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MANAGEMENT GUIDELINES FOR MONITORING USE ON BACKCOUNTRY TRAILS

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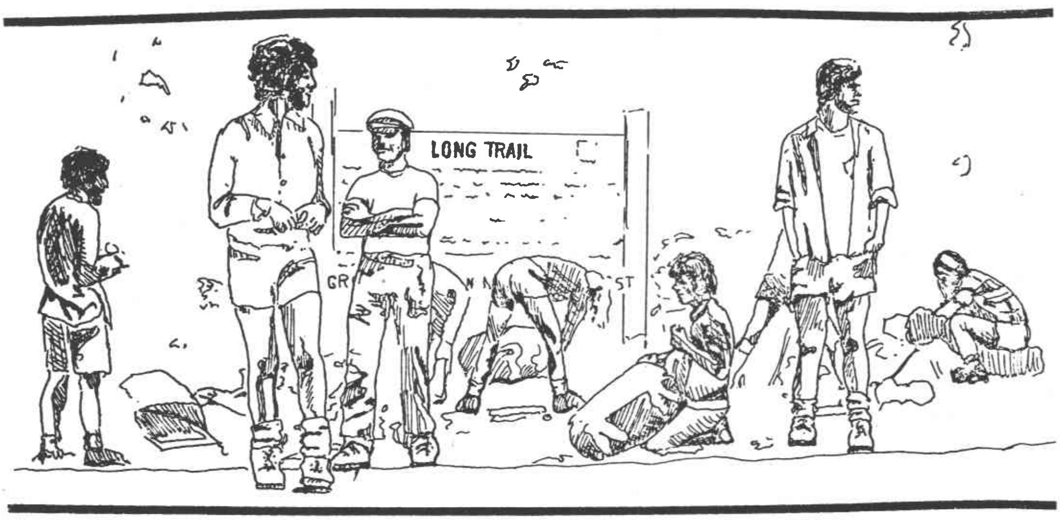
Abstract. This state-of-the-art management guideline describes the importance of knowing backcountry use patterns and the questions that should be asked before embarking on a use-monitoring program. It summarizes information about six techniques for monitoring use of backcountry trails and provides practical information about site suitabilities, installation and maintenance requirements, equipment costs, and data analysis considerations of each monitoring system.



A NOTE TO THE READER

These guidelines have been prepared under the direction of the Backcountry Research Program, USDA Forest Service, Northeastern Forest Experiment Station, Durham, N.H. in cooperation with other groups and individuals as mentioned. Their purpose is to present up-to-date, practical information on a number of subjects concerning backcountry management. The guidelines are not meant as policies, regulations, or rules, but simply a summary of the "state of the art."

Because these documents are contemporary, they will be updated in future years, as additional information becomes available. Therefore, if you have comments or suggestions please send them along to the Backcountry Project. Guidelines will be revised as time and funds permit. Appropriate credit will always be given.

Also, if you have suggestions for areas of major interest that might deserve treatment in a guideline, please send them along, too.

R. E. LEONARD
Project Leader

PREFACE

This guideline has been prepared to collect diverse and scattered information on methods of monitoring backcountry trail use. It is intended to give managers of public and private backcountry recreation lands a comparative view of the techniques that have been used for counting trail users and sampling their characteristics.

Some of the monitoring systems only count trail traffic; others provide additional information about trail users. Some of the systems are technologically sophisticated; some are labor-intensive. Descriptive information about each system is presented in the text of the guidelines. Practical information about site suitabilities, installation and maintenance requirements, equipment costs, and data analysis considerations of each monitoring system is presented in the appendix. It is hoped that this information will help managers select and manage use-monitoring systems that will suit their needs and budgets.

Information in this report has been developed for the guidance of the employees of the Forest Service, U.S. Department of Agriculture, its contractors, and its cooperating Federal and State agencies. The Department of Agriculture assumes no responsibility for the interpretation or use of this information by other than its own employees.

The use of trade, firm, or corporation names is for the information and convenience of the reader. Such does not constitute an official evaluation, conclusion, recommendation, or approval of any product or service to the exclusion of others which may be suitable.

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PART I. MONITORING VISITOR USE

Importance of knowing backcountry use patterns

In the early 1960's, public forest managers and leaders of private trail organizations became aware of a substantial increase in recreational use of backcountry. This increase led to more active management of backcountry recreational areas to protect the trail environment and at the same time preserve the intangible, but much sought, "backcountry experience."

To manage a backcountry trail system, an inventory of site conditions and use patterns is essential. The former can be assessed readily enough by a competent site survey. Because of the diffuse nature of dispersed forest recreation, use patterns are more difficult to determine. Nevertheless, with the right monitoring system or combination of systems much useful information can be obtained.

This information is important in backcountry management to:

- Develop and assign priorities to maintenance programs for specific areas
- Determine long- and short-term use trends
- Make requests for financial support commensurate with actual use levels
- Plan and implement long-term facility development and educational programs
- Determine correlations between site impacts and use levels in specific areas
- Set up systems models to help manage use patterns in heavily used areas.

The early 'double-sampling' or 'cordon-sampling' method of estimating total dispersed use of a large area of forest land relied on the determination of a relationship between some indicator count, such as a vehicle count, and the desired statistic, such as the number of site visits. Visitors had to be interviewed at a roadblock near the forest land (Cushwa 1963; James 1967). This system posed practical limitations for forest lands accessed by several major highways and for Federal agencies needing questionnaire/interview approval. The 'double-sampling' method is, however, readily applicable to developed roadside campgrounds and picnic areas where traffic funnels through one access road.

Several site-specific backcountry monitoring systems are now available that can provide much useful information without the need for roadblocks. Some are quite simple; others are complex. Before any system can be used effectively, however, monitoring goals and costs must be determined.

Determining monitoring goals and costs at the outset

Trail use should not be monitored without a specific reason or plan. Because even the simplest system requires a substantial investment of time and money, care should be taken in choosing and administering a counting system. A number of questions might be asked to help with this process:

1. *Is a monitoring system needed?*

Some backcountry areas receive relatively little use. Physical impacts and facility needs may be negligible. Under such conditions, the time and effort involved in running a monitoring system might better be spent on other projects.

However, a trail system in which the physical impacts of recreationists are evident requires active management. Decisions to improve, expand, or close overnight sites and trails should be made in recognition of existing or accepted visitor use levels. For example, at physically damaged sites that receive frequent and heavy use, site maintenance facilities and management could be increased to accommodate the heavy use. If this is not possible because management funds or time are limited, the site could be closed for rehabilitation or put under stringent use restrictions. At sites designed to handle heavy use, but where use is found to be low, managers could either encourage more visitors to use the site, or reduce the management attention given to it. Site durability and use levels should be matched with management procedures to prevent site degradation. Without information on use levels, management decisions are difficult to make.

2. *If a monitoring system is needed, exactly what information is desired?*

Managers must determine what information they need and whether and how it can be obtained. Some monitoring systems can be used for more than counting trail traffic. Information obtainable by one or more of the various systems includes:

Use levels
- Number of individual users
- Number of one-way trips
- Date of use

Details of use
- Number of groups
- Size of groups
- Mode of travel (hiking, horseback, etc.)
- Direction of travel
- Trails used
- Duration of trip

Details of users
- Name
- Address
- Age
- Occupation and/or similar information
- Main purpose of trip (hiking, hunting, fishing, etc.).

Basically, use-monitoring systems fall into two major categories: those that provide use numbers only (pressure plate and photoelectric counters), and those that provide information on both use and users (permits, self-registrations, time-lapse photography). A decision should be made initially as to which type of system will better serve management purposes.

Some management questions may require knowledge of more than simple numbers of users. Information about visitors' residences can indicate where to direct information and education ("I&E") efforts. A percentage breakdown of group sizes can help to determine overnight facility needs, e.g., size and spatial distribution of shelters or tent platforms at some overnight sites. A temporal and geographic distribution of dispersed recreationists can indicate when and where to station backcountry patrols or where to upgrade the facilities (Plumley et al. 1978). Visitor information may also be used to aid in search-and-rescue operations and, in the case of mandatory permits, to control use levels in restricted use areas.

3. *Is the management value of the desired information equal to the cost of getting it?*

Monitoring systems differ greatly in complexity and precision. When the sort of information and level of precision desired have been determined, the simplest, least expensive system that satisfies the basic data requirements can be selected.

All monitoring systems require regular maintenance and at the outset these costs, including vehicle expense, travel time, and wages, should be evaluated along with the cost of setting up a system initially. Some visitor information may need to be collected over more than one season, or at several sites, to be of value for management decisions. The length of time and expense of data collection should be considered in the cost also. With some of the monitoring systems now available, a wide variety of information on users can be obtained. Much of it, however, is of questionable management value and may border on an invasion of privacy, e.g., sex or race of users, income or education, etc. Questions that simply satisfy management's curiosity should be omitted. The cost of acquiring visitor use data should be weighed against the "cost" of making a wrong management decision. For example, overuse of an alpine site results in very high rehabilitation costs.

The importance of determining monitoring goals before choosing a system cannot be overemphasized. After the three questions listed above have been reviewed, an appropriate system should be chosen with full recognition of its shortcomings and maintenance requirements.

PART II. THE MONITORING SYSTEMS

A variety of use-monitoring systems is available. Several are sophisticated electronic systems that are likely to be refined and improved rapidly.

Comparing systems is difficult because many variables are involved, e.g., site conditions, use levels, available funding, and competence of maintenance personnel. An attempt has been made here to describe each system briefly and discuss its advantages, disadvantages, and applications. A chart in the last section of this guideline summarizes some of these points. Detailed operational information for each system may be found in the appendix.

Field sampling

1. *The system.* Until the development of mechanical counters in the late 1960's, random field-sampling of visitors was often used to estimate use levels in backcountry areas. The usual procedure is to station people on selected trails to observe or interview users.

Simple observations provide information on numbers, direction of travel, and other clearly observable characteristics; interviews may be as detailed as desired. "Cordon sampling"—interviewing users as they leave or enter an area at checkpoints on every access road or trail—has been used in some studies.

2. *Advantages and disadvantages.* Experience has shown that backcountry use, and particularly day use, is profoundly affected by time of year, day of week, weather, and many other variables (Bowley 1977). In order to obtain use estimates of high accuracy (e.g., ± 2 parties per day with 95 percent confidence), quite a few sampling times must be chosen (see Appendix A). On trails where use does not fluctuate by more than ± 2 parties per day, the random sampling method can be quite practical, as the amount of sampling time required for an accurate estimate is low.

Sampling, particularly interviewing, may be perceived by many users as obtrusive and inappropriate. Federal regulations require a rationale for every question and a strict review and approval procedure for studies by Federal agencies. This provides some degree of protection against invasion of privacy.

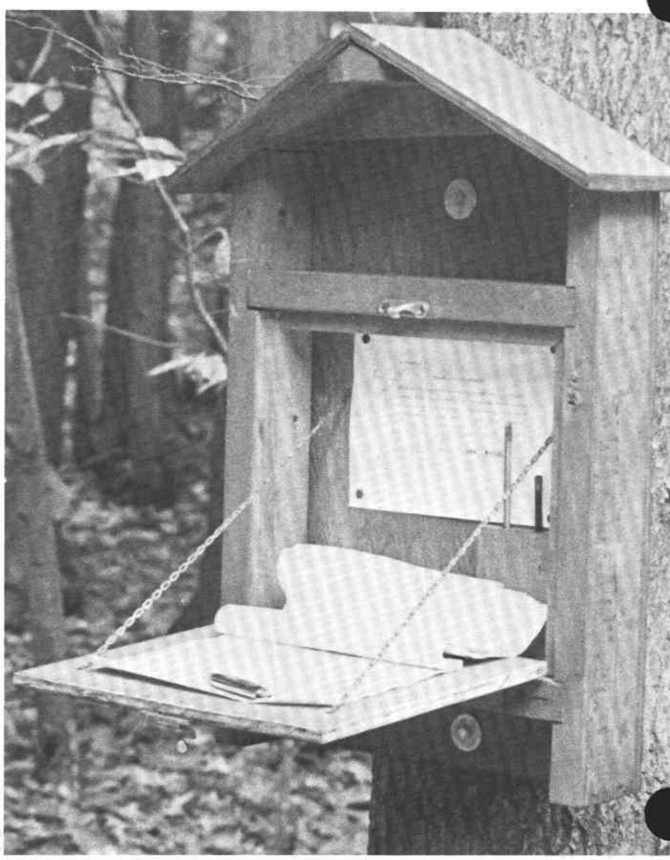
3. *Application.* Where information about users and/or their opinions is needed, random sampling can be very useful. Occasional sampling in conjunction with other monitoring systems can help to improve the reliability of such systems.

Voluntary self-registration

1. *The system.* For many years backcountry use estimates have been based largely on information from sign-in registration stations. Visitors simply register and provide the requested information. The trailside stations have consisted of (1) coffee cans nailed to trees, (2) drop-leaf wooden register boxes with register sheets or books (Fig. 1), or (3) individual register cards that are deposited in slot-style boxes. The latter style provides confidentiality between hiking parties. The former styles provide space for parties to communicate with other parties by leaving messages.

The format of the registration sheet or card depends on what agency is seeking the information. Private hiking clubs have designed their own sheets to obtain the information they want at the time. The U.S. Forest Service has used a standard form for registering visitors to western wilderness areas. Its format is very similar to the "Wilderness Permit" used by the Forest Service in eastern wilderness areas. Standardization of registration forms allows forest managers to collect comparable information so that nationwide statistics can be compiled. Within one management unit, standardization can also provide more

Figure 1.—Register boxes usually contain register sheets, pencils, and some educational informatio



useful (comparable) information on hiker use patterns.

2. *Advantages and disadvantages*. Voluntary self-registration systems have a number of advantages. Both initial costs and maintenance costs are low because of the simplicity and durability of the system. The register boxes are portable and easy to install. Vandalism has been rare in backcountry studies (Wenger 1964), although damage by animals may be a problem in some areas.

Registration stations can serve secondary functions. Maps and educational information can be put in them, and the register information can be of some value in search-and-rescue operations. Self-registration systems normally provide information on date, name, address, and number in group. Many forms also request information on duration of visits, direction of travel, destination, etc. An effort should be made to avoid requesting too much information, as lengthy or complex forms are more likely to be left uncompleted.

The greatest shortcoming of voluntary self-registration systems is the lack of followup procedures to determine visitor sign-in rates. Although studies have shown that a compliance rate of between 60 percent and 80 percent is likely (Wenger 1964; James and Schreuder 1971; Lucas, Schreuder and James 1971), some studies have shown rates as high as 89 percent (James and Schreuder 1972) and as low as 28 percent (Lucas 1975). Because of this variability, managers should avoid the temptation to apply a conjectural compliance rate to the figures they gather from the boxes.

In order to estimate trail use, the registration sign-in rate must be determined for each station, unless very similar characteristics and users are found at different stations. The accuracy with which this rate should be determined depends on the manager's need for accurate trail-use numbers. A sampling scheme for validating registration box sign-ins is presented in Appendix B. The validation procedure involves stationing someone in the vicinity of the register box to count the number of hikers and compare that number with the number of those who have signed in. Eventually, a compliance rate for that particular station can be derived. Because this procedure does not require special training, it is possible for volunteers (e.g., trail club members or Scouts) to do this work, thereby reducing costs considerably.

Researchers who want to study hiker characteristics or attitudes from mailed questionnaires can obtain hiker addresses from the registration station. However, the sample may be biased if registrations are the only source of addresses. Studies have shown lower-than-average compliance rates among solo hikers, day-users, and local people, and substantially lower compliance among horseback riders, fishermen, and hunters (Lucas and Oltman 1971). Therefore, registers on a trail with substantial non-hiker use may bias the final user profile. In addition, most register forms ask only one person from each party to sign in. Other party members, especially if they live at different addresses, will not be surveyed.

If greater accuracy is needed, the register system can be supplemented by random interviews combined with the validation process. In some cases, a separate compliance rate can be developed for readily observable user groups such as horseback riders.

3. *Applications*. Despite the shortcomings discussed above, self-registration systems have many applications, especially where funds are low and volunteers can be used for validation. Wherever names, addresses, and other hiker characteristics are desired, self-registration provides an unobtrusive and inexpensive way to collect this information. Additional information about use of trail registers can be found in Wenger and Gregerson (1964).

Mandatory permit system

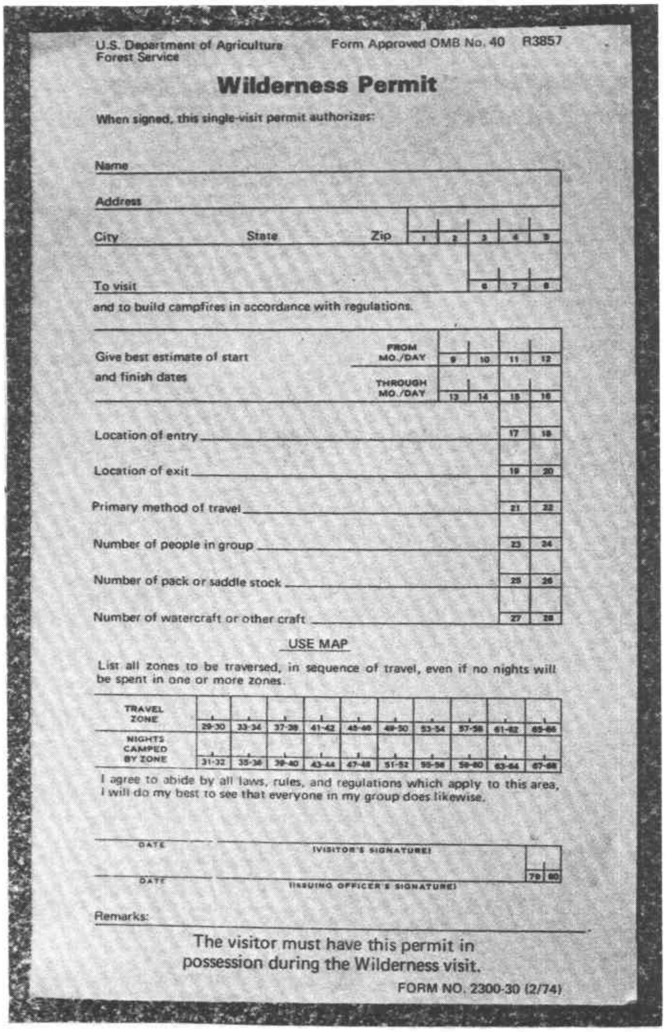
1. *The system*. Mandatory use permits or reservations have been used where daily or overnight use limits have been imposed to keep visitor levels from exceeding site capacities. Permits are issued to persons stopping at local agency offices, or by mail or a first-come, first-served basis (see Appendix C).

Some of the nation's designated wilderness areas use a mandatory permit system. This should not be confused with the voluntary permit system (registration system) used by many Federal wilderness areas in the West.

The current standard Federal wilderness permit requires information on name, address, area to be visited, estimated start and finish dates, locations of entry and exit, primary method of travel, number of people in group, and "travel zones" to be traversed (see Fig. 2). Permit information is currently fed into a nationwide computer so that each national forest can receive a quick tabulation of user characteristics.

As with any system that requires personal registrations, the compliance rate is rarely 100 percent. In areas with mandatory permits, rangers or backcountry patrols travel through the area to enforce the permit requirement as well as assist visitors with other needs. Failure to have a permit may result in a legal citation and fine, but often the hiking party is simply issued a permit by the patrol and advised of the importance of obtaining a permit on the next trip.

Figure 2.—Wilderness permits supply managers with useful information in addition to being an effective means of limiting use in an area.


U.S. Department of Agriculture
Forest Service
Form Approved OMB No. 40 R3857

Wilderness Permit

When signed, this single-visit permit authorizes:

Name
Address
City State Zip 1 2 3 4 5
To visit 6 7 8
and to build campfires in accordance with regulations.

Give best estimate of start and finish dates
FROM MO./DAY 9 10 11 12
THROUGH MO./DAY 13 14 15 16

Location of entry 17 18
Location of exit 19 20
Primary method of travel 21 22
Number of people in group 23 24
Number of pack or saddle stock 25 26
Number of watercraft or other craft 27 28

USE MAP

List all zones to be traversed, in sequence of travel, even if no nights will be spent in one or more zones.

TRAVEL ZONE	29-30	33-34	37-38	41-42	45-46	49-50	53-54	57-58	61-62	65-66
NIGHTS CAMPED BY ZONE	31-32	35-36	39-40	43-44	47-48	51-52	55-56	59-60	63-64	67-68

I agree to abide by all laws, rules, and regulations which apply to this area. I will do my best to see that everyone in my group does likewise.

DATE (VISITOR'S SIGNATURE)
DATE (ISSUING OFFICER'S SIGNATURE) 79 80

Remarks:

The visitor must have this permit in possession during the Wilderness visit.

FORM NO. 2300-30 (2/74)

2. *Advantages and disadvantages.* Mandatory use permits have a number of significant attributes. Because they are compulsory, permits can be used to limit or control access to heavily used or fragile areas. They are also valuable information and education tools because they provide direct contact with users. In addition, they can be used to help find lost or injured persons.

As use-monitoring tools, however, mandatory permits have some significant disadvantages. The cost to administer the system is quite high. The permit system incurs printing and distribution costs, clerical time to issue the permits to hikers, and daily patrolling time to enforce the system. In fiscal years 1976 and 1977, the cost per permit in the Federal wildernesses of New England was estimated at \$5.84, not including printing, processing, and analysis costs (Guldin 1978).

Reliance on permit data for estimating use of an area, or determining patterns of use, can lead to erroneous conclusions. While some hiking parties fail to obtain permits, others apply for permits and never use them. Permit compliance among actual users in one New England wilderness was found to be about 60 percent for day users and 80 to 90 percent for overnight users. A higher average compliance rate, 78 percent, was calculated when all permits issued (used or not) were included in the figures. Total use of an area would be inflated if all issued permits were counted. In addition to the difficulty of estimating total use, the patterns of use that can be derived from the permit information are not completely dependable or accurate. The activities and travel routes listed on the permits are anticipatory, so the information supplied by the hiking party does not always reflect the actual trip itinerary (Leonard, Echelberger, and Schnitzer 1978). As with the self-registration system, the permit compliance rates and information must be validated.

3. *Applications.* Mandatory permits are valuable in areas where day or overnight use must be limited, such as fragile alpine or subalpine campsites. As a use-monitoring system,

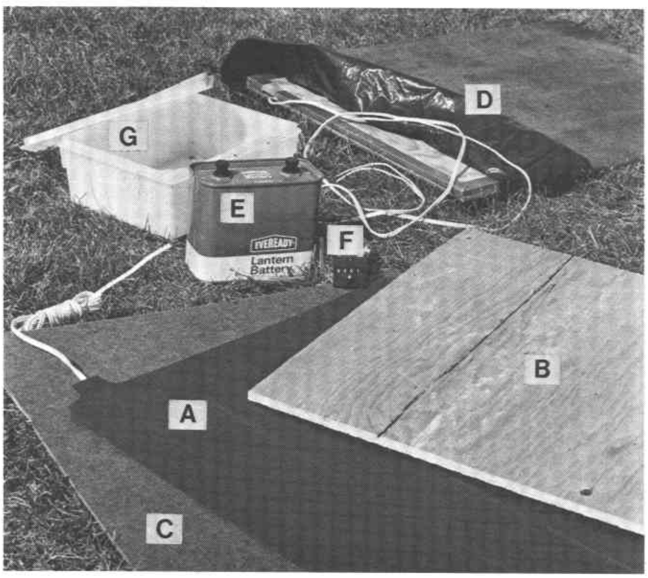
the permit system requires validation and enforcement to yield reliable information. The self-registration system provides comparable information at much lower cost; however, in areas with a multitude of access points or a complex trail network, permit systems may be easier to administer and easier to estimate total use of the area from than a system of trail-specific counting devices. Further information about mandatory permits can be found in Behan (1974), Godin and Leonard (1977), Hendee and Lucas (1973), Lime and Lorence (1974) and Lime and Buchman (1974).

Pressure plate electric counters

1. *The system.* Pressure plate counters were developed in the mid-1960's, using components from a variety of commercial sources. Despite the popularity of the system in some areas, no prepackaged pressure plate counter is available.

The components consist of a flat 18 x 24-inch plastic-covered mat switch, which is placed in a sandwich of plywood, masonite, or other material. Mat switches are common, and often used to ring bells in stores. The sandwich is designed to protect the mat switch from sharp rocks and to distribute the weight of a hiker's foot evenly over it. The sandwich is wrapped in a plastic trash bag, which in turn is wrapped in burlap, and buried a couple of inches below the surface of the trail. The plastic bag serves to waterproof the system and the burlap provides a rough surface to which the soil will cling.

Figure 3.—The pressure plate (A), sandwiches between plywood (B), and masonite (C), protected with a layer of plastic and burlap (D), is buried several inches below the trail surface. A 6-volt battery (E) and counting mechanism (F) are housed in a plastic container (G), wired to the pressure plate and hidden near the trail.



From the buried mat, leads run to a 6-volt lantern battery and a small digital counter stored in a buried, watertight container about 6 feet away from the trail. When a hiker walks on the buried mat, the switch is closed; as the person's foot is lifted from the mat, the switch is opened and the counter advances one digit (see Fig. 3).

2. *Advantages and disadvantages.* Pressure plate counters have a number of significant advantages. Component costs are relatively low (from \$40 to \$70, depending on materials), and operating costs are also low. The 6-volt lantern battery usually lasts from 14 to 20 weeks. The components are good for at least four seasons, and even longer if carefully protected from moisture. The components are portable, so maintenance is relatively straightforward because infrequent malfunctions can be repaired easily in the field by simply replacing defective parts. Should a malfunction occur, however, or the batteries become exhausted, there is no way of establishing the date or time of the breakdown. Therefore, the counters should be checked regularly. We suggest biweekly checks.

Placement and installation are critical. Ideally, the trail should be nearly as narrow as the plate. On wider trails it may be possible to funnel traffic over the plate by discreetly placing rocks or dead branches on the trail edges. Sections of trail that are extremely wide, not flat, or have poorly drained soil or soil of high stone/gravel content, will not be suitable for pressure plate counters.

Like any counting system, pressure plate counters do not record traffic perfectly—some people may walk around or step over the plate and large animals (over about 40 pounds) will be counted. Careful placement and installation will alleviate many of these problems, but any counter should be observed during periods of use to be sure it is working properly (see Appendix D).

3. *Applications.* The pressure plate counter is an economical and reliable tool to measure total trail use. At present the pressure plate counter cannot distinguish direction of travel and so counts use in both directions.

The counter may be used alone or in conjunction with another system to count hikers. Where additional information on hiker characteristics is desired, or where trail conditions are not suitable for the pressure plate installation, an alternative system should be used.

Photoelectric traffic counters

1. *The system.* A photoelectric trail traffic counter was developed in the late 1960's by the Equipment Development Center of the USDA Forest Service at Missoula, Montana. The system consists of a scanner that emits a beam of pulsed infrared light, a reflector that returns the beam to the scanner, and a battery box containing one 6-volt and two 12-volt lantern batteries. The scanner is mounted on a tree and directed toward the reflector affixed to another tree up to 75 feet away (see Fig. 4). When an object passes on the trail and interrupts the beam, the counter on the scanner advances one digit.

2. *Advantages and disadvantages.* The photoelectric counter, like the pressure plate counter, estimates total trail use. Its advantages are that it may be used over any trail surface and does not require a flat or nonsloping trail. The counter may be used to monitor a variety of backcountry users, from horseback riders to cross-country skiers. A narrow trail tread at the counting site is still recommended to funnel trail users by the scanner in single file.

When trail counts are desired at sites above treeline or in sparsely forested areas, the light beam counter is not suitable. The scanner and reflector need to be mounted inconspicuously to prevent vandalism (see Appendix E). In addition, these elements should be protected from direct sunlight and precipitation.

Although the infrared scanner is an ingenious application of sophisticated electronics to the problem of measuring trail use, reports from the field on the counter's reliability and

Figure 4.—The photoelectric counter (A) is inconspicuously mounted on a tree directly opposite a reflector (B), also affixed to a tree across the trail. The counter is wired to a battery in a box (C), buried nearby.

accuracy have been mixed, according to a telephone conversation with Loren Delan of the Equipment Development Center in July, 1978. A number of studies (James and Schreuder 1971; James and Schreuder 1972; Lucas, Schreuder, and James 1971; and Bowley 1977) indicate that overcounting is a problem. Incorrect installation is usually blamed for these problems. Ten of 19 counters field-checked by the Equipment Development Center on various national forests had been improperly installed (Tietz 1973). Scientific Dimensions, Inc., the manufacturer of the counters, suggests that faulty components in some of the early models made the scanners unduly sensitive to fog and rain. Scientific Dimensions recommends reducing the distance between scanner and reflector by 30 to 50 percent of the specified maximum range in areas likely to have dense fog.

3. *Applications*. The photoelectric counter is moderately expensive but because it does not require foot pressure, it may be used to count hikers where pressure plates cannot be installed. It can also monitor winter use by cross-country skiers or snowshoers. One model of scanner will count objects moving as fast as 40 miles per hour, such as snowmobiles and trail bikes. Further information about photoelectric trail counters can be found in DeLand 1976.

Time-lapse photography

1. *The system*. In the early 1970's, some interest developed in the use of photography for monitoring recreational use and particularly for counting boaters on remote lakes and rivers. Systems considered included video tape, closed-circuit television, and aerial photography. Costs of these systems were deemed prohibitive under most circumstances, but a related system using a super-8 movie camera and time-lapse photography may be practical for some applications.

The time-lapse photography system is still being developed and refined, but to date it has usually used a Kodak "Analyst" or other movie camera that can be set to expose frames at various intervals. The camera is mounted as inconspicuously as possible at a favorable angle to the trail or waterway to be monitored. With the camera is a battery pack and usually a timer to shut it off at night to save film and batteries (see Fig. 5). Very recently, the Equipment Development Center has developed a system using a Canon 814-XL camera that can expose a single frame when triggered by an infrared or other electrical impulse counter. This system greatly conserves film and batteries, and requires much less field maintenance than the more primitive system.

The super-8 films are processed and reviewed with a projector especially designed for time-lapse work (see Fig. 6). Some systems include timed light-emitting diodes to provide an hourly time reference.

2. *Advantages and disadvantages*. The most obvious advantage of time-lapse photography is that it approximates having a person at the site counting people. When properly installed and operating, it should provide nearly 100-percent accuracy. Whether this theoretical perfection can reasonably be achieved in the field, or is worth the extra cost, are separate, but important, considerations.

Time-lapse photography is expensive, although not so much so as might be expected. Two major studies (Marnell 1975, Bowley 1977) found an average cost of about $1.50 per hour of surveillance. In each case, at least two-thirds of this cost was attributed to vehicle operation and field maintenance salaries. These relatively high labor costs reflect the need to replace batteries and film at short intervals. A refined design would drastically reduce these expenses.

Information available from the time-lapse system includes mode of travel, direction of travel, and number of users. Group size and day or overnight users are possible to discern in many cases. However, infomation on names and addresses is, of course, not possible. Some legal questions are involved in photographic surveillance, and managers should check with legal counsel before embarking on a time-lapse project. Restrictions placed on one study, for example, included an assurance that individuals could not be recognized and that the film would be destroyed at the end of the study (Marnell 1975).

3. *Applications*. Time-lapse photography is applicable wherever more informative counts are needed and sufficient funds are available. It may be especially useful for periodic vali-

Figure 5.—The movie camera (A) is housed in a weather- and sound-proof box (B) and fixed in the required monitoring position. The system includes a battery-operated automatic timing device (C) which turns the camera off at night and on in the morning, or, when AC power is available, an AC-DC converter and automatic timing device (D) that serves the same function.

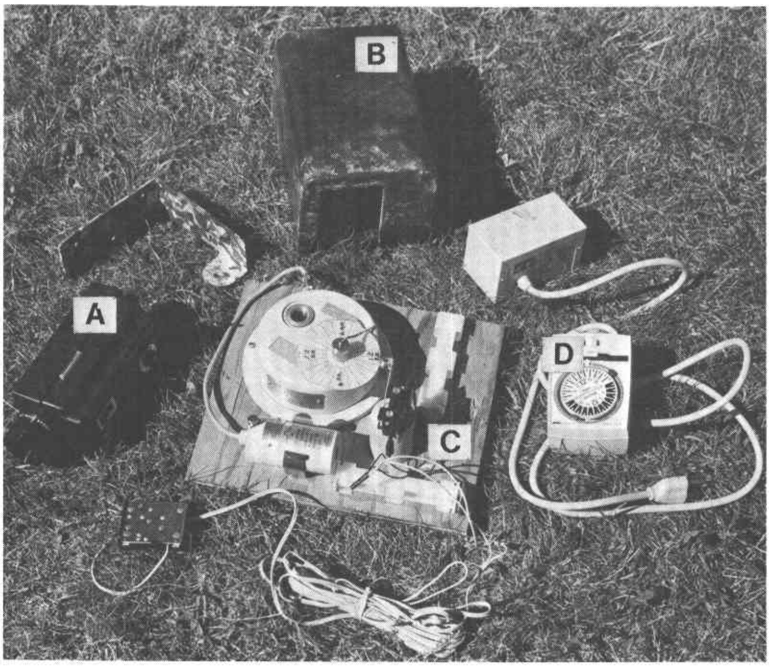
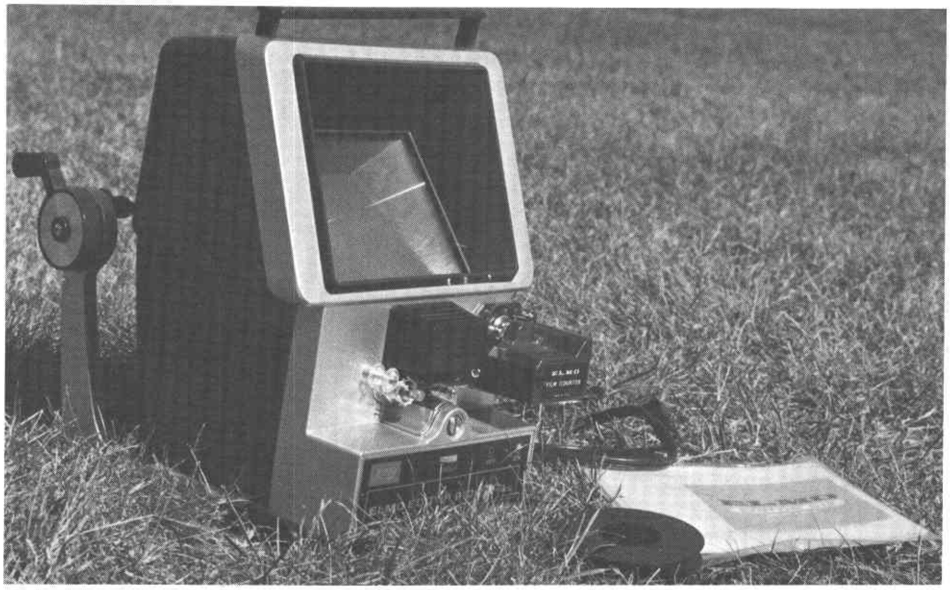


Figure 6.—Editing machine for 8-mm movie film is used to view and analyze film taken by the automatic monitoring camera.



dation of the performance of other use-monitoring systems.

Detailed information on setting up two different types of time-lapse systems is found in Bowley 1977, Gasvoda 1978, and Marnell 1975.

PART III. SUMMARY

Studies and field experience in the Northeast have shown that when only total trail use numbers are desired, pressure plate electric counters are likely to provide the least expensive, most reliable system. Where more information on users is desired, e.g., name and address, date, or group size, the sign-in register box with regular validation may prove to be the best system.

Special applications may require random sampling, photoelectric counters, or time-lapse photography. Special management units, such as Federal wildernesses, may require mandatory permits to control use. These systems may be used alone or in combination to get the desired results.

Each of these systems has advantages, limitations, and shortcomings (Table 1). Improperly used, they can produce expensive, misleading information. But carefully planned and managed, each can produce valuable information at reasonable cost to aid backcountry management.

Table 1.—Comparison of use-monitoring systems

Data yielded	Field sampling	Voluntary self-reg.	Mandatory permits	Pressure plates	Photoelectric counter	Time-lapse photography
Number of passes across trail	C	C	C	X	X	X
Number of individual users	C	C	C			S
Number of groups	C	C	C			S
Group size	X	X	X			S
Name	X	X	X			
Address	X	X	X			
Date	X	X	X			S
Mode of travel	X	X	X			X
Direction of travel	X	X	X			X
Duration of trip	X	X	X			
Other capabilities						
Information and education distribution	X	X	X			
Public relations potential	X	X	X			
Aid in search and rescue		X	X			
Potential to limit use of an area or specific site			X			
Other characteristics						
Initial equipment and assembly cost (per unit)		$20 to $35		$50 to $85	$300	$250 to $750+
Average battery life				16 wks	8 wks	variable
Time to install unit on site		0.5 h		1 h	1 h	1 h
Time to check and maintain hardware		10 min every 2 wks		¼-½ h every 2 wks	¼-½ h every 2 wks	1 h per film roll
Time to validate or sample trail use	Time depends on accuracy desired See App. A.	Time depends on accuracy desired & trail traffic volume. See App. B.	Personnel required to check permit compliance, e.g., 1 person 8 h/day/20 mi of trail. This job can include additional duties.			

Symbols: X = Available
C = Calculated from sample
S = Sometimes available
(Blank) = Not available

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APPENDIX A

Field Sampling by Personnel

A sampling scheme can be established to determine an average visitor use per time period, such as 4 hours or 1 day. The sample size required (n), which in this case is the number of observation periods, can be calculated by statistical methods. The sample size to be selected depends on (1) the maximum error of estimate about the mean desired (E); (2) the confidence level desired in the estimate (associated with a value of t that can be found from a table); and (3) the variance of visitor use per observation period (S^2). This last factor must be computed from previous or preliminary trail observations, either by field personnel or from a self-registration box. Many pocket calculators will compute variance. It indicates the degree of variation in number of visitors per observation period. Total trail use volume, however, does not affect the amount of time required for sampling. The formula for calculating a sample size from these variables is:

$$n = \frac{t^2 s^2}{E^2}$$

This method is described in Avery (1975) and in most survey sampling textbooks. Observations for n periods will provide an estimate of the average number of visitors per period, ± E visitors, at a confidence level of t, such as at 95 percent confidence. (At 95 percent confidence, $t = 1.96$ and at 90 percent confidence, $t = 1.645$.) If one desires an estimate of the number of parties per period, then E must be specified in number of parties, not number of persons.

For example, if after 5 days of observations the number of parties per day were found to be 8, 10, 8, 5 and 1, the variance would be computed to be 12.3 and the number of sampling days required to estimate use at ±1 party per day at a confidence level of 90 percent would be 33 days. Likewise, with the same variance and confidence level, four sampling days would be required to estimate use within ±3 parties per day.

As the variance in trail use increases, the number of sample periods increases rapidly. To reduce the number of sample periods, the sampling scheme may be "stratified" between two or more types of periods or days that are known to have vastly different use patterns, e.g., weekdays versus weekend days. Also, longer observation times, e.g., all day rather than 2 hours, can reduce the observed variance. If sampling is stratified, sample sizes must be computed separately for each selected condition.

To select periods for observation, once sample size has been determined, a table of random numbers may be used. All the potential observation periods for each stratum should be sequentially numbered, and the ones used whose numbers are given by the table of random numbers. Wagar (1969) provides a detailed description of this process.

The field sampling technique may be used to obtain more information than simple hiker numbers. Surveys of hiker attitudes or characteristics may be obtained during the sampling periods. If a Federal agency is administering the survey, however, it must comply with Federal regulations governing public surveys.

APPENDIX B

Managing a Voluntary Self-Registration System

The effectiveness and reliability of register box data is highly dependent on the care with which the system is organized and maintained. The following suggestions are based on field experience:

A. *Design*

1. *Station design.* Over the years, many different station designs have been used. Field experience indicates that the dropped or notebook type wooden register box mounted on a tree or post is quite serviceable. The slot-type station in which individual registration cards are inserted into a locked slotted box have also been used successfully.

The registration station is a good place to put maps or other pertinent trail information. A small calendar is important to assure accurate dating of entries. A pencil holder helps to encourage the return of the pencil(s).

2. *Sign design.* Signs requesting people to register have varied from a simple "Please

Register" on the box itself to large signs telling users they "must" register. Studies have shown that a firm but not demanding sign is slightly more effective than other signs. Clarity and brevity are probably equally important.

3. *Register sheet/card design.* Register forms should appear straightforward and uncluttered. The more complicated the form the greater the likelihood of incomplete registration.

The register form should clearly state whether *one* member from each party or *all* members of each party should sign in. In addition, the form should state whether the party is to sign both in and out or only in. Experience has shown that hikers are confused by "in and out" registration (Wenger 1964). Requesting hiking parties to sign in once before entering the area may help.

B. *Register placement*

Placement and installation of register boxes is of critical importance. Generally, registers should be:

1. A reasonable distance (usually at least 0.3 miles) from the nearest road or trailhead to avoid tampering by nonrecreationists. Remote locations (i.e., more than 3 miles from the nearest access point) should be avoided because of the time required for maintenance and validation.

2. At a natural momentary resting point in the trail, e.g., stream crossing, ridgetop vista. Areas likely to be used for overnight camping should be avoided.

3. Located far enough from side trails to avoid confusion in validation.

4. Mounted low enough for young hikers to sign in—usually about 3½ feet above the ground. If posts are used, they must be firmly anchored, because hikers tend to lean on the boxes while signing in. Likewise, drop-door register boxes require fastenings strong enough that the door won't pull off when hikers lean on it. In areas of heavy snow accumulation, the boxes should be raised late in the fall if an attempt to monitor winter use is planned.

5. Mounted so they are equally obvious from either direction on the trail.

C. *Maintenance and validation*

Regular maintenance of a self-registration system is essential. A register box without sheets or pencils not only fails to produce data, but it also hurts the credibility of more carefully maintained registers elsewhere. Regular validations, normally combined with routine maintenance visits, provide information for calculating the compliance rate for that particular station. The validator should avoid revealing the purpose of his/her presence on the trail.

Validators should always carry extra pencils, register sheets, pocket calendars, and any other materials used at the register. In some cases, it may be advisable to carry tools and spare parts in the car in case the register box has been vandalized or destroyed by animals.

D. *Determining sample size for validation*

To determine a compliance rate for a register box, a certain number of hiking parties must be observed. Observing more parties increases the accuracy and confidence in the findings. Trail managers should select an accuracy level and confidence level that they feel is just necessary to make the kinds of management decisions they need to make. Accuracy beyond that point will be of little additional utility and will waste effort.

The required sample size can be calculated from a statistical formula used for estimating the proportion of a population that possesses a specified characteristic. The sample size required depends on (1) the estimated *probability* that a hiking party will sign in; (2) the level of confidence desired; and (3) maximum error desired in the compliance rate.

The formula to compute sample size is:

$$n = p(1-p)\ (t/E)^2$$

where p = probability of a hiking party signing in, expressed as a percent

t = value from a statistical table of t-values associated with the percent confidence desired. (For 90 percent confidence, $t = 1.645$. For 95 percent confidence, $t = 1.96$.)

E = the maximum error desired in the compliance rate, expressed as a decimal, e.g., $E = .10$ for a compliance rate $\pm$ 10 percent.

Where there is no idea about the probability value, $p = .50$ is used (i.e., for a 50 percent probability that a hiking party will sign in).

A discussion of this statistical method can be found in Mendenhall (1971) or most survey sampling textbooks.

As it is necessary to observe n hiking parties, the relative trail use will affect the amount of time that a validator must spend on a trail. For very low-use trails, it would probably not be worthwhile to spend the time required to obtain very accurate sign-in rates.

For example, if the probability of a party signing in is 50 percent and an estimate within 10 percent is desired at a confidence level of 95 percent, the validator will need to observe 96 parties. If trail use averages 20 parties per day, this will take 5 days; at 10 parties per day it will take 10 days, and at 3 parties per day it will take 32 days.

To estimate the compliance rate within 5 percent under the same conditions would require observing 384 parties, which could take 128 days on a trail used by an average of 3 parties per day.

Validation (or sampling) times should be selected randomly in the same manner described for field sampling in Appendix A.

In some cases, volunteers may be available to do validations. Scout troops or clubs can have a number of members share the responsibility for making the validations, thereby reducing the burden on any one person. Volunteers must understand the importance of following the procedure, so that they do the validations properly. They should be provided with forms to make the data-gathering easier. Because the enthusiasm of volunteer validators tends to lag in the course of the season, it is a good idea to provide some incentive for completing the project, and also to have a paid backup validator available.

Preliminary field experience in Vermont with volunteer validators who were given little guidance was not very satisfactory. Four volunteer validators were found in 1976 and 1977 to validate four register boxes in the Green Mountains. The volunteers were told to validate the boxes about twice a week, or whenever they found the time. Total validation time during a summer season for each volunteer was between 4 and 17 hours. For a comparison, four Green Mountain Club employees responsible for shelter caretaking were also told to validate register boxes whenever they had time. Total validation time for each of them was 7 to 44 hours. It was more convenient for these field personnel to validate boxes as they were already near the register sites. In addition, they were directly involved with site management and therefore more highly motivated to validate trail registers.

E. *Interpreting the register sheets*

The most frequent problem in interpreting register sheets is overregistration—several individuals signing in separately from the same group or a group signing both in and out during a round trip. Usually, this duplication can be detected by the repetition of date, group size, and residence, but the person doing the tabulations must be alert to it. Overregistration should be struck out and gratuitous entries should be ignored.

Disappearance, or theft, of the pencils may occur from time to time, and can usually be determined by the beginning of entries in a variety of inks and leads. Since many users don't carry pens or pencils and are therefore unable to sign in, registrations may be lower than normal while pencils are missing.

Estimating overall use of a trail at the register station involves simply taking the total number of registrants and dividing by the compliance rate derived from the validations, e.g., 500 registrants, 75 percent compliance rate: $500 \div 0.75 = 667$ users.

APPENDIX C

Administration of Mandatory Permits

Use permits have been made mandatory on some private lands as well as on some publicly owned lands where restrictions on use are considered necessary. The federal manager does not have much administrative flexibility because the permit system has been standardized for national or regional use. States and private land-owning organizations can set up more flexible permit programs. In establishing such programs, several points should be kept in mind:

1. The permit requirement should be well publicized in areas from which users are known to come.

2. If a fee is required or a use restriction exists, these aspects should be well publicized.

3. It should be made clear whether permits are required for day or overnight use, or both.

4. Permits should be fairly short and to the point. They should be organized to facilitate data tabulation.

5. Getting a permit should be made as easy as possible to ensure high compliance. Independent issuers of permits (e.g., stores), however, should be well versed in the importance of carefully filling out the form.

6. Information and education ("I&E") material should be prepared for distribution with the permits.

7. Field personnel are needed at least periodically to check for permits and determine compliance rates.

8. Names and addresses should be saved if followup correspondence is deemed likely (e.g., for unit planning material, opinion survey).

APPENDIX D

Managing a Pressure Plate Counter System

A. *The components:*

1. Mat switch: "Tapeswitch Signal Mat" model CVP-1723
Tapeswitch Corporation of America
100 Schmitt Blvd.
Farmingdale, NY 11735

2. Sandwich: ⅜″ plywood
⅛″ tempered hardboard
2″ wide duct tape
5 mil plastic trash bag
burlap bag

3. Counter: Sodeco TCeZ4E (made in Switzerland)
Landis & Gyr
4 Westchester Plaza
Elmsford, NY 10523

4. Battery: Standard 6-volt lantern-type battery
Eveready #731

5. Plastic container: 3-qt plastic storage container with well-fitted lid to store battery and counter below ground surface.

(Addresses given are for national distributors; local retailers can be determined by writing to these addresses.)

The mat switch is simply sandwiched between the plywood and hardboard and the edges of the sandwich sealed with duct tape. The sandwich is then placed in the trash bag to protect it from moisture and covered with the burlap to provide a rough surface which will hold soil and forest litter.

B. *Placement:*

1. *Trail width.* Ideally, pressure plates should be located on trails that are little wider than 18 inches, the width of the mat. Heavily used trails are rarely that narrow, so obstructions must be used to funnel users single-file over the plate. They should be large enough to divert hikers, e.g., large rocks, large dead trees or limbs, and so placed to conceal their purpose.

2. *Slope.* Because paces and strides vary greatly on steep pitches, extreme slopes should be avoided. A flat or nearly flat stretch of trail assures even, steady foot pressure.

3. *Drainage.* Although the plastic bag should make the sandwich watertight, poorly drained places should be avoided. Mucky organic soil does not transmit foot pressure as well or as consistently as better drained mineral soils. The organic soil can also retain much water and become heavy. Rocky or stoney soils may be too heavy for the pressure plate, and keep the mat switch closed continuously.

Proper placement of the counter is critical. It may be well worth the time to walk the entire stretch of trail to be monitored before placing the counter, to locate an area that will meet as many of the site requirements as possible.

C. *Installation:*

Once a site has been selected, installation can begin. It is usually best to install counters at off-peak times to minimize the chance of discovery by users.

1. Excavate to a 4- or 5-inch depth an area slightly larger than the pressure plate. Care should be taken to smooth the bottom of the excavation and remove protruding rocks and roots.

2. Place the plate in the excavation and run the leads, with splices, to a point selected for burying the battery and counter.

3. Bury the leads at least 4 inches deep.

4. Attach the leads to the counter and battery. Polarity is not important. Running the leads through a small hole beneath the lip of the plastic container lid will help to keep moisture out of the container.

5. Bury the container and cover the top with a flat rock or twigs and leaves.

6. Cover the plate with soil and forest litter—sift out rocks and other debris. Test the buried counter by stepping lightly and then firmly over the entire plate area. If too little soil is over the plate, it may double-count. If too much soil is over the plate, it may miss counts.

7. Once any adjustments are made for plate cover, restore the site to as near a natural appearance as possible.

8. If possible, wait to observe a number of hikers as they pass over the plate. Some unanticipated problems may be observed.

D. *Maintenance:*

A maximum recommended maintenance interval is 2 or 3 weeks. The more frequently the counter is checked, of course, the more reliable the data will be.

Maintenance should include:

1. Recording the number on the counter.

2. Walking over the trail a number of times at different paces and strides to be sure the system is functioning properly.

3. Either zeroing the counter or recording the new figure so that test counts won't get confused with actual use counts.

4. Checking the battery strength with a voltmeter. Weak batteries may cause miscounts.

5. Checking the site to be sure there are no tell-tale signs of the plate, wires, or battery container.

E. *Troubleshooting:*

In making field checks, maintainers should always carry extra components and a tool kit (folding shovel, pliers, knife, etc.). This troubleshooting chart is based on the most common malfunctions, and their remedies, in order of likelihood:

1. Counter does not work at all:
   a. Dead battery.
   b. Bad connection.
   c. Bad splice.
   d. Soil too heavy over plate (frequently sodden after rain).
   e. Malfunctioning mat switch.
   f. Malfunctioning counter.
2. Counter double-counts periodically:
   a. Too little soil over the plate.
   b. Rocky soil over the plate.
   c. Warped or twisted plate.
3. Counter misses counts intermittently:
   a. Battery weak.
   b. Bad connections or splices.
   c. Too much soil over plate.
   d. Soil compacted over plate; dig up plate and replace in same spot with looser soil on it.
   e. Malfunctioning mat switch or counter.

APPENDIX E

Setting Up a Photoelectric Counter System

A. *Installation*

Installation of infrared counters is of critical importance. Most of the reported problems with the counters appear to be related to improper installation. The instruction book prepared by Scientific Dimensions, Inc., which accompanies each counter, should be followed closely, with special attention to:

- Selecting trees for scanner and reflector which will not move substantially in the wind.
- Selecting a site where hikers will pass by in single file and where there is little temptation for hikers to stop to view the scenery or wait for friends.
- Aiming the beam at waist level (about 3½ feet).
- Centering the reflector in the scanner beam and not separating the two by more than 75 feet (for standard scanner). The manufacturer recommends reducing that distance

by 30 percent to 50 percent in areas expected to be in dense fog periodically (52 feet or 37½ feet, respectively).
- Clearing branches and underbrush which might be blown in front of the scanner.
- Burying the battery box to protect it from extremes in temperature.
- Checking the beam alignment a few days after the installation to be sure the components have not settled.

Installation may be easier with the following suggestions:
- Have two people set up the counter rather than one.
- Use a string attached to the scanner to help locate the proper position of the reflector and/or attach several reflectors to a stick to minimize the amount of time spent groping about for the infrared beam.

The potential for vandalism or theft can be reduced by:
- Making the installation at "off-peak" use times.
- Affixing the scanner to the tree so a minimum of it shows.
- Camouflaging the reflectors by placing them on birch trees or the butt ends of sawed logs, or "decorating" the edge of the reflector with plant and leaf trimmings.
- Using a variety of paths when maintaining the scanner, none of which leads directly from the trail being monitored.

B. *Maintenance*

Replacement batteries and reflectors, as well as a tool kit, should always be carried. A pocket voltmeter will help anticipate miscounting due to weak batteries. The manufacturer recommends replacing the batteries when voltages have dropped 20 percent.

Because the digital impulse counter on the scanner cannot be zeroed, maintainers must be careful to record the reading at the beginning and end of each field check. The difference between the two figures should not be included in the traffic counts because they are simply a result of maintenance activity.

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