of transportation and recreation. David White, Stacy Tschuur, and Bill Byrne present the vehicle-based road monitoring, modeling, and evaluation in which transportation is considered recreation. This is followed by Nathan Reigner, Brett Kiser, Steve Lawson, and Robert Manning's presentation of the recreation-site pedestrian monitoring, modeling, and evaluation that addresses transportation's influence on recreation use. Doug Whittaker, Bo Shelby, Bret Meldrum, Henrietta DeGroot, and James Bacon extend discussion of the ITCA model to its application in park management, specifically the Merced River Plan. Christopher Johnson concludes the thematic set with reflections on the historical and ongoing relationships between transportation and recreation in America's parks and public lands.

Visitor use and management
With increasing visitation come corresponding visitor-use management challenges. In Yosemite these challenges are posed by both visitor use and the park's capacity and have the potential to impact the quality of visitors' experiences. In 1970, when annual visitation was two million, overcrowding in the campgrounds and meadows in Yosemite Valley sparked the Stoneman Meadow Riot. In 1997, when annual visitation reached four million, the park's capacity to accommodate visitors was compromised when Yosemite Valley infrastructure was severely damaged by flooding. Today, visitation hovers near four million annually and the park confronts a litany of resource protection, visitor enjoyment, and operational challenges as a result (National Park Service 2012). For many parks and public lands, visitor-use management challenges are often related to transportation (Daigle 2008). High levels of visitor use induce congestion along Yosemite’s roads and at major attractions nearly all days of the park’s summer season. Park staff struggle to deal with the ever-increasing use and associated impacts through education, staff-intensive on-site enforcement of regulations, and design modifications.

Transportation and recreation in national parks
The prevalence of visitor-use management challenges associated with transportation in Yosemite is emblematic of the connections between transportation and recreation in in park and on public lands in general. Transportation and recreation are connected in two basic ways. A first connection is the implicit unity of transportation and recreation (White 2008). When visiting parks, transportation activities such as driving and walking are often the primary recreation activities of visitors (Cordell 2004). Indeed, scenic driving and day hiking are some of the most common recreational activities of visitors to Yosemite. As such, the quality of recreation experiences is analogous with the quality of transportation system performance. In this case, transportation is recreation.

A second connection between transportation and recreation is processual: transportation systems largely influence the distribution of visitors within parks (Lawson et al. 2009). To the extent that visitors primarily move about Yosemite along the park’s road and trail networks, elements of the transportation system shape where visitors go and when they get there. The quality of recreation experiences, particularly with respect to crowding and congestion within recreation sites, is a function of the transportation system’s delivery and distribution of visitors. If used to deliver the “right” number of visitors to the “right” places at
the "right" times (based on resource, experiential, and park facility considerations), transportation can be an important park and outdoor recreation management tool.

Planning for visitor-use management in Yosemite

Planning history. Managers at Yosemite National Park have long understood transportation to be a key element of visitor-use planning and management. Transportation infrastructure and systems are present in the some of the earliest plans for the park (Olmsted 1865). With the 1980 General Management Plan (GMP), transportation and its connections to recreation quality and visitor experiences became a central focus of park planning and management (Yosemite 1980). This plan laid out an ambitious vision for promoting the quality of visitor experiences by removing day-use vehicular traffic from the eastern portion of Yosemite Valley. While this initiative was never implemented, the planning effort was effective at focusing attention on the connections between transportation and recreation quality.

Following the 1980 GMP, the park consolidated a number of localized management plans into comprehensive planning efforts in the form of the Yosemite Valley Plan and the Merced River Plan (National Park Service 2000a, 2000b). These plans outline a number of objectives, including preservation of high-quality natural and experiential resources and facilitation of public access and enjoyment. Transportation systems and their operation are positioned within the plans both as key components of recreation quality and important tools for managing visitor use. Subject to the public and legal process of the National Environmental Policy Act (NEPA), these plans have been challenged in court and remanded for refinement and further development.

Objectives for future planning and management. The discussions and deliberations about planning and managing visitor use in Yosemite have suggested several management objectives, including providing a diversity of recreation experiences, encompassing multiple spatial scales, being quantitatively rigorous, and being proactive and flexible. To accomplish these objectives to the satisfaction of legal requirements and public scrutiny, park managers must be able to document visitor-use levels and the quality of recreation experiences associated with these levels of use.

Integrated Transportation and Capacity Assessment

Leveraging the connections between transportation and recreation to structure the relationships between visitor use and experiential quality, Yosemite embarked on a program of research that culminated in 2010 with the ITCA project. Acknowledging transportation as recreation and transportation's influence on recreation, the ITCA project integrates monitoring and evaluation of visitor use and experiential quality for both vehicle-based and pedestrian recreation in a quantitatively explicit and proactive way.

Basic conceptual model. The ITCA project has its roots in a basic conceptual model that links visitor-use levels with experiential quality (Figure 1). This model is informed by indicators and standards of quality and powered by computer-based simulation modeling and visual simulation. Indicators of quality are measurable, manageable variables that serve as proxies for management objectives—for Yosemite, preserving natural resource and experiential quality while facilitating public access and enjoyment. Standards of quality are the minimum acceptable conditions of indicator variables; there are quantitative benchmarks by which accomplishment of management objectives can be evaluated. Computer-based simulations enable scenarios of visitor use and experiential quality to be experimented with, extending the range of ITCA beyond current use levels and patterns to incorporate many alternative future conditions. Within the basic conceptual model, conditions of visitor use are first described and then evaluated.

The basic ITCA conceptual model begins with counting visitors as they arrive at the park itself, at specified road segments, or at recreation sites to describe and monitor the level of visitor use. This level of use is then distributed throughout the park's road and trail networks by simulation models in ways representative of the observed patterns of visitor behavior and movement. These simulation models estimate the experiential conditions of visitors. Translated into indicator variables, such as the time needed to travel park roads, the number of vehicles in view along road segments, the number of people at one time at attractions, or the number of other visitors encountered along trails, these experiential conditions can be evaluated against a range of standards of quality derived from surveys of park visitors. This progression of monitoring, modeling, and evaluation transforms counts of visitor use through predictions of experiential conditions to assessments of recreation quality with flexibility and the power to proactively consider alternative park use and management scenarios.

Applied conceptual model. While the basic conceptual model has served visitor-use planners and managers well, ITCA's unique contribution is its application of the basic model to the connections between transportation and recreation. The conceptual model illustrates how the basic progression of monitoring, modeling, and evaluation is applied (1) on roads for vehicular-based recreation and (2) at recreation sites for pedestrian-based recreation (Figure 2). These dual tracks of the ITCA applied model acknowledge the connections between transportation and recreation.

The road and vehicle track addresses the transportation-as-recreation connection. The numbers of vehicles entering the park and traveling along specific road segments are counted. Simulation models of vehicle use on park roads estimate the conditions of roadway congestion visitors may experience. These estimates are translated into indicators of quality for visitors' road-based experience—a key element of visitors' recreation experience as scenic and pleasure driving is a nearly ubiquitous and important recreation activity. Finally, road-
based recreation quality is evaluated against standards of quality elicited from park visitors.

The recreation site and pedestrian track addresses transportation’s connection to visitor distribution. Based on statistical relationships between the number of vehicles entering the park and traveling specific road segments, the number of visitors expected to arrive at selected recreation sites and trailheads is estimated. The distribution and behavior of these arriving pedestrians is simulated and the experiential conditions, in terms of indicators of quality, are estimated and evaluated against a range of potential standards of quality elicited from park visitors.

Implications for visitor-use management

The ITCA conceptual models leverage the connections between transportation and recreation for the purpose of informing park planning and management. Understanding that transportation is indeed recreation for visitors in parks and that transportation systems influence recreation use enables park managers to employ transportation planning and operations as recreation management tools. Starting with counts of vehicle and visitor arrivals, the ITCA model supports these efforts with empirical data. Simulation lends flexibility and proactivity to the process by enabling alternative and hypothetical scenarios to be considered. Translation of visitor use and experiential conditions into indicators and standards of quality allows both monitoring and evaluation of recreation use and quality. By integrating transportation and recreation, roads and recreation sites, and monitoring and evaluation of visitor use, the ITCA model can provide Yosemite and other parks with a transparent, scientifically sound, and legally defensible process for examining and determining recreational carrying capacities at multiple scales and for diverse activities.

References

Assessing and Modeling Visitors’ Evaluations of Park Road Conditions in Yosemite National Park

Dave D. White, Stacy Tschur, and Bill Byrne

Introduction

Park visitors’ travel choices and behavior are longstanding concerns for the National Park Service. Travel behaviors can affect natural and cultural resources and the quality of the visitor experience. Driving park roadways has been central to the American national park experience since the earliest days of park preservation. As historian David Louter (2006) argued in his book *Windshield Wilderness*, “We cannot understand parks without recognizing that cars have been central to shaping how people experience and interpret the meaning of national parks, especially how they perceive them as wild places” (p. 164). Youngs et al. (2008) concurred, adding, “We cannot understand national parks without understanding transportation systems more broadly.” Understanding transportation in parks is thus critical to both the recreational use and preservation mandates of the National Park Service.

Nowhere are these issues more prominent than in Yosemite National Park, which has struggled with an appropriate balance between automobile access and park preservation since the turn of the 20th century (Havlík 2002). Roads were first built into Yosemite Valley in the 1870s and by 1913 the first cars entered the valley. During the 1930s, park roads were improved, widened, and paved (Runde 1990). Meanwhile the popularity of auto tourism in America expanded (Colten and Dilsaver 2005), sparked by the “See America First” campaign (Shaffer 2001) and the increase in personal automobile ownership. Private automobiles have since become entrenched in park management and visitor culture, leading to what Dilsaver and Wyckoff (1999) have called a “spiraling of interdependent development and use” (p. 76). According to Youngs et al. (2008), this “has produced a cultural landscape in portions of Yosemite Valley and other areas of the park that is dominated by roads and automobiles and fostered a widely shared and scripted visitor experience, best described as a ‘travel narrative.’” (p. 805). Many Yosemite visitors consider scenic driving to be an important activity (NPS 2009) and they value the sense of freedom, convenience, and access driving provides (White 2007).

There are, of course, also longstanding concerns about the impacts of an automobile-dominated transportation system on visitors’ experiences and park resources. Issues include perceived crowding, conflict, traffic congestion, air pollution, vegetation loss, degradation of scenic views, and visitor displacement. To address these problems, Yosemite managers have implemented strategies to improve the transportation system by adjusting traffic patterns, removing cars from the eastern section of Yosemite Valley, initiating a free public bus service in the valley (Greene 1987), and, during periods of extreme congestion, diverting inbound vehicles away from the eastern portion of Yosemite Valley. Despite these efforts, the lingering effects of geography, park design, visitors’ preferences for private automobiles, and intensive use continue to challenge the best efforts of park managers.

To deal with these ongoing challenges, Yosemite has in recent years undertaken a program of coordinated research and planning aimed at an integrated transportation capacity assessment (Meldrum and DeGroot, this volume). This program has been informed by contemporary thinking on capacity and visitor-use management in national parks (e.g., Graefe et al. 2011; Whitaker et al. 2011) and by an adaptive visitor-use management framework of management objectives and associated indicators and standards of quality (NPS 1997; Manning 2001). Generally, this approach includes: (1) crafting specific goals and objectives in terms of desired conditions and empirically based indicators and standards; (2) monitoring visitor-use levels and associated conditions of experiential quality; and (3) evaluating use levels and experiential quality in comparison with visitor-informed standards of quality to assess achievement of management objectives. This process requires research on current and potential future conditions of visitor use and their relationship to the quality of visitors’ transportation experiences. The research that informs this management by objectives, indicators, and standards of quality follows the conceptual models outlined by Meldrum and DeGroot in the introduction to this special edition of *The George Wright Forum*. This effort is also informed by long-standing traffic engineering research, modeling, and practice, which have developed indicators and standards for the quality of transportation service, largely based on measures of travel time and delay (TRB 2010).

In this paper, we present research to monitor transportation and experiential conditions on park roadways and to model elements of the relationship between use level and quality within this system. First, we describe the formulation of indicators and visitor-based evaluative standards to guide monitoring for visitors’ experiences on Yosemite roadways. This evaluative research is conducted with survey research methods. Second, we discuss descriptive modeling of roadway conditions that develops relationships between roadway use levels and indicators of quality. Additionally, this simulation modeling can be used to simulate different conditions of use and quality to assess alternative transportation management scenarios. Evaluative survey research and simulation modeling can be integrated to facilitate empirically based, visitor-informed, proactive management to assess the types and levels of visitor use that can be accommodated under varying assumptions or potential management actions while
maintaining desired conditions. In the final section of the paper, we describe implications of this research for park planning as well as research on transportation experiences in national parks.

**Methods**

**Evaluative survey research.** For the evaluative survey research component of this project, we employed a cross-sectional design (Creswell 2009) with data collected via on-site, surveyor-assisted questionnaires. To ensure the study findings were representative of visitors to the park during the study period (July 2010), we employed a stratified random sampling strategy with three-stage selection (Lohr 2009). First, we divided the park into eight geographic zones based on segments of the transportation system (see Figure 1). Second, we randomly selected sample dates within the sample period for each site, stratified by weekday/weekend. Third, each sampling day was then partitioned into morning and afternoon sampling blocks, and a block of time within each day was randomly selected. Surveyors followed a traffic control plan and flagged and pulled over motorists to administer the questionnaire at roadside pullouts, scenic overlooks, and parking areas. The questionnaire scales and visual simulation methods used in this study are well-established in the field and supported by peer-reviewed scientific literature. Several previous studies have used similar methods and questions (see Manning 2011 for a review). Specific examples include visitor surveys in Yosemite (White et al. 2011) and at Acadia National Park (Hallo and Manning 2009). We obtained 1,054 completed questionnaires with an overall response rate of 64%. The survey has a margin of sampling error of +/-3% at the 95% confidence interval. Results of a non-response bias analysis, coupled with the high response rate, ensure that there are no systematic differences between groups who did participate in the survey and those that refused, thus enhancing the generalizability of the results.

In a prior study, researchers used open-ended interviews to identify salient aspects of visitors’ transportation experience by asking them to report on what added to or detracted from the quality of their experience of driving cars on the park roadways. The findings revealed that visitors value convenience, perceived freedom, access, personal control, and opportunities to experience nature. Negative influences included feelings of stress, traffic congestion, difficult route finding, crowding, and conflict (White 2007). A subsequent study documented travel mode choices and travel patterns in Yosemite, identified the importance and satisfaction of travel by various modes, examined visitors’ perceptions of the experiential dimensions of traveling via car versus park shuttle bus, and identified visitors’ preferences regarding transportation management options (White et al. 2011). Based on these studies, and in consultation with park officials, the team selected two key variables to serve as indicators of quality for visitor experiences and to guide future monitoring and management: vehicles per viewed (VPV) and travel time.

**Vehicles per viewed.** To represent varying levels of congestion on park roadways realistically, we used a visual measurement approach to assess VPV (Manning et al. 1996; Manning and Freimund 2004). We prepared two sets of photographs: one with a representative Yosemite Valley roadway viewed and another with a representative high-alpine roadway viewed. The images, which embody the VPV indicator of quality, showed a range of roadway conditions varying from free-flow (0 VPV) to full roadway capacity (24 VPV). The photographs were prepared using digital editing software (see Figure 2).

Respondents were shown the photographs in random order and asked to rate each photograph by indicating how acceptable it was based upon the number of vehicles shown using a nine point scale ranging from −4 (“very unacceptable”) to +4 (“very acceptable”).

**Travel times.** In addition to VPV, visitors were asked to evaluate the acceptability of travel times on park roadways. Respondents were flagged and pulled over at the terminus of a study road segment, and asked to report the amount of time it had taken to travel that segment. Then, they rated the acceptability of that travel time on a nine point scale ranging from −4 (“very unacceptable”) to +4 (“very acceptable”).

Standards of quality, benchmarks by which the achievement of management objectives can be judged, are formulated from visitor evaluations of the VPV and travel time indicator variables (Shelby and Heberlein 1986; Vaske et al. 1986). This approach posits that individuals have standards for evaluating social and environmental conditions and that empirical research can measure these standards and describe the
distribution in groups. This information can then be used to inform a range of potential management standards.

Descriptive modeling research

Coinciding with visitor surveys (July 2010), we also conducted a license plate study to record and match vehicles traveling past 23 cameras placed at the entrance stations and key locations within the park. We used a license plate recognition program to match plates captured at two or more cameras and constructed a database to identify matches for any given route across camera locations. The final dataset included a total of 71,120 license plate data points with approximately 15,100 license plates matches. Traffic counts from each license plate data collection location showed that capture rates varied by location. Generally, capture rates around 90% were achieved. The information generated by this license plate study, combined with traffic counters deployed along the park’s road network, supplied counts of vehicles arriving to the park and road segments of analytical interest.

In previous work, traffic engineers developed a TransCAD travel demand model for Yosemite Valley (Smith et al. 2003) and a VISSIM transportation simulation model for the Yosemite Valley roadway network (Chase 2006). For the current project, engineers updated and expanded these demand and simulation models to include all major roadways within the park. Next, we used the license plate data and traffic counts collected in July 2010 to validate the models. The travel demand and simulation models were developed to estimate volumes and simulate vehicular traffic along the park roadways at different levels of visitor use and under different traffic management strategies. These estimates of experiential conditions along park roadways can be translated into indicators of quality, facilitating evaluation against the standards of quality formulated from the survey research described above.

The evaluation of seasonal visitation in Yosemite focused on the 100 busiest days of the summer peak use season. Figure 3 shows the number of vehicles per day entering eastern Yosemite Valley, as recorded by permanent traffic counters located near the Yosemite Chapel on Southside Drive. Data are presented for 2007, 2010, and 2011, with the days ordered from the highest entering volume to the lowest entering volume for each 100-day peak season. In 2007, benchmark volumes were established, including the “busiest day,” (i.e., highest volume), a “busier day” (i.e., 7th highest volume) and a “busy day” (i.e., median volume). The travel demand and simulation models generally follow the “busier day” traffic scenario with traffic volumes in the 90th to 95th percentile of the summer season volumes. The park-wide models were initially developed for a 2007 “busier day” traffic scenario and the current project updated the models to calibrate to the data collection time period, which was the fourth-highest visitation day of the 2010 summer season.

Figure 3. Vehicles per day entering Yosemite Valley; Summer 2007, 2010, and 2011.
Survey findings and modeling results:

Visitors' evaluations of transportation experience indicators of quality

**Vehicles per Viewshed.** To explore the range of visitor evaluations of VPV conditions as potential inputs for managerial standards, respondents were asked to evaluate the series of VPV photographs and to identify the photograph that represented: (a) the number of vehicles they preferred to see; (b) the number of vehicles on the roadway that would be so unacceptable that they would no longer visit that area of the park; (c) the number of vehicles that the National Park Service should allow on this roadway; and (d) the number of vehicles they typically saw on that day. The results for evaluation of each depicted VPV level are summarized in the graph in Figure 4, which is constructed using the mean acceptability ratings of respondents. Figure 5 summarizes visitors' evaluations of the roadway conditions on multiple dimensions. For instance, the findings show that:

- **The preferred condition** for valley and non-valley sites was 0 VPV. Thus, this is the optimum condition, which received the highest acceptability by the aggregate sample.

- **The range of acceptable conditions** for valley sites is 0 to 11 VPV; for non-valley sites, 0 to 14 VPV. Thus, all of the conditions represented in this range meet some level of acceptability by about half the respondents.

- **The minimum acceptable condition** for valley sites is approximately 11 VPV; for non-valley sites, 14 VPV. At this point, about half the sample finds these conditions acceptable.

In both sub-samples (valley and non-valley), visitors expected to encounter more vehicles than they actually reported experiencing. It is noteworthy that valley respondents identified their expected condition (11 VPV) as the point at which NPS management should take action. In both sub-samples, respondents rated the photo with maximum congestion as the point at which they would no longer visit that area of the park.

**Travel times.** Results of travel time indicator of quality evaluations suggest that, in aggregate, acceptability ratings for six of the eight segments were above 3.0 on the scale, indicating that the respondents found the travel times to be acceptable to very acceptable. For another site, Northside Drive—Curry Village to Camp 6, the mean rating was 2.88, still in the acceptable range but lower than the other sites. The mean rating for Chinquapin to Tunnel View Point was 0.86, near the unacceptable point of the scale. The results also demonstrated that the correlation between travel time and acceptability ratings was \( r = -0.287 \) (p<0.001, N=1029), indicating a small to moderate inverse relationship. That is, for each one-unit (one-minute) increase in travel time there is a corresponding -287 unit decrease in the acceptability rating.

As with VPV, respondents were asked to identify (a) the amount of time they would prefer it to take to travel that road segment; b) the amount of time that would be so unacceptable that they would no longer visit that area of the park; and (c) the amount of time that the National Park Service should allow. The results, shown in

![Mean Acceptability - Valley Sites](image)

![Mean Acceptability - Non-Valley Sites](image)

**Figure 4.** Respondent acceptability ratings for a range of VPV on Yosemite roadways.

Table 1, provide managers with information on current conditions as well as visitor-based evaluations of travel time across a range of dimensions. It is important to note that not all respondents were able to express a personal standard for travel time for the management action and displacement dimensions. Depending on the road segment and sub-sample, 1–7% of respondents answered “don’t know” on these items. Furthermore, across the entire sample for the acceptability dimension, 16% said no amount
of time would be so unacceptable that they would no longer visit this area of the park; for the management action standard, 7% responded that no amount of time is so unacceptable as to restrict vehicles using the roadway; and 13% said the number of vehicles using the roadway in this area should not be restricted at all. These respondents are not included in the calculations for travel time standards.

**Modeling transportation indicators—linking monitoring with evaluation**

We then compared visitor-based evaluative standards of quality for the travel time indicator derived from the survey study with traffic modeling results using traffic volume data from both 2007 and 2010. This allowed us to evaluate multiple scenarios of varying use levels and the potential effects on visitors’ experiences. Using travel demand and simulation models developed in 2007, we simulated travel times for a representative roadway segment within Yosemite Valley, Northside Drive from Sentinel Drive to Camp 4 (see Table 2). (Note that this roadway segment was also one of the segments for the survey research.) Comparing modeled travel times with the visitor-based evaluations for the Northside Drive segment, the results show that travel time conditions on the “busiest” scenario (3.6 minutes) were within standard for the visitor-based preference dimension (4.46 minutes). The visitor preference standard, however, was not met under the “busier” scenario (7.0 minutes) and “busiest” scenario (9.0 minutes) conditions. None of the simulated conditions exceeded the visitor’s standard for management action (17.33 minutes).

Traffic volumes entering Yosemite National Park, however, have increased since 2007. For instance, the average daily volume of traffic entering Yosemite Valley for the 100-day peak season has increased by about 24% overall. Traffic volume on the median day has increased about 30% overall, with the median day having more than 6,000 vehicles entering Eastern Yosemite Valley in 2011. While the average and median traffic volumes have increased substantially, there has been relatively less of an increase in traffic on the maximum day. This is likely reflective of the fact that the roadway system and parking areas in the East Valley have a physical capacity which is being attained on the highest use days. In addition to the constraints on traffic from the roadway system, park management takes action to redirect traffic away from the eastern portion of the valley when congestion reaches severe levels. Diverting traffic away from eastern part of the valley tends to limit the total number of vehicles that can enter over the course of a busy day. Furthermore, observations at the park entrance stations on very busy days indicate that when very long queues of vehicles form at the entrances, some visitors turn around and depart without entering the park.

<table>
<thead>
<tr>
<th>Roadway segment</th>
<th>Free-flow</th>
<th>Self-reported</th>
<th>Preference</th>
<th>Management action</th>
<th>Displacement</th>
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</thead>
<tbody>
<tr>
<td>Northside Drive - Sentinel</td>
<td>3.25</td>
<td>6.78</td>
<td>4.46</td>
<td>17.33</td>
<td>21.46</td>
</tr>
<tr>
<td>Bridge to Camp 4</td>
<td>2.56</td>
<td>5.26</td>
<td>4.36</td>
<td>23.08</td>
<td>38.91</td>
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<td>Northside Drive - Curry</td>
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<td></td>
<td></td>
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<tr>
<td>Village to Camp 6</td>
<td>7.16</td>
<td>8.66</td>
<td>6.75</td>
<td>24.95</td>
<td>30.05</td>
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<td>Southside Drive - Bridalveil</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Falls to Chapel</td>
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<td></td>
<td></td>
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<tr>
<td>South Entrance to Wawona</td>
<td>8.43</td>
<td>9.73</td>
<td>8.99</td>
<td>18.72</td>
<td>31.16</td>
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<td>26.64</td>
<td>76.16</td>
<td>66.03</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Chinequapi to Tunnel View Point</td>
<td>43.40</td>
<td>36.30</td>
<td>32.40</td>
<td>101.80</td>
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<tr>
<td>Crater Flat on Hwy 120 to its</td>
<td>10.98</td>
<td>26.23</td>
<td>24.23</td>
<td>51.41</td>
<td>64.36</td>
</tr>
<tr>
<td>intersection with Hwy 140</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Tioga Road - Lambert Dome</td>
<td></td>
<td>11.04</td>
<td>8.72</td>
<td>23.65</td>
<td>28.86</td>
</tr>
<tr>
<td>to Pothole Dome</td>
<td></td>
<td></td>
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</table>

Table 1. Summary of visitors’ evaluations of travel times.
<table>
<thead>
<tr>
<th>Scenarios Northside Drive — Sentinel to Camp 4</th>
<th>Modeled Travel Time (minutes)</th>
<th>Visitor Evaluation (minutes)</th>
</tr>
</thead>
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<tr>
<td>Free-flow conditions</td>
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<tr>
<td>2007 Busiest day</td>
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<tr>
<td>2010 Busiest day (4th busiest day)</td>
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</tr>
<tr>
<td>2007 Busier day (7th busiest day)</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>2007 Busy day (median busiest day)</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>2010 Visitor preference</td>
<td>4.46</td>
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<tr>
<td>2010 Visitor management action</td>
<td>17.53</td>
<td></td>
</tr>
<tr>
<td>2010 Visitor displacement</td>
<td>21.46</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2.** Simulation model results: Travel time on Northside Drive.

To evaluate the effects of the recent increase in traffic volume, we updated the simulation models with 2010 traffic conditions for the roadway segment along Northside Drive from Sentinel Drive to Camp 4 (see Table 2). As shown, the travel time on the roadway segment is 30% higher than the same day during the 2007 summer season, due to the general increase in traffic volumes within the park. Comparing these travel times with the visitor-based evaluations of travel time for the Northside Drive segment, the results show that the visitor preference standard was not met, but the travel time remains well under the management action standard. Future research will assess the relationship between modeled VPV conditions and visitor standards of quality.

The park is currently installing permanent traffic counters at the entrance stations and other locations within the park to establish a traffic monitoring program. The program will use the counters to measure real-time traffic volume data within key sections of the transportation system. These counters can supply the data to facilitate ongoing application of the conceptual models employed in this research to monitor use, estimate experiential conditions, and evaluate their quality. The program will also provide a more complete and reliable historical record of traffic volumes for enhanced analysis of trends and relationships among volumes at various locations in the park. This real-time monitoring will inform park staff whether management objectives are being achieved or if visitor-informed standards of quality may be violated by roadway use levels. The travel demand and simulation models can be used to proactively evaluate the impact of different management alternatives on roadway traffic volumes, travel time, and the associated impact on visitor-based evaluations.

**Conclusion**

In recent years, there has been a sharpening focus by researchers and planners on transportation experience in national parks (Hallo and Manning 2009; Holly et al. 2010; White 2007; White et al. 2011; Youngs et al. 2008). Indeed, transportation management is now considered an essential aspect of capacity and visitor use management in national parks (Daigle 2008; Lawson et al. 2009). In recognizing that transportation and recreation are often synonymous in parks, this paper illustrates a process of integrating traffic engineering modeling with transportation experience indicators and standards of quality to evaluate roadway conditions in terms of experiential quality.

In this study, visitors’ experiences of travel times and VPV along park roadways were within the range of acceptable conditions. Modeling results indicate, however, that recent visitation patterns threaten to push conditions outside of that acceptable range. Looking forward, researchers and planners will develop and assess multiple scenarios of potential future use levels and model the impact of alternative management actions on visitor experiences. This fosters an anticipatory approach to management that allows for decisions to be made that are robust against a wider range of future conditions.

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Using Transportation to Manage Recreation Carrying Capacity

Nathan Reigner, Brett Kiser, Steve Lawson and Robert Manning

Introduction

NATIONAL PARKS ARE CHARGED WITH THE DUAL AND SOMETIMES CONFLICTING MISSIONS OF providing public access while protecting park resources and the quality of visitor experiences. When demand for use is high, this two-fold mission can be daunting. Yosemite National Park may be a poster child for this issue, receiving over four million visitors per year. The majority of this use is concentrated at iconic attraction sites, with as many as 15,000 visitors occupying the narrow and confined Yosemite Valley each day (Manning et al. 2003; Lawson et al. 2009; NPS 2012).

The inherent tension between public access to parks and protection of resource and experiential quality is often discussed in terms of carrying capacity (Manning 2007). Originating in the study of biological habitat and range management, carrying capacity's applicability to parks and outdoor recreation has been widely recognized and investigated (Wagstaff 1964; Whitaker et al. 2011). Carrying capacities can be understood as the amounts and types of visitor use that can be sustained without unacceptable impacts to park resources or the quality of recreation experiences (Grafe et al. 2011; Whitaker et al. 2011). At root, the determination of recreational carrying capacity is a significant visitor-use management decision to be made by land managers and informed by research and public input.

Objectives, indicators, and standards-based adaptive management

Contemporary approaches to determining and managing visitor use and recreational carrying capacity employ a management-by-objectives framework (Manning 2001; Stankey et al. 1985). Capacity is formulated with the definition of management objectives and associated indicators and standards of quality. Management objectives are typically broad narrative statements about the level of resource protection and the type and quality of recreation experience to be maintained. Indicators of quality are measurable, manageable variables that serve as proxies for management objectives. Standards of quality are benchmarks by which achievement of objectives is judged. Once formulated, indicators of quality are periodically monitored and evaluated in comparison with standards; management actions are taken if standards of quality are threatened or violated. Monitoring and evaluation of indicators places the conditions visitors experience along the continuum of use-impact relationships and suggests when standards of quality may be violated and management action is required. This process is fundamentally adaptive in the way that cyclic monitoring informs management, and the efficacy of management actions is tested and evaluated through the monitoring program (Stankey et al. 2005).

Like realizing visitor-use objectives, the process of formulating standards of quality can be challenging. Adoption of specific standards of quality, and subsequently carrying capacities, is ultimately a judgment to be made by managers. Their judgments can benefit from public input, especially visitors' evaluations of experienced and desired conditions (Vaske and Whitaker 2004; Manning and Krymkowski 2010). By incorporating such evaluations, along with ecological constraints and administrative capacities, in the formulation and selection of standards of quality, managers can best satisfy competing access and protection demands inherent in visitor-use management.

Transportation and recreation

Transportation and recreation are inherently linked in many national parks (Daigle 2008; Hallo and Manning 2009; Pettingill et al. 2012). This is particularly true of parks such as Yosemite where much of the visitor use is concentrated along roads, trails, and public transport routes. Indeed, the spatial and temporal distribution of visitor use in Yosemite is largely a function of the transportation system (Manning et al. 2003; Youngs et al. 2008; Lawson et al. 2009). The extent of road and trail networks, availability of vehicle parking, and location of transit routes are key determinants of where and how much visitor use occurs throughout the park. From one perspective, this dependence of visitor use on transportation can be an additional challenge for management, as visitors are concentrated within relatively small areas of the park. However, the influence transportation exerts on visitor use also provides powerful leverage for carrying capacity management. If the connections between transportation system performance and the quality of recreation experiences can be understood, transportation can be used as a tool to manage visitor use, maintaining high experiential quality and mitigating some of the challenges of carrying capacity (Lawson et al. 2009; Lawson et al. 2011). These connections are reflected in the second, recreation site- and pedestrian-based track of the Integrated Transportation and Capacity Assessment (ITCA) conceptual models outlined in the introduction to this edition of The George Wright Forum (Meldrum and DeGroot, this volume).

Study objectives

The program of research described in this paper was designed to inform the use of transportation as a tool to help manage visitor use and the carrying capacity of Yosemite. Toward this end, the study seeks a systematic understanding of the relationships between visitor use and experiential quality at recreation sites and how these relationships depend on transportation systems as key origins for visitor use. Specific objectives were to (1) understand how transportation affects visitor use, (2) collect information on crowding-related indicators...
and standards of quality, and (3) illustrate the ways in which transportation might be used to manage visitor use and carrying capacity. The program of research employed visitor-use counts and observation, statistical and simulation models of visitor use, and visitor surveys incorporating visual simulations. These methods were applied at nine diverse recreation sites in Yosemite. The program of research is described in general and conceptual terms in the following section. This is followed with an illustration of its application at Hetch Hetchy, an important recreational and interpretive site in the park.

**Study sites**

Like most parks, much of the visitor use in Yosemite occurs in close proximity to its roads. A diversity of dramatic natural features and outstanding recreation opportunities are easily accessible by car and bus. Primary visitor destinations are spread throughout the park, yet are connected by less than half a day's drive along the park's extensive road network. Nine diverse sites were selected by managers and researchers to be included in this study (Figure 1). These sites are broadly distributed across the park landscape and transportation net-

![Figure 1. Study recreation sites in Yosemite National Park.](image)

work. Some sites are highly developed, while others lie within Yosemite wilderness. Some are intensively visited; others less so. All sites are accessible by the park's road and trail networks and many are also served by shuttle and tour busses. The sites cannot represent the entire diversity of the park's recreation resources or transportation contexts, but they are inclusive of many visitor uses and geographically extensive.

**Modeling transportation and the park experience**

Recreation experiences in Yosemite, particularly those at popular recreation sites easily accessible by the park's road network, typically follow a pattern of arrival, distribution, and destination (Figure 2). Visitors arrive at recreation sites, like scenic vistas, beaches, or interpretive sites, via road and trail networks. Upon arrival, perhaps by disembarking from a parked car or alighting from a shuttle bus, visitors distribute themselves throughout recreation sites. They walk paths and negotiate routes to explore rocks and rivers, search for photogenic views, and engage with interpretive installations. While such distribution and activity is part of their recreation experience, visitors are often destined for focal attractions or other essential features within recreation sites. Such destinations can include viewing platforms adjacent to natural features, beaches and swimming holes along rivers, and quintessential trails. This pattern of arrival, distribution, and destination can be broadly interpreted to represent many types of park visits and distills key elements of the park's complex use systems. This schematic pattern mirrors the conceptual models presented in the ITCA introduction (Meldrum and DeGroot, this volume; Figure 2).

Indicators of quality, such as the number of hikers encountered along trails or the number of other visitors sharing a viewing platform, capture and express important qualities of the visitor experience at these destinations (Manning 2011). Standards of quality, identified by park managers and informed by visitors, evaluate the acceptability of indicator variable conditions (Manning 2011). Coupling the progression of arrival, distribution, and destina-

![Figure 2. Conceptual and methodological models integrating transportation and recreation.](image)
Modeling arrival, distribution, destination

Visitors arrive at recreation sites within Yosemite via the park's transportation system. This system includes the modes by which visitors enter and move among locations within the park. Thus, the delivery of visitors by the transportation system is a key determinant of use levels and experiential quality at recreation sites (Lawson et al. 2009; Lawson et al. 2011). The arrival of visitors from the transportation system initiates this study's conceptual modeling and its analytical origin (Figure 2). In this program of research, arriving visitors were counted as they entered recreation sites. Counts were divided by increments of time, in this case by weekday and weekend/holiday and hour of the day. With these divisions, the arrival counts generate both the volume and temporal distribution of visitor use at recreation sites. Using regression models, these recreation site arrival patterns were related to transportation system use and performance. This relationship is the link, depicted in the applied conceptual model of the special edition's introduction, between road and vehicular modeling and recreation site and pedestrian modeling (Meldrum and DeGroot, this volume; White et al., this volume). In these models, entrances to the park and vehicular use on road sections such as Southside Drive in Yosemite Valley were used as independent variables to estimate the amount of visitor use at any particular site received. This statistical connection is a primary point of the integration between transportation and recreation experience quality.

After arriving, visitors distribute themselves throughout recreation sites and to destinations. The experiential conditions induced by these distributions, such as the numbers of hikers on trails or the numbers of visitors on viewing platforms, were modeled with computer simulations. A simulation model was built for each recreation site. Using the rate of visitor arrivals, and observations of visitor routing and travel speed collected on-site, the simulations replicate where visitors go and how long they spend there. Beginning with transportation system arrivals, the simulations distribute visitors and estimate the levels of visitor use that can be expected within the sites. These estimates document the numbers of visitors present at destinations such as viewing platforms and beaches, and along trails.

Indicators of quality

The simulation model estimates of experiential conditions at destinations constitute indicators of experiential quality that are specific, measurable, manageable, and relevant to visitors. Indicator variable estimates from the simulation models capture and communicate use levels in a way that can be measured against management objectives for experiential quality. They describe levels of use and quality in terms relevant to and actionable by managers. For this study, three indicators of quality with proven records of utility were selected by Yosemite park managers: the number of people at one time (PAOT) at experiential destinations, the number of people per view (PPV) along a section of trail, and the number of other visitors encountered (encounters) while hiking sections of trail. Each of these indicators is a ratio of use per area or time. As applied in this study, the numerators of indicator variables are either the number of people or encounters, and the denominators are either the area, length of trail, or period of time. Each indicator variable, as measured for description and presented to visitors for evaluation, expresses both numerator and denominator components of the ratio.

PAOT is used as an indicator of quality for sites whose experiential destinations are areas in which visitors linger (Manning et al. 1996). Examples of such destinations are viewing platforms and beaches. In these locations, it is assumed that the number of other people sharing a space bears a strong relationship to feelings of crowding and freedom, important elements of experiential quality in parks and outdoor recreation (Manning et al. 1996; Fleishman et al. 2007). As noted above, PAOT indicators are essentially ratios of use per space and time. In this study, experiential destinations were depicted in photographs of the area. The area bound by these photographs serves as the denominator of the PAOT ratio. The number of visitors within this area supplies the numerator. Figure 3 depicts a photographically defined PAOT indicator (Y) for a recreation site (X) at the dam at Hetch Hetchy, an important recreation and interpretive attraction in the park. While the entirety of a recreation destination often cannot be fully depicted in a single photograph, the area depicted may capture the essence of a site's experiential qualities and represent it as a whole. If visitor use and experiential quality can be effectively managed in this essential area, perhaps it will be effectively addressed throughout the site's entirety. When predicting visitor use based on arrival rates, the simulation models estimate the number of visitors that can be expected in the entirety of a destination area. These whole area estimates must be translated into PAOT values for just the area represented in a photograph, and regression models must be used for this purpose. In essence these models define the relationship: if X number of visitors are in the whole area, then Y number of visitors are expected to be in the photograph area (Figure 3). The regression equations for this study were created by simultaneously and repeatedly counting the numbers of visitors within the whole area and area of the photograph and then conducting a regression analysis on the paired observations to derive the general relationship. With these methods, PAOT serves as an indicator of quality for recreation destinations such as the dam at Hetch Hetchy.

PPV serves as an indicator of quality for relatively high-use trails (Manning 2011). PPV is similar to PAOT in that it seeks to capture and communicate the visual density of visitors. Contrary to PAOT, however, PPV is suited to characterize recreation experiences that involve movement through or along trails rather than lingering within an area (Manning et al. 2003). Like PAOT, this study operationalizes PPV photographically. A photograph depicting a section of trail bounds the area of the indicator, designating the denominator of its ratio. The number of visitors moving along this section of trail supplies the numerator. When distributing visitors throughout recreation sites, the simulation models can directly estimate the number of visitors expected to be walking along a PPV trail section, eliminating the need for the regression analysis conducted with PAOT. PPV is an indicator variable that can be used to measure and evaluate quality in highly used places where the central experience is based on movement through rather than lingering within an area.

The number of encounters with other hikers is an indicator of quality for relatively low-use trail sections (Vaske et al. 1986; Manning 2011). Like PPV, it seeks to capture and
express quality and use for recreation where movement through a landscape is central to the visitor experience. Encounters are often used as an indicator for more backcountry-oriented recreation such as wilderness hiking or backpacking (Roggenbuck et al. 1993; Lawson et al. 2006; Watson et al. 2007). Here, experiential destinations are of greater geographic extent than the socially and spatially concentrated experiences characterized by PAOT and PPV. Like those indicators, encounters is a ratio. Its numerator is a count of other hikers met. Its denominator, however, can be more varied than photographed areas of PAOT and PPV. The denominator of an encounters ratio can be either spatial or temporal. A spatial denominator is trail based, for example the number of other hikers encountered along a mile of trail. A temporal denominator is time based, for example the number of other hikers encountered during an hour of hiking. After designating either a spatial or temporal denominator, the simulation models that distribute visitor arrivals throughout recreation sites calculate estimates of the number of encounters expected.

**Standards of quality**

Standards of quality define thresholds by which to judge or evaluate the condition of indicator variables. Standards describe, in specific and numeric terms, objectives for the quality of recreation experiences and help to answer the question “how much use is too much.” While formulating standards of quality is ultimately a management judgment, eliciting visitors’ evaluations of the conditions they experienced during their visits can help inform such judgments. However, use levels and associated experiential quality vary dramatically by time of day, day of week, and season of the year. Additionally, use levels and recreation behaviors may change over time in response to management action and increasing or decreasing popularity. Reliance on existing conditions for the formulation of standards of quality limits the ability of research and management programs like that described here to adapt to these sorts of changes (Manning and Krymowski 2010).

Recognizing the potential for change in visitor-use levels and their relationships to experiential quality, a range of potential scenarios beyond just those currently experienced by visitors must be examined. Photographic simulations of a range of indicator variable conditions depicting use beyond extant levels can inform formulation of standards broad and flexible enough to guide management in the face of short- and long-term change. For PAOT and PPV, a range of indicator conditions were depicted using photographic simulation, and presented to visitor survey respondents. The photographs defining indicator areas were populated, using digital image editing software, to depict varying levels of visitor use. Encounters were simulated using a narrative text describing a range of encounters with other hikers. Visitors to each recreation site were surveyed and presented with a range of indicator conditions, either in photographic or narrative format, and asked to evaluate their acceptability on a scale from -4 (very unacceptable) to +4 (very acceptable). Resulting data allow the construction of acceptability curves that can be used to judge experiential quality at recreation sites under a range of use levels (Jackson 1966; Manning et al. 1996).

A hypothetical acceptability curve is shown in Figure 4. In the example, the curve traces aggregate acceptability evaluations for a range of encounters with other groups along a wilderness trail. The average of visitors’ evaluations fall out of the acceptable range and into the unacceptable range at 10 encounters. This information provides an empirical understanding of visitors’ crowding tolerances, and thus may help inform park managers’ judgments about crowding-related standards of quality. Respondents were also asked to indicate, from among the photo simulations and/or narrative descriptions, the level of use they preferred, the level of use at which park managers should impose limits, and the level of use that would displace them from the area. These multiple evaluations inform management judgment in the formulation of standards of quality associated with experiential quality for range of use levels and visitor arrival rates. The inherent multiplicity of potential standards of quality is depicted in Figure 2.
Figure 4. Hypothetical acceptability curve.

An example: Hetch Hetchy

Hetch Hetchy was one of the recreation areas included in this study. For the purposes of the study, it has two sites, the top of O'Shaughnessy Dam (HH2) and the trail beyond the dam leading to destinations north of the reservoir including Wapama Falls (HH7). The following description uses Hetch Hetchy to illustrate how the program of research addresses the relationship between transportation and recreation experience quality (as portrayed by the arrival, distribution, and destination conceptual model), and development and application of indicators of quality and visitor-based standards of quality. This empirical approach facilitates use of the park’s transportation system to manage carrying capacity and maintain the quality of visitor experiences. Figure 5 provides a map of the Hetch Hetchy area and its two recreation sites. HH2 occupies the top of O’Shaughnessy Dam between the locations denoted X1 and X2. HH7 occupies the trail extending north from O’Shaughnessy Dam, stretching between the locations X3 and X7.

Visitors arrive at Hetch Hetchy via a road, approaching the dam from the south, along which there is vehicle parking. After arrival, most visitors are bound, at the very least, for the top of the dam (HH2), and some for a hike along the reservoir (HH7) and perhaps onward into the backcountry. During such visits, individuals distribute themselves throughout the recreation sites, walking across the dam, enjoying the view and engaging with interpretive information, proceeding along the trail beyond the dam, eventually returning to their vehicles by crossing the dam again. While distributing themselves in this way, visitors move through destinations whose visitor-use conditions serve as indicators of quality, characterizing the visitor experience of the Hetch Hetchy area. For our Hetch Hetchy example, there are two indicators of quality: PAOT within the photograph area on top of the dam (Figure 5 between X1 and X2), and encounters along the trail beyond the dam (Figure 5 between X3 and X7). The goal of this research was to measure and evaluate the conditions of these indicators of quality based on visitor arrivals from the transportation network.

The program of research began with counting the number of visitors arriving to recreation sites via the transportation system. At the Hetch Hetchy sites, this was done with road-based vehicle counters deployed along the access road. By combining these vehicle counts with information about the number of visitors per vehicle from entrance station observations, estimates of the number of arriving visitors were generated.

Next, simulation models replicated the distribution of visitors at recreation sites. Using observations of the behavior and routes taken by visitors, the conditions of indicators of quality were estimated by simulation models. In the case of HH2, PAOT values on the dam
for various levels of vehicle arrivals were estimated. For HH\textsubscript{14}, the numbers of encounters among hiking groups along the trail beyond the dam, between X\textsubscript{3} and X\textsubscript{5}, were estimated.

The simulation and regression models described above were used to estimate the experiential conditions (PAOT and encounters) at Hetch Hetchy based on the number of visitors delivered by the park’s transportation system. But are these conditions acceptable or unacceptable? This question was evaluated, from the perspective of visitors, with visitor surveys and standards of quality. For HH\textsubscript{12}, visitors were presented with a series of photographs depicting a range of PAOT levels, representative samples of which are shown in Figure 6. Based on respondent ratings of the acceptability of these photographs, an acceptability curve was constructed (Figure 6) that facilitates evaluation of the PAOT conditions estimated by the simulation and regression models. For example, if simulation modeling estimated that 15 PAOT were at the HH\textsubscript{12} site based on the number of vehicles that arrive via the road to Hetch Hetchy, then that level of transportation system access and visitor use is considered by visitors, on average, as being highly acceptable. This is suggested by the acceptability curve in Figure 6. However, if additional vehicles arrived before any departed and 45 PAOT were estimated to be at the site, then conditions would be, according to aggregated and averaged visitor evaluations, unacceptable (Figure 6). By comparing estimates of indicator conditions to the standards of quality formulated from visitor surveys, the performance of the park’s transportation system and its influence on experiential quality can be evaluated. This, in turn, can help inform decisions about the crowding-related capacity of Hetch Hetchy.

Discussion

The research presented here addresses one of the primary connections between transportation and recreation: the role of transportation systems as a determinant of recreation use. In shaping where visitors go in parks and when they go there, visitation and crowding at recreation sites can be understood as a function of the transportation systems and facilities that provide access to the sites. The approach used in this study represents this connection in conceptual and methodological models that combine monitoring, simulation, and visitor surveys.

Like many national parks, much of Yosemite’s visitor use is centered about its transportation system, especially its roads. Typical visits to Yosemite begin with arrival to the park via one of its five highway entrances, parking personal vehicles or alighting from buses at recreation sites, then proceeding, often not very far from the roads, to experiential destinations such as overlooks, beaches, or interpretive features. Within such patterns, there is an inherent relationship between the number of vehicles on park roads and the volume and timing of visitor use at recreation sites (Manning et al. 2003; Lawson et al. 2009). The conceptual and methodological models used in this research reflect and empirically document these patterns. First, counts of visitors arriving at recreation sites are generated from observation and statistical estimation. Then, simulation models replicate the distribution of visitors throughout recreation sites, estimating corresponding experiential conditions, in terms of indicator variables. Finally, these experiential conditions are evaluated against standards of quality formulated with the help of visitor surveys. This process of monitoring and evaluation helps inform adaptive management of recreation use as it is determined by the park’s transportation network.

This integrated program of research provides park managers and scientists with two types of systematically connected information to support decision-making: descriptive and evaluative. The descriptive information characterizes what use is occurring. The evaluative component informs management about visitors’ perceptions of the amount of use that ought to be occurring. In counting visitor arrivals and estimating experiential conditions throughout recreation sites and at destinations, visitor use is described. These levels are then evaluated by visitors using surveys and photo simulations or narrative descriptions. When these methods are joined, the extent and distribution of current use can be described and its impact on experiential quality, in terms of visitor crowding, can be evaluated. By both describing and evaluating visitor use, the conceptual and methodological models lay a foundation for research to support integrated transportation and recreation carrying capacity management.

While the joining of descriptive and evaluative information establishes a foundation for carrying capacity research and management, simulations render this approach flexible and proactive. Flexibility and proactivity allow managers to explore a diversity of alternative and potential future scenarios, assessing their predicted impacts on carrying capacity and re-
complemented with information and education and transit services that direct and transport visitors to relatively little-used sites that may have an excess of visitor capacity, expanding management from a site-specific to a parkwide level. Such redirection must be done with sensitivity to the character and quality of experience unique to each site, ensuring that a range of recreation opportunities is maintained rather than homogenized. Beyond providing information to redirect visitors, informing them about what social conditions they may experience upon arrival at recreation sites may help to alter their expectations so that visitors desiring quieter or more social experiences can plan accordingly.

At Yosemite, as with many national parks, transportation and recreation are inherently connected. A primary connection is the direct influence transportation systems have on the spatial and temporal patterns of visitor use, and subsequently experiential quality; at the recreation sites they serve. Recognizing this connection, transportation and recreation can be integrated for both research and management of visitor capacity and related issues. Conceptualizing the arrival of visitors to recreation sites from the transportation system as the origin of an analytical process, a program of monitoring, simulation, and surveying can observe, estimate, and evaluate experiential quality at recreation sites in terms of transportation system facilities and operations. Ultimately, this research approach can help inform park managers' judgments about visitor carrying capacities for recreation sites and the effects existing and alternative transportation systems may have on the quality of recreation experiences.

References


Transportation, Recreation, and Capacities in Yosemite National Park

Doug Whittaker, Bo Shelby, Bret Meldrum, Henrietta DeGroot, and James Bacon

Peak-season visitors to Yosemite Valley know firsthand that use levels can affect the quality of their experiences in the park. The sheer volumes of vehicles and people sometimes produce long lines at entrance gates, traffic jams at intersections, full parking lots, and congested trails or viewpoints. These problems have been challenging the park’s infrastructure and operational staff for decades, but more frequently in recent years (White et al. 2012). A 2011 study of mid-summer river users in Yosemite Valley also helps quantify the general problem: 82% report feeling some degree of crowding during their visits (Whittaker and Shelby 2012). Meta-analyses of the hundreds of studies using this same measure suggest that recreation settings with crowding levels above 65% are probably “over capacity,” and those above 80% may be “greatly over capacity” (Shelby et al. 1989; Vaske and Shelby 2008).

More detailed information shows that Yosemite visitors feel more crowded while using the park’s transportation system than when participating in other activities. The percentage of those feeling crowded was highest while engaged in driving roads (90%), finding parking (88%), or riding free shuttles (83%), followed by hiking or biking on trails (68%). In contrast, crowding ratings were considerably lower for river-based activities, such as boating (60%), relaxing (54%), or swimming (45%). These are considered to be in “high normal” (50–65%) or “low normal” (35–50%) ranges (Shelby et al. 1989).

These general crowding ratings by themselves are insufficient to determine capacities, but they provide perspective in relation to other studies, allow comparisons among areas within Yosemite, and show that transportation conditions affect overall perceptions, as anticipated by the conceptual model developed in Meldrum and DeGroot (this volume). As the park addresses capacities and other management actions in Yosemite Valley, the transportation system is a key component of high-quality visitor experiences as well as a primary mechanism for managing use and impacts.

Previous papers in this issue have described the conceptual foundation, objectives, methods, and findings of Yosemite’s Integrated Transportation and Capacity Assessment (ITCA) program (Meldrum and DeGroot), which addresses a range of transportation (White et al.) and attraction site impacts (Reigner et al.). This information is being used to develop different potential futures (including capacities) for the Merced River Plan (MRP). The Merced is a designated national wild and scenic river, which includes segments in the park’s wilderness as well as the iconic Yosemite Valley. The MRP is the primary planning initiative that will guide transportation, development, and capacity decisions in these areas.

This paper briefly reviews the process used to develop capacities, and describes how ITCA information helped develop plan alternatives that represent tradeoffs between transportation infrastructure, visitor numbers, and the conditions that affect visitor experiences. We conclude with considerations for integrating transportation and capacity programs into planning processes, some of which are further illustrated by short sidebars with specific information from the MRP. Because the draft MRP and its environmental impact statement have not been released as this publication goes to press, information in the sidebars are preliminary capacities or conceptual alternatives presented to the public during earlier planning steps (NPS 2012a, 2012b).

Addressing Capacity in the Merced River Plan

The Wild and Scenic Rivers Act (WSRA) provides the most recent impetus for addressing capacity in Yosemite. The act requires agencies to prepare comprehensive management plans to protect and enhance a river’s “outstandingly remarkable values” by addressing resource protection, development of lands and facilities, user capacities, and other management practices (WSRA, section 3(d)(1)). Capacities specify the kinds and amounts of use the river corridor can sustain without causing unacceptable impacts to those values (Departments of Interior and Agriculture 1982). Consistent with recent literature (Whittaker et al. 2011), user capacities are numbers on a use-level scale that have units of use, timing, and location components, such as people per hour hiking along the Mist Trail or vehicles per day in Yosemite Valley.

After more than a decade of legal challenges, NPS is developing a third plan for the Merced River. The decision-making process is guided by the National Environmental Policy Act (NEPA), which requires NPS to describe the current situation (the “affected environment” and “no action alternative”), develop a “reasonable range” of alternatives, analyze their environmental consequences, and choose a preferred alternative while involving the public throughout the process.

Capacities are one component of “management prescriptions” developed for each alternative. These prescriptions describe management objectives, quantitatively define standards of natural resource health or experiential quality, and show how management actions (including capacities) will achieve those objectives (Haaas 2003; Whittaker et al. 2011). Specific steps follow from several well-established resource and visitor-use frameworks (Brown et al. 1978; Stankey et al. 1985; Shelby and Heberlein 1986; Graefe et al. 1990; and Manning 2001, 2004). Applied to wild and scenic rivers, they include:

- Describe “outstandingly remarkable” river values to be protected;
- Identify indicators to represent desired conditions;
Transportation and Visitor Capacity Research and Planning at Yosemite National Park

- Identify management standards for each indicator to define when impacts become unacceptable;
- Analyze relationships among use levels, impacts, and potential management actions; and
- Organize management actions and related capacities into a reasonable range of alternatives that are logically consistent and define alternative ways to protect river values, each with inherent tradeoffs.

The process is designed to clarify how use levels affect conditions, given assumptions about the transportation and overnight accommodation infrastructure, amount of visitor regulation, and site management or “hardening.” It also included analyses of how different use measures are related to each other, thus addressing use and impacts at different spatial or temporal scales. This an iterative process that included some adjustments after revisiting earlier steps. Alternatives were designed to have different capacities, which work with other management actions to protect or enhance river values.

ITCA information helped structure decision-making and clarify tradeoffs

Use and development in Yosemite’s Merced River Corridor is multifaceted, and developing capacities for the area is similarly complex. Resource conditions, capacities, and infrastructure are parts of a three-way tradeoff system, and ITCA information shows how changing one has implications for the others. User capacities in different alternatives show how higher and lower amounts of use fit with infrastructure and other management actions to produce different resource conditions, protecting river values in different ways. These represent choices about the kind of place the Merced River corridor will be and the visitor experiences it will offer (as required by NEPA), while at the same time protecting river values (as required by WSRA).

Transportation and capacity-focused analysis identified information needs, required explicit evaluative information and decisions, and “solved for” (1) conditions, (2) capacities, or (3) infrastructure when the other two were identified. In the Merced River planning process, ITCA-based analysis specifically helped:

- Focus attention on specific, measurable indicator variables for transportation and recreation experience conditions (e.g., travel times on key road segments, the availability of parking, and densities at specific recreation attraction sites such as falls viewpoints, hiking trails, and beaches).
- Provide evaluative information from visitor studies about specific transportation and experiential conditions (preferred and acceptable travel times or use densities), including those higher than current use levels as illustrated through photo simulations (Regnier et al., this volume; White et al., this volume; Whitaker and Shelby 2012).
- Encourage “calibration” to standardized use-level measures. Capacity analysis requires specific use-level metrics (units, location, and timing), which helps agencies and stakeholders stay on the same page when describing use and the conditions it creates. Prior to the most recent analyses, park staff and stakeholders often talked past each other by using different use-level descriptors (e.g., people vs. vehicles, different counting locations, or aggregating by time periods as different as days, months, or years).
- Describe relationships between multiple-use and impact metrics (and provide assumptions that allow “translations” between related variables). It is important to understand all the metrics in a chain of variables: at-one-time densities at a site (via photo simulations), daily use levels at the site, overall daily use levels in the valley, and overall daily use levels in the park. The goal, as Einstein once advised, is the “simplest model possible, but not simpler.” The planning process requires ITCA research and monitoring information to “connect the dots” and clarify the source of information or assumptions.
- Specify “sideboards” on the range of transportation and capacity actions to analyze. Alternative development can be overwhelming if infrastructure and capacity choices are unbounded. There are always historical, physical, legal, administrative, budget, and political constraints during decision-making, but it can be challenging for agencies to identify them. Because capacity analyses require specific input for these variables, decision-makers are encouraged to explicitly decide what is or is not “on the table” and within the “reasonable range.”
- Identify specific model input. Transportation and capacity models are relentless in requiring specific information. The models require NPS to specify circulation patterns, number and type of road intersections, parking supply, people per vehicle, numbers of day and overnight visitors, and numbers of residents and commuters.
- Vary conditions, capacities, or infrastructure in the analyses. In general, modeling scenarios for Yosemite Valley set infrastructure and use levels to provide output about resulting transportation conditions. However, one early model determined which use level would allow existing infrastructure to provide “acceptable” transportation conditions, and another estimated the highest use levels that would provide acceptable conditions if infrastructure were improved.

Transportation modeling was an integral part of the capacity analysis, and each alternative assessed how levels of vehicle use (associated with overnight accommodation and day-use parking decisions) would affect traffic circulation (Byrne et al. 2011; Chase et al. 2012). Modeling also explored relationships between circulation and infrastructure choices such as pedestrian underpasses, intersection improvements, and additional parking. Understanding relationships between use and impacts to river values (see Box 1) helped shape infrastructure choices in the alternatives.

Considerations for future capacity efforts

As ITCA information has been integrated into decision-making for the MRP, several considerations have emerged for developing capacities in similar high-use parks and resource areas. Sidebars illustrate several of these ideas with ITCA information or ITCA-based standards, capacities, or management actions in the MRP.

Focus on indicators for the most salient impacts. Indicators seldom represent all objectives and desired conditions. In Yosemite, attention has focused on travel time on specific
Box 1. Capacities in the Merced River corridor above Nevada Falls

The outstandingly remarkable value in this segment is river-related recreation in an iconic High Sierra setting. The river features “opportunities for primitive and unconfined recreation, self-reliance, and solitude which are intimately tied to the corridor’s wilderness character.” The most capacity-sensitive indicator focuses on trail encounters per hour, a salient visitor experience metric studied in many higher-use wilderness areas (Cole and Hall 2008; Broom and Hall 2010). Both overnight and day visitors contribute to trail use in the segment, requiring research to assess how existing overnight wilderness zone capacities and trailhead quotas affect trail encounters. Relationships between overall trail use levels and encounters appear to be direct and linear, with lower use and encounters on trail segments farther from trailheads and developed areas (NPS 2009–2011). Standards vary from one to four group encounters per hour across different trail segments and alternatives.

Overnight use in the segment is managed by an existing permit system developed through earlier travel pattern and ecological impact studies (van Wagendonk, 1986), updated with a more recent travel pattern assessment (Van Kirk et al. 2011) and expert judgment. The current system manages overnight use in backcountry zones. This use comes from six different trailheads with hiker-per-day quotas ranging from 10 to 50 for a total of 170 people per day. Some alternatives in the MRP reduce these quotas to reduce trail encounters and the people camping in areas such as Little Yosemite Valley (LYV).

The major user capacity tradeoffs in the segment are between use (access), infrastructure (at LYV), and social conditions (encounters on trails and at camps). The size of the designated campsites at LYV affects the levels and timing of use on trail segments. In the higher-use alternatives, encounters levels in one trail segment are twice those in lower-use alternatives. The higher-use alternatives also maintain LYV and Lake Merced High Sierra Camp (HSC) at levels similar to recent management; this requires more infrastructure (LYV toilet, HSC facilities), produces higher encounter rates with other users and stock trips, and reduces wilderness character components such as opportunities for solitude.

High use road segments in East Yosemite Valley, parking availability at specific parking lots (particularly the day use lots), and densities of people at specific “indicator sites” such as Vernal Falls, Yosemite Falls, Bridalveil Falls, high use beaches, or the East Valley boating segment. These are the “hot spots” where most crowding and congestion occurs and experiences may be degraded. Likewise, attention is focused on the highest use times of the year (the summer season from Memorial Day through Labor Day), assuming that if these areas are managed to acceptable levels, lower densities and impacts (and thus higher quality experiences) will be available at other locations and times.

Pay attention to the scale and number of capacities. Some people refer to “the capacity” of an area, but multifaceted areas like Yosemite Valley actually have several. Agencies or stakeholders may focus on the number of visitors in the entire area over the course of a day, but developing capacities for smaller areas or shorter times also may be important to protect experiences or values. This requires appropriate “boundaries” or scales for capacities, as well as appropriate use-level units (Whitaker et al. 2011). There are additional challenges in combining capacities and deciding which ones to manage.

The capacity of a hotel resort is a useful analogy. There is an overarching capacity (total guests) that can stay at a resort, but there are also capacities for the dining room, exercise facility, pool, or parking lot. The total number of guests is probably measured in groups (rooms) per night with certain assumptions about people per room, but the capacity for the dining room is independent of the overall capacity, with a different metric (people at one time) and allocation system (reservations for dinner are distinct from reservations for a room).

Capacities are designed to control impacts, so empirical relationships are important. For example, ITCA data show “vehicles per day in the valley” are directly related to intersection congestion impacts (circulation), parking availability, and densities at popular day-use attractions (e.g., Yosemite Falls, Bridalveil Falls). But “vehicles per day in the valley” have lower correlations with on-river boating, so addressing those impacts may require a sub-capacity for commercial or private boating use (see Box 2).

Analyze use-impact relationships within a reasonable range. Agencies have the most information about existing conditions, particularly across a season or on “typical” days in the primary use season. But without robust monitoring, there may be less information about peak days, or the relationships between use and impacts through a range of relevant use levels. Monitoring also may not predict how impacts increase if use rises beyond current levels.

Similarly, it is important to collect evaluative information about use levels that are higher and lower than the current situation. The ITCA photo simulation technique is particularly effective for exploring evaluations of higher use levels that have not yet occurred, although care should be exercised to avoid asking about unrealistically high levels. The goal is careful assessment of the reasonable range that will be considered during planning.

Evaluative or descriptive information for use levels above those directly observed should be interpreted cautiously. There is greater uncertainty about evaluations of conditions that have never occurred, or in extrapolating from existing use-relationship relationships. The effects of more use for transportation conditions may be particularly challenging to model at these higher levels because they include probabilistic but variable circulation “friction” (e.g., from random pedestrian crossings, wildlife sightings). In addition, specific locations of new transportation infrastructure (e.g., roads, intersections, and especially parking lots) may affect specific densities at attractions that are hard to predict. ITCA descriptive research was conducted assuming existing infrastructure and taking advantage of variable use levels through a study season. But if parking lots or circulation patterns are changed, these assumptions need to be reconsidered.

Consider other management actions (mitigation). Analyses that account for infrastructure changes (e.g., new pedestrian underpasses, new multi-use trails, and improved intersections) or other management actions (split rail fencing, boardwalks/trails, and education/enforcement programs that funnel pedestrian use away from sensitive areas) are critical. ITCA analysis is most helpful when it allows decision-makers to explore “what if” scenarios.
Box 2. Attraction site densities and capacities in Yosemite Valley

The primary indicators selected to represent social conditions in Yosemite Valley were densities at or on the way to attractions (e.g., beaches, boating, the trail to Vernal Falls, viewing areas at Yosemite and Bridalveil Falls). The focus on attraction site densities followed research in many frontcountry settings (Manning 2009), and is the higher-density analogue of encounters in backcountry settings. Information about these indicators came from ITCA studies at popular high-use sites (Manning et al. 1998; Manning et al. 1999; Manning et al. 2003; Lawson et al. 2009), plus research on shore and boating use in East Yosemite Valley (Whittaker and Shelby 2012). All densities in these studies can be translated into people at one time (PAOT), people per viewscape (PPV), or boats at one time (BAOT) in a specific photo, as evaluated in the studies. They can also be translated into daily use in an area (with assumptions about the size of the photo polygon, use in the larger attraction site area, and temporal distributions through a typical peak-season day).

Standards for these density indicators vary by type of site and alternative. Higher-use sites and alternatives have higher-density standards, and range from 35 to 70 square feet per person at higher-use areas (e.g., the trail to Vernal Falls, several popular trails in East Yosemite Valley) and 80 to 140 square feet per person on lower-density trails in the West Yosemite Valley. Higher-use beaches ranged from 5 to 20 linear feet of waterfront per person, while lower-use beaches were set at 20 linear feet per person for all alternatives. Boating standards range from one to nine boats per viewsked (about 400 feet). In all cases, standards are “better” than current visitors say “they will accept” or “not to allow,” while more stringent standards (for lower-use sites or alternatives) are closer to visitors’ preference evaluations.

Relationships between use and densities at these sites were generally direct, linear, and moderately strong. Explained variance (R²) between the number of vehicles arriving in East Yosemite Valley per day (and daily use at these attractions) was higher for iconic roadside attractions (e.g., 0.81 for Bridalveil Falls and 0.64 for Yosemite Falls) than for sites farther from the road (e.g., Vernal Falls; 0.12 and 0.24 in different years) or that require more time (e.g., river rafting; 0.11). These relationships also vary in different years, possibly due to weather and flow conditions. For example, in high-water years the waterfalls are more spectacular and attract a greater proportion of day use, while in lower-water years visitors are more likely to spread out and this reduces congestion at particular sites.

Differences in use-impact relationships and standards make setting overall capacities more challenging for Yosemite Valley than a simpler area such as Hetch Hetchy, which has a single access road, very strong use-condition relationships, and simpler standards (Reigner et al., this volume). In the valley, decision-makers need to consider several attractions, each responding differently to use and having different standards.

An analogy here is the difference between a simple boom box (with just volume, treble, and bass controls) and a professional sound system with dozens of slider controls. It is easier to make decisions about the right level of use for Hetch Hetchy, just as it is easier to “mix” the sound from a boom box. When you move to the more complicated situation in the valley, there are more variables in play and more judgments to make. ITCA information has helped inform those choices and clarify the conditions provided with higher and lower use.

Primary user capacity tradeoffs in Yosemite Valley are between the amount of use, infrastructure (especially lodging, campground, and day-use parking lots) and social conditions (densities at attraction sites, roadway travel times, and parking availability). In the lower-use alternatives, densities at attractions are closer to “preference” evaluations than “acceptability” evaluations. Higher-use alternatives allow more access, but conditions are less desirable at some sites, though still within the acceptable range identified in ITCA studies.

Focus on “limiting factor” indicators. Capacity experts have long-recognized that not all impacts are related to the same way, and some conditions become unacceptable at lower use than others (see discussion in Box 2). When setting a capacity, the focus is on the standard that is violated first as use rises because it is the most sensitive, even if that indicator may not be the most important (Whittaker et al. 2011). While some of the key transportation conditions appear to “break down” at similar use levels, standards for the experiential indicators at different attraction areas would be violated at very different use levels.

The most obvious differences are at Bridalveil and Yosemite Falls. Bridalveil has a smaller trail system, narrower trails, and a cul-de-sac viewing area, compared with the wider, longer, loop trail system at Yosemite Falls. It is not surprising that users’ evaluations of acceptable densities at Bridalveil are exceeded at lower use levels at these two sites. The questions for decision-makers are whether (1) Bridalveil should be the “limiting factor” (which would require a lower overall capacity for the valley); (2) a Bridalveil redesign can reduce site densities to acceptable levels by redistributing use temporally or spatially; or (3) conditions at Bridalveil should be allowed to exceed current users’ acceptability evaluations (thereby establishing a new higher-density standard).

Be proactive. Capacities can be most easily implemented before impacts become unacceptable, change becomes irreversible, or the public becomes accustomed to high use levels (Whittaker et al. 2011). Managers should indicate which management actions they will employ if parts of the management prescription are violated, particularly if direct use limits are contemplated, so stakeholders can prepare for them. Restrictions or allocations may be
Box 3. Meadow conditions and capacities in Yosemite Valley

An example biological indicator shows that many visitor impacts can be controlled by mitigation actions. Meadow function and health were assessed by a “fragmentation index,” the percent of a meadow in its five largest patches. The measure is sensitive to the size of intact areas and the amount of informal trails, and indicates impacts related to meadow hydrology, soil moisture, non-native species, habitat quality, and barriers to small mammals. Although research has documented visitor-related resource impacts in meadows, data and experience in Yosemite showed that fragmentation or other measures of meadow condition were related to type and location of use rather than specific amounts of use. As a result, the focus shifted to other management actions that address those impacts.

Meadow fragmentation standards were the same for all alternatives. Alternatives with different capacities thus required different levels of infrastructure (boardwalks, trails, and split rail fencing) to control the location and type of use. This addresses the impact problem by changing the impactful behavior rather than the amount of use so the meadow condition is no longer a limiting factor for capacity. New roadway designs remove most roadside parking in all alternatives, and trails/fencing are used to control impacts from increased use and development (e.g., new or expanded campgrounds) in two higher-use alternatives. The success of such approaches has been demonstrated at Stoneman Meadow, where fragmentation scores improved from 40% in 1978 to 99% in 2011 as a result of developing a single boardwalk trail, even though annual park use rose more than 50% during the same period. Monitoring will continue to assess meadow condition, use levels, and visitor compliance with formal trails and protective barriers in order to better understand relationships between these variables.

More readily accepted by users or stakeholders if they are prescribed before they need to be implemented. Management actions, including capacities, should be set so that impacts slow before they have “crossed the line.”

ITCA modeling in Yosemite shows that this is particularly important for transportation conditions, which deteriorate quickly once a tipping point has been reached. With existing infrastructure in the eastern part of the valley, there are several major bottlenecks. In some cases congestion is a function of lack of parking (vehicles clogging the roads in search of spaces), but in others it is caused by intersections or on-grade pedestrian crossings that cannot handle the volume of use. As these bottlenecks approach and exceed their design capacity, conditions such as travel times, queue lengths, and vehicles per road viewscape “go exponential” (increase at a dramatically increasing rate). Anecdotal accounts of traffic gridlock from 2011 suggest modeling may actually underestimate travel times, queue lengths, and other transportation conditions, so it is important to be conservative in choosing capacities to avoid reaching a tipping point (see Box 4).

Vary standards or mitigation across alternatives. Transportation and experiential models allow decision-makers to illustrate the tradeoffs of different infrastructure, use levels, and

Box 4. Transportation conditions and capacities in Yosemite Valley

Two frequent questions from visitors are: “How long will it take to get there?” and “Will parking be available?” Many visitors are acutely aware that congestion can affect their ability to experience the Yosemite Valley, and NPS developed two ITCA-based indicators to address transportation system performance.

Parking availability compares the number of accumulated vehicles with parking supply (number of spaces). In different alternatives, parking supply was constrained by restoration initiatives, the removal or repurposing of existing facilities, and the space occupied by camping and lodging complexes (which also varied across alternatives). Modeling then analyzed how day-use would occupy the remaining available spaces, applying assumptions about arrival and parking duration times, and about the proportion of spaces that would be paved and striped, actively managed by parking staff, or could be utilized efficiently at one time. Urban planners assume 85% maximum occupancy so drivers can find, enter, or leave spaces without creating bottlenecks; in Yosemite’s generally larger lots, planners applied a 90% standard. East Yosemite Valley currently has about 5,000 parking spaces, with 4,000 available to visitors; modeling explored a range from about 4,000 to 6,500 spaces (3,000 to 5,500 for visitors).

Travel time measures how long it takes to drive from Curry Village to Yosemite Village parking and indicates circulation efficiency. It is a function of the number of vehicles, the amount of space on roadways, the number of intersections of different types, and the amount of “friction” caused by pedestrian crossings or vehicles blocking the roadway as they enter or leave parking. Although visitors appear more sensitive to vehicles per viewshed (VPV) than travel times (White et al., this volume), modeling and observations from recent high-use days show that congested roadways can cause unacceptable travel times, interaction queues, or constrain emergency vehicle access. Alternatives ensure travel times do not reach these dysfunctional levels by increasing infrastructure in higher-use alternatives (e.g., adding up to three roundabouts and two subsurface pedestrian crossings, while substantially reducing roadside parking that encroaches on circulation). Alternatives also include congestion mitigation, such as traffic operations programs to direct parking and improve intersection efficiency, enhanced traffic information (redirecting use from congested areas on high-use days), and incentives for visitors to use transit options from gateway communities. Transit systems may help accommodate increasing visitation even when parking and circulation-based capacities are reached, assuming visitation levels are high enough to justify system costs.

If monitoring shows vehicle use levels still exceed parking or travel time standards, alternatives include on-site day use traffic restrictions (a “shunt” that delays or redirects traffic away from the East Valley) or a day use parking permit system (with potential reservation and onsite components). The full day use parking permit system would only be implemented if capacities or standards have required use of the shunt for more than 14 days per year for two consecutive years.
conditions. Differing alternatives highlight these tradeoffs through varying capacities, infrastructure, and transportation or experiential standards. For some indicators, standards may not vary across alternatives—these are situations where there is broad agreement about acceptable conditions and the park will not consider a less protected state (see Box 3). But in other cases there may be more diverse opinion about acceptable standards, and the alternatives can highlight different choices (see Box 2). A more protective standard may allow less use, while a less protective standard may allow more.

When standards do not vary across alternatives, the other choice is to vary mitigation. As discussed in the Bridalveil Falls example, NPS may choose to manage for current visitors’ acceptability evaluations across several alternatives, but vary the redesign features to allow higher use while keeping the same densities.

**Develop data describing simple use-impact relationships.** The conceptual model described in Meldrum and DeGroot (this volume) emphasizes the complex nature of transportation and capacity relationships, and the ITCA research and monitoring program collected evaluative information for multiple sites and developed sophisticated simulations with several spatial and temporal variables. This makes sense for a park with considerable research and monitoring resources, not to mention the contentiousness associated with years of litigation. But other parks have less capability, which encourages simpler observation-based relationships and logical calculations based on stated assumptions.

Regardless of the resources available, simpler and easier-to-explain relationships are often more useful than sophisticated analyses that can be opaque to some decision-makers or stakeholders. For example, ITCA analyses that involve several “translations” between density evaluations (via photos) and use-level metrics at different geographic or temporal scales require more assumptions and effort to understand, and they have greater margins of error as they model use levels further from current levels. Although complex modeling has its place, we often wished for more straightforward data that could have been collected at the same time as other ITCA information, and analyzed more simply.

**Conclusion**

Researchers have long advocated separating descriptive and evaluative information in capacity decision-making (Shelby and Heberlein 1986; Manning 2007). The descriptive component is often less complex and controversial, requiring mostly technical information about how the system works. In contrast, evaluative component is usually more contentious, because stakeholders have different value judgments about the type of experience to be provided or how much impact is acceptable. In Yosemite however, both were challenging because of the complexity of resources, development, use, and users. The ITCA research, planning, and monitoring programs recognize this in both concept (Meldrum and DeGroot, this volume) and practice (White et al., this volume; Reigner et al., this volume; Chace et al., 2012; Whittaker and Shelby 2012). As applied in the MRF process, ITCA information helps clarify the complex tradeoffs involved in choices about use, infrastructure, and the conditions that will be provided. This allows a more clear discussion of the kind of place stakeholders want Yosemite to be.

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**References**


Getting There: Yosemite and the Politics of Transportation Planning in the National Parks

Christopher E. Johnson

Yosemite is, in many respects, the prototypical national park. It was the nation’s first park devoted to the preservation of undeveloped land for public recreation and reflection. It is also where the National Park Service, since its inception in 1916, has grappled most intensely with the challenges of preserving nature for the benefit of a public accustomed to experiencing nature from their cars. Over time, higher levels of visitor use stemming from the growth of San Francisco, rising affluence, increasing automobile ownership, and the Park Service’s own road-building and promotional efforts threatened to overwhelm the scenic landscapes the park was meant to protect. Critiques of the Park Service’s accommodation of car-based tourism began to take shape as early as the 1920s, reaching a crescendo during the 1960s and 1970s with the rise of the wilderness movement. Facing criticism from some of their oldest allies in conservation, including the Sierra Club, administrators and planners at the national and park levels struggled to adapt transportation policies to evolving and increasingly contested cultural conceptions of a quality national park experience.

While always contentious, transportation planning became even more complex in the latter 20th century. The passage of the National Environmental Policy Act (NEPA) in 1969 and the suite of preservation legislation that accompanied it gave an increasingly active public a direct say in management decisions. Since then, the Park Service has faced scrutiny from environmentalists, concessionaires, local communities, recreation groups, historic preservationists, Native tribes, and others in the development and implementation of new visitor management policies for Yosemite. Although planners have devised creative strategies for anticipating, soliciting, and incorporating public responses, the costs and time commitments of preparing the required environmental impact statements and responding to public comments have resulted in a series of drawn-out battles among groups of people who, while generally sharing an interest in protecting the park for future generations, have continued to disagree over specifics.

The essays in this edition of The George Wright Forum outline a new strategy which planners in Yosemite have developed in response to the more complex politics of the present era. In part, the philosophy behind the Integrated Transportation and Capacity Assess-
Transportation and Visitor Capacity Research and Planning at Yosemite National Park

Transportation and Visitor Capacity Research and Planning at Yosemite National Park

tives of the Southern Pacific, including magnate Collis P. Huntington, who saw the creation of a large national park in the region as a way to both attract tourists and protect the watersheds supplying irrigation to railroad-owned agricultural lands in the Central Valley. If the railroads were crucial to establishing and promoting the first national parks, the automobile was the key to making the 19th-century idea of a national park relevant in the 20th century. Americans’ desire to encounter nature in the national parks through their windshields reflected a conflicted view of technology at the heart of 20th-century conceptions of modernity. As cars became more affordable and more reliable in the 1910s and 1920s, they were widely embraced as mechanical means to escape the problems of the industrial city and return to nature. They also provided an impetus for national park promotion.

If the railroads were crucial to establishing and promoting the first national parks, the automobile was the key to making the 19th-century idea of a national park relevant in the 20th century. Americans’ desire to encounter nature in the national parks through their windshields reflected a conflicted view of technology at the heart of 20th-century conceptions of modernity. As cars became more affordable and more reliable in the 1910s and 1920s, they were widely embraced as mechanical means to escape the problems of the industrial city and return to nature. They also provided an impetus for national park promotion. In 1908, Mount Rainier became the first national park to admit auto tourists. For residents of the nearby cities of Seattle and Tacoma, accommodating automobile travel to Mount Rainier would not only make the park more accessible, it would also draw attention to the region and increase tourist revenue.

From the start, automobile tourism to Yosemite was not universally embraced. Due to safety and noise concerns, cars were initially excluded from the park. Muir was also ambivalent about admitting cars. On one hand, he believed that allowing automobiles would help build a stronger constituency for the parks and perhaps even forestall the proposed dam at Hetch Hetchy. In 1912, he recommended that a road be extended up the canyon of the Merced River, through Tuolumne Meadows, and down to Hetch Hetchy to enable more people to see it. On the other hand, Muir was skeptical of automobile club delegates who spent “a prodigious lot of gaseous commercial eloquence” defending their presumed right to drive wherever they pleased. Ultimately, he recognized that lifting the ban on “these useful, progressive, blunt-nosed mechanical beasts” would be necessary to build support for preservation. Cars, he conceded, “will hereafter be allowed to puff their way into all the parks and mingle their gas-breath with the breath of the pines and waterfalls.”

In comparison to Muir, Stephen Mather, the first director of the National Park Service, was unequivocal in his embrace of the automobile. In 1915, just prior to the establishment of the agency, he drew on his own personal fortune to purchase the then-private Tioga Road. He then repaired the road and donated it to the government for use as “a motor gateway to the upper wilderness” of Yosemite. By the summer of 1918, some 50 to 60 cars were navigating the single-lane dirt track each day. In the following year, approximately 75% of all park visitors arrived in private vehicles. “The advent of the automobile,” Mather remarked in 1921, “has been the open sesame for many thousands.”

For Mather and his successor Horace Albright, accommodating auto tourism was entirely consistent with the young agency’s core mandate to preserve America’s natural treasures while providing for their enjoyment by the public. Through the 1920s, as part of his effort to promote the parks and the Park Service, Mather pushed for a 5,000-mile Park-to-Park Highway. He also worked to persuade local officials of the economic benefits of car-based tourism. Roads, he declared in 1925, would bring “a great flow of tourist gold … adding life to communities unprogressive for years.” Mather and Albright also coordinated a massive advertising campaign employing the promotional slogan “See America First!” to encourage Americans to view the national parks not only as scenery but as expressions of...
national culture. By the 1920s, the availability of cheaper, better-made cars, coupled with a rapidly expanding national network of roads, opened the parks to millions of middle-class Americans. Driving to and through the national parks came to be seen as basic American freedoms.9

Mather’s and Albright’s promotional drive was tempered by their belief that poorly planned development could detract from what they considered an appropriate national park experience. They sought out prominent landscape architects, including Frederick Law Olmsted, Jr., Herbert Maier, and Thomas Vint, to develop plans which harmonized with the natural landscape. Roads, lodges, visitor centers, and other projects were meant to enhance scenic vistas and bring visitors in closer contact with the natural features for which the parks were created. These kinds of “improvements” amounted to “the dignified exploitation of the national parks,” as one planner put it.10

Despite this restraint, by the 1920s the rapid influx of automobiles into Yosemite was beginning to stress the park’s natural environment and infrastructure. Pressures mounted as more Americans discovered that auto camping could be a cheap and enjoyable way to spend their vacations. For the most part, the Park Service welcomed the trend. Between the 1920s and 1930s, Mather and Albright oversaw improvements to the Wawona and Big Oak Flat roads and the construction of the Merced River All-Weather Highway. The Park Service also took advantage of cheap labor provided by the Civilian Conservation Corps and the Works Progress Administration during the New Deal to further develop the parks. Even with the additional infrastructure, cars backed up at the Arch Rock entrance station during busy summer weekends. Campgrounds filled to capacity and many drivers encroached into forests and onto meadows in search of free space to set up camp. In 1935, Yosemite officials sought to mitigate the problem of overcrowded campgrounds by enacting a 30-day camping limit.11

At the national level, Albright instituted a requirement that each park draw up a “Master Plan” to guide future development. Although these policies were put in place in response to rapid visitation increases, their primary purpose was to better manage growth, not to limit it.12

Wilderness and the politics of access

The unwillingness of the Park Service and other public land agencies to limit auto tourism in this period led some conservationists, including the founding members of the Wilderness Society, to form a new conception of wilderness as an area accessible only by non-mechanical means.13 Faced with the rising tide of auto tourists in Yosemite, some Sierra Club members began to rethink the club’s mission to “render accessible the mountain regions of California.” In 1930, veteran outing organizer Marion Randall Parsons proposed a new approach: “Our problem is no longer how to make the mountains better traveled and better known,” she wrote. “Rather it would seem, how from the standpoint of the mountain-lover ‘to render accessible’ may be more truly compatible with ‘to enjoy.’”14 It was no longer enough to bring people to the mountains. In Parsons’ view, the club also had a responsibility to encourage people to enjoy wilderness “appropriately”—specifically, by getting out of their cars and walking or by hiring a pack outfit to take them beyond the road head.

This redefining of the aims of wilderness preservation was put on hold as the nation's attentions shifted during World War II. After the war, the problem of defining appropriate use became acute. Population growth in western cities, better roads, and the proliferation of automobile ownership contributed to an unprecedented surge in national park tourism. Between 1944 and 1945, visits to the parks leapt from approximately 5 million to nearly 12 million per year before jumping to 25.5 million in 1947. By the mid-1950s, approximately 50 million people were visiting the parks each year, and the number kept growing.15 Roads, lodgings, campgrounds, ranger stations, and trails not upgraded since the New Deal proved inadequate to handle the barrage of tourists. In 1956, the Park Service responded with Mission 66, a program to revitalize the parks by the agency’s 50th anniversary in 1966. Director Conrad Wirth described the program as necessary to bring the parks “up to a consistently high standard of preservation, staffing and physical development.”16 However, as plans took shape for ambitious road expansion projects and huge, modern visitor centers, conservationists began to challenge the Park Service’s accommodating stance towards increasing tourism.

The Park Service’s decision to widen, pave, and reroute the Tioga Road in the Yosemite high country galvanized the growing anti-development contingent in the Sierra Club and set the tone for future debates over roads in national parks. The rationale for the project echoed the prewar aims of park planning: an improved road would accommodate more cars, but it would also make other development schemes unnecessary and would channel visitors along a single route, leaving the surrounding wilderness untouched.17

The proposal divided the Sierra Club. Traditionalists supported the plan but sought to minimize the road’s intrusiveness. A smaller but more vocal and generally younger group led by David Brower and Ansel Adams questioned whether the road should be improved at all.18 Their concerns were twofold: not only would the project damage some of the most scenic features of the high country (it would require blasting portions of the granite benches along the shore of Tenaya Lake), it would also grant easy access to “those who must have speed to be happy; those who are not sufficiently interested to invest the time and effort; those who require a house on wheels when they rough it; those who are timid, or incompetent, and realize it,” as club member Harold Bradley expressed in 1949. The presence of so many people unwilling “to pay the price in terms of effort and time,” Bradley and others felt, would destroy the qualities that defined the Yosemite high country as wilderness.19

Ultimately, the Tioga Road expansion carried too much momentum to be stopped by these objections. The availability of Mission 66 funds after 1956 all but ensured that the project would go forward. Rising affluence, population growth, and greater mobility continued to fuel massive increases in national park visitation. Public support for limiting auto access also continued to grow. By the mid-1960s, concerns over crowding in the national parks inter-mingled with other concerns about dam construction, nuclear weapons testing, chemical pesticides, air and water pollution, and the loss of open space to spark a broad-based political movement to protect environmental amenities. At the same time, the rising popularity and accessibility of hiking, backpacking, mountaineering, and other more vigorous forms of outdoor recreation contributed to a feeling among many park advocates that cars did not belong in wilderness.

The 1964 Wilderness Act inscribed this conception of wilderness into federal law. The act defined wilderness as “an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain.” It also specifically pro-
hindered permanent or temporary roads and any form of mechanical transport within designated wilderness areas. Though initially concerned about the act’s compliance requirements, the Park Service gradually incorporated these definitions into park planning. In 1968, North Cascades National Park in Washington State was created as a wilderness park entirely free of roads. However, the Park Service also recognized that most visitors might not be ready to give up their cars altogether. While no roads entered the park itself, North Cascades was established as part of a larger park complex. Roads and other accommodations were permitted in two adjacent National Recreation Areas.\textsuperscript{40}

The Wilderness Act also had no direct effect on existing developed areas within national parks. Edward Abbey, one of the more outspoken critics of the Park Service’s continuing emphasis on accessibility, saw cars and roads as exemplars of what he deemed “Industrial Tourism.” In his widely read 1968 polemic Desert Solitaire, he accused the Park Service of ignoring the protests of those visitors who were “determined to get outside of their motorcars for at least a few weeks each year” in favor of “that other crowd, the indolent millions born on wheels and buckled on gasoline, who expect and demand paved highways to lead them in comfort, ease and safety into every nook and corner of the national parks.”\textsuperscript{21} Abbey’s critique, and others like it, established a divide between a minority of park advocates who favored limiting visitor use for the sake of fulfilling the Park Service’s mandate to preserve nature “unimpaired,” and the majority of park goers who were presumably more accepting of (or even dependent upon) roads, modern campgrounds, and visitor services.\textsuperscript{25} This division underlay the political battles that erupted over transportation planning in Yosemite and other parks in the decades that followed.

\textbf{The era of public planning}

The challenges of managing visitor use in this period were especially daunting in Yosemite, where visitation numbers doubled from 1 million in 1954 to 2 million in 1967. By the late 1960s, the narrow confines of the Yosemite Valley “reflected more the noise and honky-tonk of an urban amusement park than the pristine beauty and wilderness of a national park,” as one historian has observed.\textsuperscript{23} Traffic jams, car accidents, gasoline odors, nighttime drag races, and the drone of motor home generators became unavoidable parts of the overall park experience. In 1970, Yosemite officials departed from their historically automobile-friendly orientation by closing the Mariposa Grove and the eastern third of the Yosemite Valley to private cars. From then on, these areas were served by clean propane-powered trams and shuttle buses. Beginning in 1971, the Park Service considered various proposals to exclude cars from the valley. These proposals encountered opposition not only from visitors reluctant to leave their cars behind but also from conservationists critical of plans to build large parking lots in ecologically sensitive areas outside the park. Members of the Sierra Club were especially distressed to learn that park officials were considering a gondola to run from the valley floor to Glacier Point.\textsuperscript{44}

Political disputes over transportation intensified in the years that followed. Yosemite’s struggles to gain approval for the 1974 and 1980 master plans, both of which called for limiting automobile access, reflected a new era in park planning in which new legislation enabled the public to play a more direct role in administrative decisions. Meeting the requirements of the NEPA became a central challenge. The act required all federal agencies to prepare and make available for public comment an environmental impact statement for any development project. By the early 1970s, the Park Service had also begun to place greater emphasis on ecological considerations in natural resource management. Addressing the problems resulting from high levels of visitor use within these new frameworks became a primary goal for the new general management plan.

In developing the plan, planners found themselves under attack from all sides. The Music Corporation of America (MCA), the parent company of Disney and the park’s concessionaire at the time, saw the proposed restrictions on cars as a threat to their bottom line. The company argued that if automobile traffic was to be limited, planners should consider “alternative travel options, such as the Aerial Tramway to Glacier Point and increased parking within the valley.” The Automobile Club also weighed in, urging the park to favor “those who prefer a more moderate stand, much along the lines existing today.” Fearing that park planners would bow to the demands of MCA and the automobile lobby, the Sierra Club called for even greater reductions on automobile use, including the removal of 1,200 daily-use parking spots in the valley. The club also supported providing bus service from “staging areas” outside the park, believing that Yosemite “could be a vanguard for alternative transportation systems.” Park officials attempted to steer a course between the two sides, assuring MCA that the valley would not be closed to auto traffic while also entertaining proposals for parking lots outside the park. Lacking confidence that these disputes could be resolved, the Department of Interior rejected the draft plan in December 1974, and the Park Service came out looking like “a weak sister, an outfit easy to manipulate,” as one critic put it.\textsuperscript{45}

Addressing the concerns of the various interest groups that prevented the approval of the 1974 plan became the primary consideration in developing a revised plan beginning in 1978. Park planners came up with an innovative scheme of using interactive graphic displays to allow the public to choose from a variety of alternatives. The thousands of public comments were directed towards a specific set of proposals, and the planning team revised the draft based on the results. This strategy became a model for involving the public in park planning systemwide. To meet the goals of allowing natural processes to prevail and reducing traffic and crowds, the final plan called for the removal of “all private vehicles from Yosemite Valley.” It also recommended expanding the shuttle bus system to provide service from parking areas at El Portal, Crane Flat, Wawona, and eventually from outlying areas and gateway communities.\textsuperscript{56}

While the park’s effort to incorporate public comment during the revision process was effective, implementation proved more complicated. Following the release of the final draft in 1980, concessionaires, local businesses, environmentalists, and recreational user groups continued to challenge aspects of the plan. The stricter legislative requirements also meant that the park would have to propose alternatives and conduct scientific studies to evaluate each component of the plan. These challenges were compounded by shrinking federal appropriations during Ronald Reagan’s presidential administration.\textsuperscript{57}

Some aspects of the plan were eventually carried out. In 1992, the five counties surrounding the park formed the Yosemite Area Rapid Transit System (YARTS). Budget issues and disagreements with some of the counties delayed the start, but in 2000, YARTS buses...
began transporting visitors from several staging areas located outside the park. The system received funding from a combination of user fees and federal and county subsidies and represented a crucial first step in a more extensive regional mass transit network. The rainstorm and flood that inundated the valley in January of 1997 provided another opportunity to break the political gridlock and address long-standing transportation and planning issues. An infusion of federal funds for flood repairs allowed the park to reduce the number of campstres, eliminate some infrastructure, improve the El Portal road to accommodate buses, and require reservations for overnight stays during the summer. The 1997 flood also provided the impetus for drafting the Yosemite Valley and Merced River plans.28

Despite this progress, the more substantive transportation goals outlined in the 1974 and 1980 plans remained unmet by the start of the 21st century. For instance, while the 1980 plan had called for the reduction of parking spaces in the valley from about 2,400 to 1,200, the amount had more than doubled to 5,000 by the late 1990s.29 In a speech in November 2000 announcing the release of the Yosemite Valley Plan, which reiterated many of the goals of the earlier plans, Secretary of the Interior Bruce Babbitt summed up the planning challenges of the past three decades, telling the crowd, “You are a cantankerous, irascible, quarrelsome and passionate people.” While the planners eventually “produced paper,” he said, they also developed “planning fatigue” as they struggled to navigate the complicated legislative terrain and scores of public meetings and comment sessions.30

Criticsisms persisted even after Babbitt’s announcement. Local communities remained concerned about the economic impacts of reduced visitation; representatives of Native tribes pressed for greater involvement in the planning process; and environmentalists continued to demand more attention to transportation alternatives. Just before his death on November 5, 2000, David Brower wrote an editorial charging the Park Service with “trying to do too much, too fast in Yosemite.” To him, the agency seemed “intent on converting this temple into a profit center, with pricey hotels, scant camping, few modest accommodations, wider roads to field bigger diesel busses, ecological roadside mayhem, atmospheric damage and requiring people who want to celebrate Yosemite Valley to park outside in the park in various still unspoiled places that are soon to be paved.”31 Underlying all of this, most park visitors, even those supportive of reducing car traffic, retained psychological attachments to the perceived freedom of encountering nature from their cars.32

Conclusion: Quantifying quality
Planning battles also extended into the courtroom. Between 2000 and 2008, the local environmental coalition filed three lawsuits alleging that the park’s proposed Merced River Plan (and its revisions) violated the Wild and Scenic Rivers Act (WSRA) by failing to establish limits on user capacity. In all three cases, the court agreed, ruling that the plan failed to “describe an actual level of visitor use” that would not degrade the river’s “outstandingly remarkable values” as defined under the WSRA.33

These rulings have forced the Park Service to once again rethink how it measures and evaluates the relationship between visitor use and resource quality. In the early years, agency leadership dealt with capacity issues by building roads and providing accommodations, the purpose being to satisfy public demand for car-based recreation while building support for preservation. As the pressures of increasing visitation mounted after World War II, the Park Service struggled to balance its traditional obligation to provide visitor services with new demands to limit development and restrict use. In the 1960s and 1970s, administrators adopted the concept of carrying capacity, which blended techniques from range science, ecology, and psychology to measure the impacts of backcountry recreation. The political and legal controversies of the past three decades have further elevated the importance of carrying capacity, creating a demand for more transparent, quantitative, and scientific methods of calculating user capacities for all of Yosemite’s natural and cultural landscapes.

The ITCA project, initiated in Yosemite in 2010, gives the Park Service a new tool for meeting this objective in Yosemite and elsewhere. Building on an understanding of the historical importance of transportation in Yosemite, the four preceding papers in this special issue suggest that the park’s transportation system forms the basis for how visitors engage with, perceive, and impact park landscapes and resources. By using computer simulations to integrate transportation data with visitor surveys, ITCA can help planners and managers better understand the relationship between how visitors get to and move through the park and how they perceive the quality of their experience. The resulting models quantify the quality of visitors’ experiences in terms of statistical data on pedestrian and vehicle traffic, allowing planners and administrators to propose clear, legally defensible capacity limits for different activities at multiple scales.

ITCA represents an innovative response to the complex politics of the era of public planning. By establishing a metric for measuring public perceptions of a quality experience and anticipating the impacts of different transportation options, it can provide a basis for a more proactive approach to park management. At the same time, the history of national park planning reveals that “quality” has always been a moving target. How visitors have valued their experiences in Yosemite and other parks has changed relative to broad changes in culture, politics, science, and technology. Perceptions of what constitutes a quality national park experience have also varied tremendously, especially since the 1960s when the parks became more accessible to a broader cross-section of the public. Any effort to quantify quality must contend with the possibility that measurements taken today might not apply tomorrow; and that they may not even be accepted by all (or even most) of the people with something at stake in how the parks are managed in the present.34

Endnotes
1. While Yosemite was predominantly an elite destination in its early years, as Anne Hyde points out, its proximity to urban San Francisco and Sacramento actually made it more accessible than other early parks such as Yellowstone and Glacier. Anne F. Hyde, “From Stagecoach to Packard Twin Six: Yosemite and the Changing Face of Tourism,” in Yosemite and Sequoia: A Century of California National Parks, edited by Richard J. Orsi, Alfred Runte, and Marlene Smith-Baranzini (Berkeley: University of California Press, 1993), 69.
2. Quoted in Stanford Demars, The Tourist in Yosemite, 1855–1985 (Salt Lake City: University of Utah Press, 1991), 45. Access was an administrative concern from the beginning. In 1865, famed landscape architect and chair of the Yosemite Park
Commission Frederick Law Olmsted recommended that the majority of the appropriations for the newly established reserve ($25,000 out of a total of $37,000) be dedicated to the construction of a road to the valley and the Mariposa Grove of giant Sequoias. Frederick Law Olmsted, *Yosemite and the Mariposa Grove: A Preliminary Report*, 1865. Online at www.yosemite.ca.us/library/olmsted/report.html.


8. Ibid., 334.


