

Monitor Tree Seedling Temperature Inexpensively With the Thermochron iButton® Data Logger

David S. Gasvoda, Richard W. Tinus, and Karen E. Burr

*Engineer, USDA Forest Service, Missoula Technology Development Center, Missoula, MT,
Former Plant Physiologist, USDA Forest Service, Southern Research Station, Flagstaff, AZ; and
Horticulturist, USDA Forest Service, Coeur d'Alene Tree Nursery, Coeur d'Alene, ID*

Monitoring the storage and shipping environments of planting stock is inexpensive with the \$10 button-size temperature-recording device called an iButton®. Setting data collection parameters and downloading data are easy and require only a \$15 iButton receptor that plugs into a COM port and uses free software. Tree Planters' Notes 50(1): 14-17; 2003.

Tracking tree seedling temperature from the nursery to the planting site can be the key to evaluating possible physiological causes of seedling mortality after outplanting. 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 and the durations to which seedlings are exposed to them after leaving the nursery can dramatically alter these physiological quality attributes. This may occur directly by impacting tissue viability, or indirectly by affecting respiration, transpiration, and plant water relations. To determine how the environment may have interacted with seedling physiology and affected outplanting survival and performance, the environment must be measured. This can be accomplished easily and inexpensively with the Thermochron iButton® data logger manufactured by Dallas Semiconductor Corporation¹.

Thermochron iButton Hardware and Software

The Thermochron iButton is a digital temperature recorder within a small (17.35 mm diameter x 6.76 mm thick, 0.68 in x 0.27 in), durable, water-proof, stainless steel case (figure 1). It interfaces with a computer by inserting into a receptor (Blue Dot Receptor, Serial Port, part number DS1402D-DRS, \$5) with an RJ-11 (telephone) connector, that in turn inserts into a standard 1Wire® 9-pin COM port adapter (Universal Serial Port Adapter, part number DS9097U-009, \$10), that then plugs into the serial port of the computer. These items can be purchased as a starter kit (part number DS1921K)

**1 Dallas Semiconductor Corporation, 4401 South Beltwood Parkway, Dallas, Texas 75244-3292
Tel: 972-371-6824 Fax: 972-371-3715 e-mail: <
<http://www.ibutton.com/ds1921k.htrnl> >**

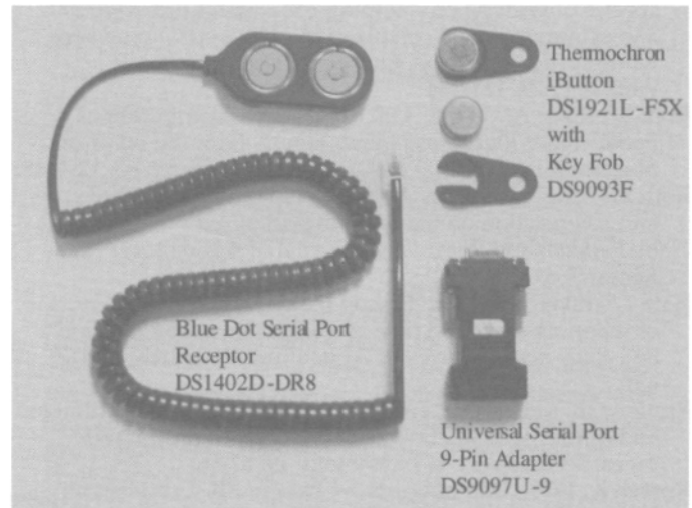


Figure 1-The Thermochron iButton' with hardware to interface to an IBM®-compatible computer using a Windows® platform.

for \$25. Additional Thermochron iButtons (part number DS1921L-F52), each with a unique 64-bit identification number, can be purchased for \$10.34. Accessories are available to attach iButtons to almost anything (for example, a plastic flanged key fob, part number DS9093F, \$0.80, figure 1). The self-extracting and installing "iButton Viewer" software, which is necessary to program Thermochron iButtons and review data, requires a Win32® platform, such as Windows 2000, 98, 95, or ND® (Microsoft Corporation), and is available without charge by downloading from the Dallas Semiconductor Web site: < <http://www.ibutton.com> >. Any of these hardware items can be ordered there as well.

The digital thermometer measures temperatures from -40 to +85 °C (-40 to +185 °F) in 1 °C (1.8 °F) increments with an accuracy of ±1 °C (±1.8 °F). A real-time, clock calendar is Y2K compliant and accurate to ±2 min/mo within a 0 to 40 °C (32 to 104 °F) range. The recording interval selected can range from 1 to 255 min in 1-min intervals, with a starting offset of 0 min 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. Recording stops or over-writes oldest data (selectable) after 2048 time-stamped temperature values are logged. The histogram feature is a long-term monitoring approach. The histogram has 63 data bins of 2 °C (3.6 °F) resolution with a maximum capacity of 65535 temperatures per bin. The lifespan of the nonreplaceable power source in the device is about 1 million measurements or 10 y, which ever comes 1st. The data sets are exportable as text (.txt) files for import into other software packages to enhance graphic presentation. Text files cannot be imported back into the iButton Viewer software.

Getting Started

A quick trip to the Web site will download the iButton Viewer software. 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 file (tm312 32.exe) to disk (your hard drive). The space required is about 1.5 MB. Execute the file (double left-mouse click) to install it on your computer. The default install location is C:\Program Files\Dallas Semiconductor. Then start the iButton Viewer from the pull-up Windows menus: Start > Programs > iButton-TMEX. The iButton Viewer Help file installed at the same location provides information on using the device successfully.

The iButton Viewer main window displays the identification number of the serial port interface (ending in 09) and the identification numbers of the 1 or 2 Thermochron iButtons in the Blue Dot receptor (ending in 21). Determine which number goes with which Thermochron iButton by removing one and watching which number disappears. Click the Thermochron iButton 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 3 tabs. Select the "wizard" tab to program a "mission." The process is straightforward and takes only a minute. Successive windows will prompt to set the Thermochron time from the computer clock, set the start delay period and sample rate, and to specify whether to over-write the first 2048 measurements. Alarm options are also set here. Selecting to view data in Fahrenheit or Celsius is accomplished at the top task bar of the iButton Viewer window in a pull-down menu under Options. 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 2nd of the 3 tabs at the Thermochron Viewer window. Three types of data are present: Temperature Alarms, Log, and Histogram. The Temperature Alarms window presents the starting and ending date and time of the occurrence of temperatures outside the high and low alarm limits. The Log window displays the date, time, and temperature of the 2048 time-stamped measurements. The Histogram window lists the 63 histogram bins and the count of the data in each bin. Viewing options available here also affect the export format of the data. They include changing the date and time to the number of minutes since the start of the mission, and various ways to describe histogram bins, such as by bin number, by the range of temperatures within the bin, or by the starting temperature of the bin. A viewing option available at the top taskbar pull-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 graphing the data in another software package easier because the numerical temperature and the alphanumeric unit are assigned to the same commadelimited data field when the data are exported.

The Log and Histogram data sets are graphed at the Mission Results window quickly by just the push of a button. This option makes it easy to scan the data for any deviations from expected temperatures that may be of concern. Although there are no edit or print options for these graphs within the iButton Viewer software, editing and printing can be accomplished by exporting the data.

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, and 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. Select "delimited," both "tab" and "comma," and "general" as each question is asked. Once in the spreadsheet, a chart can be designed to suit your needs. A 2nd method for transferring the data to another program is available. Copying data to a clipboard, exiting out of the iButton Viewer software, opening a 2nd software package, such as Microsoft Word[®], and clicking on the paste icon will import the data to a new file 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" pull-down menu at the top taskbar.

Viewing Mission Status

The "status" tab is the 3rd of the 3 tabs at the ThermoChron Viewer window. ThermoChron iButtons can be snapped into the Blue Dot receptacle and checked on 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 over-writing of data has occurred, the start delay, and the number of samples taken in the current mission and in total over all missions. All this information is included at the top of the file with each export.

The option to stop the current mission is the last item on the Options pull-down menu in the top task bar. The data recorded remain stored when the mission is stopped, and continue to be stored until the ThermoChron iButton is reprogrammed. Confirm a successful export of the data prior to reprogramming if you wish to save the data.

Sample Data

A sample data set was recorded by placing a ThermoChron iButton in a shipment of trees sent from the Colorado State Forest Service Nursery, Fort Collins, CO, to the USDA Forest Service Rocky Mountain Research Station, in Flagstaff, AZ. Twenty-three seedlings, in the nursery's standard heavy paper shipping bag, left the nursery on 2000 May 22 at 12:00 PM in a van from the private mail carrier typically used by the nursery to deliver trees. Temperature measurements were logged every 30 min until 2 h after arrival at the Station in Flagstaff at 12:00 PM on 2000 May 25. The data were exported to Microsoft Excel, and the iButton Viewer software Log and Histogram graphs were recreated (figure 2).

The seedlings left nursery storage at 3.5 °C (38 °F) at Time = 0 h (figure 2a) and quickly rose to 34 °C (93 °F) the afternoon of May 22nd. This was, of course, much too warm for packaged dormant tree seedlings. Tree temperature dropped to about room temperature (21 °C, 70 °F) during the 1st and subsequent nights, but continued to approach 30 °C (86 °F) or 35 °C (95 °F) each afternoon. At noon on May 25th (Time = 72 h), the package entered the temperature-controlled Flagstaff office complex and returned to room temperature. The histogram of the frequencies of various temperatures in 2 °C (3.6 °F) intervals provides an indication of the relative amount of time spent at the various temperatures (figure 2b). About half the total trip time was spent 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 insulative value of their packaging materials and the temperature stresses encountered en route.

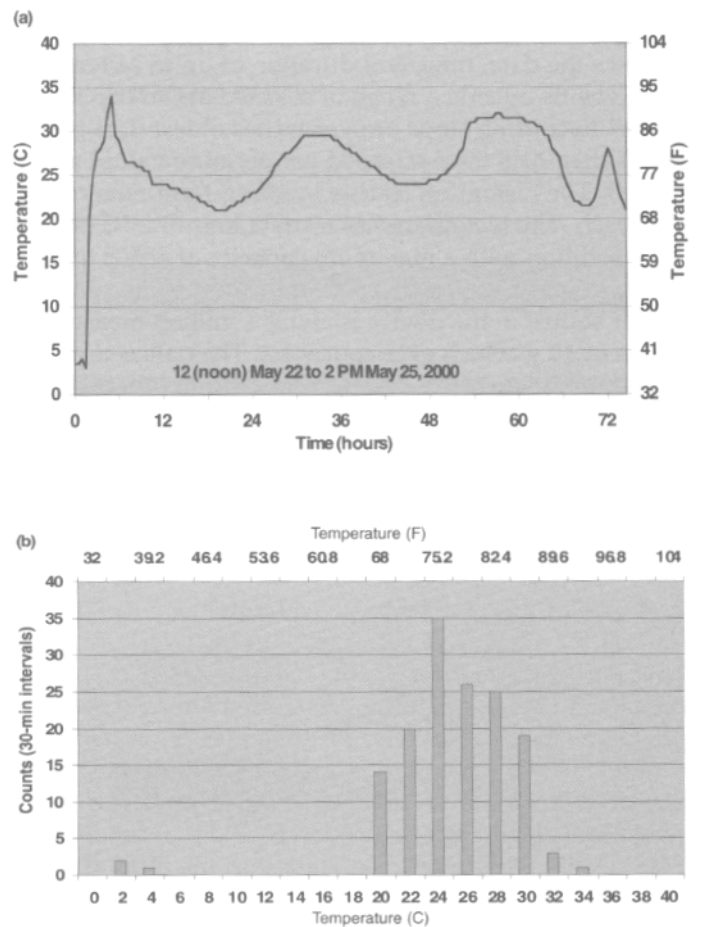


Figure 2-(a) An Excel® re-creation of the iButton Viewer® software Log graph of time-stamped data. Temperatures were measured in a shipment of trees en route from the Colorado State Forest Service Nursery, Fort Collins, CO (leaving at 12 PM on 2000 May 22), to the Rocky Mountain Station, in Flagstaff, AZ (arriving at 12 PM on 2000 May 25). (b) An Excel recreation of the iButton Viewer software Histogram graph of the same time-stamped data. Bars represent the frequency of temperatures measured at 30-min intervals in transit from Fort Collins, CO, to Flagstaff, AZ, from 2000 May 22 to 2000 May 25.

Summary

The ThermoChron iButton, manufactured by Dallas Semiconductor, has the features we were looking for in a recording device for monitoring tree temperature from nursery production to outplanting: reliability; weather resistance; a wide, measurable temperature range; ease of use; and minimal expense. This device should be very useful to both producers and receivers of tree seedlings for determining the likelihood that temperature exposure has impacted tree survival and performance.

Address correspondence to: David S. Gasvoda, USDA
Forest Service, Missoula Technology and
Development Center, Fort Missoula, Bldg. 1, Missoula, MT 59804

Acknowledgments

The authors thank Randy Moench, Manager of the Colorado State Forest Service Nursery, for participating in the testing of this product, and Jim Barnett, USDA Forest Service, Southern Research Station, Pineville, LA, and Ben Lowman, USDA Forest Service, Missoula Technology Development Center, Missoula, MT, for reviewing the manuscript.

Disclaimer

The mention of commercial products is solely for the information of the reader. Endorsement is not intended by the Forest Service or the U.S. Department of Agriculture.

References

- Burr KE. 1990. The target seedling concepts: Bud dormancy and cold hardiness. In: Rose R, Campbell SJ, Landis TD, editors. Target seedling symposium: Proceedings: Combined meeting of the Western Forest Nursery Associations; 1990 Aug 13-17; Roseburg, OR. Fort Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM200. p 79-90.
- Ritchie GA, Tanaka Y. 1990. Root growth potential and the target seedling. In: Rose R, Campbell SJ, Landis TD, editors. Target seedling symposium: Proceedings: Combined meeting of the Western Forest Nursery Associations; 1990 Aug 13-17; Roseburg, OR. Fort Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-200. p37-51.