Monitoring and Management of Visitor Flows in Recreational and Protected Areas
Conference Proceedings ed by A. Arnberger, C. Brandenburg, A. Muhar 2002, pages 180-186

Deriving Artificial Models of Visitors From Dispersed Patterns of Use in Sierra Nevada Wilderness

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Abstract: Natural resource managers are faced with a complex problem of understanding human use patterns and associated impacts in dispersed recreation wilderness settings. This is further complicated by the subsequent synthesis and modeling of those behaviors that affect such patterns of use. While conventional approaches to modeling have limited use in acquiring and understanding such complex associations, spatial simulation models have been proposed as an alternative. The purpose of this paper is to describe a project whose focus is on a dispersed recreation context of backpacking trips and commercial packstock operations in the John Muir Wilderness in the Sierra Nevada Mountains in California. This paper will discuss the data collection and synthesis to derive agent profiles and rules as a precursor to the development of a dynamic, agent based model that represent the spatial distribution of visitation patterns.

INTRODUCTION

Backcountry use from both packstock outfitters and backpackers in the John Muir and Ansel Adams wilderness areas of the Inyo National Forest is an excellent example of how increasing human uses impact a sensitive, dynamic ecosystem and threaten to degrade the quality of experience of human visitors. Over 21,000 permits are granted every season to individuals and guides to travel through sections of the Inyo National Forest. While packstock trips have been a permitted use of the wilderness areas for many years, concerns over both the environmental and social impacts have been raised. More importantly to this study are the interactions of packstock with visitors. Packstock have been shown to influence a visitor's wilderness experience by introducing smells, sounds, and sights that conflict or accord with their wilderness values (McClaren et al., 1993).

Studies by (Lucus, 1980) have clearly demonstrated that the progress of individual trips is affected by interactions with packstock and other hiking parties, and there is a general assumption (based on early research) that encounters degrade the 'wilderness character' of the trip, and that they have adverse effects on the quality of experience for individual visitors.

In (McClaren et al., 1993) they conclude that not only monitoring and management should focus on impacts of packstock use, but that visitors should be informed of what to expect in specific areas, and where they might travel to avoid unsatisfactory experiences, such as packstock encounters. The problem is that very little is known about how to predict or control the numbers of encounters (except generally to limit the number of people/packstock parties along the trails), or whether all encounters are alike regardless of the types of parties involved, the locations on the trail and campsites and the contexts in which they occur. In addition, pressures from the public and from commercial outfitters are increasing; demand for more wilderness trips is very high. The effects of increasing trips or altering schedules are difficult to predict or evaluate due to the complexity of the variables involved, and the ambiguity about what factors affect the quality of the wilderness experience and/or the levels of adverse impacts on the wilderness environment. Environmental impacts at popular camping sites are already of great concern to the forest.

Backcountry use of the Inyo National Forest presents a number of complex human-environment interaction problems; large numbers of visitors and commercial operations seek activities and experiences that depend upon the unique environment of the Inyo National Forest; quality of the wilderness experience is affected by the participants' personal characteristics (abilities and intentions), by perceptions of and responses to features of the wilderness landscape, and by perception of and responses to encounters with other recreationists in the wilderness; and individual and cumulative impacts of recreation activities threaten the fragile forest environmentDecision makers and natural resource managers recognize the need for baseline visitor use data and more sophisticated tools to help them understand the human-environment interactions in the wilderness, and to effectively respond to their mandate to manage this unique environment and the highly valued human experiences it supports. While techniques have been available to managers to guide recreation management such as the Recreation Opportunity Spectrum (ROS) and Limits of Acceptable Change (LAC), limited use of computer simulation models have been employed to resolve such complex human/landscape problems. Studies such as those by (Hull & Stewart, 1992) have shown that time, and space (location), have a profound effect on levels of encounters, perceived crowding, and satisfaction and associated recreation impacts. It is surprising that computer simulation has not been more extensively used.

Computer simulation is not a new concept in studying natural processes and in particular recreation. Models such as the Wilderness Use Simulation Model (WSUM) (Shechter & Lucus 1978) have been available to assist natural resource managers in assessing wilderness use by recreationists. The simulator was developed and successfully tested in both Spanish Peaks Primitive Area in Montana (Smith et al., 1976) and the Desolution Wilderness in California (Smith et al., 1976) and subsequently modified for river recreation management for use on the Green and Yampa Rivers in Dinosaur National Monument (McCool, Lime and Anderson, 1977) and the Colorado River in the Grand Canyon (Underhill et al., 1986). This simulation tool provided a reliable way to examine both perceived and actual encounters along the trails and rivers. It seemed particularly useful as an aid to river recreation planning and management for conducting tests of a variety of alternative policies. These models while ahead of their time suffered from ease in interpreting outputs of the model and depended heavily on field observers to supply visitor use information as input into the model.

Work by (Wang and Manning, 1989) and others have used dynamic modeling frameworks such as Extend to model recreation use in national park settings with success. While these frameworks are useful in modeling relatively homogeneous and “lumped” phenomena, they are not so easily applied to highly variable spatial phenomena. In addition, this work heavily relies on observers, capturing data about perceived use and numbers of visitors in various settings.

To improve a manager’s ability to more effectively understand highly variable spatial phenomena such the distribution of visitors in a wilderness setting, researchers have been exploring the use of agent-based modeling. This contemporary approach to modeling moves away from the mix master universe of homogeneous populations down to modeling the individual. Although potentially computationally expensive, such flexibility provides a mechanism to represent many types of entities that embody variability within them selves. For example, such agents may represent individual visitors or vehicles. A predetermined set of rules, attributes and behaviors are applied to individual agents that motivate their desire to move through the landscape. Example personalities include backcountry hiker, motoring tourist or mountain biker. In order to provide input into agent-based models that attempts to mimic visitors and their associated behaviors in a local setting, studies must be conducted in the field to capture this baseline data.

Researchers such as (Daniel & Gimblett, 2000; Gimblett et al., 2000); Itami et al., 2000) and others have been exploring the use of agent simulations integrated with a Geographic Information System (GIS) that are designed to be used as a general management evaluation tools for any recreation setting. In these simulations, resource managers can explore the consequences of change to one or more variables so that the quality of visitor experience is maintained or improved. The simulation model generates statistical measures of visitor experience to document the performance of any given management scenario. Management scenarios are saved in a database so they can be reviewed and revised. All of these simulation efforts provide information on current and future conditions so park managers can identify points of over crowding, bottle necks in circulation systems, and conflicts between different user groups. All this with the hopes of more effective visitor management with the added benefit of improved monitoring and data collection methodologies.

While all of the simulation efforts mentioned above have been developed for a variety of purposes, all have resulted in varying degrees of success. In fact it can be said that because these models provide such sophisticated ways to model spatial phenomena, their utility is only inhibited by our ability to collect meaningful spatial/temporal data about visitors in complex wilderness landscapes. The challenge to researchers and resource managers alike is to develop methods to collect spatial/temporal data about visitor use patterns that is reliable, statistically valid and defensible. This information while providing resource managers with information critical to managing visitor use can alternatively be used as input to such models as described above. It is the challenge of valid, defensible data that is the impetus for this paper. Itami in these proceedings will describe the agent-modeling framework and it’s various measures and outputs.

This paper focuses on exploring a methodology for understanding the spatial and temporal patterns of dispersed recreation in the context of backpacking trips, and commercial packstock operations in the John Muir Wilderness in the Sierra Nevada Mountains in California. Herein is discussed the data collection and statistical synthesis to characterize wilderness visitors from which could be derived agent profiles and rules that will be used in the development of an agent-based model representing the spatial distribution of visitation patterns.

METHODS

Conventional survey and interview methodologies used to characterize the recreation experience have yielded useful information about the visitor. While this information is important to understanding the general profile of visitors to a region, it does little to enhance our understanding of the spatial/temporal distribution of a visitor and their associated social and ecological impacts in the landscape. Managers require information on the spatial nature of the visitor to adequately manage for both the experience and to protect the recreation setting. This information includes the destination, arrival and departure times, number of visitors in a party, type of activity, nights camping etc. These spatial dynamic parameters likewise are imperative for constructing models to represent current conditions and testing out future management scenarios to reduce social and ecological impacts in a setting.

Some have attempted over the years to collect such data in wilderness settings. Researchers such as (Lucus & Kovalilcky, 1981) conclude in their study that the most accurate wilderness use data come from a self-issued, mandatory permit systems. This method can be one of the most effective ways for understanding recreational use in most wilderness areas. While compliance varies from wilderness to wilderness (Lucus et al., 1981) found that mandatory permit systems far outweigh trail registers or other forms of data collection. While observing a sample of trailheads on sample days produces accurate estimates of those entering the wilderness, it is labor and time intensive and tends to lead to a limited sample. Other wilderness areas have gone to agency-issued permits. While having some disadvantages such as inconveniencing the visitor and expensive to manage, this system does provide a mechanism for ensuring the visitor comes in to the agency office to pick up the permit and provide information about where they plan to go. While each of these methods has its advantages and disadvantages, the sampling methodology in this study employs a combination of techniques for acquiring an accurate, representative sample of both spatial and temporal use patterns in wilderness settings.

This study utilizes a map diary approach that is distributed to each visitor when they pick up their agency-issued permit. The diary consists of a space to capture basic trip characteristic data, a map of trails and natural features, a brief set of questions on visitor satisfaction and instructions on how to record and denote a spatial location of the types of encounters, numbers of those encountered and nightly campsite locations (See Figures 1 & 2). Data that was essential to this study was duration of visit, number in party, type of activity and spatial location of trailhead, physical encounters with other parties, type and numbers and nightly destinations (ie. campsites). In addition to being given out to all permittees, the diary is distributed at each trailhead as part of a self-administered system and hand delivered to all commercial packstock operators with instructions on how to distribute to their clientele and return to the research team.

The map diary can be dropped off at the FS station upon completion of the trip, or mailed back in self-addressed envelopes provided. While compliance is an issue with this type of distribution method, issuing the map diary with the permit provides numbers on total distribution size and when comparing to those returned, a compliance rate can easily be computed.

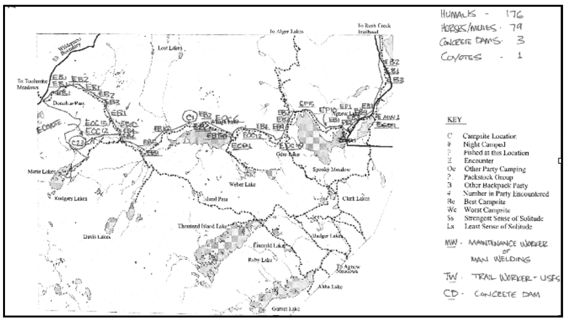

Figure 1 - An Example of the inside of the map diary used to capture overnight use

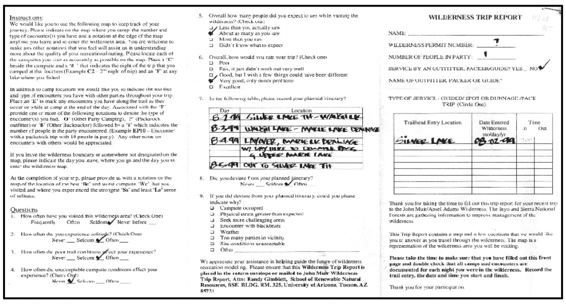

Figure 2 - An Example of the outside of the map diary used to capture overnight use

In addition, summer students randomly sampled each of the trailheads, spending days observing visitors entering the wilderness and stopping visitors to ensure they had a map diary in hand and urged others to deposit them in the return box or collected them directly from the visitor.

In May 1999, a study was undertaken to collect spatial/temporal data in nine different study areas in both the east and west sides of the Sierras. This included 3 areas of east/west complexity-Humphrey's basin, Mono Creek, and Silver Divide; and 6 areas of moderate use levels Ansel Adams West, Agnew Meadows, Cottonwood Lakes, North Fork Lone Pine, North Fork Big Pine and Rush Creek. The latter were of interest for understanding the extent of visitor use concentration in moderately used and complex areas. The primary driver of the study was the need to augment current use data for the management planning. Adequate data existed on levels of use by entry acquired by observation and permits, but assessments on distribution, congestion points, or patterns of use, encounters etc. were not confidently known, particularly the influences of east and west side entry into the large and topographically complex interior.

Secondarily, there was a desire to integrate resource data with patterns derived from the visitor use data as a mechanism for developing and evaluating management techniques. This also seemed to be a critical set of information in evaluating risks. Identifying areas of potential congestion in combination with visitor use impact data such as campsite conditions, trail use, or trail conditions, or relevant resource information on TEPS (threatened, endangered, petitioned or sensitive) species habitats, populations or potential habitats, provides decision makers with reasonable information for evaluating consequences of management actions.

Upon receiving the map diaries, all point locations denoting encounters etc. were entered into a spatial database for further analysis and all other data characterizing the party were entered into an electronic relational database. Both of these sets of data were interchangeable allowing both spatial and/or relational analysis of the data. ARC View 3.1 with the spatial analyst extension and Microsoft's database ACCESS was used in this study. Information entered into the database included:

RESULTS FROM VISITOR DATA COLLECTION

Figure 3 provides an illustration of the overall compliance rates in the nine wilderness areas studied in 1999. The highest return rate was from the Mono Creek wilderness area at 44.7% survey return. The lowest was from the Rush Creek area, with a survey return rate of only 16.1%. A the right hand side of Figure 3 can be seen a summary of the return rates as measured against the number of permits issued for the nine wilderness areas. Of the total permits issued (n=5467) for 1999 in the nine wilderness areas studied, (n=1371) or 25% complete and useful trip diaries were returned and entered into the database. While by conventional survey standards this may appear low, for wilderness areas and using this non-mandatory survey technique, 25% is considered a statistically representative sample.

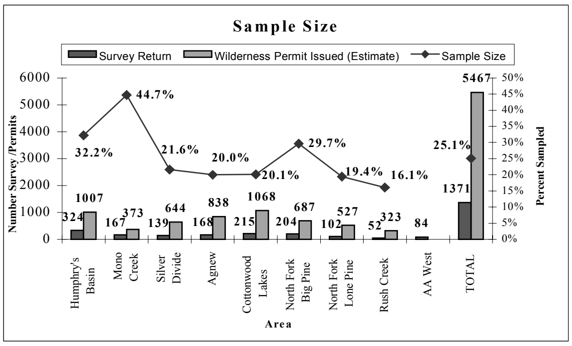

Figure 3 - Return Rate on Map Diary for all Wilderness Areas Studied

While the relational database does not provide information on the major destinations of each party, queries can be made to acquire a better understanding of the typical number of visitors per party entering and the total numbers in each of the wilderness areas. Table 1 describes the range of party sizes in each of the wilderness areas, the number of parties taking trips into each area, and the percentage of visitors visiting each area compared to the total number of visitors utilizing the wilderness in 1999.

Area	Mean # Party	# of Parties	% of Parties	Total # of Visit	% of Visits
Total	3	1455	----	4465	----
AA	4	84	5.8 %	331	7.4 %
Ag	3	168	11.5 %	538	12.0%
CL	3	215	14.8 %	646	14.5%
H	3	324	22.3 %	966	22.3%
MC	3	167	11.5 %	550	12.3 %
NFBP	3	204	14.0 %	549	12.3 %
NFLP	3	102	7.0 %	284	6.4 %
RC	3	52	3.6 %	173	3.9 %
SD	3	139	9.5 %	428	9.6 %

Table 1 – Visitors Utilizing the Nine Wilderness Areas in 1999.

The range of party size for all the areas was from (n=1 to n=15) visitors per party. In fact, there was only one area that did not have a maximum party number of (n=15). The North Fork Lone Pine recorded a maximum party size of nine. The largest mean party number came from the Ansel Adams West wilderness area with a value of four. However, this area only accounted for 5.8% of the total trips taken in 1999. There were a total of (n=4465) visitors entering all the wilderness areas that were captured in this study.

Humphrey's Basin was the most heavily used area during the 1999 season. Trips taken into the Humphrey's Basin area captured in this study totaled (n= 324) or (22.3% of the total). This, in turn, also made Humphrey's Basin the area that contributed the highest number of visitors (n=966) or 22.3% visiting all the wilderness areas in 1999. Figure 4 illustrates the tremendous increase in trips taken to the Humphrey's Basin wilderness area from mid-July to mid-September.

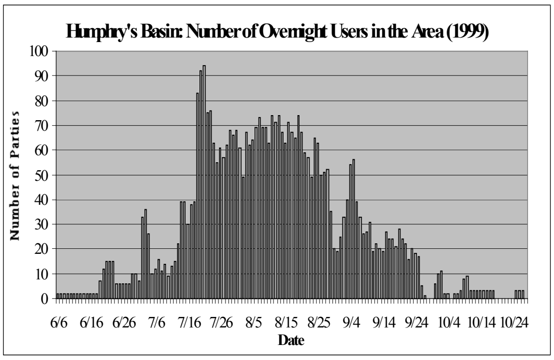

Figure 4 – Humphrey's Basin Visitor Statistics

Figure 4 provides some inside for Inyo National Forest managers are to the peak periods of use in the wilderness area. Snow pack usually limits access to the backcountry with the typical visitation periods ranging from Early June thru the beginning of October. The number of parties visiting the area increases from around 10 in early July to almost 100 toward the end of July. This number drops a little at the end of July, but is consistently above 60 parties through August when it drops through September and even more into October. Visitor information is particularly useful to managers as they can easily see that the season of visitation is short and intense in many areas. This information (percentage and intensity of use) coupled with the spatial data (destinations, duration of visit and encounter rates) provides needed information to focus management and construct policies to reduce impacts in each of the areas.

SPATIAL DATA INFORMATION ABOUT VISITOR DISTRIBUTION

One of the advantages of using a diary approach to acquire information on the spatial distribution of visitation is that once compiled the information can be visualized in many forms. For example, information about individual parties can be displayed, total number of parties summarized per locale or destination, the location of each night camped and in particular the spatial location, identity and number of reported encounters with other parties. Each trip can be dissected to observe not just the patterns of use, but assessed to identify and characterize typical types of trips that utilize the backcountry. Such as two party trips that camp in areas absent of others, typically seeking solitude and spend a minimum of five days in the backcountry. While this may seem logical, it provides valuable information to the manager as to the typical visitor that frequents specific locales and provides information that can be used in the agent-based simulations to develop virtual agents that are representative of their human counterparts.

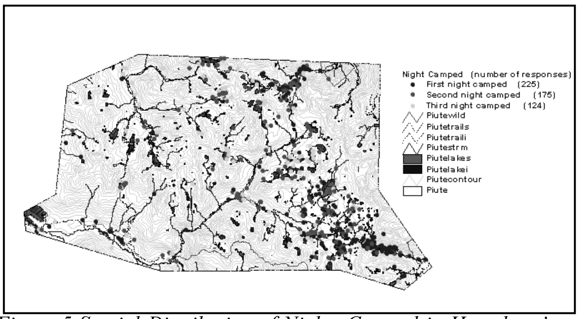

Figure 5 Spatial Distribution of Nights Camped in Humphrey's Basin

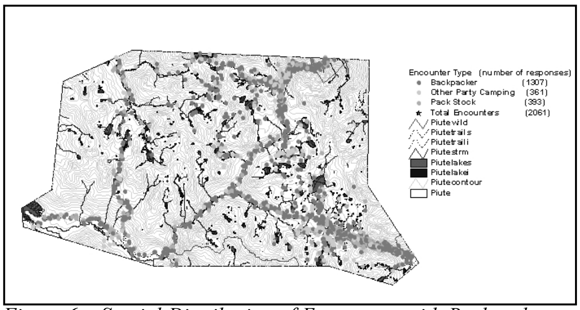

Figure 6 – Spatial Distribution of Encounters with Backpackers, Packstock and Other Parties Camping in Humphrey's Basin

Figure 1 seen previously is an example of a typical diary returned in 1999. As noted on the map, C1 indicates the location of first night camped followed by, C2, 3 where the party spent the second and third nights. The 'E' marking followed by 'B' and a number such as two indicates that this party had an encounter with another backpacking party that consisted of two. Four variables on the map serve as a measure the parties degree of satisfaction. These measures are documented on the map as Ss and Ls (Strong and Least sense of Solitude) and Bc and Wc (Best and Worst campsite). Once all diaries are compiled with this type of spatial information, areas of high concentrations of visitors can be discovered, potential conflicts between and within recreation use groups and correlated with recreation impact data can provide insight into opportunities for creative management. Figures 5 & 6 are examples of this type of output. For example, figure 5 illustrates the patterns of 1st, 2nd and 3rd nights camped in the Humphrey's basin. Aside from tight clustering of campsite nights this type of spatial information illustrates the age-old hypothesis that backcountry visitors typically camp near trails. Visitors in Humphrey's basin tend not to stray far from the trails and logically camp near high elevation lake destinations.

Trip Type	Responses	Tot.Responses
Guided	n=0	0%
Spot	n=15	1%
Dunnage	n=42	3%
pack trip	n=219	15%
backpackers	n=1179	81%
Total n for 1999	1455	
Party Size	**Responses**	
1-2 visitors	n=1032	71%
3-5 visitors	n=237	16%
6+ visitors	n=186	13%
Total n for 1999	1455	
Trip Duration	**Responses**	
1-2 days	n=961	66%
3-4 days	n=231	16%
5+ days	n=263	18%
Total n for 1999	1455	

Table 2 – Summary of Visitor in Cluster Analysis

Figure 6 illustrates the spatial distribution of encounters with backpackers, packstock and other parties camping in Humphrey's Basin. It is clear from the spatial information that there are considerable numbers of encounters with stock along the trails and at specific locations. As is true of other backpackers frequenting the backcountry. While this analysis says nothing about the quality of the encounters it does indicate the spatial patterns along the trails and at destinations where and how many per party intercept each other. This analysis provides three important sources of information to the manager. First it provides information on locations where one would expect to find varying degrees of use patterns in the backcountry. Second, it provides information on where more detailed monitoring should occur to examine both social and ecological conditions. This would include both conflicts between and within recreation activities and their associated impacts. Finally, the mapped information coupled with the information gathered about the typical trips provides a more accurately way to characterize the behaviors of visitors using the backcountry.

DERIVING VISITOR PROFILES FOR CHARACTERIZING AGENTS

The information provided by the diary has immediate value to the manager for understanding spatial use patterns of their management settings. In addition, this information is valuable in characterizing the visitor and their associate behavior. To do so this study utilized analytical procedures on the visitor information to determine statistically characterize and derive typical groups/visitor profiles. This information will be used in the future in agent-based models for simulation alternative management scenarios. A visitor profile is a combination of information, both categorical and quantitative, to describe the wilderness trip, visitor, and length of

trip. In other words, it is a way of simplifying a wilderness experience surveys into a few groups of similar features.

Data used for statistically deriving visitor profiles for characterizing agents were number in party, type of trip (commercial/non –commercial), and trip duration. Trip duration was not a direct question asked on the survey. It was calculated by computing the difference between the entry and exit dates logged on the surveys. Over the twelve-month survey in 1999, 1455 trips were sampled in the John Muir and Ansel Adams Wilderness areas. K-Means Cluster analysis was performed to combine the trips into groups of similar party size, trip type, and trip duration. In terms of party size, out of the (n=1455) trips surveyed, (n=1032), 71% were classified as 1-2 visitor parties. Out of the same number of surveys, (n=1179), 81% were classified as backpackers, and (n=961), 66% were trips of 1-2 days in length (See Table 2)

Summarized in Table 3 are the results of the K-Means Cluster analysis run on each of the nine wilderness areas in the Ansel Adams and John Muir Wilderness Areas. This analysis was undertaken to statistically aggregate trips according to party size, trip type, and trip duration. The cluster analysis for each of the wilderness areas were aggregated down to three statistically significant clusters that represent all trips documented in the data base. These clusters are represented in Table 3 and depicted are Group 1 thru 3. Each group consisted of a coding based on the three variable entered into the cluster analysis ie. number in party, trip type and duration of visit. For example, after running the cluster analysis for Humphrey's Basin and aggregated to three clusters or group types. The first statistically significant cluster consists of the numbers 2,5,2 which represents two visitors in the party, backpackers and spending a total of two nights in the backcountry.

Area	Mean # Party	# of Parties	% of Parties	Total # of Visit	% of Visits
Total	3	1455	----	4465	----
AA	4	84	5.8 %	331	7.4 %
Ag	3	168	11.5 %	538	12.0%
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SD	3	139	9.5 %	428	9.6 %

Table 3 – K-Means Cluster Analysis Summary

Cluster 2 is represented by eight visitors per party, being serviced by a packstation, and on a four-day trip. Finally Cluster 3 is a three visitor party, backpackers and duration

An analysis of trips across all wilderness areas studied reveals that 65% of all visits to the wilderness areas can be accounted for by two person parties on backpack trips, typically spending two days. This is an interesting result considering the perceived need for increased commercial use in many wilderness settings.

From the cluster analysis it can clearly be seen that visitors can be aggregated into groups that share common trip characteristics in wilderness areas tested. Discussed earlier in this paper was the idea of using visitors as surrogates for agent-based simulations for developing and testing out management scenarios. While the simulations have not been discussed in this paper, Table 3 provides statistically significant information that could be used to characterize agents based on trip type, number in the party and trip duration. These three variables say little about visitor satisfaction or even preferences for recreation settings, but results of this study do suggest consistency in the patterns in which the backcountry is explored. More research obviously needs to be undertaken to tease out more salient factors that effect behavior in these settings from which rules could be develop for the agent-based simulations.

CONCLUSION

This purpose of this paper was to develop a methodology for acquiring data on dispersed recreation in the John Muir Wilderness in the Sierra Nevada Mountains. Results of this study clearly illustrate that reliable and valid sampling can be used to obtain representative information from visitors reporting information about their trips in the nine different wilderness areas in the Sierras. Further this paper has presented the case for collecting spatial/temporal data about visitor use patterns in wilderness settings. This information not only can aid managers to better understand both social and ecological impacts in their respective settings, it can alternatively be synthesized to characterize wilderness visitors as surrogates for agent-based simulations. Agent-based simulations are exploratory, but as discussed earlier in this paper have produced excellent results in evaluating management actions. Finally using spatial/temporal information collected in the field coupled with agent-based modeling techniques reveals where varying degrees of use patterns exist and can serve to direct managers to these areas resulting in more cost effective methods for long term monitoring of visitor use patterns.

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