Transportation, Recreation, and Capacities in Yosemite National Park

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Peak-season visitors to Yosemite Valley know first-hand 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

The George Wright Forum, vol. 29, no. 3, pp. 338–350 (2012).

ISSN 0732-4715. Please direct all permission requests to info@georgewright.org.

(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 (Haas 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;

- 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 is 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 are 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 (Reigner et al., this volume; White et al., this volume; Whittaker 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 Wagtendonk,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, encounter 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 (Whittaker 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–condition 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 from 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 indictors 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 viewshed (about 400 feet). In all cases, standards are "better" than current visitors say "they will accept" or "NPS 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 (R^2) 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.

across a full range of actions, as demanded in multi-dimensional planning efforts. Trade-offs can be best understood through multiple model iterations, with systematic variation of key infrastructure, use, and condition variables. In some cases, mitigation actions essentially solve a capacity-related impact (see Box 3); in others, they trade off different capacities and levels of infrastructure. Yosemite ITCA transportation analyses, for example, showed how "fixing" parking or intersection congestion alone was destined to fail. More parking without intersection improvement, or redesigned intersections without commensurate parking, were both recipes for exponentially increasing traffic queues and travel times.

Focus on "limiting factor" indicators. Capacity experts have long-recognized that not all impacts are related to use in 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 5,550 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, intersection 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 sub-surface 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 or 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 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, the 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, uses, 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; Chase et al. 2012; Whittaker and Shelby 2012). As applied in the MRP 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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