Forest Nursery Notes

January 1993

This Technology Transfer Service is provided by:

USDA Forest Service
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THOUGHT FOR THE DAY

"I look on that man as happy, who, when there is a question of success, looks into his own work for a reply"

-Ralph W. Emerson

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FNN Mailing List

After removing non-respondents and adding new contacts, we still have over 1,000 people on the mailing list. The cost of providing this service is substantial, and so we will be periodically evaluating the status of each listing. The easiest way to maintain your active status is to return the Literature Order Form that comes with each issue of FNN. Even if you don't want to order any articles, please fill out the Form and return it. You don't have to fill out all the information on the form if it hasn't changed from the last issue, but please note and highlight any permanent address changes. IF WE HAVEN'T HEARD FROM YOU WITHIN THE PAST YEAR (FOUR ISSUES OF FNN), THEN YOU WILL AUTOMATICALLY BE PURGED FROM THE LIST!!

USDA Forest Service subscribers--please indicate your DG mailing address on the Literature Order Form, so that we can communicate by computer.

Nursery Meetings

The fifth biennial Northern Container Nursery Association meeting will be held in Chisolm, MN on ***Feb. 9-10, 1993***. The meeting will be jointly hosted by the Iron Range Resources and Rehabilitation Board (IRRRB) Mineland Reclamation Division and Itasca Greenhouse, Inc. The technical agenda consists of a wide variety of container propagation subjects and should stimulate some good discussion. In addition, a field trip to the 3 container nurseries are scheduled: the state-of-the-art IRRRB production growth chamber, Itasca greenhouse (heated by waste heat), and the hybrid aspen greenhouse at the Aspen/Larch Cooperative. For last minute details, contact:

Dan Jordan IRRRB
P.O. Box 392
Chisolm, MN 55719
(218) 254-3369

The 12th Annual Western Forest Nursery Pathologists' Workshop will be held at the Pacific Forestry Centre in Victoria, BC on ***Feb. 22-24, 1993***. Rooms have been reserved at the Imperial Inn Hotel--let them know that you are with the nursery group to receive the preferred rate. On the first day, attendees will give brief presentations on their recent work followed by discussion and questions. The morning of the second day will be devoted to formal presentations, followed by a field trip to MacMillan Bloedel's McBean Nursery in the afternoon. The formal presentations will be wrapped-up on the morning of the third day.

Technical Agenda
Jack Sutherland/John Dennis
Pacific Forestry Centre
506 W. Burnside Road
Victoria, BC
CANADA V8Z 1M5
PHONE: (604) 363-0600

Accommodations
Imperial Inn
1961 Douglas Street
Victoria, BC
CANADA V8T 4K7
PHONE: (604) 382-2111

The Fourth International Symposium on Windbreaks and Agroforestry is scheduled for ***July 26-39, 1993*** in Hedeselskabet, Viborg in Denmark. The main theme for the meeting will be how agroforestry can contribute to future energy supplies and improve the environment. Nurseries are specifically mentioned in the program. Viborg is an ideal location for the symposium because it is the headquarters for the Danish Land Development Service and the Agricultural School. If you would like to present a volunteer paper or poster, or just want more information, write to the following address:

4th International Symposium
Hedeselskabet
P.O. Box 110
DK-8800, Viborg
DENMARK

The only nursery workshop in the US this summer will feature ***a special joint meeting of the Northeastern Area Nurseryman's Association, the Intermountain Conservation Nursery Association, and the Midcontinental Nursery Pathologists***. The technical sessions will be held at a convention center in St. Louis, MO on ***August 2-5, 1993*** and will feature focus topics on Soils, Organic Matter Management, Integrated Pest Management/Biocontrol, and General Nursery Topics. Field trips to the George O. White State Forest Nursery, and a variety of local tours are interspersed throughout the program. Call me about the technical sessions or, for information on local arrangements, contact:

Bill Yoder
George O. White State Nursery
Route 2, Box 465
Licking, MO 65542

(314) 674-3229

The Third North American Agroforestry Conference will be held at Iowa State University in Ames, Iowa on ***August I5-18, 1993***. The theme is "Opportunities for Temperate Zone Agroforestry--Worldwide" and the agenda will include technical presentations, workshops, and field trips. Submit an abstract of 250 words or less by April I, 1993 if you would like to make a presentation. For more information, contact:

Richard C. Schultz
Dept. of Forestry
251 Bessey Hall
Iowa State University
Ames, Iowa 50011
PHONE: (515) 294-7602 FAX: (515) 294-1337

The 24th Biennial meeting of the Canadian Tree Improvement Association will be held in Fredericton, New Brunswick on ***August 17-19, 1993***. The theme for the symposium will be "Future Forests--Options and Opportunities" and the agenda will include technical sessions, workshops, and field trips. For further information, contact:

Kathy Tosh
Dept. of Natural Resources
Kingsclear Provincial Forest Nursery
RR #6 Fredericton, NB .
CANADA E313 4X7
PHONE: (506) 453-9101

In 1994, the ***Western Forest Nursery Association*** will be meeting in conjunction with the Forest Nursery Association of British Columbia in Moscow, ID. We have reserved the conference center the Best Western University Inn for the dates of ***August 15-19, 1994***. I know that it's a long way off but this will be a meeting that you won't want to miss. For more information, contact me or:

Kas Dumroese
Forest Research Nursery
University of Idaho
Moscow, ID 83843
PHONE: (208) 885-7017 FAX: (208) 885-6226

National Nursery Issues

A Cause for Optimism

Earth in the Balance--Ecology and the Human Spirit

I bought this book last summer but held off discussing it here until after the election. Now that the author, Al Gore, has been elected vice-president, I want to share some of his published philosophy on reforestation:

> *Balance at Risk, (p.* 125)--"Those lands that have been degraded frequently offer some of the best opportunities for restoration of the environment in a way that not only halts the destruction but reverses it and begins the process of recovery. Specifically, reforestation programs offer one of the most accessible and effective strategies for removing carbon dioxide from the environment, halting soil erosion, and restoring habitats for living species."
>
> *A Global Marshall Plan, (pp.* 323-324)--"A strategic initiative to plant billions of trees throughout the world, especially on degraded lands, is one of the most easily understandable, potentially popular, and ecologically intelligent efforts on which the Global Marshall Plan should concentrate. The symbolism--and the substantive significance--of planting a tree has universal power in every culture and every society on earth, and it is a way for individual men, women, and children to participate in creating solutions for the environmental crisis. But for a tree planting program to be truly successful, two other tasks must be performed, one preceding the planting and the other following it. First, the seedling must be both genetically appropriate for its particular ecological niche and available in adequate numbers at the right times and in the right places. Second, whatever incentives are used to encourage the planting of trees must be keyed, not to the planting itself, but to the appropriate follow-up visits to ensure the survival of the seedling with adequate water and protection from grazing animals until it is sufficiently well established to grow on its own."
>
> *The US Role in the Global Marshall Plan--Point #7,* (p. 351)--"Tree planting programs--with carefully selected seedlings appropriate to the areas being planted and careful follow-up to ensure tree survival--should be part of workfare programs in communities where work requirements are attached to welfare payments. Similarly, tree planting projects should be given higher priority in summer jobs programs for teenagers."

Well, I think that you can see that the vice-president elect has some very definite and enlightened opinions about the benefits of tree planting. In particular, I was encouraged to read that he understands the importance of using source--identified, locally-adapted seedlings. Other government tree planting programs often become obsessed with the number of seedlings that are planted with little concern about the use of appropriate stock. The other thing that caught my eye is that the stated measure of outplanting success is a free-to-grow tree--a concept that many well-meaning people fail to appreciate. Granted, these are only opinions but I feel hopeful just knowing that someone of Al Gore's political stature has an appreciation of these important concepts. Now, all we have to do is wait and see if these ideas will be translated into national policy.

Reference: Gore, A. 1992. *Earth In the Balance: Ecology and the Human Spirit.* New York, Houghton Mifflin Company. 407 p.

Pine Shoot Beetle Quarantine

A scolytid beetle (*Tomicus pipiperda* L.), commonly known as the pine shoot beetle, was found on a Christmas tree farm in Ohio In July of this year. Entomologists from APHIS (Animal and Plant Health Inspection Service) believe that this insect pest was brought in from Europe on dunnage. The pine shoot beetle is the most destructive pest of pines in Europe and poses an extreme threat to urban and timber trees as well as Christmas trees and nursery stock. As of mid-November, the pest had been confirmed in northeastern Ohio, north central Illinois, northern Indiana, southern Michigan, northwest Pennsylvania, and western New York state. As of Nov. 13, 1992, federal and state quarantines of these areas are in effect but the full impact of these quarantines is unknown at this time. Nursery stock grown in enclosed greenhouses and seedlings less than 24 inches in height can be visually inspected, but no inspection procedure has been approved for larger ornamental plants and Christmas trees. For more information, contact:

Milton C. Holmes
USDA, APHIS, PPQ
Federal Building, Rm 642
6505 Belerest Road
Hyattsville, MD 20762
PHONE: 301-436-8247

Methyl Bromide Update

The American Association of Nurserymen reports that the U.S. Environmental Protection Agency has proposed that methyl bromide be listed as a Class I Ozone Depleting Substance under the Clean Air Act. If approved, then methyl bromide production would not increase beyond 1992 levels and would eventually be phased-out by the year 2000. See the April-October, 1992 issues of FNN for more background information. It remains to be seen, but this proposal will probably be received more favorably under the Clinton/Gore administration than it was under President Bush.

Reference: Update--Dec. 14, 1992. Washington, DC: American Association of Nurserymen.

Ecological Alternatives

Those of you who have suffered through one of my training sessions may have heard me refer to tree seedlings as a "root crop". Granted, this stretches the standard horticultural definition to the breaking point but I'm trying to make you think. The true value of a tree seedling is reflected by it's ability to form new roots and become established on the outplanting site--often under harsh environmental conditions. Root growth potential is widely considered to be one of the primary measures of seedling quality and so any product which could be applied to the root system to stimulate new root growth would be of great value. Well, several new organic root-promoting substances are now on the market.

Organic root treatments

The trend away from synthetic products and towards more "natural" materials has reached the nursery:

Rhizopon

In January, 1992 issue of FNN I mentioned this product in the Nursery Products and Services section. Rhizopon is an organic root treatment used to induce rooting on cuttings, and is also reported to stimu-

late the development of new roots on transplanted nursery stock. Rhizopon has been used on many species of ornamental plants around the world and the US distributor, Hortus USA, would like to try their product on forest and conservation species. If you would like a trial supply of Rhizopon, contact Joel Kroin at the following address:

Hortus USA
245 West 24th St.
New York, NY 10011-1717
PHONE (212) 929-0927
FAX (212) 929-0927

Roots Concentrate®

At a nursery meeting in Montana last fall, Bill Sayward told me about this product which is another root promoting product that was developed at the Yale School of Forestry. Roots Concentrate is called "an organic biostimulant" that is a combination of several different extracts such as peat humus and kelp. When applied as a drench or soak to seedling root systems, it is supposed to increase root activity and stimulate new root growth. The promotional literature cites 45 research studies that support its efficacy and, of particular interest to us, treated seedlings have performed better on stressful outplanting sites. Bill says that he has tested Roots Concentrate in his own greenhouse and has observed improved root development. Several of his customers have also experienced positive results after outplanting. Bill is also a distributor for this product, so contact him at:

Itasca Greenhouse, Inc.
P.O. Box 273
Cohasset, MN 55721
PHONE: (218) 328-6261
OUTSIDE MN: (800) 538-8733

Vitamin B- I (Thiamine hydrochloride)

Vitamin B-1 products, such as Up-Start' which is marketed by Ortho, are recommended by many gardening experts for reducing transplant shock and improving root growth and development. I can't find any technical information on the use of these products in any of my plant propagation references. So, in the spirit of good investigative journalism, I bought a bottle but I won't have the opportunity to try it out in the garden until next spring.

My Humble Opinion

I am always skeptical about any product that purports to produce amazing results, and am reminded of the "snake oil" health remedies were so common in times past. My major objection to any miracle product is that growers will try to use it as a substitute for good cultural practices or to correct an existing root disease condition. To be completely fair, however, I am maintaining an open attitude. I'd like to hear from any of your who have used any of these organic root promoting products, and hope somebody will test them in their nursery. A good double-blind experiment that evaluates both root growth potential and outplanting performance shouldn't be too difficult to set-up.

Notable Publications

The following publications are featured here because they are of special interest to nursery folks. If you would like a copy, there are two different ordering procedures. *Numbered or Lettered* publications can be requested by circling the appropriate listing on the Literature Order Form and returning it to me. *Special Order (SO)* publications are either too long or too expensive for us to provide free copies, but prices and ordering instructions are provided here and following the individual listings in the New Nursery Literature section.

SO ***Methods of applying herbicides***. McWhorter, C.G.; Gebhardt, M.R. Monograph No. 4. Champaign, IL: Weed Science Society of America. 358 p. 1987.

This hardbound book is advertised as "the most comprehensive monograph ever published on methods of applying herbicides" and I have to agree. The 22 chapters document current herbicide application methods and also present the potential for future technology. Chapter 6--Spray Application Technology--is particularly well-written and informative. It discusses types of nozzles, pumps, and sprayers and has many informative tables and illustrations. Other chapters include: Relationship of plant morphology to herbicide application and absorption, Wiper application, Protective apparel, and Effect of weather factors on the application of herbicides.

COST: $ 35.00
ORDER FROM:
Weed Science Society of America
309 W. Clark St.
Champaign, IL 61820

SO ***Currently registered pesticides for use in tree nurseries in the Pacific Northwest.*** Hildebrand, D.M.; Smith, G.K. Publication No. R6-93-01. USDA Forest Service, Pacific Northwest Region. 69 p. 1992.

This handy spiral-bound report is organized into 6 chapters: Animal repellents, Fungicides, Herbicides, Insecticides, Soil fumigants, and Surface Treatments. The listings for each pesticide entry include chemical properties, pests controlled, chemical characteristics, and operational considerations. As the title states, these products are only registered for forest nursery crops in the Northwest US, but growers in other regions will also find the publication very useful. You are all painfully aware of the myriad pesticide restrictions and differences in label terminology so please contact your local pest specialist before using any chemical.

COST: Free
ORDER FROM:
USDA Forest Service
Forest Pest Management
P.O. Box 3623
Portland, OR 97208-3623
PHONE: (503) 326-2728 FAX: (503) 326-5569

SO ***Proceedings, Southern Forest Nursery Association Conferences.*** Branan, J.; Moorhead, D. comp. 1992 July 20-23; Pine Mountain, GA. Macon, GA: Georgia Forestry Commission. 136 p. 1992.

This publication contains 14 papers on all aspects of nursery culture in the southern US as well as abstracts from 7 posters. I was particularly interested in the articles on hardwood propagation: seed treatments, seedling culture, and effects of nursery practices on root morphology. Articles on alternative treatments to methyl bromide fumigants, the impacts of tree improvement on nursery management, and other relevant topics fill out the proceedings.

COST: Free
ORDER FROM:
Georgia Forestry Commission
P.O. Box 819
Macon, GA 31298-4599
PHONE: (912) 744-3354

SO ***Ecophysiology of ectomycorrhizae* of *forest trees.*** Marcus Wallenberg Foundation Symposia Proceedings No. 7. 1991 Sept. 27; Stockholm, Sweden. Falun, Sweden: The Marcus Wallenberg Foundation. 1991. 90 p.

This softbound publication contains 3 classical review papers on ectomycorrhizae. The keynote paper is entitled *"The practical significance of ectomycorrhizae in forest establishment"* and was written by Don Marx, the recipient of the Wallenberg prize. The other two papers are also well written: The fungal partner in the mycorrhizal symbiosis, and The role of the mycorrhizal symbiosis in the nutrition of plant communities. In addition to valuable technical information, the book also includes some of the best color photographs of the ectomycorrhizal root systems of tree seedlings that I have ever seen.

COST: Free
ORDER FROM:
The Marcus Wallenberg Foundation
S-791 80
Falun, SWEDEN
PHONE: 46-23-80309

COME AND GET THEM! I have been going through my stock of nursery publications and would like to get rid of surplus copies. You can order a free copy of the following publications by circling the appropriate letter on the Literature Order Form. Supplies vary and so orders will be filled on a first-come, first-served basis.

A. ***How to test herbicides at forest tree nurseries.*** Sandquist, R.E.; Owston, P.W.; McDonald, S.E. Gen. Tech. Rep. PNW-127. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 1981. 24 p. (22 copies)

This classic publication describes how to properly design, lay out, and evaluate herbicide trials in bareroot nurseries. The procedures would also be applicable to other pesticide trials.

The following are Proceedings from past western nursery meetings and contain many good articles on a variety of nursery subjects. Sorry, that's not too definitive but there are too many articles to list them individually:

B. ***Proceedings of Intermountain Nurseryman's Association and Western Forest Nursery Association Combined Meeting.*** Gen. Tech. Rep. INT-109. 1980 August 12-14; Boise, ID. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 1981. 148 p. (17 copies)

This proceedings contains articles on seed and cone processing and bareroot nursery subjects including: weed control, irrigation, seedling quality, and stock handling on the outplanting site.

C. ***The Challenge* of *producing native plants for the* Intermountain areas *Proceedings:* Intermountain Nurserymen's *Association 1983 Conference.*** Murphy, P.M. comp. Gen. Tech. Rep. INT-168. 1983 August 8-11; Las Vegas, NV: USDA Forest Service, Intermountain Forest and Range Experiment Station. 1984. 96 p. (33 copies)

This meeting focused on the propagation and use of native plants, but this proceedings also contains other articles on container production and seedling quality.

D. ***Proceedings: Western Forest Nursery Council--Intermountain Nurseryman's Association Combined Meeting.*** Landis, T.D. comp. Gen. Tech. Rep. INT-185. 1984 August 14-16; Coeur d'Alene, ID. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 1985. 140 p. (11 copies)

This proceedings contains articles on a wide variety of bareroot and container nursery subjects.

E. ***Proceedings: Intermountain Nurseryman's Association Meeting.*** Landis, T.D.; Fischer, J.W. tech. coord. Gen. Tech. Rep. RM-125. 1985 August 13-15; Ft. Collins, CO. Ft. Collies, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 1986. 111 p. (15 copies)

This proceedings contains articles on three focus topics (weed control, seedling quality, and bareroot fertilization), as well as a section on general bareroot and container nursery topics.

Cultural Perspectives

Limiting Factors--Humidity

Plants need six different limiting factors for good growth, four of which are found in the ambient environment (Figure A). In the last two issues, we looked at light and temperature and so humidity is next on the list. I can hear many of you bareroot nursery folks saying, "Oh great, humidity, there's no way that I can manage that in my nursery." Well, hold on. Although container nurseries have many more opportunities, humidity can be managed in one phase of bareroot culture-refrigerated storage.

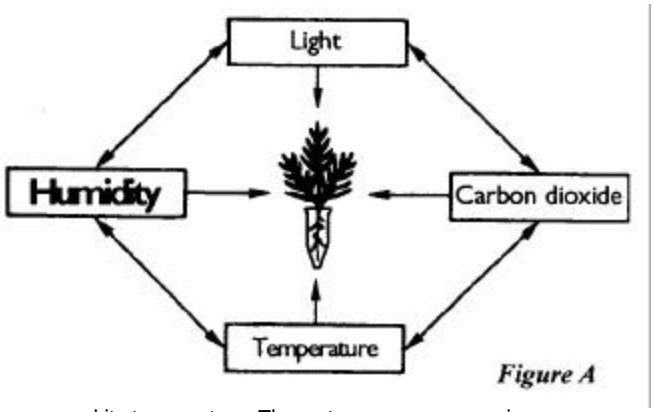


Figure A

What is humidity--pretty simple, right? Humidity is moist air: it feels hot and sticky in the summer, and cold and chilly in the winter. As you may have guessed, it's actually more complicated than that--isn't everything?

Biophysics of water vapor

Moist air can be defined as a two-component mixture of dry air and water vapor. The air and the water vapor simultaneously occupy the same space, but the water vapor acts independently of the other gases. The partial pressure of water vapor is a function of temperature and is unrelated to the total pressure of the air-water vapor mixture. So, the key to managing humidity is to realize that it is so closely tied to temperature.

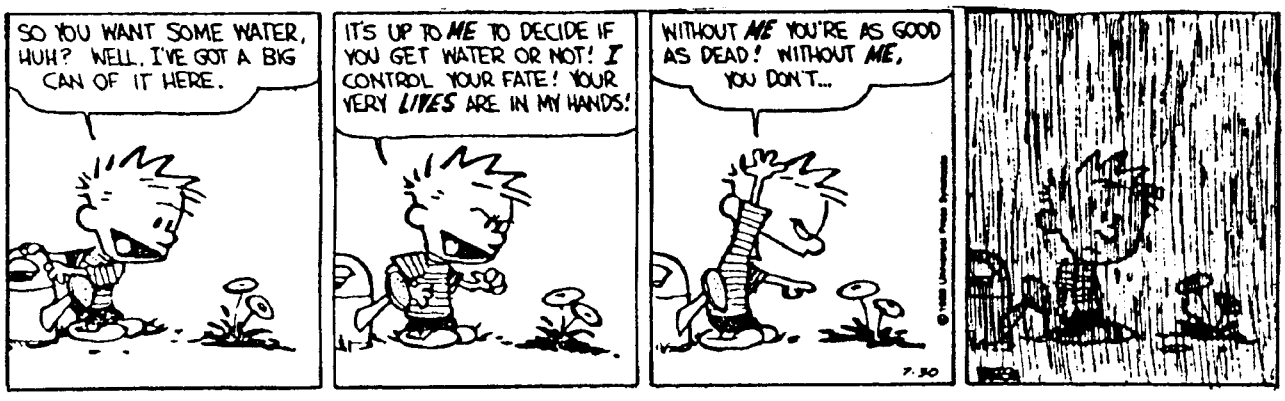
Water vapor pressure--The water vapor in a given volume of air exerts a partial pressure (e) that depends on the amount of the water vapor and its temperature. The water vapor pressure in the surrounding air is called the ambient water vapor pressure (e_a), and the vapor pressure of completely saturated air is the saturation water vapor pressure (e_s). The amount of water that the air can hold increases dramatically with temperature--the e_s approximately doubles for each 11 ° C (20° F) increase in temperature.

Water vapor pressure deficit (VPD)--The difference between the saturation water vapor pressure and the ambient water vapor pressure at the same temperature:

$$VPD = e_s - e_a$$

Dew point--The temperature at which $e_a = e_s$, and condensation occurs.

The VPD is important in horticulture because it represents the evapotranspirational demand of the surrounding atmosphere, as well as the proximity to the dew point. Therefore, growers can use the VPD to determine whether to irrigate because



seedling transpiration will be high, or whether to ventilate to avoid condensation. The dew point temperature is also handy to know because it helps growers minimize condensation which quickly leads to disease problems.

Relative humidity (RH)--Although the actual amount of water vapor in a given volume of air is called the absolute humidity, the most practical measurement of humidity is the relative humidity, RH can be defined as the ratio of the amount of moisture in a volume of air to the total amount of moisture that can be held at saturation at a given temperature and atmospheric pressure. To compute RH, the ambient water vapor pressure is divided by the saturation water vapor pressure and is expressed as a percentage: e

$$RH\ (\%) = \frac{e_a}{e_s} \times 100$$

Because both RH and VPD are related to temperature, these humidity indexes can be obtained from handy reference charts when two of the three values are known (Table 1).

Measuring humidity

It is relatively difficult to measure humidity compared to the other atmospheric variables. Relative humidity is the only measure of humidity that is routinely monitored in forest and conservation nurseries, although new environmental computer systems can now calculate vapor pressure deficit.

Any instrument that measures humidity is called a hygrometer. A psychrometer is a common type of hygrometer that consists of two adjacent temperature sensors: a dry bulb sensor that measures ambient temperature and a wet bulb sensor that is covered with an absorbent cloth. This cloth is wetted with distilled water and both sensors are ventilated with air moving at a rate of at least 3.5 m/s (12 feet per second) until the wet bulb temperature reaches a steady state. The difference in temperature between wet bulb and dry bulb sensors is known as the wet-bulb depression. Charts and tables are available for converting the wet and dry bulb temperature to relative humidity or dew point.

Three types of psychrometers are commonly used in container nurseries. The sling psychrometer (Figure B) is whirled manually in a circular motion until the wet bulb temperature stabilizes. With the aspirated psychrometer, the thermometer; remain stationary is drawn across the bulbs with a small fan. A hygrothermograph measures relative humidity as well as air temperature, and records them on a chart to document diurnal and daily trends.

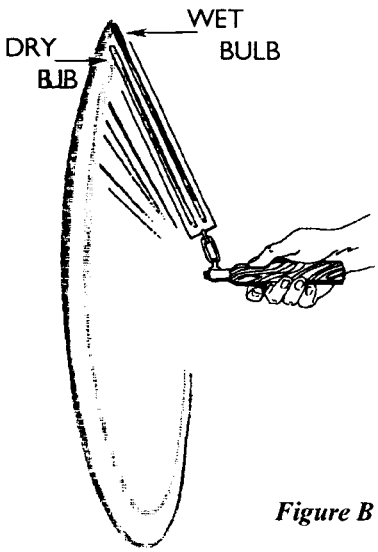
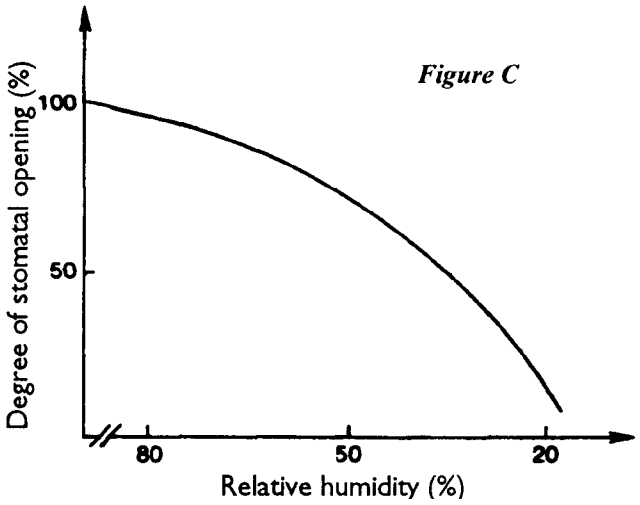


Figure B

Effects of humidity on seedling growth

Managing the proper humidity level in forest and conservation nurseries is biologically important for two reasons. First, a moderate 1-rufl-nidity level keeps the stomata open so that seedlings can photosynthesize without losing excessive amounts of water through transpiration (Figure C). This is even more important when plants are being propagated vegetatively by cuttings or grafting. Most of the transpirational water loss occurs through the stomata on the leaves, which must also remain open long enough to absorb sufficient

Figure C



carbon dioxide (C02) for photosynthesis. A moderate transpiration rate is also beneficial because it cools the leaf and keeps it near the optimum temperature for photosynthesis and other metabolic processes. Other seedling growth processes, such as cell enlargement, also depend on positive turgor pressure.

The second effect of humidity on seedling growth is indirect. Excessive humidity encourages nursery pests, especially fungal pathogens, but also algae, mosses, and liverworts. Even some insect pests, such as fungus gnats, thrive under the high humidity conditions that are often found in nurseries.

The challenge to the nursery manager is to maintain humidities that are high enough for good seedling growth but not so high as to encourage pests.

Seedling water relations--Humidity has a significant effect on evapotranspiration rates, but remember, relative humidity is controlled by temperature. Under still conditions, the rate of evaporation from a wet surface is a function of the relative humidity and temperature and is proportional to the vapor pressure deficit. At a constant temperature, the higher the relative humidity, the lower the vapor pressure deficit (Table 1). And so, under operational conditions, increasing temperature is more of a controlling factor than absolute humidity in determining evapotranspirational demand. For example, when the RH of the air decreases 30% (from 80 to 50%) and the temperature stays at 30° C (86° F), the VPD increases 2.5 times; however, if the absolute humidity remains constant and the leaf temperature increases just 101 C, from 10 to 200 C (50 to 68° F), then the VPD increases over five times.

Another less-appreciated factor affecting evapotranspiration is wind. Under calm conditions, water vapor collects near an evaporating surface, forming a boundary layer. If the humidity in the boundary layer approaches saturation, the evaporation rate will almost cease, even though the surrounding air is much drier. Wind removes the boundary layer and replaces it with drier air, thus increasing the evaporation rate. For example, if the air in the boundary layer was 20° C (68° F) with 90% RH, and it was replaced by air at the same temperature and 60% RH, the VPD would increase over fourfold--from 0.23 to 0.93 kPa (Table 1).

Vegetative propagation--Maintenance of the proper humidity is of particular concern in

Table 1—*The evapotranspirational demand, as measured by the water vapor pressure deficit, is a function of relative humidity (RH) and temperature*

Air Temp.		Vapor Pressure Deficit (kPa)										
°C	°F	0%RH	10%RH	20%RH	30%RH	40%RH	50%RH	60%RH	70%RH	80%RH	90%RH	100%RH
40	104	7.37	6.63	5.90	5.16	4.42	3.69	2.95	2.21	1.47	0.74	0.00
35	95	5.63	5.07	4.50	3.94	3.38	2.82	2.25	1.69	1.13	0.56	0.00
30	86	4.24	3.82	3.39	2.97	2.54	2.12	1.70	1.27	0.85	0.42	0.00
25	77	3.17	2.85	2.54	2.22	1.90	1.59	1.27	0.95	0.63	0.32	0.00
20	68	2.33	2.10	1.86	1.63	1.40	1.17	0.93	0.70	0.47	0.23	0.00
15	59	1.71	1.54	1.37	1.20	1.03	0.86	0.68	0.51	0.34	0.17	0.00
10	50	1.23	1.11	0.98	0.86	0.74	0.62	0.49	0.37	0.25	0.12	0.00
5	41	0.87	0.78	0.70	0.61	0.52	0.44	0.35	0.26	0.17	0.09	0.00
0	32	0.61	0.55	0.49	0.43	0.37	0.31	0.24	0.18	0.12	0.06	0.00

vegetative propagation. The transpiration rate of cuttings must be kept low for several weeks or even months so that they can maintain enough turgor to produce new roots. Special rooting environments are constructed to maintain these higher humidifies. Grafted seedlings are often kept in greenhouse conditions because the high humidifies reduce the moisture stress on the scions.

Nursery pests--Although most pathogenic fungi thrive under high humidity, certain plant pathogens particularly favor this environment. The fungus that causes grey mold is a notable example. The spores of *Botrytis cinerea* require free moisture to germinate and penetrate seedling foliage, and high humidifies are conducive to the subsequent spread of the fungus. Grey mold becomes serious in the fall when cooler temperatures cause moisture to condense on seedling foliage, especially in overly dense seedling canopies. Grey mold is also one of the most common storage molds in forest and conservation nurseries. Latent infections are often not noticed during seedling grading, and so the fungus is introduced into the storage container. Botrytis thrives in the humid, dark environment of seedling storage.

The growth of cryptogams (moss, algae, and liverworts) is stimulated by high humidifies. In extreme cases, mosses can form mats that completely prevents the infiltration of water and liquid fertilizers. Even some insect pests can be related to high humidity environments. Dark-winged fungus gnats can build up damaging populations in greenhouses that have excessive amounts of moss and algae.

Modifying Humidity in Nurseries

Bareroot nurseries have few options for modifying humidity, but can manage the microenvironment in their seedbeds by careful control of seedling spacing and irrigation rate and timing. Container nurseries with enclosed growing structures can use heating and ventilation equipment to manage humidity. The type of greenhouse covering has even been shown to affect humidity levels.

It is extremely difficult to set ideal humidity levels for nurseries because relative humidity varies so much with temperature. Optimum humidity levels change during the growing season, and are also different for seedlings and cuttings.

Seedlings-- Little formal research has been done on ideal humidity levels for nurseries. Most of our current knowledge has been obtained through experience and observation in operational container nurseries. Container growers try to keep their RH levels from 60 to 80% during the growing season, and from 45 to 50% during the hardening phase. Managing humidity is most critical during the germination period. Seeds must never be allowed to dry out and so mulches or seed coverings are commonly used. Many nurseries use light, frequent irrigation to keep the soil or growing medium "moist but not wet" to discourage damping-off. When temperatures in the growing area become excessive, many nurseries apply a fine mist to cool the seedlings. Some of the mist evaporates before reaching the ground, thus lowering the air temperature. Irrigation should be scheduled early in the day to allow time for the moisture on the seedling foliage to evaporate.

At the beginning of the Hardening Phase, many bareroot and container nursery managers curtail irrigation and induce a moderate moisture stress. Because this is difficult in container nurseries with enclosed growing structures, many nurseries move their seedlings from the greenhouse at the beginning of the hardening phase, and others remove the covering.

Vegetative propagation-- Significantly higher humidifies are required for all types of vegetative propagation compared to seedling culture. In all types of cuttings, the normal water supply has been completely severed and so water stress can quickly become severe. This problem is particularly critical with softwood cuttings, which have leaves that are still transpiring, and hardwood cuttings, which root slowly. Maintaining relative humidity values as close to 100% as possible is

desirable; once cuttings have rooted, they are gradually hardened to ambient conditions by allowing humidities to decrease. Newly grafted plants also benefit from highly humid environments until the grafts have taken and normal internal water relations have resumed.

During vegetative propagation, humidity can be increased by spraying fine droplets of water into the air. Both mist and fog systems have been used--the difference is the size of the droplet. Mist droplets are large enough to settle out in a few seconds and will wet the surfaces on which they land. Fog droplets are almost invisibly small and will remain suspended for several minutes, during which most will evaporate. When properly applied, fog will not wet seedling foliage. So, although they are considerably more expensive, fog systems are less likely to stimulate nursery pests.

Overwinter storage-- Control of humidity is very critical during the storage period, but it is a balancing act: seedlings must be kept humid enough so that they don't dry out, but not so wet that they are damaged by storage molds.

Seedlings can be stored under refrigeration (1 to 2° C) for a few months provided they are disease--free, clean, and properly packaged. Most nurseries used some sort of storage container with a moisture-retentive plastic liner, whereas others try to humidify the storage environment. The latter is much easier in theory than in practice. A recent trial showed that unbagged Sitka spruce (*Picea sitchensis)* seedlings in humidified cold storage had significantly poorer root growth potential, outplanting survival, and first-season shoot growth compared to seedlings stored in plastic bags. The cause of this difference in outplanting performance was poor humidity control--the unbagged seedlings had significantly lower root moisture content (Table 2). Also significant was the fact that the moisture loss was greatest during the first month of storage. The take-home lesson is that proper packaging maintains high in-bag humidity levels, which are much more important than the ambient humidity in the storage facility.

Storage molds get worse with time and so, for long-term storage (> 3 months), most nurseries are using freezers (-1 to -2° C). It is operationally difficult to maintain 100% humidity in freezer storage, and the physics of humidity at subfreezing temperatures is something that we really don't want to get into here. Proper packaging is even more critical for freezer storage. You all can relate to what happens to food that is kept in your frost-free refrigerator too long--it gets "freezer-burned." Bags or boxes with moisture-retentive liners have proven effective in maintaining high in-bag humidity in freezer storage.

So, there's a brief introduction to humidity and how it affects seedling growth. We've discussed light, temperature, and humidity so far, and next issue we finish-up the atmospheric limiting factors and take a look at carbon dioxide.

Table 2--*Root moisture content (RMC) and root growth potential (RGP) for Sitka spruce seedlings under three cold storage treatments at four dates during the storage period*

STORAGE TREATMENT	ASSESSMENT DATE							
	JANUARY 17		FEBRUARY 15		MARCH 15		APRIL 24	
	RMC	RGP	RMC	RGP	RMC	RGP	RMC	RGP
Humidified--Unbagged	296	4.0	127	5.3	117	2.2	62	2.6
Humidified--Bagged	342	4.5	226	4.7	225	4.7	219	5.2
Unhumidified--Bagged	352	4.5	265	5.9	234	4.2	224	4.8

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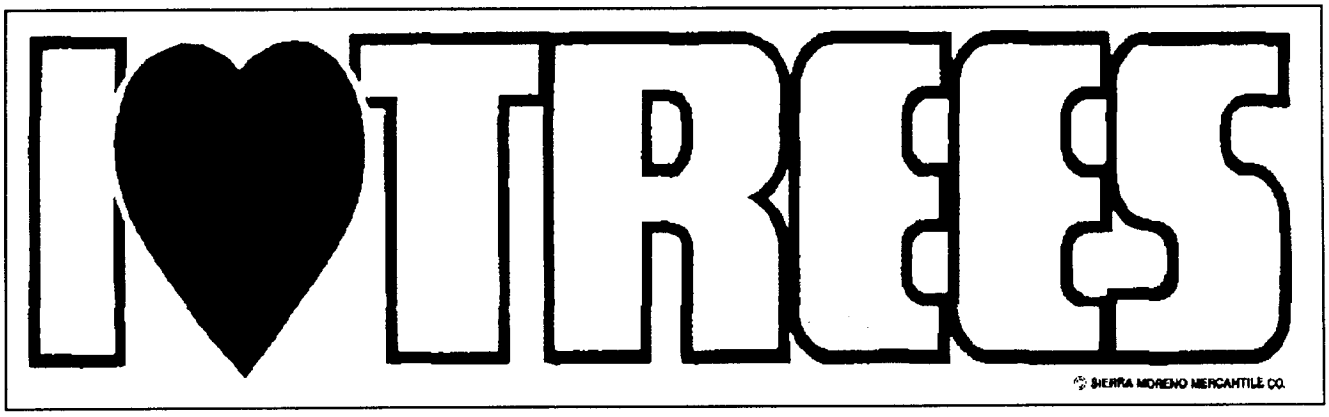


Editorial

New Year's Resolution

"One always has time enough, if one will apply it well "

- J.W. Von Goethe

One of the things that has struck me as I've talked to many of you over the past year is that everyone is just way too busy. Sure, we're all professionals and take our jobs seriously but I get the distinct feeling that the problem of time management has gotten worse for many of us.

One real threat is the increasing number of communication options nowadays. Although computer networks, FAX machines, and portable phones offer unlimited communication possibilities, they also intrude on our privacy and are annoying interruptions. Maybe it's just a sign of my advancing age, but I am finding it increasingly difficult to refocus my attention after I have been interrupted.

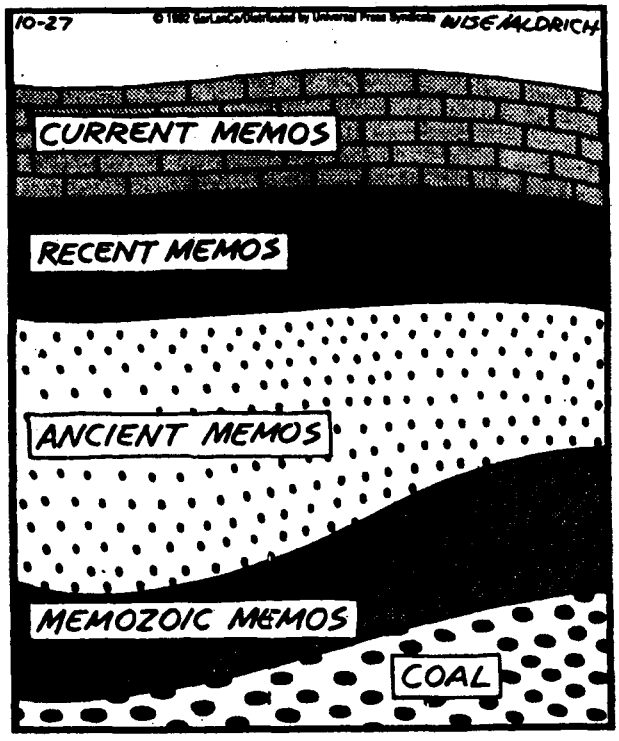
The information explosion is also to blame. I don't know about you, but I can't even begin to read all the professional magazines, notices, etc. that flood my mailbox. While reviewing journals for the New Nursery Literature Section of FNN, I make an extra copy of articles that look particularly interesting. Well, they get put in the "To Read" pile where I let them cure awhile until they go to another file or the recycling bin.

"Close enough for government work"--I'm sure that you've all heard this old adage and, being a government worker and a perfectionist, I've always taken offense at it. But, like most things, it does contain a kernel of truth. One reason that I'm usually behind schedule is that I never know when a project is good enough, and am always trying to make it better. Unfortunately, there is no end to this mode of thinking and it invariably contributes to the "not enough time" syndrome.

I know that you've heard all of this from me before (cf. "Time Management???" in FNN 07-90, and "Saying No" in FNN 04-91), so you can appreciate that the problem hasn't gotten any better. The Christmas holidays are the time of hope, however, and New Year's Resolutions are a time-honored tradition. So, let's resolve to practice better time management by:

* Continually evaluating how we spend our time
* Eliminating things that are not critical
* Devoting more time to high priority tasks
* Wrapping up projects when they reach the "acceptable" category.

Sounds good, huh? We'll see how it goes but don't be too surprised if you hear this same song again next year.



Somewhere at the bottom of your desk, old memos are being pressed into coal

New Nursery Literature

Please obtain these articles from your local forestry library or literature service if at all possible. Numbered or lettered articles can also be ordered directly through this service, using the Literature Order Form on the last page-Just circle the appropriate number or letter and return the form to me. These free copies are a technology transfer service of USDA Forest Service, State and Private Forestry.

Items bordered with asterisks (* 1 *) are copyrighted and require a fee for each copy, so you will only be sent the title page and abstract. If you desire the entire article, follow the ordering instructions that follow the abstract. Special Order (SO) articles or publications must be ordered directly from the publisher. Prices and ordering instructions follow each listing.

Bareroot Production

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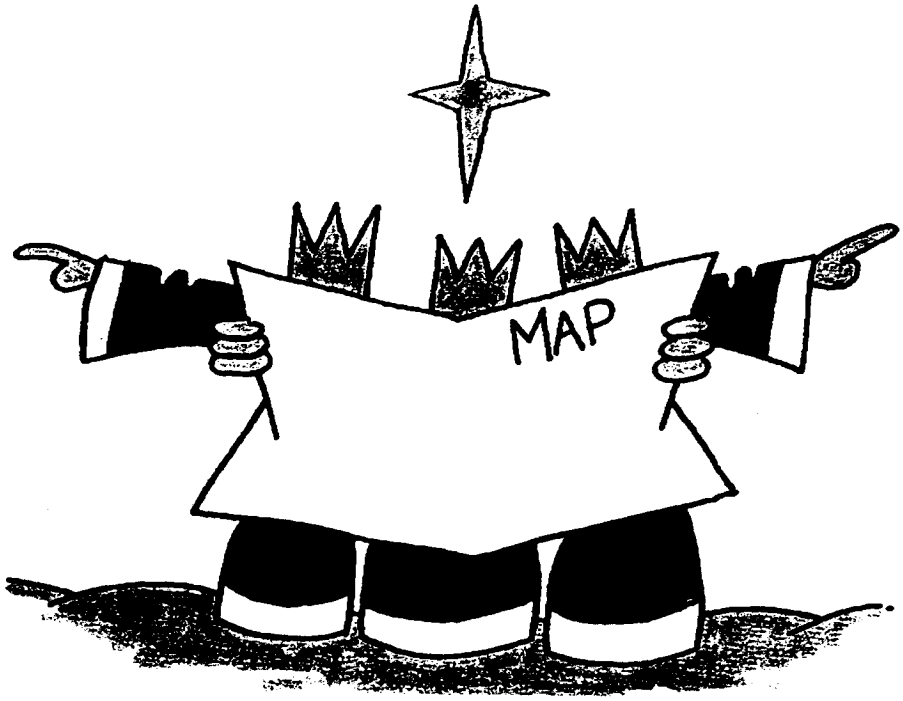

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