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From a drone's eye view: indicators of overtourism in a sea, sun, and sand destination

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ABSTRACT

This article examines overtourism indicators at Kailua Beach Park in Hawai'i, and demonstrates a systematic approach to assessing carrying capacity by pairing descriptive indicators with more commonly used evaluative indicators. Data were obtained from an onsite survey of 452 visitors. Questionnaires with embedded photographs measured visitors' perceived encounters, norms, and crowding (evaluative indicators), while an unmanned aerial vehicle (UAV) was used to collect actual use levels at the site (descriptive indicator). In total, 63% of respondents felt crowded at this site, suggesting that it is nearing over-capacity. Respondent norms showed that no more than approximately 950 people should be allowed. Use levels exceeding 700 people caused respondents to feel moderately or extremely crowded, yet use levels commonly exceeded this threshold. Standards representing these numeric thresholds should be set at this site, and management action is critical (e.g., quotas, reservations, fees, encourage alternative sites). This research contributes to the literature by demonstrating the importance of all four indicators (use levels, encounters, norms, crowding) when investigating overtourism issues, and the potential of UAVs to support the measurement of descriptive indicators.

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Introduction

Translating sustainable tourism theory and concepts into practice presents many implementation challenges (McCool et al., 2013), and various tools have been developed for managing sustainability at the business and destination levels (Lesar et al., 2020a, 2020b). Sustainability indicators represent a critical part of this toolkit for destination management, as these measurable and manageable parameters can be used for defining quality tourism experiences and settings (Manning, 2011). Numerous indicators for sustainable tourism exist (World Tourism Organization, 2005) and developing indicators that distinguish "how much impact is acceptable or should be allowed" is of paramount importance for destinations struggling to manage impacts stemming from excessive visitation (Manning, 2011; Weaver, 2008). Excessive visitation in tourism settings has given rise to the phenomenon of "overtourism" (Dodds & Butler, 2019) which is characterized by a spatial and/or temporal surge in visitation that exceeds a destination's carrying capacity and creates unacceptable impacts (Cheer et al., 2019).

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Overtourism affects some sea, sun, and sand destinations, including Hawai'i in the United States, that has regularly set new records for arrivals over the past decade. An estimated 10 million tourists, both domestic and international, visited Hawai'i in 2019 and these visitors spent close to $17 billion USD (Hawai'i Tourism Authority (HTA), 2020). Both arrivals and spending have increased approximately 25% since 2007 (DBEDT, 2019). A majority of visitors engage in coastal recreation activities, such as swimming and sunbathing, in Hawai'i (Needham, 2013), and local beaches are an important resource for both visitors and local residents who take part in a wide range of activities in these settings. Concerns about "too many tourists" have become common in Hawai'i's media (Nguyen, 2020) and excessive use of this state's popular coastal sites can degrade experiences for locals and visitors.

In response to overtourism and sustainability concerns, managers of sea, sun, and sand destinations, such as Hawai'i, can draw on the rich heritage of recreation carrying capacity scholarship that has been conducted in a diverse range of environments (Manning, 2007, 2011; Needham et al., 2016; Shelby & Heberlein, 1986). Recreation carrying capacity has commonly been defined as use beyond which impacts exceed acceptable levels as specified by evaluative standards (Shelby & Heberlein, 1984). The integration of this scholarship from the outdoor recreation literature into the tourism field has been slow and incomplete, and fundamental elements have often been applied without a full appreciation of the theory, concepts, methods, and applications that have been tested and refined (Butler, 2019; Wall, 2020).

The foundation for most recreation carrying capacity research is the conceptual framework developed by Shelby and Heberlein (1984). Key to this framework is the relationship between evaluative and descriptive indicators. *Descriptive indicators* define the directly observable and objective elements of a tourism or recreation system such as actual use levels, whereas *evaluative indicators* include subjective evaluations of visitors such as their perceived encounters, norms, and crowding. These evaluative indicators have been a focus of considerable research and testing (Manning, 2007, 2011; Needham et al., 2016), but integrating these with descriptive indicators has received less attention given the challenges associated with tracking and counting individuals over space and time (Ancin-Murguzur et al., 2019; D'Antonio et al., 2010).

This article examines the ability of unmanned aerial vehicles (UAVs), also known as drones, to support the measurement of descriptive carrying capacity indicators in a destination subject to overtourism. Its purpose is to demonstrate a systematic approach to assessing carrying capacity in a sea, sun, and sand destination by integrating descriptive data collected by UAV technology with more traditional approaches that measure evaluative indicators. By using both descriptive and evaluative indicators, this study contributes to the tourism literature by more fully operationalizing Shelby and Heberlein (1984) framework. The study area for this research was Kailua Beach Park, a popular sea, sun, and sand tourism destination in Hawai'i that has been the focus of local concerns about overtourism stemming from growing visitation (Cave, 2017). UAV technology was used to measure descriptive use level indicators at this destination, and relationships between use levels and evaluative indicators associated with overtourism (encounters, norms, crowding) are examined. Although tourism has declined in 2020 due to the COVID-19 pandemic, this pause provides an opportunity to identify and address overtourism and sustainability concerns proactively.

Conceptual background

Descriptive indicators

The descriptive component of recreation carrying capacity focuses on objective parameters with various impacts produced by different management alternatives. This includes observable behavior, quantifiable consequences of behavior, management parameters, impact parameters, and relationships among these factors (Shelby & Heberlein, 1986). Individuals are not static when engaging in tourism or recreation. They participate in different activities and behave in different ways at various places and times, and this activity is described as *use level*. Fundamental to understanding use levels in a tourism context is an appreciation of relationships among the numbers of visitors, their access and egress points, and the spatial characteristics of their visit (English & Bowker, 2018). Use levels that are being controlled represent a management parameter, but this is not the case when access to a site is unrestricted. Information about use levels in unrestricted access situations can still be valuable for understanding demand trends or providing an early warning of emerging social or environmental impacts (Wilmot & McIntosh, 2014). In addition to controlling use levels through strategies such as quota systems, other management parameters can also influence the type of use. Scheduling, zoning, or informing visitors can limit or reduce impacts from overuse (Manning, 2011). Levels and patterns of use represent important descriptive inputs to the carry capacity model, and it is assumed that a relationship between use and impact exists unless other management parameters alter the relationship or significant changes to management objectives occur (Manning, 2011; Shelby & Heberlein, 1986).

Evaluative indicators

Tourism and recreation managers are not simply interested in objective use levels; they are also interested in visitor evaluations of conditions because negative conditions can impact visitor experiences. Evaluative indicators related to use levels include encounters, crowding, and norms (Manning, 2007, 2011; Needham et al., 2016). *Reported encounters* are subjective evaluations of the number of people that an individual remembers seeing during a recreation experience (Vaske & Donnelly, 2002). Reported encounters and use levels are rarely identical, as encounters are based on a visitor's subjective estimate of the number of other people seen in an environment, whereas use levels represent objective counts. *Perceived crowding* is a subjective measure defined as a negative evaluation that the number of encounters is excessive (Manning, 2011; Vaske & Shelby, 2008). Studies have examined encounters and crowding in tourism and recreation (Manning, 2007, 2011; Needham et al., 2016; Shelby et al., 1989; Vaske & Donnelly, 2002; Vaske & Shelby, 2008) with some in sea, sun, and sand destinations (Bell et al., 2011; Lankford et al., 2008; Shafer & Inglis, 2000; Szuster et al., 2011).

Understanding reported encounters and perceptions of crowding may not, however, reveal maximum acceptable or tolerable levels of use, or reveal how use should be monitored and managed (Needham et al., 2004). The concept of norms provides a theoretical and applied basis for addressing these issues (Vaske & Whittaker, 2004). *Norms* represent subjective standards used by individuals to assess whether activities, environments, or conditions are good or bad, better or worse (Shelby et al., 1996). Norms clarify what people believe should or should not be allowed, and they are typically used for identifying the number of individuals that people will accept or not accept in tourism or recreation settings (Manning, 2007, 2011).

Research has shown that when encounters exceed an individual's norm for seeing other people, perceived crowding is often higher compared to those who encounter fewer people than their norm. A comparative analysis of 13 studies involving more than 10,000 tourists and recreationists, for example, demonstrated that people reporting fewer encounters than their norm did not feel crowded, whereas individuals encountering more than their norm felt slightly to moderately crowded (Vaske & Donnelly, 2002). This pattern was consistently present and statistically significant, which suggests that encounters, norms, and crowding are linked. This finding has also been replicated in more recent studies (Bell et al., 2011; Needham et al., 2018) and illustrates the concept of *norm congruence* where respondents judge conditions as less acceptable when they experience conditions violating their norms (Manning et al., 1996).

Most normative studies in recreation and tourism are based on Jackson's (1965) model that measures norms on impact acceptability or social norm curves (Manning et al., 1999; Shelby et al., 1996). These curves represent the amount of indicator change increasing from left to right along the horizontal axis. The vertical axis depicts evaluative responses with the most positive evaluation at the top of the axis, most negative on the bottom, and a neutral category in between. There are a number of characteristics of these curves (Manning, 2011; Needham et al., 2016; Shelby et al., 1996). The *minimum acceptable condition* is the point where a majority of respondents perceive that conditions are no longer acceptable or impacts should not be allowed. This point is often considered the standard or threshold for the indicator being measured. *Norm intensity* measures the salience of the indicator to respondents, and is usually the distance from the neutral line at each point on the curve independent of the number and direction of respondent evaluations. One measure of intensity involves summing these distances across all points on the curve. The greater the cumulative distance from the neutral line, the higher the norm intensity and more important the indicator is to respondents. Conversely, a flat curve close to the neutral line suggests that the indicator is of little importance and few people will be upset if the indicator conditions deteriorate. *Norm crystallization* measures normative consensus or agreement among respondents regarding acceptable and unacceptable conditions. One approach for measuring crystallization is to average the standard deviations for points comprising the curve.

Evaluative indicators such as encounters, crowding, and norms are central to planning and management frameworks such as the Limits of Acceptable Change (LAC), Visitor Experience and Resource Protection (VERP), Tourism Optimization Management Model (TOMM), and Visitor Use Management Framework (Interagency Visitor Use Management Council (IVUMC), 2016; Manning, 2004). In these frameworks, the traditional carrying capacity question of "how much use or impact is too much" is redefined as "how much use or impact is acceptable or should be allowed" (Manning, 2007, 2011). This focuses management attention on desirable conditions rather than just the amount of use and its impact.

Use levels, encounters, and technology

Both descriptive and evaluative indicators are required to fully operationalize carrying capacity models and management frameworks in tourism and recreation. Numerous studies have refined techniques for measuring evaluative indicators (Manning, 2011; Needham et al., 2016), but far less research has focused on improving measures of descriptive indicators such as use levels. Until recently, studies on use levels have employed techniques such as trailhead registrations or self-counting methods (Jones et al., 2018) or simple automated technologies such as trail or vehicle counters (Hollenhorst et al., 1992). These techniques possess well-known limitations (e.g., effort, expense, inaccuracy) and managers are often forced to adopt ad hoc field approaches or convenience samples to collect descriptive data (Monz et al., 2019).

A variety of newer technologies have emerged to address these limitations, including video (Balouin et al., 2014; Smallwood et al., 2011), mobile device data (D'Antonio et al., 2010; Monz et al., 2019), and simulation models supported by remote sensing imagery (Huamantinco et al., 2016). These approaches can improve the collection of use level data in many environments, but a continuing problem exists in areas such as beaches that possess porous boundaries or unspecified access points (Ziesler & Pettebone, 2018). UAV technology can potentially overcome this issue because it is now affordable, easy to operate, and can obtain imagery within a short period of time (Ancin-Murguzur et al., 2019; Provost et al., 2019).

This article addresses four research questions:

Research Question 1: What are the use levels at Kailua Beach Park as measured by UAV technology?

Research Question 2: What are the reported encounters, perceptions of crowding, and normative evaluations of use (minimum acceptable condition, crystallization, intensity) among visitors at this site?

Research Question 3: How do the use levels compare to these evaluations of encounters and crowding?

Research Question 4: What proportion of visitors experience use levels and report encounters that are greater than their norm, and to what extent do these visitors feel more crowded than those experiencing use levels and reporting encounters less than their norm?

Methods

Data collection

Kailua Beach Park is located on the eastern (windward) coast of the island of Oahu in Hawaiʻi. This park has long been recognized as a premier sea, sun, and sand destination possessing sandy beaches, protected turquoise waters, and abundant outdoor recreation opportunities (CNN, 2019). Local concerns over crowding have emerged as more people visit the area as an alternative to other established coastal recreation sites on the island, such as Waikiki Beach and Haunama Bay (Cave, 2019). Activities in the area include sunbathing, swimming, kayaking, kitesurfing, windsurfing, and outrigger canoeing. These activities typically occur between 8:00 AM and 6:00 PM daily, with most people visiting between 10:00 AM and 4:00 PM. Peak visitation periods in Hawaiʻi are June to August and December to January, but weather conditions in Hawaiʻi are consistent throughout the year, and visitation levels are stable without any month(s) forming a pronounced low season (HTA, 2020).

Data from visitors at Kailua Beach Park were collected during July and August 2019 via questionnaires administered face-to-face during their visit (i.e., not during exit or entry to the beach park). Trained research assistants administered questionnaires on each day of the week spread over the study period, and within three time periods during each of the seven days of data collection (8:30 to 11:00 AM, 12:00 to 2:30 PM, 3:00 to 5:30 PM). People were selected through a systematic sampling procedure to reduce selection bias with one random individual selected from every 5th group (Vaske, 2019). Incentives and other recruitment tools were not used, and a total of 452 visitors to this beach park completed questionnaires with 69 rejections for an overall response rate of 87%. This response rate is consistent with an earlier study at this beach park (Needham, 2013) and other tourism and recreation research of this type involving face-to-face data collection (Vaske, 2019). This sample size allows generalizations about the overall population of visitors to Kailua Beach Park during this time at the 95% confidence level with a ± 4.61% margin of error (Vaske, 2019).

Descriptive indicators

Use levels were measured using a UAV to collect imagery along the 1 km (0.6 mi) transect matching the coastal boundaries of Kailua Beach Park. Oblique photographs were taken by a licensed pilot flying a DJI Mavic Pro UAV over water to avoid flying directly above people. This drone flew at approximately 22 meters above sea level (approximately 72 feet) with the camera slightly tilted to mainly observe the beach and nearshore waters. Flights were performed at three different times (approximately 9:00 AM, 12:00 PM, 3:00 PM) each day during the study period, and a total of 16 photographs were taken each flight to cover both the beach and nearshore waters. A total of 336 photographs were obtained and all individuals shown on the images were manually labeled with bounding boxes (Figure 1). No privacy issues were created during the collection or analysis of this drone imagery, as image resolution and flight elevation made it impossible to identify individuals.

Evaluative indicators

Image capture technology (i.e., manipulated photographs embedded in questionnaires) was used to measure *reported encounters* in a manner identical to an earlier study at Kailua Beach Park (Needham, 2013) and studies in other areas (Bell et al., 2011; Manning & Freimund, 2004; Needham et al., 2004; Szuster et al., 2011). Visual methods are considered to be more realistic than written approaches because photographs

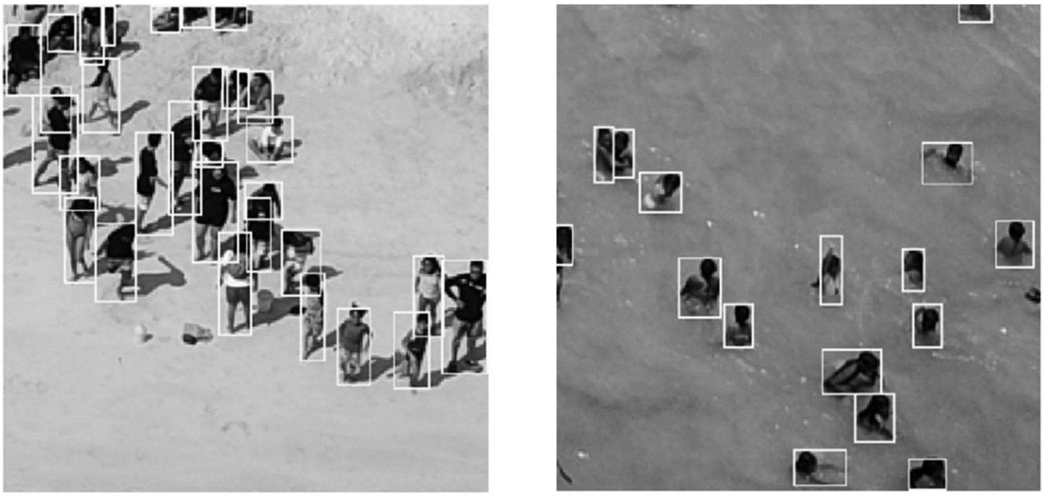

Figure 1. Examples of magnified drone images on land and water at Kailua Beach Park.

allow respondents to see and consider various site conditions. There are, however, some disadvantages of this approach, including respondent burden and the imposition of static site conditions (Manning, 2007, 2011).

Six photographs (Figure 2) were created depicting a 500 × 200 yard (approximately 457 × 183 meter) area where the width was equally divided between land (100 yards) and water (100 yards). The length of both land and water areas was the same (500 yards). The number of people doubled across each image (0, 50, 100, 200, 400, 800 people) with 70% on land and 30% in the nearshore waters to reflect conditions on most days. The photograph of 800 people was created first and people were then randomly removed to create other images depicting lower use densities. Individuals were randomly positioned with variables such as age, gender, and foreground/background density relatively balanced.

Consistent with previous research (Manning, 2007, 2011; Needham et al., 2004), respondents were told to ignore the generic background, focus on the use density in each image, and assume it was occurring at Kailua Beach Park. To measure reported encounters, respondents were asked to select one of the six photographs that most accurately represented conditions they encountered during their visit to Kailua Beach Park on the day they were surveyed. This approach for measuring reported encounters is identical to other studies examining this concept (Bell et al., 2011; Needham et al., 2004; Vaske & Donnelly, 2002). Total encounters at the site were estimated by: (a) dividing the site's actual area by the corresponding area in the photographs to create a conversion factor, and then (b) multiplying this conversion factor by the number of people in each photograph. This produced conversion ratios of 3.335 for the land area and 0.575 for the nearshore waters (Table 1).

For example, Photograph E contained 400 people, with 280 on the beach (land area) and 120 in the nearshore water. The conversion factor was derived by dividing the actual land area (1150 × 145 yards [1051.6 × 132.6 meters]) and nearshore waters of the site (1150 × 25 yards [1051.6 × 22.9 meters]) by the area shown in the photographs (each 500 × 100 yards [457.2 × 91.4 meters]). If a respondent indicated that Photograph E represented their level of encounters experienced at Kailua Beach Park on the day they were surveyed, this would convert to approximately 1003 people at the site. Estimated site encounters associated with each of the six photographs are in Table 2.

To measure *norms*, respondents rated conditions in each of the six photographs on 9-point recoded scales of −4 "definitely should not be allowed" to +4 "definitely should be allowed" with interior labels of "maybe should not be allowed" and "maybe should be allowed." These labels are more consistent with conventional definitions of norms than other scale labels commonly used for measuring the concept (e.g., acceptance, preference) as they reinforce the sense of obligation

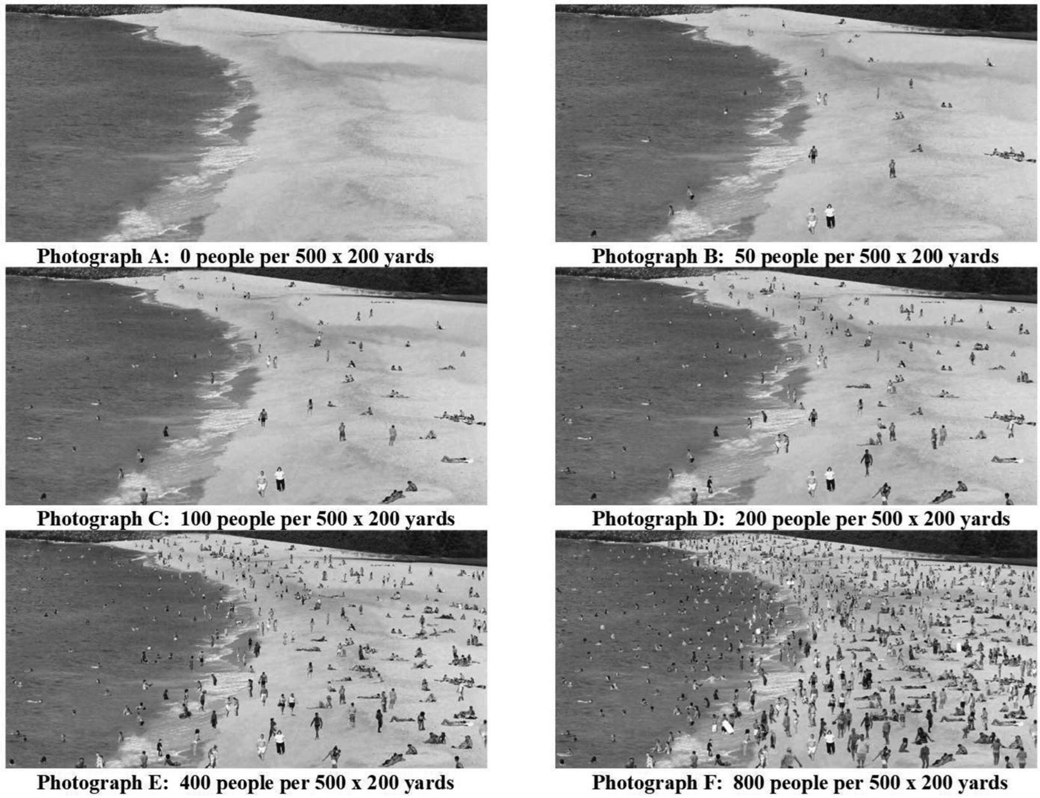

Figure 2. Photographs for measuring encounters and norms (Needham, 2013).

Table 1. Example formula for estimating number of people at site based on the photographs.

	Actual Site Area (yards)		Photograph Area (yards)		Conversion Ratio		People in Photograph		People at Site
Land and beach area	1150 × 145	÷	500 × 100	=	3.335	x	280	=	934
Nearshore waters	1150 × 25	÷	500 × 100	=	0.575	x	120	=	69
							Total = 400		Total = 1003

associated with norms and eliminate temporal aspects inferred in other scales using similar labels (Heywood & Murdock, 2002). Nine-point scales such as this are common for measuring norms in recreation (Manning, 2007, 2011), and both validity and reliability tests comparing these labels to the more commonly used labels for measuring norms ("very unacceptable" to "very acceptable") showed minimal differences and generated similar evaluations (Ceurvorst & Needham, 2012).

Perceived crowding was measured by asking respondents how crowded they felt by the total number of people at Kailua Beach Park on the day they were surveyed. Responses were recorded on the commonly used 9-point perceived crowding scale of 1 "not at all crowded" to 9 "extremely crowded." This scale has been extensively used and rigorously tested for both validity and reliability (Shelby et al., 1989; Vaske & Donnelly, 2002; Vaske & Shelby, 2008).

Results

Respondent profile

The average age of respondents was 39.6 years old with the 18-29 year old cohort making up the largest group of respondents (29%). Children and minors under the age of 18 often

Table 2. Estimated number of people at site based on the photographs.

Photograph A	0 people in photograph	=	0 people at site
Photograph B	50 people in photograph	=	125 people at site
Photograph C	100 people in photograph	=	251 people at site
Photograph D	200 people in photograph	=	501 people at site
Photograph E	400 people in photograph	=	1003 people at site
Photograph F	800 people in photograph	=	2006 people at site

accompany adults on trips to Kailua Beach Park, but no one under the age of 18 was surveyed because of human subjects research compliance protocols. First time visitors made up only 28% of the sample, as return trips to Kailua Beach Park are common, particularly for local residents. More than 47% of respondents had visited Kailua Beach Park more than 10 times with 31% visiting more than 50 times. Most respondents lived in the U.S. (88%) with the largest percentages from Hawaiʻi (47%) or the U.S. mainland (40%). International visitors from Asia, Canada, Australia, and Europe made up 12% of respondents. Residents of Kailua comprised 18% of the sample. Most respondents participated in a range of activities at Kailua Beach Park, but the most popular primary activities were sunbathing (46%) and swimming (40%).

Use levels

The daily pattern of site use at Kailua Beach Park is quite predictable with visits building from nearly zero before sunrise, and slowly increasing through the morning until peak use is attained mid-day and in the afternoon (Table 3). Site use remains high and relatively consistent in the early to mid-afternoon before falling in the late afternoon and dropping back to nearly zero after sunset. Site use ranged from a low of 123 individuals on a Sunday morning to 1039 on a Tuesday afternoon. Site use at Kailua Beach Park can be higher during weekdays because local residents often visit more distant sites on weekends. Average morning site use was consistently lower ($M = 219$ people, $SD = 79$) than both noon ($M = 715$, $SD = 60$) and the afternoon ($M = 784$, $SD = 141$), which both averaged more than 700 people.

Comparing this objective site use to the times when respondents were surveyed defines the level of site use experienced by these visitors to Kailua Beach Park (Table 4). The majority of respondents (65%) were surveyed when site use was between 600 and 799 individuals. Site use was below 600 individuals for 20% of the sample and 800 or more individuals for only 15% of the sample. Average site use when respondents were surveyed was 638 individuals ($SD = 232$).

Reported encounters

Respondents were asked to select the photograph (Figure 2) that most accurately depicted what they encountered on the day they were surveyed at Kailua Beach Park. The largest percentage of respondents (46%) selected the photograph depicting 200 people per 500 × 200 yards (501 people total at site; Table 5). Photographs containing 100 people (251 people total at site) and 400 people (1003 people total at site) were selected by 22% and 25% of respondents, respectively. The other encounter levels were selected by only 1-6% of respondents. The average number of encounters reported by respondents was 221 individuals (553 total at site, $SD = 309$). Although these reported encounters were slightly more varied and had a lower mean than the objective use levels discussed in the previous section, it is notable that the upper boundary of one standard deviation was almost identical for both measures (use level: $638 + 232 = 870$ people, encounters: $553 + 309 = 862$ people).

Table 3. Use levels at Kailua Beach Park determined by drone imagery.[a]

	Morning	Noon	Afternoon
Monday	279	768	873
Tuesday	302	774	1039
Wednesday	196	719	826
Thursday	317	665	760
Friday	179	779	689
Saturday	140	647	660
Sunday	123	654	644
Mean	219	715	784
Standard deviation	79	60	141

[a]Cell entries are total numbers of people at Kailua Beach Park.

Table 4. Use levels (from drone imagery) experienced by respondents at Kailua Beach Park.

Use levels (from drone imagery) experienced by respondents when surveyed[a]	Percent[b]
Fewer than 200 people at site	11
200 – 599 people at site	9
600 – 699 people at site	38
700 – 799 people at site	27
800 – 999 people at site	10
1000 or more people at site	5
Mean	638 total at site
Standard deviation	232 total at site

[a]Drone image counts of site use within 30 minutes (morning) or 60 minutes (noon and afternoon) of the time respondents were surveyed.
[b]Cell entries are rounded percentages (unless a mean or standard deviation) of respondents who experienced a use level within 30 minutes (morning) or 60 minutes (noon and afternoon) of the time they were surveyed.

Table 5. Encounters reported by respondents at Kailua Beach Park.

Encounters[a]	Percent[b]
0 people / 500 × 200 yards (0 people total at site)	1
50 people / 500 × 200 yards (125 people total at site)	6
100 people / 500 × 200 yards (251 people total at site)	22
200 people / 500 × 200 yards (501 people total at site)	46
400 people / 500 × 200 yards (1003 people total at site)	25
800 people / 500 × 200 yards (2006 people total at site)	1
Mean	221 (553 total at site)
Standard deviation	123 (309 total at site)

[a]Respondents were asked which photograph most accurately represented what they saw most often on the day they were surveyed.
[b]Cell entries are rounded percentages unless specified as means or standard deviations.

Perceived crowding

Respondents were asked how crowded they felt by the number of people at Kailua Beach Park on the day they were surveyed. On average, respondents felt slightly crowded ($M = 3.74$ on 9-point scale, $SD = 2.38$) and 63% felt crowded to some degree (3-9 on scale; Table 6). More than one-third (38%) of respondents felt moderately or extremely crowded (5-9 on scale).

Norms

The norm curve is shown in Figure 3. Most respondents believed that 0, 50, 100, and 200 people per 500 × 200 yards (0-501 people total at site) should be allowed at Kailua Beach Park, and that 400 and 800 people per 500 × 200 yards (1003-2006 total at site) should not be allowed. The photograph containing 50 people per 500 × 200 yards (125 total at site) was slightly more positively evaluated than the image containing no people. The minimum acceptable condition was

Table 6. Perceived crowding reported by respondents at Kailua Beach Park.

Crowding[a]	Percent[b]
1 Not at all crowded	24
2 Not at all crowded	14
3 Slightly crowded	16
4 Slightly crowded	9
5 Moderately crowded	14
6 Moderately crowded	9
7 Moderately crowded	7
8 Extremely crowded	4
9 Extremely crowded	4
Mean (on 1 – 9 scale)	3.74
Standard deviation (on 1 – 9 scale)	2.38

[a]Respondents were asked to what extent they felt crowded by the total number of people on the day they were surveyed, measured on a 9-point scale of 1 "not at all crowded" to 9 "extremely crowded".
[b]Cell entries are rounded percentages unless specified as means or standard deviations.

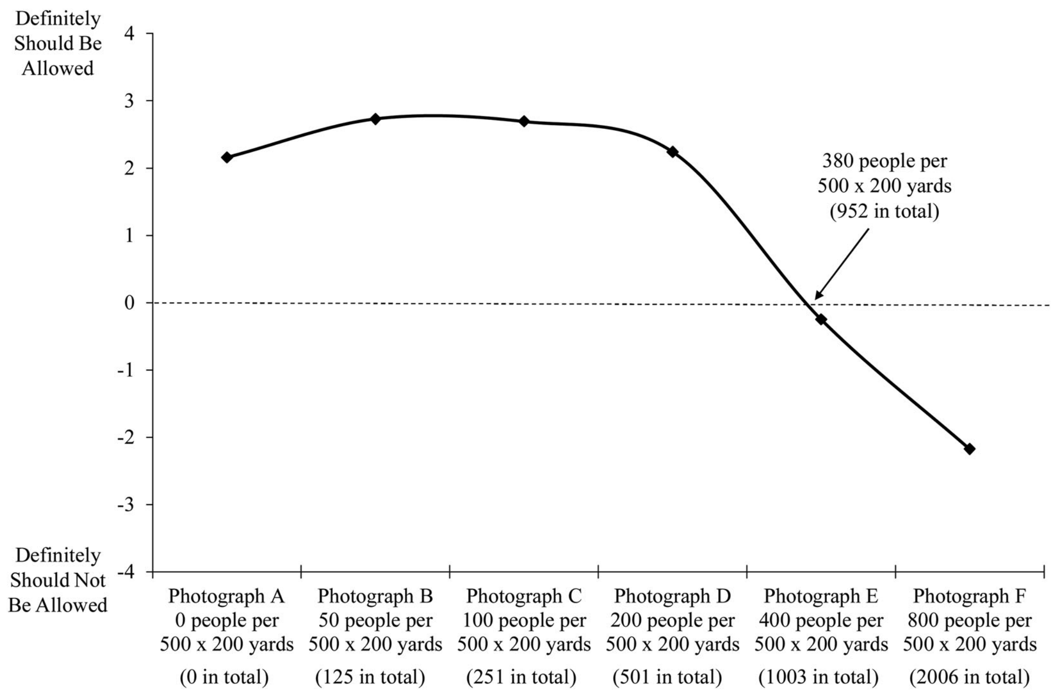

Figure 3. Social norm curve for Kailua Beach Park.

379.87 people per 500 × 200 yards (952.47 people total at site). Norm crystallization (i.e., average of standard deviations of all points on the curve) was 2.41, suggesting moderate consensus among respondents (Krymkowski et al., 2009). Norm intensity (i.e., total distances from neutral line across all points on the curve independent of the direction of evaluation) was 12.25 (maximum = 24), suggesting that respondents believed this is a relatively important indicator at this site (Needham et al., 2004).

Relationships among use levels, encounters, norms, and crowding

Relationships among descriptive (use levels) and evaluative (encounters, norms, crowding) indicators can clarify potential carrying capacity issues, and in particular, it is essential to understand if visitors are experiencing conditions where more people are present than they feel is appropriate.

Table 7. Pearson bivariate correlations among use, encounters, crowding, and norms.

	Use Levels	Reported Encounters	Perceived Crowding	Norms[a]
Use Levels	1.00	.52***	.26***	.02
Reported Encounters		1.00	.31***	.11
Perceived Crowding			1.00	−.16**
Norms[a]				1.00

**$p = .006$, ***$p < .001$.
[a]Represented by minimum acceptable conditions (point where norm curves crossed neutral "0" line).

Table 8. Relationships among encounters, crowding, and norms at Kailua Beach Park.

	Percent	Perceived Crowding[a]	*t*-value	*p*-value	r_{pb}
Reported encounters compared to norm			3.74	< .001	.20
Encountered less than norm	75	3.47 (2.24)			
Encountered more than norm	25	4.57 (2.57)			
Use levels compared to norm			3.64	< .001	.18
Use level less than norm	70	3.45 (2.31)			
Use level more than norm	30	4.41 (2.43)			

[a]cell entries are mean perceived crowding scores on 9-point scale of 1 "not at all crowded" to 9 "extremely crowded" (with standard deviations in parentheses).

Table 9. Use levels and encounters for each level of crowding at Kailua Beach Park.

	Reported Encounters[a]		Actual Use[b]
Crowding	People / 500 × 200 Yards (photographs)	Total People at Site (photo conversion)	Total People at Site (drone)
1 Not at all crowded	187 (134)	470 (336)	570 (258)
2 Not at all crowded	195 (123)	489 (307)	568 (274)
3 Slightly crowded	200 (110)	501 (275)	630 (241)
4 Slightly crowded	207 (109)	519 (272)	646 (243)
5 Moderately crowded	213 (97)	533 (244)	684 (161)
6 Moderately crowded	256 (119)	642 (298)	708 (147)
7 Moderately crowded	319 (100)	798 (251)	745 (180)
8 Extremely crowded	300 (121)	752 (304)	733 (147)
9 Extremely crowded	306 (112)	768 (282)	707 (173)

[a]cell entries are means (standard deviations in parentheses) $F = 6.28$, $p < .001$, eta (η) = .35.
[b]cell entries are means (standard deviations in parentheses) $F = 3.64$, $p < .001$, eta (η) = .27.

Use levels and reported encounters were significantly and strongly positively correlated ($r = .52$, $p < .001$, Table 7). Significant and small to moderate positive correlations were also found between crowding and both use levels ($r = .26$, $p < .001$) and encounters ($r = .31$, $p < .001$). Relationships between norms and the other indicators were insignificant or weakly negative ($r = -.16$, $p = .006$ between norms and crowding).

In total, 25% of respondents reported encountering more people at Kailua Beach Park than their norm for this site, and 75% encountered fewer than their norm (Table 8). Consistent with the concept of norm congruence, perceived crowding was higher for respondents encountering more than their norm ($M = 4.57$ on 9-point scale [moderately crowded], $SD = 2.57$) than for those who encountered fewer than their norm ($M = 3.47$ [slightly crowded], $SD = 2.24$). This difference was significant ($t = 3.74$, $p < .001$) and the point-biserial correlation (r_{pb}) effect size of .20 characterizes the strength of this relationship as "small" to "medium" (Cohen, 1988) or "minimal" to "typical" (Vaske, 2019).

In addition, 30% of respondents experienced actual use levels at Kailua Beach Park that were higher than their norm for this site, whereas 70% experienced use levels lower than their norm (Table 8). Perceived crowding was, on average, higher for respondents experiencing use levels greater than their norm ($M = 4.41$ on 9-point scale [moderately crowded], $SD = 2.43$) compared to those experiencing use levels below their norm ($M = 3.45$ [slightly crowded], $SD = 2.31$). This difference was significant ($t = 3.64$, $p < .001$) with an effect size of $r_{pb} = .18$ ("small" to medium" [Cohen, 1988] or "minimal to typical" [Vaske, 2019]).

Reported encounters and actual use levels were then compared to the level of crowding perceived by respondents at Kailua Beach Park. Both the number of encounters (determined by the photographs) and actual use levels (determined by the drone) increased in tandem with higher crowding scores (Table 9). Relationships between crowding levels and both reported encounters and actual use were significant ($p < .001$) and the eta (η) effect sizes (.27, .35) suggest that the strength of these relationships can be characterized as between "medium" and "large" (Cohen, 1988) or "typical" and "substantial" (Vaske, 2019). There were natural breaks at the lower and upper ends of the crowding scale. On average, respondents did not perceive any crowding (1-2 on scale) when they reported encounters with fewer than 500 people in total at the site (photographs) or actually experienced use levels below 600 people (drone). In contrast, they perceived moderate to extreme crowding when encounters exceeded approximately 600 people or there were more than approximately 700 people actually at this site.

Discussion

Research implications

These results have implications for both research and management. From a research perspective, numerous conceptualizations of overtourism exist, but most acknowledge carrying capacity as a foundational concept (Dodds & Butler, 2019). It is logical, therefore, that both descriptive and evaluative indicators of carrying capacity be used to systematically investigate overtourism and generate a pathway toward the improved management of destinations such as Kailua Beach Park (Butler, 2019; Wall, 2020). Most recent studies emphasized evaluative indicators with few integrating descriptive information (Manning, 2007, 2011; Needham et al., 2016), but this study achieves richer insights by applying both measures. Of course, these social indicators represent just one dimension of carrying capacity, and ecological and managerial dimensions also need to be examined at destinations to provide a comprehensive approach (Manning, 2011; Riungu et al., 2018; Shelby & Heberlein, 1986).

The use of UAV technology in this study has addressed certain limitations (e.g., effort, expense, inaccuracy, difficulties in areas with porous boundaries or unspecified access points) associated with conventional methods of collecting use level data such as trail counters or GPS trackers. UAV technology is no longer limited to specialists, as affordable hardware is now available to both researchers and managers (Turner et al., 2016). Compared to conventional methods, UAVs have cost, logistical, and safety benefits because modern commercial drones are affordable, easy to operate, and can acquire imagery within a short time period (Colomina & Molina, 2014; Mancini et al., 2013). The manual counting of people from drone footage is still a tedious and labor-intensive process that limits the full impact of this technology (Provost et al., 2019). If drone data can be supplemented with machine learning technologies, this approach has the potential to significantly improve the collection of descriptive data. Research on artificial intelligence methods called deep learning could also greatly simplify the analysis of UAV imagery (Ammour et al., 2017). Deep learning has demonstrated superior performance in object recognition (He et al., 2016) and its potential use in automating the analysis of site use data has great potential to support future carrying capacity studies (Ilyas et al., 2019).

Photographs embedded in the questionnaires were used for measuring evaluative indicators in this study in a manner similar to other research (Manning, 2007, 2011). Most respondents (72%) encountered more than 500 people at Kailua Beach Park during their visit and thought that approximately 950 people or more should not be allowed. Interestingly, the photograph containing 50 people per 500×200 yards (125 total at site) was more positively evaluated than the image containing no people. One potential explanation of this result may be that an absence of visitors could generate concerns over environmental conditions or public safety in this relatively urban beach park. Photographs depict static representations of indicator conditions, so videos or other multimedia accompanying questionnaires could potentially depict more realistic and dynamic conditions (Manning & Freimund, 2004).

Although 63% of respondents felt crowded at Kailua Beach Park, only 25% encountered more people than their norm and 30% experienced actual use levels that were higher than their norm for this site. This finding is consistent with previous studies, both at this site and elsewhere, suggesting that people may report feeling crowded even if their norms have not been exceeded (Needham, 2013; Vaske & Donnelly, 2002). People are not always evenly distributed across a site. They often gather in groups and this close proximity may cause people to feel crowded even though there are fewer people in total at the site than they would tolerate. For example, a person may be surrounded by three or four groups who make this individual feel crowded, but the total amount of use at the site may still be lower than their norm. More research is needed to determine if uneven distributions and proximities influence encounters and crowding (Bell et al., 2011; Manning, 2011).

People also frequently underestimate use levels and report fewer encounters because it can be difficult to see, count, and accurately report the total number of people at a site (Manning, 2011). Inaccurate estimates of use levels and encounters in crowded locations can also occur because manually counting large groups is difficult (Bell et al., 2011). This is one advantage of using photographs rather than asking respondents to report specific numbers (Manning & Freimund, 2004). For example, at a site where there are actually 250 people per 500×200 yards present, a person may report seeing 150 people per 500×200 yards and feel that no more than 200 people per 500×200 yards should be allowed. This person's norm (200) would not be surpassed by their reported encounters (150) and if this trend is consistent across visitors, managers might erroneously conclude that norms are not being violated by actual use levels and management is unnecessary, whereas the opposite is true.

Underestimation can also stem from photographs used for measuring encounters and norms. The images here showed 0, 50, 100, 200, 400, and 800 people per 500×200 yards to represent a realistic range of possible use densities, but gaps between these numbers may generate error in some responses. A visitor who encountered 350 people per 500×200 yards, for example, would be forced to choose between photographs showing 200 and 400 people, causing them to inaccurately report encounters. Given that these reported encounters were used for determining if norms were violated, some visitors may have been slightly misclassified. This limitation applies to all normative studies using image capture technology (Manning, 2007, 2011) and compromises are inevitable to limit respondent burden.

In this study, respondents encountered an average of 553 people at Kailua Beach Park during their visit, but drone imagery showed that actual use levels averaged 638 people. This is a difference of only 85 people along a beach that is approximately 1 km (0.6 mi) in length. In addition, the upper boundary of one standard deviation was almost identical for both reported encounters and actual use levels (use level: $638 + 232 = 870$ people, encounters: $553 + 309 = 862$ people). The similarity between these measures is likely due to the physical characteristics of Kailua Beach Park where the open bay and beach allow visitors to see almost all of the park and other visitors from most vantage points. UAVs may serve as a validity check on reported encounter data collected using image capture technology (and vice versa) in locations such as Kailua Beach Park where visitors can see almost the entire site. Use level indicators may also be appropriate for monitoring at this particular site given the similarities between encounters and use levels.

Identical to past studies and consistent with the concept of norm congruence, findings here showed that crowding was higher when encounters (from questionnaires) exceeded norms compared to when encounters were less than norms (Bell et al., 2011; Needham, 2013; Needham et al., 2014, 2018; Vaske & Donnelly, 2002). This article expanded this relationship by showing that crowding was also higher for respondents experiencing actual use levels (from drone imagery) greater than their norm compared to those experiencing use levels less than their norm. Results showing a strong positive correlation between use levels and reported encounters are also consistent with studies in other areas where visitors can easily see others (Manning, 2007, 2011). The positive correlations between crowding and both use levels and encounters are also consistent with some, but not all, studies because the nature of these relationships often depends on site attributes, visitor behavior, and respondent ability to rationalize or cope with situations (Manning, 2011). Relationships between norms and the other indicators were either weakly negative or insignificant, which is to be expected because norms represent independent expectations of conditions that should or should not be allowed, whereas the other indicators represent actual or perceived site conditions (Needham et al., 2016; Vaske & Whittaker, 2004).

Management implications

From a management perspective, 63% of respondents felt crowded at Kailua Beach Park with 38% feeling moderately or extremely crowded. Shelby et al. (1989) and Vaske and Shelby (2008) stated that when 50-65% of people feel crowded at a site, it should be characterized as "high normal" with carrying capacity not yet exceeded, but trending in that direction. This site will be "over-capacity" if only 3% more visitors feel crowded in the future, and management responses will be necessary to preserve experiences and conditions (Vaske & Shelby, 2008).

One technique for managing use is to ensure that conditions do not exceed visitor norms. Given the relatively high norm intensity and crystallization, indicators of use were important to respondents and there was some agreement about conditions that should and should not be allowed to occur at Kailua Beach Park. On average, respondents possessed normative standards that an absolute maximum of no more than 952 people in total (379.87 per 500 $\times$ 200 yards) should be allowed at any one time at this site. On average, respondents reported encountering 553 people at this site and experienced an actual total use level of 638 people. Approximately 26% of respondents reported that they encountered more than 1000 people and 25-30% reported encounters or experienced use levels that exceeded their norm. Overtourism occurs when visitation breaches tolerable thresholds (Cheer et al., 2019) and these results suggest this is occurring to some extent for almost one-third of visitors surveyed at Kailua Beach Park. However, most respondents did not feel crowded when actual use levels were below 600 people in total and reported encounters were below 500 people at the site. Moderate to extreme crowding only occurred when use levels rose above approximately 700 people in total and reported encounters exceeded approximately 600 individuals.

Sustainable tourism can manifest as minimalist (i.e., status quo sustainability) or comprehensive (i.e., enhancement sustainability), as described by Weaver (2006). The minimalist approach favors more relaxed standards, whereas a comprehensive approach favors stricter standards and the enhancement of conditions (Lesar et al., 2020; Weaver, 2006). A transition to comprehensive models is a desired trajectory in overtourism contexts, and indicator-based thresholds or standards can inform this approach. For Kailua Beach Park, managers might consider a comprehensive approach that enhances site conditions by limiting site use to approximately 700 people at one time so few visitors feel moderately or extremely crowded (rather than a minimalist approach that adopts a minimum acceptable condition of approximately 952 visitors). An even stricter standard of approximately 600 people at one time could ensure that most visitors feel little or no crowding.

Strict standards can improve visitor experiences and alleviate impacts such as crowding, but many people could also be restricted from visiting. More lenient standards potentially impact fewer visitors, but site conditions could deteriorate to a point where visitors could be displaced to other settings and not return. It remains an issue for managers to specify clear objectives for a site, identify indicators, and determine standards that meet these objectives. Interventions for maintaining standards could include encouraging the use of nearby alternative sites, implementing fees, reducing parking, educating visitors, or implementing quota limits and reservation systems (Manning, 2011). Kailua Beach Park currently has no formal management plan or use limits in place, and the development of a detailed plan for this site should be a priority for the City and County of Honolulu, which manages this site.

Before considering any interventions, it is important to recognize that the UAV images showed use levels at Kailua Beach Park to be quite low ($\leq$ 317 people) in the morning, but much higher at noon (647-779) and in the afternoon (660-1039). Use levels that exceeded the average minimum acceptable condition (952 people) all occurred at noon or later and were associated with people feeling moderately or extremely crowded. Managers may, therefore, only need to consider interventions after mid-day, or could encourage people to visit earlier in the day. Temporal management actions such as these are common in tourism and recreation (Manning, 2011; Weaver, 2008).

Regardless of the strategies adopted, implementation must be followed by monitoring to assess change over time. In doing so, it is important to measure both descriptive (use levels) and evaluative (encounters, norms, crowding) indicators to facilitate management. Use levels, for example, describe existing conditions, whereas evaluations such as perceived crowding describe visitor feelings about these conditions. These concepts do not, however, reveal thresholds when conditions become unacceptable (Needham, 2013). Norms facilitate an understanding of these conditions and provide a basis for developing standards and informing management responses (Shelby et al., 1996). In addition to these four indicators, managers might also consider additional potential indicators of use (e.g., noise or other depreciative behaviors) that can impact experiences and conditions.

In conclusion, these results and recommendations are limited in space and time to a single beach park that is unrestricted and managed mostly for human use. Cross-sectional findings such as these do not necessarily generalize across time or to other coastal and marine settings where tourism and recreation are common. This study was conducted before the COVID-19 pandemic emerged and in the short term, sites such as Kailua Beach Park may see fewer visitors, different types of visitors (e.g., decrease in international visitation due to border restrictions, changes in major markets), and different visit characteristics (e.g., social distancing). In the future, researchers are encouraged to examine beach use issues using both descriptive (e.g., use levels) and evaluative (e.g., encounters, norms, crowding) indicators, and apply innovative measurement techniques such as photographs and UAV imagery to address both sustainability and overtourism issues.

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