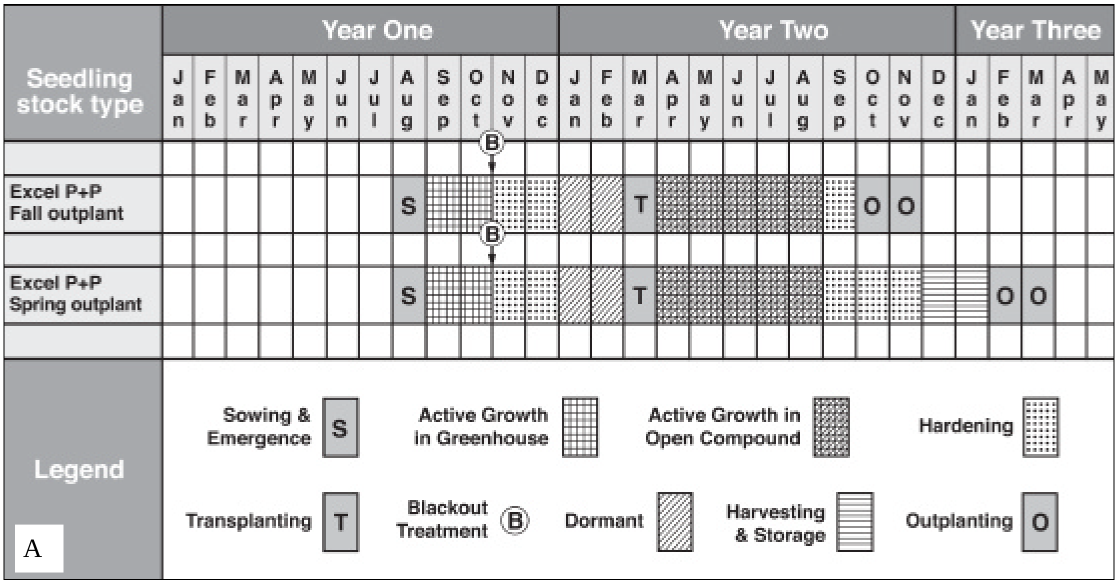
Larger native plants are also in demand for restoration projects. For example, when 3 stocktypes of blue oak (*Quercus douglasii* Hook. & Arn.) were grown in northern California, the miniplug transplants were considerably larger, especially in root mass and survived and grew as good or better than the other stocktypes after outplanting (Table 2).

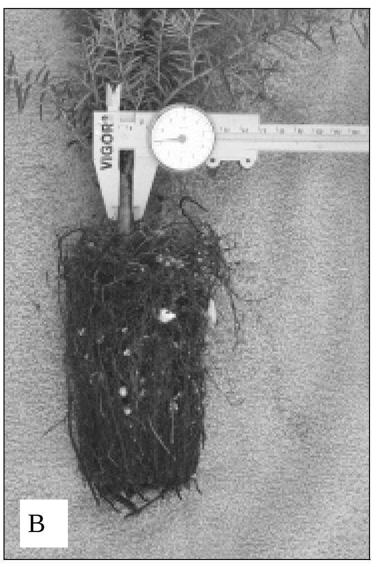
**Shorter nursery crop cycles.** In addition to larger plants, nursery customers are asking for their stock in less time. Planning horizons for reforestation and restoration are becoming shorter and shorter, and so one-

**Table 2—Comparison of blue oak (*Quercus douglasii* Hook. & Arn.) stocktypes in California***

| Stocktype | Stem Wt.** | Root Wt. | Shoot:Root Ratio | Outplanting Survival% | Cost/100 Plants (1990$) |
|---|---|---|---|---|---|
| 1+0 Container | - - - - - - | - - - - - - | - - - - - - | 88 | $92 |
| 1+0 Bareroot | 1.4 a | 3.9 a | 0.36 b | 91 | $50 |
| 2+0 Bareroot | 3.8 b | 5.3 a | 0.68 a | 97 | $65 |
| Miniplug + 1BR Transplant | 4.6 b | 10.4 b | 0.43 b | 95 | $111 |

* Modified from McCreary and Lippitt (2000)
** In each column, means followed by different letters are significantly different by a Fishers Protected Least Significant Difference (LSD) Test.



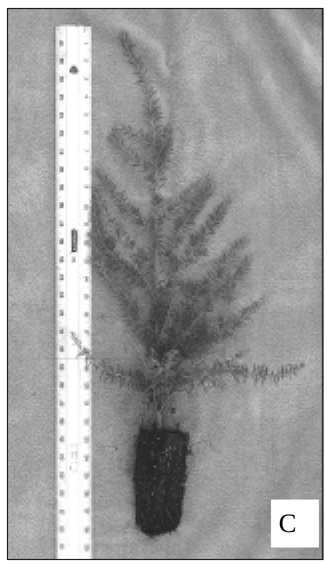




*Figure 4—At Microseed Nursery, the crop schedule for container-to-container ("plug-to-plug") miniplug transplants includes a blackout treatment to induce hardiness before transplanting (A). The resultant stock have impressive stem diameters (B), and a well-balanced shoot-to-root ratio (C).*

year stocktypes are increasingly popular. This is particularly true in fire restoration where the number of acres won't be known until the fire is suppressed. Then, restorationists want the nursery stock as soon as possible. A delay in outplanting allows competing vegetation become established, which increases planting costs and decreases seedling growth and survival (Rose and Haase 2005). The miniplug transplant is ideally suited for these situations because they produce large plants in one year or even less.

**Efficient use of nursery production space.** Nursery efficiency is best measured by the number of shippable plants harvested per area of production space, either in the greenhouse or in nursery beds. Miniplugs are popular with nursery managers because they take up so little space. For example, the Q Plugs® used for transplanting at the JH Stone nursery come from Styroblock™ containers that yield 80 plants per $ft^2$ (861 per $m^2$) and are ready for transplanting in as little as 12 weeks. This space efficiency carries over into the transplant beds in the bareroot nursery because the precise spacing of 15 per $ft^2$ (161 per $m^2$) produces plants with few culls at harvest time. This greatly reduces the costs of lifting and packing.

Container-to-container miniplugs make the most efficient use of expensive greenhouse bench space in both the donor container and the destination container. For example, if miniplugs were grown in a Styroblock™ 440/10 container and then transplanted to a Styroblock™ 35/340, there would be an almost 10X

| Table 3—Growing space comparison between donor and destination container in plug to plug transplants | | |
|---|---|---|
| **Container Type** | **Cell Volume - $in^3$ (ml)** | **Cells per $ft^2$ ($m^2$)** |
| Donor Container—Stryroblock™ 440/10 | 1.1 (18) | 197 (2,121) |
| Destination Container—Stryroblock™ 35/340 | 20.5 (336) | 19.8 (213) |

savings in bench space (Table 3). In actual practice, the savings would be even higher because the miniplugs would be graded before transplanting and produce almost 100% yield. Pelton (2003) estimates that sowing in miniplugs saves approximately 70% in heating costs during that production phase, when compared to direct sowing in the same size destination container. After transplanting, most nurseries move the large containers to open growing compounds where production costs are much lower than in greenhouses.

**Increased seed use efficiency**. One of the most attractive advantages of miniplug transplants is that they have much better seed-to-seedling ratios than other stocktypes. This is because weak seeds or seedlings are culled out early in the crop cycle, and only vigorous miniplug seedlings are transplanted to bareroot beds or other containers. In some of the very first trials with miniplugs in Ontario, they were able to reduce the seed - to-seedling ratio from 12:1 to 3:1 (Klapprat 1988). Increased seed use efficiency is even more important with genetically-improved forest tree seeds, or with native plants where seed is scarce or has irregular germination due to complicated dormancy requirements (Figure 5).

*Figure 5—Native plants, like this red alder, are being sown in miniplugs because it is easier to manage uneven germination rates.*

**Summary**

Miniplug transplants are the newest stocktype in forestry, conservation and native plant nurseries, and I predict their popularity will continue to increase because they come closest to achieving nursery production goals:

- Close to 100 % yield – few culls
- Highest plant density per production area
- Maximum use efficiency of seeds or cuttings
- Shortest crop rotation
- Stock quality - plants with large stem diameter and fibrous root systems.

**Acknowledgements**
The author was to gratefully thank the following organizations and people for sharing their knowledge and experience:

JH Stone Nursery - Ken Wearstler and Steve Feigner
Microseed Nursery - Raúl Moreno
Weyerhaeuser Nurseries - Gale Thompson & Tina Herman
Jiffy Products - Don Willis
International Horticultural Technologies - Cor Baars
Nursery-to-Forest Solutions - Steve Grossnickle

## References

Bartok JW Jr. 2003. Container-to-container transplanting operations and equipment. IN: Riley LE, Dumroese RK, Landis TD, technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—2002. Ogden (UT): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-28: 124-126.

Hahn, PF. 1984. Plug+1 seedling production. IN Duryea ML, Landis TD, eds. Forest Nursery Manual: Production of Bareroot Seedlings. Martinus Nijhoff/Dr W. Junk Publishers. The Hague/Boston/Lancaster, for Forest Research Laboratory, Oregon State University. Corvallis. 386 p.

Hee SM, Stevens TS, Walch DC. 1988. Production aspects of mini-plug transplants. IN: Landis TD, comp. Proceedings, combined meeting of the Western Forest Nursery Associations. Vernon ,BC. 8-11 Aug 1988. Ft. Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Gen. Tech. Rep. RM-167: 168-171.

Klapprat, RA. 1988. Techniculture transplants - an innovation in planting stock production. IN: Taking stock: the role of nursery practice in forest renewal. OFRC Symposium Proceedings O-P-16. Kirkland Lake, ON. 14-17 Sep 1987. Sault Ste. Marie (ON): Canadian Forestry Service, Great Lakes Forestry Centre: 31-33.

Forest and conservation nursery trends in the northwestern United States. IN: Landis TD and Barnett JP, eds. National Proceedings: Forest and Conservation Nursery Association— 1998. Asheville (NC): USDA Forest Service, Southern Research Station:General Technical Report SRS-25. 78-80

Moreno RA 2006. Personal Communication. Ridgefied (WA): Microseed Nursery.

McCreary DD, Lippitt L. 2000. Blue oak mini-plug transplants: how they compare to standard bareroot and container stock. Native Plants Journal 1(2): 84-89.

Pelton S. 2003. Aspects to make plug-to-plug transplanting a success, or, "If you think that something small cannot make a difference -- try going to sleep with a mosquito in the room." IN: Riley LE, Dumroese RK, Landis TD, technical coordinators. . National Proceedings: Forest and Conservation Nursery Associations—2002. Ogden, (UT): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-28: 117-123.

Rose R, Haase DL. 2005. Rapid response reforestation studies in fire restoration. IN: Dumroese RK, Riley LE, Landis, TD, comp. National proceedings, Forest and Conservation Nursery Associations, 2004. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-35: 90-93.

Styer RC, Koranski, DS. 1997. Plug and transplant production: a grower's guide. Batavia (IL): Ball Publishing. 315 p.

Tanaka Y, Carrier B, Dobkowski A, Figueroa P, Meade, R. 1988. Field Performance of Mini-Plug Transplants. Landis TD, comp. Proceedings, combined meeting of the Western Forest Nursery Associations; 1988 August 8-11; Vernon, British Columbia. Gen. Tech. Rep. RM-167. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 172-181.

Wearstler KA. 2006. Personal communication. Central Point (OR): USDA Forest Service, JH Stone Nursery.

Windell 2002. Tree seedling transplanters. IN: Riley LE, Dumroese RK, Landis TD, technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—2002. Ogden (UT): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-28: 108-116.

**Ethylene in Cold Storage - Is It a Problem?**
by Thomas D. Landis

During winter, many nursery plants are in refrigerated storage and, almost every year, I get a question about possible ethylene injury. Ethylene is a plant hormone that is unique because it is a gas, and is best known for its ability to hasten the ripening of fruit. In ancient times, Egyptians used ethylene to stimulate the ripening of figs and Chinese burnt incense in closed rooms to enhance the ripening of pears. Ethylene has also been shown to have detrimental effects on stored plants; for example, when carnations were exposed to 0.5 to 1.0 ppm ethylene in storage, their buds failed to open (Sherman 1985).

In addition to ripening fruit, ethylene also affects many other vital plant functions such as:

- release of dormancy
- shoot and root development
- leaf and fruit abscission
- increased seed germination
- bud development
- protects plant against bacteria and fungi.

Although it is produced naturally produced by plants as part of normal metabolic activity, ethylene is also generated by stress or wounding. This stress ethylene can be induced by mechanical injury, extreme heat or cold, and moisture stress. In fact, stress ethylene evolution has been used as an indicator of plant stress and was even considered to be potential index to cold hardiness. Subsequent testing, however, refuted this hypothesis (Burr and others 1990).

**Ethylene in cold storage**. Forest nurseries have often used commercial refrigerated fruit storage units for long-time overwinter storage and, because ethylene is known to be produced by ripe fruit, there has been concern about possible harmful effects. This concern spawned several research trials in the 1980's and early 1990's. The first tests showed that very high ethylene levels caused significantly reduced shoot growth in Fraser fir (*Abies fraseri*), and inhibited root growth in Douglas-fir (*Pseudotsuga menziesii)* (Table 1). Subsequent research confirmed that rough handling of nursery stock could increase the amount of ethylene produced in storage containers. Hand-lifted loblolly pine (*Pinus taeda*) seedlings produced significantly less ethylene compared to machine-lifted stock (Figure 1), in which root were torn and stem compressed by lifting belts (Johnson and Stumpff 1985).

This concern lead to a search for a treatment to reduce ethylene inside refrigerated storage bags and boxes. Purafil ES® is a commercial ethylene absorbent that consists of alumina pellets saturated with potassium and is widely used to reduce the risk of ethylene damage to stored fruits and vegetables. When Purafil packets were included in kraft-poly storage bags, the initial tests were promising – the absorbent did reduce ethylene concentrations and increased new root growth and

**Table 1—Published research on the effects of ethylene on forest nursery stock stored under refrigeration**

| Species Studied | Effects of Ethylene | Source |
|---|---|---|
| *Abies fraseri* | Shoot growth reduced at very high concentrations (17.5 ppm) | Hinesley and Saltveit (1980) |
| *Pseudotsuga menziesii* | Lateral root growth inhibited at 0.15 ppm | Graham and Linderman (1981) |
| *Pinus taeda* | Addition of ethylene absorbent increased root growth and survival after outplanting | Barnett (1983) |
| *Pinus taeda* | High concentrations increased outplanting performance | Johnson and Stumpff (1984) |
| *Pinus taeda, P. elliottii, P. virginana* | 1) No effect on outplanting performance<br>2) Minor effects on root growth potential | Garrett-Kraus and others (1985) |
| *Pseudotsuga menziesii, Tsuga heterophylla, Abies procera* | 1) Variable effects on new root growth<br>2) High concentrations (3 to 5 ppm) improved outplanting performance<br>3) Addition of ethylene absorbent did not increase performance | Blake and Linderman (1992) |

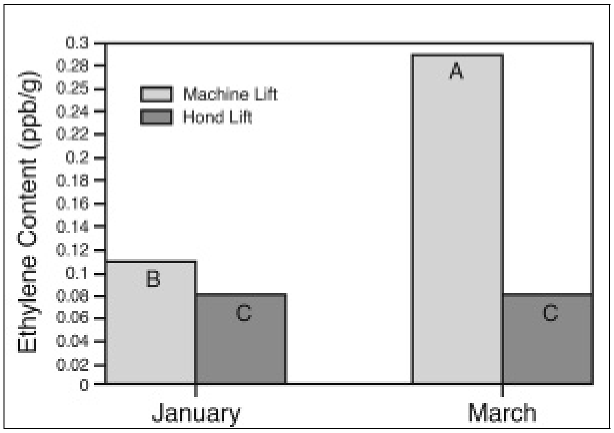



*Figure 1 - When ethylene concentration was monitored in storage containers, a significant difference was shown between hand and machine harvesting. The amount of wound ethylene also increased in March compared to the ideal lifting window in January (modified from Johnson and Stumpff 1985).*

survival after outplanting (Barnett 1983). Subsequent research trials confirmed that Purfil ES® was effective in reducing ethylene levels but did not find the same beneficial effects on seedling performance (Barnett and others 1985). In fact, the higher ethylene concentrations actually improved outplanting performance of loblolly pine nursery stock (Figure 2). Working with Douglas-fir, western hemlock (*Tsuga heterophylla*), and noble fir (*Abies procera*), Blake and Linderman (1992) monitored ethylene concentration in refrigerated storage containers and found that Purfil ES® packets did not consistently improve seedling quality. They also observed that high (3 to 5 ppm) concentrations of ethylene improved seedling vigor and survival after outplanting.

There has been no additional published research on the effects of ethylene on stored nursery stock. However, in case you are still considering ethylene absorbents for your storage containers, some recent research by Reid and Dodge (1995) tested Purafil ES® against some newer mineral ethylene absorbents. They found that Purafil ES® absorbed the ethylene almost immediately whereas the other products were totally ineffective.

**Summary**

Ethylene is a gaseous plant hormone that has been shown to increase in closed storage containers, especially when stock has been handled roughly . Purafil ES® ethylene absorbent packets are effective in lowering ethylene concentrations in storage bags or boxes, but research results on whether they improve outplanting performance are inconsistent.

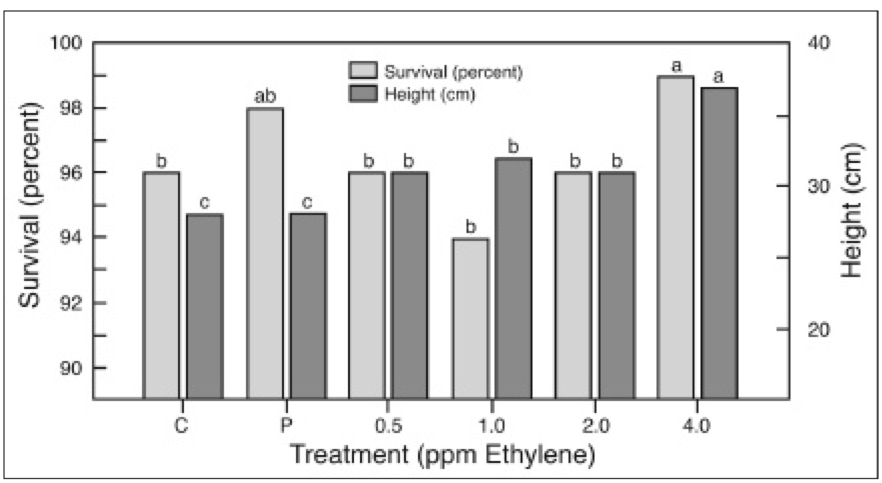



*Figure 2— Although Purafil ES® ethylene absorbent packets significantly increased outplanting survival compared to the control, the highest ethylene concentrations actually increased both survival and growth (modified from Barnett and others 1985).*

**Sources**

Barnett JP. 1983. Ethylene: a problem in seedling storage? Tree Planters' Notes 34(1): 28-29

Blake JI, Linderman RG. 1992. A note on root development, bud activity, and survival of Douglas-fir, and survival of western hemlock and noble fir seedlings, following exposure to ethylene during cold storage. Canadian Journal of Forest Research 22(8):1195-1200.

Burr KE, Wallner SJ, Tinus RW. 1991. Ethylene and ethane evolution during cold acclimation and deacclimation of ponderosa pine. Canadian Journal of Forest Research 21(5):601-605.

Ethylene. http://www.plant-hormones.info/ethylene.htm (Accessed 31 Jan 2007)

Garrett-Kraus K, Blanche CA, Elam WW. 1985. Ethylene production by stored pine seedlings and its relation to root regeneration and survival. Auburn (AL): Proceedings of the International Symposium on Nursery Management Practices for the Southern Pines: 363-371.

Hinesley LE, Saltveit ME. 1980. Ethylene adversely affects Fraser fir planting stock in cold storage. Southern Journal of Applied Forestry 4: 188-189.

Johnson JD, Stumpff NJ. 1984. Loblolly pine seedling performance is affected by ethylene. Alexandria (LA). Southern Nursery Conference Proceedings: 169-173.

Reid M, Dodge L. 1995. New ethylene absorbents: no miracle cure. Perishables Handling Newsletter 83:8.

Sherman M. 1985. Control of ethylene in the postharvest environment. HortScience 20(1):57-60.

**Managing Fungus Gnats in Container Nurseries**
By Thomas D. Landis

Way back in the late 1980's, when I was working on the nursery pests chapter for the Container Tree Nursery Manual, I did a lot of research on fungus gnats because I'd found them to be a serious pest in my nursery. The entomologists that I talked to then considered them to be more of a nuisance than a real threat to container stock but I'd observed injury to both seeds and seedlings. Boy, have things changed. In the past 25 years, there have been many articles published on fungus gnats and their control.

Fungus gnats (*Bradysia* spp.) are small, black flies that are a common nuisance in greenhouses, but actually, the adults are harmless. The larvae, however, can feed on the roots of young succulent tree seedlings, cuttings, or fleshy seeds when conditions are favorable. In a survey for the Container Tree Nursery Manual, fungus gnats placed fifth in the ranking of insect pests. The role of these insects in disease transmission has always been suspected and now has recently been confirmed. The adult gnats can carry spores of fungi and bacteria from one container to another and may be one of the primary reasons for the formation of disease pockets.

**Hosts**. The larvae normally feed on soil fungi and organic matter, but larger larvae can attack healthy root tissue of many plants including tree seedlings. Seeds and cuttings of many native plants have also been damaged.

**Symptoms & damage**. The first evidence of a fungus gnat problem is the presence of the adults, which hover around the host plants and fly when disturbed. Fungus gnat adults are small, dark, mosquito-like flies that are initially difficult to distinguish from to many other small flies common in greenhouses. In particular, growers often confuse fungus gnats with shore flies which are harmless. If you look at a fungus gnat under a hand lens, you can see the "Y"-shaped vein in the wing which is diagnostic (Figure 1A)

Symptoms of injured seedlings include wilting and sudden loss of vigor. Examination of affected plants with a hand lens may reveal the presence of larvae in the upper layer of the growing media. Fungus gnat larvae are legless, semitransparent worms with black heads and range up to 0.5 cm (0.2 in) in length (Figure 1B). Several websites contain excellent color photographs of both fungus gnat adults and larvae which is a great help in identification.

The larvae may consume small roots completely or just the exterior of the larger roots, leaving just the stripped vascular tissue (Figure 2). By the time symptoms become evident, damage is usually so severe that control of the larvae is not practical. Instead, the adults should be controlled as soon as they are noticed.

**Life history.** Female gnats lay eggs on moist surfaces, preferring growing media that are rich in organic matter. Infestations appear to be most severe in containers that

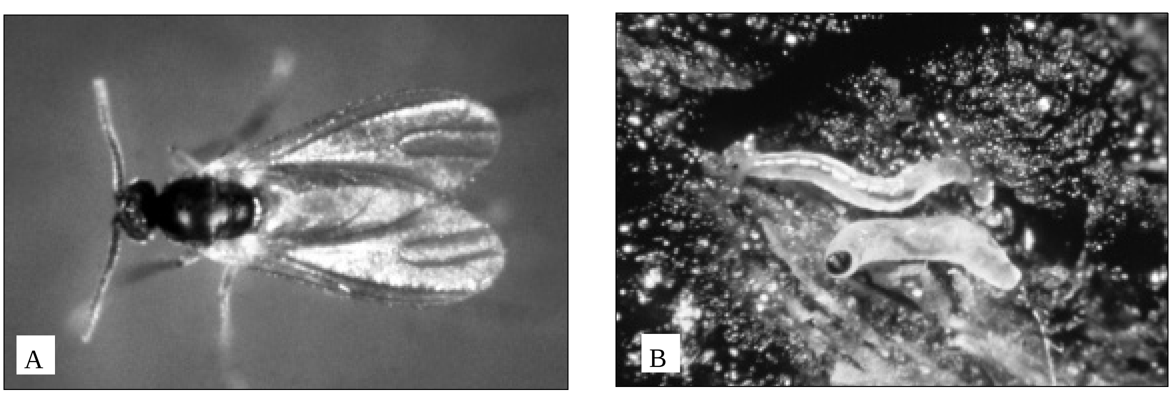



*Figure 1—Use a hand lens to confirm the identity of fungus gnat adults – the "Y"-shaped vein in the wing help distinguish them from shore flies (A). Larvae are small, clear worms with black heads (B) which can be difficult to find in the growing medium.* (Photos courtesy of Robin Rosetta)

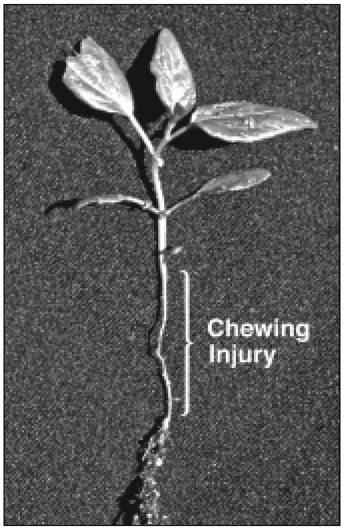



*Figure 2—The larvae of fungus gnats chew on germinating seeds and the roots of seedlings like this quaking aspen (*Populus tremuloides*). These injuries serve as entrance wounds for pathogenic fungi which the adults have been shown to transmit.*

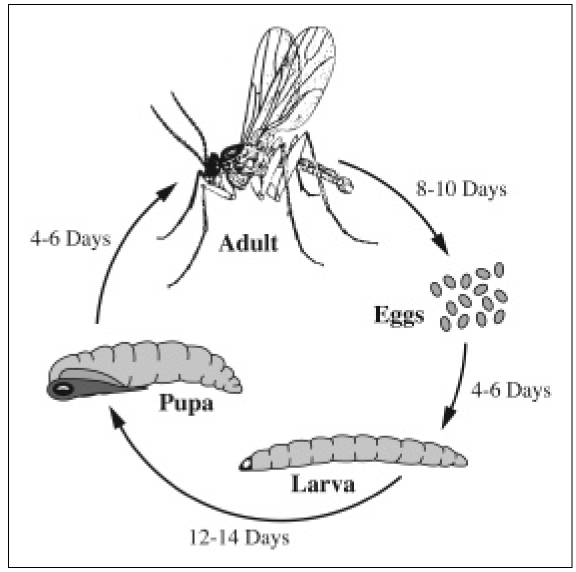



*Figure 3—The life cycle of fungus gnats can be less than a month in the warm, humid environment of a greenhouse. Controls should target the larval stage which does the real damage.*

contain algae or moss, which develop in response to overwatering. Eggs hatch in about 6 days, and the larvae feed for a couple of weeks and pupate in the growing medium. After 5 to 6 days, the adult flies emerge, completing the life cycle (Figure 3). Because of this short life cycle, populations of dark-winged fungus gnats can build-up rapidly in warm, moist greenhouse environments where algae and moss are present.

**Pest management.** Prevention and early detection are the keys to controlling fungus gnats and, in my experience, sanitation and proper irrigation practices are crucial.

**Monitoring** - The most effective way to identify the presence of fungus gnats and monitor their populations is with yellow sticky cards (Figure 4). Adult fungus gnats are attracted to the color and become stuck, and the relative numbers of gnats per card per unit of time gives a good estimate of fungus gnat populations. We are more interested in the number of larvae, however, and so a more recent survey technique has real application. Freshly-cut slices of potato are stuck into the growing medium and left for 48 hours. Recording the number of larvae on or near the discs provided a useful indication of fungus gnat larvae populations (Cabrera and others 2004).

**Traditional Pesticides** - Insecticides can be used to control either larvae or adults but, since the larvae are doing the damage, it makes more sense to target them. Insecticides can be applied as drenches to control the larvae, but all surfaces where the gnats are breeding must be treated. Hamlen and Mead (1979) tested 12 common insecticides on fungus gnats and found that all were effective, and that surface-applications were as effective as drenches. Today, many more insecticide options are available (Table 1). A recent test of several registered pesticides showed that some are better than

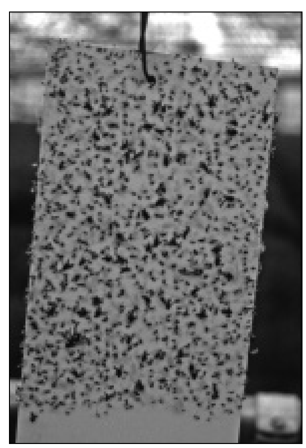


*Figure 4—Yellow sticky cards are the most popular way to identify adult fungus gnats but potato slices have also proven useful for monitoring larval populations*

| **Table 1—Insecticides commonly used to control fungus gnats** | | | | |
|---|---|---|---|---|
| **Trade Name** | **Active Ingredient** | **Type of Pesticide** | **Safety Class** | **Restricted Entry Interval (hours)** |
| **Traditional Pesticides** | | | | |
| DuraGuard™ | Chlorpyrifos | Insecticide | Caution | 24 |
| Adept® | Diflubenzuron | Growth regulator | Caution | 12 |
| Distance® | Pyriproxyfen | Growth regulator | Caution | 12 |
| Marathon® | Imidacloprid | Systemic insecticide | Caution | 12 |
| Citation® | Cyromazine | Insecticide | Caution | 12 |
| Safari™ | Dinotefuran | Systemic insecticide | Caution | 12 |
| **Organic Controls** | | | | |
| Azatin® | Azadirachtin | Growth regulator | Caution | 4 |
| Nemasys® | *Steinernema feltiae* | Parasitic nematode | None | 0 |
| BotaniGuard®<br>Naturalis O® | *Beauveria bassiana* | Incetivorous fungus | None | 4 |
| Predatory Mite | *Hypoaspis miles* | Predatory mite | None | 0 |
| Gnatrol® | *Bacillus thuringiensis israelensis* | Pathogenic bacteria | None | 0 |
| **Sterilants** | | | | |
| ZeroTol™<br>OxiDate® | Hydrogen dioxide | Algaecide & fungicide | None | 0 |

others and that multiple applications are more effective (Figure 5**)**. Due to their short life cycle, multiple treatments will be necessary to completely eliminate severe fungus gnat infestations.

Although they are not specifically labeled for fungus gnats, chemical sterilants such as hydrogen dioxide kill the spores of algae and moss which reduces their food source. They can be injected into the irrigation system, and when used regularly, operational experience suggests that these products are very effective in controlling fungus gnat populations.

**Organic Controls** - One encouraging development is the variety of organic controls for fungus gnats that are now available (Table 1). Some have been more effective than others so it makes sense to give some thought to their mode of action. Pathogenic bacteria and fungi are not very mobile and so must come in direct contact with the larvae. On the other hand, parasitic mites and nematodes will actually search out their prey which is extremely helpful when larvae have migrated deep into the growing medium.

**Cultural Controls** - As previously mentioned, the presence of algae and moss and overwatering provide the ideal conditions for fungus gnats. Cultural control methods involve general greenhouse sanitation: removing infested containers, avoiding excessive irrigation, controlling algae and mosses, and sterilizing containers and surfaces. The type of growing medium affects fungus gnat populations and also the efficacy of

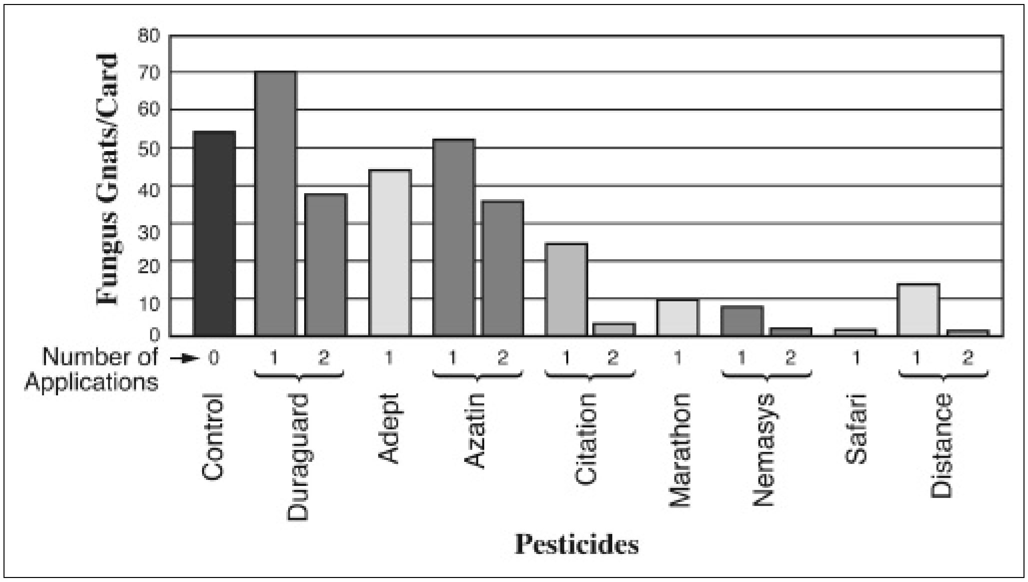



*Figure 5—A recent comparison of commercial pesticides and organic controls showed that some products were much more effective than others and that multiple applications are necessary (modified from Fisher and others 2006).*

insecticides: more adult fungus gnats emerged and insecticides were less effective in a medium containing composted bark (Lindquist.1996). The type of seed coverings is extremely important. Moss and algae thrive on wet, fertile growing medium surfaces which are an open invitation to fungus gnats. On the other hand, seed coverings such as grit, perlite, and coarse sawdust create a dry surface layer that is not attractive to these common greenhouse pests.

**Summary**

Fungus gnat larvae are common in greenhouse environments and can do considerable damage to germinating seeds, cuttings, and young seedlings. They are attracted to moss and algae and thrive in wet, humid conditions and prevention is much easier than control. Therefore, growers should regularly sanitize their facilities between crops, clean greenhouse surface and floors regularly, and irrigate only when needed. Yellow sticky cards and potato disks work well for monitoring. For existing populations, several new effective insecticides and organic controls are available.

**Sources**

Cabrera AR, Cloyd RA, Zaborski ER. 2004. The spuds have it: potato disks are an efficient technique in monitoring for fungus gnat larvae. Greenhouse Grower 22(10):48, 50, 52, 54.

Fisher P, Eaton A, Cloyd R. 2006. Fungus gnat management. Greenhouse Grower 24(11): 20,22,24.

Hamlen RA, Mead FW. 1979. Fungus gnat larval control in greenhouse plant production. Journal of Economic Entomology 72:269-271.

IPM of Alaska. 2004. The problem: fungus gnats & shore flies. Technical Bulletin: Greenhouse crop management series. URL: http://www.ipmofalaska.com/files/fungusgnats.html (accessed 23 Jan 2007).

Landis TD, Tinus RW, McDonald SE, Barnett JP. 1989. The Biological Component: Nursery Pests and Mycorrhizae, Vol. 5, The Container Tree Nursery Manual. Agric. Washington (DC): USDA Forest Service. Agriculture Handbook 674. 171 p.

Lindquist, R. 1996. Shore flies and fungus gnats. URL: http://floriculture.osu.edu/archive/dec96/gnats.html (accessed 23 Jan 2007).

Price JF, Nagle C, McCord E. 2001. Insect and mite management options on commercial greenhouse-grown flower crops in Florida. Publication ENY-656. URL: http://edis.ifas.ufl.edu/IN399 (accessed 23 Jan 2007).

**New Stock Types and Species from Stooling Beds**
by Thomas D. Landis and Tara Luna

Stooling beds are hedge-like rows of mother plants that are established in bareroot nurseries or in vacant fields adjacent to container nurseries. They have been a traditional way of propagating poplars, cottonwoods, and willows in forest and conservation nurseries for well over a century (Figure 1). The term “stool beds” or “stooling beds” is unique to forestry; in horticulture, they are known as “stock hedges” (Macdonald 1986). Regardless, the concept is the same - to establish a ready source of cuttings of known genetic quality for propagation or other purposes.

Stooling beds take advantage of the ability of many broadleaved woody plants to sprout profusely from the base after being cut-off just above the root crown. This happens because the plants are still in the juvenile state which means that they have a higher tendency to sprout and produces roots. Once stooling beds are established, annual cutting ensures that juvenility can be prolonged indefinitely.

**Advantages of Stooling Beds**

Stooling beds allow the efficient collection of dormant hardwood cuttings during the winter when it may be difficult or impossible to make field collections. Because they are located at nurseries, the beds can be irrigated and cultured; processing and storing the cuttings is also much more efficient and cost-effective. Stooling beds have several advantages over wild collected cuttings:


*Figure 1—Stooling beds, like this one of black cottonwood (A), are a traditional way of producing rooted cuttings in bareroot and container nurseries (B).*

**1. Maintaining genetic and sexual diversity.** It is much easier to correctly identify different species and ecotypes from labeled stooling beds compared to wild collections. For example, willows often grow together along streams and can be difficult to identify during the winter dormant season. Stooling beds offer the ability to bulk-up unique species or ecotypes quickly and easily.

Many government nurseries have established stooling beds of the species and ecotypes that are adapted to their local area and thus can be a potential source of cutting material for private growers or restorationists. In addition, private native plant nurseries are also establishing stooling beds of desirable species for their local areas and several are specializing in riparian and wetland species. For specific restoration projects, however, the odds of a nursery having existing stooling beds of the proper species and local ecotype is problematic. Therefore, collecting cuttings and establishing stooling beds should be done early in the planning process so that a good supply of cuttings will be available when needed.

For dioecious species like willows and cottonwoods, there is also the issue of proper representation of male and female plants. If a balanced mixture of male and female plants are not collected at the start, the resultant stooling beds will not produce both male and female cuttings. So, when working with dioecious plants, the sexual identify of potential mother plants must be made ahead of time. This is easiest when plants are flowering. Depending on species, willow catkins may appear before, during, or after new leaves appear in spring. Identifying anthers in male catkins and pistils in females with a hand lens is relatively easy, especially with a little practice. During the winter dormant season, it is possible to identify the sex of dormant cottonwoods by dissecting floral buds although this is more difficult with willows. Detailed instructions on how to “sex” willows and cottonwoods can be found in Landis and others (2003).

**2. Producing healthy and vigorous cuttings.** Cuttings from stooling beds are usually healthier and more vigorous than those from wildland collections. Willows are host to many insect and fungal pests such as galls and cankers (Figure 2) that lower the quality of wild-collected cuttings. For example, on a riparian restoration project in Idaho, cuttings were collect from heavily browsed willows on the project site and then planted in nursery beds to produce rooted cuttings. However, the yield of shippable plants was low and these

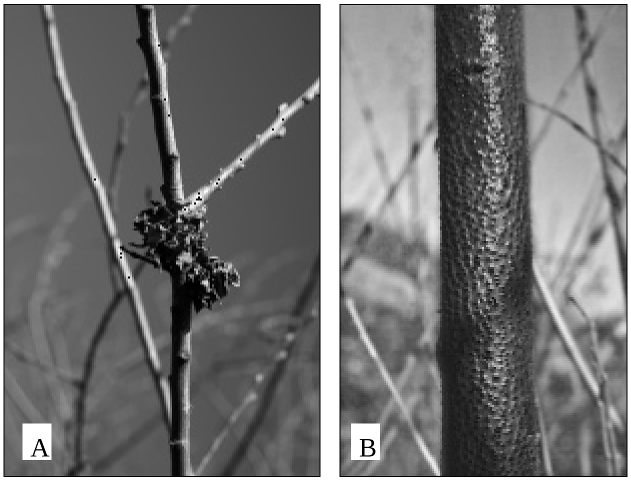



*Figure 2—Stooling beds can be cultured to prevent the occurrence of insect galls (A) and fungus cankers, such as* Cytospora *(B)*

wild-collected cuttings rooted poorly (> 50%) when outplanted. These failures increased production costs and threatened the project's replanting schedule. So, about 150 rooted cuttings from the first nursery crop were used to start a stooling bed. The following year, harvesting just half of the stooling bed yielded more than 6,000 healthy cuttings. Cuttings from the stooling beds rooted at over 99%, thereby lowering establishment costs and keeping the project on-schedule (Dumroese and others 1998).

So, to summarize, a well-planned stooling bed will produce health, vigorous cuttings of the proper plant species. A known mixture of male and female plants to ensure that the resulting plant materials will be able to produce viable seeds soon after outplanting, and achieve the ultimate goal of a diverse, sustainable plant community.

**Types of Plant Materials from Stooling Beds**

Nurseries can harvest several different plant materials from stooling beds. They can use propagation cuttings to start their own bareroot or container plants, or can sell other types of plant materials to clients for use on restoration sites (Figure 3). These plant materials can be collected during winter or very early spring that are usually "slow times" at many nurseries.

**Hardwood cuttings for nursery propagation.**
Historically, the main purpose of stooling beds was to provide a ready and reliable source of propagation cuttings (Figure 3) for use at the nursery. Cuttings were collected during the winter dormant season, processed, stored, and then stuck into bareroot beds or containers to produce rooted cuttings (Mathers 2003). These stock types take only one growing season.

**Hardwood cuttings for restorations sites.**
Stooling beds can also be sources of several types of nonrooted cuttings:

**Live stakes** - Live stakes are so-named because, in addition to providing stability on restoration sites, they are expected to root and sprout after installation. Because they will be pounded into the ground, live stakes are cut from relatively straight sections of second or third year wood. Live stakes are typically 18 to 24 in (46 to 61 cm) in length and at from 1 to 3 in (2.5 to 7.6 cm) in diameter (Figure 3). However, because dimensions will vary with each application, specifications should be negotiated with individual customers. Depending on the plant species, it can take 2 to 4 years for a stooling bed to produce large enough branches for live stakes. Some of the smaller willow species will never grow large enough.

**Branched cuttings** - Fascines, vertical bundles, and other bioengineering structures (Hoag and Landis 2001) require a large number of dormant, nonrooted, branched, hardwood cuttings (Figure 3). Usually, these are gathered on-site but, for restoration projects that will require a large amount of plant material over several years, cuttings of a variety of species can be brought back to a nursery to start stooling beds. Stooling beds

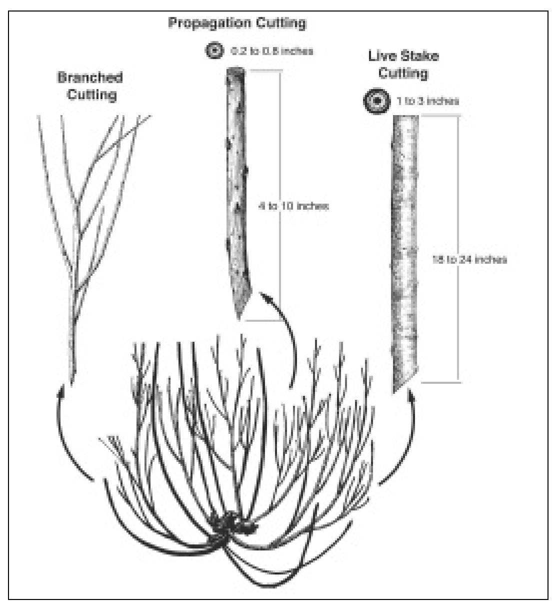



*Figure 3—Several types of hardwood cuttings can be obtained from stooling beds, including cuttings for propagation at the nursery or live stakes and branches cuttiings for restoration projects. Note that large plant materials require extra time to produce.*

may take 2 or more years to produce significant numbers of harvestable cuttings.

**Pole cuttings** - Pole cuttings (Figure 4) are large diameter main stems that have all side branches and the top 30 to 60 cm (1 to 2 ft) removed. They have primarily been used in riparian restoration projects where normal-sized cuttings fail, such as riparian systems where high water velocities can rip cuttings out before they have a chance to establish. Poles should also have applications in roadside revegetation and other restoration projects where stability is a main concern. Because of the large size of the plant material necessary for pole cuttings, nursery stooling beds are ideal. Cottonwoods have been the main species used for poles but the larger tree-sized willows such as Goodding's willow *(S. gooddingii*) also have potential.

Dreesen and Harrington (1997) were able to produce large Fremont cottonwood poles from stooling beds at the Los Lunas Plant Materials Center in New Mexico in as little as 3 years. They also tested other southwestern riparian species in pole plantings, and found that New Mexico olive (*Forestiera neomexicana*), seepwillow (*Baccharis glutinosa*), and false indigo bush (*Amorpha fruticosa*) had potential.

Stooling beds can remain productive for many years, depending on species, ecotype, and nursery cultural practices, especially pest management. For cottonwood, stooling beds typically remain productive for 4 to 8 years after which vigor and productivity start to decline; however, other nurseries have maintained stooling beds of willow and cottonwood for 12 to 15 years without decreases in vigor. Cytospora canker, caused by fungi of the genus *Cytospora* spp. (Figure 2B) is a particularly serious pest of all Salicaceae and, because it is transmitted and thrives in wounded stem tissue, can ruin a productive stooling bed. The productivity and longevity of a stooling bed is a direct function of the amount of care given them.

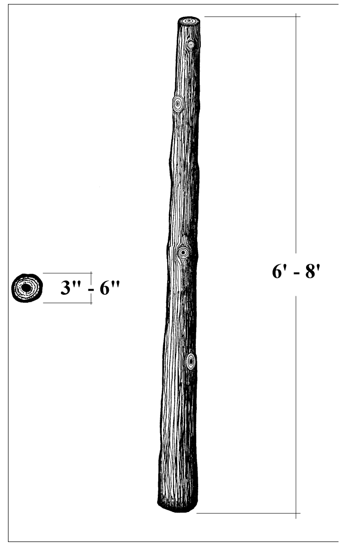



*Figure 4—Pole cuttings of cottonwood and larger willows can also be produced in stooling beds, and have application in restoration outplanting where stability is a concern.*

**Plant Species Suitable for Stooling Beds**

As mentioned, most stooling beds have been of poplars, cottonwoods, and willows. However, it should not be assumed that all species of the willow family are good candidates for stooling beds. Some species have growth characteristics which reduces their potential. For example, trials at the Colorado State Forest Service Nursery in Ft Collins have shown that narrowleaf cottonwood (*Populus angustifolia*) and coyote willow (*Salix exigua*) do not "stool" well and must be propagated by other methods (Grubb 2007).

On the other hand, there is great potential for using other woody species that have the propensity to sprout and form roots easily. For example, redstem dogwood (*Cornus sericea*) is commonly grown in stooling blocks and used as a source of cuttings for restoration sites. Outplanting success is higher than with native collections on site and have ranged from 50 to 90% (Hoag 2007). In North Dakota, black twinberry honeysuckle (*Lonicera involucrata*) is being investigated (Morgenson 2007).

Clearly, native species that root easily from hardwood cuttings have the potential to be grown in stooling beds to generate cuttings. This is especially true for those species whose seed have inherent deep seed dormancy characteristics, such as snowberry, honeysuckle, elderberry, and some species of currants. Other species such as mock orange and ninebark (*Physocarpus* spp.), that often have consistent low seed viability, may also be produced more economically by stooling beds.

The Plant Materials Centers of the USDA Natural Resources Conservation Service have done an good job of identifying the potential of a wide variety of woody native plants that would be suitable for stooling beds (Table 1). For example, Crowder and Darris (1999) do an excellent job of discussing which plants are suitable in the Pacific Northwest and then provide a wealth of information on the installation and culture of stooling beds.

**Table 1—Native woody plants of the Pacific Northwest with potential for propagation in stooling beds**

| **Plant Species** | | **Rooting Ability** | **Growth Rate** | **Field Success** (1=Poor, 5=Good) |
|---|---|---|---|---|
| **Scientific Name** | **Common Name** | | | |
| *Baccharis pilularis* | Coyote brush | Fair to good | Moderate | 3 |
| *Cornus sericea* | Red-osier dogwood | Good | Fast | 3 |
| *Oemleria cerastiformis* | Indian plum | Poor to Good | Moderate | 1 |
| *Physocarpus capitatus* | Pacific ninebark | Good to Very Good | Moderate to Fast | 4 |
| *Philadelphus lewisii* | Lewis mockorange | Fair | Moderate | 1 |
| *Populus trichocarpa* | Black cottonwood | Fair to Very Good | Very Fast | 3 |
| *Rosa woodsii* | Woods' rose | Poor to Fair | Moderate to Fast | 1 |
| *Salix amygdaloides* | Peachleaf willow | Excellent | Very Fast | 5 |
| *Salix exigua* | Coyote willow | Very Good | Fast | 4 |
| *Salix lasiolepis* | Arroyo willow | Excellent | Very Fast | 5 |
| *Salix scouleriana* | Scouler's willow | Good to Very Good | Very Fast | 4 |
| *Spirea douglasii* | Douglas spirea | Very Good | Fast | 4 |
| *Symphoricarpos albus* | Snowberry | Very Good | Fast | 4 |

* = modified from Crowder and Darris (1999)

Darris (2002) performed extensive greenhouse and field trials to test the potential of several woody plants for live stake applications. Common snowberry (*Symphoricarpus albus*), salmonberry (*Rubus spectabilis*), Pacific ninebark (*Physocarpus capitatus*) and black twinberry (*Lonicera involucrata*) have all proved effective as live stakes for soil bioengineering in the Pacific Northwest. Notably, several have proven superior to willow on some sites such as salmonberry in wet, shaded environments and snowberry on drier, exposed locations.

**Summary**

Stooling beds have been producing cuttings of willows, cottonwood, and poplars for many years but also have the potential for supplying other plant materials for restoration projects. Because of their proven application, nursery managers should work with their customers to establish stooling beds of woody plant species.

**Sources**

Crowder W, Darris D. 1999. Producing pacific northwest native trees and shrubs in hardwood cutting blocks or stooling beds. Portland (OR): USDA Natural Resources Conservation Service. Plant Materials No 24. 13 p.

Darris D. 2002. Native shrubs as a supplement to the use of willows as live stakes and fascines in western Oregon and western Washington. Portland (OR): USDA Natural Resources Conservation Service. Technical Notes, Plant Materials No. 31. 10 p.

Dreesen DR, Harrington JT. 1997. Propagation of native plants for restoration projects in the southwestern U.S. - preliminary investigations. IN: Landis,TD, Thompson, JR, tech. coords. National Proceedings, Forest and Conservation Nursery Associations. Portland (OR): US Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-419: 77-88.

Dumroese RK, Stumph T, Wenny DL. 1998. Revegetating Idaho’s Henry’s Fork: a case study. In: Rose R, Haase DL, editors. Native plants: propagation and planting; 1998 Dec 9–10; Corvallis, OR. Corvallis (OR): Oregon State University, Nursery Technology Cooperative. 108–112.

Grubb, B. 2007. Personal communication. Nursery Grower. Colorado State Forest Service Nursery. Fort Collins (CO).

Hoag JC. 2007. Personal communication. Plant Ecologist and Wetland Specialist. USDA National Resource Conservation Service. Aberdeen Plant Materials Center. Aberdeen (ID).

Hoag JC, Landis, TD. 2001. Riparian zone restoration: field requirements and nursery opportunities. Native Plants Journal 2(1): 30-35

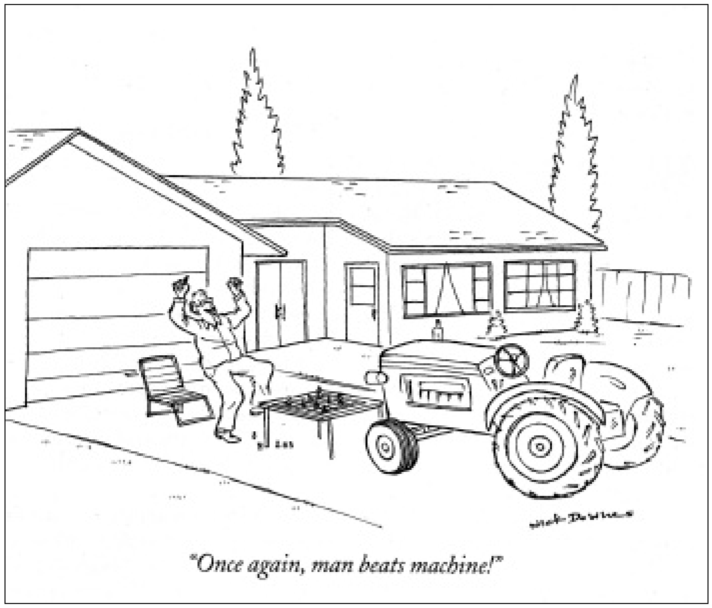
Landis TL, Dreesen DR, Dumroese RK. 2003. Sex and the single *Salix*: considerations for riparian restoration. Native Plants Journal 4(2): 111-117.

Mathers T. 2003. Propagation protocol for bareroot willows in Ontario using hardwood cuttings. Native Plants Journal 4(2): 132-136.

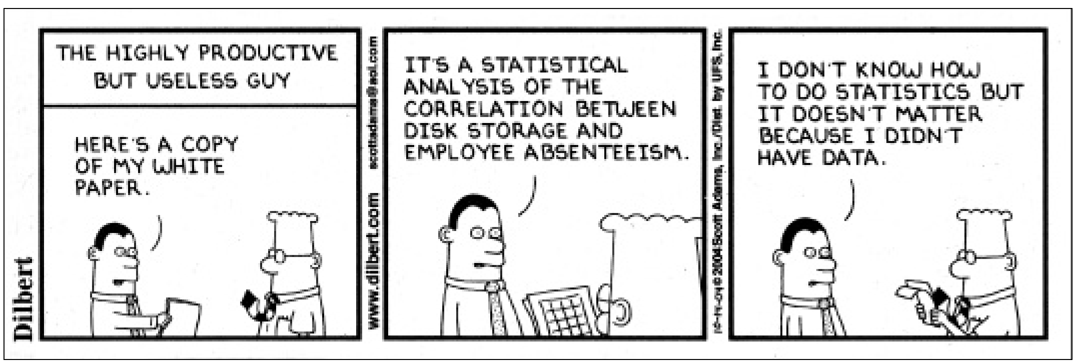
Macdonald B. 1986. Practical woody plant propagation for nursery growers. Volume 1. Portland, OR: Timber Press Inc. 669 p.

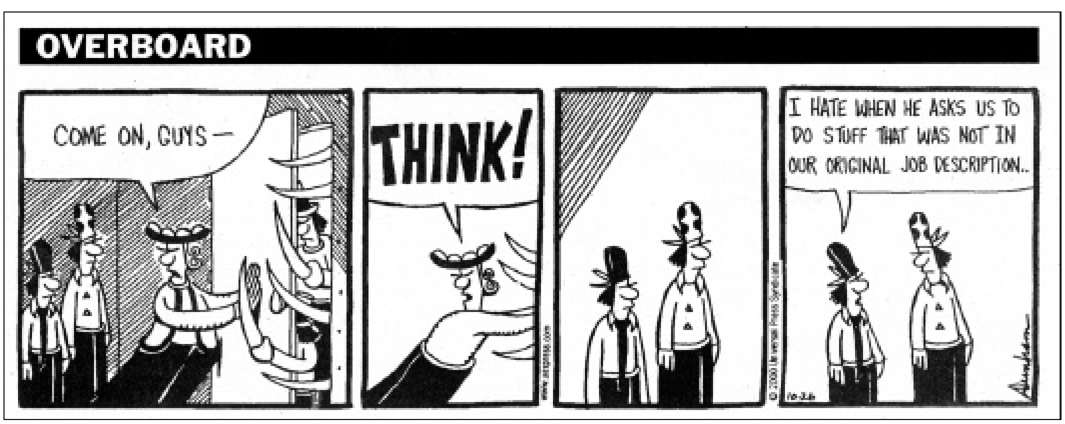
Morgenson G. 2007 Personal communication. Bismark (ND): Lincoln-Oakes Nurseries. Nursery Manager.

# Horticultural Humor



"Once again, man beats machine!"



# New Nursery Literature

Copies of the following journal articles or publications are free and can ordered using the Literature Order Form on the last page of this section. Just write in the appropriate number or letter on the form and return it to us. Note that there are three restrictions:

**1. Limit in Number of Free Articles:** In an effort to reduce mailing costs, we are limiting the number of free articles that can be ordered through FNN literature service. All subscribers will be restricted to 25 free articles per issue. **Electronic Adobe PDF Copies** are now available. The copyright restriction still applies, but the 25 article limitation does not. Instructions for accessing electronic copies are included on the Literature Order Form.

**2. 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, then you can order a copy from a library service.

**3. 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.

## Bareroot Production

**1. © Effects of seedbed density on one-year-old *Fraxinus angustifolia* seedling characteristics and outplanting performance.** Cicek, E., Cicek, N., and Bilir, N. New Forests 33(1):81-91. 2007.

**2. An evolution of bareroot cultural practices at J. Herbert Stone Nursery.** Riley, L. E., Steinfeld, D., and Feigner, S. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.51-60. 2006.

**3. Stock quality of black walnut (*Juglans nigra*) seedlings as affected by half-sib seed source and nursery sowing density.** Jacobs, D. F., Woeste, K. E., Wilson, B. C., and McKenna, J. R. Acta Horticulturae 705:375-381. 2006.

## Business Management

**4. Designing and implementing a new nursery computer program at George O. White State Nursery, Missouri Department of Conservation.** Diram, D. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.134-136. 2006.

**5. Experience of applying lean manufacturing on a container nursery.** Dowling, G. International Plant Propagators' Society, combined proceedings 2005, 55:288-290. 2006. Lean manufacturing is about improving efficiency and productivity and decreasing waste in the workplace. By following 7 sequential improvement steps, a business can save time and costs in all areas of activity.

**6. How to develop an effective safety committee.** Mauschbaugh, A. Greenhouse Management and Production 27(1):99-100, 102. 2006.

**7. Specialisation -- advantages and disadvantages compared.** Bingham, P. International Plant Propagators' Society, combined proceedings 2005, 55:79-81.

2006. One of the most significant changes in the nursery trade is the trend toward specialisation in one form or other -- species, pot sizes, growing media, customer base, etc.

**8. Summer hazards.** Mauschbaugh, A. J. American Nurseryman 204(4):30-32, 34-35. 2006. Protect your employees from summer heat and pest dangers with these pointers.

**9. Use of cost analysis to improve nursery profitability.** George, W. International Plant Propagators' Society, combined proceedings 2005, 55:281-287. 2006.

## Container Production

**10. Companies market biodegradable pots to growers, retailers and consumers.** Rodda, K. Greenhouse Management and Production 26(9):35-36, 38, 40, 42. 2006.

**11. © Enhancement of photosynthesis and growth of tomato seedlings by forced ventilation within the canopy.** Shibuya, T., Tsuruyama, J., Kitaya, Y., and Kiyota, M. Scientia Horticulturae 109:218-222. 2006.

**12. Environmentally sustainable production systems for producing ornamental plants.** Bunker, J. International Plant Propagators' Society, combined proceedings 2005, 55:41-47. 2006.

**13. Growing plants in hot climates.** Chin, R. International Plant Propagators' Society, combined proceedings 2005, 55:142-147. 2006.

**14. © Impacts of nursery cultural treatments on stress tolerance in 1+0 container white spruce (*Picea glauca* [Moench] Voss) seedlings for summer-planting.** Tan, W. New Forests 33(1):93-107. 2007.

**15. Panel discussion: container stock and why?** Friedlander, R. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.68-72. 2006.

**16. Panel discussion: Red Lake Forestry greenhouse operations** Whitefeather-Spears, G. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.82-83. 2006.

**17. Panel discussion: Trends in container types.** Stuewe, E. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.73-81. 2006.

**18. Run for cover! What's covering your greenhouse and how it is affecting seedling growth?** Pinto, J. R., Dumroese, R. K., and Marshall, J. D. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.44-50. 2006.

**19. Subirrigation reduces water use, nitrogen loss, and moss growth in a container nursery.** Dumroese, R. K., Pinto, J. R., Jacobs, D. F., Davis, A. S., and Horiuchi, B. Native Plants Journal 7(3):253-261. 2006.

## Diverse Species

**20. Antelope bitterbrush reestablishment: a case study of plant size and browse protection effects.** Johnson, G. R. and Okula, J. P. Native Plants Journal 7 (2):125-133. 2006.

**21. © Can a post-harvest ripening treatment extend the longevity of *Rhododendron* L. seeds?** Hay, F., Klin, J., and Probert, R. Scientia Horticulturae 111 (1):80-83. 2006.

**22. Collecting tapertip onion (*Allium acuminatum* Hook.) in the Great Basin using traditional and GIS methods.** Adair, R., Johnson, R. C., Hellier, B., and Kaiser, W. Native Plants Journal 7(2):141-148. 2006.

**23. The effect of gibberellic acid, potassium nitrate, and cold stratification on the germination of goldenseal (*Hydrastis canadensis*) seed.** Follett, J. M., Douglas, J. A., and Littler, R. A. International Plant Propagators' Society, combined proceedings 2005, 55:165-170. 2006.

**24. © Effect of light on seed germination of eight wetland *Carex* species.** Kettenring, K. M., Gardner, G., and Galatowitsch, S. M. Annals of Botany 98(4):869-874. 2006.

**25. Establishment of wetland ground flora: an analysis of planting methodologies.** Ireland, S. N., Hedges, P. D., and Fermor, P. M. IN: Natural and constructed wetlands - nutrients, metals and management, p. 91-111. J. Vymazal, ed. Backhuys Publishers. 2005.

**26. Ethylene improves germination of arrow-leaved balsamroot seeds.** Chambers, K. J., Bowen, P., Turner, N. J., and Keller, P. C. Native Plants Journal 7(2):108-113. 2006.

**27. Genetic fingerprinting of goldenseal, *Hydrastic canadensis*, using AFLP markers: an update.** Zhou, S. and Sauve, R. J. Native Plants Journal 7(3):284-285. 2006.

**28. Growing shrubs at the George O. White State Forest Nursery: what has worked and what has not.** Hoss, G. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.111-114. 2006.

**29. Hand-pollination of *Cardamine californica* improves seed set.** Ariyoshi, K., Magnaghi, E., and Frey, M. Native Plants Journal 7(3):249-252. 2006.

**30. © Improving germination in windmillgrass ecotypes.** Herrera-C., F., Ocumpaugh, W. R., Ortega-S., J. A., Lloyd-Reilley, J., Rasumuusen, G. A., and Maher, S. Rangeland Ecology and Management 59(6):660-663. 2006.

**31. Inadvertent selection in the propagation of native plants: a cautionary note.** Dunwiddie, P. and Delvin, E. Native Plants Journal 7(2):121-124. 2006.

**32. Meadow restoration in the Sawtooth National Recreation Area in southern Idaho.** Sloan, J. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T. D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.21-26. 2006.

**33. *Mespilus canescens* a newly discovered species: propagation by grafting onto *Crataegus*.** Barnes, H. W. International Plant Propagators' Society, combined proceedings 2005, 55:449-451. 2006.

**34. Modifications improve seed harvest with the Woodward flail-vac seed stripper.** Kees, G. Native Plants Journal 7(2):149-150. 2006.

**35. Panel discussion: Stocktypes for outplanting in Zion National Park.** Decker, C. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.61-67. 2006.

**36. © Passive establishment of vegetation in constructed wetlands in agricultural settings: a case study.** Luckeydoo, L. M., Fausey, N. R., Davis, C. B., Regnier, E., and Brown, L. C. Ohio Journal of Science 106(4):164-168. 2006.

**37. © Population and environmental effects on seed production, germination, and seedling vigor in western wheatgrass (*Pascopyrum smithii* [Rydb.] A. Love).** Waldron, B. L., Robins, J. G., Jensen, K. B., Palazzo, A. J., Cary, T. J., and Berdahl, J. D. Crop Science 46:2503-2508. 2006.

**38. © Production, losses, and germination of *Ceanothus fendleri* seeds in an Arizona ponderosa pine forest.** Huffman, D. W. Western North American Naturalist 66(3):365-373. 2006.

**39. Propagating native plants for the Hopi Nation.** Landis, T. D., Dreesen, D. R., Pinto, J. R., and Dumroese, R. K. International Plant Propagators' Society, combined proceedings 2005, 55:520-523. 2006.

**40. Propagation and cultivation of *Arctostaphylos* in relation to the environment in its natural habitat in California, U.S.A.** Hart, L. International Plant Propagators' Society, combined proceedings 2005, 55:291-295. 2006.

**41. Propagation of *Osmanthus armatus* from hardwood cuttings.** Barnes, H. W. International Plant Propagators' Society, combined proceedings 2005, 55:448-449. 2006.

**42. Propagation of *Sarracenia* species.** Heffner, R. A. International Plant Propagators' Society, combined proceedings 2005, 55:356-360. 2006.

**43. The propagation of uluhe fern (*Dicranopteris linearis*): vegetative versus spores.** Romanchak, E. A., Criley, R. A., and Sugii, N. International Plant Propagators' Society, combined proceedings 2005, 55:517-519. 2006.

**44. Propagation protocol for *Jacquemontia reclinata* House, a federally endangered species of south Florida.** Roncal, J., Fisher, J. B., Wright, S. J., Frances, A., Griffin, K., Maschinski, J., and Fidelibus, M. W. Native Plants Journal 7(3):301-306. 2006.

**45. Propagation protocol for spicebush, *Lindera benzoin*.** Hoss, G. Native Plants Journal 7(2):134-136. 2006.

**46. Revegetation of reconstructed reaches of the Provo River, Heber Valley, Utah.** Rice, J. A. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T. D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.27-34. 2006.

**47. Revegetation strategies and technologies for restoration of aridic saltcedar (*Tamarix* spp.) infestation sites.** Lair, K. D. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.10-20. 2006.

**48. Selection of mycorrhizal fungi for California native plants.** Corkidi, L., Evans, M., and Bohn, J. International Plant Propagators' Society, combined proceedings 2005, 55:489. 2006.

**49. Softwood cutting propagation of native Lauraceae (*Lindera benzoin* and *Sassafras albidum*) as alternatives to invasive horticulture plants.** Sicuranza, J., Castrataro, N., Johnson, B., and Maynard, B. International Plant Propagators' Society, combined proceedings 2005, 55:415-417. 2006.

**50. Strategies for seed propagation of native forbs.** Meyer, S. E. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.3-9. 2006.

**51. © Techniques for enhancing saltgrass seed germination and establishment.** Qian, Y. L., Cosenza, J. A., Wilhelm, S. J., and Christensen, D. Crop Science 46 (6):2613-2616. 2006.

**52. Tolerance of hardy ferns to selected preemergence herbicides/** Fain, G. B., Gilliam, C. H., and Keever, G. J. HortTechnology 16(4):605-609. 2006.

**53. Using compost for container production of ornamental wetland and flatwood species native to Florida.** Wilson, S. B. and Stoffella, P. J. Native Plants Journal 7(3):293-300. 2006.

## Fertilization and Nutrition

**54. © Calcium addition at the Hubbard Brook Experimental Forest reduced winter injury to red spruce in a high-injury year.** Hawley, G. J., Schaberg, P. G., Eagar, C., and Borer, C. H. Canadian Journal of Forest Research 36(10):2544-2549. 2006.

**55. © Developmental disorders in buds and needles of mature Norway spruce, *Picea abies* (L.) Karst., in relation to needle boron concentrations.** Sutinen, S., Vuorinen, M., and Rikala, R. Trees 20:559-570. 2006.

**56. Exponential nutrient loading as a means to optimize bareroot nursery fertility of oak species.** Birge, Z. K. D., Jacobs, D. F., and Salifu, F. K. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.147-151. 2006.

**57. Leaching of nitrogen from upland forest-regeneration sites into wetland areas.** Kubin, E. IN: Environmental role of wetlands in headwaters, p. 887-94. J. Krecek and M. Haigh, eds. Springer. 2006.

**58. MIYOBI: a new fertilizer containing abscisic acid.** Kamuro, Y. International Plant Propagators' Society, combined proceedings 2005, 55:216-218. 2006.

**59. © NPK fertilization at planting of three hybrid poplar clones in the boreal region of Alberta.** DesRochers, A., van den Driessche, R., and Thomas, B. R. Forest Ecology and Management 232(1-3):216-225. 2006.

**60. Perfecting the pour-through.** Altland, J. Digger 50 (8):99-103, 105-107. 2006. Avoid common pitfalls of this seemingly simple method for measuring container nutrition.

**61. Response of grafted *Juglans nigra* to increasing nutrient availability: growth, nutrition, and nutrient retention in root plugs.** Salifu, K. F., Jacobs, D. F., Pardillo, G., and Schott, M. HortScience 41(6):1477-1480. 2006.

**62. © The roles of nitrogen and phosphorus in increasing productivity of western hemlock and western redcedar plantations on northern Vancouver Island.** Blevins, L. L., Prescott, C. E., and Van Niejenhuis, A. Forest Ecology and Management 234(1-3):116-122. 2006.

**63. Sample to diagnose nutrient disorders.** Kackley, K., Ferry, S., and Peters, C. Greenhouse Management and Production 26 (8):80-82, 84-86. 2006.

**64. © Seedling biomass and element content of *Pinus sylvestris* and *Pinus nigra* grown in sandy substrates with lignite.** Baumann, K., Rumpelt, A., Schneider, B. U., Marschner, P., and Huttl, R. F. Geoderma 136:573-578. 2006.

**65. Trials with natural growth promoting products.** Keller, J. International Plant Propagators' Society, combined proceedings 2005, 55:481-488. 2006. Products tested include humate products, mycorrhiza, fulvic acid, kelp extract. Effects on growth, rooting, suppression of Phytophthora were tested.

## General and Miscellaneous

**66. Financial viability of reforesting reclaimed surface mined lands, the burden of site conversion costs, and carbon payments as reforestation incentives.** Sullivan, J., Aggett, J., Amacher, G., and Burger, J. Resources Policy 30(4):247-258. 2006.

**67. Forest Service requirements for nursery stock.** Connelly, J. IN: Plant quality: a key to success in forest establishment, proceedings of the COFORD conference, 2005, p.55-59. 2006. In Ireland.

**68. © Impact of afforestation, deforestation, and reforestation on forest cover in China from 1949 to 2003.** Zhang, Y. and Song, C. Journal of Forestry 104(7):383-387. 2006.

**69. Improvement of plant quality through nursery research and added value.** Long, P. IN: Plant quality: a key to success in forest establishment, proceedings of the COFORD conference, 2005, p.35-37. 2006.

**70. Integrating establishment practice and plant quality.** Perks, M. P., Harrison, A. J., and Bathgate, S. J. IN: Plant quality: a key to success in forest establishment, proceedings of the COFORD conference, 2005, p.47-53. 2006. Describes the development of an Establishment Management Information System decision support tool that integrates existing silvicultural advice for tree establishment in upland forest restocking in Britain on a site-specific basis.

**71. Plant quality - what the grower needs.** O'Reilly, J. IN: Plant quality: a key to success in forest establishment, proceedings of the COFORD conference, 2005, p.61-65. 2006. In Ireland.

**72. Practical management for quality in nursery production** Kavanagh, J. IN: Plant quality: a key to success in forest establishment, proceedings of the COFORD conference, 2005, p.33-34. 2006.

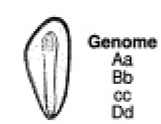
**73. A propagator's notebook.** LeBlanc, C. International Plant Propagators' Society, combined proceedings 2005, 55:566-570. 2006. One propagator's observations and thoughts from her journey in the world of propagation.

**74. Using spatial technology for analyzing disturbed areas and potential site selection in Chihuahua, Mexico.** Tena, V. M., Pinedo, A. C., Rubio, A. H., de L.G. Barragan, P., Pinedo, A. A., Hernandez, M. V., and Velez, C. WIT Transactions in Ecology and the Environment 89:401-409. 2006.

**75. Weather or not.** Miller, T. I. Digger 50(9):40-42-47. 2006. Nurseries rely on forecasting firms to help protect crops from meteorological events.

**SO. Plant quality: a key to success in forest establishment.** MacLennan, L. and Fennessy, J. Proceedings of the COFORD Conference, September 20-21, 2005. National Council for Forest Research and Development, Dublin, Ireland. 74 p. 2006. ORDER FROM: COFORD, www.coford.ie. E10 + S&H. Papers may be downloaded free from the web site. All papers are listed individually in this issue of FNN.

## Genetics and Tree Improvement




**76. © Effect of regeneration method of RAPD-based genetic variation of *Cyclobalanopsis glauca* (Fagaceae).** Zhang, X., Chen, X.-Y., and Zhang, D. New Forests 32(3):347-356. 2006.

**77. © Genetic variation in fall cold hardiness in coastal Douglas-fir in western Oregon and Washington.** St. Clair, J. B. Canadian Journal of Botany 84(7):1110-1121. 2006.

**78. © Identification of European and Japanese larch and their interspecific hybrid with morphological markers: application to young seedlings.** Paques, L. E., Philippe, G., and Prat, D. Silvae Genetica 55(3):123-134. 2006.

**79. The role of tree improvement in plant production and quality.** Thompson, D. IN: Plant quality: a key to success in forest establishment, proceedings of the COFORD conference, 2005, p.25-31. 2006.

**80. © Survival, growth and wood specific gravity of interspecific hybrids of *Pinus strobus* and *P. wallichiana* grown in Ontario.** Lu, P. and Sinclair, R. W. Forest Ecology and Management 234(1-3):97-106. 2006.

## Nursery Structures And Equipment

**81. Backup generators: easy sleep made easy.** Kenney, B. P. Greenhouse Grower 24(13):82. 2006.

**82. Bioheat waste oil may cut costs.** Bartok, J. W., Jr. Greenhouse Management and Production 26(10):64. 2006.

**83. Coal provides heat alternative.** Bartok, J. W., Jr. Greenhouse Management and Production 26(11):63-65. 2006.

**84. Control your energy costs: a whole lot of hot air.** Kenney, B. Greenhouse Grower 24(12):82-83. 2006.

**85. Gizmos and gadgets from Missoula Technology and Development Center** Vachowski, B. Native Plants Journal 7(3):308-310. 2006. Shielded herbicide sprayer; ATV-mounted native grass seeder; wildlife fencing; whitebark pine seed scarifier; reusable toweling for wrapping tree seedlings.

**86. Hot houses.** Bramwell, J. American Nurseryman 204 (2):29-33. 2006. The market for greenhouses with retractable roofs is booming because these structures enable nurseries to grow hardier plants faster.

**87. Melting greenhouse snow.** Bartok, J. W., Jr. Greenhouse Management and Production 27(1):110-111. 2006.

**88. New technologies increase greenhouse efficiency.** Devaney, N. Greenhouse Management and Production 26 (11):31, 33, 34-36. 2006. 5 places you can save money by reducing energy and labor costs.

**89. Plan before you sign a contract.** Bartok, J. W., Jr. Greenhouse Management and Production 26(9):84-86. 2006.

**90. Root-zone heating can save energy by reducing needs.** Bartok, J. W., Jr. Greenhouse Management and Production 26(8):94, 96-97. 2006.

**91. Save energy, but watch for hidden risks.** Ling, P., Pasian, C., and Jones, M. Greenhouse Management and Production 26(8):74-76, 78-79. 2006. Tightening a greenhouse saves money but may create other problems.

**92. © A specially designed air-assisted sprayer to improve spray penetration and air jet velocity distribution inside dense nursery crops.** Zhu, H., Brazee, R. D., Derksen, R. C., Fox, R. D., Krause, C. R., Ozkan, H. E., and Losely, K. Transactions of the ASABE 49(5):1285-1294. 2006.

**93. What's new with nurseries and reforestation projects at the Missoula Technology and Development Center.** Vachowski, B. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.102-107. 2006. Current projects: Nursery soil moisture meter; Remote data collection systems; Low cost weather stations; Soil compaction tester; Shielder herbicide sprayer; Seedling wrap; Container sterilizer; Whitebark pine seed scarifier; Reofrestation toolbox; Animal management economic fencing; Mechanical forbs seed harvester; Hardwood cuttings preparation equipment.

## Outplanting Performance

**94. Container plants and mechanised planting - the way forward?** Keane, M. IN: Plant quality: a key to success in forest establishment, proceedings of the COFORD conference, 2005, p.67-71. 2006. Discusses the Lannen FP-160, the EcoPlanter and the Bracke planter.

**95. © Diversifying native pinewoods using artificial regeneration** Ogilvy, T. K., Legg, C. J., and Humphrey, J. W. Forestry 79(3):309-317. 2006.

**96. © The effect of weed control and fertilization on survival and growth of four pine species in the Virginia Piedmont.** Amishev, D. Y. and Fox, T. R. Forest Ecology and Management 236(1):93-101. 2006.

**97. Effects of flooding on pitch pine (*Pinus rigida* Mill.) growth and survivorship.** Craine, S. I. and Orians, C. M. Journal of the Torrey Botanical Society 133(2):289-296. 2006.

**98. © Effects of forest floor planting and stock type on growth and root emergence of *Pinus contorta* seedlings in a cold northern cutblock.** Campbell, D. B., Kiiskila, S., Philip, L. J., Zwiazek, J. J., and Jones, M. D. New Forests 32(2):145-162. 2006.

**99. © From planting to 26 years of age -- actual growth and estimated volume scenarios for spruces and pines.** Johansson, T. and Naumburg, J. New Forests 32(2):163-178. 2006.

**100. © Growth and survival of *Pinus taeda* in response to surface and subsurface tillage in the southeastern United States.** Carlson, C. A., Fox, T. R., Colbert, S. R., Kelting, D. L., Allen, H. L., and Albaugh, T. J. Forest Ecology and Management 234(1-3):209-217. 2006.

**101. © Growth of Douglas-fir, lodgepole pine, and ponderosa pine seedlings underplanted in a partially-cut, dry Douglas-fir stand in south-central British Columbia.** Vyse, A., Ferguson, C., Simard, S. W., Kano, T., and Puttonen, P. Forestry Chronicle 82 (5):723-732. 2006.

**102. © Interactions between soil scarification and Norway spruce seedling types.** Johansson, K., Nilsson, U., and Allen, H. L. New Forests 33(1):13-27. 2007.

**103. © Mounding site preparation for forest restoration: survival and short term growth response in *Quercus robur* L. seedlings.** Lof, M., Rydberg, D., and Bolte, A. Forest Ecology and Management 232(1-3):19-25. 2006.

**104. © Nursery practices and field performance for the endangered Mediterranean species *Abies pinsapo* Boiss.** Navarro, R. M., Retamosa, M. J., Lopez, J., del Campo, A., Ceaceros, C., and Salmoral, L. Ecological Engineering 27(2):93-99. 2006.

**105. © Planting oaks in group selection openings on upland sites: two case studies from Arkansas** Heitzman, E. and Grell, A. Southern Journal of Applied Forestry 30(3):117-122. 2006.

**106. © Predicting regeneration establishment in Norway spruce plantations using a multivariate multilevel model.** Miina, J. and Saksa, T. New Forests 32 (3):265-283. 2006.

**107. Red oak research and demonstration area in Phelps township, North Bay, Ontario - 2004 to 2005.** Deugo, D., Morneault, A., Othmer, D., and Smith, M. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.127-133. 2006.

**108. © Release potential of giant sequoia following heavy suppression: 20-year results.** York, R. A., Battles, J. J., and Heald, R. C. Forest Ecology and Management 234(1-3):136-142. 2006.

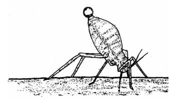
**109. Survival and growth of container and bareroot shortleaf pine seedlings in Missouri.** Gwaze, D., Melick, R., Studyvin, C., and Hoss, G. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.123-126. 2006.

**110. Underplanting cherrybark oak (*Quercus pagoda* Raf.) seedlings on a bottomland site in the southern United States.** Gardiner, E. S. and Yeiser, J. L. New Forests 32(1):105-119. 2006.

**111. Whitebark pine germination, rust resistance, and cold hardiness among seed sources in the Inland Northwest: planting strategies for restoration.** Mahalovich, M. F., Burr, K. E., and Foushee, D. L. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T. D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.91-101. 2006.

**112. Whitebark pine guidelines for planting prescriptions.** Scott, G. L. and McCaughey, W. W. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.84-90. 2006.

# Pest Management



**113. Best management practices at Monrovia growers to prevent the introduction and spread of *Phytophthora ramorum*.** Keller, J. International Plant Propagators' Society, combined proceedings 2005, 55:491-492. 2006.

**114. © Effect of slash removal on *Gremmeniella abietina* incidence on *Pinus sylvestris* after clear-cutting in northern Sweden.** Bernhold, A., Witzell, J., and Hansson, P. Scandinavian Journal of Forest Research 21 (6):489-495. 2006.

**115. © Effect of the latitude of seed origin on moose (*Alces alces*) browsing on silver birch (*Betula pendula*).** Vihera-Aarnio, A. and Heikkila, R. Forest Ecology and Management 229(1-3):325-332. 2006.

**116. © Effects of dazomet, metam sodium, and oxamyl on *Longidorus* populations and loblolly pine seedling production.** Fraedrich, S. W. and Dwinell, L. D. Southern Journal of Applied Forestry 29(3):117-122. 2006.

**117. © Etiology and real-time polymerase chain reaction-based detection of *Gremmeniella*- and *Phomopsis*-associated disease in Norway spruce seedlings.** Borja, I., Solheim, H., Hietala, A. M., and Fossdal, C. G. Phytopathology 96(12):1305-1314. 2006.

**118. Fungus gnat management.** Fisher, P., Eaton, A., and Cloyd, R. Greenhouse Grower 24(11):20, 22, 24. 2006.

**119. Healthy roots lead to healthy plants.** Douglas, S. M. Greenhouse Management and Production 27(1):90-92, 94, 96. 2006. Plants with healthy roots have fewer disease problems and should bring higher returns.

**120. Investigating koa wilt in Hawaii: examining *Acacia koa* seeds and seedpods for *Fusarium* species.** James, R. L., Dudley, N. S., and Yeh, A. Native Plants Journal 7(3):315-323. 2006.

**121. © Microwave energy supplied by a prototype oven prevents the spread of *Fusarium* wilt during the propagation of melon plantlets by seed.** Soriano-Martin, M. L., Porras-Piedra, A., Goldaracena, I. M., and Porras-Soriano, A. Spanish Journal of Agricultural Research 4(3):207-212. 2006.

**122. Molecular characterization of *Fusarium oxysporum* and *Fusarium commune* isolates from a conifer nursery.** Stewart, J. E., Kim, M.-S., James, R. L., Dumroese, R. K., and Klopfenstein, N. B. Phytopathology 96:1124-1133. 2006.

**123. New technologies for pest management.** Wainwright-Evans, S. American Nurseryman 204(11):19-22, 24. 2006. Highlights some recent developments such as nematodes for black vine weevils, ladybugs that won't leave, mite destroyers, beneficial thrips, predatory mites, new insecticides Safari, BotaniGard, TriCon, and Shuttle, and pheromones.

**124. Pests can be unintentionally spread in New Zealand through commercial transport of nursery plants.** McNeill, M., Proffitt, J., and Phillips, C. International Plant Propagators' Society, combined proceedings 2005, 55:198-207. 2006.

**125. *Phomopsis* and sudden oak death: a tale of two nursery nuisances.** Moltzan, B. D. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.141-142. 2006.

**126. © Port-Orford-cedar resistant to *Phytophthora lateralis*.** Oh, E., Hansen, E. M., and Sniezko, R. A. Forest Pathology 36(6):385-394. 2006.

**127. © Potential climatic suitability for establishment of *Phytophthora ramorum* within the contiguous United States.** Venette, R. C. and Cohen, S. D. Forest Ecology and Management 231(1-3):18-26. 2006.

**128. © Risk from *Sirococcus conigenus* to understory red pine seedlings in northern Wisconsin.** Bronson, J. J. and Stanosz, G. R. Forest Pathology 36(4):271-279. 2006.

**129. © Role of monoterpenes in *Hylobius abietis* damage levels between cuttings and seedlings of *Picea sitchensis*.** Kennedy, S., Cameron, A., Thoss, V., and Wilson, M. Scandinavian Journal of Forest Research 21 (4):340-344. 2006.

**130. Strawberry nurseries: summaries of alternatives and trials in different geographic regions.** Porter, I., Mattner, S., Mann, R., and Gounder, R. Acta Horticulturae 708:187-192. 2006.

**131. © Structure-activity relationships of benzoic acid derivatives as antifeedants for the pine weevil,**

***Hylobius abietis*.** Unelius, C. R., Nordlander, G., Nordenhem, H., Hellqvist, C., Legrand, S., and Borg-Karlson, A.-K. Journal of Chemical Ecology 32 (10):2191-2203. 2006.

**132. © Survival and vitality of *Gremmeniella abietina* on *Pinus sylvestris* slash in northern Sweden.** Witzell, J., Bernhold, A., and Hansson, P. Forest Pathology 36 (6):406-412. 2006.

**133. Survival of *Phytophthora ramorum* compared to other species of *Phytophthora* in potting media components, compost, and soil.** Linderman, R. G. and Davis, E. A. HortTechnology 16(3):502-507. 2006.

**134. © Use of selenate-resistant strains as markers for the spread and survival of *Botrytis cinerea* under greenhouse conditions.** Korolev, N., Katan, T., and Elad, Y. Phytopathology 96(11):1195-1203. 2006.

**135. Variability associated with suppression of gray mold (*Botrytis cinerea*) on geranium by foliar applications of nonaerated and aerated compost teas.** Scheuerell, S. J. and Mahaffee, W. F. Plant Disease 90 (9):1201-1208. 2006.

**136. Weed and pest control in nursery production and their impact on plant quality.** Losing, H. IN: Plant quality: a key to success in forest establishment, proceedings of the COFORD conference, 2005, p.21-23. 2006.

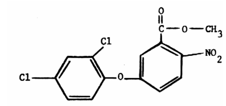
**137. What's new in bug control?** Cloyd, R. A. Greenhouse Management and Production 26(10):49-50, 52, 54. 2006. Gives details on Celero, Aria, Judo, Safari, TriCon, Overture.

**138. What you need to know about *P. ramorum*.** Mickelbart, M. V. and Beckerman, J. American Nurseryman 204(10):20-23. 2006.

**139. What you need to know about viruses.** Yoshimura, M. A. International Plant Propagators' Society, combined proceedings 2005, 55:459-461. 2006.

**140. All in the family.** Pottorff, L. American Nurseryman 204(5):21-22, 24. 2006. A plant pathologist takes us back to the classroom because knowing what family a particular insecticide belongs to helps growers and landscapers use each material more effectively.

## Pesticides



**141. © Foliar deposition and off-target loss with different spray techniques in nursery applications.** Zhu, H., Derksen, R. C., Guler, H., Krause, C. R., and Ozkan, H. E. Transactions of the ASABE 49(2):325-334. 2006.

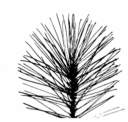
**142. New ethylene absorbents: no miracle cure.** Reid, M. and Dodge, L. Perishables Handling Newsletter 83:8. 1995.

## Seedling Harvesting And Storage

**143. © Overwinter storability of conifer planting stock: operational testing of fall frost hardiness.** L'Hirondelle, S. J., Simpson, D. G., and Binder, W. D. New Forests 32(3):307-321. 2006.

**144. Applying the target plant concept to nursery stock quality.** Landis, T. D. and Dumroese, R. K. IN: Plant quality: a key to success in forest establishment, proceedings of the COFORD conference, 2005, p.1-9. 2006.

## Seedling Physiology And Morphology



**145. © Chill unit models and recent changes in the occurrence of winter chill and spring frost in the United Kingdom.** Sunley, R. J., Atkinson, C. J., and Jones, H. G. Journal of Horticultural Science and Biotechnology 81(6):949-958. 2006.

**146. Chlorophyll fluorescence: what it is and what do the numbers mean?** Ritchie, G. A. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.34-43. 2006.

**147. © Critical night length for bud set and its variation in two photoperiodic ecotypes of *Betula pendula*.** Vihera-Aarnio, A., Hakkinen, R., and Junttila, O. Tree Physiology 26(8):1013-1018. 2006.

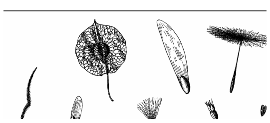
**148. The effects of lifting and handling on plant quality: the Ontario perspective.** Colombo, S. IN: Plant quality: a key to success in forest establishment, proceedings of the COFORD conference, 2005, p.39-46. 2006.

**149. © Foliar application of $GA_3$ during terminal long-shoot bud development stimulates shoot apical meristem activity in *Pinus sylvestris* seedlings.** MacDonald, J. E. and Little, C. H. A. Tree Physiology 26 (10):1271-1276. 2006.

**150. © Geographic and seasonal variation in cold hardiness of whitebark pine.** Bower, A. D. and Aitken, S. N. Canadian Journal of Forest Research 36(7):1842-1850. 2006.

**151. © Influence of nutrient supply and water vapour pressure on root architecture of Douglas-fir and western hemlock seedlings.** Conlin, T. S. S. and van den Driessche, R. Functional Plant Biology 33(10):941-948. 2006.

## Seeds



**152. Morphology, physiology, survival, and field performance of containerized coastal Douglas-fir seedlings given different dormancy-induction regimes.** MacDonald, J. E. and Owens, J. N. HortScience 41 (6):1416-1420. 2006.

**153. Assessing viability of northern red oak acorns with X-rays.** Goodman, R. C., Jacobs, D. F., and Karrfalt, R. P. Native Plants Journal 7(3):279-283. 2006.

**154. © Effects of different pretreatments on the germination of different wild cherry (*Prunus avium* L.) seed sources.** Esen, D., Yildiz, O., Cicek, E., Kulac, S., and Kutsal, C. Pakistan Journal of Botany 38(3):735-743. 2006.

**155. © Effects of drought stresses induced by polyethylene glycol on germination of *Pinus sylvestris* var. *mongolica* seeds from natural and plantation forests on sandy land.** Zhu, J., Kang, H., Tan, H., and Xu, M. Journal of Forest Research 11(5):319-328. 2006.

**156. © Germination and seedling growth of *Quercus vulcanica*: effects of stratification, desiccation, radicle pruning, and season of sowing.** Tilki, F. and Alptekin, C. U. New Forests 32(3):243-251. 2006.

**157. © Mistakes in germination ecology and how to avoid them.** Baskin, C. C., Thompson, K., and Baskin, J. M. Seed Science Research 16(3):165-168. 2006.

**158. Pressure-time dependency of vacuum degassing as a rapid method for viability assessment using tetrazolium chloride: a comparative study of 17 *Pinus* species.** Daws, M. I., Cousins, C., Hall, J., and Wood, C. B. Seed Science and Technology 34(2):475-483. 2006.

**159. Reaping what you sow -- seeds and plant quality.** O'Reilly, C. and Doody, P. IN: Plant quality: a key to success in forest establishment, proceedings of the COFORD conference, 2005, p.11-20. 2006.

**160. Some common misconceptions about seed dormancy.** Geneve, R. L. International Plant Propagators' Society, combined proceedings 2005, 55:327-330. 2006.

**161. The USDA Forest Service National Seed Laboratory.** Karrfalt, R. P. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.115-118. 2006.

**162. Using x-ray image analysis to assess the viability of northern red oak acorns: implications for seed handlers.** Goodman, R. C., Jacobs, D. F., and Karrfalt, R. P. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.143-146. 2006.

## Soil Management and Growing Media

Peat Moss
Selected Canadian Sphagnum

**163. © Alleviation of soil compaction: requirements, equipment and techniques.** Spoor, G. Soil Use and Management 22(2):113-122. 2006.

**164. The art of soil mediums.** Rafter, D. Digger 50 (8):143-147. 2006.

**165. Container no-brainer.** Altland, J. Digger 50 (11):24, 26-27. 2006. The physical properties of substrates play a big part in crop health and costs.

**166. The development of sustainable growing media components from composted specific bio-waste streams.** Bragg, N., Brocklehurst, T. F., Smith, A. C., Bhat, M., and Waldron, K. W. International Plant Propagators' Society, combined proceedings 2005, 55:256-258. 2006.

**167. An insight into an accredited potting mix supplier in Australia.** Windrim, S. International Plant Propagators' Society, combined proceedings 2005, 55:73-74. 2006.

**168. © Kenaf (*Hibiscus cannabinus* L.) core and rice hulls as components of container media for growing *Pinus halepensis* M. seedlings.** Marianthi, T. Bioresource Technology 97(14):1631-1639. 2006.

**169. A tricky topic: research suggests it's best to aim low when managing substrate pH.** Altland, J. Digger 50(12):42-44, 46-47. 2006.

**170. Use of paper-mill sludges and municipal compost in nursery substrates.** Chong, C. and Purvis, P. International Plant Propagators' Society, combined proceedings 2005, 55:428-432. 2006.

## Tropical Forestry and Agroforestry

**171. © Achieving conservation objectives through production forestry: the case of *Acacia koa* on Hawaii Island.** Pejchar, L. and Press, D. M. Environmental Science and Policy 9(5):439-447. 2006.

**172. Can lessons from the Community Rainforest Reforestation Program in eastern Australia be learned?** Vanclay, J. K. International Forestry Review 8(2):256-264. 2006. Offers a brief overview and attempts to compile a "lessons learned" synthesis that is lacking from the book "Reforestation in the Tropics and Subtropics of Australia".

**173. Evaluation of seedling quality and planting tools for successful establishment of tropical hardwoods.** Mexal, J. G., Negreros-Castillo, P., Cuevas Rangel, R. A., and Moreno, R. International Plant Propagators' Society, combined proceedings 2005, 55:524-530. 2006.

**174. Macropropagation of *Shorea guiso* using stem cuttings.** Patricio, H. P., Castaneto, Y. T., Vallesteros, A. P., and Castaneto, E. T. Journal of Tropical Forest Science 18(3):198-201. 2006.

**175. © Prioritization of target areas for rehabilitation: a case study from West Kalimantan, Indonesia.** Marjokorpi, A. and Otsamo, R. Restoration Ecology 14 (4):662-673. 2006.

**176. © Rehabilitating degraded forest land in central Vietnam with mixed native species plantings.** McNamara, S., Tinh, D. V., Erskine, P. D., Lamb, D., Yates, D., and Brown, S. Forest Ecology and Management 233 (2-3):358-365. 2006.

## Vegetative Propagation and Tissue Culture

**177. Collecting dormant hardwood cuttings for western riparian restoration projects.** Luna, T., Dumroese, R. K., and Landis, T. D. USDA Forest Service, Technology & Development Program 0624-2332-MTDC. 8 p. 2006.

**178. © Container type and volume influences adventitious rooting and subsequent field growth of stem cuttings of loblolly pine.** LeBude, A. V., Goldfarb, B., Blazich, F. A., Wright, J. A., Cazell, B., Wise, F. C., and Frampton, J. Southern Journal of Applied Forestry 30 (3):123-131. 2006.

**179. Correlation of growing degree days and the timing of cuttings.** Barnes, H. W. International Plant Propagators' Society, combined proceedings 2005, 55:386-392. 2006.

**180. Grafting of *Acacia koa* Gray onto young *Acacia* seedlings.** Nelson, S. C. Native Plants Journal 7(2):137-140. 2006.

**181. Influences of cutting diameter and soil moisture on growth and survival of black willow, *Salix nigra*.** Greer, E., Pezeshki, S. R., and Shields, F. D., Jr. Journal of Soil and Water Conservation 61(5):311-323. 2006.

**182. Methods and techniques to improve root initiation of cuttings.** Crawford, M. International Plant Propagators' Society, combined proceedings 2005, 55:581-585. 2006.

**183. Optimizing the water relations of cuttings during propagation.** Davies, F. T., Jr. International Plant Propagators' Society, combined proceedings 2005, 55:585-592. 2006.

**184. The role of clonal propagation in forestry and agriculture in Australia.** Radke, P. International Plant Propagators' Society, combined proceedings 2005, 55:96-99. 2006.

**185. Severe cutback of stock plant influences rooting in shoots of *Quercus bicolor* and *Quercus macrocarpa*.** Amissah, N. and Bassuk, N. International Plant Propagators' Society, combined proceedings 2005, 55:436-438. 2006.

**186. Somatic embryo development in willow oak.** Wells, S., Kester, S. T., and Geneve, R. L. International Plant Propagators' Society, combined proceedings 2005, 55:451-453. 2006.

**187. Stacked propagation: a new way to grow native plants from root cuttings.** Dreesen, D. R., Landis, T. D., and Pinto, J. R. Native Plants Journal 7(3):286-292. 2006.

**188. Successfully propagating cuttings takes planning.** Runkle, E. S. Greenhouse Management and Production 26(8):92-93. 2006.

## Water Management and Irrigation

**189. Avoid irrigation system design flaws.** Merrill, L. and Konjoian, P. Greenhouse Management and Production 26(9):66-68, 70, 72, 74-75. 2006. The challenges of cleaning a contaminated irrigation system have more to do with plumbing and design than with algae and microbial growth.

**190. Challenges and opportunities for extension educators involved in best management practices.** Simonne, E. H. and Ozores-Hampton, M. HortTechnology 16(3):403-407. 2006.

**191. Evaluating an irrigation system upgrade.** Messina, J. International Plant Propagators' Society, combined proceedings 2005, 55:136-138. 2006.

**192. Get ready for runoff regulation.** Eberly, D. Greenhouse Grower 24(12):32, 34-35. 2006.

**193. It's in the $H_2$0.** Altland, J. Digger 50(10):47, 49-51. 2006. High-quality irrigation water makes the Willamette Valley a great place to grow nursery stock.

**194. Nutrient management of nursery runoff water using constructed wetland systems.** Taylor, M. D., White, S. A., Chandler, S. L., Klaine, S. J., and Whitwell, T. HortTechnology 16(4):610-614. 2006.

**195. Some problems in water recycling.** Leach, S. International Plant Propagators' Society, combined proceedings 2005, 55:128-131. 2006.

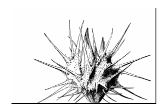
**196. Sprinkler uniformity in greenhouses and nurseries.** Savory, P. International Plant Propagators' Society, combined proceedings 2005, 55:206-207. 2006.

**197. Water disinfecting techniques for plant pathogen control.** Yiasoumi, W. International Plant Propagators' Society, combined proceedings 2005, 55:138-141. 2006.

**198. Water recycling: how we do it.** Deckys, E. International Plant Propagators' Society, combined proceedings 2005, 55:53-55. 2006.

**199. Water saving, more than just recycling.** Heyne, G. International Plant Propagators' Society, combined proceedings 2005, 55:131-136. 2006.

## Weed Control



**200. Basamid G for weed control in forest tree nurseries.** Muckenfuss, A. and Isaacs, B. IN: National proceedings: forest and conservation nursery associations 2005. Riley, L.E.; Dumroese, R.K.; Landis, T.D., technical coordinators. USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-43, p.119-122. 2006.

**201. Burning nettle, common purslane, and rye response to a clove oil herbicide.** Boyd, N. S. and Brennan, E. B. Weed Technology 20(3):646-650. 2006.

**202. © Effect of neem (*Azadirachta indica* A. Juss) leachates on germination and seedling growth of weeds.** Sindhu, A., Kumar, S., Sindhu, G., Ali, H., and Abdulla, M. K. Allelopathy Journal 16(2):329-334. 2005.

**203. © Effect of vegetation control on the survival and growth of Scots pine and Norway spruce planted on former agricultural land.** Jylha, P. and Hytonen, J. Canadian Journal of Forest Research 36(10):2400-2411. 2006.

**204. © Effects of full and partial clearing, with and without herbicide, on weed cover, light availability,**

**and establishment success of white ash in shrub communities of abandoned pastureland in southwestern Quebec, Canada.** Cogliastro, A., Benjamin, K., and Bouchard, A. New Forests 32(2):197-210. 2006.

**205. Effects of mulch types and concentrations of 1,3-dichloropropene plus chloropicrin on fumigant retention and nutsedge control.** Santos, B. M., Gilreath, J. P., Motis, T. N., von Hulten, M., and Siham, M. N. HortTechnology 16(4):637-640. 2006.

**206. Evaluation of quinoclamine and diuron for postemergence control of liverwort.** Newby, A. F., Gilliam, C. H., Wehtje, G. R., and Altland, J. E. International Plant Propagators' Society, combined proceedings 2005, 55:556-561. 2006.

**207. © Five-year growth responses of Douglas-fir, western hemlock, and western redcedar seedlings to manipulated levels of overstory and understory competition.** Harrington, T. B. Canadian Journal of Forest Research 36(10):2439-2453. 2006.

**208. Glyphosate-induced weed shifts.** Culpepper, A. S. Weed Technology 20(2):277-281. 2006.

**209. © Growth and development of ponderosa pine on sites of contrasting productivities: relative importance of stand density and shrub competition effects.** Zhang, J., Oliver, W. W., and Busse, M. D. Canadian Journal of Forest Research 36(10):2426-2438. 2006.

**210. © Interactions between influences of genotype and grass competition on growth and wood stiffness of juvenile radiata pine in a summer-dry environment.** Mason, E. G. Canadian Journal of Forest Research 36(10):2454-2463. 2006.

**211. Little weed, big trouble.** Altland, J. Digger 50 (9):23-24, 26-29. 2006.

**212. The natural history of soil seed banks of arable land.** Baskin, C. C. and Baskin, J. M. Weed Science 43 (3):549-557. 2006.

**213. Pick your battles: eliminating weedy cottonwood is a fight worth taking on.** Altland, J. Digger 51(1):34-36, 38-42. 2007.

**214. Pinebark mini-nuggets provide effective weed control in nursery crops grown in large containers.** Richardson, B. M., Gilliam, C. H., and Wehtje, G. R. International Plant Propagators' Society, combined proceedings 2005, 55:561-566. 2006.

**215. Practical changes to single-boom sprayers for zone herbicide applications.** Donald, W. W. and Nelson, K. Weed Technology 20(2):502-510. 2006.

**216. © Twelfth-year response of Douglas-fir to area of weed control and herbaceous versus woody weed control treatments.** Rose, R., Rosner, L. S., and Ketchum, J. S. Canadian Journal of Forest Research 36 (10):2464-2473. 2006.

# Literature Order Form

## Winter 2007

**Electronic Adobe PDF Copies** - To save the costs of copying and mailing hard copies of requested articles, we are offering a new service. You can download any of the articles listed in the New Nursery Literature section by going to the Reforestation, Nurseries, and Genetics Resources (RNGR) website: www.rngr.net. There you will have to fill out a form and then you will have access to the articles. Note that the copyright restriction still applies, but the 25 article does not so you can download as many articles as you want.

**Hard Copies** - Please fill out a separate order form for each person ordering literature. Write in the number or letter of the articles in which you are interested in the spaces at the bottom of this page. Note that we will only provide free copies of the first 25! 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: 541.858.6131
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:** ______________________

Fill in the number or letter each article from the New Nursery Literature section in the following spaces:

______ ______ ______ ______ ______ ______ ______ ______ ______ ______

______ ______ ______ ______ ______ ______ ______ ______ ______ ______

______ ______ ______ ______ ______

**RNGR Contacts**
**Contact Information for Reforestation, Nurseries, and Genetic Resources (RNGR) Team**

| Technology Transfer Services | Region of Responsibility | Who to Contact |
|---|---|---|
| Technical Assistance about Forest and Conservation Nurseries | Western US | M. Gabriela Buamscha<br>USDA Forest Service<br>Cooperative Forestry<br>PO Box 3623<br>Portland, OR 97298-3623<br>Tel: 503.808.2349<br>Fax: 503.808.2339<br>E-Mail: gbuamscha@fs.fed.us |
| National Nursery Specialist<br>Forest Nursery Notes<br>Container Tree Nursery Manual<br>Proceedings of Nursery Meetings<br>Native Plants Journal | US and International | Kas Dumroese<br>USDA Forest Service<br>1221 S. Main Street<br>Moscow, ID 83843<br>TEL: 208.883.2324<br>FAX: 208.885.2318<br>E-Mail: kdumroese@fs.fed.us |
| Technical Assistance about Tree Improvement and Genetic Resources<br><br>Technical Assistance about Forest and Conservation Nurseries | Southeastern US | George Hernandez<br>USDA Forest Service<br>Cooperative Forestry<br>1720 Peachtree Road NW, Suite 811N<br>Atlanta, GA 30367<br>TEL: 404.347.3554<br>FAX: 404.347.2776<br>E-Mail: ghernandez@fs.fed.us |
| Technical Assistance about Tree Improvement and Genetic Resources<br>Tree Planters' Notes | Northeastern US and International | Ron Overton<br>Regeneration Specialist<br>USDA Forest Service, S&PF<br>Purdue University<br>1159 Forestry Building<br>West Lafayette, IN 47907-1159<br>TEL: 765.496.6417<br>FAX: 765.496.2422<br>E-Mail: roverton@fs.fed.us |
| Technical Assistance about Tree and Shrub Seed | US and International | Bob Karrfalt<br>Director<br>National Seed Laboratory<br>5675 Riggins Mill Road<br>Dry Branch, GA 31020<br>TEL: 478.751.4134<br>FAX: 478.751.4135<br>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