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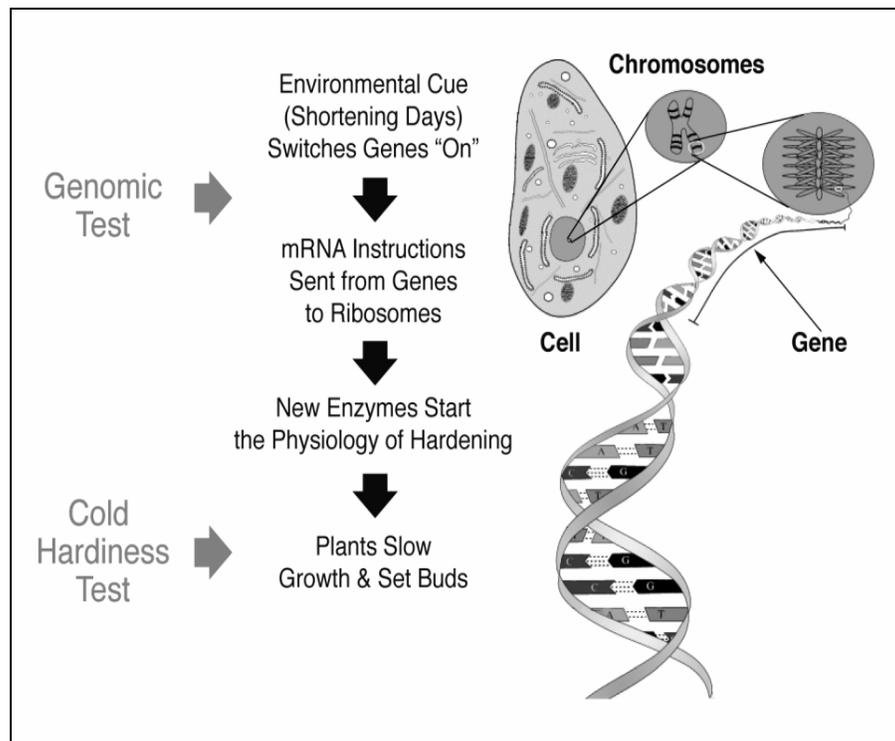
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Region

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



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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 exhibition, **Nursery Machinery 2006**, is taking place **August 17 and 18, 2006** at the Horticulture Centre in Ellerhoop, Kreis Pinneberg, Germany. Exhibition and registration forms are available at:

E-Mail: info@baumschultechnik.de
TEL: 0049.0.4101.205922
FAX: 0049.0.4101.20593
WEB: www.baumschultechnik.de
www.nurserymachinery.com

The 26th Annual Meeting and Conference of the **Forest Nursery Association of British Columbia** will be held September 18 to 20, 2006 at the Penticton Lakeside Resort Convention Centre and Casino in Penticton, BC.

For conference information please contact:

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For registration information please contact:

FNABC 2006
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The **5th Eastern Native grass Symposium** is scheduled for **October 10-14, 2006** at the Holiday Inn Conference Center in New Cumberland, PA. This meeting will be a great opportunity to meet and network with others who are growing, planting or managing native grasses. The comprehensive agenda includes over 50 oral presentations, 30 posters, and several field trips. You can save \$50 by registering before September 1. To view the latest agenda and motel registration information, go to:

<http://www.pa.nrcs.usda.gov/engs.html>

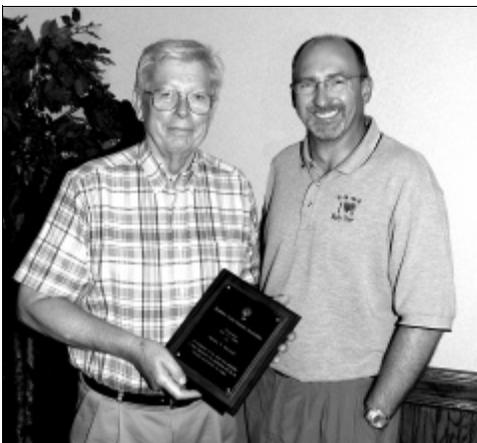


Photo by AL Myatt

Dr. James P. Barnett (left) received a life-time achievement award from the Southern Forest Nursery Association during their bi-annual meeting held in Tyler, Texas, July 10–13, 2006. Dr. Barnett was recognized for more than four decades of scientific research as a USDA Forest Service employee. Jim dedicated his career to enhancing seed germination and nursery practices toward improved reforestation and afforestation success of southern pines in the southeastern United States, and was recognized as an international authority on nurseries and regeneration. The award was presented by Kas Dumroese, a scientist in Jim's research project.

In recognition of his vision and leadership in Forest Regeneration his contributions will live on through generations to come.

Seedling Quality Testing at the Gene Level

By Thomas D. Landis and Monique F. van Wordragen

Nursery managers are all too familiar with the critical importance of determining the proper lifting window for nursery stock. Plants that are harvested too early are damaged during the lift-and-pack process and also store poorly. Currently, the best physiological test for determining the lifting window is to measure cold hardiness by the whole plant freezing or electrolyte leakage tests. For example, conifer nurseries in British Columbia use 0 °F (-18 °C) as the hardiness level when it is safe to begin harvesting. While these cold hardiness tests are useful, they typically take one to several weeks to produce results and a series of tests must be done during the fall to track cold hardiness development. Wouldn't it be great if there were a quick and accurate test to determine exactly when the cold hardiness process started?

Genomic Testing— Genomics, or gene-expression analysis, is a relatively new discipline that allows us to look inside plant tissues at the chemical signals that trigger specific physiological events such as the development of cold hardiness (Figure 1). In living organisms, each developmental step and every interaction with the environment is orchestrated by DNA encoded genes. Therefore, the physiological condition of a plant can be determined by analyzing the activity profile of its genes.

Sounds great, but the trick is to identify which gene or genes are involved in the cold hardiness process. Gene expression analysis uses microarrays or biochips to simultaneously examine thousands of genes from a sample of plant tissue and determine their level of activity. In this way, plant response to environmental cues can be closely examined and this information used to identify the genes that are involved in hardening. Once these indicator genes have been identified, then a chemical assay can be developed to measure their activity. Changes in the expression of specific genes are thus an accurate and early indicator for the development of cold tolerance. And, because it can identify the start of the hardening process, genomic testing is much more useful than traditional cold hardiness tests that only provide information several weeks after hardiness has already developed (Figure 1).

The Research— I know that this sounds like Star Wars technology but researchers in Europe have already identified the genes involved in the cold hardiness of Scots pine (*Pinus sylvestris*) and European beech (*Fagus sylvatica*) seedlings. The study was performed in 4 countries (Denmark, the Netherlands, Scotland, and Sweden) and involved both research institutes and

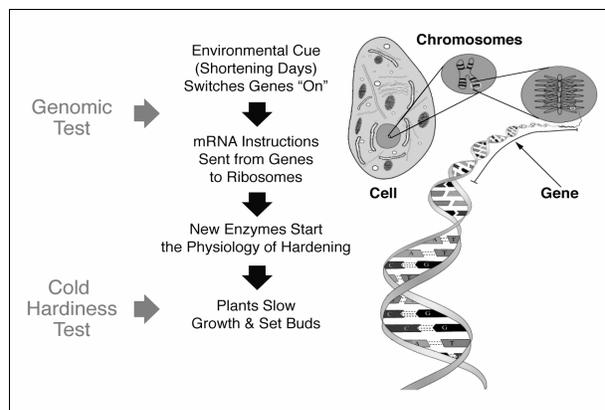


Figure 1 – Genomics tests of physiological and morphological processes such as cold hardening will give nursery managers an early warning, compared to traditional seedling quality testing.

operational forest nurseries. The main objective was to monitor shoot cold tolerance and bud dormancy of pine and beech seedlings before, during, and after refrigerated storage with the shoot electrolyte leakage (SEL) test. Because pine and beech represent broadleaved and gymnosperm trees, they differ in the morphological and perhaps physiological development of cold hardiness. These cold hardiness test results were correlated with gene expression using genomics technology, which led to the development of a rapid, predictive molecular diagnostic test.

Seedlings were grown in climate-controlled environments for the initial identification of the relevant hardiness genes, followed by outdoor nursery trials to monitor the actual development of cold hardiness. A standard provenance of each species was tested at each research location along with seedlings from a local seed source. This testing procedure allowed comparisons of most parameters that are known to influence dormancy and cold hardiness such as geographic origin, genetic background, and nursery cultural history

Dehydrins are one of several proteins that were already known to be specifically associated with the onset of cold hardiness in red-osier dogwood, rhododendron, and blueberry. The European research trials identified the specific dehydrins and other proteins that are linked to cold hardiness in Scots pine and European beech seedlings. Once the specific genes were identified, the researchers used genomics technology to identify when they were activated. These genetic response data were analyzed with sophisticated statistical techniques, which revealed 3 different gene groups that were correlated to the cold hardening process. In samples from different provenances, genes from each group displayed a characteristic gene expression profile during the acquisition of frost hardiness.

A Simple Explanation of How the Test Works—

Enzymes are proteins that trigger all of the many physiological processes in organisms, and they are created out of amino acids in the cell nucleus. If you ever wondered why your nursery crops require so much nitrogen, each amino acid contains nitrogen and the proteins they constitute make up about half of the dry weight of a cell. Each type of protein has its own unique structure and function. An *E. coli* bacterium, one of the simplest organisms, contains over a 1000 different proteins that switch on and off at genetically-controlled times to perform the chemical reactions that sustain life.

To create an enzyme, the cell must first transcribe the genetic information stored in the DNA into messenger RNA (mRNA). The strand of mRNA then moves over to a ribosome which is an enzyme that can stitch the proper sequence of amino acids together using the mRNA blueprint. The long chain of amino acids is an enzyme that folds into its characteristic shape, floats free, and begins performing a specific reaction (Figure 1).

The N-Sure Cold Hardiness Test – The European research identified three indicator genes that together provide enough information to give an accurate estimate of the cold hardiness stage of the seedling. The corresponding genes dominate the hardening process in all of the Scots pine provenances that were studied and strongly correlated with SEL values. Activity of indicator genes, two differentially-regulated dehydrins and one control gene, is measured in a cold hardiness test developed by the company N-Sure. The dehydrin genes have different biological roles – one is involved in general drought and cold resistance and is active during growth and initial stages of hardening. The other one is highly specific for development of fully hardened buds, and the activity of the corresponding gene peaks when maximum cold hardiness has been attained. The assay is based on the relative activity of these 3 genes. The N-Sure test has been validated with many seed sources of Scots pine grown at different geographical locations in Europe with different nursery regimes and has proven to be highly consistent. The reason for this is that a biological process of crucial importance for hardiness is monitored. Recently, the test has been adapted for use with Norway spruce (*Picea abies*) as well.

The assay will be sold as a sampling kit that contains all necessities for taking and stabilizing a representative sample from a batch of seedlings. For example, a composite sample of bud tissue could be collected from seedlings receiving cultural treatments to stimulate dormancy. The stabilized sample can be sent by regular mail, and upon arrival in the test lab the result will be available within 24 to 48 hours (Figure 2). The company that will commercialize the tests is a spin-off from

Wageningen University and Research Centre, the Netherlands, and is called N-Sure. The seedling assay will be part of the first market introduction series of N-Sure, planned for 2007. If there is interest from the US and Canadian nurseries, N-Sure will be looking for a business partner in Northern America for reselling the tests.

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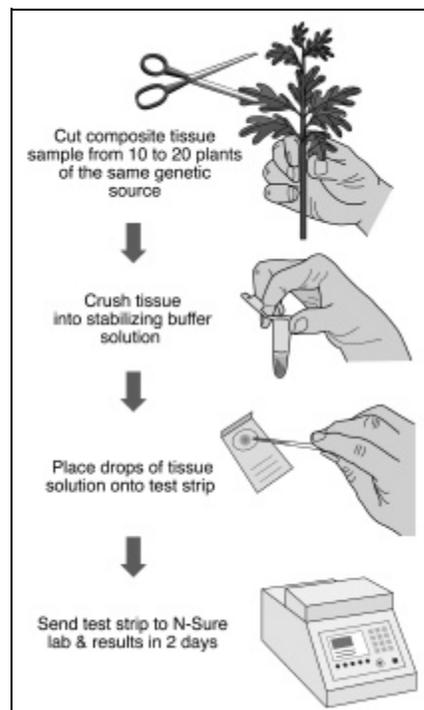


Figure 2 – The N-Sure test provides a quick and accurate way to monitor cold hardiness and dormancy of nursery stock.

Summary - Gene expression analysis is a promising new way to determine when the cold hardiness and dormancy process starts in plants. One of the most attractive features of genomic testing is that it provides a much earlier indication than traditional cold hardiness testing. While it has proven its usefulness in European Forest Nurseries, with pine, beech, and spruce, further operational testing needs to be done with North American species and nursery cultural practices.

Monitoring Electrical Conductivity in Soils and Growing Media

By Thomas D. Landis and R.Kasten Dumroese

Introduction

As part of the Western Forest and Conservation Nursery Association meeting this year, we held a training session on monitoring electrical conductivity (EC) in container stock. There are many new testing instruments and techniques that make monitoring quicker and easier so let's look at some of them. Note that, due to space limitations, this is a condensed version and a much more detailed article will appear in the 2006 National Nursery Proceedings.

What is EC? EC is a measure of the salinity (total salt level) of an aqueous solution. Pure, distilled water is a perfect insulator and it's only because of dissolved ions that it can conduct electricity at all (Figure 1A). An EC meter measures the electrical charge carried by the ions that are dissolved in a solution—the more concentrated the ions, the higher the reading.

In nurseries, dissolved ions come from two sources (Figure 1B). First, all irrigation water contains some salt ions as rain water trickles through the soil and rocks. The amount of the “background” salinity is a function of the local geology and climate. Soils and parent material

have a major effect. Soils derived from marine sediments will contain high levels of sodium, chloride and sometimes boron. Water running through calcareous rocks or soils picks up calcium, magnesium and bicarbonate ions. Irrigation water from dry climates will have higher salinity than water from a humid climate. This only makes sense because, when water evaporates, the dissolved salts are left behind and the remaining solution would have a higher EC reading.

The second source of salinity in soils or growing media is from added fertilizers (Figure 1B). The release of salts varies considerably depending on how you are fertilizing. When fertigrating, the soluble fertilizer that you inject into the irrigation water can be measured immediately. In fact, the best way to check the accuracy of your injector is to measure the EC of the applied fertigation solution. If you are incorporating controlled-release fertilizers into the soil or growing medium, however, then the salts are released according to fertilizer coating, water levels, and temperature. Most solid organic fertilizers release their nutrients very slowly and are less temperature or moisture dependent. Liquid organics release nutrients more rapidly but still much slower than soluble fertilizers.

EC Units. The physics and politics of this subject are complicated but think of it this way. We're measuring electrical conductance which is the inverse of resistance.

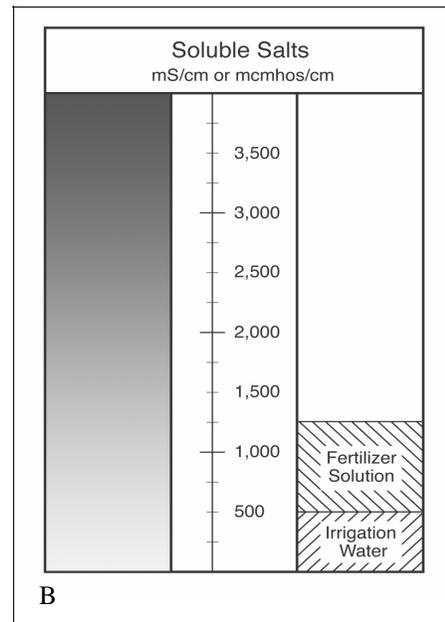
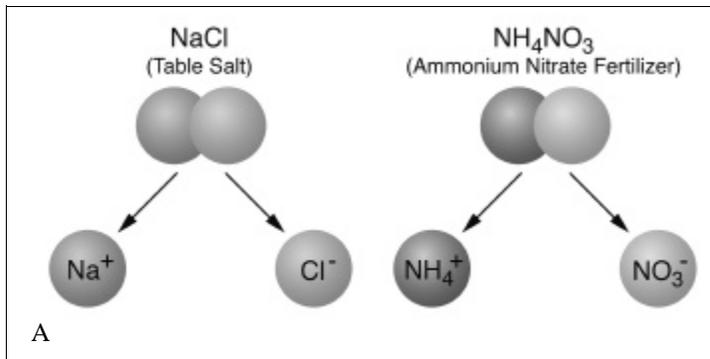


Figure 1A/B - Dissolved salts in irrigation water can be measured with electrical conductivity because they are electrically charged (A). In soil or growing media, the total salt load comes from natural sources and fertilizers (B).

The unit of resistance is an ohm, and just to be cute, they call the unit of conductance a mho (pronounced "mow"), which is ohm spelled backwards. The most commonly used EC units in horticulture are micromhos per centimeter ($\mu\text{hos/cm}$), and the SI units of microsiemens per centimeter ($\mu\text{S/cm}$) which are equivalent. Because electron activity is strongly dependent on temperature, all EC measurement must be adjusted to a standard temperature of 77 °F (25 °C).

EC Sampling Procedures

Remember that we are interested in measuring the conductivity of an aqueous solution. With irrigation water, this is simple but sampling becomes more difficult when we are measuring EC in field soil or in the growing medium inside a container. Remember also that conductivity changes with water content. With that in mind, let's look at 5 common techniques for measuring EC in nurseries. All have advantages and disadvantages, and each will give you a different EC reading. Note that we are concerned with both absolute readings, and relative changes over time.

The best EC technique will also depend on where you are using it - in bareroot soils or in containers. The EC method you choose will also depend on what size container you are sampling.

For every EC technique described below, use distilled water that you can buy at your grocery store. This prevents confounding the EC readings with background salinity of the irrigation water.

Saturated Media Extract (SME). This technique is the laboratory standard that is used by commercial soil and water testing laboratories. If you are interested in absolute EC values, this is the only choice. The SME method uses saturation as the standard soil or media

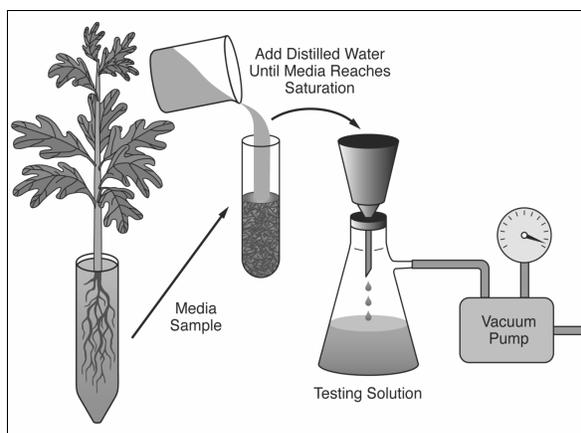


Figure 2 - The saturated media extract (SME) technique is the laboratory standard, and is the only way to obtain absolute EC readings.

water content, and hence the name. Okay, but how do you get the saturated water out of the soil or container and how do you get enough solution so that you can measure the EC?

The laboratory technique consists of collecting a sample and adding enough distilled water so that it just glistens. Then, a vacuum pump sucks the solution into a beaker so that it can be measured (Figure 2). A practical modification of the SME technique is to collect a sample of soil or growing medium, bring it to saturation moisture content, place it into cheesecloth, and squeeze to obtain the solution.

The SME has a major advantage over the other methods in that the amount of water is always the same, and so the moisture content of the soil or media at the time of monitoring isn't important. Of course, even if you had the necessary laboratory equipment, you probably wouldn't have the time to do this procedure every time.

EC Technique	EC Readings ($\mu\text{S/cm}$)				Soil	Containers	Soil	CRF
Saturated Media Extract	1,000	2,000	3,000	4,000	Yes	All but miniplugs	Yes	Yes*
1:2 Dilution	300	700	1,200	1,600	Yes	All but miniplugs	Yes	No
Pour-Through	1,500	2,800	4,200	5,500	No	All but miniplugs & very large sizes	No	Yes
Plug Squeeze	1,300	2,700	4,100	5,600	No	Jiffy, Cone-tainers, Rootainers, miniplugs	No	No
Direct Sensor	700	1,300	1,800	2,400	Yes	All but miniplugs	Yes	Yes

(modified from Fisher and others 2006b) * = vacuum extraction, not squeezing

Off the record, this is the reason that growers didn't use to monitor EC very frequently.

Since SME is the lab standard and is the only way to measure absolute EC, researchers have constructed a table to illustrate how the other techniques compare (Table 1). Note that all the techniques are not suitable for bareroot soils. Container size and controlled release fertilizers also have an effect on which of the EC monitoring techniques will work. Mini-plugs are so small that they are hard to handle or the stabilized media creates problems; on the other hand, the plug squeeze technique is ideal for mini-plugs with stabilized media. It also works well for Jiffy cells, Ray Leach and Spencer-Lemaire containers. Obviously, very large (> 1 gallon) containers have size and weight limitations.

The use of controlled-release fertilizers (CRF) has complicated the measurement of EC. Because the prills are very fragile, even collecting a sample or squeezing it can damage them. Broken prills will release all their fertilizer salts at once and artificially elevate the EC reading. Thus, some of the EC monitoring procedures should not be used when incorporating CRF (Table 1).

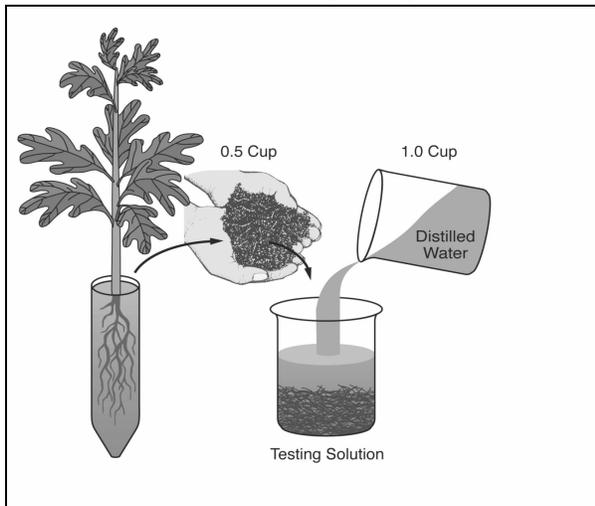


Figure 3 - The 1:2 dilution procedure produces plenty of solution to measure but is destructive and must be calibrated to the SME technique.

1:2 Dilution. This is the most popular of the several dilution techniques and uses 1 part of soil or growing media to 2 parts distilled or deionized water (Figure 3). For example, take a half cup of soil or media, place it into a beaker, and add 1 cup of water. Remember that you can't use tap water because it will contain some dissolved salts and will confound your readings. Compress or squeeze the slurry and take your EC reading. This is a popular technique because it gives you plenty of solution to measure but, because it contains much more water than at saturation, your readings will

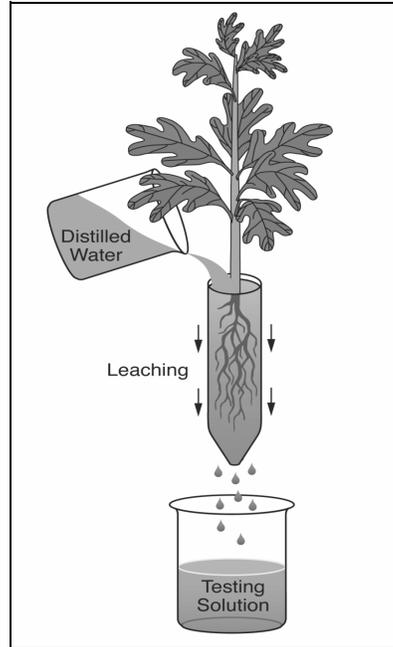


Figure 4 - The pour-through technique works for all containers except mini-plugs and large sizes, and is ideal when using controlled-release fertilizers

also be "diluted" compared to the standard SME technique (Table 1). Also, it's difficult to always use the same amount of pressure to squeeze out the sample solution. However, if you are consistent in the volume and compression of your samples and always sample at about the same degree of soil or media moisture content, the 1:2 dilution will give you good relative EC readings for tracking changes.

Pour-Through. This is a relatively new technique for measuring EC in containers, and works for all container types except for mini-plugs where their short height stops the media solution from freely draining. It would also be impractical for very large containers which are difficult to move (Table 1). The pour-through process consists of 2 steps (Figure 4). First, medium in a container is progressively irrigated until saturated, and then left to stand for about 2 hours. Or, just do the procedure 2 hours after irrigation. Next, pour a volume of distilled water onto the media surface to produce about 100 ml of leachate. Of course, this depends on container volume and type of growing media. Make sure and apply the water slowly enough that it doesn't run off and down the insides of the container. The idea is to have the applied water force out the solution surrounding the roots. The pour-through technique is ideal for growing media with controlled-release fertilizers because the prills are not squeezed or otherwise damaged (Table 1). Therefore, this method is ideal for outdoor growing compounds where controlled release fertilizers are the standard.

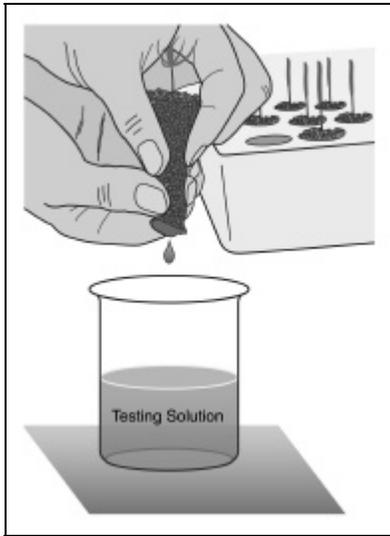


Figure 5 - Although developed for miniplugs, the plug squeeze technique can be used for any containers where the root plug can easily accessed.

Plug Squeeze. This procedure, which is also known as the press extraction method, was developed for monitoring miniplugs, especially with stabilized media (Figure 5). It can also be used with Jiffy™ pellets, flexible containers such as RL Cone-tainers™ which can be squeezed, and with Spencer-Lemaire Rootainers™ where the plug can be easily removed (Table 1). The plug squeeze technique would also work with any container type after the root plug has developed to a point where it can be easily extracted. The plug squeeze technique begins with saturating the plugs and waiting about 1 hour for excess water to drain away. Then, just remove the plugs and squeeze the media solution into a beaker. Depending on plug size, it will take several repetitions before enough solution is obtained to take a reading. The obvious question is whether the amount of squeeze pressure will affect the results, but research has proven that this is not a concern for miniplugs. For larger plugs, however, it would be best to keep the amount of squeeze pressure fairly constant.

Direct Sensor. This last EC monitoring technique has only been possible within the last decade or so because of new instruments such as the Field Scout® Soil & Water EC Meter. These new EC meters have probes small enough that they can be inserted directly into growing media (Figure 6). The obvious advantage of the direct sensor procedure is that readings can be taken quickly and non-destructively. Just be sure that the probe has good contact into the growing medium, and always test at the same media moisture content. The recommendation is to monitor about 1 hour after irrigation or fertiligation. Operational testing with this procedure has shown that it

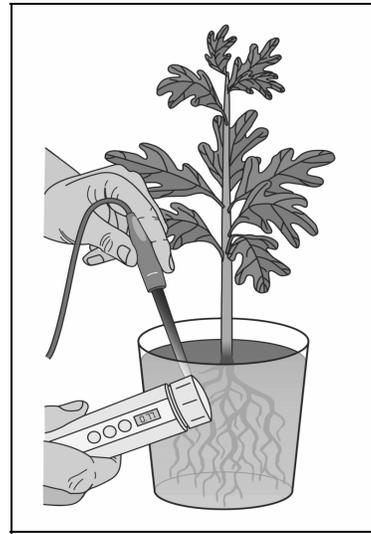


Figure 6 - The newest EC meters have probes small enough that you can take measurements directly from soil or growing media.

works best on miniplugs and other small containers. Readings in larger containers can show serious variation and so the reading should always be at a standard depth and at the same moisture content. As with any of the other techniques, it would be best to calibrate your direct sensor meter to standard SME measurements (Table 1). Just a word of caution—if you insert the probe into a medium containing CRF and the tip of the probe punctures a prill or is in very close proximity to a prill, the EC reading might be extremely high, requiring a second insertion of the probe into a different area.

Evaluating EC test results

Okay, now that you've got a bunch of EC values from your soil or growing medium, what do they mean? The first thing to remember is that your EC reading is a combination of the base salinity of your irrigation water and dissolved fertilizer salts (Figure 1A):

$$\text{Soil or Media EC} = \text{Water Salinity} + \text{Fertilizer}$$

The second consideration is that plants vary considerably in their salinity tolerance and nutritional requirements. Some native plants, like quaking aspen, seem to grow without almost any fertilizer at all whereas others, like western white pine, have to be forced with high fertility levels.

Absolute values. By far, the most research has been done with the SME technique so that should always be your standard. For ornamental plants, researchers have developed some relative ranges when using one of the

other field techniques (Table 2). Of course, the best recommendation is to monitor your crops regularly and record the information along with growth measurements and observations on plant health.

Trends. One of the real benefits from monitoring EC during the crop cycle is to develop your own standards and to plot your readings to show trends. Monitoring trends is particularly important when using CRF fertilization where nutrient release is completely dependent on temperature and moisture.

Conclusions and Recommendations

Monitoring electrical conductivity is a good way for growers to keep track of fertilization, and several techniques are available. The most appropriate technique depends on whether you grow in bareroot beds or in containers, the size and type of container, and whether you fertigate or use controlled-release fertilizers. For absolute EC values, the saturated media extract technique is the accepted standard and the other methods can be calibrated to it. Monitoring EC trends also provides very good information and, because the values are relative, any of the techniques can be used.

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Spectrum Technologies. 2006. Field Scout® Soil & Water EC Meter. URL:<http://www.specmeters.com> (accessed 17 July 2006).

Fertility Level	SME	1:2 Dilution	Pour-Through	Plug Squeeze
None	0.00 to 0.75	0.00 to 0.25	0.00 to 1.00	0.00 to 1.00
Low	0.75 to 2.00	0.30 to 0.75	1.00 to 2.50	1.00 to 2.50
Ideal	1.50 to 3.00	0.30 to 1.50	1.00 to 6.00	1.00 to 5.00
High	2.50 to 4.00	0.75 to 1.50	4.00 to 6.00	2.50 to 5.00
Danger	>4.00	>2.50	>8.00	>8.00

(modified from Fisher and Argo 2005)

Integrated Pest Management

Plastic Tarping Increases Efficacy of MITC Fumigants

by Thomas D. Landis

Soil fumigation is one of those topics that just won't seem to go away. When I first left college and started working in a nursery, I was idealistic and strongly anti-pesticide. However, it only took me one growing season of fighting weeds and diseases to call the fumigator.

Soil fumigation has been a standard cultural practice in bareroot nurseries for decades to control soilborne pests. Until the last 10 years or so, the fumigant of choice was a gaseous mixture of methyl bromide and chloropicrin (MBC) which was injected under a plastic tarp to contain the fumigant long enough for it to be effective (Figure 1). MBC fumigation was very effective but the future of this popular fumigant is in serious doubt. Methyl bromide has been identified as a significant ozone depleting substance, resulting in regulatory actions being taken by the U.S. Environmental Protection Agency and by the United Nations Environment Program (Montreal Protocol). MB is scheduled for eventual phase-out and, while this still hasn't happened, decreased availability has caused the cost of MBC fumigation to increase.

With the projected loss of MBC fumigants, many forest nurseries switched to fumigants using methyl isocyanate



Figure 1—Plastic tarping is standard practice for methyl bromide/chloropicrin fumigation, whereas dazomet and meta-sodium fumigants are contained with a roller and water seal.

(MITC) which is applied as a powder (Basamid®) or liquid (Vapam®). Following application, the MITC converts to a gas which is contained by a compressed “water seal” on the soil surface. MITC fumigants, especially Basamid®, has become the preferred fumigant in many forest nurseries although there have been problems with phytotoxicity to adjacent conifer crops. The escape of MITC gas in concentrations high enough

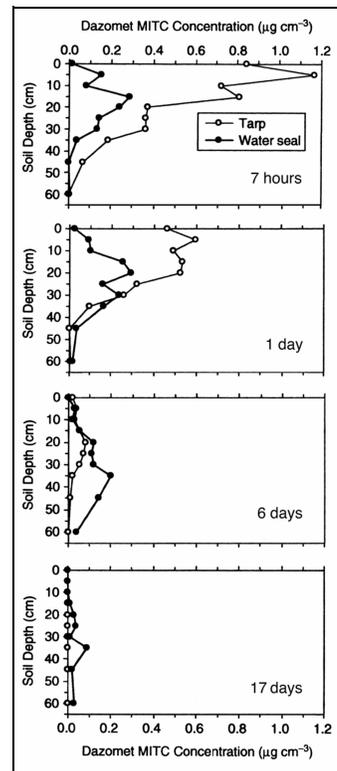


Figure 2—Recent research demonstrated that covering dazomet and metam-sodium with plastic tarps greatly increased the penetration and distribution of the gas (modified from Wang and others 2006).

to damage plants is evidence that the water seal isn't always effective. This is especially problematic on the coarse-textured sandy soils preferred for forest and conservation nursery crops.

I had always wondered why someone didn't try containing MITC with a plastic tarp, and was told that it was cost prohibitive and tarp disposal was also an issue. Recently, however, researchers conducted fumigation tests comparing the traditional water seal against a plastic tarp. The trials were done at 2 forest nurseries in Wisconsin and Georgia, both of which had sandy soils. Two fumigants were applied at each test site in the fall: dazomet (Basamid®), and a combination of metam-sodium (Vapam HL™) and chloropicrin. The metam-sodium/chloropicrin co-application has been shown to be as effective as MBC, especially against yellow nutsedge (*Cyperus esculentus* L), a weed with tubers resistant to fumigation. At each nursery, the 2 fumigants received either a water seal or a plastic tarp covering and the fumigant gases were monitored at regular depths in the soil.

Following fumigation, soil gas tests showed MITC concentrations remained high in soil layers above 12 inches, which is the effective rooting zones of most forest nursery crops (Figure 2). Fumigant concentrations were significantly higher under the plastic tarps than under the water seal, and the effect lasted for at least 3 days. The researchers concluded that the lower fumigant concentrations under the water seal, especially near the soil surface, were too low to be effective. At the Wisconsin nursery, over irrigation of the water sealed plots caused the fumigant to leach to lower soil depths, reducing its potential effectiveness.

In searching the FNN database, I found out that tarping of dazomet had been tried before. Bill Carey reported non-significant differences between tarped and not tarped applications of dazomet in southern pine nurseries but admitted being surprised at the results.

I would be remiss if I didn't mention that exhaustive research has been done to identify alternatives to chemical soil fumigation including bare fallowing, sawdust incorporation, solar treatments, steam treatments, and biocidal cover crops. While some treatments showed promise at certain nurseries, none worked at all nurseries and with all crops. Still, integrated pest management is the way to go and I'll continue to monitor the published literature for any new findings.

Summary— This research shows that plastic tarping is a more effective way to contain MITC fumigants, especially in sandy soils. However, follow-up research is needed to prove tarping reduces population levels of soil pathogens such as *Pythium*, *Phytophthora*, and *Fusarium*. More importantly, comparisons need to be done at different nurseries and with several crops to show

that tarping of MITC fumigants increases seedling survival and growth. Future research could also be designed to test whether plastic tarping would also eliminate phytotoxicity damage to adjacent conifer crops.

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Controlling Moss in Nurseries

by Thomas D. Landis and James A. Altland

In the Winter, 2006 issue, Tom Landis mentioned the excellent article “Get a handle on liverwort” in which James Altland discusses all aspects of managing these plant pests. Since then, we thought we’d continue this theme with an article on ways to control mosses. These lower plants are similar to liverworts in that they reproduce from spores instead of seeds and thrive in moist and fertile nursery environments. Although they can become pests in both bareroot and container nurseries, mosses are particularly serious in containers where they cover the surface of the growing medium and interfere with water and nutrient infiltration (Figure 1). Larger mosses can also physically overshadow small seedlings and out compete them for light. The exact amount of damage caused by these plant pests is difficult to determine and varies from nursery to nursery, but Ross and Puritch (1981) conclude that damage is increasing, especially in older growing facilities.

Hosts. All species of seedlings can be affected by mosses but slower-growing conifers such as spruces and true firs are particularly vulnerable.

Moss Development. Mosses develop quickly and can affect the establishment of species that germinate and grow slowly. Once they cover the growing medium, they can choke out small seedlings, causing stunting and chlorosis. Even if the crop plants become established, moss “caps” interfere with water infiltration and reduce the effectiveness of fertigation or top-dressed fertilizers (Figure 1). Although no studies have been done, mosses may monopolize nutrient release from controlled-release fertilizer prills which are applied to the top of the container. Mosses and liverworts are more of a problem in open growing areas and shadehouses, where it is difficult to completely eliminate them between crops.

Although mosses continually enter nurseries by airborne spores, the main source of inoculum is from used containers or holdover plants. In a comprehensive study in British Columbia, no moss or liverwort spores were found in irrigation water or from peat or growing media samples (Ross and Puritch 1981). They concluded that the major sources of contamination in greenhouses were used containers and airborne spores, which are easily spread by fans.

Cultural controls. Mosses can be controlled by encouraging quick seed germination and vigorous early seedling growth. If they become established, the following practices have proven effective:



Figure 1 - When moss “caps” develop on small containers, they intercept water and fertilizer and retard seedling growth and development.

- Use a light-colored seed mulch or grit that completely covers the surface of the growing medium. Many container nurseries in the western US and western Canada use Target™ Forestry Sand as a seed covering, and perlite has also been effective. At a recent Growers’ meeting, sawdust was mentioned as an excellent seed mulch that retards the moss development.
- Reduce irrigation amount and frequency to allow the growing medium surface to dry out, which discourages moss development.
- Sanitize greenhouse benches and floors between crops and pay special attention to used containers. If you must holdover nursery stock that is already infested with mosses, treat them with one of the following chemicals.

Chemical controls

- Preventing spore germination— Of course, the ideal chemical will prevent mosses from developing in the first place. ZeroTol™ has hydrogen dioxide as the active ingredient but also contains peroxyacetic acid, other surfactants, stabilizers and buffering agents. Tests have shown that ZeroTol has an oxidizing power 10 times that of ordinary hydrogen peroxide. When injected into irrigation water or sprayed on surfaces, ZeroTol kills the spores of algae, mosses, and liverworts before they can germinate.
- Killing mosses in containers— Several other chemicals have been used to control mosses on soils or growing media but few materials are registered specifically for that purpose. Haglund and others (1981) initiated a moss control test with several fungicides and surfactants, alone or in combination. X-77® was the least phytotoxic of the eight surfactants tested, and a tank mix of X-77® and the fungicide Captan gave "virtually complete" moss control. It was suggested that applications be made in the late afternoon on a cloudy day because phytotoxicity is more severe in bright sunlight. Where labeled, some preemergence herbicides prevent moss growth in containers or non-crop areas. Herbicides classified as PPO inhibitors (including oxyfluorfen, flumioxazin, and oxadiazon) provide contact postemergence burndown of small weeds including mosses and liverworts, and effective preemergence weed control up to 12 weeks. Fausey (2003) demonstrated that Goal (oxyfluorfen) and SureGuard (flumioxazin) provided excellent pre-emergence and postemergence moss control in containers.
- Controlling mosses in non-crop areas— Several chemicals have been used to control moss growth on greenhouse surfaces including Safer's De Moss®, copper sulfate and calcium hydroxide. Most common disinfectants such as chlorine bleach or even vinegar will kill mosses in non-crop areas. In a side-by-side comparison of chemicals thought to provide postemergence burndown of liverworts and mosses, Fausey (2003) demonstrated Scythe (pelargonic acid) to be the most effective product.

Obviously, any potential chemical control method should be carefully reviewed and tested before being attempted operationally.

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Surround[®] Crop Protectant

by Thomas D. Landis

I'm always on the lookout for new pest control products that show promise for native plant crops, especially ones that are bio-friendly. So, when I heard about Surround[®] Crop Protectant at the recent Westside Greenhouse Growers' meeting, it sounded very promising.

Surround[®] is sprayed onto plants and forms a thin white "particle film" coating (Figure 1). According to their website, this coating acts as a protective barrier and repellent to insects while reflecting heat, keeping the plant cooler. The active ingredient is a specially modified kaolin, a naturally occurring clay that is also used as a food additive, in toothpaste, and in cosmetics. So, obviously, it's very safe to use. Surround[®] can be applied with standard commercial sprayers, hand-held sprayers and backpack sprayers and, because it is inert, it does not interfere with most other products when tank-mixed.

Surround[®] is still relatively new and I couldn't find any published research to support the manufacturer's claims. However, several Northwest growers have found it effective in preventing the sunscald that occurs when container seedlings are moved outside from the greenhouse or when plug seedlings are transplanted to bare-root beds. Of course, the coating only protects the current foliage and any new growth will be vulnerable. It should also have application for preventing outplanting shock, but again, that's just my conjecture. The Nursery Technology Cooperative at Oregon State University has established trials with Surround[®] at 2 Pacific Northwest nurseries. Initial observations indicate that it does indeed protect transplants from excessive light and heat, and it will be very interesting to see the final results.

I'm curious about the possibility of protecting crops from insect damage. The coating doesn't appear thick enough to physically prevent damage from piercing/sucking insects such as Lygus bug (*Lygus* spp.). I'm no entomologist but it could be that the whitish coating masks the normal light reflection of the host plant and therefore confuses the insects. If any of you have experience with Surround[®], I'd appreciate hearing about it.

For more information, check out their website (<http://www.engelhard.com/>) or contact your local farm chemical supplier.

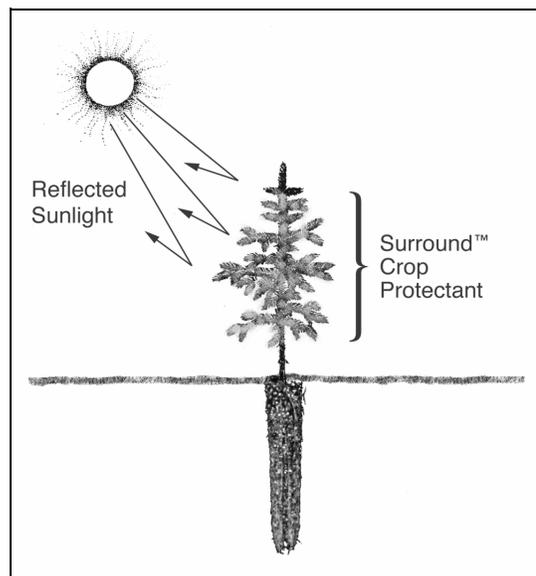
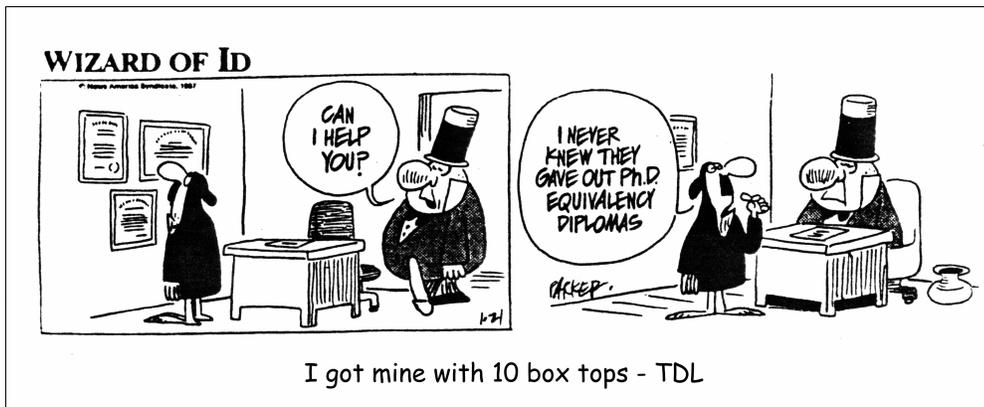
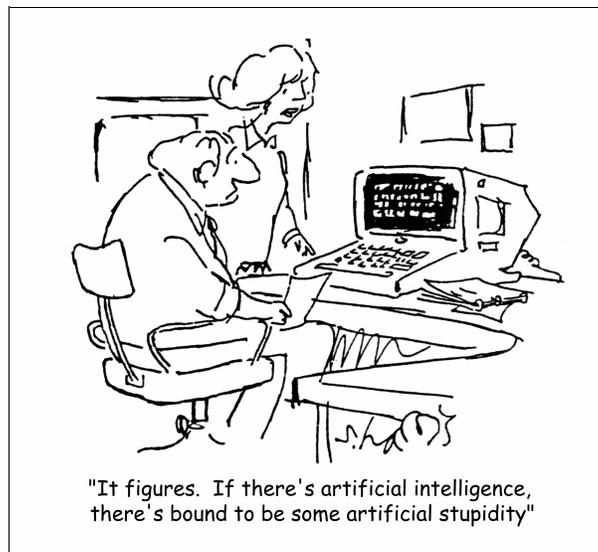
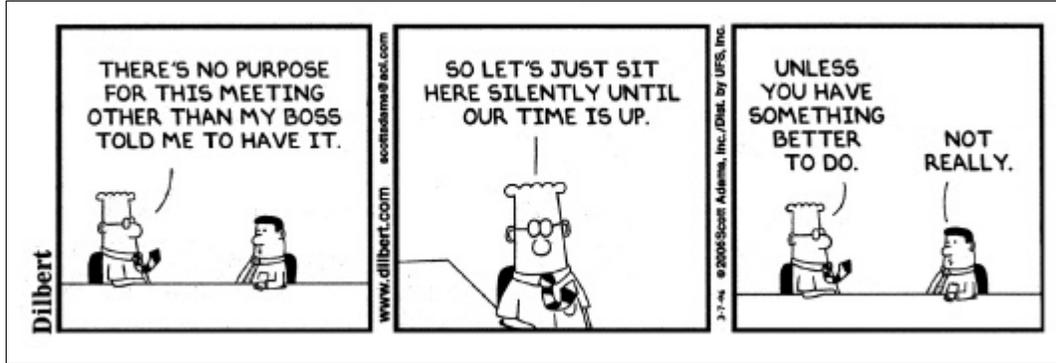


Figure 1 - When sprayed on plant foliage, Surround[®] forms a whitish coating that protects against sunscald and is also reported to retard insect attack.

Horticultural Humor





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In order to keep costs reasonable we will provide free copies of the first 25 articles. Fill in the number or letter each article from the New Nursery Literature section in the following spaces:

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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	To Be Determined
National Nursery Specialist Forest Nursery Notes Container Tree Nursery Manual Proceedings of Nursery Meetings Native Plants Journal	US and International	Kas Dumroese USDA Forest Service 1221 S. Main Street Moscow, ID 83843 TEL: 208.883.2324 FAX: 208.885.2318 E-Mail: kdumroese@fs.fed.us
Technical Assistance about Tree Improvement and Genetic Resources Technical Assistance about Forest and Conservation Nurseries	Southeastern US	George Hernandez USDA Forest Service Cooperative Forestry 1720 Peachtree Road NW, Suite 811N Atlanta, GA 30367 TEL: 404.347.3554 FAX: 404.347.2776 E-Mail: ghernandez@fs.fed.us
Technical Assistance about Forest and Conservation Nurseries	Northeastern US	Ron Overton Regeneration Specialist USDA Forest Service, S&PF Purdue University 1159 Forestry Building West Lafayette, IN 47907-1159 TEL: 765.496.6417 FAX: 765.496.2422 E-Mail: roverton@fs.fed.us
Technical Assistance about Tree Improvement and Genetic Resources	US and International	
Technical Assistance about Tree and Shrub Seed	US and International	Bob Karrfalt Director National Tree Seed Laboratory 5675 Riggins Mill Road Dry Branch, GA 31020 TEL: 478.751.4134 FAX: 478.751.4135 E-Mail: rkarrfalt@fs.fed.us

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