Timber Tech Tips

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Monitoring the Temperature of Tree Seedlings With the Thermochron iButton Data Logger

David S. Gasvoda, Electrical Engineer; Richard W. Tinus, Plant Physiologist, Flagstaff, AZ; Karen E. Burr, Horticulturist, Coeur d'Alene, ID; and Andy Trent, Project Leader

Tracking the temperature of tree seedlings from the nursery to the planting site can be the key to evaluating possible physiological causes of mortality after seedlings are planted. Seedlings enter and leave nursery storage with easily documented levels of cold hardiness, root growth potential, and general stress tolerance (Burr 1990; Ritchie and Tanaka 1990). The temperatures to which seedlings are exposed after leaving the nursery, and the duration of the exposure, can dramatically alter these levels. The effects may be direct, affecting tissue viability, or indirect, affecting respiration, transpiration, and plant-water relations. Environmental conditions seedlings experience must be measured to determine how those conditions may have altered seedling physiology and affected outplanting survival and performance. Temperatures can be measured easily and inexpensively with the Thermochron iButton data logger manufactured by:

Dallas Semiconductor Corp.
4401 South Beltwood Parkway
Dallas, TX 75244–3292
Phone: 972–371–6824
Fax: 972–371–3715
Web site: http://www.ibutton.com/

Thermochron iButton Hardware and Software

The Thermochron iButton is a digital temperature recorder in a small, 17.35 millimeters diameter by 6.76 millimeters thick (0.68 by 0.27 inches), durable, waterproof, stainless-steel case (figure 1). It can communicate with a computer after it has been inserted into a receptor (Blue Dot receptor, serial port, part number DS1402D-DR8, $5) with an RJ-11 (telephone) connector that is inserted into a standard nine-pin COM port adapter (universal serial port adapter, part number DS9097U-9, $10) that plugs into the computer's serial port. These items can be purchased as a starter kit (part number DS1921K, $25). Additional Thermochron iButtons (part number DS1921 L-F5x) can be purchased. Each iButton has a unique 64-bit identification number. Accessories can attach iButtons to almost anything (for example, a plastic flanged key fob, part number DS9093F, $0.80, see figure 1). The 'iButton viewer' software, needed to program Thermochron iButtons and review data, can be downloaded free from the Dallas Semiconductor Web site (*http://www.ibutton.com/software/thermochron/index.html*). The software can be installed on computers running Windows 2000, 98, 95, or NT.

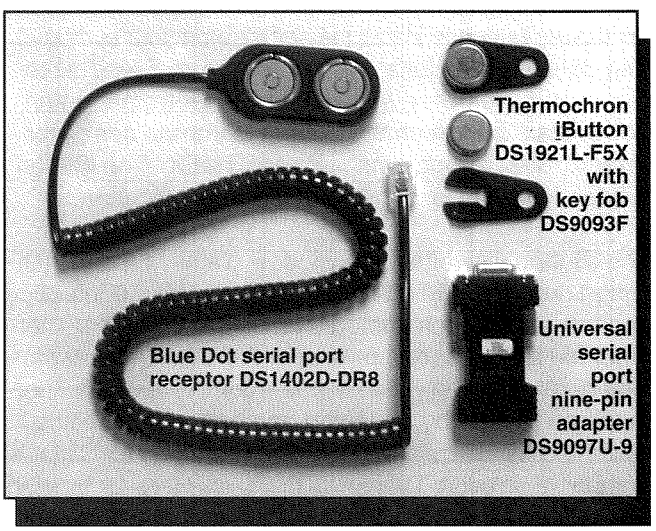

Figure 1—The Thermochron iButton data logger with hardware that allows it to communicate with an IBM-compatible computer.

For additional information, contact: *Andy Trent, Project Leader, USDA Forest Service, MTDC; 5785 Highway 10 West; Missoula, MT 59808. Phone: 406–329–3912; Fax: 406–329–3719; E-mail: atrent@fs.fed.us*

The digital thermometer measures temperatures from –40 to +85 °C (–40 to +185 °F) in 1 °C increments with an accuracy of ±1 °C. A real-time clock calendar is accurate to ±2 minutes per month within a 0 to 40 °C range. The recording interval can range from 1 to 255 minutes in 1-minute intervals, with a starting offset of 0 minutes to 46 days. At each recording interval, the Thermochron iButton logs the date, time, and temperature; updates a frequency histogram of temperature values; and, if requested, updates the date, time, and duration of up to 24 temperature events outside a range of selected alarm trip points. After 2,048 time-stamped temperature values have been logged, recording stops or values are overwritten (depending on the alternative selected). Long-term monitoring data can be recorded as histograms. The histogram has 63 data bins of 2 °C resolution with a maximum capacity of 65,535 temperatures per bin. The lifespan of the iButton's nonreplaceable power source is about 1 million measurements or 10 years, whichever comes first. The data sets can be exported as text (.txt) files and imported into other software packages for enhanced graphic presentation. Text files cannot be imported into the iButton viewer software.

Getting Started

Download the iButton viewer software from the Dallas Semiconductor Web site: *http://www.ibutton.com/software/thermochron/index.html*. Select 'iButton-TMEX Runtime Environment Install for 32-Bit [Windows 98, 95, NT] (Version 3.12) (Y2K Update)' near the bottom of the page. Save the 1.5-megabyte file (tm312_32.exe) to your hard drive. Highlight the file name and double-click your left mouse button to install the software on your computer. The default install location is *C:\Program Files\Dallas Semiconductor*. Start the iButton viewer from the Windows 'Start' button on the bottom left of the computer screen: 'Start > Programs > iButton-TMEX.' The iButton viewer 'Help' file is installed at the same location.

The iButton viewer's main window displays the identification number (ending in 09) of the serial port interface and the identification numbers (ending in 21) of the Thermochron iButtons (one or two) in the Blue Dot receptor. You can determine which number goes with which Thermochron iButton by removing one button and seeing which number disappears. Click the Thermochron iButton's number to select it. Then click the 'Click Here for Viewer' box in the lower right corner of the window and select 'Thermochron Viewer.' The Thermochron viewer window has three tabs. Select the 'Wizard' tab to program a "mission." The process is straightforward and takes only a minute. Successive windows will prompt you to set the Thermochron time from the computer clock, set the start delay period and sample rate, and specify whether to overwrite the first 2,048 measurements. Alarm options are also set here. The dropdown 'Options' menu on the menu bar at the top of the iButton viewer window allows you to select whether to view data in Fahrenheit or Celsius. Data can be converted from one scale to the other at any time.

Viewing and Exporting Data

Stored data can be viewed and saved during or after a mission by selecting 'Mission Results,' the second of the three tabs on the Thermochron viewer window. The iButton stores three types of data: temperature alarms, log, and histogram. The 'Temperature Alarms' window presents the starting and ending date and time of temperatures outside the high and low alarm limits. The 'Log' window displays the date, time, and temperature of the 2,048 time-stamped measurements. The 'Histogram' window lists the 63 histogram bins and the count of data in each bin.

Viewing options not only change the display, but also affect the export format of the data. Options include changing the date and time to the number of minutes since the start of the mission, and describing histogram bins in different ways: by bin number, by the range of temperatures within the bin, or by the starting temperature. A viewing option available on the drop-down 'Option' menu, 'Show F/C on Temperatures,' adds or removes °F or °C from the log and histogram data. Removing the units can make it easier to graph the data in another software package. The numerical temperature and the alphanumeric unit are assigned to the same comma-delimited data field when the data are exported.

The log and histogram data sets can be graphed at the 'Mission Results' window quickly with just the push of a button. This option makes it easy to scan the data for any deviations from expected temperatures. Although the iButton viewer software has no edit or print options for these graphs, the data can be exported from the iButton and imported into another software package for printing.

Data can be exported to a text file with a .txt extension by clicking the 'Export' button in the 'Mission Results' window. Mission status information is exported in a tab-delimited sentence structure. The actual logged data follows in a comma-delimited format. To open the text file from within Microsoft Excel, for example, use the 'Text Import Wizard' in Excel. Select 'Delimited,' both 'Tab' and 'Comma,' and 'General' as each question is asked. Once the data are in the spreadsheet, a chart can be designed to suit your needs. A second method can be used to transfer the data to another program. The data can be copied to the Windows clipboard and pasted from the clipboard into another software package, such as Microsoft Word. This file can be saved with a '.doc' extension. This is a quick way to get a hard copy of the raw data. The iButton viewer software 'Copy Export Data to Clipboard' option is in the 'File' dropdown menu on the top menu bar.

Viewing Mission Status

The 'Status' tab is the third tab on the viewer window. Thermochron iButtons can be snapped into the Blue Dot receptacle and checked at any time without disrupting a mission. Information provided includes: current and starting date and time, whether the mission is in progress, the sample rate, whether data has been overwritten, the start delay, the number of samples taken in the current mission, and the total number of samples taken during all missions. When data are exported, this information is included at the beginning of the file.

The option to stop the current mission is the last item on the 'Options' dropdown menu on the menu bar. The data remain stored even after the mission has ended. The data continue to be stored until the iButton is reprogrammed. Make sure that data have been exported successfully before reprogramming the iButton.

Sample Data

A sample data set was recorded by placing a Thermochron iButton in a shipment of seedlings sent from the Colorado State Forest Service Nursery at Fort Collins, CO, to the USDA Forest Service, Rocky Mountain Research Station in Flagstaff, AZ. Twenty-three seedlings left the nursery in the nursery's standard heavy paper shipping bag at noon on May 22, 2000, in the private mail carrier's van that typically delivers trees. Temperature measurements were logged every 30 minutes until the trees arrived at the research station in Flagstaff at noon on May 25. The data were exported to Microsoft Excel and the iButton viewer software log and histogram graphs were recreated (figures 2 and 3).

The seedlings left nursery storage at 3.5 °C (38 °F) at time = 0 hours (figure 2) and quickly rose to 34 °C (93 °F) the afternoon of May 22. This is much too warm for packaged dormant tree seedlings. Tree temperature dropped to about room temperature (21 °C, 70 °F) during the evenings, but continued to approach 30 °C (86 °F) or 35 °C (95 °F) each afternoon. At noon on May 25 (time = 72 hours), the package entered the temperature-controlled Flagstaff office complex and returned to room temperature. The histogram (figure 3) of the frequencies of temperatures in 2 °C intervals provides an indication of the relative amount of time spent at the various temperatures. For about half the trip the trees were at temperatures greater than or equal to 26 °C (79 °F). Nurseries shipping trees through the mail can easily conduct similar tests to assess the insulating ability of their packaging materials and the temperature stresses trees encountered during shipping.

Summary

The Thermochron iButton, manufactured by Dallas Semiconductor, has features that make it ideal for a recording device to monitor tree seedling temperatures from nursery production to outplanting: reliability, weather resistance, a wide temperature range, ease of use, and minimal expense. Nurseries and field units receiving seedlings should find that this device could help determine whether temperatures during shipping have affected tree survival and performance.

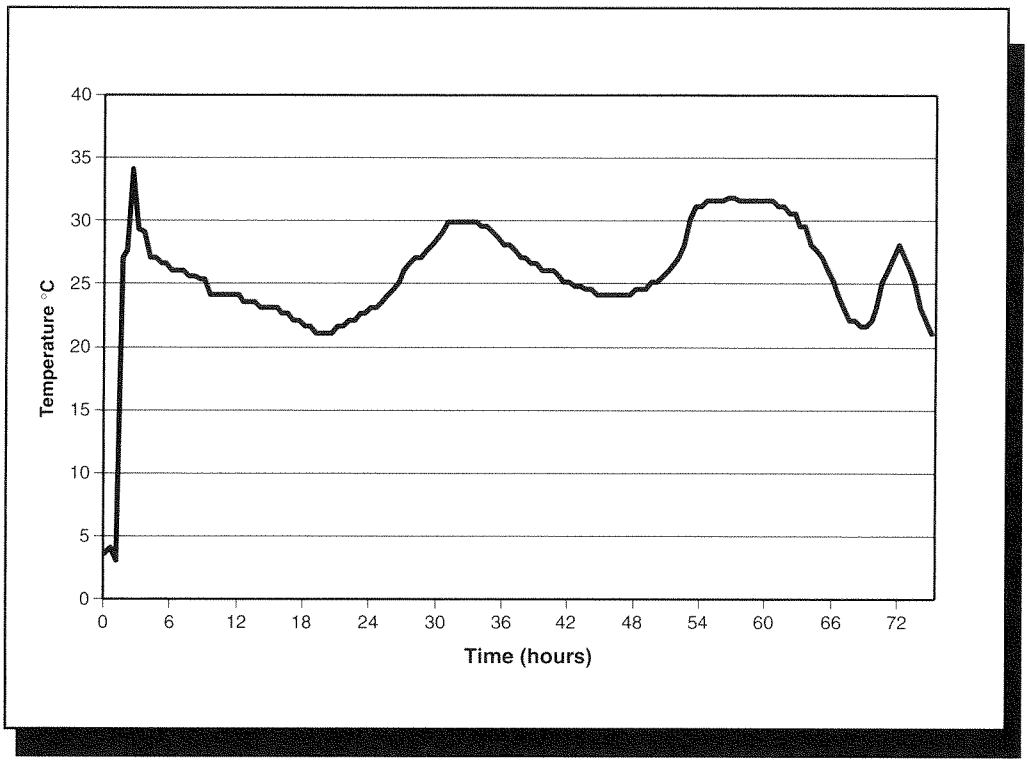

Figure 2—An Excel recreation of the iButton viewer's log graph of time-stamped data gathered while seedlings were shipped from the Colorado State Forest Service Nursery at Fort Collins, CO, to the Rocky Mountain Research Station, in Flagstaff, AZ.

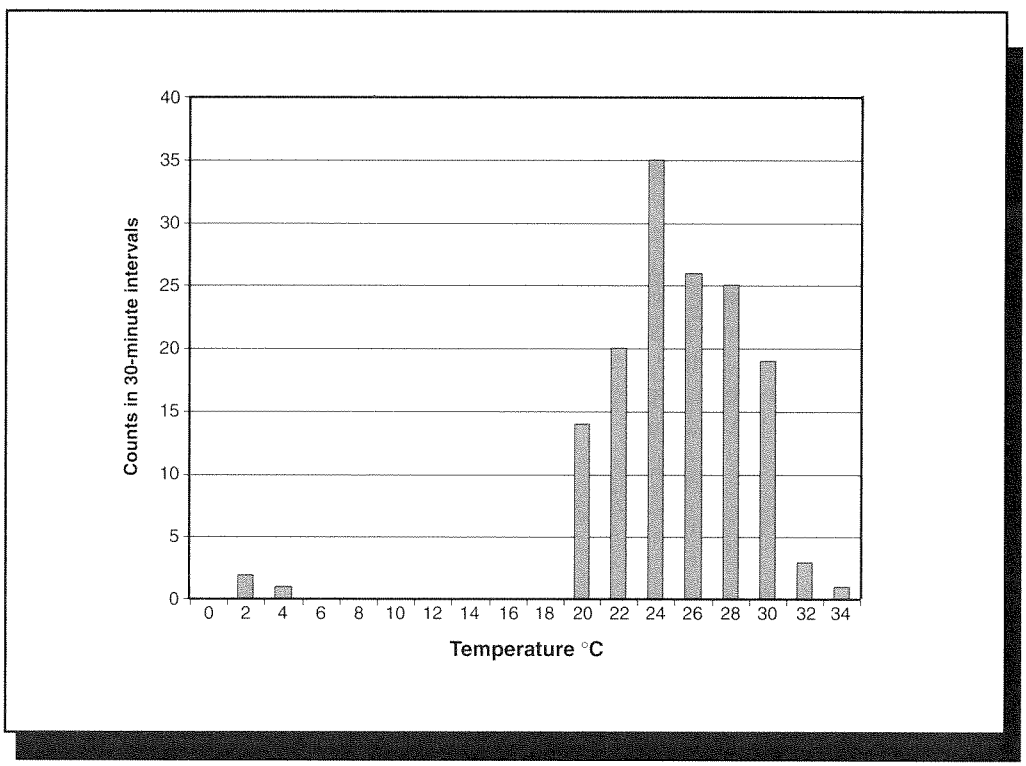

Figure 3—An Excel recreation of the iButton viewer's histogram graph of time-stamped data gathered while seedlings were shipped from the Colorado State Forest Service Nursery at Fort Collins, CO, to the Rocky Mountain Research Station, in Flagstaff, AZ.

Acknowledgments

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Ritchie, G. A.; Tanaka, Y. 1990. Root growth potential and the target seedling. In: Rose, R.; Campbell, S. J.; Landis, T. D.; eds. Gen. Tech. Rep. RM-200. Target seedling symposium: proceedings: combined meeting of the Western Forest Nursery Associations; August 13–17, 1990; Roseburg, OR; Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 37–42.

About the Authors

David S. Gasvoda has a B.S. degree in electrical engineering from Montana State University. He joined the Missoula Technology and Development Center in 1969 and worked on a wide variety of projects before retiring in 2001. Electronic devices he designed have saved Forest Service nursery workers hours of backbreaking labor. He has been awarded one patent and has another pending.

Karen E. Burr is a horticulturist at the USDA Forest Service Coeur d'Alene Tree Nursery overseeing seed and seedling quality activities. She was formerly a research plant physiologist at the Forest Service Rocky Mountain Research Station in Flagstaff, AZ. She received her Ph.D. in horticulture from Colorado State University.

Richard W. Tinus was a USDA Forest Service plant physiologist from 1968 to 2001. He worked for the Rocky Mountain Research Station, initially in Bottineau, ND, and then in Flagstaff, AZ. In 1996, Dr. Tinus transferred to the Southern Research Station to serve as a national nursery consultant. He is perhaps best remembered for his groundbreaking work in greenhouse container tree seedling production and his dedication to technology transfer in the United States and abroad.

Andy Trent is a project engineer at MTDC. He received his bachelor's degree in mechanical engineering from Montana State University in 1989. Before coming to MTDC in 1996, Andy worked as a civilian engineer for the Department of the Navy. Andy works on projects in the nurseries and reforestation, forest health protection, and watershed, soil, and air programs.

Library Card

Gasvoda, David S.; Tinus, Richard W.; Burr, Karen E.; Trent, Andy. 2002. Monitoring the temperature of tree seedlings with the Thermochron iButton data logger. Tech Tip 0224-2311-MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 6 p.

Describes the use of a small (¾- by ¼-inch), durable data logger to record the temperatures to which tree seedlings are exposed when they are transported from the nursery to the planting site. Seedlings enter and leave nursery storage with easily documented levels of cold hardiness, root growth potential, and general stress tolerance. The temperatures to which seedlings are exposed after leaving the nursery, and the duration of the exposure, can dramatically alter these levels. The Thermochron iButton data logger, manufactured by Dallas Semiconductor Corp., measures temperatures in increments of 1 °C with an accuracy of ±1 °C. The real-time clock calendar is accurate to ±2 minutes per month within a 0 to 40 °C range. The recording interval can range from 1 to 255 minutes in 1-minute intervals, with a starting offset of 0 minutes to 46 days. After 2,048 time-stamped temperature values have been logged, recording stops or values are overwritten (depending on the alternative selected). Nurseries and field units receiving seedlings should find that this device could help determine whether temperatures have affected tree survival and performance.

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USDA Forest Service, MTDC
5785 Highway 10 West
Missoula, MT 59808-9361
Phone: 406–329–3978
Fax: 406–329–3719
E-mail: wo_mtdc_pubs@fs.fed.us

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For further technical information, contact Andy Trent at MTDC.

Phone: 406–329–3912
Fax: 406–329–3719
E-mail: atrent@fs.fed.us

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