Applications of Portable Data Recorders In Nursery Management and Research[1]

W. J. Rietveld and Russell A. Ryker[2]

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Abstract.--A portable data recorder is a specialized electronic device for recording and storing data in the field, then transmitting the data directly to a computer, eliminating the time and errors associated with manual data transcription. Use of a data recorder allows error and completeness checking in the field, direct data collection from instruments, and minimum turnaround time between data collection and completed data analysis. Considerations for selecting a data recorder to meet individual needs, and some drawbacks, are discussed. Specific applications in nursery management and research are presented.

INTRODUCTION

A portable data recorder (PDR) is a hand-held, battery-powered, microprocessor-controlled computer terminal (Cooney 1987). PDR's are specialized electronic devices designed to collect and store data in the field or laboratory (in place of data forms), then transmit the data directly to a computer for processing. They differ from laptop computers and hand-held calculators in that they are constructed for outdoor use and their main purpose is to store data, not process it. As microcomputer use increases in forestry, more resource professionals are turning to automated data processing to increase their productivity. Although computer hardware and software have advanced substantially in recent years, data are still collected and entered into computers by hand in many cases. These two steps done manually can be expensive, time-consuming, and full of errors. Alternatively, data can be keyed into a PDR as they are collected, automatically checked for errors and completeness, then the completed data file can be transmitted directly to a computer. Because manual data transcription is eliminated, PDR's can significantly reduce costs, number of errors, and turnaround time. PDR's are becoming the technological link between field measurements and data analysis.

Portable data recorders were first used in supermarkets to expedite inventories. In recent years they have found a new home in forest inventory because of the volume and diversity of data that are collected, the need for error checking during data collection, cost savings in data transcription, and reduced time to obtain results (Anonymous 1987, Bergstrom 1987, Bottenfield and Meldahl 1987, Fins and Rust 1987, Scott 1987). Bluhm (1986) recently reported using a PDR in nursery seedling inventory. Applications in research have increased in recent years, not only because more efficient data handling is needed, but also because some PDR's can be interfaced to digital and analog instruments to collect data directly.

All these applications have certain characteristics in common: (1) a large amount of data needs to be collected and transferred to a computer for summary, (2) the costs of manual data entry and verification need to be reduced, (3) errors must be minimized, and (4) the time between data collection and data processing should be reduced. In this paper, we will discuss some benefits and drawbacks of using PDR's, list some considerations to help you decide which one to purchase, and present some ways we use PDR's in nursery management and research.

SELECTING A PORTABLE DATA RECORDER

Approximately two dozen devices on the market could qualify as portable data collectors. Specifications for most of the dedicated PDR's are reviewed by Cooney (1985, 1987).They differ

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[2]W. J. Rietveld is Research Plant Physiologist, North Central Forest Experiment Station, Rhinelander, Wisconsin; Russell A. Ryker is Research Silviculturalist (retired), Intermountain Forest and Range Experiment Station, Boise, Idaho.

widely in size, environmental durability, keyboard configuration, operating system, memory capacity, programmability, and communications. Most are powered by rechargeable batteries, have some form of battery backup, and have some sort of low battery warning, so there is a low risk of losing data. The devices differ greatly in other specifications; users need to determine what configuration they need and select the appropriate device. For example, in forest inventory error-checking and completeness checking routines should be built into the data collection scheme so that complete and error-free data are obtained while the survey crew is on site. For those applications, a PDR that supports BASIC, a powerful and versatile programming language, is highly recommended. Many other applications are more straightforward, amounting to filling in the blanks with data, so a simple edit mode may suffice for entering data. Certain PDR's can be interfaced with digital and analog instruments--such as calipers, balance, area meter, porometer, thermometer, and string potentiometer -- so that data can be transmitted directly to the data file with the push of a button. In some cases the PDR can be set up to take unattended readings from an instrument at set times. Note, however, that these applications require a custom program to read the device and record the data. All PDR's are equipped with a serial port for RS-232 communications via direct cabling or a modem to a host computer.

Programmability is desirable for controlling cursor movements, performing mathematical functions, displaying menus and messages, checking for errors, checking for completeness, and accepting data from interfaced instruments. Most devices provide some degree of programmability using either a proprietary language that the user must learn, or BASIC, a more universal language. Although the proprietary languages can be used to provide extensive error checking and to perform mathematical functions, there are advantages to purchasing a PDR that is programmable in BASIC because the same language can be used for programming on a microcomputer. However, a proprietary language may be more suitable for programming the PDR to accept data from connected instruments. While building in some programmed error checking routines and minor manipulations of the data may increase efficiency of data collection, don't expect the PDR to perform the data summary and analysis. For most applications, it is easier to first transmit the data to a computer, then perform the analyses using existing, more powerful application software. The examples in the applications section will illustrate this point.

We recommend the following approach to selecting a PDR: (1) list all applications where a PDR may be useful, (2) evaluate that list and retain only the applications where a PDR is truly needed to increase efficiency (i.e. large amounts of data, repetitive measurements, need to transmit data to a computer, minimization of errors, and cost savings from eliminating data transcription), (3) make a list of capabilities and features that the PDR must have to meet your needs, (4) compare your list against the tables of specifications provided by Cooney (1985, 1987), and (5) evaluate product information and any available published reports in making your decision. Several companies and agencies have conducted their own evaluations and may be willing to share their information.

You may also wish to evaluate the economics of using a PDR instead of conventional field forms and manual data entry. You can do this by following the procedure outlined by Fins and Rust (1987). Assuming that data collection takes the same amount of time by both methods, data transmission and manual entry times can be estimated closely enough to perform the comparative cost estimates without actually using a PDR.

DRAWBACKS TO USING A PORTABLE DATA COLLECTOR

Some special problems, limitations, and conflicts that may be encountered in using a PDR are: (1) "computer phobia", (2) limited view of the data file, (3) conflict with existing data collection methods, and (4) cabling and communications between connected devices.

Many people get "computer phobia" when they are asked to record numbers electronically rather than writing and storing them physically on a tangible sheet of paper. The task of training personnel to use a PDR should be taken seriously. It is a good idea to develop flow charts and provide practice data for them to learn with before important data are recorded. As a transition, it may be helpful to first write the data on data forms, then enter the data into the PDR.

One limitation of most PDR's is the restricted view of the data file, i.e. only a small portion of the file is seen (and accessible) on the display at one time. It is more difficult for the user to compare current measurements with previous measurements, which are more easily seen on data forms. This is not a problem if you take advantage of the PDR's power by writing a short program to have the PDR display the previous measurement (which must exist in the same file), or you can have it compare the new measurement with the previous measurement, beep if it is smaller, and otherwise enter the data in the file. A second problem related to the restricted view is keeping track of your location in the file. Because one row in the file is usually the data for one tree, beginning users may skip a tree and get out of sequence with the data file. There are two ways to avoid this problem. One is to print a copy of the data file with lines numbered so users can keep track of their location by line number, and the other is to program the PDR to display the descriptors (e.g. block, treatment, tree number) pertinent to each measurement being entered.

Use of a PDR may not be compatible with established plot measurement methods. For example, some crews like to have one person record data while two people measure trees in adjacent rows. This does not work out very well using a PDR because it cannot easily switch back and forth in the data file. The same is true for measuring adjacent rows in opposite directions, unless either the plot or the data file is arranged that way. When using a PDR, it is easiest to enter data in the sequence they occur in the data file. If more than one person is taking measurements, they should leapfrog and provide the data in the file sequence.

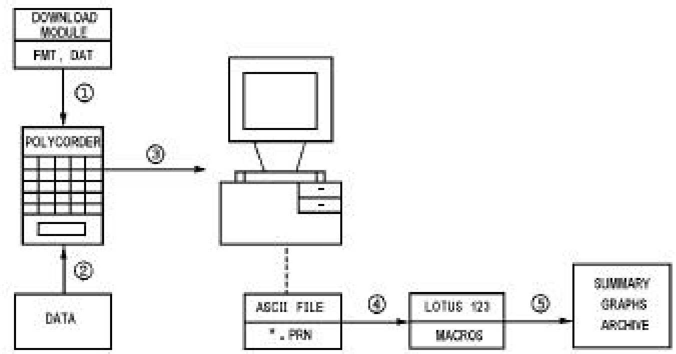
Cabling and communications between connected devices are common obstacles when any peripheral device is connected to a computer or PDR. Cabling from a PDR to a microcomputer is usually not a problem because the manufacturer often has a serial cable available. Communications between a PDR and a computer is best done with a communications program. Establishing communication is a matter of setting up matching protocol (baud rate, parity, duplex; data bits, stop bits, etc.) between the two devices. The PDR manual will usually give some helpful advice on this, but there is no one solution because computers differ widely. The same situation arises when a PDR is cabled to an instrument to collect data. In some cases, e.g. digital calipers, the device, cable, and programming may be available from the PDR manufacturer. In other cases, you purchase the peripheral device with its optional serial port, and the cabling and communications to the PDR are up to you.

SPECIFIC APPLICATIONS OF PORTABLE DATA RECORDERS

In this section we will present two applications of the Polycorder[3] (Omnidata International, Logan, UT) in nursery management and research. Published applications of other PDR's are: Hewlett-Packard model 71 (Bluhm 1986); Husky Hunter (Bergstrom 1987, Bottenfield and Meldahl 1987); Husky Special Performance (Scott 1987); Oregon Digital Serial Plus II 7100 (Anonymous 1987); and Datamyte 1003 (Nieman et al. 1984).

Nursery Application

The USDA Forest Service Reforestation Improvement Program (Rietveld et al. 1987) involves repetitive measurement of several seedling variables (seedling growth, morphology, root growth potential, cold hardiness, stress test, plant moisture stress, and field plot measurements) at 11 nurseries. The same variables are repeatedly measured using the same sampling scheme, so the basic data forms will be used over and over. To facilitate data collection, summarization, file organization, and archiving, a systematic approach was developed that utilizes the Polycorder to record the data and transmit it to a microcomputer. The following diagram shows how the data will be processed:



The Polycorder requires a format file for each data file that will be created. The format file designs the data form. The data file is the actual form, which is blank until data are entered. Format and data files may be keyed into the Polycorder, loaded from a download module (1), or downloaded from a computer. The next step is to key the data into the data file (2). This can be done in edit mode or in program mode, but the latter requires writing a short Polycode program to control cursor movements and must be matched to the number of columns receiving data. Once the data file is complete, the data are transmitted to the computer (3) using direct cabling between serial ports on each device. A communications program, Crosstalk, is used to capture the data and create an ASCII file with a .PRN extension. The ASCII data file is then imported into a preformatted Lotus 123 worksheet (4) where the data are summarized, graphs are created, and archiving is done (5) by running specialized macros (preassembled lists of commands) on the worksheet.

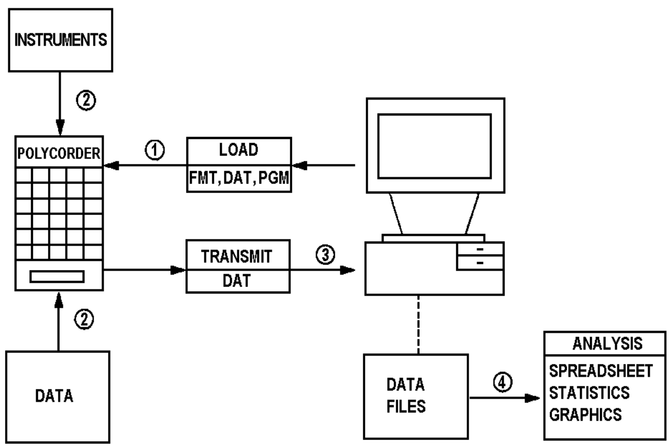
This scheme offers many conveniences as a result of the repetitive nature of the application: 1) because the same data files are used over and over, they may be stored in a download module (or the computer) and loaded into the Polycorder whenever they are needed; 2) after the data are offloaded to a computer, they may be erased from the Polycorder file, retaining the blank data file in the Polycorder for reuse; and 3) automated data processing is optimized, thus the data can be transmitted to a computer and summarized in minutes.

Research Application

The above approach works well for repeatedly measured variables where the same data forms are consistently used. However, that is often not the case in research. Each study typically has one or more unique data files; the data files will usually be more complex, e.g. containing several columns of descriptors for block, treatments (in random order), and seedling number;

[3] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

there may be a need to append additional columns onto the original file for annual measurements; and some data types may be transmitted to the PDR via a serial port from a digital balance, calipers, area meter, porometer, or other device. The following diagram shows a typical data collection and processing scheme in research applications of PDR's:



The format and empty data files are more easily created on a computer, stored as ASCII files, then downloaded directly to the Polycorder (1). The format file can be written with EDLIN or any word processor that will output an ASCII file. The data file containing the descriptors (block, treatment, tree number, etc.) in the desired sequence can be "constructed" using Lotus 123, or can be created directly with certain statistical programs such as Minitab. The ASCII format and data files are downloaded to the Polycorder using a communications program. This step can be expedited by using a communications program that has versatile command and script file capabilities. An example is presented in Table 1.

Data are entered into the PDR through the keyboard (2) or by direct transmission from instruments (2). Direct transmission of data from instruments is very fast, but requires that a Polycode program be written to accept, manipulate, and file the transmitted data. For example, we weigh dried plant samples without removing them from the bags. Paper bags of the same size are surprisingly consistent in weight. We dry a group of empty bags along with our plant samples, determine an average empty bag weight, then enter that value into a Polycode program. The program subsets the measured weight from an alphanumeric string transmitted by the balance, subtracts the average empty bag weight, records the tissue dry weight in the data file, performs cursor movements, and provides file location prompts. This technique works well for samples that have a dry weight greater than 1 gram; the experimental error is no greater than that introduced by removing the plant samples from the bags to weigh them.

The completed data file is transmitted back to the computer (3), using a communications program. File redirection programs such as Dpath and File Facility are handy for organization purposes because they allow you to store data files in separate subdirectories on a hard disk, rather than storing them all in the same subdirectory with the communications program. The final step of the scheme shows the data files being imported into various spreadsheet, statistical, or graphics programs for analysis (4).

DISCUSSION

Portable data recorders have the potential to increase efficiency of data collection in a variety of applications. However, they are not for everyone. Converting to a different method

Table 1. A Crosstalk script file (*.XTS) for transferring files between a PDR and a microcomputer. The script file loads automatically when it is given the same prefix as the command file (*.XTK). The communication protocols used in the command file must match those of the PDR.

```
GO LOCAL
CLEAR
ASK Type L for Load, T for Transmit, E for Edit, or Q for Quit
JUMP DO-@
LABEL DO-Q
QUIT
LABEL DO-L
SCREEN D
CLEAR
LWAIT CHAR " "          ;insert mating call character sent by PDR, if used
SEND
RWIND
LABEL DO-T
SCREEN D
CLEAR
CA
WHEN " " ALARM NOW      ;insert end of file character sent by PDR
WAIT STRING " "         ;insert end of file character sent by PDR
CA -
RWIND
LABEL DO-E
RUN
```

requires an investment in new equipment, and time to evaluate the actual need for the device, to learn how to use it, to develop a system to apply it, and to train personnel to use it properly. Thus, there will be a start-up period before a net increase in efficiency is realized. You should be reasonably certain that using a PDR is justified before you make a commitment. Use of a PDR (and a computer for that matter) may well help you reach a higher level of technology, efficiency, and productivity. However, that is only achieved through learning, commitment, and adaptability.

In research applications, we find that using PDR's allows us to take more data than would otherwise be possible with available personpower. This is especially true when instruments are interfaced with a PDR. One person can take several times more data in a single day, with good precision and less fatigue. Most technicians are enthusiastic about using data collectors because they save time, and the person feels a sense of accomplishment for mastering the use of a sophisticated electronic tool. Because data entry and verification are eliminated, the technicians are relieved of those tasks, and the computer is freed for other uses.

In summary, PDR's are a cost-effective alternative to conventional data sheets for data collection and manual entry of data into a computer. Data collection time is about the same with a PDR, but the need for manually entering data into a computer and verifying them is eliminated. Other benefits are the opportunity to perform error checking in the field, interface with instruments, and obtain faster turnaround of completed data analyses. In general, if a PDR is used frequently, the labor savings will pay for the device in 1-2 years.

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