

A CASE STUDY COMPARISON OF VISITOR SELF-REPORTED AND GPS RECORDED TRAVEL ROUTES

Jeffrey C. Hallo
Graduate Research Assistant
Rubenstein School of Environment and Natural Resources
University of Vermont, Burlington, VT 05405
jhallo@uvm.edu

Robert E. Manning
Professor
Rubenstein School of Environment and Natural Resources
University of Vermont

William Valliere
Research Data Specialist
Rubenstein School of Environment and Natural Resources
University of Vermont

Megha Budruk
Graduate Research Assistant
Rubenstein School of Environment and Natural Resources
University of Vermont

Abstract

The study of crowding in national parks and other protected areas most often examines concentrations of visitors along existing travel pathways, such as roads or trails. Data on travel routes have typically been gathered using visitor self-reporting where participants are asked to manually record their routes on maps. Since its inception in the 1970s, the satellite-based Global Positioning System (GPS) has become increasingly more accurate and has seen diverse use in public, private and academic realms. The survey of individual travel routes of visitors to national parks with GPS is a relatively recent but promising methodological application. Surveys at Muir Woods National Monument, California and Acadia National Park, Maine provide case studies for comparison of visitor self-reported and GPS-reported routes, respectively. Survey participants at Muir Woods were asked to manually record their travel route on a paper map. At Acadia, GARMIN eTrex Legend hand-held GPS units were provided to individuals upon their entrance. The GPS method recorded far more detailed and accurate travel routes than those from visitor self-reported routes. Furthermore, the GPS method collected a larger number of individual routes over fewer days and with a much lower refusal rate. The recording of

similar data using self-reporting at Muir Woods was not humanly or technologically feasible. Despite the apparent advantages of GPS for surveying travel routes, several issues warrant consideration prior to its use, such as cost, operability in the area of study, and respondent handling of the GPS units. A brief assessment of the advantages and disadvantages of each methodology are presented in this paper. GPS technology has implications for researchers and managers in that it may produce more robust, detailed, and accurate studies of visitor travel patterns.

1.0 Introduction

Visitors to National Park Service (NPS) units almost exclusively use roadways and trails to access scenic vistas, attraction sites, or as a means for experiencing these natural areas. Manning (1979) described this pattern of spatial distribution as a system of links and nodes. For example, visitors may encounter each other as they move along a trail (link) or congregate at trailheads and shelters (nodes). Recreation use is generally characterized by spatial concentration along these links and nodes, which typically constitute a small percentage of the area within parks and wildlands (Hammit and Cole 1998). This trend also results in concentrating and, in cases, exacerbating impacts – both social and ecological.

As visits to national parks have grown to over 260 million (NPS 2003) crowding has become a topic of increasing concern. NPS policies have directed superintendents to address the issue of crowding (NPS 2001) through structured decision making processes such as the Visitor Experience and Resource Protection (VERP) (NPS 1997). A fundamental step in frameworks such as VERP is the inventory of existing conditions. In terms of visitor use patterns, this means gathering site-specific data on where people go in a NPS unit and the how long they stay at certain sites. Collection of such information has traditionally involved asking visitors to record their own travel routes on paper map diaries. More recently the Global Positioning System (GPS) has been used to collect similar travel route data.

The objectives of this paper are to (1) introduce GPS technology as a means for collecting location information and (2) to present a comparison of two methods for

gathering visitor route information. Case studies from two national park units will be presented to make this comparison.

1.1 The Global Positioning System

In 1973, the U.S. Department of Defense (DoD) began use of a satellite-based system to provide location information to military units and equipment. This system, then known as NAVSTAR, has developed into the modern-day GPS. NAVSTAR operated solely for military purposes until the 1980s, when civilian use was first permitted. In 1994 GPS reached its full operational capacity when the last of 24 satellites was placed into orbit around the earth. This constellation of satellites provided GPS capability to the entire surface of the earth. To prevent use of the system for unauthorized purposes, the civilian mode was subject to an imposed inaccuracy known as selective availability (SA). This limited the accuracies obtained by civilian GPS units to approximately 100 meters. In 2000, the DoD removed the SA interference, which resulted in a greatly improved accuracy, to about 20 m (Garmin 2004). Further advances in GPS technology (Differential GPS and the Wide-Area Augmentation System 'WASS') now allow civilian GPS units to potentially record locations to accuracy of 3 m or less.

GPS operates based on the triangulation of highly accurate and precise satellite signals. Obtaining a GPS-derived location begins when a receiver (e.g., a hand held GPS unit) acquires a signal from one of the 24 satellites in the worldwide GPS constellation. The signal used for civilian purposes, designated as L1, operates at 1575.42 MHz in the UHF band (Garmin 2004). This signal contains a pseudorandom code that identifies the transmitting satellite, almanac data providing the satellite's orbit information to the receiver, and ephemeris data. The ephemeris data is constantly transmitted by the satellite and contains information that includes the current date and time. Each GPS satellite has 4 atomic clocks that provide the extremely accurate and precise times required for the receiver to calculate its distance from the satellite based on the time delay between when a signal was sent and when it was received. This narrows the solution space for the receiver's location to a circular path circumscribed by all points on the earth's surface with the measured distance equal to that calculated by the receiver. By acquiring signals, and thus distances,

from two additional satellites, the solution space is narrowed to one possible location on the earth's surface. Finally, the time measurement of the L1 signal made by the receiver, and any associated error, is corrected by comparing the GPS-location with the distance from a fourth satellite – this sets the receiver's time measurement nearly equal to that of an atomic clock. For a more detailed description of GPS technology see El-Rabbany (2002).

The L1 signal follows a line of sight, capable of passing through transparent (e.g., glass) and some translucent objects (e.g., clouds). However, the signal will not reach the receiver if its path from the satellite is opaquely obscured – perhaps by topography, dense vegetation, or buildings. Use of GPS is restricted by this line of sight principle. Despite this limitation, GPS has successfully been used in many research contexts including, tracking wolves within Yellowstone; surveying archeological sites; and recently in collecting recreation use pattern information on trails, roads, and at attraction sites for developing computer simulation models of visitor use.

2.0 Study Sites

2.1 Muir Woods National Monument

After intensive harvesting in the 1800s, few stands of Coast Redwoods were left in the San Francisco region of California at the turn of the 20th century. Due largely to its inaccessibility, however, a 295-acre portion of virgin timber remained uncut. Congressman William Kent purchased this tract and donated it to the federal government in 1908, stipulating only that it be managed as a park and named after his friend John Muir (Runte 1997). In a letter of appreciation to Kent, Muir wrote that the land was "the best tree-lover's monument that could possibly be found in all the forests of the world."

Muir Woods National Monument is located in Redwood Canyon approximately 15 miles northeast of San Francisco. The monument receives over 700,000 visits annually (NPS 2003). A network of both paved and unimproved trails are used to experience the stands of Coast Redwoods, which serve as the primary attraction for most visitors. Trails generally meander through the bottom of Redwood Canyon with views constrained by the steep slopes of the canyon, other topography, or by the tree canopy (Figure 1).



Figure 1.—Trails through Redwood Canyon.



Figure 2.—The scenic road

2.2 Acadia National Park

Established as the first eastern national park, Acadia currently receives more than 2.5 million visits annually (Runte 1997; NPS 2003). Acadia National Park is located along the coast of Maine and consists of three geographically separate sections – Mount Desert Island, Isle au Haut, and the Schoodic Peninsula. The latter of these is a 2,266-acre area located approximately 1 hour's drive from the Mount Desert Island portion of the park.

A scenic park road is the only travel route through Schoodic Peninsula. The road follows the shoreline of the peninsula, providing access to two of the most frequently visited areas, Frazer Point and Schoodic Point. These locations are used by 88% and 52% of visitors to the Schoodic Peninsula, respectively (Manning et al. 2002). The road permits only one-way vehicle travel, except on short access roads to both scenic points. The scenic park road is the only entrance and exit point to this portion of the park.

Both the vegetation cover and land topography at Frazer Point, Schoodic Point, and on the scenic road are highly open. Each of the points provides visitors with relatively unobscured views of the coastline. The scenic road, likewise, allows views of the ocean, with relatively few trees or visual obstructions on the seaward side (Figure 2).

3.0 Methods

3.1 Muir Woods National Monument

In August 2003 visitors to the main trail system of Muir Woods National Monument were asked to participate in a survey of spatial use patterns. A researcher was stationed at the entrance during 15 days and gave participants a paper map diary to complete as they used the trails. The first visitor to arrive at the start of the data collection period was invited to participate in the study. Once the researcher completed providing a map diary and instructions to this visitor the next available visitor entering Muir Woods was selected. People were instructed to record on the map where they hiked/walked in the park. Participants were asked to mark the beginning and ending times of their hike/walk, locations where they stopped for greater than 5 minutes, and the amount of time spent at each stop. A sample route was provided to participants for reference in filling out their own map diary (Figure 3).

3.2 Acadia National Park

Visitor travel routes in the Schoodic Peninsula portion of Acadia National Park were collected using GPS. During nine days in July 2003 occupants of the first 10 cars to enter Schoodic Peninsula at the start of the daily data collection period (9 a.m.) were asked to participate in a study by carrying a GPS unit in their car. Each participant was given one of 10 GARMIN eTrex Legend GPS units used in the study. If any of the occupants of

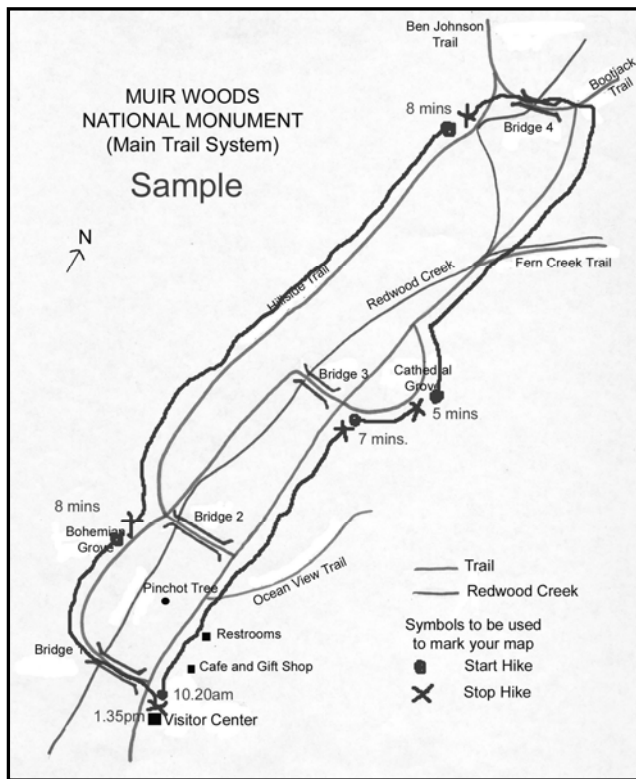


Figure 3.—Sample route provided to Muir Woods study participants to follow in filling out their own map diary.

the first 10 cars refused to participate, then additional cars were asked in the order of their arrival.

The GPS units used in this study are commercially available off-the-shelf and retail (in 2004 dollars) for \$214. Each unit provided to visitors was on its default settings, which recorded individual location points automatically instead of at a defined time or distance interval. Participants were instructed to keep the GPS unit in their car and on their dashboards while driving. If they decided to leave their vehicle, the GPS units were to be kept in the vehicle but removed from direct exposure to the sun. Preliminary trials had determined that units were susceptible to overheating and malfunction when left in the sunlight on the dashboard of a vehicle.

The GPS units were collected from participants at the Schoodic Peninsula exit, and the route data were downloaded to a computer using Topofusion, one of the many available GPS route-mapping software programs. GPS units were then returned to the park entrance for collection of additional routes throughout the sampling day.

4.0 Results

4.1 Muir Woods National Monument

A total of 588 visitors were asked to participate in the study at Muir Woods by completing a map diary. Of these people, 407 were provided a paper map diary to complete and the remaining 181, or 30.8%, refused to participate. Furthermore, 94 (23.1%) of the map diaries collected were unusable, primarily because they were incomplete or unintelligible. In most of these cases either the direction of travel or the starting or stopping time was omitted.

The paper map diaries needed to be entered into a computer readable format for subsequent use. To digitize the route information a number was assigned to all stopping points indicated in the entire collection of sampled routes. These identifiers were then used to enter each individual route into a spreadsheet as a time-ordered series of stops. Time spent at each stop was also transferred into the spreadsheet.

4.2 Acadia National Park

Over 9 days a total of 215 individual travel routes were collected, and 11 people, or 4.9% of all those asked, refused to participate by carrying a GPS unit in their car. Of the routes collected, 22 (10.2%) were unusable due to either equipment malfunction or participant tampering. Each GPS route file downloaded contained numerous location points all with an associated latitude, longitude, altitude, and time. Each route was unique and provided great detail regarding where each car traveled, with an approximate accuracy of 20 feet and exact times at each location.

Preparation of GPS recorded routes for further use – in the case of this study a computer simulation model of automobile traffic at the Schoodic Peninsula – required harvesting data points of interest from the many collected for each route. This was accomplished using an Arc Macro Language (AML) script. The script set a circular zone of predetermined radius around each intersection or point of interest. The radii of these zones of interest ranged from 27 to 120 feet, depending on the number of location points likely recorded around a particular point of interest. Zones were set visually by mapping all of the routes using Topofusion. They were then adjusted to ensure the smallest radius that would adequately capture data points of interest for each route. The AML script was written to select the earliest and latest recorded

data points from all of those within a particular zone of interest. The AML script was run for each of the 193 usable routes, resulting in greatly narrowed data set. The harvested data consisted of a maximum of two GPS locations at each point of interest.

5.0 Discussion and Implications

Comparison of travel routes obtained at Muir Woods and Acadia suggest several benefits in using GPS over self-reported travel routes. First, the GPS collected routes consisted of considerably more detailed and accurate location information. Even relatively minute directional changes or delays in travel, such as a vehicle pulling off the road at an undesignated scenic point, were recorded in the GPS route. Map diaries, such as the one used at Muir Woods, often show particular locations of interest (Bohemian and Cathedral Groves in Figure 3). The sites shown may affect respondents' record of their travel. GPS instead allows collection of route information without the potential bias associated with respondents recording their locations on a map. Furthermore, stopping times recorded by GPS are not subject to any appreciable rounding because GPS records locations so frequently and with times that are exact. Self-recorded routes have stopping times that are inherently rounded. The time burden for respondents and for data entry is also significantly reduced with GPS, which digitizes locations in a computer readable format as they are collected. Map diaries require substantial effort to translate the routes recorded on paper into files that can be use in computer based analysis or simulation modeling. Finally, the lower rate of refusal to participate, the smaller number of unusable routes, and the collection of a greater number of routes per day suggest that GPS reduces the burden placed upon respondents while permitting the collection of a greater amount of data.

Despite the apparent advantages of GPS for surveying travel routes, several drawbacks to the technology warrant consideration. Using GPS requires a modest capital investment and data collection is limited to the availability of units. Adding to this disadvantage is a concern for recollecting units. Multiple entry and exit points add complexity to ensuring their return. At the Schoodic Peninsula, a single entry and exit point facilitated recollection of units. Different approaches to recollect units are being used in other studies, such as having participants return them by mail (Topofusion,

2004). The abundant data collected is also a potential disadvantage. The data points of interest often must be harvested from the many collected. The script used to select such points from the GPS data collected at Acadia automated this process, but several work days were still required to run the script for each route, confirm the results, and correct any discrepancies in the points selected. Another shortcoming of GPS is the need for a line of sight with a minimum of four satellites. This requirement prevented GPS from being considered for use at Muir Woods. The steep canyon walls and the dense tree canopy did not permit the GPS unit to acquire the signal from enough satellites. Lastly, GPS provides no opportunities for respondents to indicate the purpose of their trip or other descriptive elements. Paper map diaries can easily overcome this problem while also having the advantages of being inexpensive, requiring no specialized knowledge or training regarding GPS technology, and they can be conducted regardless of topography or vegetation.

The use of GPS technology has implications for better understanding visitor use patterns. GPS recorded travel routes provide opportunities for more robust, detailed, and accurate studies. GPS can be used to capture travel that does not follow existing pathways or visit predetermined sites. Sites of interest may be selected after data is collected, instead of prompting participants to record time spent at specific preset locations. It also permits capturing highly complex travel routes, the full detail of which may not be represented in data collected by self-reported routes. The potential for more representative route data must, however, be weighed against the cost, technical complexity, and limitations associated with the technology. All factors equal, GPS-reported routes seem to offer an accuracy and wealth of data that cannot be obtained by self-reporting. Further recreation related studies will likely be required to realize the full potential and limitations of GPS as a methodology for collecting information on visitor use patterns.

6.0 Citations

El-Rabbany, A. (2002). *Introduction to GPS: the Global Positioning System*. Boston: Artech House.

Garmin Ltd. (2004). *What is GPS*. Retrieved May 24, 2004, from <http://www.garmin.com/aboutGPS/>

- Hammitt, W. E. and D. N. Cole. (1998). *Wildland recreation: Ecology and management* (2nd ed.). New York: John Wiley & Son.
- Manning, R. E. (1979). Impacts of recreation on riparian soils and vegetation. *Water resources bulletin* 15:30-43.
- Manning, R. E. (1999). *Studies in outdoor recreation: Search and research for satisfaction* (2nd ed.). Corvallis, OR: Oregon State University Press.
- Manning, R. E., Lawson, S., Valliere, W., Bacon, J., & Laven, D. (2002). *Schoodic Peninsula, Acadia National Park Visitor Study 2000-2001*. University of Vermont: Park Studies Laboratory.
- National Park Service. 1997. *VERP: The Visitor Experience and Resource Protection (VERP) Framework – a handbook for planners and managers*. Denver, CO: Denver Service Center.
- National Park Service. (2001). *Management policies 2001*. Retrieved on May 24, 2004, from <http://www.nps.gov/policy/mp/policies.pdf>
- National Park Service (2003). *National Park Service public use statistics: Statistical abstract 2003*. Retrieved on May 24, 2004, from <http://www2.nature.nps.gov/stats/>
- Runte, A. (1997). *National parks: The American experience* (3rd ed.). Lincoln, Nebraska: University of Nebraska Press.