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Wilderness Recreation Use Estimation: A Handbook of Methods and Systems

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Abstract

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Documented evidence shows that managers of units within the U.S. National Wilderness Preservation System are making decisions without reliable information on the amount, types, and distribution of recreation use occurring at these areas. There are clear legislative mandates and agency policies that direct managers to monitor trends in use and conditions in wilderness. This report is specifically designed as a convenient resource for wilderness managers and others who have the responsibility of monitoring and describing visitor use in wilderness. It is a comprehensive manual on estimation techniques and procedures that are essential to appropriately and accurately measure visitor use-related characteristics and conditions. Guidelines enable the manager to evaluate options and decide on a use estimation system that meets the needs of a specific area and set of circumstances. This handbook provides, in a single source, all relevant information on setting objectives, making decisions about what to monitor, developing a sampling plan, collecting the needed information, and computing basic statistics to provide input into management decisions. The user should have mathematical abilities at least through algebra; knowledge of statistics and calculus would be helpful.

Keywords: National Wilderness Preservation System, visitation, visitor use, visitor use estimation

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Introduction

As stipulated by the Wilderness Act of 1964 (PL 88-577), the National Wilderness Preservation System (NWPS) is established "…to secure for the American people of present and future generations the benefits of an enduring resource of wilderness." This legislation now applies to more than 625 separate areas in 44 states, comprising nearly 105 million acres.

The goal of the Act may be stated briefly as the mandate to manage wilderness areas so as to leave them unimpaired for future use and enjoyment *as wilderness*. Each individual area is to be managed to maintain natural conditions and provide opportunities for "solitude" or "primitive and unconfined" recreation experiences. However, it is apparent that these two responsibilities of management may become contradictory: to maintain or minimize loss of ecological integrity (and ensure quality solitude experiences), while simultaneously providing access for human use and enjoyment for unconfined experiences.

Although human use is part of the wilderness mandate, human use nevertheless results in unavoidable impact on the resource. Even at low use levels, visitors cause substantial disturbance, both to the wilderness resource itself, and to the wilderness experiences of others. Because recreational use of wilderness continues to increase (Cole 1996), the potential for disturbance and wilderness degradation is very great. It follows that:

(1) the management of wilderness visitors is a priority, and

(2) in order to make effective management decisions, the manager must have reliable information about visitor use of wilderness (Watson 1990).

Monitoring wilderness status is mandated in the Act, with the primary goals being to (1) improve wilderness management, (2) improve the acquisition and use of knowledge from wilderness, and (3) improve assessment of status and trends. Managers must monitor wilderness use through a systematic description. In general, use measurement has two aspects: first, the inventory of human uses that provide a baseline for planning and management, and second, a means of determining how human use and resource conditions of the wilderness are changing. Evaluation of standards may be performed by cataloging real and potential threats to the resource, and by monitoring trends in condition and changes in demand and use (Landres and others 1994). At the same time, management techniques must not detract from "primitive and unconfined" types of experience (Cole 1995). Therefore, empirical studies are required for both deciding upon, and verifying, the most effective management techniques for (1) resolving a given management problem, and (2) reducing visitor burden.

The Problem: Inadequate Wilderness Use Data

Unfortunately, wilderness use has been, and continues to be, inadequately measured and described. A recent survey of wilderness managers (comprising 423 out of a total of 440 wilderness areas) reported that 63 percent relied on "best guesses" to estimate visitor use. Only 16 percent reported that they used any sort of systematic procedure for determining amount of use; an additional 22 percent reported that they made estimates based on "frequent field observation" (McClaran and Cole 1993).

There are several reasons why wilderness use is not assessed adequately:

1. *Difficulty in quantifying and measuring wilderness use.* Lack of funding is the most common problem facing managers. Apart from financial considerations, logistic problems result from the size of the area, number of access points and relative ease of accessibility, the amount of visitor use (for example, low numbers are difficult to detect), the type of visitor use, and the amount of resources (personnel, time) available to monitor use.

2. *Little or no coordination across wilderness areas.* NWPS comprises extremely diverse units, that vary in ecosytem type, geographical location, unit size, use, and perceived benefits. Furthermore, administration is divided among four different federal agencies: the Forest Service in the Department of Agriculture, and the National Park Service, Bureau of Land Management, and the Fish and Wildlife Service in the Department of The Interior. As a result, there is a lack of unanimity in purpose; perceived management goals will differ widely between units.

3. *Lack of quantitative and practical skills.* Managers have no training on techniques and processes available for collecting and analyzing data.

4. *Lack of decision-making and judgment skills*. Employment of any given technique requires that the manager decide between competing restrictions and priorities with respect to study objectives, desired level of accuracy, availability of personnel, time commitment, acceptable visitor burden, and cost. Managers may lack knowledge of the various options available for the most appropriate and cost-effective techniques.

With little or no reliable wilderness use information, managers cannot adequately judge resource condition trends. Visitor opinions alone are inadequate for evaluation purposes; there may be little agreement between visitor perceptions and the actual condition of the resource, or even on the conditions that determine "primitive and unconfined" experiences. Quality wilderness use information is absolutely essential for examining and testing the various tenets, principles, and dogmas of wilderness management; for optimal management of the resource, it is critical to distinguish management principles which have been empirically verified from those which have never been tested, and are based on nothing more than "authoritative opinions" (Cole 1995).

What is a Wilderness Use Estimation System?

To many managers, a use estimation "system" is nothing more than some kind of measurement technique: a mechanical counter, a permit, or a self-registration station. *Measurement techniques alone do not constitute a use estimation system*. Instead, a use estimation "system" is a conceptual structure, comprising five essential steps:

1. A statement of objectives.
2. Identification of the specific use characteristics to be measured.
3. Choice of appropriate wilderness visitor use measurement techniques.
4. Choice of the appropriate strategy for sampling.
5. Choice of a specific technique and/or procedure for data analysis and summary.

If any of these elements is missing from the system, the exercise of data collection is of little or no value. Given the investment in data collection, it is important to derive the maximum value from the data, and to avoid inappropriate analyses which will generate misleading conclusions. Reliable and high-quality data ("good" data) are obtained, not only by the type of information collected, but also by the relevance of that information to the study objectives, and the accuracy of the techniques used in data collection.

Handbook Organization

This report is specifically designed as a convenient resource for wilderness managers and others who have the responsibility of monitoring and describing visitor use in wilderness areas. It also should be more broadly of value to any manager or planner trying to monitor human use of any type of nonroaded, nonmotorized protected areas. It is a comprehensive manual on estimation techniques and procedures that are essential to *appropriately and accurately measure visitor use-related characteristics and conditions.* Guidelines are presented that enable the manager to evaluate options and decide on a use estimation system that meets the needs of a specific area and set of circumstances.

This handbook is divided into two organizational units. **Part I: Elements of a Use Estimation System**, consists of three chapters introducing the fundamental components of a use estimation system. These chapters provide the basic information necessary to adequately and reliably describe visitor use. **Chapter 1: Visitor Use Characteristics**, details the types of visitor use data that can be measured, together with methods of reporting such data and specific areas of application. Because the selection of use characteristics to be measured must be determined *a priori* in accordance with the goals of the study, we present general guidelines for formulating study objectives. In **Chapter 2: Visitor Use Estimation Techniques**, we describe specific measurement techniques and equipment used in data collection. Also specified are the types of visitor use information that can be obtained with each technique, estimates of relative accuracy, visitor burden, and associated management costs. **Chapter 3: Sampling Strategies,** describes practical and systematic methods of developing statistically based and field-oriented strategies of data collection. Specific statistical methods required for elementary data analysis are included in the appendix section.

Part II: Selecting and Building a Use Estimation System, presents the basic criteria for the evaluation, design, and step-by-step implementation of 10 major use estimation systems. The information presented in each section should enable the reader to quickly evaluate each system in the context of management objectives set on a case-by-case basis.

Part I: Elements of a Use Estimation System

Chapter 1: Visitor Use Characteristics

The two aspects to the initial formulation of a use estimation system are:

1. The statement of objectives
2. Identification of the specific use characteristics to be measured

Objectives

The statement of objectives is a justification or outline of the reasons for collecting a specific set of information; in other words, why wilderness use measurement and monitoring are to be performed. A clearly defined objectives statement directs the entire course of the project by determining both the type of information that needs to be collected and the purpose for which it is collected. However, all phases of the objectives statement may be progressively updated and revised as the planning process continues.

It is important to emphasize that the objective is not accumulation of use information for its own sake; nor are objectives defined in terms of methods, numerical goals or quotas, or specific measurement techniques. Instead, a statement of objectives involves the identification of a specific wilderness management "problem" in terms that allow some assurance of its solution (Ackoff 1953); the collection of visitor use data will be essential to resolving the identified problem. A management "problem" exists where there are one or more desired objectives.

The objectives statement consists of six components (Ackoff 1953):

1. Potential participants
2. Their respective goals
3. Prioritization of the respective goals
4. Alternatives
5. Practical applications
6. The scope of inference of the intended study

1. Participants.—These involve all individuals or groups associated with a particular use problem. At the very least, these will include the manager and the various types of wilderness visitors. Participants outside this immediate loop include the relevant agency, special-interest groups, legislators and congressional representatives, and so on.

2. Goals.—Goals are defined in terms of some thing, some motivation, or some end, to be attained. Goals of the wilderness manager can be summarized as: the collection of "basic" information; identification of constraints (finances, time, labor), which may prevent or hinder data collection; and the practical application of this information.

(a) "Basic" information may be collected in response to an immediate problem perceived by the manager, or in accordance with one or more wilderness directives. Such directives may result from legislative mandates, agency reporting requirements, the requirement for feasible management objectives, or the need to associate funding levels, maintenance, and educational programs with amounts and types of clientele served (Watson 1990). Regardless of directive origin, "basic" information conforms to one or more of the following categories (Landres and others 1994):

(1) *Descriptors*. These data constitute the basic supply side of the NWPS. Examples include the number of miles of trail, number of visitors per day or season in a given area, and so on. In addition, "background" description data may be critical in formulating and clarifying management objectives. Background information includes such descriptors as the number and description of major ecosystem types, the number and location of endangered species, and specific area issues and concerns identified by managers and various public groups.

(2) *Threats*. A threat is any significant potential agent of change to the wilderness resource. Relevant information includes identification of the specific threat, how that agent threatens wilderness attributes, the attributes under threat, specifics of impact (type, amount, and time frame), potential areas or specific resources most susceptible to damage, long-term *versus* short-term threats, and so forth

(3) *Trends in condition*. Monitoring of both resource condition and use patterns over time are essential for evaluating and directing effective wilderness management (Cole 1989; Stankey and others 1985). Unfortunately, monitoring is performed relatively rarely, although information on some types of monitoring procedures is available (Cole 1989; McClaran and Cole 1993).

(4) *Demands and uses* may be categorized as either *expressed*, that is, use and use applications that are actually performed, or *latent*, those uses that are desired but not achieved. This information is critical for predicting patterns of use and potential impact.

(5) *Societal values and benefits*. Public input is important in identifying potential problems and formulating management decisions about which impacts are potentially significant, which characteristics should be monitored, what constitutes the limits of acceptable change, what are appropriate management strategies, and what methods of strategy implementation should be utilized. Public involvement is critical in identifying potential sources of conflict between managers and users, and between different user groups (McClaran and Cole 1993).

(b) Constraints, or potential limiting factors, on the amount of information that can be collected, include finances, time, labor, and potential visitor burden. The motivation to save time and money is almost always operative in the selection of the methods used to collect data. The budget should be formulated with contingency planning incorporated in the event of unexpected expenses or budget cutbacks. The potential visitor burden must also be assessed as a constraint; the use variables to be measured must always be selected with the goal of placing little or no burden on the visitor.

3. Prioritization.—There is no management "problem" if there are no goals to be attained, or no alternative courses of action available. However, it is inevitable that goals will vary from group to group. For example, the

manager's first priority may be to protect the resource, whereas visitors, although agreeing in principle with the concept of wilderness protection, may nonetheless resent restrictions on their own wilderness experiences. Other groups may be actively hostile to the entire wilderness concept, or conversely, they may advocate wholesale wilderness protection at the expense of even mandated recreational opportunities.

4. Alternatives.—As a consequence of competing goals, and because of constraints on finances, time, and other resources for accomplishing the necessary work, the various objectives will have to be prioritized. Priorities will be partially determined by the alternative courses of action available for attaining the objectives. Available courses of action that will be open to the investigator will be dictated by considering the relative efficiency of each means, as well as the specific goals to be addressed.

5. Practical Application.—How the information will be used in the context of the study should be clearly stated and given a practical working definition. An example of a general application statement is the manager's wish to "learn more about visitor preferences and expectations so that responses to management changes can be anticipated." "Learning more" and "anticipating visitor response" are too vague to be useful. A practical redrafting of this objective would involve:

(a) Identifying one or more specific visitor responses.

(b) Listing the methods of evaluating response.

(c) Setting practical guidelines for identifying changes in response (that is, some baseline level would have to be identified).

(d) Identifying what management actions could be implemented if the response is affected.

6. Scope of Inference.—The scope of the project describes the extent to which the results can be applied and the future implications of the results.

Identification of Visitor Use Characteristics

Once the primary objectives of the study are clearly established, the investigator must decide on the kinds of observations that must be made. The use characteristics chosen must adequately characterize wilderness "use" as defined by the study objectives.

In general, visitor use data may be either quantitative or categorical. Strictly quantitative data are usually compiled in the form of **visit counts**. Count data provide a tally, or overall census, of the number of times an individual or a group passes a specific site during a certain time period. In contrast, other types of visitor use data may be a combination of categorical and quantitative information. These data describe some feature or attribute of (1) the visit, (2) the visitor, or (3) some aggregate feature of the visit, visitor, or both. **Visit attribute** data describe relevant characteristics of visits, such as length of stay, number of people per group, and activities participated in. **Visitor attributes** describe traits characterizing wilderness visitors, such as experience, demographics, and preferences. Finally, **summary use statistics** describe aggregate attributes; these provide an additional perspective on total amount of use by combining characteristics of the visit with visit counts.

In this section we describe several of the most commonly used types of observations obtained in wilderness use measurement. Data are described in terms of their working definitions, methods of reporting, the practical applications of specific types of data, and, when applicable, the advantages and disadvantages of certain methods of categorization.

Visit Counts

Visit counts may be recorded as either individual visits or group visits.

Individual Visits

The individual visit count is defined as the total number of single-person visits made by people that enter (or leave) a given area during a specified time period, without regard for length of stay. For example, a person making a 2-week trip into the area is counted as one visit, two people in a group entering the area for a single visit are counted as two visits, and so on. Conversely, a person camping outside the area who takes two single-day trips into the wilderness is counted as two visits.

Reporting.—Typically, individual count data are reported on a per-area and per-time basis. Individual visits may be tallied for portions of areas. For example, if there is particular interest in the number of visits along a specific trail or at a specific destination area, counts of individuals can be confined to those sites. Similarly, individual visit data may be obtained for relatively short time periods; for example, on a per-hour, per-weekend, or per-season basis. Alternatively, individual count data may be combined over areas or time periods to form aggregate counts. For example, the total number of visits to wilderness was reported to be approximately 5 million in 1986 (Lucas 1990).

Applications.—Individual visit data are required for devising site-specific management plans. Since management emphasis is on areas of heavy use, and use often occurs sporadically during the year, visit counts may be necessary only during high-use periods, such as the summer season or holiday weekends. In areas with high day use, the measurement period may be only in peak periods.

Individual visit totals aggregated at the regional and national level provide a gross estimate of participation levels. Such estimates provide effective descriptions of agency output, and are important for monitoring societal trends and developing demand/supply comparisons. These data may be critical in regional economic analyses where it is necessary to estimate the total effect of visitor influx and expenditures on local economies (Cordell and others 1992).

The individual visit count is the simplest method of obtaining quantitative data on visitor use. No additional information is required about either the nature of the visit or the visitor. However, because such factors as length of stay are ignored, the amount of use occurring in an area may be underestimated. These data should be combined with other measures of visit information.

Group Visits

A group is defined as a collection of individuals taking a wilderness trip together. It is implicit in this definition that travel and camping are shared to some extent by members of the party. This does not preclude separate travel arrangements to and from the wilderness site (more than one vehicle could have transported the group to the site, different members of the group may have originated from different places, arrival and departure times may differ), nor does it imply that all members of the group will necessarily be together the whole time in the wilderness. However, if camping, members of the group usually share a common site, and much of the traveling time is spent together.

A group visit count is defined as the total number of single-group visits made by groups that enter (or leave) a given area during a specified time period, without regard for length of stay. The working definition is essentially that of the individual count, except that the unit considered is the group rather than the individual.

Reporting.—As with individual visit counts (see above).

Applications.—Group visit data are relevant if use is heavily oriented toward organized groups. These data will be of particular interest to management if use-rationing is contemplated, with the objective of limiting the number of groups allowed access. Restricting access on the basis of groups, rather than on the basis of individuals, will be appropriate in many cases because the number of groups is the primary influence on demand for campsites and influences visitor perceptions of solitude (Roggenbuck and others 1982).

Visit Attributes

Observations describing attributes of each visit may be either quantitative (such as **group size, length of stay**), or qualitative (such as **method of travel, use of commercial services, types of activity, use distribution patterns, wilderness conditions, visitor perceptions**, and so forth). Various **miscellaneous** concerns, such as degree of compliance with low-impact regulations, may also be documented.

Method of Travel

Although a few wilderness areas permit motorized terrestrial and water-based transport and aircraft landings, these are rare exceptions (Browning and others 1989). In general, transport in wilderness areas is nonmechanized. Hiking is by far the most common method of wilderness travel. Ski and snowshoe travel may be included with hiking (as a form of self-propelled transport), or documented in separate categories. In many wilderness areas, other forms of nonmotorized transport, such as canoeing, rafting, and horseback riding, may approach or exceed hiking. Packstock (for example, horses, llamas, and goats) are commonly used in wilderness travel.

Reporting.—Specific categories of travel are usually reported as a percentage, or proportion, of the total number of groups or individuals surveyed. If these data are used to develop population estimates, estimates of the sample mean should be accompanied by the sample size and an estimate of variation—all of which can be used to express a confidence interval.

Applications.—Both the location and nature (social and physical) of impact problems will change with major shifts in travel method. Thus, need for adjustments in management strategies and priorities in a given area may be acquired by documenting trends in travel methods. For example, repeated visitor surveys in the Bob Marshall Wilderness revealed that mode of travel had shifted from predominantly horse use prior to 1970, to predominantly hiker use by the 1980's (Lucas 1985).

Group Size

This refers to the number of individuals in a group (or party) of visitors; as defined above, a group includes all individuals visiting the wilderness as a unit.

Reporting.—Group size may be treated as either a quantitative or a categorical variable. As a quantitative variable, group size is usually reported as an average (together with some measure of variation). The most common (mode) and maximum group sizes are also sometimes reported. Alternatively, the data set can be partitioned into several group-size classes; the number of observations in each size class can be used to calculate the relative proportion of groups in each class. For example, a study of visitors entering the Bob Marshall Wilderness in 1982 reported a mean group size of 4.7; 61 percent of all groups consisted of two to four people, while only 8 percent comprised more than 10 people (Lucas 1985).

Applications.—Group size data are important for evaluating impact on wilderness areas, and for the planning, implementation, and assessment of management strategies for specific groups and types of activities. Information about maximum group size may be valuable in determining if facilities can accommodate the largest groups. For example, groups travelling with recreational packstock are generally larger than hiking groups (Watson and others 1993). Restrictions applying specifically to packstock use may be necessary because of trail degradation and erosion, and conflict with other users. Many wilderness areas do not offer sufficient grazing to accommodate "large" numbers of stock. Thus, reliable information is required to set reasonable limits to packstock access.

Use of Commercial Services

This information indicates whether the services of an outfitter were used on the trip and the nature of services provided. Types of service provided vary greatly between commercial outfits. Many outfitters provide all-inclusive packages consisting of transportation, equipment, and guides. More limited services may be provided, consisting only of shuttle service to trailheads, transportation of gear to a base camp, equipment rentals, or guides. It is useful to differentiate between the major categories of commercial services prevalent in any area, and classify groups according to the type of commercial service utilized.

Reporting.—Data may be reported as either categorical or quantitative. Categorical information recorded includes type of commercial service provided, extent of services, target groups, major activity of target group, and so forth. Quantitative information may be appended with categorical data—proportion of groups utilizing various services, average group size, time of year, length of stay. For example, hunters use outfitters more than twice as frequently as nonhunters do; thus, much outfitter use is concentrated in the fall. However, in other areas, and during warm-weather seasons, river-float operators will be more prevalent.

Applications.—These data are useful for monitoring outfitter service allocations and for evaluating the relative necessity for, and impact of, outfitter services. In addition, these data provide a means of determining the magnitude of visitor impact on local economies in terms of visitor expenditures, employment opportunities, and income generated (Bergstrom and others 1990; Watson and Cordell 1990).

Activity Participation

The types of activities visitors engage in while visiting the area are critical for evaluating consumer use patterns, and potential impact on wilderness. Examples are on-trail hiking, off-trail hiking, horseback riding, hunting, fishing, mountain climbing, rock climbing, photography, nature study, swimming and sunbathing, collecting berries or mushrooms, and spending time in camp. Less common activities (such as cave exploration, nude sunbathing, athletic training, and survival training, for example) may be of sufficient magnitude and impact to warrant documentation and monitoring.

Reporting.—Data are generally presented in a combined format of qualitative and quantitative information. Subclasses may be identified by such categories as reasons for visit and range of activities engaged in; the number of observations in each category are used to compute proportion of visitors in each category. For example, a survey of wilderness visitors in the Bob Marshall and Linville Gorge Wilderness areas determined the proportion of visitors participating in hunting and nature study. In the Bob Marshall survey, the proportion of visitors in each category was 16 percent and 28 percent respectively; in contrast, for the Linville Gorge area, these proportions were 3 percent and 41 percent (Roggenbuck and Lucas 1987).

Applications.—Information on type of activity is important for characterizing differential effects of visitor-expenditure patterns. Specifically, economic impact analysis determines the effect of changes in final demand on specified economies; the change in final demand is often expressed as a change in numbers of a certain type of recreation visitor. To date, most analyses characterize visitor "type" in terms of activities participated in. For example, short-term users, such as those camping at developed or improved sites and resort customers making day trips into a wilderness, exhibit different expenditure patterns (and thus have different impacts on the local economy) than relatively long-term users do who stay in wilderness areas for long periods (Watson and others 1989).

Length Of Stay

Length of stay is defined as the total amount of time spent within the wilderness area boundaries on each trip. It may be calculated by reporting the date and hour of entrance and exit, or by reporting the total number of time units spent in the area (hours, days, nights, and so forth).

Reporting.—Length of stay is a quantitative variable; therefore, any convenient measure of location and variation can be calculated (mean, median, mode, variance, and so forth). Alternatively, observations can be partitioned into various time classes (for example: day trip, 2 to 4 days, more than 4 days, and so forth), and proportions of visits calculated for each category. For example, a survey of visitors to the Bob Marshall Wilderness Complex reported a mean length of stay of 4.7 days, and 54 percent of all trips lasted for 4 days or longer; in contrast, a survey of visitors to the Mission Mountains Wilderness reported an average length of stay of 1.7 days, with 62 percent of all visits being day trips (Roggenbuck and Lucas 1987).

Applications.—Length of stay can be used as a crude measure of success in attracting the public to recreation sites (Collings and Grayson 1977). Campsite demand may be assessed by calculating the proportion of visitors that camp overnight. Relative impact may be assessed by evaluating the proportion of visitors taking long trips of a week or more *versus* the proportion of users making only day trips. Finally, trends in length of stay measures indicate the need to revise or implement area management strategies.

Temporal Use Distribution

The distribution of use through time measures the extent to which "use" is concentrated in certain seasons, certain days of the week, or during certain times of the day. Measures of use distribution can be obtained by reporting date and time of entry of the individual or group, then categorizing by season, day of the week, or period of the day.

Reporting.—Use distribution may be reported as the proportion of total visitation that occurs in each time period (for example, per season, or on weekends as opposed to weekdays). Alternatively, patterns may be determined by plotting use data in time order.

Applications.—Understanding temporal use distribution is important for directing management decisions concerning the placement of survey and maintenance personnel in the field. Data on temporal use are critical in assessing and predicting rates of deterioration, and formulating strategies to shift use patterns in time, thus minimizing impact due to temporal crowding.

Spatial Use Distribution

The distribution of use across the area is a measure of the extent to which it is concentrated on certain trails or destinations. The simplest and most commonly recorded information is the entry and exit point for each visitor or group. An alternative is specification of the primary destination for the trip. Detailed information on internal use distribution may be obtained by subdividing areas into zones and reporting the time spent in each zone by an individual or group; alternatively, visitors may provide maps of trip routes with each campsite noted.

Reporting.—Spatial distribution is reported as area-specific proportion of total use; for example, the proportion of users in a wilderness area that enters (or exits) at a specific trailhead. Information on destination may be used to compute the proportion of visitors that go to particular destinations within the wilderness.

Applications.—This information can be useful in setting management priorities and evaluating the extent of use concentration. Educational messages may be targeted on trailheads that account for a large proportion of use. Use concentration problems are likely to be particularly severe where a few trailheads account for a large proportion of total use; these trailheads will receive priority for development and maintenance. Mapping the amount of use for specific zones, routes, and campsites within the wilderness is useful in devising site-specific management plans, predicting spatial distribution patterns of impact, and anticipating the effect of changes in specific areas on other sites.

Conditions and Visitor Perceptions

Measures of "conditions" include information on number of encounters with groups, individuals, or packstock along trails or at campsites; amount of litter seen; number of encounters with wildlife; and the physical condition of trails and campsites. Relevant measures of condition will vary from area to area.

Reporting.—Visitor perception of conditions, and their reactions to perceived conditions, are obtained retrospectively. This is performed via visitor surveys in which visitors are asked for their subjective assessment of conditions. Examples include ranking conditions from "very good" to "very poor"; evaluating numbers of encounters in terms of "too many people," "about the right number," or "too few"; evaluating certain factors, such as amounts of horse manure on trails, as a "problem" or "acceptable."

Applications.—This information is commonly collected by researchers in visitor surveys, but has seldom been part of use estimation systems. However, visitor opinions on current conditions, and how conditions are perceived to be changing over time, provide valuable auxiliary information for monitoring programs. Because such information provides a good perspective on the extent to which problems are a concern to visitors, this information can be used to direct management priorities and strategies.

Miscellaneous Visit Characteristics

Wilderness managers can collect a wide variety of additional information pertaining to visits; the type of information collected, its relevance, and its priority need to be carefully considered in the context of the stated objectives of the study. One example of interest to managers is the assessment of compliance with low-impact recommendations. Examples of compliance measures include: the number of groups using stoves instead of campfires, the proportion of groups with dogs visiting the wilderness, the incidence of off-trail travel, the proportion of groups exceeding the maximum allowable number per party, the proportion of packstock groups that hobble or picket stock rather than tie animals to trees, and so on.

Visitor Attributes

The behavior of wilderness visitors is influenced by the type of activity participated in, visitor origins and background, and visitor perceptions of wilderness and its management. The attributes of targeted visitors will determine certain management priorities, methods of communicating management information, and the relative effectiveness of education programs.

Specific visitor attribute data of interest commonly include **sociodemographic** characteristics (such as age, sex, ethnicity, and education), level and type of **past experience**, **knowledge** of wilderness conditions and regulations, and **attitudes** toward and **preferences** for management practices and environmental conditions encountered.

Sociodemographics

These variables describe visitors in terms of age, gender, ethnicity, education, occupation, income, and place of residence.

Reporting.—Sociodemographic data are usually collected by categorizing each individual according to classes established for each of these variables, and reporting the resulting proportion of visitors in each class. Comparisons can be conducted with other areas within the wilderness or with other wilderness areas. For example, a survey of visitor occupation conducted in the Bob Marshall Wilderness Complex showed 37 percent of visitors were professional or technical, 18 percent were craftsmen or operators, and 11 percent were students. In contrast, a survey of the Adirondack High Peaks

Wilderness showed that students comprised 43 percent of the sample (Roggenbuck and Lucas 1987).

Applications.—Management strategies for visitor contact and assessing relative needs will be affected by the sociodemographic profile of the various users groups. For example, local *versus* distant users will require different methods of visitor contact; relative requirements for developed campsites close to trailheads will also vary according to the proportion of nonlocal users in the user population. It has been suggested that the generally high educational levels of wilderness users should make it relatively easy to alter behavior through education. This may not be true for a place where a large proportion of visitors is unusually young and/or poorly educated. Place of residence information enables managers to target specific populations for news releases about upcoming management changes, educational programs, or public meetings. A more general application is the economic assessment of visitor contribution to the local economy. Economic assessments usually exclude visitors who live inside the economic region of interest; expenditures by "outsiders" are evaluated in the context of, for example, location of trip expenditures, the distance traveled from place of residence to the recreation site, and the geographic boundaries of the economic region (Bergstrom and others 1990).

Past Experience

"Past experience" refers to the relative familiarity of the visitor with wilderness areas and wilderness practices.

Reporting.—There has been little consensus about how to measure "past experience." For example, one optional question on the approved Forest Service Visitor's Permit (FS-2300-30) is "number of times you visited this area in past 10 years." Even without permit information, managers frequently categorize users as either "novice" or "highly experienced."

Two separate domains, or classes, of experience are relevant: (1) experience at a particular place, and (2) experience with a particular style of recreation (Watson and Niccolucci 1992; Watson and others 1991). Within these classes, experience may be measured in terms of length of time or frequency of visits. The most commonly used measures of experience include:

(1) the length of time the visitor has been going to a specific wilderness area;
(2) the frequency of visits to the specific wilderness area (either the total number of times or the typical number of times per year);
(3) the length of time the visitor has been going to any wilderness;
(4) the frequency of visits to any wilderness;
(5) the total number of wilderness areas visited.

Applications.—Visitor management strategies will differ according to user experience. Experienced users may be more likely to exhibit appropriate low-impact behaviors, and are therefore less in need of education or regulation. They may also have more attachment to particular places, be more sensitive to change, and be more tolerant of management practices involving curtailment of activities geared toward protection of the resource. More direct management strategies may be needed with less-experienced visitors: safety risks may be higher and high-impact behavior may be more prevalent.

Visitor Knowledge

Visitor behavior is partially influenced by awareness of appropriate low-impact practices, regulations, and rationale for management decisions which may curtail visitor use. Knowledge does not necessarily translate into practice; lack of compliance may be due to inappropriate behavior rather than ignorance of appropriate behavior. Inappropriate behavior in defiance of either regulations or expectations of appropriate behavior may stem from lack of support for certain management directives. As a result, level of support for potentially unpopular wilderness uses and practices must also be assessed (Manfredo and others 1990)

Reporting.—Visitor knowledge may be assessed by questionnaires or interviews. Visitors are questioned as to their awareness of (1) appropriate low-impact practices, (2) regulations for the given wilderness area, and/or (3) rationale for potentially controversial management decisions. Measures of tolerance or level of support for certain practices or mandates is obtained by asking visitors for their subjective assessment of each issue and ranking level of tolerance (for example, “problem” versus “acceptable”; “do not support,” “indifferent,” “strongly support”).

Applications.— Where levels of knowledge are low, it may be important to increase education. The success of educational programs can be assessed by periodic evaluations of visitor knowledge of appropriate low-impact practices or regulations in the area. Knowledge of, and level of support for, appropriate but unpopular management mandates (for example, domestic livestock grazing, permitting certain fires to burn) are likewise important to assess on a regular basis (Manfredo and others 1990).

Visitor Attitudes and Preferences

“Attitude” and “preference” information is a means of assessing (1) the qualities and characteristics of the wilderness experience important to the visitor, (2) how these expectations are met in practice, (3) current levels of “satisfaction,” (4) “satisfaction” in comparison with previous visits to the wilderness area or visits to other areas, and (5) perceived “defects” or causes of dissatisfaction. Topics for assessment include both conditions encountered in a specific wilderness setting and opinions on management.

Reporting.—Visitor attitudes and preferences may be assessed by questionnaires or interviews. There are three aspects to attitude/preference information: (1) definition of the characteristic to be measured, (2) specification of alternatives, and (3) conflicts.

It is critical that intangibles such as “attitudes” and “preferences” are given a concrete working definition in terms of a number of measurable attributes. This will be accomplished within the context of the stated objectives of the study. For example, visitors may place a high premium on the “quality” of a wilderness experience. However, “quality” may be defined in a number of ways. For example, “quality” may be expressed in terms of “solitude” (for example, number of encounters per trip, number of groups camping within sight or sound, visibility of lights originating from outside the wilderness area), “lack of observed habitat degradation” (for example, number of encounters with wildlife, amount of litter seen, perception of trampling damage), “provision” of certain goods and services (for example, number of designated campsites, number of stock corrals). Alternative attitudes and preferences may be expressed negatively in terms of characteristics which create dissatisfaction or are perceived as defects. Finally, a number of visitor preferences and attitudes will likely conflict. Within a particular user group certain characteristics may rank as desirable, whereas others will rank low; for example, a wilderness area may be excellent from the standpoint of "facilities" provided, but rank low from the standpoint of various measures of solitude. Conflicting attitudes and preferences may exist between user groups; for example, hikers may be relatively tolerant of llama users, whereas horse users may not.

Applications.—Knowledge about attitudes and preferences gives valuable information on both the motivation of the visitor and on possible courses of action for management. These data can be used as valuable input to selection of indicators and standards for conditions (Lucas and Stankey 1985). This information can be used to design quality recreation experiences and to identify and either avoid or predict response to management actions.

Summary-Use Statistics

Frequently, measures of visitor use are reported as a combination of several different use measures, forming a new, aggregate variable.

Visitors

This refers to the total number of people that visit an area during some unit of time, usually a year. One person would be recorded as one visitor, regardless of how many times he or she visited the area during the year.

Reporting.—This index is difficult to calculate. A crude measure is the count of all visits to the defined area, summed over the period of time of interest. Alternatively, the total number of visitors to an area may be estimated as the ratio of the total number of individual visits to the estimated mean frequency of visits, if this information is available.

Applications.—This index is used as a measure of the proportion of either a particular population, or of society in general, that derives recreational benefits from a wilderness.

Visitor-Day

A visitor-day is defined as one 24-hour day spent by one visitor at a given site.

Reporting.—A visitor-day is calculated as the product of the number of visits and length of stay (in days); in effect, the visit count is weighted by the time involved. If group counts are obtained, the visitor-day index can be obtained if information on group size is available.

Applications.—To determine use by specific categories of interest, total visitor-days may be categorized by user type, method of travel, activity, and so on. This requires data on the proportion of time spent engaged in each activity, as well as length of stay.

Visitor-Hours

This is calculated in a manner similar to visitor-days, in that 1 visitor-hour is defined as 1 hour of recreation at the site. Thus, one person spending 12 hours onsite is recorded as having spent 12 visitor-hours, a two-person group spending 1 hour at the area would be described as 2 visitor-hours, and so on.

This index is not in common use. If length of stay can be measured to the nearest hour, it may be a more accurate measure than visitor-days.

Overnight Stays

One overnight stay is defined as the presence of one visitor over one night. The aggregate is the total number of nights spent by all individuals in the area. This index is calculated as the product of the number of individual visits and the number of nights spent during each visit. Day use does not contribute to the calculation of overnight stays.

Reporting.—Calculation of this index is affected by the measurement technique used to collect the data. If a mechanical counter or observer is used to record individual visits, the resulting estimate of total visits is multiplied by an estimate of the mean length of stay, expressed in number of nights. (Day users are recorded as having stayed zero nights). If visits are recorded by means of registration stations or permits, the number of nights per visit may be obtained simultaneously. If each individual visit is recorded, the aggregate measure is obtained by summing the data. If group data are obtained, group size is multiplied by the number of nights the group stayed; the resulting value is summed for all groups.

Applications.—This is the standard unit for backcountry and wilderness use in the National Park Service. Information on overnight stays can be used as a measure of campsite impact and usage. However, the proportion of day excursions are common in many wilderness areas, and vary in frequency between areas; thus the overnight stay may be an incomplete measure of total use.

Recreation Visitor-Days

A recreation visitor-day is defined as 12 hours of recreation at the site. One visitor-day can be one person inside a wilderness for 12 hours, or two persons present for 6 hours, and so on.

Reporting.—As with overnight stays, both a measure of number of individual visits and a measure of length of stay are required. If mechanical counters or observers are used, the number of individual visits is multiplied by mean length of stay (expressed in 12-hour units). Alternatively, the mean length of stay (in hours) is multiplied by the number of individual visits and the product divided by 12 to get total recreation visitor-days. Where data are recorded on registers or with permits, the number of visitor-days is recorded for each trip and summed.

Recreation visitor-day measures may be combined with other visit characteristics. Examples include reporting the number of recreation visitor-days by transportation method (for example, horse users or hikers), activity categories (for example, hunting, skiing, or hiking), and type of commercial service used (for example, fully outfitted trips, drop trips).

Applications.—This is the standard unit used by the Forest Service for all types of recreational use. This index accounts for both day and overnight use, and is therefore one of the better measures for comparing total amounts of use.

A major source of inaccuracy is the difficulty of assessing lengths of stay shorter than 12 hours. Where day use is common, estimates of visitor-days may be highly inaccurate unless some means of reporting or estimating length of stay (in hours) is built into the system.

Chapter 2: Visitor Use Estimation Techniques

After it has been decided what data are to be collected, the manager must select a specific measurement technique and/or device for collecting those data. *The most appropriate data collection technique is one that is capable of providing the data required with a sufficient level of accuracy while maintaining both management costs and visitor burden at acceptable levels.*

This section discusses various techniques available for the systematic collection of wilderness use data. A summary of use estimation techniques and range of application are given in table 1. Nonsystematic techniques and methods based primarily on guesswork are not included. Each technique is described in terms of (1) specific **methods** and equipment required, (2) **visitor use characteristics** (the type of data) that can be obtained, (3) **visitor burden**, (4) **management costs** associated with equipment purchase and setup, and data collection, and (5) **accuracy**. **Comments** are added as applicable.

External Visual Observations

Methods.—This technique involves the visual observation of individuals or groups outside the wilderness area; that is, as they enter or leave. Human observers can be stationed at, or close to, trailheads to observe visitors and record visitor use characteristics required by the study. Direct observation is most feasible for an area with (1) a small number of access points which account for a large proportion of total use, or (2) a program in which visitors are regularly contacted by agency or volunteer personnel at access points. Indirect observation methods include movie cameras or video recorders

Table 1—Summary of visitor use estimation techniques.

Technique	Use characteristics[a]	Visitor burden	Management costs	Accuracy
External visual observation	1 2 3 5	None	High	Variable
Stationary internal observation	1 2 3 5 6	None	Variable	Variable
Roaming internal observation	1 2 3 5 6	None	Low	Low
Mechanical counters	1, 6	None	High	High
Registration	All	Low	Moderate	Variable
Permits	All	Moderate to high	Variable	High
Surveys	All	Moderate	High	Variable
Indirect estimation	1, 5	High → low	High → low	Variable
Aerial surveys	1, 2?, 3?, 5?, 6?	High	High	?

[a]Specific use characteristics are indicated as follows: 1 = Individual/group counts; 2 = Group size; 3 = Method of travel; 4 = Length of stay; 5 = Activity type; 6 = Use patterns; 7 = Nonobservable characteristics (sociodemographics, attitudes, experience, etc.); ? = Unknown

(modified to expose one frame at a time), or single lens reflex cameras modified to shoot one frame either at pre-set intervals or when triggered by visitor traffic. A mechanical counter may be used to signal visitor presence. Observations are recorded by viewing the film in the office at a later date. An example of a typical data sheet for reporting observations obtained from either direct or indirect observations is shown in figure 1.

Systematic observations should be directed by a formal sampling plan. Sampling may be randomized across access points; alternatively, stratified sampling plans may be used, with strata consisting of access points or specific time periods (for example, weekday/weekend or holiday/nonholiday). Care must be taken to assure coverage of visitors entering (or leaving) in the very early or late hours of the day.

Visitor Use Characteristics.—Data obtained by this method can include the number of individual or group visits, group size, method of travel, location of entry or exit, and date of entry or exit. Gender and age estimates may occasionally be determined, but individuals may not always be distinguishable. Likewise, although day and overnight users can be distinguished by the amount of gear carried, it is generally not possible to determine length of stay.

Visitor Burden.—None. Visitors are not contacted, and may not be aware that they are being observed.

Management Costs.—Relatively high. Substantial personnel time is required, regardless of whether cameras or human observers are used to monitor visitor traffic. When human observers are used, the primary costs are personnel time, wages, and transportation. Costs can be reduced somewhat if volunteer labor is available, or if personnel are able to combine observations with other tasks in the vicinity of observation points. When cameras are used, costs include equipment (cameras, traffic counters, batteries, a film editor, film), film processing, personnel and transportation costs associated with locating, maintaining, and periodically moving the equipment, and costs associated with film viewing.

Accuracy.—Variable. Considerable sampling effort is required for even modest levels of accuracy (Roggenbuck and Lucas 1987). Accuracy is reduced if sampling intensity is low, the sampling plan is poor, or if there is no commitment to following the plan. Because data obtained from human observers are highly accurate, human observers are the preferred method of data collection. Large variation in response and equipment failure reduces the accuracy of mechanical counters; if mechanical counters are used, *data collected from human observers should always be used to assess the accuracy of mechanical counters*. Nonsystematic methods for obtaining observations are used frequently; however, unknown sources of bias associated with haphazard data collection result in data of dubious or no value.

Comments.—Possibly because of the expense involved, systematic visual observation is not in common use. Nonsystematic visual observations are used frequently; however, nonsystematic methods result in worthless data.

The most common mechanized method in use is a video- or camera-based system triggered by a traffic counter. Limitations include high rates of maintenance (for example, 35-mm cameras can provide a maximum of only 36 exposures per roll of film, thus requiring frequent visits to replace film),

WILDERNESS AREA

VISUAL OBSERVATION DATA SHEET

Date ____________________________________ Weather ____________________________________

Sample time ______________________________ Location ___________________________________

Observer ________________________________

(Example of Observable Visitor Characteristics)

Group #	Group size	Time	Exit/ Enter[a]	Overnight or day use[b]	Mode of travel[c]	# dogs	Age (approx.) <= 16	17- 30	31- 45	46- 55	Over 55
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

[a] 1 = Exit, 2 = Enter

[b] 0 = Unsure, 1 = Day use, 2 = Overnight

[c] 1 = Foot travel, 2 = Horse, 3 = Hike with packstock, 4 = Water craft

Figure 1—Sample data recording sheet for observable visitor characteristics.

equipment obsolescence (for example, obtaining, developing, and viewing film for 8-mm movie cameras is an increasing problem), and expense.

There are ethical, and sometimes legal, concerns about using cameras to observe visitors. Privacy can be safeguarded by (1) adjusting distance or focus so that individuals cannot be identified, and (2) destroying the film after observations are recorded. In Canada there is a legal requirement to post a notice that observation monitoring activities are occurring. Only public areas through which visitors pass should be filmed, not campsites or swimming areas (Lucas and Kovalicky 1981).

Internal Visual Observations: Stationary

Methods.—Observations are taken only at specific locations within the wilderness area. For example, if the objective is to assess visitor use along a particular trail segment, or at a particular destination, cameras or human observers are installed along the specific trail segment or at all entrances to the destination area.

Visitor Use Characteristics.—Data include the number of individual or group visits, group size, method of travel, and date of entry or exit. Additional information such as gender and approximate age may be determined, but individuals are not always distinguishable. Summary visitor use statistics, such as overnight stays and recreation visitor-days, can be compiled for destination areas. Examples of spatial use-pattern information that can be obtained are (1) order in which available campsites are selected, and (2) use intensity at specific target areas at destination sites (such as lakeshores).

Visitor Burden.—None. Privacy concerns must be considered because observations are made at places where people expect privacy. When cameras are used, they should be slightly out of focus and the film should be destroyed after information is recorded.

Management Costs.—Variable. Costs may be relatively high if there are a number of remote locations to be monitored; substantial transportation costs are associated with maintaining cameras or observers in a number of remote locations. However, if only a few sites are to be monitored, or sites are close and popular, total costs may be relatively low. Use of observers is likely to be more cost-effective than use of cameras; systematic observations by employees or volunteers located at a popular destination may add little additional cost beyond normal operations.

Accuracy.—Variable. As with external observations, accuracy depends on the adequacy of sampling. Although nonsystematic observations are commonly made, data collected haphazardly are biased, and therefore are of little or no value. Mechanical equipment, such as cameras, are liable to failure; equipment must be maintained, checked, and calibrated at regular intervals.

Comments.—Internal visual observation with human observers is in relatively common use. If use is to be estimated for a few popular destinations, and personnel have other things to do, this technique can provide cost-effective results. However, if visitors are relatively uncommon, observer boredom and fatigue can be a problem; as a result, there may be no consistency in sampling, or observers may fail to adhere to the study plan after a time. Mechanical equipment, such as cameras, are liable to failure;

equipment purchase and setup can become prohibitively costly if more than a few places need to be observed.

Internal Visual Observation: Roaming

Method.—Visitors are observed during wilderness ranger patrols; patrols are commonly scheduled for times or areas known to have heavy use.

Visitor Use Characteristics.—As above. The most useful application is to obtain estimates of the number of overnight stays, tabulated by trail section or destination area within the wilderness.

Visitor Burden.—None. Visitors are not contacted, and may not be aware that they are being observed.

Management Costs.—Low. Data are collected during routine wilderness ranger patrols.

Accuracy.—Low. Because scheduling is not random, but deliberately selected to coincide with periods of heaviest use, this type of counting results in highly biased measures of visitor use. Lucas and Oltman (1971) cautioned that the "roaming technique" cannot yield a definable probability sample. This is because the probability of any person being contacted depends on where the observer travels, and these probabilities will generally be unknown to the observers. For example, if the observer is deep in the wilderness, there is zero probability of counting people who make short trips; the probability of counting people who hike off trails is proportional to the amount of time the observer spends offtrail; the probability that a user will be enumerated is directly proportional to the length of time spent in a given area, and so on. A reasonably accurate visitor count can be obtained if ranger movement occurs in the reverse direction of anticipated traffic flow (Schreuder and others 1975); however, such planning is generally impossible for wilderness areas.

Comments.—Techniques and strategies for observing visitors as an observer passes through the area have never been refined and tested. The difficulties involved with counting mobile traffic with a roaming observer are obvious. Systematic sampling strategies must be incorporated into this method to obtain unbiased data. Further research as to appropriate strategies is required.

Mechanical Traffic Counters

Methods.—The three most commonly used types of trail-traffic counters are photoelectric, sensor-plate, and loop-type counters. Detailed information on suppliers, specifications, options, and prices (2000) is given in table 2.

1. *Photoelectric counters* consist of a scanner that emits an infrared beam, and a reflector that returns the beam to the scanner; the counter is advanced when the beam is interrupted (active infrared detection), or if the sensor detects body heat and motion (passive infrared). Counts, and date and time to the minute can be recorded. Group counts can be registered if counters have a programmable delay that can be set to avoid multiple counts from one group. Photoelectric counters may activate cameras; cameras may be used either to record use directly or to calibrate the mechanical counters. Timers

Table 2—Specifications for trail traffic counters and associated equipment.

Type	Supplier	Model	Specifications	Cost
Photoelectric	Diamond Traffic Products, Oakridge, OR (541) 782-3903	TTC-442	Sensitivity: 110 ft Power source: 4 D-cell batteries Operational Life[a]: 12-15 months	Counter: $399 with 35-mm camera: $1215 with video camera: $2245
	Trailmaster Lenexa,, KS (913) 345-8555	TM-550	Weight: 12 oz. Sensitivity: 65 ft, width 150°, height 4°. Temperature range: –40° to +120°F. Power source: 4 C-cell batteries Operational life: 1000 events, 1 year	Counter: $180 Data collector: $250 Printer: $250 35-mm camera: $290
		TM-700V	as above, range to 100 ft, Activates video camera Power source: 4 C-cell batteries Operational life: 3-6 months	Counter: $595 video camera: $1200 weatherproof housing for video camera: $950
		TM-1000	Sensitivity: 90 ft Temperature: –40° to +130°F Power source: 4 C-cell batteries Operational life: 1000 events, 30-90 days	Counter: $205
		TM-1500	as above	
	Compu-Tech Systems, Bend, OR (503) 389-9132	PIR-70	Passive infrared sensor system Size: 3" x 6" Sensitivity: 100' x 4' x 2' Temperature: ? Power source: 3 AA batteries Operational life: up to 2 years	CALL FOR PRICES
		TR-41 series 41IR	Counters Size: 4" x 5" Power source: 2 N-cell batteries Operational life: up to 4 years	
		41	Size: 4" x 6" Power source: 4 D-cell batteries Operational life: up to 1 year	CALL FOR PRICES
Seismic (pressure-sensitive)	Compu-tech Systems	TSP-45	Weight: 3 lbs.; 3" x 10" Sensitivity: 100 yds. Temperature: ? Power source: 8 AA batteries Operational life: up to 3 months	CALL FOR PRICES
Loop-type	Interprovincial Traffic Services, Surrey, BC (604) 594-3488	ADR-1000	Weight: 2.6 kg Sensitivity: Variable Temperature: –40° to +60°C Power source: 3 to 6 V rechargeable sealed lead acid battery (solar power option) Operational life: 40 days	Counter: CAN $1150
		ADR-2000	Data collector (include PC software) Size: 0.75 kg; 10 x 20 x 5 cm Temperature: –20 to +50°C Power source: 1 to 9 V alkaline battery	Collector: CAN $1095 (Price includes batteries, RS232 connector for downloading to a micro-computer, computer soft-ware for calculating summary statistics, and shipping costs). Spare battery: CAN $235 Battery charger: CAN $150

[a]Operational limit before unit must be reset, recalibrated, recharged, or resupplied.

may be set to take photographs automatically at specified time intervals during the day.

Careful site selection and proper installation are critical to ensure accurate counts (Deland 1976). Scanners and reflectors must be mounted at about waist level, so there must be trees or posts on each side of the trail. Scenic overlooks or level areas at the top of steep grades should be avoided; in these areas people tend to stop and move back and forth across the beam of the counter, resulting in inaccurate counts. If counts of individual visitors are desired, it is important to select a place where trail users must pass single file and cannot detour around the counter. It may also be important to place the counter far enough along the trail to avoid the most casual visitors—those who do not actually travel along the trail a significant distance.

Because visitors may tamper with, vandalize, or steal counters, counters must be concealed and secured. There must be adequate cover to conceal or camouflage the counter and the reflector. However, counter housing also affects relative security. Counter housing varies with manufacturer; for example, TrailMaster counters are housed in plastic exteriors mounted with nylon straps, whereas Diamond Traffic Products counters are contained in heavy steel exteriors. Securing the unit to trees with screws or bolts stabilizes the equipment on the tree trunk and makes equipment more difficult to remove, leaving only the plastic reflector susceptible to vandalism.

2. *Sensor-plate counter (seismic sensors)*. Pressure-sensitive sensor plates or mats are buried in the trail; sensors are connected to the counter unit concealed off-trail. The sensor mat is installed 6" to 8" below the ground surface; to ensure that visitors cross in single file, the sensor is located in a narrow portion of the trail (36" to 40" wide) in an area that is relatively flat and free of large rocks.

The counting unit should be concealed in a location where disturbance will be minimal. The dust cover which fits over the liquid-crystal display of the counter may be camouflaged with dirt and plant material. Connecting wires (available in lengths up to 50 feet) must also be buried for concealment. The counter must be adjusted for both sensitivity and length of delay between readings; these must be set carefully to avoid multiple counts for people, horses, or groups. Counters may activate cameras or be connected to other sensors if other applications are desired. Different types of seismic sensors may be required according to the type of ground cover. For example, sensors used to detect cross-country skiers on snowpack will have different specifications from sensors used to monitor hikers on hard-packed dirt trails.

3. *Loop-type counter*. This is a relatively new type of mechanical counter which employs microprocessor technology to store data. The counter is in the form of a large loop (approximately 8" by 48"), which is concealed under a layer of earth or snow (or any convenient form of covering) in the center of the trail. Impulses triggered by visitors (hikers, horses, or skiers) passing over the loop are stored as counts in the memory unit of the device; date and time may also be recorded. Data may be retrieved, and the counter reset, by using a radio transmitter and receiver, or stored.

In general, counters should be located such that travel time to and from the counting location is minimized; however, it is also important to place the counter far enough from the trailhead to be reasonably confident that everyone who trips the counter actually enters the wilderness area. Initial setup for both photoelectric and sensor-plate counters takes approximately 1 hour; this includes setting the sensitivity and time-delay, and concealing

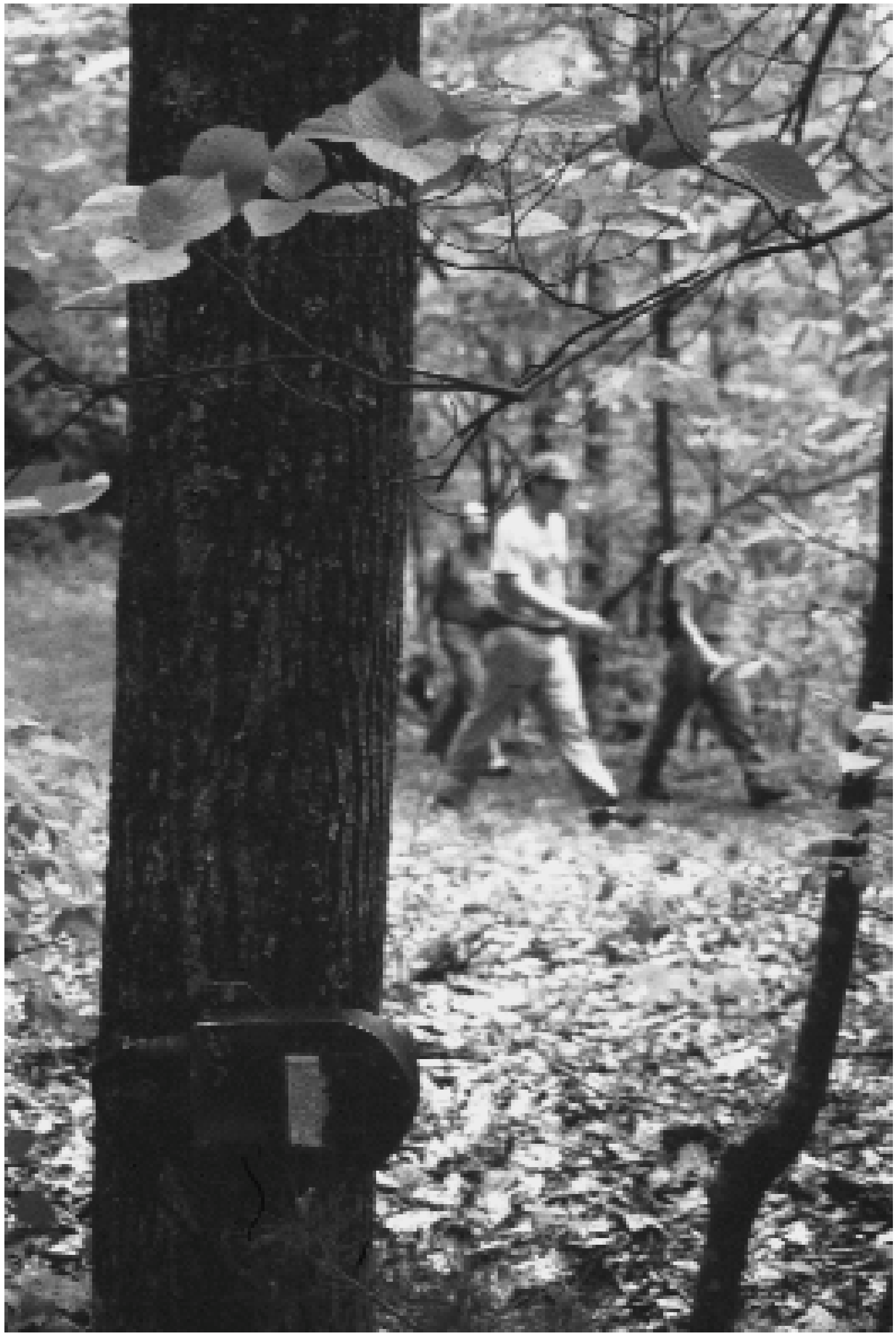


Photo-electric counters emit an infrared beam, and a reflector returns the beam to the scanner. Careful site selection and proper installation of photo-electric counters are critical to ensure accurate counts.

the unit. The units are battery-powered; therefore, primary maintenance requirements will be battery replacement, and if camera attachments are included, units will have to be checked for mechanical failure and film replaced at regular intervals. The equipment is lightweight, reasonably easy to conceal, has a reasonably long operational life, and functions under a wide range of weather conditions.

Visitor Use Characteristics.—Data obtained from mechanical counters are restricted to individual or group counts, and the location and extent of use during a specified time period (between counter readings). However, when combined with visual observations, data can be obtained for group size, method of travel, approximate length of stay (overnight versus day use) and gender and approximate visitor age. When counters are used near trailheads, additional information will be required to estimate distances traveled and use patterns within the wilderness area. For example, in the Great Smoky Mountain National Park, only 25 percent of trail users counted with a mechanical device hiked beyond ½ mile from the parking lot on one trail, while more than 50 percent completed an 8-mile round trip on another trail (Burde and Daum 1988).

Visitor Burden.—None. Visitors unknowingly trip the counting mechanism when passing the counter trigger.

Management Costs.—High. Equipment requirements and costs are outlined in table 2. Associated personnel costs (wages, time, and labor) are incurred with installation, maintenance, and calibration of the counters. Installation time will vary by the method selected. For example, selection of an appropriate site depends on both the nature of the counter, as well as the need for concealment; adjusting the aim of infrared beam is tricky. A possible option to incurring the large initial expense of equipment purchase and installation involves cooperation with state highway transportation departments. Because these departments already possess traffic counting equipment and experience with calibration and maintenance, managers may prefer to explore this possibility rather than duplicate equipment and training.

The greater the number of access points that need to be monitored, the higher the cost is going to be for equipment and maintenance. Calibration is expensive if performed on a regular basis; to check the validity of mechanical counters, either human observers will have to periodically observe use, or cameras will have to be installed and film viewed. Rarely, visitors or wildlife may damage counter equipment, necessitating equipment replacement.

Accuracy.—High. However, *accuracy is high only if care is taken in installation and calibration, and routine maintenance is performed*. Accuracy is seriously compromised if battery power runs low or other mechanical failure occurs, or if calibration procedures are neglected. The sampling effort required will be substantial because of high variability in certain classes of visit and visitor characteristics (for example, group size or gender); accurate estimates of such groups will require large sample sizes.

It is extremely important that units are calibrated on a regular basis. Counter readings are subject to many sources of inaccuracy. For example, wildlife using the trail may not be differentiated from people; passive infrared counters may count even small animals which are not on the trail. Sensitivity of sensor-plate counters, if set too high or too low, will over- or underestimate use. Therefore, readings must be validated independently.

Counter readings can be calibrated by visual observation, either by people or with cameras. Use of field personnel has the advantage of making it possible to derive additional information on visitor use. Counter sensitivity and delay may be adjusted in some cases to match counter readings with observations. Any residual difference will have to be accounted for through correction factors.

Most operational problems are related to improper initial setup and installation. Most devices are resistant to false tripping when correctly installed. However, significant counter error associated with photoelectric sensors may occur as an indirect result of various environmental factors: for example, wind-induced sway of the tree on which the counter or reflector was fastened, snow and fog, and falling leaves.

Comments.—Traffic counters are used relatively frequently; however, calibration is usually sporadic at best. This is unfortunate because *unless equipment is calibrated against a known and accurate standard, use estimates will be highly inaccurate and misleading*. Traffic counters may be much less expensive than direct observation, but costs increase greatly with the frequency of calibration.

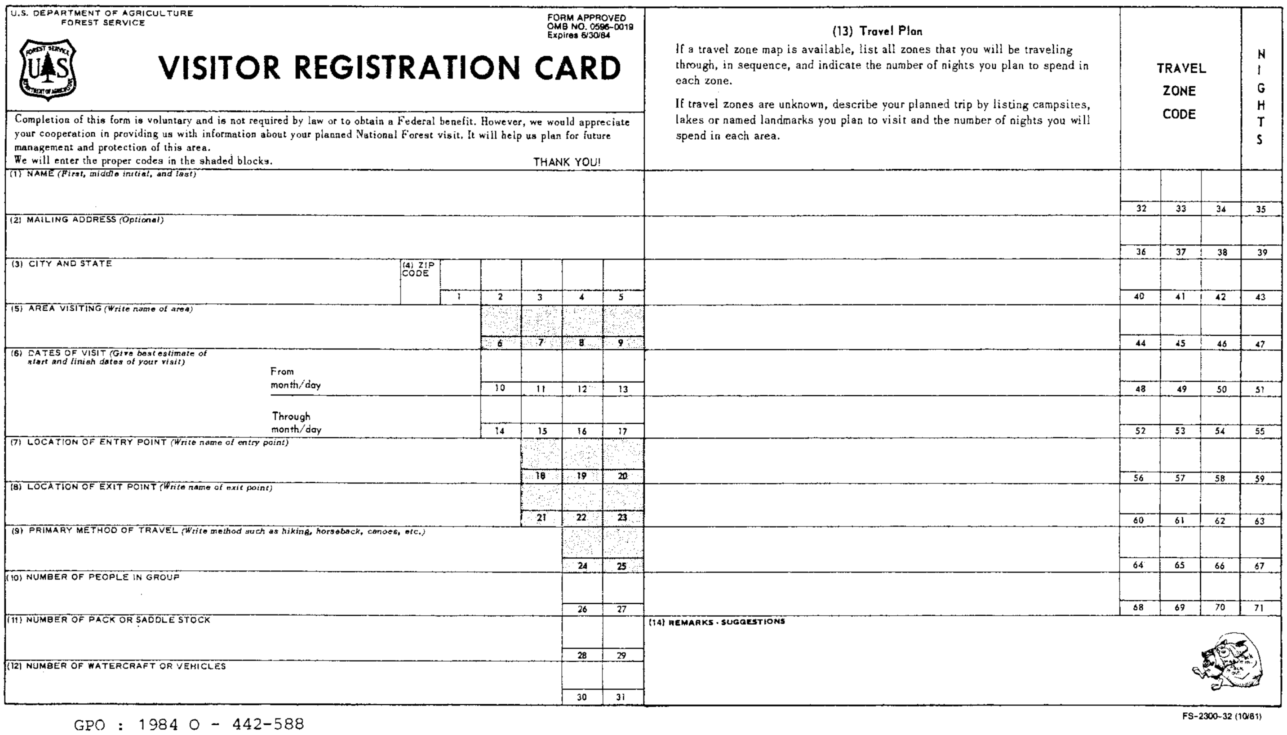
Because of counter bias and errors induced by mechanical failures, use estimates obtained from counter data are usually much less accurate than those obtained by visual observation. A less-expensive and highly efficient strategy combining both methods could employ visual observation at high-use areas, and mechanical counters (calibrated with cameras) at low-use areas.

Registration

Methods.—Visitors voluntarily register by filling out survey cards before entering the area, and use characteristics are obtained from the resulting information. Registration stations are usually unstaffed and located at, or close to, trailheads; registration stations may also be located at staffed visitor centers or ranger stations.

The distinguishing feature of this technique is that registration is voluntary. However, the location, design, and maintenance of registration stations all influence the likelihood of visitor registration. Stations located a mile or two up the trail have considerably higher registration rates than stations at trailheads (Petersen 1985). This observation suggests that criteria for a "good" location include lack of competing information, a reduced concern with packing up and getting on the trail, and opportunities to stop or rest. Places where users are likely to stop are points of interest, a scenic view, a stream crossing, the top of a hill, terrain allowing users (especially stock) to stop safely and easily, or an area where the station is easily seen by approaching visitors. Registration by stock users is difficult to obtain; targeting stock users by installing registration stations at stock-unloading facilities may increase registration rates.

Registration rates are increased if registration stations are marked by an attractive sign. The message on the sign should (1) clearly and simply explain the purpose of collecting information from visitors (Petersen 1985), and (2) provide clear instructions as to what the visitor is expected to do. Registration stations should be maintained on a regular basis, keeping them supplied with registration cards and pencils and collecting the completed cards.



U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

FORM APPROVED
OMB NO. 0596-0019
Expires 6/30/84

VISITOR REGISTRATION CARD

Completion of this form is voluntary and is not required by law or to obtain a Federal benefit. However, we would appreciate your cooperation in providing us with information about your planned National Forest visit. It will help us plan for future management and protection of this area.
We will enter the proper codes in the shaded blocks. THANK YOU!

(1) NAME *(First, middle initial, and last)*

(2) MAILING ADDRESS *(Optional)*

(3) CITY AND STATE — (4) ZIP CODE — 1 2 3 4 5

(5) AREA VISITING *(Write name of area)* — 6 7 8 9

(6) DATES OF VISIT *(Give best estimate of start and finish dates of your visit)*
From month/day — 10 11 12 13
Through month/day — 14 15 16 17

(7) LOCATION OF ENTRY POINT *(Write name of entry point)* — 18 19 20

(8) LOCATION OF EXIT POINT *(Write name of exit point)* — 21 22 23

(9) PRIMARY METHOD OF TRAVEL *(Write method such as hiking, horseback, canoes, etc.)* — 24 25

(10) NUMBER OF PEOPLE IN GROUP — 26 27

(11) NUMBER OF PACK OR SADDLE STOCK — 28 29

(12) NUMBER OF WATERCRAFT OR VEHICLES — 30 31

(13) Travel Plan
If a travel zone map is available, list all zones that you will be traveling through, in sequence, and indicate the number of nights you plan to spend in each zone.
If travel zones are unknown, describe your planned trip by listing campsites, lakes or named landmarks you plan to visit and the number of nights you will spend in each area.

TRAVEL ZONE CODE — NIGHTS
32 33 34 — 35
36 37 38 — 39
40 41 42 — 43
44 45 46 — 47
48 49 50 — 51
52 53 54 — 55
56 57 58 — 59
60 61 62 — 63
64 65 66 — 67
68 69 70 — 71

(14) REMARKS - SUGGESTIONS

GPO : 1984 O - 442-588

FS-2300-32 (10/81)

Figure 2—Voluntary registration card as used in the Bob Marshall Wilderness, MT.

One variation of the registration technique is to have visitors complete registration cards both when they enter and when they leave the area. This system has been tested in National Park backcountry and in some Forest Service wilderness areas. Visitors pick up two cards when they enter the area. They are asked to fill out and leave the first card when they pass the registration station, and to complete the second card during their visit and deposit it when they leave the area. One variation is to affix a postage stamp to the second card so it can be sent in from the visitor's home, if he or she forgets to deposit it upon exit. More visit characteristic information can be obtained by this method than by standard registration techniques; for example, routes of travel, points of entry and exit, social and resource conditions encountered, and reactions to those conditions, and more accurate estimates of length of stay. Because many trips do not last as long as originally expected (van Wagtendonk and Benedict 1980), length of stay is usually overestimated when data are obtained from visitors before their trips.

The disadvantages of this technique are that (1) registration rates would likely vary for the two cards, and both would have to be estimated, (2) clearance by the Office of Management and Budget (OMB) of any questions not currently approved for visitor registration must be obtained, (3) this technique is not in sufficient use to be evaluated rigorously. However, it offers several advantages over standard registration formats. More information can be collected than with standard registration cards, at little added cost to visitors or to managers. It seems to be particularly useful for more remote places when managers are interested in getting information on conditions that visitors encounter (such as the number of people they meet) or in their satisfaction with conditions and/or management. It is a much cheaper method of collecting this information than by the more commonly used visitor surveys.

Estimation of registration rates remains a challenge, particularly at remote places. However, pilot tests using cameras to estimate registration rates have found sufficiently high rates of registration by hikers at remote access points to allow highly accurate estimates of use.

Visitor Use Characteristics.—The types of information that can be collected are constrained only by what can be placed on a registration form. Currently, the Forest Service uses a card that has been approved by the Office of Management and Budget (OMB) (fig. 2). The OMB-approved Forest Service visitor registration form (FS-2300-32) provides information on the number of individual and group visits, group size, method of travel, length of stay, entry and exit locations, destinations, dates of entry and exit, and place of residence. The number of overnight stays can be calculated and recreation visitor-days can be estimated.

Additional information may be collected for other purposes. If visit or visitor characteristic data are required beyond what is on the registration form, a sample of registrants could be asked the supplemental questions. This information, in conjunction with an estimate of registration rate, would allow the manager to predict these additional items for the population of registrants. For example, suppose the manager wished to determine how many visitors had made previous visits to the area, as a means of estimating how many novice *versus* how many experienced visitors the area might be expected to accommodate each year. A sample of registrants would be surveyed. Then, if it were determined that, for example, 20 percent of hikers and 60 percent of stock users had made previous visits, these data can be applied to the larger population estimate of users to obtain an estimate of novice *versus* experienced visitors of each use category which enter the area.

Variations in survey cards must receive prior approval from OMB. It should be noted that registration rates are likely to decline if too much information is requested.

Visitor Burden.—Low. Registration is voluntary, and it takes little time to fill out a survey card. If the station is suitably placed at a point that visitors would naturally stop, registration is more convenient. However, associated visitor burden is higher than for visual observation or traffic counts.

Management Costs.—Moderate. Registration stations must be constructed and installed. Location will influence registration rates (as indicated previously) as well as the relative incidence of vandalism; stations located a ways up the trail from the trailhead have higher registration rates and are less prone to vandalism. However, because transportation time increases, distant stations are more costly to maintain.

Stations must be maintained on a regular basis by supplying them with cards and pencils, and collecting completed survey cards. Data must be compiled on a regular basis. The time commitment is probably comparable to that involving the use of traffic counters, and is less than that associated with visual observation. Checking registration rates requires additional time and equipment (if cameras are used); however, time and equipment needs are not likely to be substantially higher than that required to calibrate traffic counters.

Accuracy.—Variable. The level of accuracy depends on maintenance of the station and the adequacy of registration rate estimates. If funding is insufficient to keep stations supplied with cards and pencils, the resulting data will be of dubious value. However, estimation of rates of registration is the most critical factor in the estimation of total visitor use.

Data will not be accurate if registration rates are unknown or only crudely estimated. Estimates of registration rates are necessary because registration is voluntary and there is no official sanction against not registering; therefore, a large and variable proportion of visitors do not register. Registration rates vary greatly between location (for example, rates for day-use horseback riders range from a low of 0 percent in the Bob Marshall Wilderness (Lucas 1983) to 89 percent in the Rawah Wilderness (Roggenbuck and Lucas 1987)), main activity (hunters register at a lower rate than hikers; hikers register at higher rates than horse users), length of stay (overnight users register more frequently than day users do), party size (large parties have higher registration rates than small parties have), place of residence (visitors who come from far away register more often than local people do), time of day (those arriving after 6 p.m. were less likely to register than those arriving at other times; Leatherberry and Lime 1981), season of visit (spring and fall visitors were less likely to register than summer visitors), and frequency of previous use of an area (Wenger and Gregerson 1964).

Registration rates can be determined in a number of ways, including visual observation by human observers and the use of sensor-triggered cameras. The most common and cost-effective techniques used in recent years is a movie camera triggered by a photoelectric counter (Roggenbuck and Lucas 1987), or human observers stationed at high-use entrances.

Estimates of registration rates used to correct for nonregistering visitors are called the "expansion factor." For example, if only 50 percent of users register, registration data will need to be doubled to obtain a representative visitor total; therefore, the expansion factor is 2. Accuracy is greatly increased if separate registration rates and expansion factors are calculated for different subgroups of the population. Alternatively, if it can be assumed that the mix of visitors using a given trail is relatively stable, registration rates and corresponding expansion factors can be calculated for each separate trailhead.

Comments.—Registration is relatively inexpensive and places little burden on the visitor. The major consideration is the requirement for reliable estimates of registration rates. Although methods of estimating registration rates are neither highly complex nor expensive, many managers fail to commit necessary resources. As a result, much registration data collected is of unknown accuracy, and is therefore useless for estimating wilderness use.

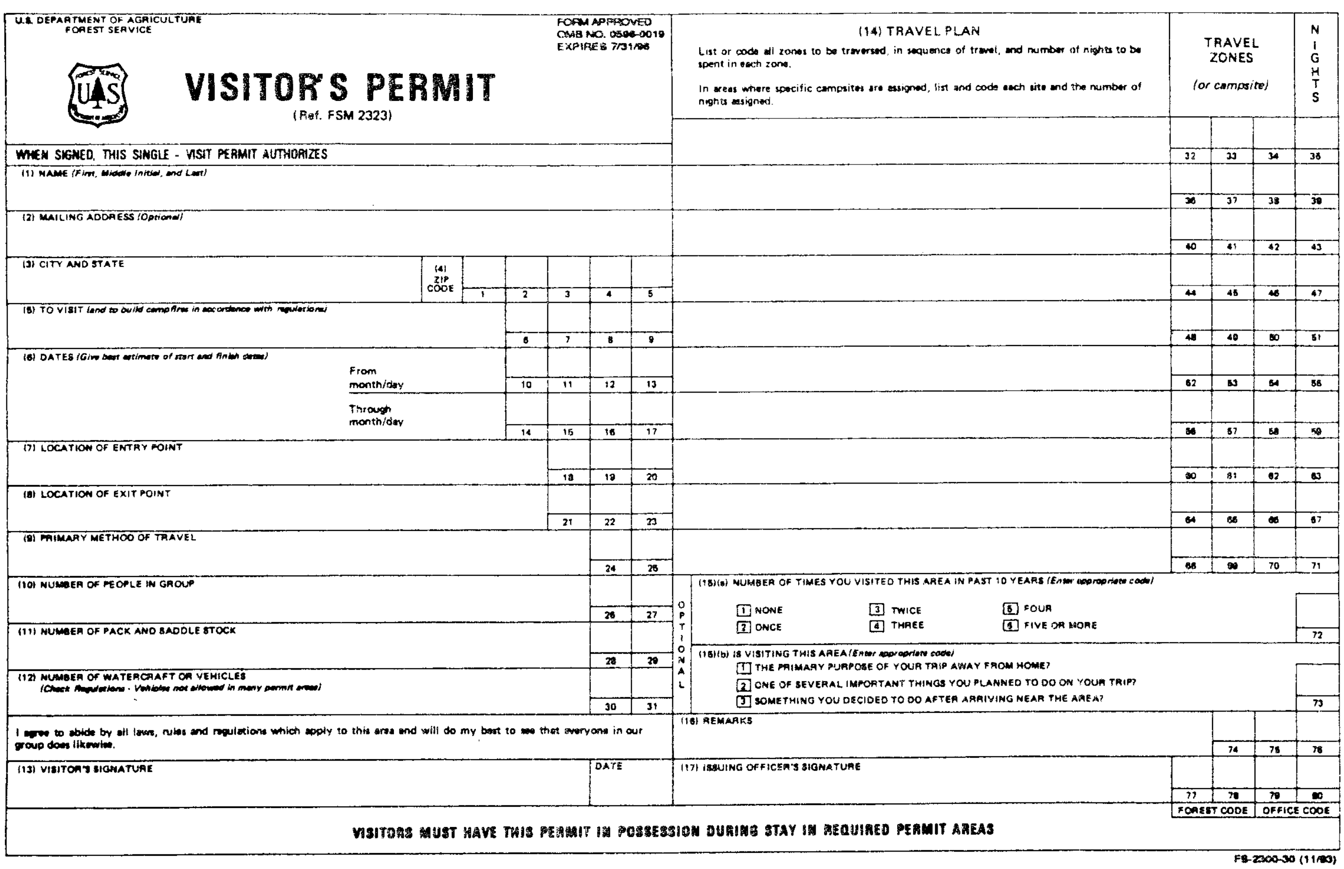
Permits

Methods.—Permits are use-authorization forms issued by the agency. In many cases, the available number of permits is limited to control amount of use in a wilderness area. Permits may be obtained from the agency office, by mail, over the phone, in person, or may be self-issued; self-issued permits are usually obtained at the trailhead or immediately outside agency offices. Visitors fill out the permit, leaving a copy at the station and taking the original with them on their wilderness visit. General permit categories are summarized as follows:

1. Source of issue. Permits may be self-issued or issued only by agency personnel.
2. Restrictions on type of use. Use allowed by permits may be either limited or unlimited.
3. Restrictions on type of user. Permits can be required for all users, only overnight users, only overnight users during high-use times (for example, summer weekends). Combinations are also possible. For example, the Desolation Wilderness has a limited number of agency-issued permits for overnight users, whereas there is (currently) an unlimited number of self-issued permits available for day users.

Permit format must be approved by OMB; Forest Service-issued visitor permits are authorized under the same OMB clearance (0596-0019) as the registration form.

Visitor Use Characteristics.—As with registration data, the information that can be collected is constrained by what can be placed on the permit form. A sample OMB-approved permit is shown in figure 3. Data obtained from permits can include number of individuals/groups, group size, method of travel, length of stay, entry and exit locations, destinations, routes of travel, dates of entry and exit, and place of residence. This information may be sufficient to estimate other categories of use, such as number of overnight


U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

FORM APPROVED
OMB NO. 0596-0019
EXPIRES 7/31/96

VISITOR'S PERMIT
(Ref. FSM 2323)

WHEN SIGNED, THIS SINGLE - VISIT PERMIT AUTHORIZES

(1) NAME *(First, Middle Initial, and Last)*

(2) MAILING ADDRESS *(Optional)*

(3) CITY AND STATE

(4) ZIP CODE — 1 2 3 4 5

(5) TO VISIT *(and to build campfires in accordance with regulations)* — 6 7 8 9

(6) DATES *(Give best estimate of start and finish dates)*
From month/day — 10 11 12 13
Through month/day — 14 15 16 17

(7) LOCATION OF ENTRY POINT — 18 19 20

(8) LOCATION OF EXIT POINT — 21 22 23

(9) PRIMARY METHOD OF TRAVEL — 24 25

(10) NUMBER OF PEOPLE IN GROUP — 26 27

(11) NUMBER OF PACK AND SADDLE STOCK — 28 29

(12) NUMBER OF WATERCRAFT OR VEHICLES
(Check Regulations - Vehicles not allowed in many permit areas) — 30 31

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

(13) VISITOR'S SIGNATURE — DATE

(14) TRAVEL PLAN
List or code all zones to be traversed, in sequence of travel, and number of nights to be spent in each zone.
In areas where specific campsites are assigned, list and code each site and the number of nights assigned.

TRAVEL ZONES *(or campsite)* — NIGHTS

OPTIONAL

(15)(a) NUMBER OF TIMES YOU VISITED THIS AREA IN PAST 10 YEARS *(Enter appropriate code)*
1 NONE
2 ONCE
3 TWICE
4 THREE
5 FOUR
6 FIVE OR MORE

(15)(b) IS VISITING THIS AREA *(Enter appropriate code)*
1 THE PRIMARY PURPOSE OF YOUR TRIP AWAY FROM HOME?
2 ONE OF SEVERAL IMPORTANT THINGS YOU PLANNED TO DO ON YOUR TRIP?
3 SOMETHING YOU DECIDED TO DO AFTER ARRIVING NEAR THE AREA?

(16) REMARKS

(17) ISSUING OFFICER'S SIGNATURE

FOREST CODE — OFFICE CODE

VISITORS MUST HAVE THIS PERMIT IN POSSESSION DURING STAY IN REQUIRED PERMIT AREAS

FS-2300-30 (11/93)

Figure 3—OMB-approved mandatory permit form.

stays and recreation visitor-days. Information on other types of visitor characteristics, such as gender and age, can be obtained if permits are issued at offices, or during compliance checks.

The Forest Service permit includes two optional questions which may be completed if the permit is issued at the agency office. These are:

(A) “The number of times you visited this area in past 10 years”

(B) “Is visiting this area (1) the primary purpose of your trip away from home, (2) one of several important things you planned to do on your trip, or (3) something you decided to do after arriving near the area?”

The National Park Service backcountry use permit includes the same basic information as the Forest Service visitor registration and visitor permit. However, the Park Service requires more specific information on camping locations; the two optional questions are not included.

Visitor Burden.—Relatively high. One component of burden may be the perceived sense of regimentation and control implied by permits. Burden is increased when visitors are required to visit agency offices. Office visits may represent a logistic problem for some users; for example, groups that arrive at trailheads after office hours will have difficulty complying with requirements to obtain an agency-issued permit. The self-issued permit will not be as much of a problem for users if permits are made available at the trailhead; in this case, visitor burden would not differ from that associated with trailhead registration. However, this option can only be used where the number of permits issued is unlimited. Alternatives which increase user convenience include mail, telephone, and even private sector cooperators. In general, visitor reactions to permits have been highly positive, as long as the rationale for permit issuance is considered worthwhile (Lucas 1990).

Strategies for reducing visitor burden (Leonard and others 1980) include:

1. Publicizing requirements for permits in areas where users are known to live or start their trips.
2. Ensuring that the potential user population is made aware of use limits or restrictions that are enforced through the permit system.
3. Clarifying the type of use, or user, requiring a permit.
4. Minimizing (as far as possible) the amount of information required from users.
5. Increasing the convenience in obtaining a permit.

Management Costs.—Variable. Management costs will vary greatly according to the type of permit system. For example, a system of unlimited self-issued permits is relatively inexpensive. Apart from the costs involved in managing the registration system, additional costs are incurred by enforcement; however, these costs will be minimal if other enforcement duties and field tasks can be performed simultaneously. In contrast, where the number of permits are limited and demand for those permits is high, administrative costs can be relatively expensive. (However, those costs do not result from the use of permits as a use estimation *system*; they result from the use limitation *strategy*). Where permits are agency-issued but unlimited, costs are moderate.

Office personnel must be available to issue permits. This might involve directly issuing permits to visitors coming to the office, which requires a more centralized distribution. In contrast, indirect methods may impose less burden on both users and personnel, and less restrictions on location; these include mailing out permits, or posting permits outside the office after hours for late arrivals, or providing for permit issue on the basis of telephone requests. In some cases, outfitters are allowed to issue agency permits for their own trips; these permit receipts need to be retrieved periodically from outfitter offices and checked for completeness and accuracy. Field personnel are less involved in data collection than they would be with visual observation or traffic counter systems.

Accuracy.—Usually high. Permit systems differ from registration systems in that permits are mandatory, rather than voluntary. Visitors must obtain a permit to enter an area, otherwise they are in violation of regulations.

Accurate estimation of use characteristics from a permit system is reduced by lack of compliance. When permit requirements are well enforced, compliance is usually relatively high. For example, compliance in a number of National Park wilderness areas is more than 90 percent; compliance is more variable with self-issue day-use permits, ranging from 53 percent in one area (Lucas and Kovalicky 1981) to as high as 80 percent in other areas. Permit compliance increases with increased levels of enforcement, increased publicity about permit requirements, and increased visitor awareness of requirements (Lime and Lorence 1974).

The level of accuracy depends primarily on the accuracy of estimated levels of compliance. An estimate of compliance rates is required to correct for the unknown proportion of visitors not in compliance; this is the "expansion factor" similar to that determined for registration data. The compliance rate (which is identical to a registration rate) is simply the proportion of all groups encountered that have permits. It can be estimated by checking permits, either systematically or randomly; checks can be performed by rangers on patrol or stationed at or near trailheads. Ranger checks are most often performed within the limits of a normal work schedule, often at high-use times; however, reliability of compliance estimates can be increased if checks are assigned randomly. Because of observed differences between different types of users (Lime and Lorence 1974), expansion factors to account for noncompliance rates should be calculated by user subgroup (for example, horse users *versus* hikers, or day-users *versus* campers). Accuracy may also be compromised by visitors changing their plans after obtaining their permit. Such changes usually result because people overestimate their abilities, or do not account for changes in weather. For example, at Yosemite National Park, 62 percent of all groups deviated from their planned trip; as a result, permit data overestimated use by 12.5 percent (van Wagtendonk and Benedict 1980). Compliance with permit requirements by visitors to Sequoia and Kings Canyon National Parks was 97 percent; however, changes in plans resulted in overreporting of total visitors by 8 percent, and of visitor-nights by 23 percent (Parsons and others 1982). The validity of permit data can be checked by contacting a sample of visitors, either as they leave the area or at their home after the trip, and asking them about their travel behavior.

Comments.—The use of permits is controversial (Behan 1974). Most of the controversy stems from the use of permits as part of a use-limitation system. This is unfortunate because permits have many positive attributes that do not have to be coupled to a use-limitation system. For example, when compliance is high, permits are a simple method of collecting accurate use data; a large number of visitor use statistics can be gathered. Permit issuance offers an opportunity for contact between visitors and agency personnel. This can be used to increase visitor knowledge about regulations, recommended low-impact behaviors, and potential hazards. It gives visitors a chance to obtain information of interest to them, it increases the professional image of the agency, and it may add an element of increased safety (Hendee and Lucas 1973).

In 1980, permit systems were in use in 69 wilderness areas. Of these areas, 17 limited use and 52 did not (Washburne and Cole 1983). Recent informal surveys suggest that the number of wilderness areas that issue permits has declined since that time. Approximately 50 areas currently require permits; however, the number of areas that limit use has increased to about 25. Most of these changes have occurred in areas managed by the Forest Service. These findings suggest that use of permits as a tool for collecting visitor data and communicating with the public is decreasing.

Visitor Surveys

Methods.—A visitor survey consists of two parts: (1) **contacting a sample of visitors** (either at trailheads, within the wilderness, or at home); and (2) **obtaining visitor use information** by either interviewing visitors or asking them to respond to a questionnaire.

1. **Visitor contact**. Strategies of contacting visitors must identify the sampling design to be used, the timing of visitor contact, and the location of contact.

There are three principal types of sampling design used to obtain a representative sample of visitors:

(a) *Stratified samples* of visitors at, or close to, trailheads.

(b) *Random or systematic sampling* of either permits or registration forms, or both.

(c) *Convenience sampling.*

Stratified sampling involves the placement of personnel at or close to randomly selected trailheads; the strata are time blocks selected from available weekdays, weekends, and holiday periods. Visitors are interviewed or asked to complete a questionnaire as they enter or leave the wilderness; alternatively, personnel can obtain names of visitors who are then sent a mailback questionnaire. Personnel could also ask visitors for information regarding length of stay; this information can be used for estimating such summary visitor use statistics as recreation visitor-days. Stratified sampling is most efficient if observers can combine interviewing with counter validity checks or monitoring registration rates.

Random or systematic sampling of permits may be used to obtain the names and addresses of visitors; the visitors thus sampled are subsequently sent mailback questionnaires. Sampling from permit lists is inexpensive. However, the information provided is usually restricted to the permit compliers, group leaders, or whoever registers or fills out the permit. Information regarding other party members can be obtained by asking group leaders to supply names and addresses of party members; questionnaires may be subsequently mailed to a sample of party members. Some wilderness areas (for example, the Okefenokee National Wildlife Refuge Wilderness) require the names of all members of the party on the permit.

Visitor contact strategies for surveys must identify the sampling design to be used, the timing of visitor contact, and the location of contact.

In theory, registration information could be used in the same manner as permits to derive a sample of wilderness users, especially if registration rates are known to be high. However, registration rates are much lower in general than permit compliance rates. Examples of visitor use surveys using registration data are (1) at Cranberry Backcountry in West Virginia, where registrants were randomly selected, and nonregistrants were systematically selected on randomly selected days (Echelberger and Moeller 1977); (2) at the Bob Marshall Wilderness Complex, where visitors were sampled directly at moderate- to high-use trailheads, and registration cards were sampled at more remote, low-use trailheads (Lucas 1985).

Convenience sampling does not provide a representative sample of the population, because the lack of true randomness in sample selection introduces an unquantifiable amount of bias. Convenience samples may be justified occasionally as a means of obtaining information on, for example, visitors to a specific internal location (such as a lake basin), or noncompliers (Lucas and Oltman 1971; Watson 1993). Sampling is performed by patrolling rangers, or by personnel stationed at entry points to the wilderness. Personnel would then interview all the visitors encountered in that particular location. The National Park Service, through their Visitor Service Project, advocates what they call “taking the pulse” of visitor use with intense convenience samples of visitors.

Other methods of contacting visitors may be required when trailheads are not established, use is very low or follows unknown patterns, or cost-efficient alternatives are not readily available. For example, the Corps of Engineers attempted to contact a sample of dispersed hunters by placing response cards on vehicle windows on selected sample days; respondents were asked to deposit completed forms in a designated roadside box. Unfortunately, this approach provided a response rate of only 25 percent. The Forest Service, working at Upland Island Wilderness in Texas with very dispersed and unpredictable entry and exit patterns, contacted apparent recreation visitors by placing mailback cards on vehicle windows; response rates were almost equally low (Watson and others 1992). In contrast, roadside traffic surveys were used to contact visitors in a Forest Service wilderness in Indiana, characterized by an abundance of easy access points from along adjacent roads; visitors were contacted at places where all visitors to the area had to pass (Watson and others 1993). Although visitor contact was highly successful, approximately 50 percent of all vehicles stopped were not wilderness-visit-related traffic. Further consideration of alternative sampling designs are required.

The timing of visitor contact is important. Visitors may be contacted when either entering or leaving the area. Information obtained from visitors after their trips is generally more useful; in addition, visitors may be more open to questions when leaving the area. The most cost-effective method, when possible, is to contact visitors arriving and departing during a selected time period.

The location of visitor contact must be carefully selected in order to avoid undesirable intrusion into the wilderness experience of visitors. Surveys conducted at trailheads are considered most acceptable. Visitors have occasionally been contacted at campsites and along trails in the wilderness, but these locations are generally considered intrusive.

2. **Obtaining information**. Information is solicited from visitors by means of interviews or questionnaires. Interviews should be kept short, limiting content to easy-to-answer, factual questions. Whether the visitor is either just setting out, or leaving for home, there will be low tolerance for complicated and difficult-to-understand questions, and long, time-intensive interviews.

The second option for collecting detailed visit and visitor characteristic data is the mailback questionnaire. Typical response rates to questionnaires 4 to 16 pages long range between 77 percent and 85 percent (Dillman 1978). However, this level of response usually entails diligent followup; followup procedures include (1) provision of a postage-paid envelope with the questionnaire, (2) mailing out a reminder postcard, (3) mailing a complete second questionnaire and return envelope 3 weeks after the first mailout, and (4) a final mailing of a third questionnaire and return envelope after 7 weeks.

Visitor Use Characteristics.—Any type of visitor information can be obtained.

Visitor Burden.—Moderate. The extent of visitor burden is determined by the location and timing of visitor contacts, and the time required for each visitor to respond to the questions on the survey.

Most visitors appear to value the chance to provide input on wilderness issues, because these issues are important to them. This suggests that visitor burden will be a problem (1) where visitors are contacted within the wilderness (many visitors enjoy this contact, but some do not), or (2) if interviews are too long, and visitors are anxious to either enter the wilderness or get home. Visitors seldom complain about mailback surveys, even those that require as much as 30 minutes to complete.

Management Costs.—High. Statistically valid visitor surveys are expensive. Personnel costs include transportation and time required to monitor different trailheads; administration of the survey may require additional field personnel. When names and addresses need to be collected in the field, there are no great savings associated with mailback surveys. When names can be obtained from a list of permits, however, costs are dramatically reduced because no field contacts are needed. Costs of mailbacks include the cost of questionnaire preparation, printing and mailing, and follow-up costs (postage-paid envelopes, reminder postcards, and follow-up questionnaires). Personnel time is needed to code and enter data and to analyze the results.

Convenience samples can be substantially less expensive. Data can be collected as a part of field employees' normal jobs, so little additional cost is incurred. However, the quality and utility of information is substantially less than that obtained from a valid sample.

Additional costs may be incurred by the time and effort it takes to obtain OMB approval. *Federally sponsored information collection procedures requiring individual responses must receive clearance by OMB.* The approval process requires a lead time of about 3 months from the time of submission to approval; a substantial amount of paperwork is involved. However, the review and justification required to obtain this clearance assures a high-quality survey plan. OMB clearance is critical when important management decisions are to be based on collected information. The clear approval and support of the agency, the Department, and OMB will avoid later problems concerning questions of authority and legality.

Accuracy.—Variable. The level of accuracy is largely dependent on the sampling procedure. Statistically sound, unbiased sampling techniques produce the most accurate information. Convenience samples do not provide a representative sample of the population because the amount of associated bias is unknown; the quality of the data obtained from convenience samples is therefore low.

Comments.—Surveys are the most frequently used method of obtaining detailed information on visitor characteristics, visitor attitudes, and visitor preferences. The use of surveys is increasing with the current emphasis on "knowing your customer" and maximizing "customer satisfaction." The survey has been used almost exclusively by researchers; however, it is a practical technique for managers needing to collect information about recreational use.

Indirect Estimation

Methods — Indirect estimation techniques involve the prediction of some desired visitor use characteristic from one or more easy-to-measure variables. These surrogate measures are the predictor variables. The relationship between the predictor(s) and the use measure is quantified by linear regression. The relative "success" of the predictor variables in predicting the use characteristic is evaluated by the R^2 value calculated for the regression, or the width of the confidence interval for the estimate of the "new" predicted value. The higher the R^2, the more successful the regression model will be in explaining the variation in the use characteristic. Once this relationship is quantified, it is only necessary to monitor the predictor variable(s) to obtain an estimate of the desired use characteristic. Examples of such predictive relationships are:

1. The estimation of dispersed recreation day use in Glacier National Park from weather factors, campground occupancy rates, and the total number of vehicles entering the Park; variation explained by the predictive model was 75 percent (McCool and others 1990).

2. The estimation of the number of people using the Kissimmee River Basin, Florida, from lake water levels, daily maximum temperature, and daily rainfall; variation explained by the predictive model was 69 percent (Gibbs 1973).

3. The estimation of the number of visitors per day to a given lake basin from systematic car counts obtained at the trailhead parking lot; variation explained by the predictive model was 94 percent (Watson and Cronn 1999).

4. The estimation of dispersed recreation use from vehicle traffic recorder counts placed along major access roads (Erickson and Liu 1982; James 1967; James and Ripley 1963).

5. The estimation of fishing visitor-days from vehicle traffic counts obtained at both ends of a parking lot (James and others 1971).

An affiliated method of some promise is "double-sampling." This involves the simultaneous measurement of a given use variable and a suitable predictor variable on a predetermined number of randomly selected sample periods during the use season. Common predictor variables used in double-sampling designs are traffic counts or rates of water consumption at developed sites. Other potential predictor variables include the number of cars parked at the trailhead or the number of trailhead brochures or maps taken by wilderness visitors. Double-sampling is closely related to "cordon" sampling (Erickson and Liu 1982, Roggenbuck and Watson 1981, Saunders 1982); cordon sampling is a method of estimating annual recreation use by interviewing recreational users at roadblocks situated along wilderness area access roads.

How the predictor variables are measured obviously depends on the types of variables chosen. For example, several studies estimated dispersed recreation use as a function of vehicle traffic recorder counts (Erickson and Liu 1982; James 1967; James and Ripley 1963). In these studies, use characteristics were determined by survey sampling of traffic along major access roads; these surveys were coupled with vehicular counts obtained by inductive loop or pneumatic tube counters.

The predictor variables selected must be carefully evaluated, both for their initial suitability as a predictor variable, and for their continued suitability over seasons. For example, measures of trail deterioration, such as trail width and condition, will be adequate predictors of trail use only if trail use is classified simply on the basis of light *versus* heavy use; these predictors will be inadequate if more rigorous predictions of trail use are required (More 1980). Furthermore, the predictive power of certain predictor variables may be affected by both the activity being evaluated and the location of the study. For example, the precision of various categories of predicted visitor use in the Eldorado National Forest was described with 95 percent confidence intervals; precision ranged from ± 15.8 percent for fishing activity over the entire forest, to ± 130.6 percent for swimming and sunbathing at one site (James and Henley 1968).

Some indirect relationships may be useful for long periods of time if use patterns do not appear to change noticeably. For example, the predictive relationships established between visitor use and traffic counts may be valid for 3 to 5 years (Saunders 1982). However, periodic checks should be scheduled to ensure the continued validity of the predictive relationship.

Visitor Use Characteristics.—Potentially, indirect measurements could be used to predict many types of wilderness use characteristics. However, certain use characteristics may not be modeled adequately by a suitable predictor variable; this must be ascertained in preliminary, or pilot, studies.

To date, the use characteristics most commonly evaluated have been total amount of visits, and time involved in a particular activity. Inter-party encounter rates have been successfully predicted from a combination of mechanical counts, visitor counts, and systematic counts of parked vehicles (Watson and others 1999). The relative success of predicting other visit and visitor characteristics is untested.

Visitor Burden.—Variable, but should decline to zero. During initial data collection for establishing the predictive relationship, visitor burden will be determined by the number and type of use statistics to be predicted, and the method of obtaining visitor information (on-site interviews, observation, mailed questionnaires, and so forth).

Once the predictive relationship is established, visitor burden should go to zero, except for periodic checks required to ensure the continued validity of the predictive relationship.

Management Costs.—Initially high, but should decline to low levels. Considerable effort must be expended in developing the predictive relationship between the use characteristic of interest and some appropriate predictor. Accurate information must be obtained for both the use characteristic and the selected predictive variables. Pilot studies are imperative to determine whether there is in fact a relationship between the given use characteristic and the proposed predictor variables, and whether the proposed relationship is sufficiently strong to be of any use as a means of prediction.

Initial costs would include the purchase cost of equipment required to monitor the predictor variable and personnel costs associated with collecting initial data. However, these costs may be incurred only over the short-term, generally for a single year or use season. The resulting predictive relationship may be able to be used for several years with some confidence before reevaluation of the predictive relationship is needed. Large initial expenses may be avoided by cooperation with other agencies (borrowing or time-sharing of equipment and personnel).

Accuracy.—Variable. Accuracy depends on the type of predictor variable, and the strength of the relationship between the predictor and the use characteristic being estimated. Tarbet and others (1982) emphasized the need for formalized sample selection and improved quality control for this type of estimation method.

Aerial Surveys

Aerial photography has been considered as a potential method of counting wilderness visitors since the 1960's. At that time, remote sensing techniques to measure outdoor recreation use were not feasible, as desired resolution would have required flights at altitudes of 500 feet or less (Schnell and Taft 1972). Even with modern improvements in instrumentation and technology, an estimated maximum of 1,000-foot altitude flights (or a scale of 1:2,000) are required to obtain the desired amount of image resolution (Aldritch 1979). Low-altitude flights are incompatible with wilderness values. Satellite imagery (obtained at a scale of 1:120,000) may be appropriate for monitoring recreation areas. There are few data which test the relative discrimination of aerial photographs at different scales and varying degrees of cover. Aerial photography has been demonstrated to be a reasonable method of measuring use on some rivers (Becker and others 1980).

Visitor Use Characteristics.—Visitor counts, spatial use patterns, activity type.

Visitor Burden.—High. Visitors are not contacted directly, but low-altitude flights are extremely intrusive, and incompatible with wilderness values.

Management Costs.—High. Costs include survey aircraft flight time, pilot and personnel wages, camera equipment, film purchase and developing, film viewing and data analysis.

Accuracy.—Undetermined for most wilderness situations.

Comments.—Aerial surveys are probably inappropriate for most wilderness situations, but may be a reasonable method of measuring use on some rivers (Becker and others 1980).

Chapter 3: Sampling Methods

Sampling is the systematic strategy by which data are to be collected. Sampling is essential in some form for all use estimation systems because proper sampling techniques ensure that the data are representative of the larger population from which they are drawn. Representative sampling assures the investigator that the resulting statistics calculated from those data are reliable estimates of the population values.

There are two general categories of sampling procedures. The first is convenience or judgment sampling; the data are selected according to the discretion and subjective knowledge of the investigator. Drawbacks to this method are discussed in detail below. Probability or statistical sampling techniques are preferable to convenience sampling because they are based on the statistical principle of randomization.

We discuss a number of statistical sampling designs appropriate for use in monitoring wilderness users and use characteristics. Guidelines for selecting the size of the sample are also detailed. General references for sampling methods and sample size determination include Ackoff (1953), Cochran (1967), Deming (1960), Scheaffer and others (1986), and Steel and Torrie (1980).

Convenience or Judgment Sampling

Methods based on "professional judgment," "best guesses," or "common sense" are the most frequently used so-called "sampling" techniques. A recent survey of wilderness managers (covering 423 out of a total of 440 wilderness areas) reported that 63 percent relied on "best guesses" to estimate visitor use; 61 percent relied on "professional judgment" to formulate regulations (McClaran and Cole 1993). In some cases, on the basis of previous knowledge and experience, the investigator may consider that certain well-defined groups are somehow "representative" of the population as a whole. In other cases, time and logistics may seem to prevent or preclude the use of statistical sampling methods.

In reality, convenience or judgment samples are an extremely poor alternative to statistical sampling procedures. The use of human judgment invariably results in biased sample selection; judgment is unavoidably influenced by untested assumptions of how the various properties of the users or visit characteristics, or both, should be related. Furthermore, it is impossible to determine the size of the bias from sampling methods of this kind. *The samples obtained from judgment surveys are therefore not representative of the population as a whole.* Examples are wilderness users that are convenient or easy to survey, vocal supporters or critics of special interest groups at public meetings, users surveyed at easily accessed trailheads. The characteristics of the individuals sampled will invariably differ from those of users who travel into more remote or less-accessible areas, or who do not belong to a special-interest group. *Because standard errors cannot be calculated for such samples, statistical testing procedures and analyses cannot be used.*

Statistical Sampling Designs

Why Use Statistical Sampling?

Although the research ideal would seem to entail the complete census of all possible members of a population, in fact statistical sampling actually results in substantial accuracy for far less time and cost. Reasons are as follows:

1. Elimination of bias in data collection. Bias inevitably results from reliance upon personal judgment and wishful thinking, and will result in a sample that is distorted or otherwise unrepresentative of the population under study. Appropriate sampling is based on randomization techniques, which ensure protection against unknown bias.
2. Probability theory can be used to measure the precision of sample results. Because it is impossible to know the "real" population values, sample statistics should be selected that estimate underlying population parameters and quantify the certainty of such estimates.
3. Speed. In general, patterns of wilderness visitation do not allow 100 percent monitoring. A complete census might require an entire season or even years to complete; certain significant segments of the population may be completely unavailable for censusing. Regardless, extremely large surveys require substantially longer time periods for data processing; additional costs will be incurred by overtime needed to process extra information and finding and eliminating mistakes. Much of the same information could be obtained through sampling in just a few days or weeks.
4. Fewer personnel are required to do the work. Smaller numbers of personnel make for better and more streamlined selection, training, and crew coordination. Furthermore, even if sufficient money and resources could be allocated for the transportation, supplies, and labor required by a large project, government offices are often constrained by personnel ceilings that restrict the number of people that can be assigned to a single project.
5. Accuracy and quality of data. Sample information will be more accurate, first, because crews can be more carefully selected and trained, and second, because personnel are required to spend relatively less time on the job, thus reducing fatigue and boredom.
6. Flexibility. Increased speed of sampling means that a canvass can be conducted and completed at any time; thus, the logistics of the canvass can be modified relatively quickly to fit the convenience of the study.
7. Reduced visitor burden. Minimizing visitor burden must be a primary consideration in any visitor use study. Good sampling designs reduce visitor burden by maximizing the information content for the fewest number of visitor contacts.

What is a Good Sampling Design?

Because populations are characterized by variability, a good sample design is characterized as efficient if the sampling variation is as small as possible.

The standard error of the mean is a measure of the precision of the sample estimate (that is, how far an average sample mean deviates from the population mean). Thus, a given sampling design is more efficient than another if it results in

(1) a smaller standard error with the same sample size;
(2) the same standard error with a smaller sample size.

Simple random sampling is free of bias because every member of the population has the same chance of occurring in the sample. However, simple random sampling does not make use of additional information about the population structure; for example, that hikers are more likely to have a college education than other wilderness users, or that wilderness users from one part of the country are more likely to travel further distances to a wilderness area than those from other parts of the country. The statistical efficiency of a simple random sampling design can be increased only by increasing the sample size. Therefore, in many circumstances it may be more efficient (as well as less costly and time intensive) to use more complex sampling designs that utilize additional information about the sample.

Sample Size Determination

When planning a wilderness use study, the essential steps to be performed before the sampling design is specified are definition of the sampling unit, and determination of the appropriate sample size.

Defining the Sampling Unit

The first step in sample design is definition of the sampling unit. The collection of sampling units makes up a subset of the population which is to be sampled; it follows that there must be a clear and explicit definition of the population of interest in the statement of objectives. The population is all people, groups, conditions, levels, and so forth, that the investigator wishes to learn about, whether or not these are available; examples are all wilderness users who buy a certain product, all wilderness users entering a given wilderness area, all university students, or all commercial outfitters using a specific wilderness area.

The population is physically defined by the “list” or “frame.” As defined by Deming (1960), the frame is a set of physical materials that enumerates the population and allows it to be sampled. The frame must show a definite location, address, boundary, or set of rules to define the sampling units to be drawn by the random sampling process. Examples of suitable frames are maps, directories, membership lists of hunting or outdoors associations, telephone directories, lists of state license plates, voter lists, permit numbers, and census statistics. Alternatively, there may be no concrete sampling frame; in these cases a frame may consist of clearly defined rules for creating and defining the sampling unit. In still other cases it may be impossible to obtain a representative sample.

Even with a well-designed selection procedure, a poor response rate to a set of interviews or questionnaire items may invalidate the results of the study. Suggestions for improving response rates when these techniques are used are given in part II. However, the problem of nonresponse should be anticipated in the early design stage and contingency plans made for handling nonrespondents.

Example: The manager of a wilderness area wishes to determine the extent of wilderness use during various times of the season. There are several possible scenarios that dictate the sampling frame chosen:

1. The wilderness area has a strictly enforced permit system; very few wilderness users enter undetected. Suppose permits numbered 3782 through 10532 were issued for a given year. The manager wishes to mail a detailed questionnaire to 50 randomly selected wilderness users. The frame, or listing, of the population to be sampled is the total number of issued permits, or permit numbers 3782 through 10532.

2. The wilderness area is "open"; that is, there is virtually no regulation of visitor entry and exit. A potential frame for a given wilderness area is the list of all households within a 100-mile radius. All households within this area are numbered, and all those households randomly selected by the sampling process are enumerated. Some of the sampling units within the sample will be blank; that is, there are no wilderness users in a given household. Blanks will be a problem if wilderness users (the feature of interest) are relatively rare in the population. Considerable time and money may be required to canvass the sample, only to find few or no representatives of the group of interest.

3. The wilderness area is "open", and there is no practical list of potential wilderness users that could be used to draw up a sampling frame. Instead, the manager opts for a set of rules defining the frame. The manager defines a temporal frame consisting of all the days in the entire season; a random selection of days will provide a random collection of wilderness visitors.

Sample Size

The most frequently asked question when designing a wilderness use study is "How large a sample?" Unfortunately, there are no simple answers. In fact, without an estimate of the variability of the response or outcome of interest, no answer at all can be given. Estimates of the variability must be obtained from preliminary data obtained either from a pilot study or from data obtained during previous years.

Most often managers want estimates of the total number of users or an average of some characteristic of wilderness visitors. These are but two examples of parameters of interest that will be determined for some sample of wilderness visitors. If the sampling is in accordance with some statistical design, then a measure of uncertainty called the estimated standard error for the estimate will also be developed. This standard error, denoted SE, may be thought of as the average amount the estimate from (conceptually) repeated samples will deviate from the underlying population value. Estimates with small standard errors are more precise than estimates with large standard errors.

Armed with an estimate of the standard error, a confidence interval may be constructed using rules of probability. In general, twice the SE added and subtracted to the estimate form lower and upper confidence bounds that bracket the unknown population parameter with probability of about 95 percent. This means that there is about one chance in 20 (5 percent) that the unknown population parameter lies outside such an interval or that the interval is incorrect. But we are pretty certain, 95 percent (or 19 times in 20), that the unknown population parameter lies within the confidence interval.

If a higher level of confidence than 95 percent is desired, the “2” is replaced by 2.57 for 99 percent. For lower confidence, say 90 percent, the 2 is replaced by 1.645. Therefore, for a 99 percent confidence interval, 2.57 times the SE is added and subtracted to the estimate; for a 90 percent confidence interval, 1.645 times SE is added and subtracted.

Formulas in the appendix show how the SE and desired width of the confidence interval may be used to determine the required sample size for generating a confidence interval of desired width for a specified level of confidence for several parameters. Briefly, this is accomplished by setting the value to be added and subtracted equal to a value and solving for the sample size, which is an integral part of the SE formula. Further details are given or referenced in the appendix.

Sampling Designs

Simple Random Sampling

Simple random sampling, or random sampling without replacement, is the selection of items from the population such that each item has an equal probability of being selected. That is, the selection of the sample is entirely due to chance; *it does <u>not</u> mean that selection of a sample is haphazard, unplanned, or based on guesswork.*

The random selection of items is performed by means of a random number table. A random number table is a sequence of numbers generated by (conceptually) repeatedly drawing numbers from 0 through 9 from a hat, replacing each number before the next draw, such that each digit 0 through 9 has an equal probability of occurring in each position in the sequence. Therefore, we have no reason to expect that any one number will appear more often than any other number, nor that any sequence of numbers should occur more often than another sequence, except by chance. Table 3 contains 2,000 computer-generated random digits arranged for convenience in 10 columns and 40 rows of 5-digit groups.

How to Obtain a Random Sample

Suppose we want a random sample of size n from a population of size N. We will draw n consecutive numbers from the random number table in table 3, ignoring any number greater than N, and any number drawn for the second time (if we are sampling without replacement). If the population is less than 100, we are required to draw a sample of n two-digit numbers; if n is equal to or larger than 100 and less than or equal to 999, we will be required to draw a sample of n consecutive three-digit numbers, and so on. The start point may be anywhere in the table, but a more satisfactory method is to poke at any spot in the table with a pencil, read the four digits closest to the pencil point, and use those to locate a start point. Digits read in any direction are random—left to right, top to bottom, and so forth.

Procedure for Random Sampling

1. Obtain a list or “frame” for a population of size N; number each item in the frame.
2. Decide on the appropriate sample size n to be drawn from the population.
3. Pick n random numbers from the random number table, excluding those that are greater than N. If the end of the table is reached, simply “wrap” up to the top.

Table 3—Random number table.

	Column									
Row	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	10486	24171	46732	28740	26899	19318	44151	05478	65089	13978
2	73679	78358	79152	99760	84501	58832	44612	98740	19052	36084
3	63865	21629	21229	09131	27787	15262	65766	44905	28331	07628
4	49726	40330	44578	39100	14112	30815	21024	47700	20198	32921
5	54523	34394	91794	42527	31970	94092	08841	01786	04623	70491
6	01822	33331	94062	18259	15477	99842	49073	61869	57548	36566
7	97111	41959	87141	28730	19725	63425	42713	79053	89896	88309
8	26649	22013	57096	15949	38399	96190	86375	60585	84033	92924
9	29713	91004	21915	47233	19757	23067	47654	84324	53456	64015
10	75572	94458	30359	96818	12370	98566	82734	74119	57274	21327
11	51353	82896	34206	44715	46721	52506	52375	17401	75584	05222
12	42146	99692	65221	48951	34071	71623	67643	81184	27069	52048
13	59492	61189	23032	22544	38697	98425	71524	57779	84992	11737
14	49613	85175	55232	21373	54868	03444	37782	46427	22917	63802
15	87528	99124	85858	24274	94713	62191	43189	52137	96329	63053
16	38404	34306	23636	61542	68318	43052	44517	57935	41493	21232
17	42298	87135	56083	23148	12226	87360	66392	01842	47682	05849
18	53635	03919	10864	52861	97661	37910	81404	64731	34166	12428
19	41576	20335	40541	09596	24638	47172	38594	50446	38071	41489
20	32611	61789	62034	52161	83326	71415	71683	14277	94489	86411
21	51569	86030	57005	78733	38783	32056	93193	71194	64960	13532
22	92326	24128	14447	27220	70432	00403	55787	89970	45706	90644
23	24430	51212	71687	17866	72434	37132	37025	54517	61746	95219
24	16956	93082	85099	94246	96284	92649	78831	48646	28247	08542
25	35743	50061	36735	93985	91804	49702	87864	95530	35266	76978
26	45371	94239	58168	55388	77872	64363	78120	58078	87229	96888
27	22031	71445	27735	41272	49040	36759	11921	81538	03294	53928
28	58625	14121	72519	36231	99379	17692	70647	34479	59956	23509
29	18256	46418	81212	48594	19727	32483	61344	79533	32039	13373
30	67460	37690	09210	23301	99668	78223	40589	79996	63419	04596
31	95316	35722	32124	47004	40391	25743	11719	23695	73648	22306
32	99806	85844	78984	01557	59797	32480	26817	20216	81800	42301
33	97548	17286	51371	97245	45991	47590	99571	02891	03712	14906
34	88279	52919	09766	91898	90506	65424	10383	41660	53965	62208
35	80223	73728	83290	77247	07426	58769	59858	48176	58750	80039
36	57685	44187	34178	88661	19728	97953	02030	29292	60970	50840
37	47053	79853	83152	69627	69031	37207	63480	20292	73725	48762
38	12516	13362	77021	97117	80076	24403	29688	04008	13554	93159
39	87686	90153	54670	49189	86081	65526	54774	97169	19535	81816
40	24452	00090	42790	70979	96357	50047	25974	60145	39649	10062

4. Obtain the observations for the items whose identification number corresponds to the selected random numbers.

Example: Suppose we need to select a sample of size $n = 10$ from a population of size $N = 30$.

1. In the random number table (table 3), the pencil falls on the digits 32039 in row 29 and column 9.

2. Go to row 32, column 3 (ignore the last digit) as the start point.

3. Record 10 consecutive pairs of digits less than or equal to 30 by moving right from the start point. The first eight "usable" numbers are 15, 24, 26, 02, 16, 04, 23, 01. At this point, the line ends; proceed by dropping down to the next line. The remaining two numbers are 19 and 14.

Advantages of Random Sampling

1. It is fair—every item in the population has an equal chance of being selected and measured.
2. It protects against bias or misrepresentation of the population.
3. It allows easy data analysis and error calculation.
4. It requires minimal prior knowledge of the population; that is, no further information is required as to how the population is structured.

Disadvantages of Random Sampling

1. It is less statistically efficient than other sampling methods.
2. It does not make use of additional knowledge of how the population is structured.
3. It may be difficult or extremely expensive to implement because all potential sample items must be able to be inventoried or listed.

Systematic Sampling

Systematic sampling is an approximation of random sampling. The sample is obtained by randomly selecting the first item of a sample; the remaining items are selected by systematic selection of each item at some predetermined interval. Examples of systematic sampling schemes in wilderness use estimation are the selective censussing of every tenth wilderness user, every fifth car passing a checkpoint, or every fourth group of visitors encountered during a day of ranger patrol.

Procedure for Systematic Sampling

1. Given a population of size N, determine the appropriate sample size n.
2. Calculate the sampling interval k between selected items; k is calculated as the ratio N/n. This ratio is then rounded off to the nearest whole number.
3. Using the random number table, randomly select some number i between 1 and k.
4. Sample the items identified by the following sequence of numbers:

$$i,\ i + k,\ i + k + k,\ i + k + k + k,\ ....,\ \textit{and so forth}$$

or

$$i,\ i + k,\ i + 2k,\ i + 3k,\ ....,\ \textit{and so forth}$$

Advantages of Systematic Sampling

1. Systematic sampling may reduce variability (it may be more efficient than random sampling), especially if there are patterns or time-order in the data.
2. It is simple to perform (because only one random number is required).
3. Sampling effort is guaranteed to be distributed evenly over the population.

Disadvantages of Systematic Sampling

1. There is only a limited number of different possible samples; since every kth item is sampled after a random start, there are only k distinct samples.

This is in contrast to the almost limitless number of different possible random samples.

2. Estimates may be severely biased if there are any patterns in the data. For example, if the sampling units were days over the entire summer season, and if the 1 in k sampling interval happened to coincide with multiples of 24 hours or 7 days, the same time period would be sampled each day or week.

3. There is no reliable method of estimating the standard error of the sample mean.

Example: Suppose we wish to select 25 permits from a total of 8,743 permit applications. The sampling interval is then 8,743/25 = 349.7 or 350. If the permit cards were arranged in numerical order, we would select a random number between 001 and 350 as the first element of the sample. Suppose this random number was 074; the permits for the sample would be found by successively adding 350 to successive numbers in the series; in other words, we would select permits numbered 74, 424, 774, ..., 8474.

Frequently, permits are stored haphazardly in drawers or boxes, and are not in numerical order. In these cases, much time and labor would be required to either sort or renumber permits to allow randomization. However, we can use an alternative sampling method which utilizes a given height of the permit stack as a selection criterion rather than an assigned numerical interval. For example, suppose the 8,743 permits are in a stack or drawer 75 inches in depth. Choose a random number i from the range 001 to 350. Count to the ith permit from the front of the stack. From that permit, select 25 permits at 3-inch intervals.

Computations for Systematic Samples

If the analyst is confident that the systematic sampling produced a sample free of bias due to patterns in the ordering of data, the sample can be considered equivalent to a simple random sample for analysis.

Multiple Systematic Sampling

Samples obtained from a systematic sampling procedure may be severely biased if there is any form of cyclic variation in the data and the interval between consecutive sampling units equals the period of the variation. Some protection against this form of bias can be obtained by partitioning the sample into m groups, and changing the random start number for each group. If the desired sample size is n, then each group will be of size $n_g = n/m$. For example, suppose the total sample size desired is 30. Therefore, a possible sampling scheme would involve selecting a sample divided into $m = 5$ groups, of size $n_g = 30/5 = 6$ each. A new random start number is then selected for each of the m groups.

Computations for Multiple Systematic Samples

Example: For the East Hickory Creek trail data (table 4), we wish to estimate the mean number of users over the summer season. We have a sequence of 112 consecutive days, and require a sample of size $n = 20$. The sampling interval is thus 112/20 = 5.6; that is, we are required to sample one day in every 5. To select the random starting position, choose a number between 1 and 5 from the random number table. Record this number, add 5 to obtain the second number, and so on. For example, suppose the random

Table 4—Estimated daily user and group counts for East Hickory Creek Trail during a 16-week summer season in the Cohutta Wilderness.

Time	Wk	Day	Usr	Gp	Time	Day	Wk	Usr	Gp	Time	Wk	Day	Usr	Gp
1	1	1	57	26	39	6	4	28	5	77	11	7	13	7
2	1	2	46	23	40	6	5	14	9	78	12	1	75	30
3	1	3	11	7	41	6	6	9	5	79	12	2	33	19
4	1	4	19	8	42	6	7	9	5	80	12	3	21	9
5	1	5	21	11	43	7	1	33	16	81	12	4	34	9
6	1	6	13	6	44	7	2	57	29	82	12	5	7	5
7	1	7	13	9	45	7	3	10	5	83	12	6	9	4
8	2	1	58	31	46	7	4	8	3	84	12	7	8	7
9	2	2	57	27	47	7	5	9	9	85	13	1	28	19
10	2	3	10	5	48	7	6	19	10	86	13	2	38	21
11	2	4	13	7	49	7	7	13	7	87	13	3	14	9
12	2	5	11	6	50	8	1	69	28	88	13	4	9	3
13	2	6	4	4	51	8	2	58	24	89	13	5	20	7
14	2	7	10	6	52	8	3	18	8	90	13	6	18	7
15	3	1	34	17	53	8	4	13	6	91	13	7	14	7
16	3	2	65	26	54	8	5	7	5	92	14	1	27	17
17	3	3	13	6	55	8	6	5	2	93	14	2	48	24
18	3	4	5	4	56	8	7	5	2	94	14	3	3	1
19	3	5	15	10	57	9	1	41	25	95	14	4	26	7
20	3	6	31	9	58	9	2	57	28	96	14	5	8	5
21	3	7	21	6	59	9	3	7	6	97	14	6	11	6
22	4	1	41	25	60	9	4	15	6	98	14	7	10	8
23	4	2	41	21	61	9	5	14	9	99	15	1	78	29
24	4	3	36	7	62	9	6	10	4	100	15	2	34	19
25	4	4	11	5	63	9	7	7	6	101	15	3	7	4
26	4	5	5	5	64	10	1	83	34	102	15	4	18	5
27	4	6	13	6	65	10	2	47	26	103	15	5	12	7
28	4	7	12	3	66	10	3	8	5	104	15	6	16	5
29	5	1	43	24	67	10	4	8	5	105	15	7	11	4
30	5	2	43	24	68	10	5	9	6	106	16	1	26	16
31	5	3	12	6	69	10	6	12	6	107	16	2	53	24
32	5	4	6	5	70	10	7	15	7	108	16	3	16	4
33	5	5	8	4	71	11	1	27	17	109	16	4	16	6
34	5	6	12	7	72	11	2	43	22	110	16	5	9	5
35	5	7	5	5	73	11	3	15	7	111	16	6	25	8
36	6	1	45	25	74	11	4	7	4	112	16	7	14	5
37	6	2	47	23	75	11	5	17	7					
38	6	3	9	7	76	11	6	11	8					

start number chosen is 2. The days to be sampled are then 2, 2 + 5 = 7, 7 + 5 = 12, 12 + 5 = 17, and so on. The resulting systematic sample is as follows:

Day	No. users	Day	No. users	Day	No. users	Day	No. users
2	46	27	13	52	18	77	13
7	13	32	6	57	41	82	7
12	11	37	47	62	10	87	14
17	13	42	9	67	8	92	27
22	41	47	9	72	43	97	11

The sample mean for the number of users is 20.0, and the estimated standard error, or *SE*, is 2.98.

However, a time plot of the data shows that the number of users increases dramatically on weekends (fig. 4); the data are in fact strongly periodic. As a result, the estimates for the mean and standard error will be biased. We can correct this bias to a certain extent by frequently changing the random start number; in other words, by performing multiple systematic sampling.

We decide to draw m = 4 systematic samples, each of size n = 5. The sampling interval k is 112/5 = 22.4, or 22. Thus, we need to choose 4 random numbers between 1 and 22. In this example, the random numbers are 17, 6, 12, and 13. The 4 samples are as follows:

Sample 1		Sample 2		Sample 3		Sample 4	
Day	**No. users**	**Day**	**No. users**	**Day**	**No. users**	**Day**	**No. users**
17	13	6	13	12	11	13	4
39	28	28	12	34	12	35	5
61	14	50	69	56	5	57	41
83	9	72	43	78	75	79	33
105	11	94	3	100	34	101	7
Means	15.0		28.0		27.4		18.0

The mean of the 4 sample means is 22.1. For a sub-sampling approach such as this, the standard error is estimated directly from the four sample means, that is:

$$SE = \sqrt{[(15.0-22.1)^2 + (28.0-22.1)^2 + (27.4-22.1)^2 + (18.0-22.1)^2]/(4-1)/4} = 3.292$$

Stratified Sampling

Stratified sampling assumes that an extremely diverse, or heterogeneous population can be divided into non-overlapping groups; these groups are referred to as strata. A random sample of items is selected from each stratum.

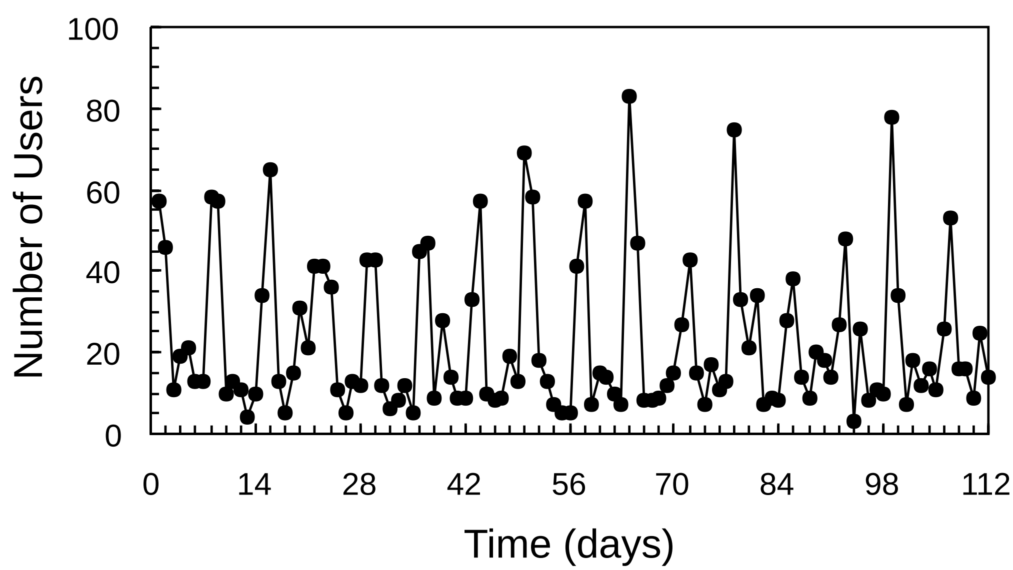


Figure 4—Time plot of the number of visitors using the East Hickory Creek trail in the Cohutta Wilderness during a single summer season.

These samples are then combined to form a single estimate for the population under consideration. Strata may be very different from one another, but should be homogeneous within each strata. Examples of strata are types of users (hikers, horse users, hunters, mountain bikers), amount of trail use ("light," "moderate," "heavy"), gender (male, female), user education levels, and trailhead elevation (high, low).

Procedure for Stratified Sampling

1. Identify the sampling unit.
2. Decide on the total sample size N (number of visitors to be surveyed).
3. Define the strata.
4. Determine sample size n_i for each stratum (see below).
5. Draw random sample of n_i items from each stratum.
6. Take complete data for each randomly selected item from each stratum.

Choosing Stratum Sample Size

There are three procedures for selecting the appropriate sample size for each stratum: <u>proportional</u>, <u>disproportional</u>, and <u>optimal allocation</u>.

1. A <u>proportional</u> sample is chosen so that the number of items selected from each stratum is proportional to the size of the strata. That is, a fixed percentage of each strata is sampled.
2. A <u>disproportional</u> sample results when the number of items selected from each stratum is independent of its size. A disproportional sample naturally results when the sample size for each stratum is constant.
3. <u>Optimal allocation</u> results in a sample size proportional to both the size of the sampling units and the variance within each stratum; estimated costs associated with each sample may also be incorporated into sample size computations. *To estimate sample size with this method, preliminary estimates for both costs and strata standard deviations must be obtained from a pilot study, or from surveys performed in previous years.* Estimates can be easily obtained if the population can be sampled repeatedly; estimates need not be highly accurate to give satisfactory results. If the standard deviation and the cost of sampling are the same for all strata, this method is the same as proportional allocation.

Advantages of Stratified Sampling

1. If each stratum is relatively homogeneous and there are large differences between strata, stratified sampling is more statistically efficient than simple random sampling.
2. Sample sizes can be chosen separately for each stratum. This is important when different elements of the population must be handled separately or they present different problems of listing and sampling. The investigator has more freedom in allocating resources to sampling within each stratum.

Disadvantages of Stratified Sampling

1. Strata must be well defined so that items may not inadvertently be classified into more than one group.
2. There must be accurate information available on the proportion of the population in each stratum.
3. There may be considerable costs associated with the preparation of stratified lists.

Example: There are 50 trailheads (the sampling units) classified by relative amount of use, defined here as the number of visits per day at a given trailhead. Four strata of use can be defined: "light use" (≤2 visits/day), "moderate use" (3-9), "medium use" (10-19), and "heavy use" (≥20). The manager has resources sufficient to monitor only 17 trailheads.

In this example, N_i represents the number of trailheads in each use category ($i = 4$), n_i is the number of sample trailheads to be selected from each use category, and $f_i = n_i/N_i$ is the sampling fraction for each use category. Then, the sampling effort required for a proportional and disproportional stratified random sample is as follows:

Stratum: number of visitors per day		**Proportional**		**Disproportional**	
	N_i	**n_i**	**f_i**	**n_i**	**f_i**
2 or less	24	8	0.33	5	0.21
3 to 9	15	5	0.33	5	0.33
10 to 19	8	3	0.33	4	0.50
≥20	3	1	0.33	3	1.00
Total	50	17		17	

The manager decides to concentrate sampling effort on the more heavily used trailheads, while minimizing sampling effort on the less frequently used trailheads. This decision is justified on several grounds. First, more heavily used trails are expected to have a larger influence on the overall estimate of wilderness usage. Second, because potential impact is correlated with use, monitoring the heavily used trails will provide a more reliable means of gauging environmental damage. Thus, the manager opts for the disproportional sampling scheme.

Computations for Stratified Samples

Since stratified sampling selects a simple random sample from each strata, the initial analysis requires calculation of a sample mean and estimated standard error of the sample mean for each strata. Strata sizes are then used as weights in computing weighted averages of the strata means and standard errors.

Cluster Sampling

Many types of populations in wilderness studies are difficult or impossible to enumerate completely. For example, it is impossible to draw up a list of all potential wilderness users. However, it may be possible to identify certain subgroups, or clusters, relatively easily. Cluster sampling involves a simple random sample of clusters, with the complete census of all items in each cluster. Clusters are similar, or homogeneous, units, with a high degree of diversity, or heterogeneity, within each cluster. These characteristics of cluster sampling contrast to those found in a stratified sample where a random sample is selected within each stratum, and strata are themselves diverse with a high degree of within-stratum homogeneity.

Typical clusters are geographical units or areas, social units (such as households, families), agencies, or temporal units. For example, suppose we require an evaluation of impact in nondesignated campsite areas in a given wilderness area. It would take far too much time, resources, and personnel to systematically search the entire area. Instead, we might define quarter-sections as the clusters. Then we would randomly sample clusters in a given wilderness area, locate and enumerate all campsites occurring in the sampled clusters. Stopping all cars for interviews with occupants on randomly selected days would be one example of a temporal cluster, expected maximum heterogeneity within the day and homogeneity across days.

Procedure for Cluster Sampling

1. Define the "cluster" to be used as sampling unit.
2. Number clusters sequentially from 1 to N.
3. Determine the appropriate number of clusters to be sampled.
4. Draw a random sample of clusters.
5. Take complete data from each of the sampled clusters.

The efficiency of cluster sampling may be increased further by stratification, reducing cluster size, and subsampling. See Ackoff (1953) for details.

Advantages of Cluster Sampling

1. Relatively low field costs, since it requires the enumeration of individuals in selected clusters only.
2. The characteristics of clusters, as well as those of the population, can be estimated.
3. Data can be combined with those obtained in subsequent samples, since clusters, not individuals, are selected.

Disadvantages of Cluster Sampling

1. It has lower statistical efficiency than other sampling techniques.
2. Each member of the population must be uniquely assigned to a cluster; this may be difficult if the characteristics defining the cluster are ambiguous.
3. Cluster properties may change so that the cluster sample may not be usable in later data analysis.

Effects of Sample Design on Use Estimates: A Case Study

As part of a study estimating visitor impact in the East Hickory Trail in the Cohutta Wilderness, visitor counts were obtained on a daily basis over the entire summer season (table 4 and fig. 4). The manager's immediate objective was to estimate the daily average number of users. To illustrate the effects of sampling method on the efficiency of the sample estimate, we analyzed the same data set using several sampling techniques.

The sampling frame is the total number of days in the season, or $N = 112$ consecutive days, from the beginning to the end of the summer season. Assume that a sample size $n = 20$ will allow estimates of the preferred population characteristics with the required precision.

1. **Random sampling.** We need to select 20 consecutive three-digit numbers between 1 and 112. Suppose the randomly selected start point occurred on row 36, column 7. Thus, the first random triplet is 020, or 20. The next three-digit number, 302, is larger than 112, and is discarded, as are the next 13 sets of triplets. The next two "usable" random numbers are 031 and 076. The triplet 020 in row 37 columns 7 and 8 is less than 112, but was selected previously; this second value is discarded. In this example, the unique set of random numbers obtained was as follows: 020, 031, 076, 040, 081, 015, 090, 097, 006, 054, 084, 052, 107, 033, 044, 001, 101, 046, 049, 073.

Once the entire set of 20 random numbers is obtained, the numbers are ordered and observations are made on those days. The data are:

Day	No. users	Day	No. users	Day	No. users	Day	No. users
1	57	33	8	52	18	84	8
6	13	40	14	54	7	90	18
15	34	44	57	73	15	97	11
20	31	46	8	76	11	101	7
31	12	49	13	81	34	107	53

The estimated mean number of users is 21.45 (the mathematical average) and the standard error is 3.79 (from computations described in the appendix).

2. **Systematic sampling.** Computations for systematic sampling follow those for simple random samples. The standard error is 3.44.

3. **Multiple systematic sampling.** Computations for multiple systematic sampling are given in Chapter 3: Sampling Methods. The standard error is 3.292.

4. **Stratified sampling: proportional *n*.** The manager decided to stratify days on the basis of relative use, as defined by the number of visitors entering the area. "Light" use occurred on normal business days (Monday through Friday), whereas weekends (Saturday and Sunday) were characterized by "heavy" use. There are therefore two strata, weekdays and weekends. In a 112-day season, there were 80 weekdays and 32 weekend days.

For a proportional stratified sampling design, the manager could afford to take 20 observations, which is about 18 percent of the 112 day season or 18 percent of 32 and 80, which gives 6 and 14 days allocated between the weekend days and the week days. For convenience, a systematic sample was used in each stratum after the days in each stratum are numbered separately. The first stratum ("weekday") consists of 80 days; therefore the sampling interval is 80/14 = 5.7, or 6, and the start value is selected from the random numbers between 1 and 6. There are 32 days in the second ("weekend") stratum. Therefore the sampling interval will be 32/6 = 5.3, rounded to 5, and the start value will be chosen by selecting a random number between 1 and 5.

Suppose the random start values for each stratum are 4 and 1 respectively. Then the two stratified samples are as follows:

	Weekend days		Weekdays			
	Day	No. users	Day	No. users	Day	No. users
	4	57	1	11	43	14
	9	43	7	13	49	12
	14	57	13	15	55	13
	19	83	19	13	61	14
	24	33	25	5	67	26
	29	78	31	10	73	12
			37	13	79	25
Mean		58.5				14.0
SD		19.37				5.43

The combined estimate of the population mean is: (32/112)·(58.5) + (80/112)·(14.0) = 26.71 with an estimated standard error of 2.25.

5. **Stratified sampling: disproportional *n*.** For a disproportional sample, the sample sizes for each group will be the same; that is, $n_1 = n_2 = 10$. The sampling interval for the weekend stratum is 32/10 = 3.2, or 3, and the start value is a random number between 1 and 3. For the weekday stratum, k is 80/10 = 8, and the start value is a random number between 1 and 8. Suppose the random start values were 1 and 4 for the first and second strata respectively. Then the sample days and their corresponding data are as follows:

	Weekend days		Weekdays	
	Day	**No. users**	**Day**	**No. users**
	1	57	4	13
	4	57	12	5
	7	41	20	12
	10	43	28	14
	13	33	36	18
	16	58	44	10
	19	83	52	7
	22	43	60	8
	25	28	68	8
	29	48	76	16
Mean		49.1		11.1
SD		15.63		4.20

The combined estimate of the population mean is 21.96 with an estimated standard error of 1.62.

The results for the five types of sampling procedures are summarized as follows:

Sampling method	Estimated population mean	Standard error
Random	21.45	3.44
Systematic	20.00	2.98
Multiple systematic	22.10	3.29
Stratified: proportional	26.71	2.25
Stratified: disproportional	21.96	1.62

Note that the estimated population means differ for each of the five sampling methods since they use different samples, but all are reasonably consistent. Random sampling is least efficient because it has the largest standard error in comparison with other methods with the same sample size. Stratified sampling gives the most efficient sample estimates.

Field Sampling Strategies

Sampling strategies must be developed for scheduling the rotation of "observers" across trailheads, scheduling "observer" effort (observation periods), calibration, compliance estimation, and visitor selection.

Scheduling "Observer" Rotation Across Trailheads

Monitoring every access point is feasible only if the wilderness area has relatively few access points and funding is not restricted; in this case, a rotation strategy is not required. However, it is more likely that the number of available "observers"—mechanical counters, human observers, cameras, or registration stations—will be insufficient for large-scale monitoring.

Therefore, available resources must be rotated systematically. Rotation schedules will depend on the number of access points to be surveyed and the frequency for which use estimates are required.

Rotation strategies are determined primarily by perceived differences in use occurring in either space or time. We recommend a more-or-less permanent allocation of an "observer" to each high-use trailhead; the overall accuracy of total use estimates will depend primarily on the accuracy of estimates obtained for high-use trailheads.

As a general rule of thumb, it is suggested that an "observer" is allocated to the trailhead with the highest amount of visitor traffic; other "observers" are rotated systematically across the remaining trailheads, such that the amount of time allocated to each trailhead is proportional to the use that trailhead is expected to receive.

Scenario 1. Suppose a manager must monitor use at four trailheads, but only two mechanical counters are available. One trailhead is believed to account for about 60 percent of use in that wilderness area; a second trailhead is believed to account for about 20 percent of the use and the two remaining trailheads receive an equal amount of the remaining use. Therefore, the second counter is allocated to the second trailhead for half of the time, and allocated between the two remaining trailheads in proportion to anticipated use.

Scenario 2. Suppose use estimates are required for an entire wilderness area over an entire season. It has been determined by preliminary surveys that use patterns are fairly stable within a particular geographic section of the wilderness area, but extremely variable over the use season. Therefore, widespread sampling of the wilderness area is required.

> **Strategy**: Account for use in each section by allocating one counter for every *x* access points.

Scenario 3. Suppose more intense sampling of a particular section is required, but use patterns are sufficiently stable such that monitoring every other year is sufficient to generate adequate use estimates.

> **Strategy**: (1) Divide wilderness access points into two to four sections, such that each section contains an equal number of access points or trailheads (say four or five); (2) place counters on all trailheads within a randomly selected section for 1 year; (3) rotate counters to a new section each year.
>
> This strategy would reduce costs associated with moving counters; the obvious disadvantage is that use estimates for a given section can be obtained only every 2 to 4 years.

Example. Suppose the manager wishes to estimate use for the entire 16-week summer season; there are four trailheads and two mechanical counters. One counter is permanently allocated to the high-use trailhead, leaving three trailheads to be monitored with one counter. The 16-week season is partitioned into eight 2-week blocks. The counter will be allocated to each trailhead for two separate time blocks; this leaves two blocks as discretionary time.

The order in which the counter is assigned to each of the three trailheads is determined randomly. Suppose the random number sequence for the eight time blocks is 5 7 8 3 2 6 1 4, and the random sequence for the three trailheads is 3 4 2. Then the counter will be assigned to trailhead 3 on time blocks 5 and 7, to trailhead 4 on time blocks 8 and 3, and to trailhead 2 for time blocks 2 and 6.

Scheduling Observer Effort

Observation periods are determined by partitioning the visitor season into defined time blocks, numbering the blocks, then randomly selecting the time blocks for which observations are to be made. The length of the observation period is determined by operational convenience; it may be measured in minutes, hours, days, or weeks. As a general rule of thumb, “observers” should be placed at each trailhead for at least two observation periods.

Example. A preliminary study of use patterns in a certain wilderness area suggests that the number of visitors is fairly constant over the season. It was observed that approximately 20 percent of wilderness users entered the area on weekdays, another 40 percent of users entered on Saturday mornings, 10 percent on Saturday afternoons, 20 percent on Sunday mornings, and 10 percent on Sunday afternoons. A total of 10 observation periods can be sampled with the resources available.

The manager decided to partition the sampling day into morning and afternoon time blocks. Time blocks were further stratified into three operationally defined use categories: low, medium, and high. Observer effort was allocated in proportion to amount of use. Thus 20 percent of sampling effort was allocated to low-use periods (that is, two time blocks occurring on either a weekday morning or afternoon); 40 percent effort to high-use periods (four Saturday mornings), and the remaining effort to medium-use time periods (one Saturday afternoon, two Sunday mornings, and one Sunday afternoon. The specific time blocks to be monitored were selected by random sampling.

The entire monitoring period required for this sampling plan is approximately 4 weeks.

Calibration

Calibration requires that observations obtained from the primary counting device (usually a mechanical counter) are paired with observations obtained by a method of known accuracy (either human observers or cameras). The number of calibration samples to be taken will depend on the amount of precision required, the resources available for calibration, and the relative stability of use over time. The accuracy of calibrations must be spot checked at intervals and updated as required; if use patterns change substantially over the season, calibrations made at the beginning of the season will not be applicable to counts made later in the season.

Camera Calibration.—Use of hidden cameras requires a minimum amount of personnel involvement. Cameras are installed on the traffic area where the item to be calibrated (mechanical counter, registration station, and so forth) is installed. To maximize the efficiency of the method, cameras must be set up so that traffic will be visible for long distances.

There are two general sampling strategies for camera calibration: fixed-interval monitoring and counter-activated monitoring.

(1) Fixed-interval monitoring. The camera is activated at programmed time intervals; all traffic during a sample period is photographed. Specific intervals are selected by random sampling procedures.

(2) Counter-activated monitoring. The camera is attached to a mechanical counter, and takes photos only when the counter is activated by visitor traffic. *This technique provides a measure of overestimation bias only;* it does not provide information on error occurring because of visitors undetected by the counter. An alternative may be to have a separate activator for the camera.

For example, a counter may be activited by an active infrared sensor, while the camera is activated by a passive infrared sensor, or a very sensitive seismic sensor.

Calibration by Human Observers.—Calibration with observations taken by human observers is more labor intensive than use of cameras, but is more accurate. Observers should be stationed close enough to the item to be calibrated (counter, registration station, and so forth) so that all traffic is observed; although observers need not be exactly by the check point, they should not wander up and down the trail.

Scheduling of agency personnel may have to occur within the confines of the workweek. However, if significant amounts of use occur outside of normal working hours, it is essential that these time blocks are covered; volunteer labor may be one option. Observer fatigue and boredom may be a significant problem if time blocks are extremely long and few visitors are encountered. Sampling effort may be apportioned according to operationally defined amounts of relative use observed per time block. At least two observation periods should be scheduled for each category.

Compliance Estimates

Compliance is the estimate of the number of visitors who actually register or obtain permits. Compliance estimation is essentially similar to the calibration procedures described above; visitor registration is "calibrated" by supplementary observations so that the number of wilderness users who do not register can be accounted for, and total visitor counts can be adjusted accordingly. The number of supplementary observations taken will depend on the amount of precision required, the resources available for compliance checks, and the relative stability of visitor use over time. If use patterns change substantially over the season, registration rates or permit compliance rates estimated at the beginning of the season will not be applicable later in the season; the accuracy of registration rates must be spot checked at intervals and updated as required.

Frequently, permit or registration compliance estimates are obtained in the course of routine wilderness ranger patrol. In the so-called "roaming observation" technique, rangers check for compliance as visitor groups are encountered, and tally the proportion of those encountered who are not in compliance. However, this type of visitor sampling results in highly biased estimates of visitor use. Bias occurs for a number of reasons: (1) because the probability of visitor contact depends on when and where the observer travels, (2) scheduling is not random but deliberately selected to coincide with periods of heaviest use, and (3) the probability that a visitor group will be encountered is proportional to the length of time spent in a given area, observer location in relation to visitor distance traveled, and so on.

Unbiased data can be obtained only by implementing predetermined statistical sampling strategies. Permit checkpoints are established in accordance with a spatial sampling scheme (see above); sampling of visitors at each checkpoint may be completely random, systematic (for example, selective censusing of every tenth wilderness visitor, or every fifth car passing a checkpoint), stratified, or a combination of these.

Determining Total Population Size from Compliance Sampling.—The size of the total wilderness visitor population is estimated by the direct sampling procedures used to estimate compliance or registration rates. The method is analogous to the Peterson or Lincoln capture-recapture indices used in wildlife population estimation. It should be used whenever total population size is to be estimated from ratio data.

The total number of visitors in a given time period is N, the quantity to be estimated. The total number of permits issued (or registration cards completed) is t. At some period during the visitor season, wilderness rangers survey n visitors, of which s are found to be in compliance (that is, have actually obtained a permit or registered). Then the compliance rate is estimated as the proportion of the surveyed sample, or $r = s/n$. The total population is estimated as:

$$\hat{N} = \frac{n}{s} \cdot t = \frac{t}{r}$$

The 95 percent confidence interval is $N \pm 2 \cdot SE$, where SE is approximately

$$SE = \sqrt{\frac{t^2 \cdot n(n-s)}{s^3}}\ .$$

Example. A total of 300 permits were issued for a given wilderness area. Subsequently, the wilderness ranger randomly sampled 50 visitors, of which 30 had permits. The compliance rate was therefore $r = 30/50 = 0.6$, or 60 percent. The total number of visitors entering the area was estimated as $N = 300/0.6 = 500$, with a 95 percent confidence interval of approximately 500 ±

$$2\sqrt{\frac{(300)^2 \cdot 50(50-30)}{(30)^3}} \cong 500 \pm 115,$$ or between 385 and 615 visitors.

Visitor Selection

The sampling strategy for visitor selection requires both an estimate of the sample size, and a time schedule. Unless the wilderness area has a strictly enforced permit program, visitors cannot be randomly selected prior to arrival. If there is no regulation of visitor entry and exit, the investigator must make a random selection of "contact days", followed by random selection of visitors within the contact day. Sampling may be completely random, systematic (for example, selective censusing of every tenth wilderness visitor, or every fifth car passing a checkpoint), stratified, or a combination of these.

The number of visitors that must be sampled is determined with reference to the population of interest, the type of response variables to be measured (categorical, count, continuous), the expected variation of the response variables, and the specified sampling strategy. Determination of the appropriate sample size requires a preliminary estimate of the variability in the observations. Preliminary estimates are obtained from a pilot study, or from data collected in previous years.

Part II: Selecting and Building a Use Estimation System

Introduction

There are 10 major use estimation systems described in separate sections within part II. Each section is divided into two parts consisting of a **System Description** and a description of the **Operational Procedures**. Operational procedures are detailed in a series of steps, with their number varying according to the particular system of interest. Procedural guidelines are given for the following elements:

1. Use characteristics that can be measured with the particular system
2. Measurement techniques
3. Equipment purchase
4. Equipment installation
5. Data collection strategies
6. Visitor use calculations

Because each section is intended to be self-contained, there is some overlap in information between sections. Additional information required for implementing the specifics of data collection, sampling strategies, and data analysis are discussed in part I.

The 10 use systems are summarized (table 5) in terms of two organizational categories: **information category** and **data collection techniques**. Each column represents a system, designated by a capital letter (A, B, C, and so forth), followed by the page number indicating where that system is described. The components of each system are indicated by an **X** in the appropriate row representing various required components. The potential for each system to provide needed information is evaluated through categorization of potential objectives:

I. **Visit counts**

II. **Observable visit and visitor characteristics**

III. **Simple nonobservable characteristics** (easily reported information implying minimal visitor burden—for example, length of stay, age)

IV. **Complex nonobservable characteristics** (more complicated or involved information, implying increased visitor burden—for example, attitudes, opinions)

V. **Summary use statistics**

The use of table 6 is illustrated in the following example. Suppose the stated management objective is to obtain a visit count for a certain time period. Table 5.I. ("Visit Counts") shows that all systems A through J provide that information; thus, choice of a system will be dictated by cost and ease of implementation. However, suppose information must be obtained on some nonobservable visit characteristic such as length of stay. Table 5.III. ("Simple Nonobservable Visit and Visitor Characteristics") shows that systems A, B, and D will not provide this information at all; options are restricted to the remaining seven systems.

Table 5—Summary of 10 user-estimation systems categorized by information category and system elements.
System A. Mechanical counters with visual calibration
System B: Mechanical counters with observer calibration and sample observations
System C: Mechanical counters with observer calibration and sample interviews
System D: Visitor registration system with checks for registration rate
System E: Visitor registration system with registration rate checks and sample interviews
System F: Permit system with compliance checks
System G: Permit system with compliance checks and sample interviews
System H: Permit system with compliance checks and mailback questionnaires
System I: Indirect counts
System J: General visitor surveys

Table 5 (cont.)

I. Visit Counts
(individual counts, group counts)

	Use estimation system									
Data collection techniques	**A p. 68**	**B p. 79**	**C p. 90**	**D p. 101**	**E p. 110**	**F p. 121**	**G p. 128**	**H p. 138**	**I p. 150**	**J p. 158**
Mechanical counters	X	X	X	.	.	.	.	.	.	.
Visual calibration (accuracy)	X	X	X	.	.	.	.	.	.	.
Sample observations	.	X	.	.	.	.	.	.	.	.
Sample interviews	.	.	X	.	.	.	.	.	.	.
Visitor registration	.	.	.	X	X	.	.	.	.	.
Registration rate check	.	.	.	X	X	.	.	.	.	.
Sample interviews	.	.	.	.	X	.	.	.	.	.
Permits	.	.	.	.	.	X	X	X	.	.
Permit compliance checks	.	.	.	.	.	X	X	X	.	.
Sample interviews	.	.	.	.	.	.	X	.	.	.
Sample mailback surveys	.	.	.	.	.	.	.	X	.	.
Indirect counts	.	.	.	.	.	.	.	.	X	.
General visitor surveys	.	.	.	.	.	.	.	.	.	X

Table 5 (cont.)

II. Observable Visit and Visitor Characteristics
(individual counts, group counts, group size, number of stock, method of travel, gender, approximate age classes, time of entry or exit, day use vs. overnight use)

	Use estimation system									
Data collection techniques	**A p. 68**	**B p. 79**	**C p. 90**	**D p. 101**	**E p. 110**	**F p. 121**	**G p. 128**	**H p. 138**	**I p. 150**	**J p. 158**
Mechanical counters	.	X	X	.	.	.	.	.	.	.
Observer validation (accuracy)	.	X	X	.	.	.	.	.	.	.
Sample observations	.	X	.	.	.	.	.	.	.	.
Sample interviews	.	.	X	.	.	.	.	.	.	.
Visitor registration	.	.	.	X	X					
Registration rate check	.	.	.	X	X	.	.	.	.	.
Sample interviews	.	.	.	X	X	.	.	.	.	.
Permits	.	.	.	.	.	X	X	X	.	.
Permit compliance checks	.	.	.	.	.	X	X	X	.	.
Sample interviews	.	.	.	.	.	.	X	.	.	.
Sample mailback surveys	.	.	.	.	.	.	.	X	.	.
Indirect counts	.	.	.	.	.	.	.	.	X	.
General visitor surveys	.	.	.	.	.	.	.	.	.	X

Table 5 (cont.)

III. Simple Nonobservable Visit and Visitor Characteristics
(length of stay, travel routes, sociodemographics., etc.)

	Use estimation system									
Data collection techniques	**A p. 68**	**B p. 79**	**C p. 90**	**D p. 101**	**E p. 110**	**F p. 121**	**G p. 128**	**H p. 138**	**I p. 150**	**J p. 158**
Mechanical counters	.	.	X	.	.	.	.	.	.	.
Observer validation (accuracy)	.	.	X	.	.	.	.	.	.	.
Sample interviews	.	.	X	.	.	.	.	.	.	.
Visitor registration	.	.	.	.	X	.	.	.	.	.
Registration rate check	.	.	.	.	X	.	.	.	.	.
Sample interviews	.	.	.	.	X	.	.	.	.	.
Permits	.	.	.	.	.	X	X	X	.	.
Permit compliance checks	.	.	.	.	.	X	X	X	.	.
Sample interviews	.	.	.	.	.	.	X	.	.	.
Sample mailback surveys	.	.	.	.	.	.	.	X	.	.
Indirect counts	.	.	.	.	.	.	.	.	X	.
General visitor surveys	.	.	.	.	.	.	.	.	.	X

Table 5 (cont.)

IV. Complex Nonobservable Visit and Visitor Characteristics
(visitor attitudes and preferences, perceptions of social and resource conditions, and so forth)

	Use estimation system									
Data collection techniques	**A p. 68**	**B p. 79**	**C p. 90**	**D p. 101**	**E p. 110**	**F p. 121**	**G p. 128**	**H p. 138**	**I p. 150**	**J p. 158**
Mechanical counters	.	.	.	.	.	.	.	.	.	.
Observer validation (accuracy)	.	.	.	.	.	.	.	.	.	.
Sample interviews	.	.	.	.	.	.	.	.	.	.
Visitor registration	.	.	.	.	X	.	.	.	.	.
Registration rate check	.	.	.	.	X	.	.	.	.	.
Sample interviews	.	.	.	.	X	.	.	.	.	.
Permits	.	.	.	.	.	.	X	X	.	.
Permit compliance checks	.	.	.	.	.	.	X	X	.	.
Sample interviews	.	.	.	.	.	.	X	.	.	.
Sample mailback surveys	.	.	.	.	.	.	.	X	.	.
Indirect counts	.	.	.	.	.	.	.	X	.	
General visitor surveys	.	.	.	.	.	.	.	.	.	X

Table 5 (cont.)

V. Summary Use Statistics
(recreation visitor-days, visitor-hours, and so forth)

	Use estimation system									
Data collection techniques	**A p. 68**	**B p. 79**	**C p. 90**	**D p. 101**	**E p. 110**	**F p. 121**	**G p. 128**	**H p. 138**	**I p. 150**	**J p. 158**
Mechanical counters	.	.	X	.	.	.	.	.	.	.
Observer validation (accuracy)	.	.	X	.	.	.	.	.	.	.
Sample observations	.	.	X	.	.	.	.	.	.	.
1 registration	.	.	.	.	X	.	.	.	.	.
Registration rate check	.	.	.	.	X	.	.	.	.	.
Sample interviews	.	.	.	.	X	.	.	.	.	.
Permits	.	.	.	.	.	X	X	X	.	.
Permit compliance checks	.	.	.	.	.	X	X	X	.	.
Sample interviews	.	.	.	.	.	.	X	.	.	.
Sample mailback surveys	.	.	.	.	.	.	.	X	.	.
Indirect counts	.	.	.	.	.	.	.	.	X	.
General visitor surveys	.	.	.	.	.	.	.	.	.	X

System A: Mechanical Counters With Visual Calibration

System Description

This system enables the manager to obtain visit counts (individual or group visits). Mechanical counters are set up to count trail traffic; the reliability of counter data is assessed by simultaneous monitoring of trail traffic by either human observers or cameras. These reliability checks (**calibration**) are the key feature of the system. Because data recording and calibration are performed without contacting visitors, there is little or no visitor burden.

Summary of System A:

Type of observations:	Counts
Measures of visitor use:	Number of individual visits Number of group visits
Data collection strategies:	Sample plan for counter rotation (if applicable) • spatial • temporal Sample plan for visual calibration
Techniques/procedures:	Mechanical counters Calibration by visual observations • cameras • human observers
Visitor burden:	None

Operational Procedures

Step 1: Decide on Use Characteristics

The use characteristics estimated with this system are limited to individual or group visit counts. Calibration determines the accuracy of the counts; it does not provide additional data for estimating total use.

Step 2: Decide on Counter Type

There are three main types of counters currently available: photoelectric counters, sensor pad counters, and loop-type sensor counters. Counter selection depends on installation site, vandalism concerns, potential environmental influences on counter accuracy, equipment cost, and maintenance requirements.

1. Installation Site.—Characteristics of the proposed installation site will determine the type of counter that is most appropriate. Site characteristics to be evaluated include the presence or absence of tree cover, soil type, and

slope. Photoelectric counters must be attached on a vertical surface so that the sensor and the reflector are opposite each other and located at a distance of 100 feet or less. If counter components are attached to trees, each tree should be large enough to prevent excessive swaying. If there are no suitable trees at the proposed site, posts may be installed if the soil allows digging; however, posts must be concealed in brush to avoid vandalism. Soil type and depth are important if sensor pads and loop-type counters are considered, as these sensors should be buried to be operative. If digging is difficult, or the proposed monitoring site is located on a steep or unstable surface, or both, these counters will not be appropriate.

2. Equipment Vandalism.—Vandalism, theft, and tampering with counter equipment are serious concerns, especially in heavy-use areas near trailheads or parking areas. Because counter components are above ground, photoelectric counters are the most vulnerable to vandalism. Camouflaging the equipment may prevent detection. The plastic housing of the TrailMaster counters makes them the most susceptible to vandalism or animal damage; the long-term durability of these counters has not been assessed. Sensor pads are less susceptible to vandalism because they are buried, although the counter mechanism itself must be located so that the counter display can be read easily. The counter mechanism must therefore be camouflaged. Loop-type counters are completely buried and therefore are relatively free from the potential of damage. Avoid creating obvious trails to equipment placed off the trails. Visitors may follow these trails out of curiosity, but this traffic may increase the likelihood of tampering with equipment or disrupt normal traffic flow.

3. Environmental Influences on Accuracy.—Environmental factors influencing counter accuracy include habitat structure, weather, and wildlife. Structural factors include canopy density and substrate. For example, counts obtained from sensor pads may be overestimated by vibration generated by swaying trees or by other ground vibrations which are not related to visitor traffic; extremely deep or dense snow may diffuse foot traffic vibrations and bias counts upward. Count underestimates occur with photoelectric counters if the emitted beam misses the reflector, as occurs with excessive tree sway. Wildlife passing within the detection region of passive-infrared sensors may register a count. During rain events moisture on receivers and reflectors may affect count accuracy.

4. Equipment Cost.—Prices vary from approximately $300 to $500 for photoelectric and sensor pad counters to over $1,200 for loop-type counters. Expense is increased with the inclusion of various options, such as camera attachments. It is highly desirable that counters provide time and date stamping of count readings; this option facilitates calibration. See table 2 for details of equipment manufacturers, specifications, options, and associated costs.

5. Maintenance Requirements.—Visitation of each counter station should be performed regularly; schedules will depend on battery life, data storage capacity, potential for equipment failure or vandalism, and counter rotation schedules (determined before the monitoring program is in place; see below). Data must be downloaded before batteries begin to fail, or before storage capacity is exceeded. Battery life varies from 60 to 90 days for photoelectric counters to over 1 year for loop-type counters. Data storage capacity is usually much less than battery life. For example, memory capacity of loop-type counters is limited to 40 days of hourly time-stamped data; this type of

counter would have to be visited at least this often. Memory capacity of certain photoelectric counters may be count-limited rather than time-limited; for example, standard TrailMaster counters have a storage limit of approximately 1000 counts. For these counters, the time between data downloadings would depend on visitor traffic volume. Finally, the time order and intervals of counter rotation and calibration must be scheduled.

Step 3: Decide on the Number of Counters Needed

The number of counters to acquire will be determined by the number of access points to be monitored and the equipment budget. Ideally, mechanical counters should be acquired for every access point. In practice, funding limitations, the size of the wilderness area to be monitored, and relatively large numbers of potential access points mean that the number of available counters will be far fewer than the number required. In this case, counters must be rotated systematically (see step 5).

Step 4: Choose the Calibration Method

Calibration is the procedure for assessing the reliability of the counting device by comparing its output to some alternative method of known accuracy. Calibration is performed by recording the number of individuals or groups passing the mechanical counter during a specified observation period; simultaneous counter readouts are obtained for the same period.

The calibration method chosen depends on:

1. The relative amount of labor and resources required for implementation.
2. The type of bias that must be estimated.

Counter output may show either **overestimation bias** (the counter registers something it should not count), or **underestimation bias** (the counter does not count something it should). The calibration technique chosen should provide an accurate measure of one or both types of bias if possible.

The two methods of calibrating counters: with cameras, or with human observers.

1. Camera Calibration.—Cameras are installed at the traffic area where the counter is installed; to maximize the efficiency of the method, cameras should be set up in places where traffic will be visible for long distances. This method minimizes the amount of personnel involvement and both types of counter bias.

(a) Fixed-interval monitoring. All traffic during a sample period is photographed. The camera is activated at programmed time intervals; these intervals are selected by statistical sampling procedures.

(b) Counter-activated monitoring. The camera is attached to the counter itself, and takes photos only when the counter is activated by visitor traffic. *This technique provides a measure of overestimation bias only;* that is, it does not provide information on errors occurring because of visitors undetected by the counter. This strategy enables the investigator to verify group size, traffic direction, and so forth, for visitors who actually activate the camera; blank photos and wildlife photos enable estimates of false counts.

2. Observer Calibration.—Calibration by human observers is more labor intensive than camera calibration, but it is more accurate. Observers should

be stationed close enough to the counter so that all traffic activating the counter is observed; although observers need not be right on top of the counter, they should not wander up and down the trail.

For calibration purposes, the minimum information to be recorded by observers includes: number of individuals, number of groups, method of travel, direction of travel, and date and time of entry or exit. Additional information on visit or visitor characteristics may be obtained if desired; a sample observer recording sheet is shown in figure 1. However, it must be emphasized that observation is remote; *observers do not stop visitors*.

Step 5: Develop a Sampling Plan

Sampling plans must be developed for:

1. Systematic scheduling of counter rotation across trailheads (if the number of counters does not equal the number of access points), and
2. Calibration (if observers or cameras cannot provide for continuous calibration).

Step 6: Purchase Equipment

Table 2 gives information on counter manufacturers, equipment specifications and associated costs (1995 prices).

Step 7: Install Equipment

Specifics for site location were discussed in step 2. In general, counters should be placed some distance away from the trailhead so that only *bona fide* wilderness visitors are counted, and casual visitors (those who travel only an extremely short distance) are excluded. However, if the wilderness boundary is an extremely long distance from the trailhead, the increase in personnel time involved in traveling to the counter site for reading and calibrating counters may make this option untenable. We do not advise locating counters where the trail is unduly wide (thus allowing visitors to travel two or more abreast and underestimating counts), or at natural resting places (where they may mill around and cause multiple counts). Narrow portions of the trail at locations where traffic flow is more or less continuous offer the best count locations.

The time required for counter installation will vary according to distance from the trailhead and counter type. After arriving at the selected site, at least 1 hour will be required for counter installation. This includes time spent examining the site, selecting the best place for counter location, installing the sensor and the counting mechanism, setting counter sensitivity or delay, and testing counter operation. If a counter is mounted on a tree trunk (as is the case for photoelectric counters), the counter will likely shift slightly within the first day or two as a result of tree wounding; the counter should therefore be checked, and realigned if necessary, on the second day after initial installation. If cameras are used for calibration, additional time is required to address privacy concerns (the camera must be located far enough from the trail so that individuals cannot be identified in the pictures, camera adjusted to be slightly out of focus, and so forth).

After the equipment has been installed, observe conditions for a short time to make certain that the counter is functioning correctly and that any camouflage is not obscuring or tripping the counter continuously. Walk over the pad or through the beam several times to check counter sensitivity, and adjust accordingly.

All equipment should be labeled with agency identification, a statement of purpose, and the name, address, and telephone number of a designated contact person. A message explaining that the camera is for detecting use levels, and that individual identities cannot be determined, may reduce the risk of vandalism if visitors do locate the equipment.

Step 8: Collect Calibration Data

Calibration information is collected according to a specific sampling strategy (as described in step 5). The specifics of collecting calibration information will depend on whether cameras or human observers are used.

1. Camera Calibration.—Calibration observations are recorded with either motion picture (8-mm or VHS recorder) or a camera. If the camera is on a timer, photos, or a series of frames, can be obtained at fixed intervals; the camera can be attached to a mechanical counter and triggered to shoot by visitor traffic. Because camera detection could result in theft or vandalism of equipment; cameras must be positioned far enough from the trail so that visitors cannot hear the shutter or motor action; camera equipment should be well camouflaged. When performing routine visits, do not approach equipment over the same route every time; frequent travel could result in the development of a recognizable path and subsequent detection of equipment by unauthorized persons.

Film consumption should be monitored closely; calibration data will be useless if the camera runs out of film during this phase. After removing exposed film from the camera, label immediately with the date, time, and location. Protect exposed film from extreme heat and cold until developed.

Record necessary observations from the developed film; observations include number of individuals, number of groups, date and time of entry or exit. The method of recording observations should be standardized to minimize errors in recording. After observations are recorded, destroy negatives and developed photos to assure visitor privacy.

2. Observer Calibration.—The observer must be stationed somewhere near the counter where the trail is clearly visible. If trail traffic is low, observers may perform other tasks in the vicinity of the counter, such as trail clearance and maintenance, visitor education, or reading; these help pass the time and reduce observer fatigue and boredom. However, if the observer is stationed at some distance and by observing traffic through binoculars, it is not advisable to engage in other types of activity because of the potential for missing visitors if attention is diverted from the trail. Observers should be in appropriate uniform and possess necessary communication and safety equipment.

Observations must be recorded in a standardized format. For each data sheet the observer should record his or her name, the sampling location, the date, start time, the initial counter reading, end time, and the final counter reading for that sample period. During the sample period the observer records the number of individuals or groups passing the observation station, the time of the event, and the direction of travel. The observer must be provided with sufficient data forms for the observation period. Observers must understand the need to completely fill out the data form; sample observations will be useless if the data collected by the observer cannot be matched with the appropriate counter data. Observation sheets should be filed in a designated place after the observer returns to the office.

Step 9: Collect Counter Data

Counts logged by the mechanical counter are recorded at intervals determined by the sampling plan. If counters are permanently allocated to a given location, the frequency of recording will be determined by the calibration sampling plan. At a minimum, counts should be recorded at least twice per month to ensure that data are not lost because of equipment malfunction. The person obtaining count readings should check battery power and equipment operation, and for any changes in the surrounding area which may affect count accuracy. For example, fallen branches or trees could block the electronic beam from the scanner, or result in the rerouting of trail traffic away from the counter path.

Step 10: Estimate Use

Use data are collected in accordance with the desired sample size and the sampling strategy. Because mechanical counters are the sole method of data collection, use characteristics estimated with this system are limited to individual or group visit counts. Use data may be expressed as a rate (for example, number of visitors/day), or total (for example, number of visitors for the season). In general, totals are estimated by multiplying the average daily rate by the number of days in the time period of interest, corrected for possible bias in estimated counts. Data collected during the calibration phase may be used to provide estimates of the sample size required for the actual observation phase of the study.

Example. Visitor traffic in the Alpine Lakes Wilderness was studied in 1991. Measures of use were assessed at the primary trailhead access for Snow Lake—an easily accessed high-use trail with a high concentration of day users. The total length of the visitor season was 100 days.

1. Calibration.—The initial calibration period was 15 observation days. The paired data used to establish the calibration relationship were as follows:

Day	Mechanical counts (X)	Visitors observed (Y)
Friday	132	119
Saturday	514	408
Sunday	604	556
Wednesday	107	119
Thursday	74	74
Friday	107	113
Saturday	423	424
Sunday	438	323
Friday	92	78
Saturday	370	380
Sunday	406	356
Wednesday	127	98
Thursday	80	87
Saturday	325	252
Sunday	400	361

The summary statistics for these data are as follows: n = 15, ΣX = 4,199, ΣX^2 = 1,643,937, ΣY = 3,748, ΣY^2 = 1,294,490, ΣXY = 1,450,388, $\bar{X}$ = 280, $\bar{Y}$ = 250. If no mechanical counters were used or if their data is ignored, the observed data could be used to compute an estimate of total use. The mean of the 15 observed values is 250 with a standard error of 41, making the 95 percent confidence interval 250 ± 2·41 = (167, 332). If the data is stratified by weekends and weekdays, the estimated means and confidence intervals are 382 (320, 445) and 98 (84, 113), respectively. Since there were 72 weekdays and 28 weekend days in the 100 day season, these individual estimators are combined as weighted averages to make overall estimators of 17,786 (15,755, 19,817). Differences from the overall (unstratified) estimator above may be due to an over representation of weekend days in the sample.

The mechanical counter data may be used to increase precision by estimating a regression relationship (see appendix): $Y = 10.15 + 0.86 \cdot X$. The standard error of the regression equation ($\sqrt{MSE}$) is 33.31. The R^2 value is high (0.96), suggesting that a straight line is a good approximation of the relationship between the two variables. However, examination of the data plot (fig. 5) shows that there are two distinct subgroups in the data. These subgroups correspond to the day of the week on which observations were obtained; weekends had substantially higher counts than weekdays. This suggests that the sampling plan for the observation phase should incorporate stratification by time periods.

Because the regression slope is less than 1, the actual number of visitors will be overestimated by the mechanical counter data. A crude estimate of the

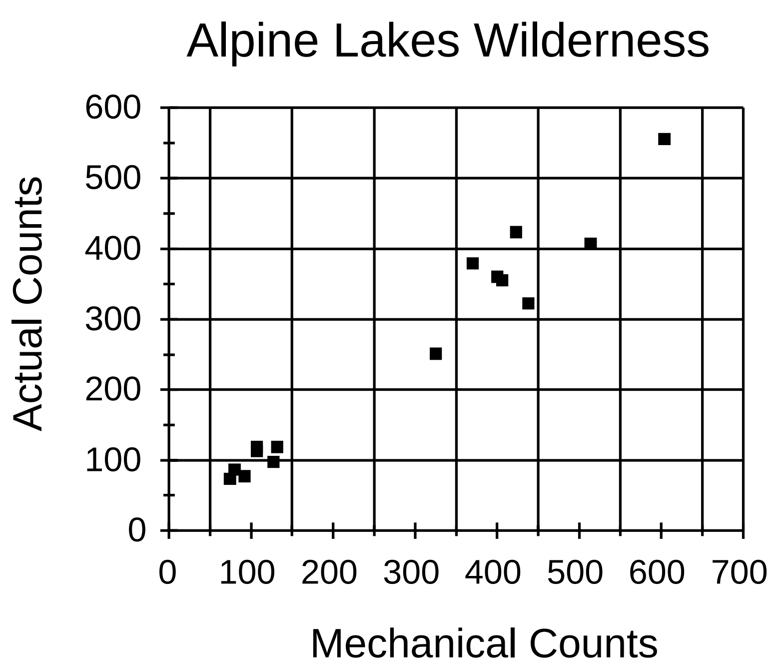


Figure 5—Plot of visitor counts derived from a mechanical counter in comparison to those obtained from human observers (Alpine Lakes Wilderness, 1991).

amount of bias is given by the ratio estimator $r = \frac{\overline{Y}}{\overline{X}}$ = 250/280 = 0.89; that is, 89 percent of counts registered by the mechanical counter could be attributed to visitor traffic, with the remaining 11 percent due to other causes. If visitor totals are estimated for relatively long time periods, there may be a substantial amount of accumulated error in the results. Standard errors and confidence intervals for ratio estimators are not generally recommended and are beyond the scope of this handbook.

2. Sample Size Estimation.—Because count data are collected by mechanical counters, large sample sizes for counts are relatively easy to obtain. However, observation data are time-intensive and expensive to collect and process; logistically feasible sample sizes should reflect reasonable operational costs associated with equipment and personnel.

(a) Count data. The relation used to estimate sample size is:

$$n \cong \left[4 \cdot \frac{S}{L}\right]^2$$

If the sampled population is small, the finite population correction (fpc) is used to correct for overestimation bias. Using the fpc, the estimated sample size is:

$$n \cong \frac{N \cdot S^2}{S^2 + \frac{L^2 \cdot N}{4(2)^2}}$$

where L is the width of the interval around the projected average, and N is the size of the true population. In this case, N is the number of days in the season. Precision is estimated by the confidence level (generally 95 percent) and the desired width of L. For example, the investigator may wish to be 95 percent certain that the results have a precision of ± 5 percent of the total. Operationally feasible sample sizes are obtained by varying the amount of precision of the estimate; highly precise estimates may require sample sizes that are too large for practical purposes.

Example. The average number of visitors observed per day during the calibration phase was 250, with $S = 160$. There are 100 days in the season (N). Suppose we want to be 95 percent certain that results will have a precision of ± 5 percent, or ± 13 visitors/day. The estimated number of sampling days is $\approx \frac{100(160)^2}{(160)^2 + \frac{(13+13)^2(100)}{16}}$ = 86. If the precision is adjusted to ± 10 percent (or ± 25 visitors per day), then $n = 62$. Both of these are too large or too close to the entire season of 100 days to be of practical use due to the large underlying variance. A more reasonable level of precision would be ± 30 percent (or ± 75 visitors per day), which would call for a sample size of $n = 15$ as in the example above.

(b) Proportion data. Sample size (n) will be at a maximum when the proportion of observations (p) in any given category is 0.5 (or 50 percent). The sample size required to estimate an interval of width L around the sample mean will be:

$$n = \frac{4 \cdot (2)^2 \cdot p(1-p)}{L^2}$$

which is maximized for $p = 0.5$ or $n = 16(0.5)(0.5)/L^2$.

Example. Preliminary data showed that for 40 randomly selected visitors, 24 appeared to be day users. Therefore, the proportion of day users,

$$p = 24/40 = 0.60$$

and the standard error is $\sqrt{p(1-p)/n} = \sqrt{(0.60)(0.40)/40} = 0.0775$.

The 95 percent confidence interval based on these data is approximately 0.6 ± 2(0.0775) = 0.6 ± 0.15, for a confidence interval of (0.45, 0.75). The sample size n required for a 95 percent confidence interval with a length of at most 0.10 (regardless of the resulting value of p) is approximately $n = \frac{16(0.5)^2}{(0.10)^2} = 400$. Therefore, it would be necessary to observe 400 visitors to obtain this amount of precision for the estimate.

(c) Stratified sampling. If the data are stratified according to trailhead or time block, sample sizes of each stratum must be calculated to ensure accurate representation of the population. Sample sizes may be either proportional or disproportional to stratum size (part I, chapter 3). Proportional sampling subdivides the sample population proportional to the size of each strata or subgroup. Optimal allocation is a type of stratified sampling where the sample size within each strata is proportional to both the size and the variability of the sample within each stratum; the proportionality factor is calculated as $[N_i \cdot S_i / \sum(N_i \cdot S_i)] \cdot n$. Disproportional sampling occurs when the same size sample is drawn for each stratum (assuming equal costs to sample each strata).

Proportional sampling should be performed if strata are fairly homogeneous (that is, the standard deviations observed for each stratum are similar), whereas optimal allocation should be chosen if strata differ in the amount of variability.

Example. In this example, data are stratified by two time blocks—weekend days and weekdays. This stratification strategy separates out time periods according to relative intensity of use, with the heaviest and most variable use occurring on weekends, and relatively light and uniform use on weekdays. For a 100-day season, there are about 72 weekdays and 28 weekend days. Suppose the available resources (budget, labor, time) dictated that the maximum number of days that could be sampled was $n = 25$. The initial value for the standard deviation for each stratum was estimated from the data obtained during calibration. Sample sizes for each time block are calculated as follows:

		Proportional		**Disproportional**		**Optimal allocation**	
Stratum	***s*[a]**	***f*[b]**	***n*[c]**	***f***	***n***	***f***	***n***
Weekends ($N_1 = 28$)	88.0	0.25	7	0.43	12	0.64	16
Weekdays ($N_2 = 72$)	19.2	0.25	18	0.17	12	0.36	9

[a]Standard deviation.
[b]Sampling proportion.
[c]Sample size.

Because the two strata differ considerably in variability, the preferred sampling scheme is optimal allocation; with this strategy the investigator randomly selects 16 weekend days and 9 weekdays for data collection.

(3) Use Estimation.—Use characteristics estimated with this system are limited to individual or group visit counts. Data may be expressed in terms of: (a) the rate (for example, number of visitors per day), or (b) the total (for example, number of visitors for the season).

(a) Rate of use. In this example the observation period was 15 days; the counter registered a total of 4,199 counts, averaging 280 counts per day. The calibration or regression line is used to "correct" for counter bias by using it to estimate the "actual" value as follows:

$$Y = 10.15 + 0.86 \cdot (280) = 250 \text{ visitors per day.}$$

The 95 percent confidence limits are estimated as:

$$250 \pm 2(33.31)\sqrt{\frac{1}{15} + \frac{(280-280)^2}{(1,643,937) - 4,199^2/15}} = 250 \pm 17, \text{ or between 233 and}$$

267 visitors per day.

Accuracy may sometimes be increased if regressions are calculated within each stratum rather than pooled over the entire observation period. In this example, over 80 percent of all counts registered occurred on weekends; there were 3,480 counts for the 8 weekend days monitored (averaging 435 counts per day) and 719 counts for the 7 weekdays (averaging 103 counts per day). The resulting regression estimates for each strata are as follows:

Weekend: $Y = 1.71 + 0.875 \cdot (435) = 382$ visitors per day, with 95 percent confidence limits 382 ± 94, or between 288 and 476 visitors per day.

Weekday: $Y = 31.1 + 0.654 \cdot (103) = 98$ visitors per day, with 95 percent confidence limits 98 ± 27, or between 72 and 125 visitors per day.

These estimators may be combined to get a "corrected" average daily total by forming a weighted average of the individual estimates. Since there were 72 weekdays and 28 weekend days during the 100 day season, these two estimates can be combined with weights of 72/100 and 28/100 to make an overall estimate of visitors over the entire season. This overall estimator is $(72/100) \cdot 98 + (28/100) \cdot 382 = 178$. A confidence interval for the average daily use would be formed similarly as a weighted average of the lower and upper confidence limits of the weekend and weekday usage rates of (132, 224).

In this example the small sample sizes and greater variability within strata make the confidence interval for the stratified estimator much wider than the unstratified estimator. The moral is that stratification may not always result in narrower confidence intervals, but it will give more specific information about individual strata that may be very useful.

(b) Total use. Total visitor use is estimated by multiplying the "corrected" average daily rate by the number of days in the time period of interest, corrected by the estimated bias in counts. *The assumption implicit in this method is that use remains uniform over the time period of interest; if use patterns fluctuate considerably over the season, calibration relationships should be updated as required, and the new relationship used to calculate use rates for that time interval.*

In this example, season length was 100 days. The overall visitor use estimate is therefore 250 (100) = 25,000 visitors (23,300 to 26,700 visitors). Using the stratified regression estimators, the total count estimates are 17,800 with a confidence interval of (13,200, 22,400).

System B: Mechanical Counters With Observer Calibration and Sample Observations

System Description

This system provides information on both visit counts and simple observable visit and visitor characteristics. Observable characteristics are those which can be directly observed and need not be determined by contacting visitors; these include group size, number of stock, method of travel, gender, approximate age, time of entry or exit, and whether a user appears to be a day user or an overnight camper. Mechanical counters are set up to count trail traffic. Monitoring by either human observers or cameras is used to assess the reliability of counter data (**calibration**) and obtain information on simple observable characteristics. Because there is no visitor contact, there is no visitor burden.

Summary of System B:

Type of observations:	Counts Observable characteristics
Measures of visitor use:	Number of individual visits Number of group visits Use by categories of user
Data collection strategies:	Sample plan for counter rotation (if applicable) • spatial • temporal Sample plan for calibration Sample plan for observations
Techniques/procedures:	Mechanical counters Visual observations (cameras, human observers)
Visitor burden:	None

Operational Procedures

Step 1: Decide on Use Characteristics

Direct measures of use include individual or group visit counts; mechanical counters are used to collect count data, and count accuracy is assessed by calibration with remote observation of actual traffic. However, additional visit and visitor characteristics are acquired during the calibration process. These data are simple observable characteristics which are recorded without visitor contact; these include group size, number of stock, method of travel, gender, approximate age, time of entry or exit, and whether a user appears to be a day user or an overnight camper. Information on user characteristics is used to categorize count data.

Step 2: Decide on Counter Type

There are three main types of counter currently available: photoelectric counters, sensor pad counters, and loop-type sensor counters. Counter selection depends on installation site, vandalism concerns, potential environmental influences on counter accuracy, equipment cost, and maintenance requirements.

1. Installation Site.—Characteristics of the proposed installation site will determine the type of counter that is most appropriate. Site characteristics to be evaluated include the presence or absence of tree cover, soil type, and slope. Photoelectric counters must be attached on a vertical surface so that the sensor and the reflector are opposite each other and located at a distance of 100 feet or less. If counter components are attached to trees, each tree must be large enough to prevent excessive swaying. If there are no suitable trees at the proposed site, posts may be installed if the soil allows digging; however, posts should be concealed in brush to avoid vandalism. Soil type and depth are important if sensor pads and loop-type counters are considered, as these sensors should be buried to be operative. If digging is difficult, or the proposed monitoring site is located on a steep or unstable surface, or both, these counters will not be appropriate.

2. Equipment Vandalism.—Vandalism, theft, and tampering with counter equipment are serious concerns, especially in heavy-use areas near trailheads or parking areas. Because counter components are above ground, photoelectric counters are the most vulnerable to vandalism. Camouflaging the equipment may prevent detection. The plastic housing of the TrailMaster counters makes them the most susceptible to vandalism or animal damage; the long-term durability of these counters has not been assessed. Sensor pads are less susceptible to vandalism because they are buried, although the counter mechanism itself must be located so that the counter display can be read. The counter mechanism must therefore be camouflaged. Loop-type counters are completely buried and therefore are relatively free from the potential of damage. Avoid creating obvious trails to equipment placed off the trails. Visitors may follow these trails out of curiosity, but this traffic may increase the likelihood of tampering with equipment or disrupt normal traffic flow.

3. Environmental Influences on Accuracy.—Environmental factors influencing counter accuracy include habitat structure, weather, and wildlife. Structural factors include canopy density and substrate. For example, counts obtained from sensor pads may be overestimated by vibration generated by swaying trees or by other ground vibrations which are not related to visitor traffic; extremely deep or dense snow may diffuse foot traffic vibrations and bias counts upward. Count underestimates occur with photoelectric counters if the emitted beam misses the reflector, as occurs with excessive tree sway. Wildlife passing within the detection region of passive-infrared sensors may register a count. During rain events moisture on receivers and reflectors may affect count accuracy.

4. Equipment Cost.—Prices vary from approximately $300 to $500 for photoelectric and sensor pad counters to over $1,200 for loop-type counters. Expense is increased with the inclusion of various options, such as camera

attachments. It is highly desirable that counters provide time and date stamping of count readings; this option facilitates calibration. See table 2 for details of equipment manufacturers, specifications, options, and associated costs.

5. Maintenance Requirements.—Visitation of each counter station should be performed regularly; schedules will depend on battery life, data storage capacity, potential for equipment failure or vandalism, and counter rotation schedules (determined before the monitoring program is in place; see below). Data must be downloaded before batteries begin to fail, or before storage capacity is exceeded. Battery life varies from 60 to 90 days for photoelectric counters to over 1 year for loop-type counters. Data storage capacity is usually much less than battery life. For example, memory capacity of loop-type counters is limited to 40 days of hourly time-stamped data; this type of counter would have to be visited at least this often. Memory capacity of certain photoelectric counters may be count-limited rather than time-limited; for example, TrailMaster counters have a storage limit of approximately 1,000 counts. For these counters, the time between data downloadings would depend on visitor traffic volume. Finally, counter rotation or calibration schedules must be considered.

Step 3: Decide on the Number of Counters Needed

The number of counters to acquire will be determined by the number of access points to be monitored and the equipment budget. Ideally, counters should be acquired for every access point. In practice, funding limitations, the size of the wilderness area to be monitored, and relatively large numbers of potential access points mean that the number of available counters will be far fewer than the number required. In this case, counters must be rotated systematically (see step 5).

Step 4: Choose the Calibration Method

The calibration method chosen depends on the relative amount of labor and resources required for implementation, and the type of bias that must be estimated.

Counter output may show either **overestimation bias** (the counter registers something it should not count), or **underestimation bias** (the counter does not count something it should); the calibration technique chosen should provide an accurate measure of one or both types of bias if possible.

The two methods of calibrating counters are with cameras, and with human observers.

1. Camera Calibration.—Strategies of camera setup will be dictated by the relative
importance to the manager of the competing goals of labor allocation and minimization of bias.

(a) Fixed-interval monitoring. All traffic during a sample period is photographed. The camera is activated at programmed time intervals; these intervals are selected by statistical sampling procedures (part I, chapter 3). Cameras are installed at the traffic area where the counter is installed; to maximize the efficiency of the method, cameras should be set up in places where traffic will be visible for long distances. This method minimizes the amount of personnel involvement and both types of counter bias.

(b) Counter-activated monitoring. The camera is attached to the counter itself, and takes photos only when the counter is activated by visitor traffic. *This technique provides a measure of overestimation bias only;* it verifies group size, traffic direction, and so forth, for visitors which actually activate the camera, and blank photos and wildlife photos enable estimates of false counts. This method does not provide information on errors occurring because of visitors undetected by the counter.

2. Observer Calibration.—Calibration by human observers is more labor intensive than camera calibration, but it is more accurate. Observers should be stationed close enough to the counter so that all traffic activating the counter is observed; although observers need not be right on top of the counter, they should not wander up and down the trail.

For calibration purposes, the minimum information to be recorded by observers includes: number of individuals, number of groups, method of travel, direction of travel, and date and time of entry or exit. Additional information on observable visit or visitor characteristics (for example, group size, number of stock, gender, approximate age, time of entry or exit, and whether a user appears to be a day user or an overnight camper) are recorded at this time; a sample observer recording sheet is shown in figure 1. Some information (such as gender and age categories) may not be easily determined from observations. However, it must be emphasized that observation is remote; *observers do not stop visitors*.

Step 5: Develop a Sampling Plan

Sampling plans must be developed for:

1. scheduling counter rotation across trailheads on a systematic basis (if the number of counters does not equal the number of access points).
2. calibration (if observers or cameras cannot provide for continuous calibration).

Step 6: Purchase Equipment

Table 2 gives information on counter manufacturers, equipment specifications, and associated costs (1995 prices).

Step 7: Install Equipment

Specifics for site location were discussed in step 2. In general, counters should be placed some distance away from the trailhead so that only *bona fide* wilderness visitors are counted, and casual visitors (those who travel only an extremely short distance) are excluded. However, if the wilderness boundary is an extremely long distance from the trailhead, the increase in personnel time involved in traveling to the counter site for reading and calibrating counters may make this option untenable. We do not advise locating counters where the trail is unduly wide (thus allowing visitors to travel two or more abreast and underestimating counts), or at natural resting places (where they may mill around and cause multiple counts). Narrow portions of the trail at locations where traffic flow is more or less continuous offer the best count locations.

The time required for counter installation will vary according to distance from the trailhead and counter type. After arriving at the selected site, at least 1 hour will be required for counter installation. This includes time spent examining the site, selecting the best place for counter location, installing the sensor and the counting mechanism, setting counter sensitivity or delay, and testing counter operation. If a counter is mounted on a tree trunk (as is the case for photoelectric counters), the counter will likely shift slightly within the first day or two as a result of tree wounding; the counter should therefore be checked, and realigned if necessary, on the second day after initial installation. If cameras are used for calibration, additional time is required to address privacy concerns (the camera must be located far enough from the trail so that individuals cannot be identified in the pictures, camera adjusted to be slightly out of focus, and so forth).

After the equipment has been installed, observe conditions for a short time to make certain that the counter is functioning correctly and that any camouflage is not obscuring or tripping the counter continuously. Walk over the pad or through the beam several times to check counter sensitivity, and adjust accordingly.

All equipment should be labeled with agency identification, a statement of purpose, and the name, address, and telephone number of a designated contact person. A message explaining that the camera is for detecting use levels, and that individual identities cannot be determined, may reduce the risk of vandalism if visitors do locate the equipment.

Step 8: Collect Calibration Data

Calibration information is collected according to a specific plan (as described in step 5). The specifics of collecting calibration information will depend on whether cameras or human observers are used.

1. Camera Calibration.—Calibration observations are recorded with either motion picture (8-mm or VHS recorder) or a camera. If the camera is on a timer, photos, or a series of frames, can be obtained at fixed intervals; the camera can be attached to a mechanical counter and triggered to shoot by visitor traffic. Because camera detection could result in theft or vandalism of equipment; cameras must be positioned far enough from the trail so that visitors cannot hear the shutter or motor action; camera equipment should be well camouflaged. When performing routine visits, do not approach equipment over the same route every time; frequent travel could result in the development of a recognizable path and subsequent detection of equipment by unauthorized persons.

Film consumption should be monitored closely; calibration data will be useless if the camera runs out of film during this phase. After removing exposed film from the camera, label immediately with the date, time, and location. Protect exposed film from extreme heat and cold until developed.

Record necessary observations from the developed film. Observations must be recorded in a standardized format to minimize errors in recording. Observations include location, date, number of individuals, number of groups, date and time of entry or exit. Observers must understand the need to completely and correctly fill out the data form; sample observations will be useless if the data collected by the observer cannot be matched with the appropriate counter data. Observation sheets should be filed in a designated place. After observations are recorded, destroy negatives and developed photos to ensure visitor privacy.

2. Observer Calibration.—It is essential that personnel are thoroughly trained in the data collection procedures. Training ensures that observers

are already familiar with the research directives and the data collection process before actual fieldwork begins. As a result, errors involved in the learning process are reduced, and there will be greater consistency in identifying the sampling units and recording responses. Training enables observers to become familiar with various contingency plans, to identify potential problems in the research directives, and to make decisions if problems occur.

Preliminary, or pretest, fieldwork should be conducted before the actual survey begins. These rehearsals ensure that personnel understand procedures, and serve as a test for the efficiency of the methods; problems or inadequacies in the procedures can be identified, and the consistency and accuracy of personnel can be observed and analyzed.

Observers should be screened at intervals and their performance compared either with each other or at different time points for the same observer; screening provides a check on performance and identifies sources of error in the data.

The observer must be stationed somewhere near the counter where the trail is clearly visible. If trail traffic is low, observers may perform other tasks in the vicinity of the counter, such as trail clearance and maintenance, visitor education, or reading; these help pass the time and reduce observer fatigue and boredom. However, if the observer is stationed at some distance and is observing traffic through binoculars, it is not advisable to engage in other types of activity because of the potential for missing visitors if attention is diverted from the trail. Observers should be in appropriate uniform and possess necessary communication and safety equipment.

Observations must be recorded in a standardized format. For each data sheet the observer should record his or her name, the sampling location, the date, start time, the initial counter reading, end time, and the final counter reading for that sample period. During the sample period the observer records the number of individuals or groups, the time visitors pass the observation station, and the direction of travel. The observer must be provided with sufficient data forms for the observation period. Observers must understand the need to completely and correctly fill out the data form; sample observations will be useless if the data collected by the observer cannot be matched with the appropriate counter data. Observation sheets should be filed in a designated place after the observer returns to the office.

Step 9: Collect Count Data

Counts logged by the mechanical counter are recorded at intervals determined by the sampling plan. If counters are permanently allocated to a given location, the frequency of recording will be determined by the calibration sampling plan. At a minimum, counts should be recorded at least twice per month to ensure that data are not lost because of equipment malfunction. The person obtaining count readings should check battery power and equipment operation, and for any changes in the surrounding area which may affect count accuracy. For example, fallen branches or trees could block the electronic beam from the scanner, or result in the rerouting of trail traffic away from the counter path.

Step 10: Estimate Use

Use data are collected in accordance with the desired sample size and the sampling strategy. Because data from mechanical counters are supplemented with direct observations, use can be estimated for observable categories of visitors, in addition to information on individual or group visit counts. Use data may be expressed as a rate (for example, number of visitors per day), or total (for example, number of visitors for the season). In general, totals are estimated by multiplying the "corrected" average daily rate by the number of days in the time period of interest. If observations can be classified into two or more observable categories, the number in each category can be expressed as a proportion or percentage of the total number of users. However, if sample sizes are very small, proportion data are useless for evaluation purposes. Data collected during the calibration phase may be used to provide estimates of the sample size required for the actual observation phase of the study.

Example. Visitor traffic in the Alpine Lakes Wilderness was studied in 1991. Measures of use were assessed at the primary trailhead access for Snow Lake—an easily accessed, high-use trail with a high concentration of day users. The total length of the visitor season was 100 days.

1. Calibration.—The initial calibration period was 15 observation days. The paired data used to establish the calibration relationship were as follows:

Day	Mechanical counts (X)	Visitors observed (Y)
Friday	132	119
Saturday	514	408
Sunday	604	556
Wednesday	107	119
Thursday	74	74
Friday	107	113
Saturday	423	424
Sunday	438	323
Friday	92	78
Saturday	370	380
Sunday	406	356
Wednesday	127	98
Thursday	80	87
Saturday	325	252
Sunday	400	361

The summary statistics for these data are as follows: $n = 15$, $\Sigma X = 4{,}199$, $\Sigma X^2 = 1{,}643{,}937$, $\Sigma Y = 3{,}748$, $\Sigma Y^2 = 1{,}294{,}490$, $\Sigma XY = 1{,}450{,}388$, $\overline{X} = 280$, $\overline{Y} = 250$.

If no mechanical counters were used or if their data is ignored, the observed data could be used to compute an estimate of total use. The mean of the 15 observed values is 250 with a standard error of 41, making the 95 percent confidence interval $250 \pm 2 \cdot 41 = (167, 332)$. If the data is stratified by weekends and weekdays, the estimated means and confidence intervals are 382 (320, 445) and 98 (84, 113), respectively. Since there were 72 weekdays and 28 weekend days in the 100 day season, these individual estimators are combined as weighted averages to make overall estimators of 17,786 (15,755, 19,817). Differences from the overall (unstratified) estimator above may be due to an over representation of weekend days in the sample.

The mechanical counter data may be used to increase precision by estimating a regression relationship: $Y = 10.15 + 0.86 \cdot X$ ($\sqrt{MSE} = 33.31$). The R^2 value is high (0.96), suggesting that a straight line is a good approximation of the relationship between the two variables. However, examination of the data plot (fig. 5) shows that there are two distinct subgroups in the data. These subgroups correspond to the day of the week on which observations were obtained; weekends had substantially higher counts than weekdays. This suggests that the sampling plan for the observation phase should incorporate stratification by time periods.

Because the regression slope is less than 1, the actual number of visitors will be overestimated by mechanical counter data. A crude estimate of the amount of bias is given by the ratio estimator $r = \frac{\overline{Y}}{\overline{X}}$ = 250/280 = 0.89; that is, 89 percent of counts registered by the mechanical counter could be attributed to visitor traffic, with the remaining 11 percent due to other causes. If visitor totals are estimated for relatively long time periods, there may be a substantial amount of accumulated error in the results. Standard errors and confidence intervals for ratio estimators are not generally recommended and are beyond the scope of this handbook.

2. Sample Size Estimation.—Because count data are collected by mechanical counters, large sample sizes for counts are relatively easy to obtain. However, observation data are time-intensive and expensive to collect and process; logistically feasible sample sizes should reflect reasonable operational costs associated with equipment and personnel.

(a) Count data. The relation used to estimate sample size is:

$$n \cong \left[4 \cdot \frac{S}{L}\right]^2$$

If the sampled population is small, the finite population correction (fpc) is used to correct for overestimation bias. Using the fpc, the estimated sample size is:

$$n \cong \frac{N \cdot S^2}{S^2 + \frac{L^2 \cdot N}{4(2)^2}}$$

where L is the width of the interval around the projected average, and N is the size of the true population. In this case, N is the number of days in the season. Precision is estimated by the confidence level (generally 95 percent) and the desired width of L. For example, the investigator may wish to be 95 percent certain that the results have a precision of ± 5 percent of the total. Operationally feasible sample sizes are obtained by varying the amount of precision of the estimate; highly precise estimates may require sample sizes that are too large for practical purposes.

Example. The average number of visitors observed per day during the calibration phase was 250, with S = 160. There are 100 days in the season (N = 100). Suppose we want to be 95 percent certain that the results will have a precision of ± 5 percent, or ± 13 visitors/day. The estimated number of sampling days is $\approx \dfrac{100(160)^2}{(160)^2 + \dfrac{(13+13)^2(100)}{16}} = 86$. If the precision is adjusted to ± 10 percent (or ± 25 visitors per day), then $n = 62$. Both of these are too large or too close to the entire season of 100 days to be of practical use due to the large underlying variance. A more reasonable level of precision would be ± 30 percent (or ± 75 visitors per day), which would call for a sample size of $n = 15$ as in the example above.

(b) Proportion data. Sample size (n) will be at a maximum when the proportion of observations (p) in any given category is 0.5 (or 50 percent). The sample size required to estimate an interval of width L around the sample mean will be:

$$n = \frac{4 \cdot (2)^2 \cdot p(1-p)}{L^2}$$

which is maximized for $p = 0.5$ or $n = 16(0.5)(0.5)/L^2$.

Example. Preliminary data showed that for 40 randomly selected visitors, 24 appeared to be day users. Therefore the proportion of day users, $p = 24/40 = 0.60$, and the standard error is $\sqrt{p(1-p)/n} = \sqrt{(0.60)(0.40)/40} = 0.0775$. The 95 percent confidence interval based on these data is approximately 0.6 ± 2(0.0775) = 0.6 ± 0.15, for a confidence interval of (0.45, 0.75). The sample size n required for a 95 percent confidence interval with a length of at most 0.10 (regardless of the resulting value of p) is approximately $n = \dfrac{16(0.5)^2}{(0.10)^2} = 400$. Therefore, it would be necessary to observe 400 visitors to obtain this amount of precision for the estimate.

(c) Stratified sampling. If the data are stratified according to trailhead or time block, sample sizes of each stratum must be calculated to ensure accurate representation of the population. Sample sizes may be either proportional or disproportional to stratum size (part I, chapter 3). Proportional sampling subdivides the sample population proportional to the size of each strata or subgroup. Optimal allocation is a type of stratified sampling where the sample size within each strata is proportional to both the size and the variability of the sample within each stratum; the proportionality factor is calculated as $\left[N_i \cdot S_i / \sum (N_i \cdot S_i)\right] \cdot n$. Disproportional sampling occurs when the same size sample is drawn for each stratum (assuming equal costs to sample each strata).

Proportional sampling should be performed if strata are fairly homogeneous (that is, the standard deviations observed for each stratum are similar), whereas optimal allocation should be chosen if strata differ in the amount of variability.

Example. In this example, data are stratified by two time blocks—weekend days and weekdays. This stratification strategy separates out time periods according to relative intensity of use, with the heaviest and most variable use occurring on weekends, and relatively light and uniform use on weekdays. For a 100-day season, there are about 72 weekdays and 28 weekend days. Suppose the available resources (budget, labor, time) dictated that the maximum number of days that could be sampled was n = 25. The initial value for the standard deviation for each stratum was estimated from the data obtained during calibration. Sample sizes for each time block are calculated as follows:

		Proportional		Disproportional		Optimal allocation	
Stratum	s[a]	f[b]	n[c]	f	n	f	n
Weekends (N_1 = 28)	88.0	0.25	7	0.43	12	0.64	16
Weekdays (N_2 = 72)	19.2	0.25	18	0.17	12	0.36	9

[a]Standard deviation.
[b]Sampling proportion.
[c]Sample size.

Because the two strata differ considerably in variability, the preferred sampling scheme is optimal allocation; with this strategy the investigator randomly selects 16 weekend days and 9 weekdays for data collection.

3. Use Estimation.—Use characteristics estimated with this system are limited to individual or group visit counts. Data may be expressed in terms of: (a) the rate (for example, number of visitors per day), (b) the total (for example, number of visitors for the season), or (c) use by category (for example, method of travel).

(a) Rate of use. In this example the observation period was 15 days; the counter registered a total of 4,199 counts, averaging 280 counts per day. The calibration or regression line is used to "correct" for counter bias by using it to estimate the "actual" value as:

$$Y = 10.15 + 0.86 \cdot (280) = 250 \text{ visitors per day.}$$

The 95 percent confidence limits are estimated as:

$$250 \pm 2(33.31) \sqrt{\frac{1}{15} + \frac{(280-280)^2}{(1{,}643{,}937) - 4{,}199^2/15}} = 250 \pm 17, \text{ or between 233 and}$$

267 visitors per day.

Accuracy may sometimes be increased if regressions are calculated within each stratum rather than pooled over the entire observation period. In this example, over 80 percent of all counts registered occurred on weekends; there were 3,480 counts for the 8 weekend days monitored (averaging 435 counts per day) and 719 counts for the 7 weekdays (averaging 103 counts per day). The resulting regression estimates for each strata are:

Weekend: Y = 1.71 + 0.875·(435) = 382 visitors per day, with 95 percent confidence limits 382 ± 94, or between 288 and 476 visitors per day.
Weekday: Y = 31.1+ 0.654·(103) = 98 visitors per day, with 95 percent confidence limits 98 ± 27, or between 72 and 125 visitors per day.

These estimators may be combined to get a "corrected" average daily total by forming a weighted average of the individual estimates. Since there were 72 weekdays and 28 weekend days during the 100 day season, these two estimates can be combined with weights of 72/100 and 28/100 to make an overall estimate of visitors over the entire season. This overall estimator is (72/100)·98 + (28/100)·382 = 178. A confidence interval for the average daily use would be formed similarly as a weighted average of the lower and upper confidence limits of the weekend and weekday usage rates of (132, 224).

In this example the small sample sizes and greater variability within strata make the confidence interval for the stratified estimator much wider than the unstratified estimator. The moral is that stratification may not always result in narrower confidence intervals, but it will give more specific information about individual strata that may be very useful.

(b) Total use. Total visitor use is estimated by multiplying the "corrected" average daily rate by the number of days in the time period of interest, corrected by the estimated bias in counts. *The assumption implicit in this method is that use remains uniform over the time period of interest; if use patterns fluctuate considerably over the season, calibration relationships should be updated as required, and the new relationship used to calculate use rates for that time interval.*

In this example, season length was 100 days. The overall visitor use estimate is therefore 250(100) = 25,000 visitors (23,300 to 26,700 visitors). Using the stratified regression estimators, the total count estimates are 17,800 with a confidence interval of (13,200, 22,400).

(c) Use by category. Frequently, visitor use is described in terms of categories, or groups, of users; the number of users in each category is expressed as a proportion, or percentage, of the total number of users observed in the sample.

Example. Sample observations of method of travel (the observable visit characteristic of interest) were made for 2,975 wilderness users. Three travel categories were reported: hikers, horse users, and mountain bikers. Results with a 95 percent confidence interval (using χ^2 procedure based on 2 degrees of freedom) were:

Hikers: n_1 = 2,231, p_1 = 2,231/2,975 = 0.75,

95% confidence interval = $0.75 \pm \sqrt{5.99[(0.75)(0.25)/2{,}975]} = 0.75 \pm 0.019 =$ (0.731 to 0.769);

Horse users: n_2 = 595, p_2 = 595/2,975 = 0.20,

95% confidence interval = $0.20 \pm \sqrt{5.99[(0.20)(0.80)/2{,}975]} = 0.20 \pm 0.018 =$ (0.18 to 0.22);

Mountain bikers: n_3 = 149, p_3 = 149/2,975 = 0.05,

95% confidence interval = $0.05 \pm \sqrt{5.99[(0.05)(0.95)/2{,}975]} = 0.05 \pm 0.009 =$ (0.04 to 0.06).

System C: Mechanical Counters With Observer Calibration and Sample Interviews

System Description

This system provides information on visit counts, observable characteristics, and simple nonobservable characteristics. Whereas observable characteristics can be determined by observation, nonobservable characteristics must be determined only by direct visitor contact and interviews. Simple nonobservable characteristics include length of stay, travel routes, and sociodemographic information. This is the only system based on mechanical counters that can generate aggregate, or summary-use, statistics. Mechanical counters are set up to count trail traffic. Monitoring by human observers is used to assess the reliability of counter data (**calibration**) and obtain information on both observable and nonobservable characteristics. Because there is limited visitor contact, visitor burden is low to moderate.

Summary of System C:

Type of observations:	Counts Observable characteristics Simple nonobservable characteristics
Measures of visitor use:	Number of individual visits Number of group visits Use by categories of user Summary use statistics
Data collection strategies:	Sampling plan for counter rotation (if applicable) • spatial • temporal Sample plan for visual calibration Sample plan for interviews
Techniques/procedures:	Mechanical counters Visual observations (human observers only) Interviews
Visitor burden:	Moderate

Operational Procedures

Step 1: Decide on Use Characteristics to Measure

Mechanical counters are used to collect visitor count data; count accuracy is assessed by calibration with data obtained from human observers. Nonobservable visit and visitor characteristics are acquired during the calibration process; these data are obtained by interviewing a random selection of visitors. To minimize visitor burden, only simple nonobservable characteristics are recorded; these include length of stay, group size, wilderness travel patterns, visitor residence, visit frequency, activities, and visitor perception of problems, resource conditions, and so forth. Use, in terms of number of visitors, is usually categorized by one or more nonobservable characteristics.

Step 2: Decide on Counter Type

There are three main types of counter currently available: photoelectric counters, sensor pad counters, and loop-type sensor counters. Counter selection depends on installation site characteristics and limitations, vandalism concerns, environmental factors affecting counter accuracy, equipment cost, and maintenance requirements.

1. Installation Site.—Characteristics of the proposed installation site will determine the type of counter that is most appropriate. Site characteristics to be evaluated include the presence or absence of tree cover, soil type, and slope. Photoelectric counters must be attached on a vertical surface so that the sensor and the reflector are opposite each other and located at a distance of 100 feet or less. If counter components are attached to trees, each tree must be large enough to prevent excessive swaying. If there are no suitable trees at the proposed site, posts may be installed if the soil allows digging; however, posts should be concealed in brush to avoid vandalism. Soil type and depth are important if sensor pads and loop-type counters are considered, as these sensors must be buried to be operative. If digging is difficult, or the proposed monitoring site is located on a steep and/or unstable surface, these counters will not be appropriate.

2. Equipment Vandalism.—Vandalism, theft, and tampering with counter equipment are serious concerns, especially in heavy-use areas near trailheads or parking areas. Because counter components are above ground, photoelectric counters are the most vulnerable to vandalism. Camouflaging the equipment may prevent detection. The plastic housing of the TrailMaster counters makes them the most susceptible to vandalism or animal damage; the long-term durability of these counters has not been assessed. Sensor pads are less susceptible to vandalism because they are buried, although the counter mechanism itself must be located so that the counter display can be read. The counter mechanism must therefore be camouflaged. Loop-type counters are completely buried and therefore are relatively free from the potential of damage. Avoid creating obvious trails to equipment placed off the trails. Visitors may follow these trails out of curiosity, but this traffic may increase the likelihood of tampering with equipment or disrupt normal traffic flow.

3. Environmental Factors.—Environmental factors influencing counter accuracy include habitat structure, weather, and wildlife. Structural factors include canopy density and substrate. For example, counts obtained from sensor pads may be overestimated by vibration generated by swaying trees or by other ground vibrations which are not related to visitor traffic; extremely deep or dense snow may diffuse foot traffic vibrations and bias counts upward. Count underestimates occur with photoelectric counters if the emitted beam misses the reflector, as occurs with excessive tree sway. Wildlife passing within the detection region of passive-infrared sensors may

register a count. During rain events moisture on receivers and reflectors may affect count accuracy.

4. Equipment Cost.—Prices vary from approximately $300 to $500 for photoelectric and sensor pad counters to over $1200 for loop-type counters. Expense is increased with the inclusion of various options, such as camera attachments. It is highly desirable that counters provide time and date stamping of count readings; this option facilitates calibration. See table 2 for details of equipment manufacturers, specifications, options, and associated costs.

5. Maintenance Requirements.—Visitation of each counter station should be performed regularly; schedules will depend on battery life, data storage capacity, potential for equipment failure or vandalism, and counter rotation schedules (determined before the monitoring program is in place; see below). Data must be downloaded before batteries begin to fail, or before storage capacity is exceeded. Battery life varies from 60 to 90 days for photoelectric counters to over 1 year for loop-type counters. Data storage capacity is usually much less than battery life. For example, memory capacity of loop-type counters is limited to 40 days of hourly time-stamped data; this type of counter would have to be visited at least this often. Memory capacity of certain photoelectric counters may be count-limited rather than time-limited; for example, TrailMaster counters have a storage limit of approximately 1000 counts. For these counters, the time between data downloadings would depend on visitor traffic volume. Finally, counter rotation or calibration schedules must be considered.

Step 3: Decide on the Number of Counters Needed

The number of counters to acquire will be determined by the number of access points to be monitored and the equipment budget. Ideally, counters should be acquired for every access point. In practice, funding limitations, the size of the wilderness area to be monitored, and relatively large numbers of potential access points mean that the number of available counters will be far fewer than the number required. In this case, counters must be rotated systematically (see step 5).

Step 4: Develop a Sampling Plan

Sampling plans must be developed for:

1. scheduling counter rotation across trailheads on a systematic basis (if the number of counters does not equal the number of access points).
2. calibration (if continuous calibration by observers cannot be provided).
3. visitor selection for interviews.

Step 5: Purchase Equipment

Table 2 gives information on counter manufacturers, equipment specifications, and associated costs (1995 prices).

Step 6: Install Equipment

Specifics for site location were discussed in step 2. In general, counters should be placed some distance away from the trailhead so that only *bona fide* wilderness visitors are counted, and casual visitors (those who travel only an extremely short distance) are excluded. However, if the wilderness boundary is an extremely long distance from the trailhead, the increase in personnel time involved in traveling to the counter site for reading and calibrating counters may make this option untenable. We do not advise locating counters where the trail is unduly wide (thus allowing visitors to travel two or more abreast and underestimating counts), or at natural resting places (where they may mill around and cause multiple counts). Narrow portions of the trail at locations where traffic flow is more or less continuous offer the best count locations.

The length of time required for counter installation will vary according to distance from the trailhead and counter type. After arriving at the selected site, at least 1 hour will be required for counter installation. This includes time spent examining the site, selecting the best place for counter location, installing the sensor and the counting mechanism, setting counter sensitivity or delay, and testing counter operation. If a counter is mounted on a tree trunk (as is the case for photoelectric counters), the counter will likely shift slightly within the first day or two as a result of tree wounding; the counter should therefore be checked, and realigned if necessary, on the second day after initial installation.

After the equipment has been installed, observe conditions for a short time to make certain that the counter is functioning correctly and that any camouflage is not obscuring or tripping the counter continuously. Walk over the pad or through the beam several times to check counter sensitivity, and adjust accordingly.

All equipment should be labeled with agency identification, a statement of purpose, and the name, address, and telephone number of a designated contact person.

Step 7: Collect Counter Data

Counts logged by the mechanical counter are recorded at intervals determined by the sampling plan. If counters are permanently allocated to a given location, the frequency of recording will be determined by the calibration sampling plan. At a minimum, counts should be recorded at least twice per month to ensure that data are not lost because of equipment malfunction. The person obtaining count readings should check battery power and equipment operation, and for any changes in the surrounding area which may affect count accuracy. For example, fallen branches or trees could block the electronic beam from the scanner, or cause a sufficient barrier to trail traffic to reroute traffic away from the counter path.

Step 8: Select and Train the Interview Team

Careful selection and training of the personnel who are involved in collecting data are essential if the manager or research planner is not performing the field research. The research planner must ensure that interviews are conducted and observations collected in the manner required by the study plan.

1. Personnel Selection.—Both personality and ability must be evaluated in the selection process. The importance of visitor contact extends beyond the quality of data obtained; it is an opportunity to present the image of the managing agency. Select an interviewer who is friendly, reliable, knowledgeable, flexible, and who demonstrates a positive attitude toward the project. Personnel who are convinced of the value of the work will bring a sense of

commitment to the job regardless of the amount of pay or hours worked; negative attitudes toward the overall objectives of the project, the interview topic, or the public will jeopardize research results. Personnel should be familiar with the wilderness area and be prepared to handle requests for information about the wilderness and the surrounding area. Many of the questions from visitors will not be related to the interview; providing information is a courtesy which contributes to establishing rapport with the visitors and increases visitor cooperation. Personnel should be trained in emergency procedures. When in the field, personnel should be in appropriate uniform and possess necessary communication and safety equipment.

2. Training.—It is essential that personnel are thoroughly trained in the data collection procedures. Training ensures that observers are familiar with the research directives and the interviewing process before actual fieldwork begins. As a result, errors involved in the learning process are reduced, and there will be greater consistency in identifying the sampling units (in this case visitors to be interviewed) and recording responses. Training enables observers to become familiar with various contingency plans, to identify potential problems in the research directives, and to make decisions if problems occur.

Preliminary, or pretest, fieldwork should be conducted before the actual survey begins. These rehearsals ensure that personnel understand procedures, and serve as a test for the efficiency of the methods; problems or inadequacies in the procedures can be identified and eliminated, and the consistency and accuracy of personnel can be observed and analyzed.

Observers should be screened at intervals and their performance compared either with each other or at different time points for the same observer; screening provides a check on performance and identifies sources of error in the data.

Step 9: Collect Calibration and Interview Data

Counter calibration and interview data are collected simultaneously by observers. Both calibration and interview information are collected according to a specific plan (as described in step 4). The observer must be provided with sufficient research material for the observation period; these materials include question sheets, data forms, field coding keys, writing tools, and sampling schedules.

Observers must understand the need to completely and correctly fill out the data form; sample observations will be useless if the data collected by the observer cannot be matched with the appropriate counter data. Observation sheets should be filed in a designated place after the observer returns to the office.

1. Calibration Data.—Calibration observations must be recorded in a standardized format. For each data sheet, the observer should record his or her name, the sampling location, the date, start time, the initial counter reading, end time, and the final counter reading for that sample period. During the sample period, the observer records the number of individuals or groups, the time visitors pass the observation station, and the direction of travel.

2. Interview Data.—The interview protocol consists of four steps: (a) determining question format, (b) obtaining OMB-clearance, (c) visitor selection, and (d) data collection.

(a) Question format. The questions asked of the visitor will be dictated on the basis of the study objectives; that is, on the basis of what the manager wants to know and why. Questions should be easily understood by the visitor, they should not be too long, and there should not be too many of them. *Ask only the questions necessary to meet the study objectives, and no more.* For example, suppose the manager is interested in evaluating relative impact in terms of time spent in different areas by various user groups. Interviews can be limited to determining method of travel, destination, and length of stay of visitors encountered at each trailhead; the interview will be short.

Do not add questions merely to fill up space on the interview sheet. If some inadequacy or ambiguity becomes apparent with the set questions, clarifying questions may be added, but only if they satisfy the requirements of step 1. The question designer is rarely a good judge of the clarity of the questions (Ackoff 1953); preliminary field tests are invaluable for identifying problems before the actual field surveys begin.

(b) Obtain OMB-clearance. According to federal legislation, clearance from the Office of Management and Budget (OMB) is required if federal employees ask more than nine members of the public the same set of questions. The proposed set of questions, methodology, and study justification must be submitted to OMB through the appropriate channels. For the Forest Service, application for clearance is submitted to that Agency's Information Systems office in Washington, DC, which then forwards the application to the Department of Agriculture, and from there to OMB for final approval. The time from initial submission to final OMB clearance is usually about 3 months.

(c) Interview selection. Visitors are selected in accordance with the predetermined sampling plan (step 4). The location of interviews will be determined by study objectives; visitors may be interviewed upon either entry or exit, or both. For example, if the emphasis of the study is on the effects of group size or place of residence on wilderness use, these factors are unaffected by interview location. However, if the study objectives require information on patterns of visitor use within the wilderness area (for example, travel or camping locations, length of stay), visitors should be interviewed as they leave.

(d) Data collection. When interviewing visitors, personnel should begin with a standard introduction. Personnel should give their name and agency affiliation and the reason for the interview. For example, "Hello, I am Marilyn Holgate. I work for the Missoula District of the Lolo National Forest. We are trying to learn more about the use of the Rattlesnake Wilderness. It will help us with management of the area. May I ask you a few questions about your visit today?" After the interview, thank visitors for their time. Personnel may be tempted to add additional questions "just out of curiosity"; this cannot be justified in any circumstances.

Responses should be recorded as they are given; *interviewers should not rely on memory to fill in the interview sheet at a later time.* Make sure every item is complete and legible; data forms must include date, time, location, and interviewer's name. When interview responses are coded, the interviewer should be provided with a field coding key to ensure that responses are entered correctly. Completed data forms should be filed in a safe place.

Step 10: Estimate Use

Use data are collected in accordance with the desired sample size and the sampling strategy. Because data from mechanical counters are supplemented with direct observations, use can be estimated for observable categories of visitor, in addition to information on individual or group visit counts. Use data may be expressed as a rate (for example, number of visitors per day), or total (for example, number of visitors for the season). In general, totals are estimated by multiplying the "corrected" average daily rate by the number of days in the time period of interest. If observations can be classified into two or more observable categories, the number in each category can be expressed as a proportion or percentage of the total number of users. However, if sample sizes are very small, proportion data are useless for evaluation purposes. Data collected during the calibration phase may be used to provide estimates of the sample size required for the actual observation phase of the study.

Example. Visitor traffic in the Alpine Lakes Wilderness was studied in 1991. Measures of use were assessed at the primary trailhead access for Snow Lake—an easily accessed, high-use trail with a high concentration of day users. The total length of the visitor season was 100 days.

1. Calibration.—The initial calibration period was 15 observation days. The paired data used to establish the calibration relationship were as follows:

Day	Mechanical counts (*X*)	Visitors observed (*Y*)
Friday	132	119
Saturday	514	408
Sunday	604	556
Wednesday	107	119
Thursday	74	74
Friday	107	113
Saturday	423	424
Sunday	438	323
Friday	92	78
Saturday	370	380
Sunday	406	356
Wednesday	127	98
Thursday	80	87
Saturday	325	252
Sunday	400	361

The summary statistics for these data are as follows: $n = 15$, $\Sigma X = 4{,}199$, $\Sigma X^2 = 1{,}643{,}937$, $\Sigma Y = 3{,}748$, $\Sigma Y^2 = 1{,}294{,}490$, $\Sigma XY = 1{,}450{,}388$, $\bar{X} = 280$, $\bar{Y} = 250$.

If no mechanical counters were used or if their data is ignored, the observed data could be used to compute an estimate of total use. The mean of the 15 observed values is 250 with a standard error of 41, making the 95 percent confidence interval $250 \pm 2 \cdot 41 = (167, 332)$. If the data is stratified by weekends and weekdays, the estimated means and confidence intervals are 382 (320, 445) and 98 (84, 113), respectively. Since there were 72 weekdays and 28 weekend days in the 100 day season, these individual estimators are combined as weighted averages to make overall estimators of 17,786 (15,755, 19,817). Differences from the overall (unstratified) estimator above may be due to an over representation of weekend days in the sample.

The mechanical counter data may be used to increase precision by estimating a regression relationship: $Y = 10.15 + 0.86 \cdot X$ ($\sqrt{MSE} = 33.31$). The R value is high (0.96), suggesting that a straight line is a good approximation of the relationship between the two variables. However, examination of the data plot (fig. 5) shows that there are two distinct subgroups in the data. These subgroups correspond to the day of the week on which observations were obtained; weekends had substantially higher counts than weekdays. This suggests that the sampling plan for the observation phase should incorporate stratification by time periods.

Because the regression slope is less than 1, the actual number of visitors will be overestimated by the mechanical counter data. A crude estimate of the amount of bias is given by the ratio estimator $r = \overline{Y} / \overline{X} = 250/280 = 0.89$; that is, 89 percent of counts registered by the mechanical counter could be attributed to visitor traffic, with the remaining 11 percent due to other causes. If visitor totals are estimated for relatively long time periods, there may be a substantial amount of accumulated error in the results. Standard errors and confidence intervals for ratio estimators are not generally recommended and are beyond the scope of this handbook.

2. Sample Size Estimation.—Because count data are collected by mechanical counters, large sample sizes for counts are relatively easy to obtain. However, observation data are time-intensive and expensive to collect and process; logistically feasible sample sizes should reflect reasonable operational costs associated with equipment and personnel.

(a) Count data. The relation used to estimate sample size is:

$$n \cong \left[4 \cdot \frac{S}{L} \right]^2$$

If the sampled population is small, the finite population correction (fpc) is used to correct for overestimation bias. Using the fpc, the estimated sample size is:

$$n \cong \frac{N \cdot S^2}{S^2 + \frac{L^2 \cdot N}{4(2)^2}}$$

where L is the width of the interval around the projected average, and N is the size of the true population. In this case, N is the number of days in the season. Precision is estimated by the confidence level (generally 95 percent) and the desired width of L. For example, the investigator may wish to be 95 percent certain that the results have a precision of ± 5 percent of the total. Operationally feasible sample sizes are obtained by varying the amount of precision of the estimate; highly precise estimates may require sample sizes that are too large for practical purposes.

Example. The average number of visitors observed per day during the calibration phase was 250, with $S = 160$. There are 100 days in the season (N = 100). Suppose we want to be 95 percent certain that results will have a precision of ± 5 percent, or ± 13 visitors/day. The estimated number of sampling days is $\approx \dfrac{100(160)^2}{(160)^2 + \dfrac{(13+13)^2(100)}{16}}$ = 86. If the precision is adjusted to ± 10 percent (or ± 25), then n = 62. Both of these are too large or too close to the entire season of 100 days to be of practical use due to the large underlying variance. A more reasonable level of precision would be ± 30 percent (or ± 75 visitors per day), which would call for a sample size of n = 15 as in the example above.

(b) Proportion data. Sample size (n) will be at a maximum when the proportion of observations (p) in any given category is 0.5 (or 50 percent). The sample size required to estimate an interval of width L around the sample mean will be:

$$n = \frac{4 \cdot (2)^2 \cdot p(1-p)}{L^2}$$

which is maximized for p = 0.5 or $n = 16(0.5)(0.5)/L^2$.

Example. Preliminary data showed that for 40 randomly selected visitors, 24 appeared to be day users. Therefore, the proportion of day users, p = 24/40 = 0.60, and the standard error is $\sqrt{p(1-p)/n} = \sqrt{(0.60)(0.40)/40}$ = 0.0775. The 95 percent confidence interval based on these data is approximately $0.6 \pm 2(0.0775) = 0.6 \pm 0.15$, for a confidence interval of (0.45, 0.75). The sample size n required for a 95 percent confidence interval with a length of at most 0.10 (regardless of the resulting value of p) is approximately $n = \dfrac{16(0.5)^2}{(0.10)^2}$ = 400. Therefore, it would be necessary to observe 400 visitors to obtain this amount of precision for the estimate.

(c) Stratified sampling. If the data are stratified according to trailhead or time block, sample sizes of each stratum must be calculated to ensure accurate representation of the population. Sample sizes may be either proportional or disproportional to stratum size (part I, chapter 3). Proportional sampling subdivides the sample population proportional to the size of each strata or subgroup. Optimal allocation is a type of stratified sampling where the sample size within each strata is proportional to both the size and the variability of the sample within each stratum; the proportionality factor is calculated as $\left[N_i \cdot S_i / \sum (N_i \cdot S_i)\right] \cdot n$. Disproportional sampling occurs when the same size sample is drawn for each stratum (assuming equal costs to sample each strata).

Proportional sampling should be performed if strata are fairly homogeneous (that is, the standard deviations observed for each stratum are similar), whereas optimal allocation should be chosen if strata differ in the amount of variability.

Example. In this example, data are stratified by two time blocks—weekend days and weekdays. This stratification strategy separates out time periods according to relative intensity of use, with the heaviest and most variable use occurring on weekends, and relatively light and uniform use on weekdays. For a 100-day season, there are about 72 weekdays and 28 weekend days. Suppose the available resources (budget, labor, time) dictated that maximum number of days that could be sampled was $n = 25$. The initial value for the standard deviation for each stratum was estimated from the data obtained during calibration. Sample sizes for each time block are calculated as follows:

Stratum	s[a]	Proportional f[b]	n[c]	Disproportional f	n	Optimal allocation f	n
Weekends ($n_1 = 28$)	88.0	0.25	7	0.43	12	0.64	16
Weekdays ($n_2 = 72$)	19.2	0.25	18	0.17	12	0.36	9

[a]Standard deviation.
[b]Sampling proportion.
[c]Sample size.

Because the two strata differ considerably in variability, the preferred sampling scheme is optimal allocation; with this strategy, the investigator randomly selects 16 weekend days and 9 weekdays for data collection.

3. Use Estimation.—Use characteristics estimated with this system are limited to individual or group visit counts. Data may be expressed in terms of: (a) the rate (for example, number of visitors per day), (b) the total (for example, number of visitors for the season), (c) use by category (for example, cooking method), or (d) use description (for example, length of stay).

(a) Rate of use. In this example, the observation period was 15 days; the counter registered a total of 4,199 counts, averaging 280 counts per day. The calibration or regression line is used to "correct" for counter bias by using it to estimate the "actual" value as:

$$Y = 10.15 + 0.86 \cdot (280) = 250 \text{ visitors per day.}$$

The 95 percent confidence limits are estimated as:

$$250 \pm 2(33.31)\sqrt{\frac{1}{15} + \frac{(280 - 280)^2}{(1{,}643{,}937) - 4{,}199^2/15}} = 250 \pm 17, \text{ or between 233 and}$$

267 visitors per day.

Accuracy may sometimes be increased if regressions are calculated within each stratum, rather than pooled over the entire observation period. In this example, over 80 percent of all counts registered occurred on weekends; there were 3,480 counts for the 8 weekend days monitored (averaging 435 counts per day) and 719 counts for the 7 weekdays (averaging 103 counts per day). The resulting regression estimates for each strata are:

Weekend: $Y = 1.71 + 0.875 \cdot (435) = 382$ visitors per day, with 95 percent confidence limits 382 ± 94, or between 288 and 476 visitors per day.
Weekday: $Y = 31.1 + 0.654 \cdot (103) = 98$ visitors per day, with 95 percent confidence limits 98 ± 27, or between 72 and 125 visitors per day.

These estimators may be combined to get a "corrected" average daily total by forming a weighted average of the individual estimates. Since there were 72 weekdays and 28 weekend days during the 100 day season, these two estimates can be combined with weights of 72/100 and 28/100 to make an overall estimate of visitors over the entire season. This overall estimator is

(72/100)·98 + (28/100)·382 = 178. A confidence interval for the average daily use would be formed similarly as a weighted average of the lower and upper confidence limits of the weekend and weekday usage rates of (132, 224).

In this example, the small sample sizes and greater variability within strata make the confidence interval for the stratified estimator much wider than the unstratified estimator. The moral is that stratification may not always result in narrower confidence intervals, but it will give more specific information about individual strata that may be very useful.

(b) Total use. Total visitor use is estimated by multiplying the "corrected" average daily rate by the number of days in the time period of interest, corrected by the estimated bias in counts. *The assumption implicit in this method is that use remains uniform over the time period of interest; if use patterns fluctuate considerably over the season, calibration relationships should be updated as required, and the new relationship used to calculate use rates for that time interval.*

In this example, season length was 100 days. The overall visitor use estimate is therefore 250(100) = 25,000 visitors (23,300 to 26,700 visitors). Using the stratified regression estimators, the total count estimates are 17,800 with a confidence interval of (13,200, 22,400).

(c) Use by category. Frequently, visitor use is described in terms of categories, or groups, of users; the number of users in each category is expressed as a proportion, or percentage, of the total number of users in the sample.

Example. Sample interviews recorded three types of cooking methods: stoves, wood fires, and neither for 2,975 wilderness users. Results with a 95 percent confidence interval (using χ^2 procedure based on 2 degrees of freedom) were:

Stove users: n_1 = 2,231, p_1 = 2,231/2,975 = 0.75,

95% confidence interval = $0.75 \pm \sqrt{5.99[(0.75)(0.25)/2,975]} = 0.75 \pm 0.019 =$ (0.731 to 0.769);

Wood fire users: n_2 = 595, p_2 = 595/2,975 = 0.20,

95% confidence interval = $0.20 \pm \sqrt{5.99[(0.20)(0.80)/2,975]} = 0.20 \pm 0.018 =$ (0.18 to 0.22);

Neither: n_3 = 149, p_3 = 149/2,975 = 0.05,

95% confidence interval = $0.05 \pm \sqrt{5.99[(0.05)(0.95)/2,975]} = 0.05 \pm 0.009 =$ (0.04 to 0.06).

(d) Use description. One variable that may be obtained by interview is information on length of stay. Post stratification may also be of interest.

Example. A sample of 38 interviews had an average length of stay of 2.4 nights with a standard error of 0.23 nights. This makes the 95 percent confidence interval 2.4 ± 2·0.23 = 2.4 ± 0.46 = (1.84, 2.76).

System D: Visitor Registration System With Checks For Registration Rate

System Description

This system provides information on visit counts, observable visit and visitor characteristics, and some simple nonobservable visit characteristics. In general, visitors fill out survey cards before entering the wilderness area, and use characteristics are obtained from the resulting information. Registration is voluntary; the accuracy of registration data must be determined by estimating actual registration rates, or compliance. Compliance rates are determined by sensor-triggered cameras, or by human observers. Visitor burden is low to moderate, and involves the time required by the visitor to complete the registration form.

Summary of System D:

Type of observations:	Counts Observable characteristics Simple nonobservable characteristics
Measures of visitor use:	Number of individual visits Number of group visits Use by categories of user
Data collection strategies:	Sampling plan for station rotation (if applicable) • spatial • temporal Sampling plan for compliance (cameras, humans)
Techniques/procedures:	Voluntary visitor registration Compliance checks • human observers • cameras
Visitor burden:	Low to moderate

Operational Procedures

Step 1: Decide on Use Characteristics to Measure

Direct measures of use include individual or group visit counts. Additional visit characteristics acquired from the registration cards include length of stay, entry and exit points, method of travel, group size, number of stock, and place of residence (applicable to the party leader only).

Step 2: Decide on Registration Form

Standard OMB-approved registration forms are available. Alternatively, customized registration forms can be used; however, OMB clearance must be obtained for new forms before the study begins. According to federal legislation, OMB clearance is required if federal employees ask more than nine members of the public the same set of questions. The proposed set of questions, methodology, and study justification must be submitted to OMB through the appropriate channels. For the Forest Service, application for clearance is submitted to Information Systems in Washington, DC, which forwards the application to the Department of Agriculture, and from there to OMB for final approval. The time from initial submission to final OMB clearance is usually about 3 months.

"Diary"-type registration cards can give more complete information on wilderness experiences of visitors. Visitors complete the initial portion of the card upon entry; this section requests basic information on the visitors or group. The second portion requests information on the trip itself, and is filled out by the visitor during the trip, or upon leaving the wilderness area. To reduce error, the two sections should be distinguished by separate headings and by different colors; however, each section should have the same identification number to allow matching after collection.

Step 3: Decide on Number of Registration Stations

Registration stations are relatively inexpensive to construct, install, and maintain. However, *stations must be kept supplied with adequate amounts of registration forms and pencils at all times*. The image of the agency suffers if visitors are prevented from registering because supplies are lacking. Therefore, registration stations should not be placed on every trail if personnel and time are limited and stations cannot be monitored on a regular basis. It is preferable to have only the number of registration stations that can be conveniently monitored and supplied.

Coverage of the wilderness area is performed by alternating "in-use" stations across trailheads. Strategies for rotation schedules are given in step 5.

Step 4: Decide on Method of Estimating Registration Rates

Because registration is voluntary and there are no penalties for noncompliance, the number of visitors who do register may be highly variable. Factors affecting registration rates include method of travel (hikers register at a higher rate than horse riders do), group size (at least one member from a large group is more likely to register than a member of a small group), and the location of the registration station (registration rates are lower if located at the trailhead entrance than those located further up the trail). However, there is an unknown relationship between visitor characteristics and the likelihood that a given group will register. Therefore, for practical purposes, registration stations may be regarded as a type of counter; supplementary observations must be made to estimate registration rates and "calibrate" registration information in much the same manner as observations were used to calibrate mechanical counters. Basic options for determining registration rates include use of cameras or human observers.

1. Cameras.—Either a video camera with VHS recorder or a camera may be used for recording observations. If the camera is on a timer, photos (or a

series of frames) can be obtained at fixed intervals (fixed-interval monitoring). Alternatively, the camera can be attached to a mechanical counter and triggered to shoot by visitor traffic (counter-activated monitoring).

(a) Fixed-interval monitoring. This method requires a minimum amount of personnel involvement. All traffic during a sample period is photographed. The camera is activated at programmed time intervals; these intervals are selected by statistical sampling procedures (part I, chapter 3). Cameras are installed on the traffic area where the registration station is installed. To maximize the efficiency of the method, cameras must be set up near the registration station where traffic will be visible for long distances.

(b) Counter-activated monitoring. The camera is attached to a mechanical counter, and takes photos only when the counter is activated by visitor traffic. *This technique provides a measure of overestimation bias only;* it does not provide information on error occurring because of visitors undetected by the counter.

2. Observers.—Estimating registration rates with observations taken by human observers is more labor intensive than use of cameras, but it is more accurate. Observers should be stationed close enough to the registration station so that all traffic activating the counter is observed; although observers need not be exactly by the registration station, they should not wander up and down the trail. However, it must be emphasized that observation is remote; *observers do not stop visitors*.

Step 5: Develop a Sampling Plan

Sampling plans must be developed for scheduling:

1. the rotation of registration stations and cameras (if applicable) across trailheads.
2. observer monitoring (if continuous compliance checks are not possible).

Registration stations are not expensive to construct, install, or maintain. However, if labor or supplies (such as cameras) are insufficient for all trailheads, registration stations must be rotated on a systematic basis.

Step 6: Purchase Equipment

If registration rates are estimated by camera, appropriate equipment (cameras, film, mechanical counters) must be obtained from the relevant suppliers (see part I, chapter 2, for details of counter specifications and manufacturers).

Step 7: Construct the Registration Stations

Registration rates are greatly affected by station design. Visitors are more likely to stop and register if the station is both attractive and functional. Registration stations should be designed to provide (1) a place for supplies (pencils and registration forms), (2) a convenient, solid writing surface for the visitor to use when completing the registration form, and (3) a place to deposit completed forms (normally a slot at the front). Registration stations may be constructed of wood or metal, and should be set on a post at a convenient height. Instructions must be provided which clearly detail (1) who is to register (one person or everyone in the group), (2) when to register (upon entry or exit), and (3) where to deposit the completed registration form.

A well-designed, easy-to-read, and attractive sign has the dual purpose of gaining the attention of the visitor and providing relevant information. The ideal sign is characterized by high-quality artwork depicting different types of users (hikers and stock users, and male and female users). The accompanying message should provide clear instructions for the visitor, as well as a brief explanation of management's intended use of the information provided (for example, use estimation, planning maintenance activities, and so forth).

Step 8: Install Equipment

Registration stations are installed as required. Optional equipment installation includes camera setup for registration rate estimation.

1. Registration Stations.—Registration rates are affected by station location. Do not establish registration stations at the trailhead or at parking areas; registration rates are higher and vandalism is reduced if stations are located at least one-quarter to 1 mile along the trail. However, if possible, registration stations should be outside the wilderness boundary. The registration station should be clearly visible from a distance; this is particularly important in stock-use areas, as horse users need to plan ahead for a stop. The location site must have sufficient room to allow parties leaving the area to pass a registering party, and allow members of the group the opportunity to stop and rest while the designated member registers.

In general, horse users register at much lower rates than hikers do; this is partly the result of the logistic problems associated with managing pack strings. Some experimentation with station location may be necessary to achieve acceptable horse-user registration rates. For example, registration stations may be located at designated or natural stock loading/unloading areas, where stock users can register before moving the stock out on the trail.

2. Camera Installation (optional).—When cameras are used to estimate registration rates, they must be properly placed and maintained if the resulting observations are to be usable. The camera must be positioned so that group numbers, the presence of stock and camping gear, and so forth, can be determined; however, because of privacy concerns, individual identities should not be discernible. The camera should be adjusted to be slightly out of focus. Cameras must be positioned far enough from the trail so that visitors cannot hear the shutter or motor action (camera detection could result in theft or vandalism of equipment); camera equipment should be well camouflaged.

All equipment should be labeled with agency identification, a statement of purpose, and the name, address and telephone number of a designated contact person.

Film consumption should be monitored frequently; registration rates cannot be estimated if the camera runs out of film during this phase. After removing exposed film from the camera, label immediately with the date, time, and location. Protect exposed film from extreme heat and cold until developed.

Counter-activated cameras: If mechanical counters are used to trigger the camera, extra time and labor are required for installation. Specifics for counter site location were discussed in detail for System C, step 2. In general, mechanical counters should be placed some distance away from the trailhead so that only *bona fide* wilderness visitors are counted, and casual visitors (those who travel only an extremely short distance) are excluded. However, if the wilderness boundary is an extremely long distance from the trailhead, the increase in personnel time involved in traveling to the counter site for reading and calibrating counters may make this option untenable. *Do not locate counters and counter-activated cameras at the registration station itself*; group members tend to mill around while one member is registering, and this will cause multiple counts. The counter sensor and camera should be placed a short distance beyond the registration station to ensure that all visitors pass the registration station.

The time required for counter installation will vary according to distance from the trailhead and counter type. After arriving at the selected site, at least 1 hour will be required for counter installation. This includes time spent examining the site, selecting the best place for counter location, installing the sensor and the counting mechanism, setting counter sensitivity or delay, and testing counter operation. If a counter is mounted on a tree trunk (as is the case for photoelectric counters), the counter will likely shift slightly within the first day or two as a result of tree wounding; the counter should therefore be checked, and realigned if necessary, on the second day after initial installation.

After the equipment has been installed, observe conditions for a short time to make certain that the counter is functioning correctly and that any camouflage is not obscuring or tripping the counter continuously. Walk over the pad or through the beam several times to check counter sensitivity, and adjust accordingly.

Step 9: Collect Registration Data

Completed registration cards should be collected on a regular basis. The person collecting the cards should check the station supplies (unused registration cards and pencils), and replenish if necessary. Keep track of the number of unused cards in order to assess whether the time intervals for station visits are appropriate; obviously stations will have to be visited more frequently if the supply of unused cards runs out before each scheduled supply drop.

Step 10: Obtain Registration Rate Data

To estimate registration rates, the minimum information required includes number of individuals, number of groups, method of travel, and date and time of entry or exit. Additional information on observable visit or visitor characteristics (for example, group size, number of stock, gender, approximate age, time of entry or exit, activity, and whether a user appears to be a day user or an overnight camper) are recorded at this time. A sample data sheet is shown in figure 1. However, certain classes of information (such as gender and age categories) may not be easily determined from observations.

1. <u>Cameras</u>.—Record necessary observations from the developed film. Observations must be recorded in a standardized format to minimize errors in recording. Observations include location, date, number of individuals, number of groups, date and time of entry or exit. Observers must understand the need to completely and correctly fill out the data form; sample observations will be useless if the data collected by the observer cannot be matched with the appropriate registration data. Observation sheets should be filed in a designated place. After observations are recorded, destroy negatives and developed photos to ensure visitor privacy.

2. Observers.—Observers should be stationed close enough to the registration station so that all traffic passing the station is accounted for; however, they do not need to observe whether or not visitors actually register. Although observers need not be beside the registration station, they should not wander up and down the trail. *Observers do not stop visitors*.

Observations are recorded on a standardized form (fig. 1). Observations include observer name, location, date, number of individuals, number of groups, date and time of entry or exit. Observers must understand the need to completely and correctly fill out the data form; sample observations will be useless if the data collected by the observer cannot be matched with the appropriate registration data. All deposited registration forms are collected and labeled at the end of the observation period. Observation sheets and registration cards should be filed in a designated place.

Step 11: Estimate Use

Use data are collected in accordance with the appropriate sample size and the sampling strategy. Data obtained from registration cards are supplemented with observations obtained during the registration-rate estimation phase. Use can be estimated for both observable and nonobservable categories of visitor, and visitor use is calculated as the number of visitors per category, expressed as a proportion or percentage of the total number of users.

1. Estimate Registration Rates.—Registration rate is estimated as the ratio of the number of registered visitors (determined by the total number of registration forms collected) to the total number of visitors (determined from observer counts) during the sample observation periods.

Example. A total of 575 visitors registered during the 7-day registration-rate estimation phase. A random sample of $n = 50$ visitors indicated that 10 did not register. Therefore, the estimated registration rate r was estimated as 40/50 = 0.8, or 80 percent. The total number of users (N) for a given period is estimated by the total number of registered visitors (t) divided by the registration rate:

$$\hat{N} = t/r = 575/0.8 = 719.$$

The 95 percent confidence interval for the total is estimated by $N \pm 2{\cdot}SE =$

$$719 \pm 2\sqrt{\left[(575)^2 \cdot 50(50-40)\right]/(40)^3} = 719 \pm 102, \text{ or between 617 and 821 visitors.}$$

2. Sample Size Estimation.—Because visitor count data are collected by counting registration cards, there may be insufficient resources available to cover the costs and time involved in the collection, input, and processing of large amounts of data. Sample sizes for categorical data should be specified first. Sample sizes should be estimated for each use characteristic to be measured, and the largest (feasible) sample size is chosen. If a stratified sampling strategy is used, stratum sample size is calculated according to whether proportional or disproportional representation is required.

(a) Count data. The relation used to estimate sample size is:

$$n \cong \left[4 \cdot \frac{S}{L}\right]^2$$

If the sampled population is small, the finite population correction (fpc) is used to correct for overestimation bias. Using the fpc, the estimated sample size is:

$$n \cong \frac{N \cdot S^2}{S^2 + \frac{L^2 \cdot N}{4(2)^2}}$$

where L is the width of the interval around the projected average, and N is the size of the true population. In this case, N is the number of days in the season. Precision is estimated by the confidence level (generally 95 percent) and the desired width of L. For example, the investigator may wish to be 95 percent certain that the results have a precision of ± 5 percent of the total. Operationally feasible sample sizes are obtained by varying the amount of precision of the estimate; highly precise estimates may require sample sizes that are too large for practical purposes.

Example. The average number of visitors observed per day during the compliance estimation phase was 250, with S = 160. There are 100 days in the season (N = 100). Suppose we want to be 95 percent certain that results will have a precision of ± 5 percent, or ± 13 visitors/day. The estimated number of sampling days is $\approx \frac{100(160)^2}{(160)^2 + \frac{(13+13)^2(100)}{16}} = 86$. If the precision is adjusted to ± 10 percent (or ± 25 visitors per day), then $n = 62$. Both of these are too large or too close to the entire season of 100 days to be of practical use due to the large underlying variance. A more reasonable level of precision would be ± 30 percent (or ± 75 visitors per day), which would call for a sample size of n = 15.

(b) Proportion data. Sample size (n) will be at a maximum when the proportion of observations (p) in any given category is 0.5 (or 50 percent). The sample size required to estimate an interval of width L around the sample mean will be:

$$n = \frac{4 \cdot (2)^2 \cdot p(1-p)}{L^2}$$

which is maximized for p = 0.5 or $n = 16(0.5)(0.5)/L^2$.

Example. Preliminary data showed that for 40 randomly selected visitors, 24 appeared to be day users. Therefore, the proportion of day users, p = 24/40 = 0.60, and the standard error is $\sqrt{p(1-p)/n} = \sqrt{(0.60)(0.40)/40} = 0.0775$. The 95 percent confidence interval based on these data is approximately 0.6 ± 2(0.0775) = 0.6 ± 0.15, for a confidence interval of (0.45, 0.75). The sample size n required for a 95 percent confidence interval with a length of at most 0.10 (regardless of the resulting value of p) is approximately $n = \frac{16(0.5)^2}{(0.10)^2} = 400$. Therefore, it would be necessary to observe 400 visitors to obtain this amount of precision for the estimate.

(c) Stratified sampling. If the data are stratified according to trailhead or time block, sample sizes of each stratum must be calculated to ensure accurate representation of the population. Sample sizes may be either proportional or disproportional to stratum size (part I, chapter 3). Proportional sampling subdivides the sample population proportional to the size of each strata or subgroup. Optimal allocation is a type of stratified sampling where the sample size within each strata is proportional to both the size and the variability of the sample within each stratum; the proportionality factor is calculated as $\left[N_i \cdot S_i / \sum\left(N_i \cdot S_i\right)\right] \cdot n$. Disproportional sampling occurs when the same size sample is drawn for each stratum (assuming equal costs to sample each strata).

Proportional sampling should be performed if strata are fairly homogeneous (that is, the standard deviations observed for each stratum are similar), whereas optimal allocation should be chosen if strata differ in the amount of variability.

Example. In this example, data are stratified by two time blocks—weekend days and weekdays. This stratification strategy separates out time periods according to relative intensity of use, with the heaviest and most variable use occurring on weekends, and relatively light and uniform use on weekdays. For a 100-day season, there are about 72 weekdays and 28 weekend days. Suppose the available resources (budget, labor, time) dictated that the maximum number of days that could be sampled was $n = 25$. The initial value for the standard deviation for each stratum was estimated from the data obtained during the registration rate estimation phase. Sample sizes for each time block are calculated as follows:

		Proportional		**Disproportional**		**Optimal allocation**	
Stratum	***s***[a]	***f***[b]	***n***[c]	***f***	***n***	***f***	***n***
Weekends ($N_1 = 28$)	88.0	0.25	7	0.43	12	0.64	16
Weekdays ($N_2 = 72$)	19.2	0.25	18	0.17	12	0.36	9

[a]Standard deviation.
[b]Sampling proportion.
[c]Sample size.

Because the two strata differ considerably in variability, the preferred sampling scheme is optimal allocation; with this strategy the investigator randomly selects 16 weekend days and 9 weekdays for data collection.

3. Use Estimation.—Use characteristics estimated with this system are limited to individual or group visit counts. Data may be expressed in terms of: (a) the rate (for example, number of visitors per day), (b) the total (for example, number of visitors for the season), (c) use by category (for example, cooking method), or (d) use description (for example, length of stay).

(a) Rate of use. Suppose the number of registered visitors for a 30 day time period was 772. A survey of 50 visitors showed that 46 had permits for a compliance rate of 46/50 = 0.92.The estimated number of users over the 30 day period is 772/0.92 = 839, for an estimated daily rate of 839/30 = 28 users per day. The estimated confidence interval for the 30 day rate is:

$$839 \pm 2 \cdot \sqrt{772^2 \cdot 50 \cdot (50-46) / 46^3} = 839 \pm 70 = (769,\ 909)$$

which converts to a confidence interval for the daily rate of (25.6, 30.3).

(b) Total use. Total visitor use is estimated by multiplying the "corrected" average daily rate by the number of days in the time period of interest, corrected by the estimated bias in counts. *The assumption implicit in this method is that use remains uniform over the time period of interest; if use patterns fluctuate considerably over the season, calibration relationships should be updated as required, and the new relationship used to calculate use rates for that time interval.*

In this example, season length was 100 days. The overall visitor use estimate is therefore 28(100) = 2,800 visitors (2,560 to 3,030 visitors).

(c) Use by category. Frequently, visitor use is described in terms of categories, or groups, of users; the number of users in each category is expressed as a proportion, or percentage, of the total number of users in the sample.

Example. On the registration form 2,975 visitors indicated their method of cooking during their visit: stoves, wood fires, or neither. Results with a 95 percent confidence interval (using χ^2 procedure based on 2 degrees of freedom) were:

Stove users: n_1 = 2,231, p_1 = 2,231/2,975 = 0.75,

95 percent confidence interval = $0.75 \pm \sqrt{5.99[(0.75)(0.25)/2,975]} = 0.75 \pm 0.019$ = (0.731 to 0.769);

Wood fire users: n_2 = 595, p_2 = 595/2,975 = 0.20,

95 percent confidence interval = $0.20 \pm \sqrt{5.99[(0.20)(0.80)/2,975]} = 0.20 \pm 0.018$ = (0.18 to 0.22);

Neither: n_3 = 149, p_3 = 149/2,975 = 0.05,

95 percent confidence interval = $0.05 \pm \sqrt{5.99[(0.05)(0.95)/2,975]} = 0.05 \pm 0.009$ = (0.04 to 0.06).

(d) Use description. One variable that may be obtained by registration forms is length of stay. Post stratification may also be of interest.

Example. A sample of 38 registration forms had an average length of stay of 2.4 nights with a standard error of 0.23 nights. This makes the 95 percent confidence interval $2.4 \pm 2 \cdot 0.23 = 2.4 \pm 0.46$ = (1.94, 2.86).

System E: Visitor Registration System With Registration Rate Checks and Sample Interviews

System Description

This system provides information on visit counts, observable visit and visitor characteristics, nonobservable characteristics, and summary-use statistics. In general, visitors fill out survey cards before entering the wilderness area, and use characteristics are obtained from the resulting information. Supplementary information is obtained by interviewing visitors. Because registration is voluntary, the accuracy of registration data must be determined by estimating registration rates, or compliance. Compliance rates are determined by human observers during the interview procedure. Visitor burden is low to moderate, and involves the time required by the visitor to complete the registration form and time required for interviews.

Summary of System E:

Type of observations:	Counts Observable characteristics Simple nonobservable characteristics Complex nonobservable characteristics Summary-use statistics
Measures of visitor use:	Number of individual visits Number of group visits Use by categories of user
Data collection strategies:	Sample plan for registration station rotation (if applicable) • spatial • temporal Sample plan for registration rate estimates Sample plan for visitor selection
Techniques/procedures:	Voluntary registration Visual observations (human observers) Interviews
Visitor burden:	Moderate

Operational Procedures

Step 1: Decide on Use Characteristics to Measure

Direct measures of use include individual or group visit counts. Additional visit characteristics acquired from the registration cards include length of stay, entry and exit points, method of travel, group size, number of stock, and place of residence (applicable to the party leader only). Nonobservable visit and visitor characteristics are acquired by interviewing a random selection of visitors. To minimize visitor burden, only simple nonobservable characteristics are recorded; these include average length of stay, average group size, wilderness travel patterns, visitor residence, visit frequency, activities, and visitor perception of problems, resource conditions, and so forth. Use, in terms of number of visitors, is usually categorized by one or more nonobservable characteristics.

Step 2: Decide on Registration Form

Standard OMB-approved registration forms are available. Alternatively, customized registration forms can be used; however, OMB clearance must be obtained for new forms before the study begins. According to federal legislation, OMB clearance is required if federal employees ask more than nine members of the public the same set of questions. The proposed set of questions, methodology, and study justification must be submitted to OMB through the appropriate channels. For the Forest Service, application for clearance is submitted to Information Systems in Washington, DC, which forwards the application to the Department of Agriculture, and from there to OMB for final approval. The time from initial submission to final OMB clearance is usually about 3 months.

"Diary"-type registration cards can give more complete information on wilderness experiences of visitors. Visitors complete the initial portion of the card upon entry; this section requests basic information on the visitors or group. The second portion requests information on the trip itself, and is filled out by the visitor during the trip or upon leaving the wilderness area. To reduce error, the two sections should be distinguished by separate headings and by different colors; however, each section should have the same identification number to allow matching after collection.

Step 3: Decide on Number of Registration Stations

Registration stations are relatively inexpensive to construct, install, and maintain. However, the number of registration stations in use at any one time will be determined by the availability of resources (time, supplies, labor) to ensure adequate monitoring. It is preferable to have only the number of registration stations that can be conveniently monitored and supplied. Stations must be kept supplied with adequate amounts of registration forms and pencils at all times. The image of the agency suffers if visitors are prevented from registering because supplies are lacking. The number of stations in use will also be dictated by the number of personnel available to conduct interviews.

Coverage of the wilderness area is performed by alternating, or rotating, "in-use" stations across trailheads. Strategies for rotation schedules are given in step 5.

Step 4: Develop Sampling Plan

Sampling plans must be developed for scheduling (1) rotation of registration stations (if applicable) across trailheads, and (2) observer monitoring and interviews.

1. Sample Plan for Rotating Registration Stations Across Trailheads.—Registration stations are not expensive to construct, install, or maintain. However, if labor or supplies are insufficient for all trailheads, registration stations must be rotated on a systematic basis. Rotation strategies are determined primarily by perceived differences in use occurring in either space or time. We recommend a more-or-less permanent allocation of a registration station to each high-use trailhead; the overall accuracy of total use estimates will depend primarily on the accuracy of estimates obtained for high-use areas.

(a) Spatial allocation. The following is an example of station allocation determined by patterns in spatial use. Suppose a manager must monitor use at four trailheads, but only two stations are available. One trailhead is believed to account for about 60 percent of use in that wilderness area; a second trailhead is believed to account for about 50 percent of the remaining use. A feasible plan for station allocation would be to permanently allocate one station to the high-use trailhead; the other station is rotated systematically across the remaining three trailheads, such that the amount of time allocated to each trailhead is proportional to the use that trailhead is expected to receive. That is, the second station is allocated to the second trailhead for half of the remaining time, and allocated between the two remaining trailheads in proportion to anticipated use.

(b) Time allocation. Stations should be placed at each trailhead for at least two observation periods; observation periods are determined by methods of random selection (part I, chapter 3). One option is to partition the season into 7-day weeks, then randomly select a given week or weeks as the observation period for a given station. For example, suppose the manager wishes to estimate use for the entire 16-week summer season; as in the above example, there are four trailheads and two stations. One station is permanently allocated to the high-use trailhead; there are therefore three remaining trailheads to be monitored with one station. The manager decides to partition the 16-week season into eight 2-week blocks so that the station will be allocated to each trailhead for two separate time blocks; this leaves two blocks as discretionary time. The order in which the station is assigned to each trailhead is determined randomly (part I, chapter 3). Suppose the random number sequence for the eight time blocks is 5 7 8 3 2 6 1 4, and the random sequence for the three trailheads is 3 4 2. Then the station will be assigned to trailhead 3 on time blocks 5 and 7, to trailhead 4 on time blocks 8 and 3, and trailhead 2 for time blocks 2 and 6.

2. Sample Plan for Interviews.—Both registration rates and nonobservable visit characteristics are determined by contacting visitors passing a given registration station. The procedure for estimating registration rates is similar to the calibration procedures described for systems using mechanical counters; visitor registration is "calibrated" by supplementary observations so that the number of wilderness users who do not register can be accounted for, and total visitor counts can be adjusted accordingly. Interviews are also used to obtain information on nonobservable visit characteristics. The number of interviews required will depend on the desired amount of precision of both registration rate estimates and estimates of use characteristics, the available resources, and the relative stability of visitor use over time. If use patterns change substantially over the season, registration rates estimated at the beginning of the season will not be applicable later in the season; the

accuracy of registration rates must be spot checked at intervals and updated as required.

Because human observers are used, registration rate checks may have to be scheduled within the confines of the workweek. However, if significant amounts of use occur outside of normal working hours, it is essential that these time blocks are covered; volunteer labor may be one option. Observer fatigue and boredom may be a significant problem if time blocks are extremely long and few visitors are encountered. Sampling effort may be apportioned according to operationally defined amounts of relative use observed per time block. At least two observation periods should be scheduled for each category.

Example. Past experience suggests to a wilderness ranger that the number of visitors to a certain wilderness area is fairly constant over the season, with approximately 20 percent of wilderness users entering wilderness area on weekdays, another 40 percent of users enter on Saturday mornings, 10 percent on Saturday afternoons, 20 percent on Sunday mornings, and 10 percent on Sunday afternoons. A total of 10 observation periods can be sampled with the resources available. Therefore, the ranger decides to partition the sampling day into morning and afternoon time blocks. Time blocks are further stratified into three operationally defined use categories: low use, medium use, and high use. Observer effort is allocated proportional to amount of use; thus 20 percent of sampling effort is allocated to low-use periods (that is, two time blocks occurring on either a weekday morning or afternoon); 40 percent effort to high-use periods (four Saturday mornings), and the remaining effort to medium-use time periods (one Saturday afternoon, two Sunday mornings, and one Sunday afternoon. At least 4 weeks are therefore required for this sampling plan; the specific time blocks to be monitored are selected by random sampling procedures (part I, chapter 3).

Step 5: Construct the Registration Stations

Registration rates are greatly affected by station design. Visitors are more likely to stop and register if the station is both attractive and functional. Registration stations should be designed to provide (a) a place for supplies (pencils and registration forms), (b) a convenient, solid writing surface for the visitor to use when completing the registration form, and (c) a place to deposit completed forms (normally a slot at the front). Registration stations may be constructed of wood or metal, and should be set on a post at a convenient height. Instructions must be provided which clearly detail (a) who is to register (one person or everyone in the group), (b) when to register (upon entry or exit), and (c) where to deposit the completed registration form.

A well-designed, easy-to-read, and attractive sign has the dual purpose of gaining the attention of the visitor and providing relevant information. Figure 6 illustrates an improved version of the more traditional “official-looking” signs commonly in use. The improved sign is characterized by high-quality artwork depicting different types of users (hikers and stock users, and male and female users). The accompanying message should provide clear instructions for the visitor, as well as a brief explanation of management’s intended use of the information provided (for example, use estimation, planning maintenance activities, and so forth).

Figure 6—Example of an attractive registration sign.

Step 6: Install Registration Stations

Registration rates are affected by station location. Do not establish registration stations at the trailhead or at parking areas; registration rates are higher and vandalism is reduced if stations are located at least one-quarter to 1 mile along the trail. However, if possible, registration stations should be outside the wilderness boundary. The registration station should be clearly visible from a distance; this is particularly important in stock-use areas, as horse users need to plan ahead for a stop. The location site must have sufficient room to allow parties leaving the area to pass a registering party, and allow members of the group the opportunity to stop and rest while the designated member registers.

In general, horse users register at much lower rates than hikers do; this is partly the result of the logistic problems associated with managing pack strings. Some experimentation with station location may be necessary to achieve acceptable horse-user registration rates. For example, registration stations may be located at designated or natural stock loading/unloading areas, where stock users can register before moving the stock out on the trail.

Step 7: Select and Train the Interview Team

Careful selection and training of the personnel who are involved in collecting data are essential if the manager or research planner is not performing the field research. The research planner must ensure that interviews are conducted and observations collected in the manner required by the study plan.

1. Personnel Selection.—Both personality and ability must be evaluated in the selection process. The importance of visitor contact extends beyond the quality of data obtained; it is an opportunity to present the image of the managing agency. Select an interviewer who is friendly, reliable, knowledgeable, and trained in emergency procedures. Personnel should be familiar with the wilderness area and be prepared to handle requests for information about the wilderness and the surrounding area. Many of the questions from visitors will not be related to the interview; providing information is a courtesy which contributes to establishing rapport with the visitors and increases visitor cooperation. Personnel should be in appropriate uniform and possess necessary communication and safety equipment.

2. Training.—It is essential that personnel are thoroughly trained in the data collection procedures. Training ensures that observers are already familiar with the research directives and the interviewing process before actual fieldwork begins. As a result, errors involved in the learning process are reduced, and there will be greater consistency in identifying the sampling units (in this case visitors to be interviewed) and recording responses. Training enables observers to become familiar with various contingency plans, to identify potential problems in the research directives, and to make decisions if problems occur.

Preliminary, or pretest, fieldwork should be conducted before the actual survey begins. These rehearsals ensure that personnel understand procedures, and serve as a test for the efficiency of the methods; problems or inadequacies in the procedures can be identified and eliminated, and the consistency and accuracy of personnel can be observed and analyzed. Observers should be screened at intervals and their performance compared either with each other or at different time points for the same observer; screening provides a check on performance and identifies sources of error in the data.

Step 8: Collect Registration Rate and Interview Data

Information on registration rates and interview data are collected simultaneously by observers. Both types of information are collected according to a specific plan (as described in step 4). The observer must be provided with sufficient research material—data forms, writing tools, schedules, and so forth—for the observation period. Observers must understand the need to completely and correctly fill out the data forms. Observation sheets should be filed in a designated place after the observer returns to the office.

1. Registration Rates.—Registration rate observations are obtained during the sample observation period; all traffic entering the wilderness area is monitored, but only groups designated by the sampling plan are interviewed. Observations must be recorded in a standardized format (see fig. 1 for a sample form). For each data sheet, the observer should record their name, the sampling location, the date, start time, and end time for that sample period. The minimum information required to estimate registration rates includes number of individuals, number of groups, method of travel, date and time of entry or exit, and use category (day user or overnight user). All deposited registration cards are collected at the end of the sample observation period.

2. Interview Data.—The interview protocol consists of four steps: (a) determining question format, (b) obtaining OMB clearance, (c) visitor selection, and (d) data collection.

(a) Question format. The questions asked of the visitor will be dictated on the basis of the study objectives; that is, on the basis of what the manager wants to know and why. Questions should be easily understood by the visitor, they should not be too long, and there should not be too many of them. *Ask only the questions necessary to meet the study objectives, and no more.* For example, suppose the manager is interested in evaluating relative impact in terms of time spent in different areas by various user groups. Interviews can be limited to determining method of travel, destination, and length of stay of visitors encountered at each trailhead; the interview will be short.

Personnel may be tempted to add additional questions "just out of curiosity"; this cannot be justified in any circumstances. Do not add questions merely to fill up space on the interview sheet. If some inadequacy or ambiguity becomes apparent with the set questions, questions may be added, but only if they clarify the meaning and satisfy the requirements of step 1. The question designer is rarely a good judge of the clarity of the questions (Ackoff 1953); preliminary field tests are invaluable for identifying problems before the actual field surveys begin.

(b) Obtain OMB clearance. According to federal legislation, clearance from the Office of Management and Budget (OMB) is required if federal employees ask more than nine members of the public the same set of questions. The proposed set of questions, methodology, and study justification must be submitted to OMB through the appropriate channels. For the Forest Service, application for clearance is submitted to Information Systems in Washington, DC, which then forwards the application to the Department of Agriculture, and from there to OMB for final approval. The time from initial submission to final OMB clearance is usually about 3 months.

(c) Interview selection. Visitors are selected in accordance with the predetermined sampling plan (step 4). The location of interviews will be determined by study objectives; visitors may be interviewed upon either entry or exit, or both. For example, if the emphasis of the study is on the effects of group size or place of residence on wilderness use, these factors are unaffected by interview location. However, if the study objectives require information on patterns of visitor use within the wilderness area (for example, travel or camping locations, length of stay), visitors should be interviewed as they leave.

(d) Data collection. When interviewing visitors, personnel should begin with a standard introduction. Personnel should give their name and agency affiliation and the reason for the interview. For example, "Hello, I am Marilyn Holgate. I work for the Missoula District of the Lolo National Forest. We are trying to learn more about the use of the Rattlesnake Wilderness. It will help us with management of the area. May I ask you a few questions about your visit today?" After the interview, thank visitors for their time.

Responses should be recorded as they are given; *interviewers should not rely on memory to fill in the interview sheet at a later time.* Make sure every item is complete and legible; data forms must include date, time, location, and interviewer's name. Completed data forms should be filed in a safe place.

Step 9: Estimate Use

Use data are collected in accordance with the appropriate sample size and the sampling strategy. Data obtained from registration cards are supplemented with observations obtained during the registration-rate estimation phase. Use can be estimated for both observable and nonobservable categories of visitor, and visitor use is calculated as the number of visitors per category, expressed as a proportion or percentage of the total number of users.

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$$\hat{N} = t/r = 575/0.8 = 719.$$

The 95 percent confidence interval for the total is estimated by $N \pm 2 \cdot SE =$

$$719 \pm 2\sqrt{\left[(575)^2 \cdot 50(50-40)\right]/(40)^3} = 719 \pm 102,$$ or between 617 and 821 visitors.

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If the sampled population is small, the finite population correction (fpc) is used to correct for overestimation bias. Using fpc, the estimated sample size is:

$$n \cong \frac{N \cdot S^2}{S^2 + \frac{L^2 \cdot N}{4(2)^2}}$$

where L is the width of the interval around the projected average, and N is the size of the true population. In this case, N is the number of days in the season. Precision is estimated by the confidence level (generally 95 percent) and the desired width of L. For example, the investigator may wish to be 95 percent certain that the results have a precision of ± 5 percent of the total. Operationally feasible sample sizes are obtained by varying the amount of precision of the estimate; highly precise estimates may require sample sizes that are too large for practical purposes.

Example. The average number of visitors observed per day during the compliance estimation phase was 250, with $S = 160$. There are 100 days in the season (N = 100). Suppose we want to be 95 percent certain that results will have a precision of ± 5 percent, or ± 13 visitors/day. The estimated number of sampling days is $\approx \dfrac{100(160)^2}{(160)^2 + \dfrac{(13+13)^2(100)}{16}} = 86$. If the precision is adjusted to ± 10 percent (or ± 25 visitors per day), then $n = 62$. Both of these are too large or too close to the entire season of 100 days to be of practical use due to the large underlying variance. A more reasonable level of precision would be ± 30 percent (or ± 75 visitors per day), which would call for a sample size of $n = 15$.

(b) Proportion data. Sample size (n) will be at a maximum when the proportion of observations (p) in any given category is 0.5 (or 50 percent). The sample size required to estimate an interval of width L around the sample mean will be:

$$n = \frac{4 \cdot (2)^2 \cdot p(1-p)}{L^2}$$

which is maximized for $p = 0.5$ or $n = 16(0.5)(0.5)/L^2$.

Example. Preliminary data showed that for 40 randomly selected visitors, 24 appeared to be day users. Therefore, the proportion of day users, $p = 24/40 = 0.60$, and the standard error is $\sqrt{p(1-p)/n} = \sqrt{(0.60)(0.40)/40} = 0.0775$. The 95 percent confidence interval based on these data is approximately 0.6 $\pm 2(0.0775) = 0.6 \pm 0.15$, for a confidence interval of (0.45, 0.75). The sample size n required for a 95 percent confidence interval with a length of at most 0.10 (regardless of the resulting value of p) is approximately $n = \dfrac{16(0.5)^2}{(0.10)^2} = 400$. Therefore, it would be necessary to observe 400 visitors to obtain this amount of precision for the estimate.

(c) Stratified sampling. If the data are stratified according to trailhead or time block, sample sizes of each stratum must be calculated to ensure accurate representation of the population. Sample sizes may be either proportional or disproportional to stratum size (part I, chapter 3). Proportional sampling subdivides the sample population proportional to the size of each strata or subgroup. Optimal allocation is a type of stratified sampling where the sample size within each strata is proportional to both the size and the variability of the sample within each stratum; the proportionality factor is calculated as $\left[N_i \cdot S_i / \sum \left(N_i \cdot S_i\right)\right] \cdot n$. Disproportional sampling occurs when the same size sample is drawn for each stratum (assuming equal costs to sample each strata).

Proportional sampling should be performed if strata are fairly homogeneous (that is, the standard deviations observed for each stratum are similar), whereas optimal allocation should be chosen if strata differ in the amount of variability.

Example. In this example, data are stratified by two time blocks—weekend days and weekdays. This stratification strategy separates out time periods according to relative intensity of use, with the heaviest and most variable use occurring on weekends, and relatively light and uniform use on weekdays. For a 100-day season, there are about 72 weekdays and 28 weekend days. Suppose the available resources (budget, labor, time) dictated that the maximum number of days that could be sampled was n = 25. The initial value for the standard deviation for each stratum was estimated from the data obtained during the registration rate estimation phase. Sample sizes for each time block are calculated as follows:

Stratum	s[a]	Proportional		Disproportional		Optimal allocation	
		f[b]	n[c]	f	n	f	n
Weekends (n_1 = 28)	88.0	0.25	7	0.43	12	0.64	16
Weekdays (n_2 = 72)	19.2	0.25	18	0.17	12	0.36	9

[a]Standard deviation.
[b]Sampling proportion.
[c]Sample size.

Because the two strata differ considerably in variability, the preferred sampling scheme is optimal allocation; with this strategy the investigator randomly selects 16 weekend days and 9 weekdays for data collection.

3. Use Estimation.—Use characteristics estimated with this system are limited to individual or group visit counts. Data may be expressed in terms of: (a) the rate (for example, number of visitors per day), (b) the total (for example, number of visitors for the season), (c) use by category (for example, cooking method), or (d) use description (for example, length of stay).

(a) Rate of use. Suppose the number of registered visitors for a 30 day time period was 772. A survey of 50 visitors showed that 46 had permits for a compliance rate of 46/50 = 0.92.The estimated number of users over the 30 day period is 772/0.92 = 839, for an estimated daily rate of 839/30 = 28 users per day. The estimated confidence interval for the 30 day rate is

$$839 \pm 2 \cdot \sqrt{772^2 \cdot 50 \cdot (50-46)/46^3} = 839 \pm 70 = (769, 909)$$

which converts to a confidence interval for the daily rate of (25.6, 30.3).

(b) Total use. Total visitor use is estimated by multiplying the "corrected" average daily rate by the number of days in the time period of interest, corrected by the estimated bias in counts. *The assumption implicit in this method is that use remains uniform over the time period of interest; if use patterns fluctuate considerably over the season, calibration relationships should be updated as required, and the new relationship used to calculate use rates for that time interval.*

In this example, season length was 100 days. The overall visitor use estimate is therefore 28(100) = 2,800 visitors (2,560 to 3,030 visitors).

(c) Use by category. Frequently, visitor use is described in terms of categories, or groups, of users; the number of users in each category is expressed as a proportion, or percentage, of the total number of users in the sample.

Example. On the registration form 2,975 visitors indicated their method of cooking during their visit: stoves, wood fires, or neither. Results with a 95 percent confidence interval (using χ^2 procedure based on 2 degrees of freedom) were:

Stove users: n_1 = 2,231, p_1 = 2,231/2,975 = 0.75,

95 percent confidence interval = $0.75 \pm \sqrt{5.99[(0.75)(0.25)/2,975]} = 0.75 \pm 0.019$ = (0.731 to 0.769);

Wood fire users: n_2 = 595, p_2 = 595/2,975 = 0.20,

95 percent confidence interval = $0.20 \pm \sqrt{5.99[(0.20)(0.80)/2,975]} = 0.20 \pm 0.018$ = (0.18 to 0.22);

Neither: n_3 = 149, p_3 = 149/2,975 = 0.05,

95 percent confidence interval = $0.05 \pm \sqrt{5.99[(0.05)(0.95)/2,975]} = 0.05 \pm 0.009$ = (0.04 to 0.06).

(d) Use description. One variable that may be obtained by registration forms is length of stay. Post stratification may also be of interest.

Example. A sample of 38 registration forms had an average length of stay of 2.4 nights with a standard error of 0.23 nights. This makes the 95 percent confidence interval $2.4 \pm 2 \cdot 0.23 = 2.4 \pm 0.46$ = (1.94, 2.86).

Hiking is by far the most common method of wilderness travel.

System F: Permit System With Compliance Checks

System Description

Permits are mandatory use-authorization forms issued by the agency. The information obtained is constrained by what is required by the permit form; this system provides sufficient information to estimate basic visit counts, visit and visitor characteristic data, and may enable estimates of certain summary-use statistics. Compliance checks are required for accurate estimation of total use. Because visitors are responsible for obtaining permits, visitor burden is relatively high.

Summary of System F:

Type of observations:	Counts
	Observable characteristics
	Simple nonobservable characteristics
	Complex nonobservable characteristics
Measures of visitor use:	Number of individual visits
	Number of group visits
	Total number of users
	Use by category of user
	Summary-use statistics
Data collection strategies:	Permit-issue method
	Visitor selection sampling for compliance checks
Techniques/procedures:	Permits
	Compliance checks
Visitor burden:	Moderate to high

Operational Procedures

Step 1: Decide on Use Characteristics

Use characteristics that can be obtained are restricted by the permit format. Information obtained from permits can include the number of individuals or groups, group size, method of travel, anticipated dates of entry and exit, length of stay, and place of residence. If mailback sections are included with the permit, the permit holder can document various trip-related observations, such as number of encounters, travel routes and destinations, actual length of stay, and perceptions of wilderness conditions.

Step 2: Decide on a Permit Form

Standard OMB-approved permits are available for each agency. Alternatively, customized permit formats can be used. However, OMB clearance must be obtained before the study begins if permits are to be issued in a revised format; this includes the addition of questions to standard permit forms. According to federal legislation, OMB clearance is required if federal employees ask more than nine members of the public the same set of questions. The proposed set of questions, methodology, and study justification must be submitted to OMB through the appropriate channels. For the Forest Service, application for clearance is submitted to Information Systems in Washington, DC, which forwards the application to the Department of Agriculture, and from there to OMB for final approval. The time from initial submission to final OMB clearance is usually about 3 months. Clearance is not required if shortened versions of the standard permit with fewer questions are used.

Step 3: Establish a Permit-Issue Procedure

The procedure for issuing permits will be determined by (1) the reason for issuing permits, and (2) the source of issue.

1. Reasons for Permit Issue.—Permits are issued to (a) provide a means of public contact, (b) restrict use or categories of user, and (c) monitor use.

(a) Public contact. If the objective in issuing permits is to create opportunities for public contact opportunity, visitors will be required to obtain permits in person at a centralized agency facility, such as a visitor center or ranger station. Visitor contact with a trained agency representative is valuable for promoting the professional image of the agency and increasing visitor knowledge of regulations, appropriate low-impact behaviors, potential hazards, and wilderness conditions. Visitors have the opportunity to discuss possible routes and destinations within the wilderness area, and to obtain other information of interest to them.

(b) Use restriction. If the objective in issuing permits is to restrict use, visitors will be required to obtain permits at a centralized agency facility, such as a visitor center or ranger station. Alternatively, if adequate computer facilities are available, permits can be issued from a number of different field offices by means of a computerized reservation system so that the number of permits available at any time can be tracked.

(c) Use monitoring. If permits are issued with the objective of collecting accurate visitor use data, there are no associated restrictions on where or how permits are issued. Permits may be issued by the agency or self-issued; numbers may be limited or unlimited.

2. Source of Permit Issue.—Permits are usually issued by agency personnel, but may be self-issued, or distributed through a cooperative arrangement with local vendors.

In the majority of cases, permits are issued from a central location by the managing agency. Staff at local ranger stations, information centers, or National Forest offices are responsible for issuing permits. Occasionally, permits may be reserved; reservations may be made by telephone or mail, or in other cases must be made in person if "no-shows" are a problem. Reserved permits may be mailed, or held until picked up by the visitor.

Self-issued permits are usually obtained from some convenient location. If permits are unlimited, they may be obtained from a station located outside the agency office or at trailheads, or from alternative locations, such as local businesses. However, if permit numbers are limited, they must be obtained from a central location.

If there are restrictions on certain types of users, permit-issue locations may be placed so as to accommodate different user groups. For example, if overnight use of a wilderness area must be rationed but day use is essentially unrestricted, a limited number of overnight permits are made available at some central location, whereas self-issued day-use permits are located at trailheads.

Permits may be issued through cooperative arrangements with local vendors or businesses. Wilderness permits may be issued by convenience stores, bait shops, commercial outfitters, travel information centers, or nearby campgrounds.

Step 4: Decide on Method of Implementing Compliance Checks

Unlike registration systems, which are voluntary, permit systems are mandatory. Visitors must obtain a permit to enter the wilderness area; otherwise they are not in compliance with regulations. However, accuracy of use estimation will be compromised if rates of compliance are unknown. Permit compliance may be as low as 53 percent with self-issued day-use permits to as high as 90 percent; compliance varies with type of user group, and increases with increased levels of enforcement, increased publicity about permit requirements, and increased visitor awareness of permit requirements.

The procedure for estimating compliance is similar to the calibration procedures described for systems using mechanical counters. Visitor counts obtained from a tally of permits are "calibrated" by supplementary observations so that the number of wilderness users who do not obtain permits can be accounted for, and total visitor counts can be adjusted accordingly. Interviews are also used to obtain information on nonobservable visit characteristics. The number of interviews required will depend on the desired amount of precision of both compliance estimates and estimates of use characteristics, the available resources, and the relative stability of visitor use over time. If use patterns change substantially over the season, compliance rates estimated at the beginning of the season will not be applicable later in the season; the accuracy of compliance rates must be spot checked at intervals and updated as required.

Frequently, permit compliance is determined in the course of routine wilderness ranger patrol. Rangers check for permit compliance as visitor groups are encountered, and tally the proportion of those encountered who do not have a permit; this is the so-called "roaming observation" technique. However, this type of visitor sampling results in extremely biased estimates of visitor use. Bias occurs because the probability of visitor contact depends on when and where the observer travels. Scheduling is not random but deliberately selected to coincide with periods of heaviest use; the probability that a visitor group will be encountered is proportional to the length of time spent in a given area, observer location in relation to visitor distance traveled, and so on.

Unbiased data can be obtained only by implementing statistical sampling strategies. Permit checkpoints should be established, and visitors sampled according to a predetermined sampling plan. Sampling may be strictly random, or stratified by day and systematic within that day. Sample sizes are determined with reference to the population of interest, the expected variation of the response variables, and the specified sampling plan (part I, chapter 3).

Step 5: Purchase Equipment

If permits are self-issued, permit stations need to be constructed. These stations should be both attractive and functional. Self-issue permit stations should be designed to provide (1) a place for supplies (pencils and permit forms), (2) a convenient, solid writing surface for the visitor to use when completing the permit, and (3) a place to deposit completed agency copy (normally a slot at the front). Stations may be constructed of wood or metal, and should be set on a post at a convenient height. An attractive and easy-to-read sign should be posted with instructions detailing (1) why a permit is required, (2) who is to obtain a permit (one person or everyone in the group), (3) where to deposit the completed agency copy, and (4) the consequences of being found in violation.

Step 6: Estimate Use

Use data are collected in accordance with the appropriate sample size and the sampling strategy. Data obtained from permits are supplemented with observations obtained during the permit compliance rate estimation phase. Use can be estimated for both observable and nonobservable categories of visitor, and visitor use is calculated as the number of visitors per category, expressed as a proportion or percentage of the total number of users.

1. Estimate Permit Compliance Rates.—Permit compliance rate is estimated as the ratio of the number of permit holders (determined by the total number of permits collected) to the total number of visitors (determined from observer counts) during the sample observation periods.

Example. A total of 575 visitors obtained permits during the 7-day permit compliance rate estimation phase. A random sample of n = 50 visitors indicated that 10 did not obtain permits. Therefore, the estimated permit compliance rate r was estimated as 40/50 = 0.8, or 80 percent. The total number of users (N) for a given period is estimated by the total number of permit holding visitors (t) divided by the permit compliance rate:

$$\hat{N} = t/r = 575/0.8 = 719$$

The 95 percent confidence interval for the total is estimated by $N \pm 2 \cdot SE =$

$719 \pm 2\sqrt{\left[(575)^2 \cdot 50(50-40)\right]/(40)^3} = 719 \pm 102$, or between 617 and 821 visitors.

2. Sample Size Estimation.—Because visitor count data are collected by counting permits, there may be insufficient resources available to cover the costs and time involved in the collection, input, and processing of large amounts of data. Sample sizes for categorical data should be specified first. Sample sizes should be estimated for each use characteristic to be measured, and the largest (feasible) sample size is chosen. If a stratified sampling strategy is used, stratum sample size is calculated according to whether proportional or disproportional representation is required.

(a) Count data. The relation used to estimate sample size is:

$$n \cong \left[4 \cdot \frac{S}{L}\right]^2$$

If the sampled population is small, the finite population correction (fpc) is used to correct for overestimation bias. Using the fpc, the estimated sample size is:

$$n \cong \frac{N \cdot S^2}{S^2 + \frac{L^2 \cdot N}{4(2)^2}}$$

where L is the width of the interval around the projected average, and N is the size of the true population. In this case, N is the number of days in the season. Precision is estimated by the confidence level (generally 95 percent) and the desired width of L. For example, the investigator may wish to be 95 percent certain that the results have a precision of ± 5 percent of the total. Operationally feasible sample sizes are obtained by varying the amount of precision of the estimate; highly precise estimates may require sample sizes that are too large for practical purposes.

Example. The average number of visitors observed per day during the compliance estimation phase was 250, with $S = 160$. There are 100 days in the season (N = 100). Suppose we want to be 95 percent certain that results will have a precision of ± 5 percent, or ± 13 visitors/day. The estimated number of sampling days is $\approx \frac{100(160)^2}{(160)^2 + \frac{(13+13)^2(100)}{16}} = 86$. If the precision is adjusted to ± 10 percent (or ± 25 visitors per day), then $n = 62$. Both of these are too large or too close to the entire season of 100 days to be of practical use due to the large underlying variance. A more reasonable level of precision would be ± 30 percent (or ± 75 visitors per day), which would call for a sample size of $n = 15$.

(b) Proportion data. Sample size (n) will be at a maximum when the proportion of observations (p) in any given category is 0.5 (or 50 percent). The sample size required to estimate an interval of width L around the sample mean will be:

$$n = \frac{4 \cdot (2)^2 \cdot p(1-p)}{L^2}$$

which is maximized for $p = 0.5$ or $n = 16(0.5)(0.5)/L^2$.

Example. Preliminary data showed that for 40 randomly selected visitors, 24 appeared to be day users. Therefore, the proportion of day users, $p = 24/40 = 0.60$, and the standard error is $\sqrt{p(1-p)/n} = \sqrt{(0.60)(0.40)/40} = 0.0775$. The 95 percent confidence interval based on these data is approximately 0.6 $\pm 2(0.0775) = 0.6 \pm 0.15$, for a confidence interval of (0.45, 0.75). The sample size n required for a 95 percent confidence interval with a length of at most 0.10 (regardless of the resulting value of p) is approximately $n = \frac{16(0.5)^2}{(0.10)^2} = 400$. Therefore, it would be necessary to observe 400 visitors to obtain this amount of precision for the estimate.

(c) Stratified sampling. If the data are stratified according to trailhead or time block, sample sizes of each stratum must be calculated to ensure accurate representation of the population. Sample sizes may be either proportional or disproportional to stratum size (part I, chapter 3). Proportional sampling subdivides the sample population proportional to the size of each strata or subgroup. Optimal allocation is a type of stratified sampling where the sample size within each strata is proportional to both the size and the variability of the sample within each stratum; the proportionality factor is calculated as $\left[N_i \cdot S_i / \sum\left(N_i \cdot S_i\right)\right] \cdot n$. Disproportional sampling occurs when the same size sample is drawn for each stratum (assuming equal costs to sample each strata).

Proportional sampling should be performed if strata are fairly homogeneous (that is, the standard deviations observed for each stratum are similar), whereas optimal allocation should be chosen if strata differ in the amount of variability.

Example. In this example, data are stratified by two time blocks—weekend days and weekdays. This stratification strategy separates out time periods according to relative intensity of use, with the heaviest and most variable use occurring on weekends, and relatively light and uniform use on weekdays. For a 100-day season, there are about 72 weekdays and 28 weekend days. Suppose the available resources (budget, labor, time) dictated that the maximum number of days that could be sampled was $n = 25$. The initial value for the standard deviation for each stratum was estimated from the data obtained during the permit compliance rate estimation phase. Sample sizes for each time block are calculated as follows:

		Proportional		Disproportional		Optimal allocation	
Stratum	s[a]	f[b]	n[c]	f	n	f	n
Weekends ($n_1 = 28$)	88.0	0.25	7	0.43	12	0.64	16
Weekdays ($n_2 = 72$)	19.2	0.25	18	0.17	12	0.36	9

[a]Standard deviation.
[b]Sampling proportion.
[c]Sample size.

Because the two strata differ considerably in variability, the preferred sampling scheme is optimal allocation; with this strategy the investigator randomly selects 16 weekend days and 9 weekdays for data collection.

3. Use Estimation.—Use characteristics estimated with this system are limited to individual or group visit counts. Data may be expressed in terms of: (a) the rate (for example, number of visitors per day), (b) the total (for example, number of visitors for the season), (c) use by category (for example, cooking method), or (d) use description (for example, length of stay).

(a) Rate of use. Suppose the number of visitors with permits for a 30 day time period was 772. A survey of 50 visitors showed that 46 had permits for a compliance rate of 46/50 = 0.92. The estimated number of users over the 30 day period is 772/0.92 = 839, for an estimated daily rate of 839/30 = 28 users per day. The estimated confidence interval for the 30 day rate is 839 ± $2 \cdot \sqrt{772^2 \cdot 50 \cdot (50 - 46) / 46^3}$ = 839 ± 70 = (769, 909), which converts to a confidence interval for the daily rate of (25.6, 30.3).

(b) Total use. Total visitor use is estimated by multiplying the "corrected" average daily rate by the number of days in the time period of interest, corrected by the estimated bias in counts. *The assumption implicit in this method is that use remains uniform over the time period of interest; if use patterns fluctuate considerably over the season, calibration relationships should be updated as required, and the new relationship used to calculate use rates for that time interval.*

In this example, season length was 100 days. The overall visitor use estimate is therefore 28(100) = 2,800 visitors (2,560 to 3,030 visitors).

(c) Use by category. Frequently, visitor use is described in terms of categories, or groups, of users; the number of users in each category is expressed as a proportion, or percentage, of the total number of users in the sample.

Example. On the permit form 2,975 visitors indicated their method of cooking during their visit: stoves, wood fires, or neither. Results with a 95 percent confidence interval (using χ^2 procedure based on 2 degrees of freedom) were:

Stove users: n_1 = 2,231, p_1 = 2,231/2,975 = 0.75,

$$\text{95 percent confidence interval} = 0.75 \pm \sqrt{5.99[(0.75)(0.25)/2,975]} = 0.75 \pm 0.019$$

= (0.731 to 0.769);

Wood fire users: n_2 = 595, p_2 = 595/2,975 = 0.20,

$$\text{95 percent confidence interval} = 0.20 \pm \sqrt{5.99[(0.20)(0.80)/2,975]} = 0.20 \pm 0.018$$

= (0.18 to 0.22);

Neither: n_3 = 149, p_3 = 149/2,975 = 0.05,

$$\text{95 percent confidence interval} = 0.05 \pm \sqrt{5.99[(0.05)(0.95)/2,975]} = 0.05 \pm 0.009$$

= (0.04 to 0.06).

(d) Use description. One variable that may be obtained by permits is length of stay. Post stratification may also be of interest.

Example. A sample of 38 permits had an average length of stay of 2.4 nights with a standard error of 0.23 nights. This makes the 95 percent confidence interval 2.4 ± 2·0.23 = 2.4 ± 0.46 = (1.94, 2.86).

Day-use horseback rider registration ranges from a low of 0 percent to 89 percent.

System G: Permit System With Compliance Checks and Sample Interviews

System Description

Permits are mandatory use-authorization forms issued by the agency. Use information obtained is determined by the permit form and by the interview format; this system provides sufficient information to estimate summary-use statistics, as well as basic visit counts, visit and visitor characteristic data. Compliance checks are required for accurate estimation of total use. A random selection of visitors is interviewed to obtain supplementary information not provided by the permit. Because visitors are responsible for obtaining permits, and because visitors are contacted directly for interviews, visitor burden is relatively high.

Summary of System G:

Type of observations:	Counts Observable characteristics Simple nonobservable characteristics Complex nonobservable characteristics
Measures of visitor use:	Number of individual visits Number of group visits Use by categories of user Summary-use statistics
Data collection strategies:	Permit-issue process Sampling plan for visitor selection
Techniques/procedures:	Permits Compliance checks Sample interviews
Visitor burden:	Moderate to high

Operational Procedures

Step 1: Decide on Use Characteristics

Use characteristics that can be obtained are limited only by the permit format. Information obtained from permits can include the number of individuals or groups, group size, method of travel, anticipated dates of entry and exit, length of stay, and place of residence. Mailback sections attached to the permit enable the permit holder to document various trip-related observations, such as number of encounters, travel routes and destinations, actual length of stay, and perceptions of wilderness conditions.

Nonobservable visit and visitor characteristics not on the permit form are acquired by interviewing a random selection of visitors. The characteristics include specific length-of-stay information, anticipated wilderness travel patterns and routes, visit frequency, activities, and visitor perception of problems and resource conditions, past wilderness experience, knowledge of regulations and low-impact procedures, preferences for various management strategies, and so forth.

Step 2: Decide on a Permit Form

Standard OMB-approved permits are available for each agency. Alternatively, customized permit formats can be used. However, OMB clearance must be obtained before the study begins if permits are to be issued in a revised format; this includes the addition of questions to standard permit forms. According to federal legislation, OMB clearance is required if federal employees ask more than nine members of the public the same set of questions. The proposed set of questions, methodology, and study justification must be submitted to OMB through the appropriate channels. For the Forest Service, application for clearance is submitted to that Agency's Information Systems office in Washington, DC, which forwards the application to the Department of Agriculture, and from there to OMB for final approval. The time from initial submission to final OMB clearance is usually about 3 months. Clearance is not required if shortened versions of the standard permit with fewer questions are used.

Step 3: Establish a Permit-Issue Procedure

The procedure for issuing permits will be determined by (1) the reason for issuing permits, and (2) the source of issue.

1. Reasons for Permit Issue.—Permits are issued to (a) provide a means of public contact, (b) restrict use or categories of user, and (c) monitor use.

(a) Public contact. If the objective in issuing permits is to create opportunities for public contact opportunity, visitors will be required to obtain permits in person at a centralized agency facility, such as a visitor center or ranger station. Visitor contact with a trained agency representative is valuable for promoting the professional image of the agency and increasing visitor knowledge of regulations, appropriate low-impact behaviors, potential hazards, and wilderness conditions. Visitors have the opportunity to discuss possible routes and destinations within the wilderness area, and to obtain other information of interest to them.

(b) Use restriction. If the objective in issuing permits is to restrict use, visitors will be required to obtain permits at a centralized agency facility, such as a visitor center or ranger station. Alternatively, if adequate computer facilities are available, permits can be issued from a number of different field offices by means of a computerized reservation system so that the number of permits available at any time can be tracked.

(c) Use monitoring. If permits are issued with the objective of collecting accurate visitor use data, there are no associated restrictions on where or how permits are issued. Permits may be issued by the agency or self-issued; numbers may be limited or unlimited.

2. Source of Permit Issue.—Permits are usually issued by agency personnel, but may be self-issued, or distributed through a cooperative arrangement with local vendors.

In the majority of cases, permits are issued from a central location by the managing agency. Staff at local ranger stations, information centers, or National Forest offices are responsible for issuing permits. Occasionally, permits may be reserved; reservations may be made by telephone or mail, or in other cases must be made in person if "no-shows" are a problem. Reserved permits may be mailed, or held until picked up by the visitor.

Self-issued permits are usually obtained from some convenient location. If wilderness use is unrestricted, permit access does not need to be monitored closely. As a result, permits may be obtained from a station located outside the agency office or at trailheads, or from alternative locations, such as local businesses. However, if permit numbers are limited, permits must be obtained from a central location where permit acquisition can be regulated.

If there are restrictions on certain types of users, permit-issue locations may be placed so as to accommodate different user groups. For example, if overnight use of a wilderness area must be rationed but day use is essentially unrestricted, a limited number of overnight permits are made available at some central location, whereas self-issued day-use permits are located at trailheads.

Permits may be issued through cooperative arrangements with local vendors or businesses. Wilderness permits may be issued by convenience stores, bait shops, commercial outfitters, travel information centers, or nearby campgrounds.

Step 4: Develop Sampling Plan

Sample plans must be developed for:

1. Implementing compliance checks, and
2. Selecting visitors for interviews.

1. Compliance Checks.—Unlike registration systems, which are voluntary, permit systems are mandatory. Visitors must obtain a permit to enter the wilderness area, otherwise they are not in compliance with regulations. However, accuracy of use estimation will be compromised if rates of compliance are unknown. Permit compliance may be as low as 53 percent with self-issued day-use permits, to as high as 90 percent; compliance varies with type of user group, and increases with increased levels of enforcement, increased publicity about permit requirements, and increased visitor awareness of permit requirements.

The procedure for estimating compliance is similar to the calibration procedures described for systems using mechanical counters. Visitor counts obtained from a tally of permits are "calibrated" by supplementary observations so that the number of wilderness users who do not obtain permits can be accounted for, and total visitor counts can be adjusted accordingly. The number of compliance checks required will depend on the desired amount of precision, the available resources, and the relative stability of visitor use over time. If use patterns change substantially over the season, compliance rates estimated at the beginning of the season will not be applicable later in the season; the accuracy of compliance rates must be spot checked at intervals and updated as required.

Frequently, permit compliance is determined in the course of routine wilderness ranger patrol. Rangers check for permit compliance as visitor groups are encountered, and tally the proportion of those encountered who do not have a permit; this is the so-called “roaming observation” technique. However, this type of visitor sampling results in extremely biased estimates of visitor use. Bias occurs because the probability of visitor contact depends on when and where the observer travels. Scheduling is not random but deliberately selected to coincide with periods of heaviest use; the probability that a visitor group will be encountered is proportional to the length of time spent in a given area, and observer location in relation to visitor distance traveled.

Unbiased data can be obtained only by implementing statistical sampling strategies. Permit checkpoints should be established, and visitors sampled according to a predetermined sampling plan. Sampling may be strictly random, or stratified by day and systematic within that day. Sample sizes are determined with reference to the population of interest, the expected variation of the response variables, and the specified sampling plan (part I, chapter 3).

2. Interviews.—Interviews are conducted by contacting visitors at a checkpoint station outside the wilderness boundary. Interviews are used to obtain information on non-observable visit characteristics.

The two steps in the formulation of an appropriate sampling plan for visitor selection are an estimate of the sample size, and a time schedule.

(a) Sample size estimation. Determination of the appropriate sample size requires a preliminary estimate of the variability in the observations. Preliminary estimates are obtained from a pilot study, or from data collected in previous years. A common requirement of many wilderness studies is the comparison of count or frequency data by category; categories are identified by specific visit characteristic. To ensure adequate representation, sampling may have to be stratified by category. See part I, chapter 3, for further details of sample design.

(b) Time schedule. For the sample to be representative of all visitors entering the wilderness area, interviews must be scheduled according to a statistical sampling plan. Unless the wilderness area has a strictly enforced permit program, visitors cannot be randomly selected for interviewing prior to arrival. If there is no regulation of visitor entry and exit, the alternative is the random selection of interview days, followed by random selection of visitors within the sample day. Sampling may be completely random, systematic (for example, selective censusing of every tenth wilderness visitor, or every fifth car passing a checkpoint), stratified, or a combination of these (part I, chapter 3).

Step 5: Purchase Equipment

If permits are self-issued, permit stations need to be constructed. These stations should be both attractive and functional. Self-issue permit stations should be designed to provide (a) a place for supplies (pencils and permit forms, (b) a convenient, solid writing surface for the visitor to use when completing the permit, and (c) a place to deposit completed agency copy (normally a slot at the front). Stations may be constructed of wood or metal, and should be set on a post at a convenient height. An attractive and easy-to-read sign should be posted with instructions detailing (a) why a permit is required, (b) who is to obtain a permit (one person or everyone in the group), (c) where to deposit the completed agency copy, and (d) the consequences of being found in violation.

Step 6: Select and Train the Interview Team

Careful selection and training of the personnel who are involved in collecting data are essential if the manager or research planner is not performing the field research. The research planner must ensure that interviews are conducted and observations collected in the manner required by the study plan.

1. Personnel Selection.—Both personality and ability must be evaluated in the selection process. The importance of visitor contact extends beyond the quality of data obtained; it is an opportunity to present the image of the managing agency. Select an interviewer who is friendly, reliable, knowledgeable, and trained in emergency procedures. Personnel should be familiar with the wilderness area and be prepared to handle requests for information about the wilderness and the surrounding area. Many of the questions from visitors will not be related to the interview; providing information is a courtesy which contributes to establishing rapport with the visitors and increases visitor cooperation. Personnel should be in appropriate uniform and possess necessary communication and safety equipment.

2. Training.—It is essential that personnel are thoroughly trained in the data collection procedures. Training ensures that observers are already familiar with the research directives and the interviewing process before actual fieldwork begins. As a result, errors involved in the learning process are reduced, and there will be greater consistency in identifying the sampling units (in this case visitors to be interviewed) and recording responses. Training enables observers to become familiar with various contingency plans, to identify potential problems in the research directives, and to make decisions if problems occur.

Preliminary, or pretest, fieldwork should be conducted before the actual survey begins. These rehearsals ensure that personnel understand procedures, and serve as a test for the efficiency of the methods; problems or inadequacies in the procedures can be identified and eliminated, and the consistency and accuracy of personnel can be observed and analyzed. Observers should be screened at intervals, and their performance compared either with each other or at different time points for the same observer; screening provides a check on performance and identifies sources of error in the data.

Step 7: Collect Compliance Rate and Interview Data

Information on compliance rates and interview data are collected separately by observers. Both types of information are collected according to a specific plan (as described in step 4). The observer must be provided with sufficient research material—data forms, writing tools, schedules, and so forth,—for the observation period. Observers must understand the need to completely and correctly fill out the data forms. Observation sheets should be filed in a designated place after the observer returns to the office.

1. Compliance Rates.—Compliance rate observations are obtained during the sample observation period (step 4). Observations must be recorded in a

standardized format (see fig. 1 for a sample form). For each data sheet, the observer should record their name, the sampling location, the date, start time, and end time for that sample period. The minimum information required to estimate compliance rates includes number of individuals, number of groups, method of travel, date and time of entry or exit, and use category (day user or overnight user).

2. Interview Data.—The interview protocol consists of four steps: (a) determining question format, (b) obtaining OMB clearance, (c) visitor selection, and (d) data collection.

(a) Question format. The questions asked of the visitor will be dictated by the study objectives; that is, on the basis of what the manager wants to know and why. Questions should be easily understood by the visitor, they should not be too long, and there should not be too many of them. The major principle in question development is the *necessity to keep visitor burden to a minimum. Ask only the questions necessary to meet the study objectives, and no more.*

The questions asked of the respondents will depend on what kind of information is required to meet the study objectives. Questions can be categorized on the basis of one or more of the following types of information:

- *Attitudes*: what people say they want or how they feel about something;
- *Beliefs*: what people think is true or false;
- *Behavior*: what people do;
- *Attributes*: what people are (personal or demographic features).

Questions must be clearly identified according to information type, otherwise responses will lead to a different type of information than required by the study objectives.

The question designer is rarely a good judge of the clarity of the questions (Ackoff 1953). *Preliminary field tests are invaluable for identifying problems, and should be conducted before the actual field surveys begin.* Colleagues, potential "users" of the data, and, if possible, a small pretest sample of prospective respondents should fill out the questionnaire; a debriefing session should follow to identify problems. If some inadequacy or ambiguity becomes apparent with the set questions, questions may be added, but only if they clarify the meaning and satisfy the requirements of step 1.

(b) Obtain OMB clearance. According to federal legislation, clearance from the Office of Management and Budget (OMB) is required if federal employees ask more than nine members of the public the same set of questions. The proposed set of questions, methodology, and study justification must be submitted to OMB through the appropriate channels. For the Forest Service, application for clearance is submitted to Information Systems in Washington, DC, which then forwards the application to the Department of Agriculture, and from there to OMB for final approval. The time from initial submission to final OMB clearance is usually about 3 months.

(c) Visitor selection. Visitors are selected in accordance with the predetermined sampling plan (step 4). The location of interviews will be determined by study objectives; visitors may be interviewed upon either entry or exit, or both. For example, if the emphasis of the study is on the effects of group size or place of residence on wilderness use, these factors are unaffected by interview location. However, if the study objectives require information on patterns of visitor use within the wilderness area (for example, travel or camping locations, length of stay), visitors should be interviewed as they leave. Visitors should not be interviewed inside the wilderness boundary (to avoid threats to the visitor experience from management presence).

(d) Data collection. When interviewing visitors, personnel should begin with a standard introduction. Personnel should give their name and agency affiliation and the reason for the interview. For example, "Hello, I am Marilyn Holgate. I work for the Missoula District of the Lolo National Forest. We are trying to learn more about the use of the Rattlesnake Wilderness. It will help us with management of the area. May I ask you a few questions about your visit today?" After the interview, thank visitors for their time. Personnel may be tempted to add additional questions "just out of curiosity"; this cannot be justified in any circumstances.

Responses should be recorded as they are given; *interviewers should not rely on memory to fill in the interview sheet at a later time.* Make sure every item is complete and legible; data forms must include date, time, location, and interviewer's name. Completed data forms should be filed in a safe place.

Step 8: Estimate Use

Use data are collected in accordance with the appropriate sample size and the sampling strategy. Data obtained from permits are supplemented with observations obtained during the permit compliance rate estimation phase. Use can be estimated for both observable and nonobservable categories of visitor, and visitor use is calculated as the number of visitors per category, expressed as a proportion or percentage of the total number of users.

1. Estimate Permit Compliance Rates.—Permit compliance rate is estimated as the ratio of the number of permit holders (determined by the total number of permits collected) to the total number of visitors (determined from observer counts) during the sample observation periods.

Example. A total of 575 visitors obtained permits during the 7-day permit compliance rate estimation phase. A random sample of $n = 50$ visitors indicated that 10 did not obtain permits. Therefore, the estimated permit compliance rate r was estimated as 40/50 = 0.8, or 80 percent. The total number of users (N) for a given period is estimated by the total number of permit holding visitors (t) divided by the permit compliance rate:

$$\hat{N} = t/r = 575/0.8 = 719.$$

The 95 percent confidence interval for the total is estimated by $N \pm 2 \cdot SE =$

$719 \pm 2\sqrt{\left[(575)^2 \cdot 50(50-40)\right]/(40)^3} = 719 \pm 102$, or between 617 and 821 visitors.

2. Sample Size Estimation.—Because visitor count data are collected by counting permits, there may be insufficient resources available to cover the costs and time involved in the collection, input, and processing of large amounts of data. Sample sizes for categorical data should be specified first. Sample sizes should be estimated for each use characteristic to be measured, and the largest (feasible) sample size is chosen. If a stratified sampling strategy is used, stratum sample size is calculated according to whether proportional or disproportional representation is required.

(a) Count data. The relation used to estimate sample size is:

$$n \cong \left[4 \cdot \frac{S}{L}\right]^2$$

If the sampled population is small, the finite population correction (fpc) is used to correct for overestimation bias. Using fpc, the estimated sample size is:

$$n \cong \frac{N \cdot S^2}{S^2 + \frac{L^2 \cdot N}{4(2)^2}}$$

where L is the width of the interval around the projected average, and N is the size of the true population. In this case, N is the number of days in the season. Precision is estimated by the confidence level (generally 95 percent) and the desired width of L. For example, the investigator may wish to be 95 percent certain that the results have a precision of ± 5 percent of the total. Operationally feasible sample sizes are obtained by varying the amount of precision of the estimate; highly precise estimates may require sample sizes that are too large for practical purposes.

Example. The average number of visitors observed per day during the compliance estimation phase was 250, with S = 160. There are 100 days in the season (N = 100). Suppose we want to be 95 percent certain that results will have a precision of ± 5 percent, or ± 13 visitors/day. The estimated number of sampling days is $\approx \frac{100(160)^2}{(160)^2 + \frac{(13+13)^2(100)}{16}} = 86.$ If the precision is adjusted to ± 10 percent (or ± 25 visitors per day), then $n = 62$. Both of these are too large or too close to the entire season of 100 days to be of practical use due to the large underlying variance. A more reasonable level of precision would be ± 30 percent (or ± 75 visitors per day), which would call for a sample size of n = 15.

(b) Proportion data. Sample size (n) will be at a maximum when the proportion of observations (p) in any given category is 0.5 (or 50 percent). The sample size required to estimate an interval of width L around the sample mean will be:

$$n = \frac{4 \cdot (2)^2 \cdot p(1-p)}{L^2}$$

which is maximized for p = 0.5 or $n = 16(0.5)(0.5)/L^2$.

Example. Preliminary data showed that for 40 randomly selected visitors, 24 appeared to be day users. Therefore, the proportion of day users, (p) = 24/40 = 0.60, and the standard error is $\sqrt{p(1-p)/n} = \sqrt{(0.60)(0.40)/40}$ = 0.0775. The 95 percent confidence interval based on these data is approximately 0.6 ± 2(0.0775) = 0.6 ± 0.15, for a confidence interval of (0.45, 0.75). The sample size n required for a 95 percent confidence interval with a length of at most 0.10 (regardless of the resulting value of p) is approximately $n = \frac{16(0.5)^2}{(0.10)^2}$ = 400. Therefore, it would be necessary to observe 400 visitors to obtain this amount of precision for the estimate.

(c) Stratified sampling. If the data are stratified according to trailhead or time block, sample sizes of each stratum must be calculated to ensure accurate representation of the population. Sample sizes may be either proportional or disproportional to stratum size (part I, chapter 3). Proportional sampling subdivides the sample population proportional to the size of each strata or subgroup. Optimal allocation is a type of stratified sampling where the sample size within each strata is proportional to both the size and the variability of the sample within each stratum; the proportionality factor is calculated as $\left[N_i \cdot S_i / \sum\left(N_i \cdot S_i\right)\right] \cdot n$. Disproportional sampling occurs when the same size sample is drawn for each stratum (assuming equal costs to sample each strata).

Proportional sampling should be performed if strata are fairly homogeneous (that is, the standard deviations observed for each stratum are similar), whereas optimal allocation should be chosen if strata differ in the amount of variability.

Example. In this example, data are stratified by two time blocks—weekend days and weekdays. This stratification strategy separates out time periods according to relative intensity of use, with the heaviest and most variable use occurring on weekends, and relatively light and uniform use on weekdays. For a 100-day season, there are about 72 weekdays and 28 weekend days. Suppose the available resources (budget, labor, time) dictated that the maximum number of days that could be sampled was $n = 25$. The initial value for the standard deviation for each stratum was estimated from the data obtained during the permit compliance rate estimation phase. Sample sizes for each time block are calculated as follows:

		Proportional		**Disproportional**		**Optimal allocation**	
Stratum	s[a]	f[b]	n[c]	f	n	f	n
Weekends ($n_1 = 28$)	88.0	0.25	7	0.43	12	0.64	16
Weekdays ($n_2 = 72$)	19.2	0.25	18	0.17	12	0.36	9

[a]Standard deviation.
[b]Sampling proportion.
[c]Sample size.

Because the two strata differ considerably in variability, the preferred sampling scheme is optimal allocation; with this strategy the investigator randomly selects 16 weekend days and 9 weekdays for data collection.

3. Use Estimation.—Use characteristics estimated with this system include individual or group visit counts. Data may be expressed in terms of: (a) the rate (for example, number of visitors per day), (b) the total (for example, number of visitors for the season), (c) use by category (for example, cooking method), (d) use description (for example, length of stay), or (e) summary-use statistics (for example, recreation visitor days).

(a) Rate of use. Suppose the number of visitors with permits for a 30 day time period was 772. A survey of 50 visitors showed that 46 had permits for a compliance rate of 46/50 =0.92.The estimated number of users over the 30 day period is 772/0.92 = 839, for an estimated daily rate of 839/30 = 28 users per day. The estimated confidence interval for the 30 day rate is

$839 \pm 2 \cdot \sqrt{772^2 \cdot 50 \cdot (50-46)/46^3}$ = 839 ± 70 = (769, 909), which converts to a confidence interval for the daily rate of (25.6, 30.3).

(b) Total use. Total visitor use is estimated by multiplying the "corrected" average daily rate by the number of days in the time period of interest, corrected by the estimated bias in counts. *The assumption implicit in this method is that use remains uniform over the time period of interest; if use patterns fluctuate considerably over the season, calibration relationships should be updated as required, and the new relationship used to calculate use rates for that time interval.*

In this example, season length was 100 days. The overall visitor use estimate is therefore 28(100) = 2,800 visitors (2,560 to 3,030 visitors).

(c) Use by category. Frequently, visitor use is described in terms of categories, or groups, of users; the number of users in each category is expressed as a proportion, or percentage, of the total number of users in the sample.

Example. On the permit form 2,975 visitors indicated their method of cooking during their visit: stoves, wood fires, or neither. Results with a 95 percent confidence interval (using χ^2 procedure based on 2 degrees of freedom) were:

Stove users: n_1 = 2,231, p_1 = 2,231/2,975 = 0.75,

$$95 \text{ percent confidence interval} = 0.75 \pm \sqrt{5.99[(0.75)(0.25)/2,975]} = 0.75 \pm 0.019$$

= (0.731 to 0.769);

Wood fire users: n_2 = 595, p_2 = 595/2,975 = 0.20,

$$95 \text{ percent confidence interval} = 0.20 \pm \sqrt{5.99[(0.20)(0.80)/2,975]} = 0.20 \pm 0.018$$

= (0.18 to 0.22);

Neither: n_3 = 149, p_3 = 149/2,975 = 0.05,

$$95 \text{ percent confidence interval} = 0.05 \pm \sqrt{5.99[(0.05)(0.95)/2,975]} = 0.05 \pm 0.009$$

= (0.04 to 0.06).

(d) Use description. One variable that may be obtained by permits is length of stay. Post stratification may also be of interest.

Example. A sample of 38 permits had an average length of stay of 2.4 nights with a standard error of 0.23 nights. This makes the 95 percent confidence interval 2.4 ± 2·0.23 = 2.4 ± 0.46 = (1.94, 2.86).

(e) Summary-use statistics. The recreation visitor-day is defined as 12 hours of a given recreation activity performed by the associated proportion of visitors. It is calculated as the product of the number of activity occasions and the average amount of time spent in that activity, divided by 12.

Example. The number of permits issued for a given season was 6,750, of which 1,232 were horse users. For horse users, there were 3.1 people per group, and 5.2 horses per group; the estimated compliance rate was 95 percent. The total number of horse users was 3.1(1,232)/(0.95) = 4,020 people, and 5.2(1,232)/(0.95) = 6,744 horses. The average duration of a wilderness trip was 5 days, or 120 hours. Then, the number of recreation visitor-days for horse users during the season was 4,020(120)/12 = 40,200.

System H: Permit System With Compliance Checks and Mailback Questionnaires

System Description

Permits are mandatory use-authorization forms issued by the agency. Use information is determined by both the permit form and questionnaire format; this system provides sufficient information to estimate summary-use statistics, as well as basic visit counts, visit and visitor characteristic data. Compliance checks are required for accurate estimation of total use. Mailback questionnaires provide supplementary information on complex nonobservable visit characteristics. Mail surveys are much less expensive to implement than face-to-face interviews, and the inherent problem of low response rate can be surmounted to a great extent by planned followup. Because visitors are responsible for obtaining permits, and because visitors fill out and return questionnaires, visitor burden is relatively high.

Summary of System H:

Type of observations:	Counts Observable characteristics Simple nonobservable characteristics Complex nonobservable characteristics
Measures of visitor use:	Number of individual visits Number of group visits Use by category of user Summary-use statistics
Data collection strategies:	Permits Sample plan for compliance checks Sample plan for visitor selection for questionnaires
Techniques/procedures:	Permit issue Compliance checks Mailback questionnaires Follow-up mailing Estimate response rates
Visitor burden:	Moderate to high

Operational Procedures

Step 1: Decide on Use Characteristics to Measure

Use characteristics that can be obtained are limited only by the permit format. Information obtained from permits can include the number of individuals or groups, group size, method of travel, anticipated dates of entry and exit, length of stay, and place of residence. Mailback questionnaires enable the permit holder to document various trip-related observations, such as number of encounters, travel routes and destinations, actual length of stay, and perceptions of wilderness conditions, problems and resource conditions, past wilderness experience, knowledge of regulations and low-impact procedures, preferences for various management strategies, and so forth.

Step 2: Decide on a Permit Form

Standard OMB-approved permits are available for each agency. Alternatively, customized permit formats can be used. However, OMB clearance must be obtained before the study begins if permits are to be issued in a revised format; this includes the addition of questions to standard permit forms. According to federal legislation, OMB clearance is required if federal employees ask more than nine members of the public the same set of questions. The proposed set of questions, methodology, and study justification must be submitted to OMB through the appropriate channels. For the Forest Service, application for clearance is submitted to that Agency's Information Systems office in Washington, DC, which forwards the application to the Department of Agriculture, and from there to OMB for final approval. The time from initial submission to final OMB clearance is usually about 3 months. Clearance is not required if shortened versions of the standard permit with fewer questions are used.

Step 3: Establish a Permit-Issue Procedure

The procedure for issuing permits will be determined by (1) the reason for issuing permits, and (2) the source of issue.

1. Reasons for Permit Issue.—Permits are issued to (a) provide a means of public contact, (b) restrict use or categories of user, and (c) monitor use.

(a) Public contact. If the objective in issuing permits is to create opportunities for public contact, visitors will be required to obtain permits in person at a centralized agency facility, such as a visitor center or ranger station. Visitor contact with a trained agency representative is valuable for promoting the professional image of the agency and increasing visitor knowledge of regulations, appropriate low-impact behaviors, potential hazards, and wilderness conditions. Visitors have the opportunity to discuss possible routes and destinations within the wilderness area, and to obtain other information of interest to them.

(b) Use restriction.—If the objective in issuing permits is to restrict use, visitors will be required to obtain permits at a centralized agency facility, such as a visitor center or ranger station. Alternatively, if adequate computer facilities are available, permits can be issued from a number of different field offices by means of a computerized reservation system so that the number of permits available at any time can be tracked.

(c) Use monitoring.—If permits are issued with the objective of collecting accurate visitor use data, there are no associated restrictions on where or how permits are issued. Permits may be issued by the agency or self-issued; numbers may be limited or unlimited.

2. Source of Permit Issue.—Permits are usually issued by agency personnel, but may be self-issued, or distributed through a cooperative arrangement with local vendors. In the majority of cases, permits are issued from a central location by the managing agency. Staff at local ranger stations, information centers, or National Forest offices are responsible for issuing permits. Occasionally, permits may be reserved; reservations may be made by telephone or mail, or in other cases must be made in person if "no-shows" are a problem. Reserved permits may be mailed, or held until picked up by the visitor.

Self-issued permits are usually obtained from some convenient location. If permits are unlimited, they may be obtained from a station located outside the agency office or at trailheads, or from alternative locations, such as local businesses. However, if permit numbers are limited, they must be obtained from a central location.

If there are restrictions on certain types of user, permit-issue locations may be placed so as to accommodate different user groups. For example, if overnight use of a wilderness area must be rationed but day use is essentially unrestricted, a limited number of overnight permits is made available at some central location, whereas self-issued day-use permits are located at trailheads.

Permits may be issued through cooperative arrangements with local vendors or businesses. Wilderness permits may be issued by convenience stores, bait shops, commercial outfitters, travel information centers, or nearby campgrounds.

Step 4: Develop the Mailback Questionnaire

To be effective, a questionnaire must (1) enable managers to find out what they want to know, (2) encourage respondents to answer, and (3) minimize respondent burden.

There are four major steps involved in the design of an effective questionnaire: (1) question development, (2) format, (3) mailing, and (4) followup (Dillman 1978). When in the development stages of this system, the manager is strongly encouraged to have the questionnaire and methodology reviewed by a social scientist from a university or the agency.

1. Question Development.—The questions asked of the visitor will be dictated by the study objectives; that is, on the basis of what the manager wants to know and why. Questions should be easily understood by the visitor, they should not be too long, and there should not be too many of them. The major principle in question development is the *necessity to keep visitor burden to a minimum. Ask only the questions necessary to meet the study objectives, and no more.*

The questions asked of the respondents will depend on what kind of information is required to meet the study objectives. Questions can be categorized on the basis of one or more of the following types of information:

- *Attitudes*: what people say they want or how they feel about something;
- *Beliefs*: what people think is true or false;
- *Behavior*: what people do;
- *Attributes*: what people are (personal or demographic features).

Questions must be clearly identified according to information type, otherwise responses will lead to a different type of information than that required by the study objectives.

The question designer is rarely a good judge of the clarity of the questions (Ackoff 1953). *Preliminary field tests are invaluable for identifying problems, and should be conducted before the actual field surveys begin.* Colleagues, potential "users" of the data, and, if possible, a small pretest sample of prospective respondents should fill out the questionnaire; a debriefing session should follow to identify problems. If some inadequacy or ambiguity becomes apparent with the set questions, questions may be added, but only if they clarify the meaning and satisfy the requirements of step 1.

2. Format.—There are three factors to be considered in planning questionnaire format: (a) length, (b) question ordering, and (c) design and layout.

(a) Length. Questions should not be too long, and there should not be too many of them. Questions must be worded so that respondents understand them as the investigator wants them to; language should be simple and clear, and there should not be too much information demanded in any one question. If in doubt, the question should be broken into two or more questions.

The questionnaire should be as short as possible, without compromising the study objectives, or resulting in incomplete information. A single-page questionnaire is acceptable, but may be too short to be useful. The maximum questionnaire length is approximately 12 pages (Dillman 1978).

Personnel may be tempted to add additional questions "just out of curiosity"; this cannot be justified in any circumstances. Do not add questions merely to fill up space on the questionnaire sheet.

(b) Question ordering. Questions are presented in order from simple to complex; this is the so-called "funnel" format. Question order improves data quality by encouraging respondents to answer because both resistance to answering and the perceived effort involved are lessened. Once a commitment is made to answer a few questions, there is an increased likelihood that the survey will be completed.

The questionnaire is introduced with a paragraph outlining the central topic, the interest and importance of the topic, and its interest and relevance to the respondent. The first few questions are the most important, as they will determine whether the questionnaire is completed or thrown in the garbage. The first few questions get the survey started by setting the pace and manner of the survey, and encouraging respondents to answer. In general, initial questions should be (1) relevant and interesting, (2) easy to answer, and (3) applicable to all potential visitors. The first question should obviously be related to the topic, and have socially useful implications. The questions should be easy to answer, taking only a few seconds to understand and answer. Therefore, long, complex and open-ended questions, and statements requiring the respondent to express an attitude or opinion, should be avoided. The questions should have wide applicability. Questions that involve a category of "does not apply" or "don't know" suggest to the respondent that the rest of the questionnaire is equally irrelevant; this is a major contributor to nonresponse. Simple, easy-to-answer questions include questions about wilderness travel routes and destinations, activities participated in, group size and composition, number of other users encountered and where, length of visit, and so on.

Subsequent questions are ordered in descending importance with respect to the topic; topical questions are asked before questions related to personal characteristics. Questions should be ordered so that they follow a logical sequence. More complex questions will require some thought or judgment on the part of the respondent; complex questions are formulated to attain information on visitor perceptions, judgments, opinions, or attitudes. Examples are the relative importance of various aspects of the wilderness trip in achieving “quality” wilderness experiences, attitudes toward management strategies intended to reduce visitor impact, and the acceptability of various levels of social or resource condition impacts. Personal or confidential questions should be placed last; these include extent of past wilderness experience, knowledge of low-impact procedures, income and education levels.

(c) Design and layout. Response rates are greatly affected by the details of questionnaire design and layout. Questionnaires should be attractive, easy to read, and look easy to do, so that respondents are motivated to complete them. The overall design must prevent respondents from missing or overlooking questions or whole sections.

The following design guidelines are from Dillman (1978).

• **Booklet format**. The questionnaire should be printed as a booklet, with approximate dimensions of 6" x 8". If each page is typed using 12-point font on standard 8.5" x 11" paper with ¾" margins, reduction by 79 percent will fit booklet format. The questionnaire booklet is reproduced on white or off-white paper using good-quality printing methods; if pages are printed on both sides, sixteen pound paper is recommended.

• **Cover design.** Questionnaire covers determine the overall first impression of the study, and significantly influence response rates. The front cover must include (a) a study title, (b) a graphic illustration, (c) any needed directions, (d) the name, address and logo of the sponsoring agency, and (e) the identification number. The title should give an informative and accurate impression of the study topic, make the questionnaire sound interesting, and should be neutral (that is, it should not sound threatening or imply bias). The illustration adds interest; it should be simple and representative of the topic. The address of the study sponsor is important as backup information in case respondents lose return envelopes. The name of the researcher is not included in the address; the legitimacy of the study is endorsed by the backing of the sponsoring agency, not by some unknown individual. The back cover consists of a request for additional comments, and a statement of thanks. The back cover should never include questions; because questions are ordered, the questions that would appear there are most likely to be found objectionable by respondents, and the probability of nonresponse is greatly increased.

The questionnaire is identified with a stamped individual identification number; this number corresponds to the number assigned to each recipient on the mailing list. In general, the ID number should be placed in the upper right-hand corner of the front cover.

• **Lettering**. Distinguish questions from answers by using lower-case letters for questions and UPPER-CASE LETTERS FOR POSSIBLE ANSWERS.

• **Make questions fit the page**. Questions should not continue onto the next page. Manipulate spacing (margins, line spacing), or rearrange question order. However, large blank spaces should be avoided.

• **Identification of answer categories**. Assign a number for each answer category; this provides a convenient method of coding answers for subsequent computer processing. Place numbers to the left of the answer category; this minimizes the possibility of the respondent indicating answers other than the one intended.

• **Vertical flow**. Arrange answer categories and associated numbers vertically on the page, not across the page. Vertical flow prevents the respondent from inadvertently missing questions or sections of the questionnaire, and prevents the respondent from indicating answers other than the one intended. The considerable spacing involved with this format gives the impression that the questionnaire is easy to complete; a densely worded format appears difficult.

• **Instructions for answering**. Specific instructions must be provided on (a) how to provide answers (for example, "Circle number of your answer") and (b) how to skip screen questions. Screen questions direct a certain subset of respondents to skip one or more questions, depending on the answer given. Respondents can be directed by arrows to the appropriate sections of the questionnaire.

3. Mailing the Questionnaire.—Besides the questionnaire, the two components to the mailout package include: (a) the cover letter, and (b) the mailback, or return, envelope.

(a) The cover letter. The cover letter introduces the study to the respondent. The first paragraph explains what the study is about, convinces the respondent that the study is useful, and motivates the respondent to fill out the questionnaire and return it. The study will be perceived as useful if it is seen to meet the needs of a certain group; however, it is essential that no bias in the researcher's motives is apparent. The second paragraph is designed to convince the respondent that the individual's response is important to the success of the study. The specific individual who is to complete the questionnaire should be clearly identified at this point. The third paragraph is a guarantee of confidentiality. The fourth paragraph repeats the social usefulness of the study, and contains a promise of action; for example, a copy of the results (if requested by the respondent), an expression of willingness to answer questions pertaining to the study (provide a telephone number and address). Finally, the letter concludes with a statement of thanks, a closing statement, and the sender's name and title.

The cover letter should not exceed one page and should be printed on agency letterhead. It should contain the date of mailing, the name, address and telephone number of the person sending the questionnaire, and agency affiliation. The signature should be handwritten.

(b) Return envelope. A postage-paid, pre-addressed return envelope must be included in the questionnaire package; response rates are significantly lower if return envelopes are not provided. Business reply envelopes should be used to avoid the use (and potential loss) of postage stamps.

4. Followup. Followup mailings are crucial for ensuring adequate response rates; without followup mailings, response rates will be less than half of those attained by using a comprehensive followup system (Dillman 1978). The followup procedure consists of three carefully timed mailings after the original mailout:

(a) *One week*: A postcard reminder is sent to everyone. It serves as a thank-you and acknowledgement for respondents, and as a polite reminder for nonrespondents.

(b) *Three weeks*: A second package is sent out to nonrespondents. This package contains a shorter cover letter intended to inform the nonrespondent that their questionnaire was not received and that the individual's response is important to the success of the project. A replacement questionnaire and a postage-paid return envelope are included.

(c) *Seven weeks*: A final mailing, similar to the second mailing, is sent to nonrespondents. It has been recommended that this mailing should be sent by certified mail "to emphasize its importance" to the recipient (Dillman 1978); however, the expense is considerable. Although there is some recent evidence that certified mailings result in a substantial increase in response rates, at least one study found that additional responses obtained by this method had no influence on results.

Step 5: Develop Sampling Plan for Survey

When permit access is strictly regulated, permit compliance is usually very high (over 95 percent). In this case, the entire sample population is known (in other words, all permit holders for a given time period), and the devising of a sampling plan is relatively simple; visitors to be surveyed are randomly selected from the permit numbers on file (see part I, chapter 3). To increase representation by locality, samples may be stratified by location.

Determination of the appropriate sample size (that is, the total number of questionnaires to be issued) requires a preliminary estimate of the expected variability in the response characteristics of interest. Preliminary estimates are obtained from a pilot study or from data collected in previous years. A rule-of-thumb estimate for the standard deviation is based on one-quarter of the likely range (or minimum and maximum values) of the observations (see part I, chapter 2). If several sample size estimates are available for different observations, the largest calculated sample size should be used.

Step 6: Purchase Equipment and Supplies

If permits are self-issued, permit stations need to be constructed. These stations should be both attractive and functional. Self-issue permit stations should be designed to provide (1) a place for supplies (pencils and permit forms), (2) a convenient, solid writing surface for the visitor to use when completing the permit, and (3) a place to deposit completed agency copy (normally a slot at the front). Stations may be constructed of wood or metal, and should be set on a post at a convenient height. An attractive and easy-to-read sign should be posted with instructions detailing (1) why a permit is required, (2) who is to obtain a permit (one person or everyone in the group), (3) where to deposit the completed agency copy, and (d) the consequences of being found in violation.

Additional costs are associated with the printing and mailing of questionnaires. Both printing and mailing costs are influenced by questionnaire length, the number of booklets required, stationary type and weight, method of mail delivery, and the use of repeated mail followups.

Step 7: Obtain Mailback Responses

A well-organized system must be developed to handle questionnaire returns. Returns must be individually coded so that the identification number matches that on the original questionnaire; this enables returns to be documented so that respondents who have completed questionnaires and those requiring followup mailings can be managed accordingly. As returns come in, they should be examined for problems which may result in missing data (such as sticking pages, unclear directions, and so forth). The researcher must be prepared to handle undelivered questionnaires, and answer respondent inquiries.

Step 8: Estimate Response Rates, Compliance Rates, and Use

There are four steps in the estimation procedure: (1) estimating permit compliance rates, (2) estimating questionnaire response rates, (3) estimating sample sizes, and (4) estimating total use.

Estimates of permit compliance are required to determine the relationship between the number of visitors who are in compliance with respect to the total number of visitors actually entering the wilderness area. The total number of visitors entering a wilderness area is estimated from the relationship between the number of permits issued, (N), and the rate of permit compliance, (r).

Visitor use data are collected from information provided on the submitted permit form; the collection, entry, and processing of data are therefore time intensive and relatively expensive. Consequently, sample sizes should be specified for each use characteristic to be evaluated categorically. Preliminary estimates of the required statistics (for example, standard deviation) can be obtained from observations made during the permit compliance estimation phase.

Use data are collected in accordance with the appropriate sample size and the sampling strategy. Information obtained from permits should be sufficient for obtaining data on observable and nonobservable categories of visitor. The number of visitors per category is expressed as a proportion or percentage of the total number of users. However, if sample sizes are very small, proportion data are useless for evaluation purposes. Individual and group visit count data may be expressed as a rate (for example, number of visitors per day), or total (for example, number of visitors for the season). In general, totals are estimated by multiplying the "corrected" average daily rate by the number of days in the time period of interest.

1. Estimate Permit Compliance Rates.—Permit compliance rate is estimated as the ratio of the number of permit holders (determined by the total number of permits collected) to the total number of visitors (determined from observer counts) during the sample observation periods.

Example. A total of 575 visitors obtained permits during the 7-day permit compliance rate estimation phase. A random sample of n = 50 visitors indicated that 10 did not obtain permits. Therefore, the estimated permit compliance rate (r) was estimated as 40/50 = 0.8, or 80 percent. The total number of users (N) for a given period is estimated by the total number of permit holding visitors (t) divided by the permit compliance rate:

$$\hat{N} = t/r = 575/0.8 = 719$$

The 95 percent confidence interval for the total is estimated by $N \pm 2 \cdot SE$ =

$$719 \pm 2\sqrt{\left[(575)^2 \cdot 50(50-40)\right]/(40)^3} = 719 \pm 102,$$ or between 617 and 821 visitors.

2. Response Rates.—There are several methods of calculating questionnaire response rates, (R). The first method is the ratio of questionnaires returned to those sent out, or

$$R = \frac{number\ returned}{number\ sent\ out} \times 100$$

However, if there is a certain proportion of ineligible respondents, or potential respondents who could not be contacted, the formula must be modified as follows:

$$R = \frac{number\ returned}{(number\ sent\ out)\ -\ (non\text{-}eligible\ +\ non\text{-}reachable)} \times 100$$

(Dillman 1978).

Example. Questionnaires were sent to 200 visitors randomly selected from permits issued for a given season. A total of 156 questionnaires were returned. Ten contacts were ineligible and 14 could not be contacted (questionnaires were not forwarded or returned). The response rate is:

$$R = \frac{156}{200 - (10 + 14)} \times 100 = 88.6\%$$

3. Sample Size Estimation.—Because visitor count data are collected by counting permits, there may be insufficient resources available to cover the costs and time involved in the collection, input, and processing of large amounts of data. Sample sizes for categorical data should be specified first. Sample sizes should be estimated for each use characteristic to be measured, and the largest (feasible) sample size is chosen. If a stratified sampling strategy is used, stratum sample size is calculated according to whether proportional or disproportional representation is required.

(a) Count data. The relation used to estimate sample size is:

$$n \cong \left[4 \cdot \frac{S}{L}\right]^2$$

If the sampled population is small, the finite population correction (fpc) is used to correct for overestimation bias. Using the fpc, the estimated sample size is:

$$n \cong \frac{N \cdot S^2}{S^2 + \frac{L^2 \cdot N}{4(2)^2}}$$

where L is the width of the interval around the projected average, and N is the size of the true population. In this case, N is the number of days in the season. Precision is estimated by the confidence level (generally 95 percent) and the desired width of L. For example, the investigator may wish to be 95 percent certain that the results have a precision of ± 5 percent of the total. Operationally feasible sample sizes are obtained by varying the amount of precision of the estimate; highly precise estimates may require sample sizes that are too large for practical purposes.

Example. The average number of visitors observed per day during the compliance estimation phase was 250, with S = 160. There are 100 days in the season (N = 100). Suppose we want to be 95 percent certain that results will have a precision of ± 5 percent, or ± 13 visitors/day. The estimated number of sampling days is $\approx \dfrac{100(160)^2}{(160)^2 + \dfrac{(13+13)^2(100)}{16}} = 86$. If the precision is adjusted to ± 10 percent (or ± 25 visitors per day), then $n = 62$. Both of these are too large or too close to the entire season of 100 days to be of practical use due to the large underlying variance. A more reasonable level of precision would be ± 30 percent (or ± 75 visitors per day) which would call for a sample size of $n = 15$.

(b) Proportion data. Sample size (n) will be at a maximum when the proportion of observations (p) in any given category is 0.5 (or 50 percent). The sample size required to estimate an interval of width L around the sample mean will be:

$$n = \frac{4 \cdot (2)^2 \cdot p(1-p)}{L^2}$$

which is maximized for $p = 0.5$ or $n = 16(0.5)(0.5)/L^2$.

Example. Preliminary data showed that for 40 randomly selected visitors, 24 appeared to be day users. Therefore, the proportion of day users, $p = 24/40 = 0.60$, and the standard error is $\sqrt{p(1-p)/n} = \sqrt{(0.60)(0.40)/40} = 0.0775$. The 95 percent confidence interval based on these data is approximately $0.6 \pm 2(0.0775) = 0.6 \pm 0.15$, for a confidence interval of (0.45, 0.75). The sample size n required for a 95 percent confidence interval with a length of at most 0.10 (regardless of the resulting value of p) is approximately $n = \dfrac{16(0.5)^2}{(0.10)^2} = 400$. Therefore, it would be necessary to observe 400 visitors to obtain this amount of precision for the estimate.

(c) Stratified sampling. If the data are stratified according to trailhead or time block, sample sizes of each stratum must be calculated to ensure accurate representation of the population. Sample sizes may be either proportional or disproportional to stratum size (part I, chapter 3). Proportional sampling subdivides the sample population proportional to the size of each strata or subgroup. Optimal allocation is a type of stratified sampling where the sample size within each strata is proportional to both the size and the variability of the sample within each stratum; the proportionality factor is calculated as $\left[N_i \cdot S_i / \sum \left(N_i \cdot S_i\right)\right] \cdot n$. Disproportional sampling occurs when the same size sample is drawn for each stratum (assuming equal costs to sample each strata).

Proportional sampling should be performed if strata are fairly homogeneous (that is, the standard deviations observed for each stratum are similar), whereas optimal allocation should be chosen if strata differ in the amount of variability.

Example. In this example, data are stratified by two time blocks—weekend days and weekdays. This stratification strategy separates out time periods according to relative intensity of use, with the heaviest and most variable use occurring on weekends, and relatively light and uniform use on weekdays. For a 100-day season, there are about 72 weekdays and 28 weekend days. Suppose the available resources (budget, labor, time) dictated that the maximum number of days that could be sampled was $n = 25$. The initial value for the standard deviation for each stratum was estimated from the data obtained during the permit compliance rate estimation phase. Sample sizes for each time block are calculated as follows:

Stratum	s^a	Proportional f^b	n^c	Disproportional f	n	Optimal allocation f	n
Weekends ($n_1 = 28$)	88.0	0.25	7	0.43	12	0.64	16
Weekdays ($n_2 = 72$)	19.2	0.25	18	0.17	12	0.36	9

[a]Standard deviation.
[b]Sampling proportion.
[c]Sample size.

Because the two strata differ considerably in variability, the preferred sampling scheme is optimal allocation; with this strategy the investigator randomly selects 16 weekend days and 9 weekdays for data collection.

3. Use Estimation.—Use characteristics estimated with this system are limited to individual or group visit counts. Data may be expressed in terms of: (a) the rate (for example, number of visitors per day), (b) the total (for example, number of visitors for the season), (c) use by category (for example, cooking method), (d) use description (for example, length of stay), or (e) summary-use statistics (for example, recreation visitor days).

(a) Rate of use. Suppose the number of visitors with permits for a 30 day time period was 772. A survey of 50 visitors showed that 46 had permits for a compliance rate of 46/50 = 0.92.The estimated number of users over the 30 day period is 772/0.92 = 839, for an estimated daily rate of 839/30 = 28 users per day. The estimated confidence interval for the 30 day rate is 839 ± $2 \cdot \sqrt{772^2 \cdot 50 \cdot (50-46)/46^3}$ = 839 ± 70 = (769, 909), which converts to a confidence interval for the daily rate of (25.6, 30.3).

(b) Total use. Total visitor use is estimated by multiplying the "corrected" average daily rate by the number of days in the time period of interest, corrected by the estimated bias in counts. *The assumption implicit in this method is that use remains uniform over the time period of interest; if use patterns fluctuate considerably over the season, calibration relationships should be updated as required, and the new relationship used to calculate use rates for that time interval.*

In this example, season length was 100 days. The overall visitor use estimate is therefore 28(100) = 2,800 visitors (2,560 to 3,030 visitors).

(c) Use by category. Frequently, visitor use is described in terms of categories, or groups, of users; the number of users in each category is expressed as a proportion, or percentage, of the total number of users in the sample.

Example. On the permit form 2,975 visitors indicated their method of cooking during their visit: stoves, wood fires, or neither. Results with a 95 percent confidence interval (using χ^2 procedure based on 2 degrees of freedom) were:

Stove users: n_1 = 2,231, p_1 = 2,231/2,975 = 0.75,

95 percent confidence interval $= 0.75 \pm \sqrt{5.99[(0.75)(0.25)/2{,}975]} = 0.75 \pm 0.019$ = (0.731 to 0.769);

Wood fire users: n_2 = 595, p_2 = 595/2,975 = 0.20,

$$95 \text{ percent confidence interval} = 0.20 \pm \sqrt{5.99[(0.20)(0.80)/2,975]} = 0.20 \pm 0.018$$
= (0.18 to 0.22);

Neither: n_3 = 149, p_3 = 149/2,975 = 0.05,

$$95 \text{ percent confidence interval} = 0.05 \pm \sqrt{5.99[(0.05)(0.95)/2,975]} = 0.05 \pm 0.009$$
= (0.04 to 0.06).

(d) Use description. One variable that may be obtained by permits is length of stay. Post stratification may also be of interest.

Example. A sample of 38 permits had an average length of stay of 2.4 nights with a standard error of 0.23 nights. This makes the 95 percent confidence interval 2.4 ± 2·0.23 = 2.4 ± 0.46 = (1.94, 2.86).

(e) Summary-use statistics. The recreation visitor-day is defined as 12 hours of a given recreation activity performed by the associated proportion of visitors. It is calculated as the product of the number of activity occasions and the average amount of time spent in that activity, divided by 12.

Example. The number of permits issued for a given season was 6,750, of which 1,232 were horse users. For horse users, there were 3.1 people per group, and 5.2 horses per group; the estimated compliance rate was 95 percent. The total number of horse users was 3.1(1,232)/(0.95) = 4,020 people, and 5.2(1,232)/(0.95) = 6,744 horses. The average duration of a wilderness trip was 5 days, or 120 hours. Then, the number of recreation visitor-days for horse users during the season was 4,020(120)/12 = 40,200.

In 1980, permit systems were in use in 69 wilderness areas. Of these areas, 17 limited use and 52 did not.

System I: Indirect Counts

System Description

With this system, various measures of use are estimated from one or more surrogate measures of use, referred to as predictor variables. Predictors are easier to obtain than measures of direct use, and entail less burden on wilderness visitors. The relationship between the predictor(s) and the use measure is quantified; once this relationship is established, it is only necessary to monitor the predictor to obtain an estimate of the given use characteristic. Indirect measurements can be used to predict counts and summary-use characteristics. Relationships may be valid over several seasons; however, periodic checks should be scheduled to ensure the continued validity of the predictive relationship. Visitor burden should decline once the predictive relationship is established.

Summary of System I:

Type of observations:	Counts Observable use characteristics Simple nonobservable characteristics (sometimes)
Measures of visitor use:	Number of individual visits Number of group visits Summary-use statistics
Data collection strategies:	Sampling plan for counter rotation (if applicable) • spatial • temporal Calibration
Techniques/procedures:	Mechanical counters Visual observations (cameras, human observers) Miscellaneous data collection (weather data, trailhead maps, and so forth)
Visitor burden:	Variable, declining.

Operational Procedures

Step 1: Decide on Use Characteristics

To date, the use characteristics most commonly evaluated by indirect methods have been visitor counts, time involved in a given activity, and inter-party encounter rates. The success of this method for predicting other types of use characteristics is untested; estimates of nonobservable use characteristics may not be reliable.

Step 2: Select the Appropriate Predictor Variable

Choice of the appropriate predictor variable is determined by several factors: **ease of measurement, predictive power**, and **stability** (that is, the predictive relationship should be valid for relatively long periods). The predictor variable may be another (and easier) method of obtaining visitor counts, such as vehicle axle counts, the number of visitor maps taken from trailhead stations, or the campground occupancy rates. Alternatively, predictor variables may be environmental or weather factors, such as lake-water levels, daily maximum temperature, and daily rainfall.

The predictive power of the straight-line model is estimated by the coefficient of determination, or R^2. This is interpreted as the proportion of observed variation in Y that can be explained by the straight-line model: the higher the value of R^2, the better the regression model is in explaining variation in Y. If R^2 is small, the investigator will need to search for an alternative predictor variable or variables. Pilot studies must be conducted to evaluate the initial suitability of potential predictor variables, and whether the relationship between the proposed predictor variable and the use characteristic of interest is sufficiently strong to be of any use as a means of prediction.

The stability of the model is evaluated by periodic checks over one season, or over several years. Some predictor variables may be useful for relatively long periods, but only if use patterns do not change significantly over time.

Step 3: Select a Direct Counting Method

Visitor counts are determined by observing visitors passing a given point at selected times. Human observers are preferable; however, cameras may be used if calibration procedures are strictly followed (see below). Interviews may be used to obtain information on simple nonobservable visit characteristics. To obtain information on complex nonobservable visit characteristics, mailback questionnaires may be sent to randomly selected visitors.

Step 4: Develop a Sampling Plan for Direct Counting

The procedure for indirect methods is similar to the calibration procedures described for systems using mechanical counters. The value of the predictor variable is "calibrated" by direct counts, or observations, of visitors obtained simultaneously with measures of the indirect variable so the predictive power of the predictor variable can be assessed for its adequacy. Once the adequacy of the predictor is established, visitor counts can be estimated from the predictive relationship.

The amount of effort and resources expended during this phase will depend on the required precision of use characteristic estimates, the available resources, and the relative stability of visitor use over time. If use patterns change substantially over the season, the predictive relationship estimated at the beginning of the season will not be applicable later in the season; the accuracy of the relationship must be spot checked at intervals, and updated as required.

Use of human observers is labor intensive and expensive, but provides highly accurate results and greater flexibility in data acquisition. Observers may be stationed at fixed locations, such as trailheads or campsites, or alternatively may travel assigned trail segments. For "calibration" purposes, the minimum information to be recorded by observers includes number of individuals, number of groups, method of travel, direction of travel, and date and time of entry or exit. Additional information on visit or visitor characteristics may be obtained if required by the study objectives. A sample observer recording sheet is shown in figure 1.

Sampling plans must be developed for:

1. Scheduling rotation of observers (or counters) across trailheads.
2. Calibration of mechanical counters (if applicable).
3. Visitor selection for interviews (if applicable).

Step 5: Install Equipment for Indirect Counts (If Applicable)

If cameras or mechanical traffic counters are used for measuring the values of the predictor variable, care must be taken in equipment installation, maintenance, and calibration. Follow manufacturer's directions for installation, carefully test and retest the accuracy of the counter, and frequently test battery power and sensor function.

In general, counters should be placed some distance away from the trailhead so that only *bona fide* wilderness visitors are counted, and casual visitors (those who travel only an extremely short distance) are excluded. However, if the wilderness boundary is an extremely long distance from the trailhead, the increase in personnel time involved in traveling to the counter site for reading and calibrating counters may make this option untenable. We do not advise locating counters where the trail is unduly wide (thus allowing visitors to travel two or more abreast, and underestimating counts), or at natural resting places (where they may mill around and cause multiple counts). Narrow portions of the trail at locations where traffic flow is more or less continuous offer the best count locations.

The time required for counter installation will vary according to distance from the trailhead and counter type. After arriving at the selected site, at least one hour will be required for counter installation. This includes time spent examining the site, selecting the best place for counter location, installation of the sensor and the counting mechanism, setting counter sensitivity or delay, and testing counter operation. If a counter is mounted on a tree trunk (as is the case for photoelectric counters), the counter will likely shift slightly within the first day or two as a result of tree wounding; the counter should therefore be checked, and realigned if necessary, on the second day after initial installation. If cameras are used, additional time is required to address privacy concerns (the camera must be located far enough from the trail so that individuals cannot be identified in the pictures, camera adjusted to be slightly out of focus, and so forth).

After the equipment has been installed, observe conditions for a short time to make certain that equipment is functioning correctly, and adjust accordingly. All equipment should be labeled with agency identification, a statement of purpose, and the name, address, and telephone number of a designated contact person. A message explaining that the camera is for detecting use levels, and that individual identities cannot be determined, may reduce the risk of vandalism if visitors locate the equipment.

Step 6: Collect Direct Count Data

Direct count data are generally collected by human observers. Although labor intensive and expensive, use of human observers provides accurate results, and enables greater flexibility in data acquisition. Direct count data may be obtained by observers without stopping visitors, or by observers who stop and interview randomly selected visitors.

1. Observer Data.—It is essential that personnel are thoroughly trained in the data collection procedures. Training ensures that observers are already familiar with the research directives and the data collection process before actual fieldwork begins. As a result, errors involved in the learning process are reduced, and there will be greater consistency in identifying the sampling units and recording responses. Training enables observers to become familiar with various contingency plans, to identify potential problems in the research directives, and to make decisions if problems occur.

Preliminary, or pretest, fieldwork should be conducted before the actual survey begins. These rehearsals ensure that personnel understand procedures, and serve as a test for the efficiency of the methods; problems or inadequacies in the procedures can be identified, and the consistency and accuracy of personnel can be observed and analyzed.

Observers should be screened at intervals and their performance compared either with each other or at different time points for the same observer; screening provides a check on performance and identifies sources of error in the data.

Observers may be stationed at fixed locations, such as trailheads or campsites, or alternatively may travel assigned trail segments. If trail traffic is low, observers may perform other tasks in the vicinity of the counter, such as trail clearance and maintenance, visitor education, or reading; these help pass the time and reduce observer fatigue and boredom. However, if the observer is stationed at some distance and is observing traffic through binoculars, it is not advisable to engage in other types of activity because of the potential for missing visitors if attention is diverted from the trail. Observers should be in appropriate uniform and possess necessary communication and safety equipment.

Observations must be recorded in a standardized format. The minimum information to be recorded by observers includes number of individuals, number of groups, method of travel, direction of travel, and date and time of entry or exit. Additional information on visit or visitor characteristics may be obtained if required by the study objectives. For each data sheet the observer should record their name, the sampling location, the date, start time, the initial counter reading, end time, and the final counter reading for that sample period. During the sample period the observer records the number of individuals or groups, and the time visitors pass the observation station. The observer must be provided with sufficient data forms for the observation period. Observers must understand the need to completely and correctly fill out the data form; sample observations will be useless if the data collected by the observer cannot be matched with the appropriate counter data. Observation sheets should be filed in a designated place after the observer returns to the office.

2. Interview Data.—The interview protocol consists of five steps: (a) determining question format, (b) obtaining OMB clearance, (c) selecting and training the interview team, (d) visitor selection, and (e) data collection.

(a) Question format. The questions asked of the visitor will be dictated on the basis of the study objectives; that is, on the basis of what the manager wants to know and why. Questions should be easily understood by the visitor, they should not be too long, and there should not be too many of them. *Ask only the questions necessary to meet the study objectives, and no more.* The interview should be as short as possible to minimize visitor burden.

Personnel may be tempted to add additional questions "just out of curiosity"; this cannot be justified in any circumstances. Do not add questions merely to fill up space on the interview sheet. If some inadequacy or ambiguity becomes apparent with the set questions, questions may be added, but only if they clarify the meaning and satisfy the requirements of step 1. The question designer is rarely a good judge of the clarity of the questions (Ackoff 1953); preliminary field tests are invaluable for identifying problems before the actual field surveys begin.

(b) Obtain OMB clearance. According to federal legislation, clearance from the Office of Management and Budget (OMB) is required if federal employees ask more than nine members of the public the same set of questions. The proposed set of questions, methodology, and study justification must be submitted to OMB through the appropriate channels. For the Forest Service, application for clearance is submitted to that Agency's Information Systems office in Washington, DC, which then forwards the application to the Department of Agriculture, and from there to OMB for final approval. The time from initial submission to final OMB clearance is usually about 3 months.

(c) Select and train the interview team. Careful selection and training of the personnel who are involved in collecting data are essential if the manager or research planner is not performing the field research. The research planner must ensure that interviews are conducted and observations collected in the manner required by the study plan.

- Personnel selection. Both personality and ability must be evaluated in the selection process. The importance of visitor contact extends beyond the quality of data obtained; it is an opportunity to present the image of the managing agency. Select an interviewer who is friendly, reliable, knowledgeable, and trained in emergency procedures. Personnel should be familiar with the wilderness area and prepared to handle requests for information about the wilderness and the surrounding area. Many of the questions from visitors will not be related to the interview; providing information is a courtesy which contributes to establishing rapport with the visitors and increases visitor cooperation. Personnel should be in appropriate uniform and possess necessary communication and safety equipment.
- Training. It is essential that personnel are thoroughly trained in the data collection procedures. Training ensures that observers are already familiar with the research directives and the interviewing process before actual fieldwork begins. As a result, errors involved in the learning process are reduced, and there will be greater consistency in identifying the sampling units (in this case visitors to be interviewed) and recording responses. Training enables observers to become familiar with various contingency plans, to identify potential problems in the research directives, and to make decisions if problems occur.

Preliminary, or pretest, fieldwork should be conducted before the actual survey begins. These rehearsals ensure that personnel understand procedures, and serve as a test for the efficiency of the methods; problems or inadequacies in the procedures can be identified and eliminated, and the consistency and accuracy of personnel can be observed and analyzed. Observers should be screened at intervals and their performance compared either with each other or at different time points for the same observer; screening provides a check on performance and identifies sources of error in the data.

(d) Visitor selection. Visitors are selected in accordance with the predetermined sampling plan (step 4). The location of interviews will be determined by study objectives; visitors may be interviewed upon either entry or exit, or both. For example, if the emphasis of the study is on the effects of group size or place of residence on wilderness use, these factors are unaffected by interview location. However, if the study objectives require information on patterns of visitor use within the wilderness area (for example, travel or camping locations, length of stay), visitors should be interviewed as they leave.

(e) Data collection. When interviewing visitors, personnel should begin with a standard introduction. Personnel should give their name and agency affiliation and the reason for the interview. For example, "Hello, I am Marilyn Holgate. I work for the Missoula District of the Lolo National Forest. We are trying to learn more about the use of the Rattlesnake Wilderness. It will help us with management of the area. May I ask you a few questions about your visit today?" After the interview, thank visitors for their time.

Responses should be recorded as they are given; *interviewers should not rely on memory to fill in the interview sheet at a later time.* Make sure every item is complete and legible; data forms must include date, time, location, and interviewer's name. Completed data forms should be filed in a safe place in a central location.

Step 7: Collect Predictor Variable Data

Methods of data collection will depend on the type of predictor variable. Count data may be logged by mechanical counters or obtained by visual observations (either cameras or human observers). Alternative types of predictor variables, such as environmental factors, are collected by the most appropriate means (see below). Predictor data must be collected either simultaneously or for the same sampling period as direct count data.

1. Counter Data.—Counts logged by the mechanical counter are recorded at intervals determined by the appropriate sampling plan. If counters are permanently allocated to a given location, the frequency of recording will be determined by the calibration sampling plan. At a minimum, counts should be recorded at least twice per month to ensure that data are not lost because of equipment malfunction. The person obtaining count readings should check battery power and equipment operation, and for any changes in the surrounding area which may affect count accuracy.

2. Cameras.—Record necessary observations from the developed film. Observations must be recorded in a standardized format to minimize errors in recording. Observations include location, date, number of individuals, number of groups, date and time of entry or exit. Observers must understand the need to completely and correctly fill out the data form; sample observations will be useless if the data collected by the observer cannot be matched with the appropriate registration data. Observation sheets should be filed in a designated place. After observations are recorded, destroy negatives and developed photos to ensure visitor privacy.

3. Observers.—Observers should be stationed close enough to the registration station so that all traffic passing the station is accounted for; however, they do not need to observe whether or not visitors actually register.

Although observers need not be beside the registration station, they should not wander up and down the trail. *Observers do not stop visitors*.

Observations are recorded on a standardized form (fig. 1). Observations include observer name, location, date, number of individuals, number of groups, date and time of entry or exit. Observers must understand the need to completely and correctly fill out the data form; sample observations will be useless if the data collected by the observer cannot be matched with the appropriate registration data. All deposited registration forms are collected and labeled at the end of the observation period. Observation sheets and registration cards should be filed in a designated place.

4. Other.—Daily weather data for the location closest to the wilderness area can be obtained from the National Weather Service. More accurate information can be obtained from weather-recording equipment established close to the site. If the quantity of trailhead literature (such as maps) is used as a predictor, an observer must be detailed to monitor the station supplies during time periods coinciding with those used for direct counts.

Step 8: Estimate Use

Linear regression is used to estimate the relationship between the predictor variable and the direct measure of visitor use; regression techniques are described more fully in the appendix. Before calculating the regression statistics, the data are plotted and examined for anomalies, such as excessive curvature or scatter, which would invalidate the assumption of a straight-line relationship. To predict use from values of the predictor variable, calculate the regression relationship, $Y = B_0 + B_1 \cdot X$, and the standard error of the regression equation ($\sqrt{MSE}$). The 95 percent confidence interval for value of visitor count (Y) for a given car count (X) is approximately equal to $\hat{Y} \pm 2\sqrt{MSE}$ where $\hat{Y}$ is calculated from the regression equation.

An estimate of use for the entire season is obtained by calculating the average number of users per day, and multiplying this estimate by the total number of days in the season.

Example. Visitor traffic at Snow Lake Trailhead in the Alpine Lakes Wilderness was surveyed to establish the relationship between the numbers of vehicles in the trailhead parking lot X (predictor variable X) and the number of visitors counted ½ mile up the trail (Y). The following data are plotted in figure 7.

Car counts (*X*):	10	15	18	20	21	23	25	27	32	33	60	92	105	108	132.
Visitor counts (*Y*):	25	30	50	55	62	65	61	48	75	67	77	150	158	100	200.

The relationship between car counts and visitor counts was:

$$\hat{Y} = 26.48 + 1.145 \cdot X$$

with $R^2 = 0.86$ and $\sqrt{MSE} = 19.11$.

The average number of cars in the trailhead parking lot was 45 per day. Therefore, the daily number of visitors was estimated to be 26.48 + 1.15(45) = 78. The 95 percent prediction interval for this estimate is 78 ± 38.22, or between 40 and 116 visitors per day. Given a season length of 100 days, the number of users per season is estimated as 7,800, with a 95 percent confidence interval of 4,000 to 11,600 users.

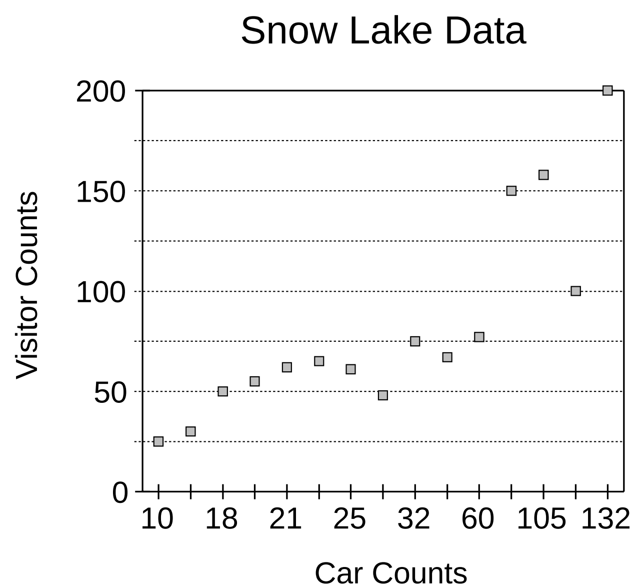

Figure 7—Plot of visitor counts on car counts for Snow Lake Trailhead.

System J: General Visitor Surveys

System Description

This system entails the direct acquisition of information from visitors to the wilderness area by either face-to-face interviews or questionnaires filled out by the visitors. Use information is determined by the interview or questionnaire format, or both. This system can provide sufficient information to enable estimates of summary-use statistics, as well as basic visit counts and visit characteristic data. A random selection of visitors is contacted at trailheads or other wilderness access points. Although visitors are contacted directly, contact time is relatively low and visitor burden is moderate.

Summary of System J:

Type of observations:	Counts
	Observable characteristics
	Simple nonobservable characteristics
	Complex nonobservable characteristics
Measures of visitor use:	Number of individual visits
	Number of group visits
	Use by category of user
	Summary-use statistics
Data collection strategies:	Sampling plan for visitor selection
Techniques/procedures:	Interviews, questionnaires
Visitor burden:	Moderate

Operational Procedures

Step 1: Decide on Use Characteristics to Measure

Use characteristics that can be obtained are determined by the question format. Information obtained from interviews or questionnaires can include basic descriptions of the visit (such as travel route, length of stay, and activities participated in), and simple visitor characteristics (such as past wilderness experience, knowledge of low-impact behavior, preference for alternative management strategies, and so forth). If mailback questionnaires are used, information can be obtained on complex nonobservable characteristics pertaining to the wilderness area itself, such as visitor attitudes and visitor preferences for conditions in wilderness.

Step 2: Decide on Survey Method

Visitors are surveyed by either interviews or questionnaires, or both. Choice of method depends on the length and complexity of the survey, the resources available to administer the survey (personnel, time, budget, and so forth), the demographics of the contact population, and the location of contact (at trailheads, at locations within the wilderness, or at their place of residence).

1. Interviews.—Directly surveying visitors by interviews is appropriate if the survey is relatively short, questions are simple (for example, questions relating to attributes rather than attitudes), and budgetary resources are limited. Interviews are especially useful if the contact population is characterized by low standards of literacy, or if there is a significant proportion of non-English-speaking visitors.

The location of interviews will be determined by study objectives; visitors may be interviewed upon either entry or exit, or both. For example, if the emphasis of the study is on the effects of group size or place of residence on wilderness use, these factors are unaffected by interview location. However, if the study objectives require information on patterns of visitor use within the wilderness area (for example, travel or camping locations, length of stay), visitors should be interviewed at exit points. In general, visitors should not be interviewed within the wilderness area, especially if surveys are long, because personnel interruptions may be perceived as an unacceptable visitor burden. However, if onsite responses are required, interviews may be conducted at campsites without interfering with travel plans or disturbing the mood of the wilderness experience.

Telephone interviews are an option if only a short time is available to complete a study. Visitors are contacted at a trailhead and asked to supply their name, address, and telephone number; they are contacted later by phone. However, this method is expensive (telephone charges, interviewer time), and has a lower response rate than other survey methods.

2. Questionnaires.—Indirect surveys by means of questionnaires are appropriate if the survey is relatively long, questions are more complex, and budgetary resources are sufficient for implementing questionnaire development and followup procedures (see Step 3: Formulate the Survey).

Step 3: Formulate the Survey

There are three steps in formulating a survey: (1) developing appropriate and effective questions, (2) constructing question format, and (3) obtaining OMB clearance. If the survey is administered by questionnaire, additional design considerations are necessary.

When in the development stages of this system, the manager is strongly encouraged to have the survey and methodology reviewed by a social scientist from a university or the agency.

1. Question Development.—To be effective, the survey must (a) enable managers to find out what they want to know, (b) encourage respondents to answer, and (c) minimize respondent burden.

The questions are asked of the visitor will be dictated by the study objectives; that is, on the basis of what the manager wants to know and why. Questions should be easily understood by the visitor, they should not be too long, and there should not be too many of them. The major principle in the development of questions is the *necessity to keep visitor burden to a minimum. Ask only the questions necessary to meet the study objectives, and no more.*

The specific questions asked of the respondents will depend on what kind of information is required to meet the study objectives. Questions can be categorized on the basis of one or more of the following types of information:

- *Attitudes*: what people say they want or how they feel about something;
- *Beliefs*: what people think is true or false;
- *Behavior*: what people do;
- *Attributes*: what people are (personal or demographic features).

Questions must be clearly identified according to information type, otherwise responses will lead to a different type of information than that required by the study objectives.

The question developer is rarely a good judge of the clarity of the questions (Ackoff 1953). *Preliminary field tests are invaluable for identifying problems, and should be conducted before the actual field surveys begin.* Colleagues, potential "users" of the data, and, if possible, a small pretest sample of prospective respondents should be surveyed; a debriefing session should follow to identify problems. If some inadequacy or ambiguity becomes apparent with the set questions, questions may be added, but only if they clarify the meaning and satisfy the requirements of step 1.

2. Question Format.—There are two factors to be considered in planning survey format: (a) survey length, and (b) relative order of questions.

(a) Length. Questions should not be too long, and there should not be too many of them. Questions must be worded so that respondents understand them as the investigator wants them to; language should be simple and clear, and there should not be too much information demanded in any one question. If in doubt, the question should be broken into two or more questions.

The survey should be as short as possible, without compromising the study objectives or resulting in incomplete information. Personnel should not ask additional questions "just out of curiosity". Do not add questions merely to fill up space on the questionnaire sheet. A single-page questionnaire is acceptable, but may be too short to be useful. The maximum length for mailout questionnaires is approximately 12 pages (Dillman 1978); self-issue questionnaires should not take longer than 10 minutes to complete.

(b) Question sequence. Questions are presented in order from simple to complex; this is the so-called "funnel" format. Question sequence improves data quality by encouraging respondents to answer because both resistance to answering and the perceived effort involved are lessened. Once a commitment is made to answer a few questions, there is an increased likelihood that the survey will be completed.

The survey is introduced with a brief outline of the central topic, the interest and importance of the topic, and its interest and relevance to the respondent. The first few questions are the most important, as they will determine whether the questionnaire is completed or thrown in the garbage. The first few questions get the survey started by setting the pace and manner of the survey, and encouraging respondents to answer. In general, initial questions should be (1) relevant and interesting, (2) easy to answer, and (3) applicable to all potential visitors. The first question should obviously be related to the topic, and have socially useful implications. The questions should be easy to answer, taking only a few seconds to understand and answer. Therefore, long, complex and open-ended questions, and statements requiring the respondent to express an attitude or opinion, should be avoided. The questions should have wide applicability. Questions that involve a category of “does not apply” or “don’t know” suggest to the respondent that the rest of the questionnaire is equally irrelevant; this is a major contributor to nonresponse. Simple, easy-to-answer questions include questions about wilderness travel routes and destinations, activities participated in, group size and composition, number of other users encountered and where, length of visit, and so on.

Subsequent questions are ordered in descending importance with respect to the topic; topical questions are asked before questions related to personal characteristics. Questions should be ordered so that they follow a logical sequence. More complex questions will require some thought or judgment on the part of the respondent; complex questions are formulated to attain information on visitor perceptions, judgments, opinions, or attitudes. Examples are the relative importance of various aspects of the wilderness trip in achieving “quality” wilderness experiences, attitudes toward management strategies intended to reduce visitor impact, and the acceptability of various levels of social or resource condition impacts. Personal or confidential questions should be placed last; these include extent of past wilderness experience, knowledge of low-impact procedures, income and education levels.

3. Obtain OMB Clearance.—According to federal legislation, clearance from the Office of Management and Budget (OMB) is required if federal employees ask more than nine members of the public the same set of questions. The proposed set of questions, methodology, and study justification must be submitted to OMB through the appropriate channels. For the Forest Service, application for clearance is submitted to Information Systems in Washington, DC, which then forwards the application to the Department of Agriculture, and from there to OMB for final approval. The time from initial submission to final OMB clearance is usually about 3 months.

4. Additional Design Considerations for Questionnaires.—If the survey is administered in questionnaire format, additional considerations include design, mailing, and followup procedures (Dillman 1978).

(a) Design and layout. Response rates are greatly affected by the details of questionnaire design and layout. Questionnaires should be attractive, easy to read, and look easy to do, so that respondents are motivated to complete them. The overall design must prevent respondents from missing or overlooking questions or whole sections.

The following design guidelines are from Dillman (1978).

• **Booklet format**. The questionnaire should be printed as a booklet, with approximate dimensions of 6" x 8". If each page is typed using 12-point font on standard 8.5" x 11" paper with ¾" margins, reduction by 79 percent will fit booklet format. The questionnaire booklet is reproduced on white or off-white paper using good-quality printing methods; if pages are printed on both sides, sixteen pound paper is recommended.

• **Cover design**. Questionnaire covers determine the overall first impression of the study, and significantly influence response rates. The front cover must include (a) a study title, (b) a graphic illustration, (c) any needed directions, (d) the name, address, and logo of the sponsoring agency, and (e) the identification number. The title should give an informative and accurate impression of the study topic, make the questionnaire sound interesting, and should be neutral (that is, it should not sound threatening or imply bias). The illustration adds interest; it should be simple and representative of the topic. The address of the study sponsor is important as backup information in case respondents lose return envelopes. The name of the researcher is not included in the address; the legitimacy of the study is endorsed by the backing of the sponsoring agency, not by some unknown individual. The back cover consists of a request for additional comments, and a statement of thanks. The back cover should never include questions; because questions are in the aforementioned order, the questions that would appear there are most likely to be found objectionable by respondents, and the probability of nonresponse is greatly increased.

The questionnaire is identified with a stamped individual identification number; this number corresponds to the number assigned to each recipient on the mailing list. In general, the ID number should be placed in the upper right-hand corner of the front cover.

• **Lettering**. Distinguish questions from answer choices by using lower-case letters for questions and UPPER-CASE LETTERS FOR POSSIBLE ANSWERS.

• **Make questions fit the page**. Questions should not continue onto the next page. Manipulate spacing (margins, line spacing), or rearrange question order. However, large blank spaces should be avoided.

• **Identification of answer categories**. Assign a number for each answer category; this provides a convenient method of coding answers for subsequent computer processing. Place numbers to the left of the answer category; this minimizes the possibility of the respondent indicating answers other than the one intended.

• **Vertical flow**. Arrange answer categories and associated numbers vertically on the page, not across the page. Vertical flow prevents the respondent from inadvertently missing questions or sections of the questionnaire, and prevents the respondent indicating answers other than the one intended. The considerable spacing involved with this format gives the impression that the questionnaire is easy to complete; a densely worded format appears difficult.

• **Instructions for answering**. Specific instructions must be provided on (a) how to provide answers (for example, "Circle number of your answer") and (b) how to skip screen questions. Screen questions direct a certain subset of respondents to skip one or more questions, depending on the answer given. Respondents can be directed by arrows to the appropriate sections of the questionnaire.

(b) Mailing the questionnaire. Besides the questionnaire, the two components to the mailout package include: the cover letter, and the mailback, or return, envelope.

• The cover letter. The cover letter introduces the study to the respondent. The first paragraph explains what the study is about, convinces the respondent that the study is useful, and motivates the respondent to fill out the questionnaire and return it. The study will be perceived as useful if it is seen to meet the needs of a certain group; however, it is essential that no bias in the researcher's motives is apparent. The second paragraph is designed to convince the respondent that the individual's response is important to the success of the study. The specific individual who is to complete the questionnaire should be clearly identified at this point. The third paragraph is a guarantee of confidentiality. The fourth paragraph repeats the social usefulness of the study, and contains a promise of action; for example, a copy of the results (if requested by the respondent), an expression of willingness to answer questions pertaining to the study (provide a telephone number and address). Finally, the letter concludes with a statement of thanks, a closing statement, and the sender's name and title.

The cover letter should not exceed one page and should be printed on agency letterhead. It should contain the date of mailing, the name, address and telephone number of the person sending the questionnaire, and agency affiliation. The signature should be handwritten.

• Return envelope. A postage-paid, pre-addressed return envelope must be included in the questionnaire package; response rates are significantly lower if return envelopes are not provided. Business reply envelopes should be used to avoid the use (and potential loss) of postage stamps.

(c) Followup. Followup mailings are crucial for ensuring adequate response rates; without followup mailings, response rates will be less than half of those attained by using a comprehensive followup system (Dillman 1978). The followup procedure consists of three carefully timed mailings after the original mailout:

One week: A postcard reminder is sent to everyone. It serves as a thank-you and acknowledgment for respondents, and as a polite reminder for nonrespondents.

Three weeks: A second package is sent out to nonrespondents. This package contains a shorter cover letter intended to inform the nonrespondent that their questionnaire was not received, and that everyone's response is important to the success of the project. A replacement questionnaire and a postage-paid return envelope are also included.

Seven weeks: A final mailing, similar to the second mailing, is sent to nonrespondents. It has been recommended that this mailing should be sent by certified mail "to emphasize its importance" to the recipient (Dillman 1978). However, the expense is considerable; although there is some evidence that certified mailings result in a substantial increase in response rates, there is at least one study which found that additional responses had no influence on the results of the study.

Step 4: Select and Train the Interview Team

Careful selection and training of the personnel who are involved in collecting data are essential if the manager or research planner is not performing the field research. The research planner must ensure that interviews are conducted and observations collected in the manner required by the study plan.

1. Personnel Selection.—Both personality and ability must be evaluated in the selection process. The importance of visitor contact extends beyond the quality of data obtained; it is an opportunity to present the image of the managing agency. Select an interviewer who is friendly, reliable, knowledgeable, and trained in emergency procedures. Personnel should be familiar with the wilderness area and be prepared to handle requests for information about the wilderness and the surrounding area. Many of the questions from visitors will not be related to the interview; providing information is a courtesy which contributes to establishing rapport with the visitors and increases visitor cooperation. Personnel should be in appropriate uniform and possess necessary communication and safety equipment.

2. Training.—It is essential that personnel are thoroughly trained in the data collection procedures. Training ensures that observers are already familiar with the research directives and the interviewing process before

actual fieldwork begins. As a result, errors involved in the learning process are reduced, and there will be greater consistency in identifying the sampling units (in this case visitors to be interviewed) and recording responses. Training enables observers to become familiar with various contingency plans, to identify potential problems in the research directives, and to make decisions if problems occur.

Preliminary, or pretest fieldwork should be conducted before the actual survey begins. Rehearsals ensure that personnel understand procedures, and serve as a test for the efficiency of the methods; problems or inadequacies in the procedures can be identified and eliminated, and the consistency and accuracy of personnel can be observed and analyzed. Observers should be screened at intervals and their performance compared either with each other or at different time points for the same observer; screening provides a check on performance and identifies sources of error in the data.

Step 5: Develop a Sampling Plan

Sampling plans must be developed for:

1. Scheduling rotation of the interview teams across trailheads.
2. Scheduling interview periods.
3. Selecting visitors to be interviewed.

Step 6: Purchase Supplies

Supply costs are associated with the printing of survey forms, and the printing and mailing of questionnaires. Both printing and mailing costs are influenced by survey length, the number of surveys required, stationary type and weight, and, when applicable, the method of mail delivery, and the use of repeated mail followups.

Step 7: Collect Interview or Questionnaire Data

Survey data are collected by trained personnel in accordance with a specific plan (as described in step 5). The interview protocol consists of (a) visitor selection, and (b) data collection. The interviewer must be provided with sufficient research material—data forms, writing tools, schedules, and so forth—for the survey period. Interviewers must understand the need to completely and correctly fill out the data forms. Interview sheets should be filed in a designated place after the interviewer returns to the office.

(a) <u>Visitor selection</u>. Visitors are selected in accordance with the predetermined sampling plan (step 5). The location of interviews will be determined by study objectives; visitors may be interviewed upon either entry or exit, or both. For example, if the emphasis of the study is on the effects of group size or place of residence on wilderness use, these factors are unaffected by interview location. However, if the study objectives require information on patterns of visitor use within the wilderness area (for example, travel or camping locations, length of stay), visitors should be interviewed as they leave. Visitors should not be interviewed inside the wilderness boundary (to avoid threats to the visitor experience from management presence).

(b) <u>Data collection</u>. When encountering and interviewing visitors, personnel should begin with a standard introduction. Personnel should give their name and agency affiliation and the reason for the interview. For example, “Hello, I am Marilyn Holgate. I work for the Missoula District of the Lolo National Forest. We are trying to learn more about the use of the Rattlesnake Wilderness. It will help us with management of the area. May I ask you a few questions about your visit today?” After the interview, thank visitors for their time. Personnel may be tempted to add additional questions “just out of curiosity”; this cannot be justified in any circumstances.

Responses should be recorded as they are given; *interviewers should not rely on memory to fill in the interview sheet at a later time.* Make sure every item is complete and legible; data forms must include date, time, location, and interviewer’s name. Completed data forms should be filed in a safe place.

Step 8: Obtain Mailback Responses

A well-organized system must be developed to handle questionnaire returns. Returns must be individually coded so that the identification number matches that on the original questionnaire; this enables returns to be documented so that respondents who have completed questionnaires and those requiring followup mailings can be managed accordingly. As returns come in, they should be examined for problems which may result in missing data (such as sticking pages, unclear directions, and so forth). The researcher must be prepared to handle undelivered questionnaires, and answer respondent inquiries.

Step 9: Estimate Use

There are three steps in the estimation procedure: (1) estimating survey response rates, (2) estimating sample sizes, and (3) estimating total use.

Visitor use data are collected from information provided on the survey forms; the collection, entry, and processing of data are therefore time intensive and relatively expensive. Consequently, sample sizes should be specified for each use characteristic to be evaluated categorically. Preliminary estimates of the required statistics (for example, standard deviation) can be obtained from observations made during a pilot study or similar studies conducted elsewhere.

Use data are collected in accordance with the appropriate sample size and the sampling strategy. Estimates of survey response rates are required to determine the relationship between the number of visitors who are interviewed with respect to the total number of visitors actually entering the wilderness area. The total number of visitors entering a wilderness area is estimated from the relationship between the total number of visitors, (N), and the rate of survey response, (r). Information obtained from survey forms should be sufficient for obtaining data on observable and nonobservable categories of visitor. The number of visitors per category is expressed as a proportion or percentage of the total number of users.

1. Response Rates.—There are several methods of calculating questionnaire response rates, (R). The first method is the ratio of questionnaires returned to those sent out, or

$$R = \frac{number\ returned}{number\ sent\ out} \times 100$$

However, if there is a certain proportion of ineligible respondents, or potential respondents who could not be contacted, the formula must be modified as follows:

$$R = \frac{\textit{number returned}}{\textit{(number sent out)} - \textit{(non-eligible + non-reachable)}} \times 100$$

(Dillman 1978).

Example. Questionnaires were sent to 200 visitors randomly selected from permits issued for a given season. A total of 156 questionnaires were returned. Ten contacts were ineligible and 14 could not be contacted (questionnaires were not forwarded or returned). The response rate is:

$$R = \frac{156}{200-(10+14)} \times 100 = 88.6\%$$

2. Sample Size Estimation.—Sample sizes for categorical data should be specified first. Sample sizes should be estimated for each use characteristic to be measured, and the largest (feasible) sample size is chosen. If a stratified sampling strategy is used, stratum sample size is calculated according to whether proportional or disproportional representation is required.

(a) Continuous data. The relation used to estimate sample size is:

$$n \cong \left[4 \cdot \frac{S}{L}\right]^2$$

If the sampled population is small, the finite population correction (fpc) is used to correct for overestimation bias. Using the fpc, the estimated sample size is:

$$n \cong \frac{N \cdot S^2}{S^2 + \frac{L^2 \cdot N}{4(2)^2}}$$

where L is the width of the interval around the projected average, and N is the size of the true population. In this case, N is the number of days in the season. Precision is estimated by the confidence level (generally 95 percent) and the desired width of L. For example, the investigator may wish to be 95 percent certain that the results have a precision of ± 5 percent of the total. Operationally feasible sample sizes are obtained by varying the amount of precision of the estimate; highly precise estimates may require sample sizes that are too large for practical purposes.

Example. From past surveys the average amount spent per trip was $250, with S = $160. Suppose we want to be 95 percent certain that results will have a precision of ± 5 percent, or ± $13 per trip. If the total number of visits to a remote trailhead was 100, then the estimated number of visits to sample is

$\approx \frac{100(160)^2}{(160)^2 + \frac{(13+13)^2(100)}{16}}$ = 86. If the precision is adjusted to ± 10 percent

(or ± 25 per trip), then n = 62. Both of these are too large or too close to the entire group of 100 visits to be of practical use due to the large underlying variance. A more reasonable level of precision would be ± 30 percent (or ± $75 per visit), which would call for a sample size of n = 15.

(b) Proportion data. Sample size (n) will be at a maximum when the proportion of observations (p) in any given category is 0.5 (or 50 percent). The sample size required to estimate an interval of width L around the sample mean will be:

$$n = \frac{4 \cdot (2)^2 \cdot p(1-p)}{L^2}$$

which is maximized for $p = 0.5$ or $n = 16(0.5)(0.5)/L^2$.

Example. Preliminary data showed that for 40 randomly selected visitors, 24 appeared to be day users. Therefore, the proportion of day users, p = 24/40 = 0.60, and the standard error is $\sqrt{p(1-p)/n} = \sqrt{(0.60)(0.40)/40}$ = 0.0775. The 95 percent confidence interval based on these data is approximately 0.6 $\pm 2(0.0775) = 0.6 \pm 0.15$, for a confidence interval of (0.45, 0.75). The sample size n required for a 95 percent confidence interval with a length of at most 0.10 (regardless of the resulting value of p) is approximately $n = \frac{16(0.5)^2}{(0.10)^2}$ = 400. Therefore, it would be necessary to observe 400 visitors to obtain this amount of precision for the estimate.

(c) Stratified sampling. If the data are stratified according to trailhead or time block, sample sizes of each stratum must be calculated to ensure accurate representation of the population. Sample sizes may be either proportional or disproportional to stratum size (part I, chapter 3). Proportional sampling subdivides the sample population proportional to the size of each strata or subgroup. Optimal allocation is a type of stratified sampling where the sample size within each strata is proportional to both the size and the variability of the sample within each stratum; the proportionality factor is calculated as $\left[N_i \cdot S_i / \sum\left(N_i \cdot S_i\right)\right] \cdot n$. Disproportional sampling occurs when the same size sample is drawn for each stratum (assuming equal costs to sample each strata).

Proportional sampling should be performed if strata are fairly homogeneous (that is, the standard deviations observed for each stratum are similar), whereas optimal allocation should be chosen if strata differ in the amount of variability.

Example. In this example, data are stratified by two time blocks—weekend days and weekdays. This stratification strategy separates out time periods according to relative intensity of use, with the heaviest and most variable use occurring on weekends, and relatively light and uniform use on weekdays. For a 100-day season, there are about 72 weekdays and 28 weekend days. Suppose the available resources (budget, labor, time) dictated that the maximum number of days that could be sampled was n = 25. The initial value for the standard deviation for each stratum was estimated from the data obtained during the permit compliance rate estimation phase. Sample sizes for each time block are calculated as follows:

Stratum	s^a	Proportional f^b	n^c	Disproportional f	n	Optimal allocation f	n
Weekends ($n_1 = 28$)	88.0	0.25	7	0.43	12	0.64	16
Weekdays ($n_2 = 72$)	19.2	0.25	18	0.17	12	0.36	9

[a]Standard deviation.
[b]Sampling proportion.
[c]Sample size.

Because the two strata differ considerably in variability, the preferred sampling scheme is optimal allocation; with this strategy the investigator randomly selects 16 weekend days and 9 weekdays for data collection.

3. Use Estimation.—Use characteristics estimated with this system are limited to individual or group visit counts. Data may be expressed in terms of: (a) the rate (for example, number of visitors per day), (b) the total (for example, number of visitors for the season), (c) use by category (for example, cooking method), (d) use description (for example, length of stay), or (e) summary-use statistics (for example, recreation visitor days)

(a) Rate of use. Suppose the number of visitors with permits for a 30 day time period was 772. A survey of 50 visitors showed that 46 had permits for a compliance rate of 46/50 = 0.92.The estimated number of users over the 30 day period is 772/0.92 = 839, for an estimated daily rate of 839/30 = 28 users per day. The estimated confidence interval for the 30 day rate is:

$$839 \pm 2 \cdot \sqrt{772^2 \cdot 50 \cdot (50-46)/46^3} = 839 \pm 70 = (769, 909)$$

which converts to a confidence interval for the daily rate of (25.6, 30.3).

(b) Total use. Total visitor use is estimated by multiplying the "corrected" average daily rate by the number of days in the time period of interest, corrected by the estimated bias in counts. *The assumption implicit in this method is that use remains uniform over the time period of interest; if use patterns fluctuate considerably over the season, calibration relationships should be updated as required, and the new relationship used to calculate use rates for that time interval.*

In this example, season length was 100 days. The overall visitor use estimate is therefore 28(100) = 2,800 visitors (2,560 to 3,030 visitors).

(c) Use by category. Frequently, visitor use is described in terms of categories, or groups, of users; the number of users in each category is expressed as a proportion, or percentage, of the total number of users in the sample.

Example. On the returned survey forms 2,975 visitors indicated their method of cooking during their visit: stoves, wood fires, or neither. Results with a 95 percent confidence interval (using χ^2 procedure based on 2 degrees of freedom) were:

Stove users: n_1 = 2,231, p_1 = 2,231/2,975 = 0.75,

$$\text{95 percent confidence interval} = 0.75 \pm \sqrt{5.99[(0.75)(0.25)/2,975]} = 0.75 \pm 0.019$$

= (0.731 to 0.769);

Wood fire users: n_2 = 595, p_2 = 595/2,975 = 0.20,

$$95 \text{ percent confidence interval} = 0.20 \pm \sqrt{5.99[(0.20)(0.80)/2,975]} = 0.20 \pm 0.018$$

= (0.18 to 0.22);

Neither: n_3 = 149, p_3 = 149/2,975 = 0.05,

$$95 \text{ percent confidence interval} = 0.05 \pm \sqrt{5.99[(0.05)(0.95)/2,975]} = 0.05 \pm 0.009$$

= (0.04 to 0.06).

(d) Use description. One variable that may be obtained by surveys is length of stay. Post stratification may also be of interest.

Example. A sample of 38 surveys reported an average length of stay of 2.4 nights with a standard error of 0.23 nights. This makes the 95 percent confidence interval 2.4 ± 2·0.23 = 2.4 ± 0.46 = (1.94, 2.86).

(e) Summary-use statistics. The recreation visitor-day is defined as 12 hours of a given recreation activity performed by the associated proportion of visitors. It is calculated as the product of the number of activity occasions and the average amount of time spent in that activity, divided by 12.

Example. The number of permits issued for a given season was 6,750, of which 1,232 were horse users. For horse users, there were 3.1 people per group, and 5.2 horses per group; the estimated compliance rate was 95 percent. The total number of horse users was 3.1(1,232)/(0.95) = 4,020 people, and 5.2(1,232)/(0.95) = 6,744 horses. The average duration of a wilderness trip was 5 days, or 120 hours. Then, the number of recreation visitor-days for horse users during the season was 4,020(120)/12 = 40,200.

A study of visitors entering the Bob Marshall Wilderness found an average group size of 4.7; 61 percent of all groups consisted of two to four people.

Groups traveling with recreational packstock are generally larger than hiking groups.

Appendices

Appendix A: References

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Appendix B: Data and Data Analysis

Observations are the raw material of any wilderness use study. Because information gained from wilderness use studies is primarily numerical, and because the manager is generally interested in populations or groups, statistical methodology is required for both the characterization and analysis of wilderness use data. In this section we describe the general types of observations that are acquired during the research process, provide elementary methods of analyzing such data, and define the statistical meaning of the various terms used throughout the text. The techniques presented in this section are found in most introductory statistics texts; we review them here in the context of monitoring wilderness use.

Variables

Variables are attributes measured by the individual observations; they are not constant from item to item, but show variation. Variables may be either quantitative or qualitative.

A quantitative variable can be measured and ranked. Observations on quantitative variables may be categorized further as continuous or discrete. A continuous variable is one which can take on virtually any possible value within some range. Examples are distances traveled per day, and times between wilderness trips. A discrete variable can take on only a distinct series of values, with no intermediate values between them; they are therefore integers. Count data are discrete variables; for example, the number of hikers per day, the number of packstock per string.

A qualitative, or categorical, variable is one which cannot be directly measured or ordered. Each observation is some property of the item in the sample; these properties are classified as belonging to one of a finite number of categories. These categories can be dealt with statistically if they can be assigned counts or frequencies. In the simplest case, there are only two categories required for describing all possible responses; such data are binomial. For example, visitors classified on the basis of gender would be either male or female. Multinomial data are described by several categories. Examples are types of users (hikers, horseback riders, canoeists), ethnic origin, state of residency, and so on.

Populations and Samples

A *population* consists of all possible values of a variable. When all values of a population are known, it follows that the population can be characterized exactly. The various characteristics of the population, such as the population mean μ and the population variance σ^2, are known as parameters. The parameter has a fixed numerical value which is usually unknown to the investigator.

A *sample* is a subset, or part, of the population. Sample characteristics, such as the sample mean and the sample variance S^2, are used to estimate population parameters; a given sample characteristic is known as a statistic. Our goal is to use characteristics of the sample to make inferences about the corresponding characteristics of the population; thus, if the inferences are to be valid, the sample must be representative of that population.

To ensure that a sample is representative of the population of interest, we must employ principles of *randomization*. When randomly selected from a population, each item has an equal probability of being selected. A random sample is not haphazard, unplanned, or based on guesswork; such methods of data selection will lead to biased results. Instead, random selection of sample items is performed by using a random number table—a sequence of numbers generated by a uniformly distributed random distribution. There are two benefits to this approach. First, the selection of items is not influenced by unknown or unsuspected biases on the part of either the investigator or the circumstances surrounding the selection of the sample. Second, we can apply the statistical laws of probability to infer the expected values of an estimate and its sampling variation. A description of random sampling and how it is performed is given in chapter 3.

Descriptive Statistics: Data Plots

Graphs are a quick and easy method of data analysis. Humans are primarily visual animals; it is much easier to understand and summarize large amounts of quantitative information when it is presented as a diagram, rather than as a list of numbers. Data plots are a highly effective means of (1) exploring the data set for patterns and relationships, (2) checking the data for conformity to basic statistical assumptions if further statistical analysis is to be performed, and (3) presenting quantitative information in as concise and effective means as possible. In fact, *plotting data is the most important step in the analysis, and should be performed first, before more rigorous analyses are performed*.

Four basic types of data plots are considered here: (1) stem-and-leaf displays, (2) histograms and bar charts, (3) scatterplots, and (4) time plots.

Stem-and-Leaf Displays

This type of data plot shows the frequency distribution of a single variable. It is also useful for obtaining ranked data arrays, and for computing the median of the sample. It is constructed by splitting the value of each observation into two parts: the stem, which consists of one or two leading digits, and the leaf, which consists of the remaining digits. Stem values are listed on the left of the page, and leaf values are listed beside the corresponding stem in the order in which they are encountered.

Example. The user count data for the East Hickory Creek Trail (table 4) consists of counts between 1 and 83. The stem would be the first digit and the leaf the second digit; for example, the “User” count 57 (observation number 1, week 1, day 1) would have a stem of 5 and a leaf of 7. The stem-and-leaf display for the East Hickory Creek Trail user data is as follows:

0 | 455685999897557788977989387
1 | 19330310351322240938354025571348410826166 4
2 | 11871807665
3 | 41633484
4 | 61133571738
5 | 7877873
6 | 59
7 | 58
8 | 3

This diagram shows that the distribution of these data is highly skewed to the right, with a few large values but with the majority of values in the lower counts. The importance of symmetrical data distributions and corrections for asymmetrical data are discussed next.

Histograms and Bar Charts

A bar chart is a method of showing the frequency distribution for a single categorical or classification variable. A bar chart is constructed by first forming a frequency table, dividing the sample into classification categories. Bars are then drawn with height proportional to the frequency or relative frequency of each category. Although pie charts are often used to display categorical data, bar charts are preferred since comparison of pie slices is not as straightforward as comparison of bars.

A histogram is another method of showing the frequency distribution for a single continuous variable. A histogram is constructed by subdividing the measurement axis into a number of nonoverlapping, consecutive intervals of equal length. Each observation is contained in one of these intervals; the number of observations in each interval is the frequency. Above each interval a rectangle is drawn with the height proportional to the frequency (relative frequency). The stem-and-leaf display discussed above is a rudimentary histogram and is easily converted to a frequency table.

Example. Horse users in a certain wilderness area were asked to indicate the type of community where they were raised. The frequency distribution for the data are shown below; the resulting bar chart is shown in Figure 8.

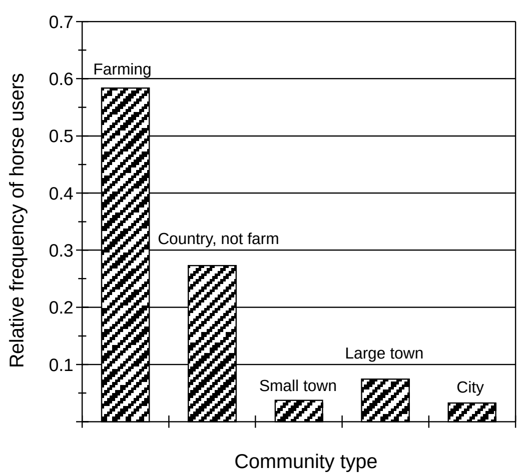


Figure 8—Bar chart showing the relative frequency of horse users coming from different community types.

Type of community	Frequency	Relative frequency
Farming	126	0.58
Country, not farm	59	0.27
Small town	8	0.04
Large town	16	0.07
City	7	0.03

Example. The user count data for the East Hickory Creek Trail (table 4) can be presented as a frequency table (below, constructed from the raw data or equivalently the stem-and-leaf display above) or as a histogram (fig. 9).

Class	Frequency	Relative Frequency
1-9	28	0.25
10-19	42	0.38
20-29	11	0.10
30-39	8	0.07
40-49	11	0.10
50-59	7	0.06
60-69	2	0.02
70-79	2	0.02
>=80	1	0.01

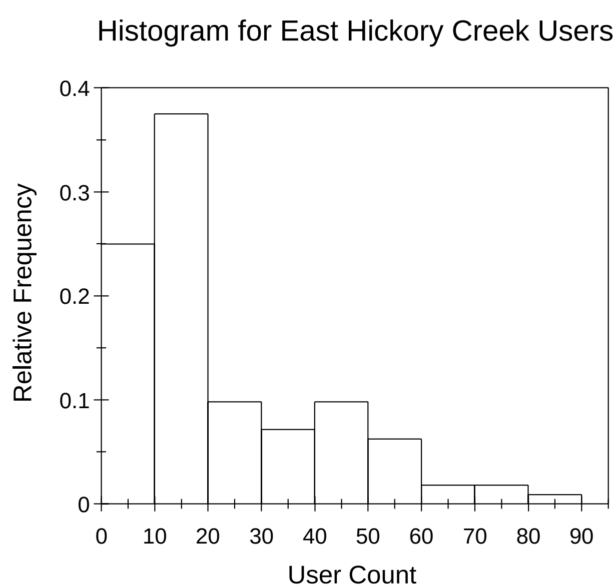


Figure 9—Histogram showing the distribution of the daily number of users for the East Hickory Creek Trailhead in the Cohutta Wilderness.

Scatterplots

When two measurements are made on each item, a scatterplot of the paired measurements can show the patterns in the data, or indicate the amount of association between the two variables. Scatterplots are useful when the data set is large, if there is a lot of variation in the data (which may mask important relationships), and for checking the linearity of the relationship. Scatterplots are especially critical in calibration problems where the relative agreement between two measures must be assessed.

Example. The following data were visitor counts obtained by a mechanical counter and by human observers at the Snow Lake Trailhead, located in the Alpine Lakes Wilderness, Washington.

Counter:	132	514	604	107	74	107	423	438	92	170	186	127	80.
Observers:	119	308	556	119	74	113	424	270	78	180	61	8	187.

The ideal relationship between the two sets of counts would be a 1:1 correspondence between the two methods. A less desirable, but still workable, situation would be one method showing consistently higher readings than the other.

The plot of these data (fig. 5) reveal a large amount of scatter about the 1:1 line. In general, data from human observers are more accurate than those from mechanical counters.

Time Plots

These are similar to scatterplots, except that each observation for the variable of interest is plotted in time order. This type of plot is extremely useful for detecting cycles or other kinds of time-dependent patterns in the data. It is an invaluable tool in monitoring programs, especially when the objective is to evaluate the effects of some intervention, such as a change in management policy or initiation of some educational program, on some visitor characteristic.

Statistical analyses of time-dependent data are mathematically very complex, and require considerable skill and judgment. (A very simple time trend analysis is presented in a later section.) However, time plots are simple to construct and can give a substantial amount of useful information which may not be immediately apparent for the tabulated data. *It should be noted that a number of statistical methods (including the calculation of descriptives such as the variance and standard deviation), are not appropriate for time-dependent observations, and will give completely misleading results*.

Example 1. Figure 4 shows a time plot of number of users monitored on the East Hickory Creek Trail for the 112 days of the summer season. It is immediately obvious from visually inspecting this plot that the data are extremely cyclic. Peak numbers of users occur (not unexpectedly) on weekends, averaging about 50 per weekend day, and declining to an average of about 10 users on weekdays. Patterns relevant to a number of management questions (what are trail use patterns? should the trail be managed for peak or average numbers? how are party averages affected by time in the week? are large party sizes unusual? etc.) can be readily answered by visual inspection.

Example 2. Figure 10 shows the number of violations committed by wilderness visitors before commencement of an education program, and the

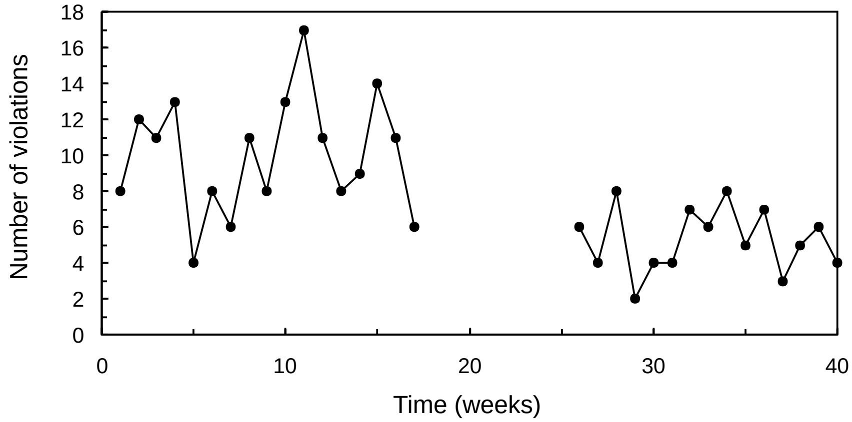


Figure 10—The number of violations committed by wilderness visitors before and after the initiation of a wilderness education program.

number of violations after the program was in place. In this instance the program appears to be effective to some extent because the number of violations has declined. However, violations are occurring at a new steady-state level. Further management could be directed toward determining whether the educational program is no longer effective for all visitors, or if only a small subset of offenders needs to be targeted by an alternative program.

It is extremely important in this kind of monitoring that there are some kind of baseline or control measurements made before the policy or program change to determine if the new situation actually has affected the response.

Determination of statistical differences between several series is beyond the scope of this handbook. Competent statistical assistance should be obtained.

Descriptive Statistics: Continuous Data

There are several types of numerical summary measures which characterize a given data set and communicate some of its more important characteristics. The two most important attributes of a set of numbers are (1) the location, or central value, and (2) the spread or dispersion around that central value.

Measures of Central Tendency

The mean.—The most common measure of central tendency for a given set of numbers is the mean, or arithmetic average. The sample mean is calculated as the sum of all the observations in the set, divided by the sample size:

$$\overline{Y} = \frac{Y_1 + Y_2 + \ldots + Y_n}{n} = \frac{\sum_{i=1}^{n} Y_i}{n}$$

Example. In a preliminary study of visitor impact on the Snow Lake Trail, the numbers of visitor groups were recorded during 8 hours of observation on each of 11 randomly selected days over the season. The data are as follows:

52, 115, 209, 46, 19, 44, 149, 158, 47, 70, 76.

The sum of these n = 11 observations is $\sum_{i=1}^{11} Y_i = 985$. The sample mean is:

$$\overline{Y} = \frac{\sum_{i=1}^{11} Y_i}{11} = \frac{985}{11} = 89.54$$

The median.—In a set of ranked or ordered observations (smallest to largest), the sample median is the middle value, so that half the numbers are less than the median value and half are greater. When the data set has an odd number of values, there is a unique middle value among the ranked numbers. When the data set has an even number of values the median is calculated as the average of the two middle values in the ordered data set.

Example. For the Snow Lake Trail data, ordering gives:

19, 44, 46, 47, 52, **70**, 76, 115, 149, 158, 209.

The median is therefore 70.

The median is insensitive to extremes in the data, such as very large or very small data values. For example, if we increased the largest observation to 500, the median would be unaffected. This contrasts with the mean, which can be markedly affected by even one extreme value.

In general, the mean and median will not be equal to each other. If the population is skewed, the arithmetic mean will be "pulled" in the direction of the skew. Thus, if the population is negatively skewed (where the distribution of the observations shows a pronounced tail to the left), the median will be smaller than the mean; if the population is positively skewed, the mean will be larger than the median. Thus, in certain cases the median may be more appropriate than the mean for describing skewed data or outlying observations.

Quartiles and percentiles.—The median divides the data set into two parts of equal size. We could obtain finer resolution of our data set by dividing it into more than two parts. Quartiles are four equal divisions of the data set, such that the first quartile separates the lower one-quarter, or 25 percent, of the data from the remaining three-quarters, the second quartile is the median, and the third quartile partitions the top quarter of the data from the lower three-quarters. Percentiles divide the data set into 100 equal parts, such that the 99th percentile separates the highest 1 percent of the data from the remaining 99 percent, and so on. Percentiles are not recommended unless the number of observations is very large (>1000).

Measures of Variability

A measure of central tendency gives only partial information for a given data set; it provides us with a measure of location but does not give any information about the amount of variability around the location. In wilderness use studies, most investigators are interested in determining the magnitude of a certain outcome, or the size of the difference of that outcome between groups. The precision of the particular sample statistic used is given by the degree of variability in the measured outcome. *Mean values should never be given without some measure of their variability.*

It is important to note that measures of variability based on random sampling give only the effects of sampling variation on the precision of the estimated statistics. They cannot correct for errors which are not related to sampling; for example, biases in study design or incorrect analyses.

Range.—The simplest measure of variability is the range, which is the difference between the largest and smallest values in a data set:

$$\text{Range} = \max(Y_i) - \min(Y_i)$$

Thus, a small range indicates a small amount of variability, whereas a large range indicates a large amount of variability. In general, the range is presented in terms of its minimum and maximum values, and the difference is not computed.

Because it depends on the two most extreme values in the data set, the range is overly sensitive to those values; the magnitudes of the intermediate observations are ignored.

The Sample Variance and Standard Deviation.—The population variance (denoted by σ^2) is a measure of the amount of variation among the observations in a population. The sample variance S^2 is calculated as the sum of squared deviations of observations from the mean, divided by $n - 1$:

$$S^2 = \frac{\sum_{i=1}^{n} (Y_i - \overline{Y})^2}{(n-1)}$$

A more accurate and computationally simpler method of calculating S^2 is:

$$S^2 = \frac{\sum_{i=1}^{n} Y_i^2 - \frac{\left(\sum_{i=1}^{n} Y_i\right)^2}{n}}{n-1}$$

First, each observation is squared and the squared values are added together. Second, the sum of all observations is squared and divided by the sample size n. This value is subtracted from the total of the squared observations and this difference is divided by $(n - 1)$. The positive square root of the sample variance is called the *sample standard deviation* (S); it is one of the most important descriptive statistics. S can be thought of as a measure of how far a typical observation deviates from the average.

If the sample comprises more than 5 percent of the population (assuming sampling is done without replacement), the S^2 is too large, on average. To correct this problem, multiply by the finite population correction factor (fpc), defined as $(N - n)/N$.

Example. For the Snow Lake Trail data, the sum of all $n = 11$ observations was $\sum_{i=1}^{11} Y_i = 985$, and the sum of squared observations was $\sum_{i=1}^{11} Y_i^2 = 124{,}073$. Then the sample variance S^2 was calculated as:

$$S^2 = \frac{124,073 - \frac{(985)^2}{11}}{10} = 3,587.0727$$

Since the season at Snow Lake is roughly 100 days, a sample of 11 days exceeds the 5 percent rule, so the estimated variance needs to be adjusted using the fpc. S^2 = 3,587.0727 (100 – 11)/100 = 3,192.495. The square root of this corrected estimate of the population variance is the sample standard deviation, $S = \sqrt{3,192.494} = 56.5$.

The Standard Error .—An investigator rarely studies every member of the population, but only a small representative sample. The mean calculated from such a sample consists of observations drawn at random from the population; therefore, there is nothing distinctive or unusual about this sample or its mean. If another sample were selected, chance alone almost always produces a sample consisting of different observations and consequently a different sample mean. Each randomly drawn sample has a mean, and each sample mean is an estimate of the true (but unobservable) population mean. If it were possible to calculate the means of all possible samples of a given size from a population, we would obtain a distribution of sample means whose values would differ from one another, but would cluster around the true population value. The standard deviation of the population of all possible sample means is called the standard error. The standard error quantifies the variability of the sample means relative to the true population mean, or the certainty with which we can estimate the true population mean from the sample. *The standard error quantifies the precision with which the sample mean estimates the true population mean.*

The standard error of the mean (*SE*) is computed for a simple random sample as:

$$SE = \frac{Standard\ deviation}{\sqrt{sample\ size}}$$

Example. For the Snow Lake data, the estimated standard error of the mean is:

$$SE = 56.5/\sqrt{11} = 17.03.$$

Confidence Intervals .—A confidence interval is the range of values for the mean that can be considered feasible for the population. The width of a confidence interval depends partly on the standard error (and therefore on both the standard deviation and the sample size), but also on the amount of "confidence" we wish to associate with the resulting interval. The investigator selects the degree of confidence to be associated with the confidence interval. A 95 percent confidence interval is the most common choice, although smaller or larger confidence intervals can be computed according to the degree of confidence required. If a 95 percent confidence level is specified, approximately 95 percent of such intervals will correctly contain the unknown population mean. This also means that about 1 in 20 such intervals (5 percent) will not contain the unknown population mean.

A value from *Student's t distribution* is multiplied by the estimated standard error when n is smaller than 30. For sample sizes of 30 or more, the multiplier is selected from the *standard normal (or z) distribution*. *For most* *practical purposes, 2.0 is an adequate approximation for the multiplier to construct a 95 percent confidence interval.*

Procedure: For a given confidence level, the confidence interval for a population mean is calculated from the mean $\bar{Y}$ the sample size n, and the standard deviation S. Recall that $SE = S/\sqrt{n}$. Then the 95 percent confidence interval is approximately:

$$\left(\bar{Y} - 2 \cdot SE, \bar{Y} + 2 \cdot SE\right)$$

Example. For the Snow Lake data, n = 11, $\bar{Y}$ = 89.54, and S = 56.5. The degrees of freedom associated with the estimate of S are (11 – 1) = 10. The approximate 95 percent confidence interval is given by 89.54 ± 34.06 = (55.48 to 123.61).

Descriptive Statistics: Categorical Data

Much of the data describing wilderness visit and visitor characteristics are *categorical*. That is, each observation in a sample belongs to one of a finite number of groups or categories. In the simplest case, such data are binomial; there are only two categories required for describing all possible responses. For example, a visitor classified on the basis of gender would be either male or female. Multinomial data are described by several categories; examples are ethnicity (white, African-American, Hispanic, Native American, etc.), marital status (single, married, divorced, widowed, separated), state of residence, and so on. Such data cannot be summarized by the statistics used for continuous data, such as mean and standard deviation. For example, if ethnic groups were classified into 10 groups labeled from 1 to 10, an "average" ethnicity code would be meaningless. Instead, the investigator is interested in the number of items in each category, expressed as a proportion or percentage of the total number of observations; measures of central tendency and spread can be calculated for data expressed in this form. The value of the total should always be presented when proportion data are used. However, if the sample size is very small, proportion data will be useless for evaluation purposes.

Binomial Data

Assumptions for binomial sampling require that observations are independent; that is, each element of the population has an equal probability of being selected, and selecting any particular observation does not influence the outcome or selection of any other observation. Furthermore, the overall proportion of observations having the feature of interest must not change during the sampling process.

In the simplest case, a given variable can be described in terms of two possible outcomes; one outcome specifies individuals which have the feature of interest ("successes", or YES = 1), and the other outcome specifies individuals which do not have that feature ("failures", or NO = 0).

Sample Calculations.—Let p represent the proportion of "successes." For a random sample of size n, the average or expected number of "successes" is $n \cdot p$. Then, where there are X individuals having the feature of interest:

$$p = X/n$$

In other words, p is a mean of a set of observations that are either 0 or 1. The standard error for the proportion of "successes", SE_p, is calculated as the square root of the product of the proportion of "successes" p and the proportion of "failures" $(1 - p)$, divided by the sample size:

$$SE_p = \sqrt{\frac{p(1-p)}{n}}$$

<u>Confidence Intervals</u>.—The 95 percent confidence interval for a proportion p may be approximated for most practical purposes by:

$$p \pm 2 \cdot SE_p.$$

Example. A survey of 100 randomly selected wilderness visitors reported that 36 visitors used a campstove. Let p denote the proportion of all visitors who used a stove. Then $p = X/n = 36/100 = 0.36$ and the estimated standard error of p is $\sqrt{\frac{p(1-p)}{n}} = \sqrt{\frac{0.36(1-0.36)}{100}}$, or 0.048.

The approximate 95 percent confidence interval for p is:

$$p \pm 2\sqrt{\frac{p(1-p)}{n}} = 0.36 \pm 2\sqrt{(0.36)(0.64)/100}$$

or (0.266 to 0.454).

The length of the 95 percent confidence interval is 0.188, or about 19 percent. Suppose we wish to increase the precision of this estimate to 10 percent. Then the sample size necessary to obtain a 95 percent confidence interval with this amount of precision is:

$$n \approx \left[\frac{4(2)^2(0.36)(0.64)}{(0.10)^2}\right] = 369$$

Multinomial Data

Multinomial responses are an extension of the simpler binomial case. Instead of only two possible outcomes, each observation results in one of k possible outcomes, where k is a number greater than two. For example, suppose we determine that there are three types of wilderness users: hiker, horseback rider, and mountain biker. There are thus $k = 3$ possible outcomes, or categories, for each visitor. A multinomial analysis would involve classifying each of n visitors who entered the wilderness area into one of the $k = 3$ categories.

<u>Sample calculations</u> : There is probability p_i that an observation will occur in category i. For k categories, there will be n_i observations in each category, and the sum of all observations $\sum_{i=1}^{k} n_i = n$.

Recall that in a two-category (binomial) situation, the expected number of "successes" and the expected number of "failures" are $n \cdot p$ and $(1 - p)n$ respectively. Similarly, in a multinomial situation, the expected number of observations resulting in category i is $n \cdot p_i$ where $i = 1, 2, ..., k$ categories, and the expected number of "failures" is $(1 - p_i)n$.

Confidence Intervals.—The 95 percent confidence interval cannot be approximated by $2 \cdot SE$. Instead, the formula used to calculate the confidence interval for the expected or mean values of each p_i is:

$$p_i \pm \sqrt{\chi^2_{\alpha,k-1} \cdot SE_i}$$

where $\chi^2_{\alpha,k-1}$ is the *100(1–α)th percentile of a chi-square (χ^2) distribution*, with $(k-1)$ degrees of freedom, and the standard error calculated for each category is $SE_i = \sqrt{\frac{p_i(1-p_i)}{n}}$.

Example. A survey of $n = 100$ wilderness visitors reported three user type categories: hikers, mountain bikers, and horseback riders. They observed $n_1 = 67$ hikers, $n_2 = 25$ horseback riders, and $n_3 = 8$ mountain bikers. The proportions of each type of user were as follows:

	Hikers	**Horse users**	**Mountain bikers**
n_i	67	25	8
p_i	$p_1 = 67/100$ $= 0.67$	$p_2 = 25/100$ $= 0.25$	$p_3 = 8/100$ $= 0.08$

To obtain the simultaneous 95 percent confidence intervals for p_1, p_2, and p_3, we use the tabulated value of $\chi^2_{3-1=2,0.95} = 5.99$. The 95 percent confidence intervals are given by:

$$p_1 : 0.67 \pm \sqrt{5.99\left[\frac{(0.67)(0.33)}{100}\right]} = (0.56 \text{ to } 0.79)$$

$$p_2 : 0.25 \pm \sqrt{5.99\left[\frac{(0.25)(0.75)}{100}\right]} = (0.14 \text{ to } 0.36)$$

$$p_3 : 0.08 \pm \sqrt{5.99\left[\frac{(0.08)(0.92)}{100}\right]} = (0.013 \text{ to } 0.15).$$

Differences Between Variables

In the previous section we demonstrated the procedures for estimating a given population parameter by using sample statistics; we evaluated the precision of that estimate by calculating confidence intervals. However, many wilderness problem situations involve the detection of differences between some observed value and some other value, either historical or maximum allowable use levels, or values derived from previous studies. In this section we discuss the procedures for testing for differences between two values.

When evaluating differences between values, in effect we are evaluating the competing claims of the two values as to which estimate of the value is the correct one for the population, or alternatively, how well the two values agree. Methods for deciding between these competing claims are called *hypothesis testing*.

Detailed information on hypothesis testing procedures are given in a number of statistical texts (for example, Neter and others 1985, Snedecor and Cochran 1980, Steel and Torrie 1980). For our purposes it is important to note that there is a close relationship between the use of a confidence interval and a hypothesis test. We can infer the result of the hypothesis test at a level of statistical significance associated with the confidence interval. For example, a value falling outside of the 95 percent confidence interval calculated for the difference between two sample means indicates that there is a statistically significant difference between the sample means at the $\alpha = 0.05$ level. This is generally interpreted as a decision to reject the null hypothesis of no difference between sample values. However, presenting differences in terms of confidence intervals is more informative than expressing the probability level of statistical test of significance. Generally, the investigator is more interested in determining the magnitude of the difference rather than a single arbitrary decision value for statistical significance; confidence intervals produce a range of values for the population value of the difference (Gardner and Altman 1986).

Determination of sample sizes necessary to detect specified differences is similar to procedures discussed previously. Those interested in further details are encouraged to consult either a statistician or a statistical text.

One-Sample Tests

A one-sample test is appropriate if interest centers on detecting departures of the sample estimate (calculated from the data) from some null, or reference, values. For example, reference values may be historical use levels or maximum allowable use levels. The null hypothesis is that there is no difference between the observed mean and the reference value; that is (Observed Mean Use Level = Historical Use Level). If the historical mean value lies outside the confidence interval constructed around the sample mean, then the equality hypothesis is rejected.

The procedure for comparing a sample proportion p to a reference proportion p_0 is similar. For the null hypothesis that $p = p_0$, if p_0 falls outside the confidence interval for p, then the null hypothesis is rejected.

Procedure:

1. Identify the parameter of interest (for example, the mean, proportion, etc.) to be estimated, and describe it in the context of the wilderness "problem" to be evaluated.
2. Determine the null value; that is, the historic value, the maximum acceptable value, the regulatory or legislated value, or other reference value of interest.
3. Calculate the mean and standard error for the sample data.
4. Calculate a confidence interval for the parameter of interest (the population mean or proportion).
5. If the reference value falls outside the confidence interval, the hypothesis is rejected.

Example. In a certain wilderness area prior to 1985, horses were the only type of packstock used; the average daily number of horse-user groups up to that time was 20. However, after 1985, llama use became more prevalent.

The manager wishes to determine whether or not the prevalence of horse use has changed from "historical" levels. The null hypothesis is that (Current Horse Use = 20).

Sample data for the number of horse-user groups collected for 10 randomly selected days over a single season were:

17, 9, 6, 5, 6, 34, 7, 21, 6, 4.

The sample mean $\overline{X}$ = 11.5, n = 10, SD = 9.67, and the reference mean is 20. Then the 95 percent confidence interval for the mean is 11.5 ± 2·(9.67/$\sqrt{10}$ = (5.38, 17.62). Because the value of 20 falls outside (above) the 95 percent confidence interval for the current horse use, the manager concludes that the prevalence of horse use measured during this particular season is in fact lower than historical levels. However, this year may be atypical in some way; for example, unusually bad weather or economic conditions may have adversely affected the numbers of horse users. To determine if this observation is actually a trend toward lower horse use in general, the manager will have to obtain data for several more seasons.

Comparing Two Samples

The investigator may be interested in detecting a difference between the means of samples from two different populations. Examples include detecting differences between current values for population and "baseline" measurements for the sampled population, or measurements made at a different location or under different circumstances.

For evaluating the difference between two independent samples, estimates of the difference between the population means and an estimate of the standard error for that difference are required. The null hypothesis is that there is no difference between means. The standard error for $\overline{X} - \overline{Y}$ is estimated by the square root of the sum of the squared standard errors for each of the two means:

$$SE_{\overline{X}-\overline{Y}} = \sqrt{\frac{S_1{}^2}{n_1} + \frac{S_2{}^2}{n_2}}$$

The 95 percent confidence interval for the difference between two means is approximated by:

$$\overline{X} - \overline{Y} \pm 2 \cdot SE_{\overline{X}-\overline{Y}}$$

The samples are judged to be significantly different if the confidence interval does not contain 0.

Evaluating the difference between population proportions is similar; the null hypothesis is that the difference between the population proportions is zero. The standard error for the difference is estimated by:

$$SE_{p_1-p_2} = \sqrt{\frac{p_1(1-p_1)}{n_1} + \frac{p_2(1-p_2)}{n_2}}$$

The 95 percent confidence interval for the difference is approximated by $p_1 - p_2 \pm 2 \cdot SE_{p_1-p_2}$.

Procedure:

1. Identify the parameter of interest (for example, the mean, proportion, and so forth), and describe it in the context of the wilderness "problem" to be evaluated.
2. Calculate the sample estimates of the mean or proportion for both groups.
3. Calculate the difference between sample estimates.
4. Calculate the standard error for the difference of the sample estimates.
5. Calculate the confidence interval for the difference between the population means.

Example. At Snow Lake wilderness area, group counts were obtained over an 8-hour period for each of 12 randomly sampled days in 1990 and 11 randomly sampled days in 1991. These counts produced the following data:

1990: 148, 138, 45, 62, 123, 340, 273, 92, 231, 205, 115, 107.
1991: 52, 115, 209, 46, 19, 44, 149, 158, 47, 70, 76.

The null hypothesis is that there is no difference in mean group size between years.

For the 1990 sample, $n_1 = 12$, $\overline{X} = 156.58$ and $S = 88.62$; for the 1991 sample, $n_2 = 11$, $\overline{Y} = 89.55$, and $S = 59.89$. The difference between the sample means is $\overline{X} - \overline{Y} = 156.58 - 89.55 = 67.03$. The estimated standard error for this difference is:

$$SE_{p_1 - p_2} = \sqrt{\frac{(88.62)^2}{12} + \frac{(59.89)^2}{11}} = 31.31.$$

The 95 percent confidence interval for the difference is $67.03 \pm 2(31.31) = (4.4, 129.7)$. The value 0 falls outside the 95 percent confidence interval; therefore, the data casts doubt on the veracity of the hypothesis of no difference between 1990 and 1991 use levels. In other words, mean group size in 1991 was significantly smaller than group size in 1990.

Comparing More Than Two Samples

Analysis of Variance.—The analysis of quantitative data obtained from more than two samples is usually performed by the procedure known as analysis of variance, or ANOVA. The independent variable whose effect on the response is to be studied is the factor under study (sometimes referred to as the treatment), and the different subpopulations, or components, are the levels of that factor.

Example. The manager of a given wilderness area wishes to determine the effects of four types of travel methods (hiking, rafting, horseback riding, mountain biking) on total distance traveled by visitors. The *response* is total distance traveled. The *factor* is travel method. The *levels* are the types of travel methods; hiking, rafting, horseback riding, and mountain biking each constitute a level.

Example. The manager wishes to determine whether the relative location of registration stations affects the number of visitors actually registering. Three locations were tested: at the trailhead, at a fixed distance down the trail (one-quarter mile from the trailhead), at a "natural" stopping place (on top of an incline). The *response* is the number of completed registration cards as a proportion of the total number of visitors passing the registration stations. The *factor* is station location. The *levels* are the three location categories.

In these examples the factor is qualitative, and the levels correspond to different qualitative attributes or categories of the factor. Factors may also be quantitative; in these cases the levels are described by a numerical quantity on a scale (for example, age in years, number of years of education).

Analysis of variance determines whether or not there are differences in the true averages associated with the different levels of the factor. If the null hypothesis is rejected, this is interpreted to mean at least two of the mean responses are different. The test statistic is the ratio of factor variance to the common variance—the F-statistic. The calculated F-value is compared to the critical F values which are tabulated in the back of many statistical texts. The appropriate critical F is determined by the number of degrees of freedom associated with the numerator and denominator of the ratio. As a general rule of thumb, when F is close to 1, the null hypothesis cannot be rejected (the average responses are similar for all groups), and if F is much larger than 1 (as determined from the appropriate table of F values), then the null hypothesis is rejected (at least one mean is different).

The calculations used to obtain the calculated F-statistic are performed by using formulae similar to those used to calculate the single sample mean $\overline{X}$ and sample variance S^2. *Because these calculations are fairly involved, standard computer statistical packages are used.*

Analysis of variance techniques are outside the scope of this handbook. For more information, the reader is encouraged to consult Neter and others (1985), or other statistical texts.

Comparison of Proportions .—A common requirement of many wilderness studies is the comparison of count or frequency data when observations can be classified according to two or more different factors. This class of problems occurs when there are R populations divided into C categories. The table that displays the observations is called a *two-way contingency table*. In these cases we wish to determine whether various categories are statistically independent; that is, if the proportions observed for all categories are similar to expected values. Under the hypothesis of statistical independence, the row (or column) classification is not influenced by the column (or row) classification. Under this hypothesis the distribution of the cell frequencies within any given row (or column) are proportional to the overall column (or row) frequencies. Examples are comparisons of patterns of use between day hikers and overnight hikers, or the proportions of wilderness users from an urban background who ride horses versus those that hike.

The test statistic used to perform this test is the *chi-square (χ^2) statistic*:

$$\chi^2 = \sum_{\text{all cells}} \frac{(Observed - Expected)^2}{Expected}$$

The observed cell counts are the number of observations in each cell. The expected cell counts are calculated as: (rth row total)·(cth column total)/n, where n is the total number of observations. The χ^2 value calculated by this formula is compared to the critical tabulated value; the appropriate χ^2 is selected with reference to a given probability α (usually 0.05), and the appropriate degrees of freedom. The number of degrees of freedom used to calculate the critical value are $(R - 1) \cdot (C - 1)$ if there are R rows and C columns. If the calculated χ^2 value is larger than the critical value, the null hypothesis of independence between row and column classifications is rejected.

Confidence intervals for individual cells or for differences between cells may be computed as described previously for multinomial proportion data.

Procedure:

1. Tabulate the sample count data according to their respective group R and category C; these are the observed cell counts.
2. Calculate the row and column totals.
3. Calculate the expected cell counts.
4. Determine the appropriate degrees of freedom $(R - 1)$ and $(C - 1)$.
5. Calculate χ^2, and compare to the tabulated value of χ^2 with $(R - 1)(C - 1)$ degrees of freedom.
6. Calculate confidence intervals for any or all differences.

Example. A wilderness manager wished to determine whether use patterns of different categories of users changed as a result of a certain specified management action. The use category was length of stay; categories of use were specified as "short-term" (under 4 hours), "intermediate" (over 4 hours but not overnight), and "overnight." The response was visitor number. A randomly selected baseline sample of 240 visitors was obtained and classified before the management action, and 200 randomly selected visitors were classified after the action. The data are:

Type of use	Before action	After action	Total
Short term	72	80	152
Intermediate	120	70	190
Overnight	48	50	98
Column totals	240	200	N = 440

The expected cell counts are:

Type of use	Before action	After action	Total
Short term	$\frac{(152)(240)}{440} = 82.91$	$\frac{(152)(200)}{440} = 69.09$	152
Intermediate	$\frac{(190)(240)}{440} = 103.64$	$\frac{(190)(200)}{440} = 86.36$	190
Overnight	$\frac{(98)(240)}{440} = 53.45$	$\frac{(98)(200)}{440} = 44.55$	98
Column totals	240	200	440

The calculated χ^2 statistic is:

$$\chi^2 = \frac{(72-82.91)^2}{82.91} + \frac{(80-69.09)^2}{69.09} + \frac{(120-103.64)^2}{103.64} +$$

$$+ \frac{(70-86.36)^2}{86.36} + \frac{(48-53.45)^2}{53.45} + \frac{(50-44.55)^2}{44.55}$$

= 1.436 + 1.723 + 2.582 + 3.099 + 0.556 + 0.667= 10.063

with $(R-1)(C-1) = (3-1)(2-1) = 2$ degrees of freedom. The critical $\chi^2_{2,\,0.95}$ = 5.992. Because 10.063 > 5.992, we conclude that there was a difference in use as a result of the management action.

To pinpoint which of the three types of users were affected by the management action, we can perform either of two tests:

(1) Calculate combined χ^2 values for each row, and compare to the critical χ^2 with $(C-1) = (2-1) = 1$ degrees of freedom. The critical $\chi^2_{1,0.95} = 3.84$. The difference between "before" and "after" groups within each user type is significant if $\chi^2_{\text{calculated}} > \chi^2_{\text{critical}}$. The χ^2 values for each of the three user categories were, respectively:

Short term: 1.436 + 1.723 = 3.183 < 3.84.
Intermediate: 2.582 + 3.099 = 5.681 > 3.84.
Overnight: 0.556 + 0.667 = 1.223 < 3.84.

(2) Calculate the approximate 95 percent confidence intervals for the differences in proportions for each of the user categories (the formula is given in the section *Multinomial Data*). The difference between "before" and "after" groups within each user type is significant if the value 0 lies outside the interval.

The proportions for each cell are:

Type of use	**Before action**	**After action**	**Difference**
Short term	0.30	0.40	–0.10
Intermediate	0.50	0.35	0.15
Overnight	0.20	0.25	–0.05

The confidence intervals for each difference (by user type) are:

Short term: (–0.19 to –0.01)
Intermediate: (0.06 to 0.24)
Overnight: (–0.13 to 0.03).

Therefore, the intermediate users were strongly affected by the management action, showing a statistically significant decline in numbers. Short-term users were marginally affected by the management action, showing a slight increase. Overnight users were relatively unaffected.

To further isolate differences between observed and expected frequencies, the individual contributions to the overall chi-square test statistic may be compared to a critical chi-square value with 1 degree of freedom, 3.843. For this example the largest cell contribution is 3.099 which is smaller than 3.843. This means there are no individual cells with observed frequencies that differ significantly from their expected frequencies under the null hypothesis of independence of the row and column classifications.

Association of Two Variables

This section describes methods of association analysis where the variation in one variable is used to account for the variation in another variable and to predict (or forecast) values of that second variable. There are four basic types of association analyses. **Regression** specifically uses the value of one variable to predict the value of the other. Regression techniques are most frequently used for obtaining indirect measures of hard-to-measure use characteristics as a function of more easily measured variables; they are occasionally used in calibration applications. **Correlation** analysis examines the strength of the linear relationship between two continuous variables. **Calibration** is the assessment of the relative agreement of two independent measures of the same use characteristic. In its simplest form, **trend detection** looks for relationships as a function of time. **Compliance estimates** are a form of "calibration"; supplementary observations are used to adjust visitor counts for the bias occasioned by visitors failing to comply with the mandatory permit or voluntary registration systems.

An introduction to the basic concepts of association analyses are given below. Detailed discussion of these topics is beyond the scope of this manual; interested readers should consult Neter and others (1985), Steel and Torrie (1980), or other statistical texts for further information.

Regression

The simplest relationship between two variables X and Y is a straight line. The data comprising X and Y are a set of pairs (x, y); Y is the dependent variable (the variable to be explained) and X is the independent (or explanatory) variable. The general relationship between Y and X is given by:

$$Y_e = \beta_0 + \beta_1 \cdot X$$

where Y_e is the expected, or mean, value of Y; β_0 is the intercept, or value of Y when $X = 0$; and β_1 is the slope of the relationship, or the change in Y for a unit change in X. There are specific assumptions regarding the distributions of each variable, the most important of which is that X, being the independent variable, can be determined with little or no error relative to Y; this is the fundamental assumption of any linear regression problem. Therefore, the investigator must be very clear about which variable can in fact be defined as the independent variable.

The intercept is estimated by:

$$b_0 = \overline{Y} - b_1 \cdot \overline{X}$$

The slope is estimated by:

$$b_1 = \frac{\sum_{i=1}^{n} X_i Y_i - \frac{\left(\sum_{i=1}^{n} X_i\right)\left(\sum_{i=1}^{n} Y_i\right)}{n}}{\sum_{i=1}^{n} X_i^2 - \frac{\left(\sum_{i=1}^{n} X_i\right)^2}{n}}$$

The percentage variation explained by the regression of Y on X is:

$$R^2 = \frac{\sum_{i=1}^{n}\left(\hat{Y}_i - \overline{Y}\right)^2}{\sum_{i=1}^{n}\left(Y_i - \overline{Y}\right)^2}$$

where $\hat{Y}_i$ is the estimated value obtained from the fitted regression; that is, $\hat{Y}_i = \overline{Y} + b_1(X_i - \overline{X}) = b_0 + b_1 \cdot X_i$. The value of R^2 is always between 0 and 1. The square root of R^2 is the correlation coefficient R, which should be given the same sign as the regression coefficient, b_1.

Most modern spreadsheets such as Excel, Lotus, or Quattro provide for regression analysis. As part of their summary output an analysis of variance (ANOVA) table is generated, similar to the one produced for comparing several groups. The sources of variability are: $SSTotal = \sum_{i=1}^{n}\left(Y_i - \overline{Y}\right)^2 = SSRegression + SSError$ where $SSError = \sum_{i=1}^{n}\left(Y_i - \hat{Y}_i\right)^2$ and $SSRegression = \sum_{i=1}^{n}\left(\hat{Y}_i - \overline{Y}\right)^2$. Note that given any two sums of squares the third may be computed by addition or subtraction. An alternate formula for *SSError* is $(1 - R^2)SSTotal$. The degrees of freedom for SSRegression for a simple linear model is 1 since there is a single predictor variable. The degrees of freedom for SSError is $(n - 2)$. Dividing the SSError by the degrees of freedom for error gives the Mean Square Error, abbreviated MSE (i.e., $MSE = SSError / (n - 2)$). As before, an F ratio is computed by changing sums of squares into mean squares and then forming their ratio, i.e., $F = (SSRegression / 1) / (SSError / (n - 2))$. The hypothesis that $\beta_1 = 0$ is rejected if the calculated F ratio exceeds the appropriate table value with 1 and $(n - 2)$ degrees of freedom.

In many analyses of wilderness use, the investigator wishes to predict the anticipated response for some given value of X. The mean response is calculated simply by plugging in the given value of X into the regression equation and calculating Y. The 95 percent confidence interval for this new observation of Y is:

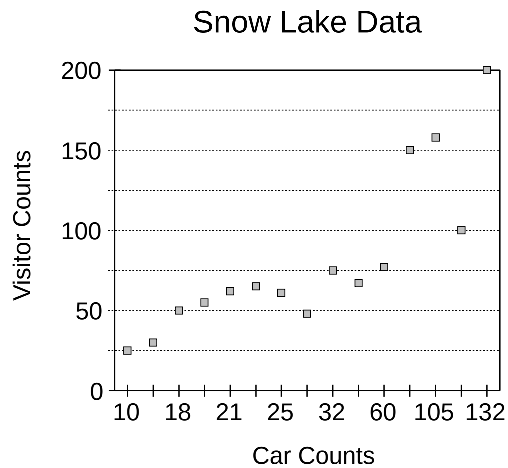
$$Y_{new} \pm 2 \cdot \sqrt{MSE\left[1 + \frac{1}{n} + \frac{\left(X_{new} - \overline{X}\right)^2}{\sum_{i=1}^{n}\left(X_i - \overline{X}\right)^2}\right]}$$

An essential first step in the analysis of regression data is to examine a scatterplot of the data. The nature of the scatter will show whether there is in fact a linear relationship between the two variables. If the relationship between X and Y is positive or increasing from left to right, b_1 will be positive, and if the relationship is negative or decreasing from left to right, b_1 will be negative.

Multiple regression models consist of two or more independent variables that are used to predict the dependent variable. See Neter and others (1985), Steel and Torrie (1980), or other statistical texts for details on computation and inference.

Example. Visitor traffic at Snow Lake Trailhead in the Alpine Lakes Wilderness was surveyed to establish the relationship between the numbers of vehicles in the trailhead parking lot (indicator variable) and the number of visitors counted ½ mile up the trail (*Y*). The data were:

Cars	Visitors
10	25
15	30
18	50
20	55
21	62
23	65
25	61
27	48
32	75
33	67
60	77
92	150
105	158
108	100
132	200



Example of the sample relationship between number of cars and visitors.

The relationship between car counts and visitor counts was:

$$Y = 26.48 + 1.15\,X$$

with $r^2 = 0.86$. That is, the mean number of visitors increases by 1.15 for every additional car, and 86 percent of the variation in direct visitor counts could be explained when car counts are considered.

The summary statistics for this relationship are:

$$n = 15, \overline{X} = 48.07, \sum_{i=1}^{n} X_i = 721, \sum_{i=1}^{n} X_i^2 = 57{,}663,$$

$$\sum_{i=1}^{n} Y_i = 1{,}223, \sum_{i=1}^{n} Y_i^2 = 134{,}651, \sum_{i=1}^{n} X_i Y_i = 85{,}139.$$

Then $\sqrt{MSE} = \sqrt{\dfrac{134{,}651 - (26.48)(1{,}223) - (1.15)(85{,}139)}{13}} = 19.11.$

The average number of cars in the trailhead parking lot was 45 per day. Therefore, the associated number of visitors was estimated to be 26.48 + 1.15(45) = 78. The 95 percent prediction interval for this estimate is:

$$78 \pm 2(19.11)\sqrt{1 + \frac{1}{15} + \frac{(45 - 48.07)^2}{57{,}633 - 721^2 / 15}} = 78 \pm 39 = (39,\ 117).$$

Correlation

Rather than predict the value of Y from X, we may be interested only in determining the strength of the linear association between the two variables. Correlation analysis does not assume a cause-and-effect relationship between X and Y.

The correlation between two variables is expressed as a coefficient (the correlation coefficient r), rather than an equation. The value of r does not depend on which variable is designated X and which is Y; neither is it affected by the units in which X and Y are measured. The correlation coefficient always takes on a value between –1 and +1. If r is near 0, this is interpreted as the absence of a linear relationship; it does not necessarily mean that there is no relationship at all. A "strong" correlation is implied if $|r| \geq 0.8$, a correlation is "weak" if $|r| \leq 0.5$, and a correlation is "moderate" if $0.5 < |r| < 0.8$. However, if the association between the two variables is curved, the calculated r will underestimate the true strength of the relationship; conversely, r will be too high if several observations are different from the rest. Therefore, *it is critical to examine a scatterplot of the data before attempting to interpret the practical significance of r.*

Example. The correlation between car counts and visitor counts is:

$$r = \sqrt{0.86} = 0.93.$$

Calibration

An important part of all wilderness use studies is the evaluation of the reliability of different methods of data collection. In general, reliability is assessed by comparing two methods of measuring a given use characteristic; calibration is the determination of how well the two measures agree. For example, it is a common practice to evaluate the effectiveness of mechanized counters for obtaining visitor traffic counts by comparing readings to data collected by human observers. In these cases, one method (for example, human observers) is known to be highly accurate, but is relatively expensive; the other method may be cheaper and less time intensive to operate, but the accuracy is unknown or variable. The investigator uses the two different methods to obtain a simultaneous measure of a given use characteristic (the observations are therefore paired). If agreement between the two methods is high, the cheaper method can be substituted with no loss of accuracy. Alternatively, there may be no agreement between methods, indicating that no substitution is possible. A third alternative is that the data obtained from the new method show consistent deviations from the values obtained by the original method. The bias associated with the new method can be quantified, and the cheaper method substituted for the old, with the data adjusted by the appropriate correction factor.

There are several cautions to be observed when collecting and analyzing calibration data:

1. The purpose of calibration is to assess the differences between paired observations; *this means the observations must be true pairs*. For example, if observations from human observers are to be used to check the accuracy of a mechanical counter, human observers must take data for the same location and for the same time periods as the mechanical counters. Suppose the

working day of the human observer is only 8 hours, but the mechanical counter can run day and night. The counts made by the mechanical counter outside the working hours of the human observer should not be included in the analysis.

2. *It is not correct to compare two methods by either (a) evaluating the means and standard errors of each group separately, or (b) calculating the correlation between methods.* Using these analyses to evaluate the relative merits of two different methods is completely misleading. A calibration problem has only one randomly selected set of visitors, but two observations are made for each individual visitor.

Comparing separately calculated means and standard errors implicitly assumes that there are two randomly sampled populations. The correlation coefficient is actually a test of how likely it is that the two variables are not related at all; on the other hand, variables in a calibration problem are obviously associated by their very nature.

3. *Many errors of analysis and interpretation can be avoided by plotting the data first*.

These last two points can be demonstrated by a simple example. Suppose A and B represent two methods of obtaining visitor count data. Figure 11 shows two situations where (a) there is little agreement between the two methods, and (b) agreement is good, but method B gives consistently higher readings than method A. Method A and method B can be summarized by the same respective means and standard errors in both instances! However, visual inspection of these data leads us to conclude that in the first case the two methods do not agree and no substitution is possible; no further analysis is required. In the second case, methods A and B appear to agree, but estimates obtained from B would require adjustment by a constant correction factor; further calculations are performed to obtain the correction factor and the associated precision.

The major assumption underlying all calibration techniques is that the original relationship calculated for the calibration data remains the same over the duration of the season. This will not be true in practice. For example, visual calibration devices such as cameras may be triggered by leaves blowing across the sensors, which will be more of a problem in autumn. The

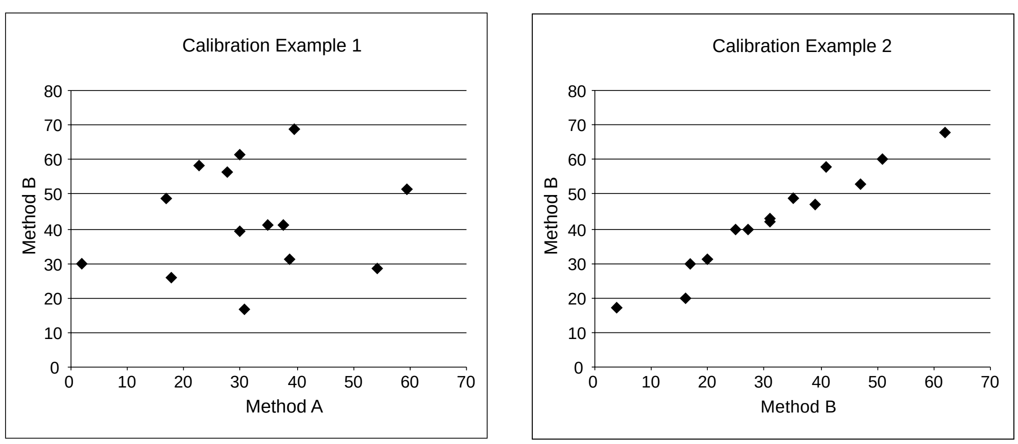


Figure 11—Hypothetical examples of patterns of visitor count data obtained by two methods. Example 1 shows poor agreement between methods. Example 2 shows good agreement between methods.

sensitivity of the trigger device will be affected by battery aging and failure. To assure accuracy in count data, calibration should be performed at frequent intervals and, if possible, whenever the power source is changed, and/or the trigger devices are altered.

The easiest method of calibrating or comparing two counting methods is to first plot the data. The method considered most accurate is plotted along the vertical axis and the candidate method is plotted along the horizontal axis. A regression line may then be fitted to the data. If the slope is not significantly different from zero, then there is no relationship between the two methods and the candidate method should be discontinued. If the intercept (b_o) is nonzero, then there is an inherent bias between the two methods.

Consider the scatter plots in Figure 11.Methods A and C are to be evaluated as more efficient or less costly alternatives to Method B. Figure 11A shows no relationship between the two figures, and in fact the R^2 value is 0.02, much too close to 0 to indicate a useful relationship. The F ratio is 0.25, much less than any critical value with 1 and 12 degrees of freedom. Figure 11B on the other hand shows a fairly strong relationship, and in fact the R^2 value is 0.94 with an F ratio of 189.84. However the intercept is computed as 13.26, meaning that Method C is underestimating the count obtained by Method B by about 13 individuals. Because this is a strong relationship, knowing the count using Method C, we can predict with good accuracy what the Method B count would be.

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