Final Report—September 2024

Literature Review

Visitor Use Estimation for National Trails and National Wild and Scenic Rivers Systems

ON THE COVER
Visitor Use on the Klamath River, Oregon
Photo by Bob Wick

Literature Review: Visitor Use Estimation for National Trails and National Wild and Scenic Rivers Systems: Literature Review

Final Report

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Final Report for NPS and Technical Guidance Team Review

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Introduction

The National Park Service (NPS) is seeking more accurate and cost-effective methods for understanding visitor use levels, characteristics, and mobility patterns in porous, often multijurisdictional, long-distance linear corridors that are part of the National Trails System (NTS) and the National Wild and Scenic Rivers System (NWSRS) and managed or administered by NPS. Due to the complexities of counting visitors and estimating visitation for these systems, not all of them are included within traditional visitation metrics and public use statistics compiled by NPS. As such, the NPS commissioned this project team to lead a literature review and needs assessment to document the various approaches for estimating visitor use levels, characteristics, and visitor use patterns. This literature review provides a concise summary of existing social science knowledge related to methods for acquiring, analyzing, and reporting data applicable to these topics. The project team worked with the NPS and partners to identify and compile the literature reviewed in this report.

Literature Review

This section of the report is organized into five subsections according to the following relevant topic areas: (1) visitor use estimation; (2) visitor profiles; (3) visitor use patterns; (4) planning documents; and (5) economic and other benefits. Each subsection consists of tabular summaries of a citation, the study or document's purpose, the study area, the managing agency/organization, recreation activity types, methods, results, conclusions, and keywords for each item of literature reviewed. Each subsection concludes with key insights based on the literature reviewed.

Within each subsection, the tabular summaries are ordered alphabetically by the author's last name. Some of the table fields were not applicable to all items of literature reviewed (e.g., not all items included a specific study area). For these cases, "N/A" is included in the table field to indicate that the field was not applicable.

Visitor Use Estimation

This subsection of the report provides a systematic review of conventional and emerging methods for estimating visitor use levels in protected areas and tourism destinations in tabular summaries. This subsection also includes a conclusion with key insights based on the literature reviewed.

Tabular Summaries

Conventional Methods

This subsection contains tabular summaries of the literature reviewed relevant to conventional methods for estimating visitor use.

STUDY COMPONENT	**DETAILED DESCRIPTION**
Citation	Pettebone, D., Newman, P., & Lawson, S. R. (2010). Estimating visitor use at attraction sites and trailheads in Yosemite National Park using automated visitor counters. *Landscape and Urban Planning*, 97(4), 229–238.
Study Purpose	Assess the performance of automated trail traffic counters and document procedures to correct counting errors associated with their use to measure visitor use.
Study Area	Yosemite National Park
Managing Agency/Organization	National Park Service
Recreation activity types	Walking, hiking, trailhead visitation

STUDY COMPONENT	DETAILED DESCRIPTION
Methods	This study was conducted in Yosemite National Park in the summer of 2007 and used automated visitor counters to estimate visitor use at attraction sites and trailheads in Yosemite Valley. A total of 135 hours of direct observation counts were conducted in tandem with the use of automated counters at six study sites to estimate counting errors in the automated counter data. A series of statistical procedures was used to calibrate raw monitoring data to accurate estimates of visitor use at each of the study sites.
Results	Results of the study suggest there is a strong statistical relationship between observation-based visitor counts and monitor counts ($R^2 > 0.95$), which supports confidence in the use of monitors to estimate recreational use in national parks and protected natural areas.
Conclusions	These results show that automated visitor monitors can provide data to accurately estimate visitor use in parks and protected areas. All of the monitors used in this study were subject to counting errors and correction factors needed to be calculated from observed counts to calculate accurate estimates of visitor use. These results suggest that researchers and managers who choose to use automated monitors to estimate visitor use need to provide personnel to collect direct visitor counts. The necessity of this step cannot be underestimated because counts from automated monitors that are not calibrated cannot be considered a proxy for visitor-use estimates. This paper provides methodologies to obtain direct observation counts and calculate correction factors in order to estimate visitor use from automated visitor counters. Moreover, the automated visitor monitors used in this study performed consistently well at all study sites and during all time periods. The findings in this paper provide a methodological base for researchers and park managers interested in using automated visitor counters to estimate visitor use in parks and protected areas.
Keywords	Visitor use estimation; Visitor use monitoring; Infrared trail and traffic counter; Calibration; Carrying capacity

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Vagias, W. M., Powell, R. B., & Haynie, L. T. (2006, April). Recreational use in the headwaters of the Chattooga River. In *Northeastern Recreation Research Symposium* (p. 206).
Study Purpose	Explore the conflict between whitewater boaters and Trout Unlimited (TU) members over access to the upper 20 miles of the Chattooga River, which has been banned for over 30 years. Sumter National Forest (SNF) was directed to conduct a visitor use capacity study in the area as a result of the boaters' appeal against the Land and Resource Management Plan. The study examines TU members and whitewater boaters' experience, involvement, and place attachment using open-ended questions and a Likert-type scale. The respondents are predominantly male, well-educated, and have high income levels. The whitewater boaters report higher scores in attraction, self-expression, and centrality subscales, and feel more connected to the Chattooga River than TU members.
Study Area	Wild and Scenic Chattooga River
Managing Agency/Organization	Sumter National Forest & Clemson University
Recreation activity types	Whitewater boaters
Methods	The study conducted a literature review of past and present river management documents and explored the visitor use capacity analysis and Limits of Acceptable Change process to identify potential future management directions. The study also identified two major stakeholders, TU and whitewater boaters, as well as several other less visible groups through attendance at public meetings. Empirical data from a secondary source were reviewed and synthesized to compare and contrast the two major stakeholders based on variables related to experience, involvement, and place bonding. Data analysis involved crosstabulations, mean scores, and t-tests. The analysis identified current informational inadequacies and future research needs regarding recreational management of the upper Chattooga River.
Results	The study conducted a literature review and empirical analysis to identify stakeholders and their perspectives on the recreational management of the upper Chattooga River. The analysis found two major stakeholders, TU and whitewater boaters, and identified information inadequacies and future research needs.
Conclusions	The study concluded that there is a need for improved communication and collaboration among stakeholders and managers in the management of the upper Chattooga River. The study also identified a need for further research on the recreational management of the river, particularly with respect to the potential impacts of increased visitation and the management of conflicting user groups. Finally, the study highlighted the importance of understanding stakeholder perspectives and the role of place bonding in shaping attitudes toward management strategies.
Keywords	Visitor use capacity; Stakeholders; Wild and Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Wallmo, K. (2003). Assessment of techniques for estimating beach attendance. Beach sampling report of NOAA, 10.
Study Purpose	Focus on three on-site survey techniques to estimate beach attendance: all day counts, periodic counts, and helicopter overflights. The results from these different techniques are discussed and some conclusions on the related merits are drawn.
Study Area	Dewey Beach
Managing Agency/Organization	National Oceanic and Atmospheric Administration
Recreation activity types	Beach visitation and activities
Methods	The sampling design resulted in counting people arriving through a subset of the access points each day for the all-day counts, conducting periodic counts at specific times and zones, and conducting two helicopter overflights each day. The number of observed beach users was adjusted by the probability that they were observed in a count. Standard errors of the estimates were calculated using a variant of the jackknife method.
Results	Results suggest that, generally, attendance estimates from all three techniques are comparable, as most estimates fall within 95% confidence intervals of each other. Sensitivity analyses results show that relatively small errors in the reporting of trip duration and re-entry can have considerable effects on the attendance estimates, and convergence of estimates can occur after modifying trip duration and beach re-entry by relatively small magnitudes. Periodic counts are shown to be the most cost-effective method for estimating beach attendance, as 25% of the effort and cost required for all day counts was required for periodic counts that produced comparable estimates.
Conclusions	In general, given the large standard errors of the estimates, the three techniques produced relatively comparable daily attendance estimates. Given the standard errors and the estimate convergence with relatively small changes to trip duration and beach re-entry, the cost effectiveness of periodic counts is superior to both all day and overflight counts. Without the appropriate software it is difficult to estimate the increased accuracy additional observations will produce with any technique. Overflight estimates produce the largest standard errors, and the technique is the most costly of the three. The estimates are sensitive to people's ability to predict their trip duration and to beach re-entry. On average, incorrect predictions of trip duration by as little as thirty minutes can significantly change attendance estimates.
Keywords	Visitor use estimation; Beach visitation; Visitor attendance; Day counts; Periodic counts; Helicopter overflights

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Ziesler, P. S., & Pettebone, D. (2018). Counting on visitors: A review of methods and applications for the National Park Service's visitor use statistics program. *Journal of Park and Recreation Administration*, *36*(1).
Study Purpose	Review various methods and applications of National Park Service's Visitor Use Statistics (VUS) program.
Study Area	National Park Service-managed units
Managing Agency/Organization	National Park Service (NPS)
Recreation activity types	Diverse recreation activities, including hiking, camping, fishing, wildlife weathering, water sports, scenic driving, etc.
Method	Provided an overview of various methods to estimate visits, visitor hours, and overnight stays, including individual counts of visits, proxy counts, statistical relationships, and fixed estimate; Discuss the strengths and limitation of each method; Reviewed the applications of visitor use data, including NPS infrastructure planning, transportation and capacity; Research, evaluation of economic benefit, etc.
Results	Proxy counts (i.e., vehicle counts times the persons-per-vehicle multiplier) are by far the most common methods of estimating visitation in the NPS. For areas not suitable for either individual counts or proxy counts, statistical relationships are used to estimate visitation from representative traffic counts or by correcting a single count using a multiplier. Periodic studies are needed to update statistical relationships or multipliers. Emerging technologies such as passive mobile data appear promising as proxy counts for parks with porous boundaries.
Conclusions	One essential component of visitor use estimation is to develop official count procedures that are consistent with definitions of visitor use employed by the agency. The authors also highlight the importance of choosing the most appropriate method for a particular park and type of use being measured.
Keywords	Visitor use estimation; Visitor use statistics; Dispersed use; Proxy counts

Emerging Methods

This subsection contains tabular summaries of the literature reviewed relevant to emerging methods for estimating visitor use.

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	AirSage (2015). Wireless signaling data to estimate monthly visitors to federal lands.
Study Purpose	Estimate monthly visitation across national park and forest sites within U.S. using AirSage visitation and statistical models.
Study Area	257 national parks and national forest units in U.S.
Managing Agency/Organization	National Park Service (NPS); US Forest Service (USFS)
Recreation activity types	Various recreation activities
Method	To address the heterogeneity across sites, the author first segmented the sites into groups based on two classification schemes: sampling rate and dominant home census geographic region of its visitors. For each sample group, fitted a log-linear model where observed monthly visitation of eight months was regressed against weighted/unweighted initial visitation estimates from AirSage sample, income, distance to home variable, seasonality, and park type dummy, as well as an accessibility measure. The author also used the models to predict visitation in order to validate the model estimates.
Results	Monthly visitation for both national parks and U.S. national forests
Conclusions	For large-scale aggregate-level analysis, the sampling rate-based segmentation scheme is recommended. Park type (i.e., recreation areas vs. preserves) is found to have a significant role in predicting visitation. Note that national trails are categorized as recreation areas in this study.
Keywords	Visitor use estimation; Passive mobile data; Sample segmentation; Sampling rate; Sample weighting

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Balmford, A., Green, J. M., Anderson, M., Beresford, J., Huang, C., Naidoo, R., Walpole, M. & Manica, A. (2015). Walk on the wild side: Estimating the global magnitude of visits to protected areas. *PLoS biology*, 13(2), e1002074.
Study Purpose	Predict visitation to protected areas (PAs) in relation to properties of PAs and to local socioeconomic conditions.
Study Area	556 PAs spread from 51 countries
Managing Agency/Organization	Multiple
Recreation activity types	Various land-based recreation activities
Method	Fitted a region-specific generalized linear model to predict variation in visitation in relation to variables including PA size, local population size, PA remoteness, a simple measure of the PA attractiveness, and national income; Derived median value of nature visits from the existing literature and applied these numbers to predicted visitation to calculate the economic impact of visits to PAs
Results	Annual visits to PAs, where each visit is defined as a person spending at least a portion of the day
Conclusions	Due to the missing data in global catalogue of PAs, their aggregate estimates of visit rates are probably conservative. Also, available data on both direct expenditure and consumer surplus were too sparse and confounded by variation in methods. Other candidate predictor variables that are worth considering: the quality of road infrastructure; distance from a major airport; the prevalence of malaria; and the incidence of armed conflict.
Keywords	Visitor use estimation; Large-scale assessment; Economic benefits

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Creany, N. E., Monz, C. A., D'Antonio, A., Sisneros-Kidd, A., Wilkins, E. J., Nesbitt, J., & Mitrovich, M. (2021). Estimating trail use and visitor spatial distribution using mobile device data: An example from the nature reserve of Orange County, California USA. *Environmental Challenges*, 4, 100171.
Study Purpose	Use StreetLight mobile-device data to quantify total use and spatial pattern of use on trails within parks and protected areas (PPAs).
Study Area	Four PPAs in Orange County, California
Managing Agency/Organization	Multiple
Recreation activity types	Beach access, watersports, camping, hiking, running, mountain biking, and equestrian use
Method	Acquired average daily number of pedestrians or bicyclists crossing a site polygon using StreetLight's Pedestrian Tool; Collected the daily counts of pedestrians and bicyclists from TRAFx trail counter and tracks of pedestrians (hikers and runners) and mountain biker from GPS tracking; Imported GPS tracks into StreetLight Pedestrian Tool to generate a grid-level (100-meter) map that calculated the sum of tracks that passed through each cell.
Results	TRAFx trail counter and StreetLight Pedestrian Tool provide similar estimates, with no significant differences in medians and a strong correlation. For both pedestrian and bicycle use types, the authors find a strong correlation between StreetLight and GPS-based estimates of visitor use.
Conclusions	Passive data contain contextual information about visitor demographics, may be more representative than social media data, and can differentiate activity type between pedestrians and cyclists. The StreetLight density of use estimates illustrate the locations where visitors entered the park from surrounding neighborhoods and secondary entrances.
Keywords	Visitor use estimation; Visitor use patterns; Passive mobile data; Urban-proximate park

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Fisher, D. M., Wood, S. A., White, E. M., Blahna, D. J., Lange, S., Weinberg, A., ... & Lia, E. (2018). Recreational use in dispersed public lands measured using social media data and on-site counts. *Journal of environmental management*, 222, 465–474.
Study Purpose	Use social media data to measure use in dispersed and low-profile destinations.
Study Area	15 trails within the Mount Baker-Snoqualmie National Forest, western Washington
Managing Agency/Organization	US Forest Service
Recreation activity types	Hiking, backpacking, camping, fishing, hunting, nature appreciation, etc.
Method	Fifteen trails were chosen at random from strata of ranger districts and use levels; Delineate polygons around trails to include trailheads, parking areas, and destinations accessed from the trail; Queried Flicker geotagged photos within the drawn polygons and calculated the number of photo-user-days (PUDs) per site; Collected trail reports from the Washington Trails Association (WTA) database and calculated monthly total trips per site; Conduct infrared sensors, time-lapse cameras, and manual on-site counts.
Results	Proxy for monthly and annual visitation to national forests units from 2005 to 2015
Conclusions	Compared to the Flickr PUD, the number of trip reports posted to WTA's website is better correlated with on-site observed counts, given the popularity of the WTA hiking guide in the region. Organizations that provide a similar online platform as WTA might be a useful source for visitor estimation. Social media platforms are useful for measuring use to dispersed recreation areas but tend to perform best at broader spatial scales than individual trails.
Keywords	Visitor use estimation; Social media data; Dispersed area

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Hamstead, Z. A., Fisher, D., Ilieva, R. T., Wood, S. A., McPhearson, T., & Kremer, P. (2018). Geolocated social media as a rapid indicator of park visitation and equitable park access. *Computers, Environment and Urban Systems*, *72*, 38–50.
Study Purpose	Identify predictors of visitation to around 2,000 inner-city parks using social media data.
Study Area	2,143 diverse parks in New York City include flagship parks such as Central Park and small community parks
Managing Agency/Organization	NYC Department of Parks and Recreation and local non-profit agencies
Recreation activity types	Walking and jogging, cycling, picnicking, playground and play areas, dog walking, cultural and educational activities, etc.
Method	Queried geotagged photos from Flickr and geotagged tweets from Twitter based on park boundary shapefiles; Estimated the number of unique Flicker-/Twitter-user-days (FUD/TUD) and divided users into resident and tourist groups based on geocoded home locations; Constructed predictors of park facilities and characteristics, park accessibility, and neighborhood characteristics; Estimated regression models that regress FUD/TUD (dependent variables) on potential predictors; Validated average daily social media-derived visitation with on-site visitor count.
Results	Proxy for annual visitation to New York City's 2143 parks from 2005 to 2014
Conclusions	Social media-derived visitation is moderately correlated with on-site visitor count, with Twitter-based visitation matching observed counts better. Less visited parks tend to have higher than expected FUD and TUD values, and more frequently visited parks have lower than expected social media values. The likelihood of social media use may vary by park type as well. Visitation surveys across a wide variety of parks that stratify across park types and neighborhood demographics could be used to validate social media-based visitation.
Keywords	Visitor use estimation; Social media data; Urban parks; Park accessibility

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Jorgenson, J., Sage, J., Harbor, L., Sage, A., Cares, C., Monz, C., D'Antonio, A., and M. Roberts. 2021. Mobility data—possible approaches and limitations for use in park settings: a review of mobile data. Natural Resource Report NPS/XXXX/NRR—20XX/XXXX. National Park Service, Fort Collins, Colorado.
Study Purpose	Outline and highlight various geolocation-based data sources for use in park and recreation settings. While various park uses are assessed, the primary purpose was to try and relate the findings to George Rogers Clark National Historical Park.
Study Area	Varies, George Rogers Clark National Historical Park
Managing Agency/Organization	National Park Service
Recreation activity types	Walking, historic activities, interpretive activities
Methods	Review of data sources
Results	Results aimed to understand geolocation data providers as well as possible use cases for park and recreation studies. The authors found that two primary types of geolocation services exist: (1) raw data providers, and (2) aggregate/platformed data providers. Each provider has specific pros and cons. Raw data are preferrable for trying to estimate use patterns in parks. For ease of access, data platforms allow for comparisons of multiple sites with similar settings. However, one limitation of aggregate data is the ability to apply large-scale algorithms for use estimation. The research team found that use estimates varied and could be useful in certain scenarios with on-the-ground validation.
Conclusions	First, mobile location data vary in the types of application and uses. Device-level data formats are best suited for looking at movement patterns, dwell times, and trip chaining throughout a park unit, but are limited when it comes to the ability to estimate overall usage volume. Aggregated/platform data generally use proprietary algorithms from the provider to estimate visitation volume, but those processes differ and are challenging to understand. Aggregated data are less powerful when looking at movements and trip patterns, though are generally available in an aggregate format. Second, regardless of the data format, on-the-ground counts are still necessary to calibrate mobile location data. Some platforms allow these counts to be automatically uploaded into their system for ease of use, while others are done through custom analyses. In either case, the process still requires some level of fieldwork to be conducted, though in most cases these can be obtained via automated means at a very limited number of locations within a given park. Each park will vary in what is necessary due to geographic locations, nearby confounding factors (e.g., busy roadways), and layout
Keywords	Visitor use estimation; Mobile device data; Porous parks; Geolocation data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Keeler, B. L., Wood, S. A., Polasky, S., Kling, C., Filstrup, C. T., & Downing, J. A. (2015). Recreational demand for clean water: evidence from geotagged photographs by visitors to lakes. *Frontiers in Ecology and the Environment*, *13*(2), 76–81.
Study Purpose	Assess the relationship between lake visitation and selected lake attributes using geotagged photos.
Study Area	1,000+ lakes in Minnesota and Iowa, USA
Managing Agency/Organization	Multiple
Recreation activity types	Swimming, boating, fishing, picnicking, wildlife viewing, etc.
Method	Established 30-m buffer zone around the water's edge of each lake; Queried Flickr geotagged images taken from 2005–2012 within the buffered boundaries; Estimated the number of unique photo-user-days per lake; Averaged across the eight years to derive an average annual photo-use-days per lake.
Results	A proxy for annual visitation to Minnesota and Iowa lakes
Conclusions	The authors find significant relationships between average annual photo-use-days and average annual trips per lake derived from a statewide survey of Iowa lake users. Lakes of greater size, with greater water clarity and a boat ramp have a higher likelihood of attracting visitors. Flicker users are not representative of the lake use population. Flicker users are more likely to be female, more educated and younger than lake users who responded to surveys.
Keywords	Visitor use estimation; Social media data; Geotagged photographs; Travel cost; Cost-benefit analysis

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Kothuri, S., Broach, J., McNeil, N., Hyun, K., Mattingly, S., Miah, M., ... & Proulx, F. (2022). Exploring data fusion techniques to estimate network-wide bicycle volumes.
Study Purpose	Develop a method for evaluating and integrating emerging sources (Strava, StreetLight, and Bikeshare) of bicycle activity data with conventional demand data (permanent counts, short-duration counts) using traditional (Poisson) and advanced machine learning techniques.
Study Area	Various U.S. cities of scale
Managing Agency/Organization	National Institute for Transportation and Communities
Recreation activity types	Biking, cycling
Methods	This research developed a method for evaluating and integrating emerging sources (Strava, StreetLight, and bikeshare) of bicycle activity data with conventional demand data (permanent counts, short-duration counts) and methods using traditional (Poisson) and advanced machine learning techniques. First, a literature review was conducted, along with cataloging and evaluating available third-party data sources and existing applications. Next, six cities (Boulder, Charlotte, Dallas, Portland, Bend, and Eugene) that represented a variety of contexts (urban, suburban) and geographical diversity were selected. Of these, Boulder, Charlotte and Dallas constituted the basic sites, where one year of data (2019) was used for modeling. Portland, Bend, and Eugene in Oregon were considered enhanced sites, where three years of data (2017–2019) were not used for model estimation. Using these data, Poisson and Random Forest models were estimated. The model estimation process was designed to allow for comparison of the relative accuracy and value added by different data sources and modeling techniques. A range of models were developed to better understand the likely feasibility and accuracy of predicting bicycle counts on a network. Three sets of models were specified—All City Pooled, Oregon Pooled and city-specific models.
Results	In general, the three available data sources (static, Strava, and StreetLight; bikeshare data were not available outside of the Oregon cities) appeared to be complementary to one another; that is, adding any two data sources together tended to outperform each data source on its own. In the All City Pooled model, the combination of all three variable types was clearly the best-performing model by most measures. While the All City Pooled model fit the data relatively well, as shown by the high pseudo-R^2 value (> 0.8), prediction success varied considerably by volume. Low-volume sites proved challenging, with the best-performing model still demonstrating considerable prediction 10 error (> 100% mean absolute percent error (MAPE), while higher-volume sites (150 annual average daily bicycle traffic [AADBT] counts or more) had much lower error rates of around 30% MAPE. Prediction at low-volume sites is also made more challenging by the lack of variety in count locations. Keeping in mind the limited samples,

STUDY COMPONENT	DETAILED DESCRIPTION
	these results are interesting and mostly in keeping with expectations that each source is providing unique and valuable information about bicycling activity. While the best-fitting model still included all three sets of variables (static, Strava, and StreetLight), a model combining just Strava and StreetLight data performed about as well in terms of predictive performance. In terms of MAPE, expected performance was better than in the All City Pooled model, with best MAPE less than 20% at mid- and high-volume sites, and low-volume MAPE as low as 55%. The increase in error observed over all the 2019 pooled and city-specific models when using Strava or StreetLight data without adjustment factors (either static variables, or the other third-party user data) were also estimated. For example, using Strava or StreetLight counts to predict AADBT without static adjustment variables increased expected prediction error by a factor of about 1.4 (i.e., a 40% increase in percent root mean squared error [%RMSE]). That rule of thumb figure of 1.4 times was only slightly lower for Strava plus StreetLight without static variables (1.3x). The case of Strava alone versus Strava plus StreetLight 11 was the only mixed result. In some cases, combining the two third-party user data sources greatly improved results versus using Strava only (Dallas, Boulder), while for the rest the addition of StreetLight only modestly improved or even reduced performance.
Conclusions	For 2019, all City Pooled and Oregon Pooled models with the full count dataset are, for the most part, consistent with the full-year permanent count pooled model results: combinations of data sources outperform single sources, and the best-fitting models combine all three. An exception is the Oregon Pooled model, where adding StreetLight to Strava data does not improve the model performance. In fact, StreetLight appears to provide the least information of the three, significantly underperforming Strava data whether individually or in combination with static variables. One possibility is that additional static variables are needed to adjust StreetLight, which is unique due to its need to impute travel mode. Variables capturing different aspects of the count location context might be needed to complement StreetLight. The general patterns also hold, for the most part, in city-specific models, with a couple of specific results worth noting. Machine learning algorithms have been used to understand how complex and flexible modeling forms could handle data variability and bias to provide a better prediction. This study used Random Forest regression to predict AADBT for All City Pooled, Oregon Pooled, and city-specific models (Portland and Eugene only) using various data and buffer fusion methods to evaluate the value of third-party user data for modeling bicycle activity. The results indicated that Strava and StreetLight played a supplementary role. When each model's performance was broken down by volume bin, the best RMSE was 14% and 8% for high- and medium-volume bins, respectively. For low volume, StreetLight alone overestimates AADBT; however, the full data fusion with static, Strava, and StreetLight significantly improved the model performance. Even though the machine learning model is more computationally complex with respect to model

STUDY COMPONENT	DETAILED DESCRIPTION
	development, the performance of the machine learning algorithm was comparable with the count models, perhaps due to limited data samples and variations within data. With more data collection capturing additional local contexts, machine learning is expected to improve model performance for a network-wide prediction. It is very difficult to identify the optimal number of sites or data collection duration that makes the machine learning model reliable and accurate, since performance levels depend on the algorithm used and the complexity of data. One previous study (El Esawey, 2015) found that at least 1,950 data points are required to obtain 10%–15% MAPE from neural network-based bicycle volume estimation models. The findings from this study indicate that rather than replacing conventional bike data sources and count programs, big data sources like Strava and StreetLight actually make the old "small" data even more important.
Keywords	Visitor use estimation; Mobility data; Transportation; Machine learning

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Kubo, T., Uryu, S., Yamano, H., Tsuge, T., Yamakita, T., & Shirayama, Y. (2020). Mobile phone network data reveal nationwide economic value of coastal tourism under climate change. *Tourism Management*, *77*, 104010.
Study Purpose	Integrate cellphone data in the monetary evaluation of the climate change impacts on coastal tourism at Japanese beaches.
Study Area	536 beaches all over Japan
Managing Agency/Organization	Multiple
Recreation activity types	Primarily beach bathing
Method	Obtained grid-level (500-meter) hourly number of mobile phone users; Overlaid the grids for which user information is available with a map of bathing areas in Japan to identify beaches with available cellphone data; the visitation rate to a beach as the ratio of the number of visitors from each city to each beach, divided by the population of each city; Estimated a travel cost model that regresses visitation rate on travel costs.
Results	Proxy for visitation rates to 536 beaches during both summer and winter season in 2015
Conclusions	Automatic data collection using the mobile phone network would mitigate existing the sampling bias introduced by volunteer information sourced from social media and app tracking. Projected economic value loss rates are more significant than the projected national physical beach loss rates. Existing physical evaluations underestimate the impacts of coastal beach loss caused by climate change.
Keywords	Visitor use estimation; Passive mobile data; Costal tourism; Travel cost; Economic benefits

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Lawson, M. (2021). Innovative new ways to count outdoor recreation: Using data from cell phones, fitness trackers, social media, and other novel data sources.
Study Purpose	(1) Review big data used to count recreation including data from social media, fitness tracking applications, cell phones, etc. and (2) conduct a case study to compare traditional counting method to novel data sources.
Study Area	43-mile dispersed trail system in Whitefish, Montana
Managing Agency/Organization	Multiple
Recreation activity types	Trail-based recreation, including hiking, horseback riding, ATVing, and mountain-biking
Method	Obtained the number of trips for individual trail segments by week from Strava Metro; Downloaded Google Trends from 2017–October, 2020; Estimate a statistical model regressing log of on-site trail counter counts (dependent variable) on the log number of Strava trips, Google Trends scores, precipitation, and seasonal controls for one trailhead; Used cross-validation to evaluate model's out-of-sample predictive accuracy; Adjusted the estimated use by a correction factor that reflects the relative difference in actual use among different trails.
Results	Estimated weekly trail use for three trails from 2017 to 2020
Conclusions	Novel data will be more valuable for populator sites, or sites closer to population center. The more users, the more accurate the predictive power. Cellphone data are promising for dispersed areas, and it is likely more representative than social media or fitness tracking apps. The accuracy of such data is highest for annual or monthly counts, rather than weekly or daily. Recent studies, rather than relying on correlations, estimate use using statistical models that predict on-site visitation along with other predictors. The findings from the case study suggest Strava trips are predictive of the on-site use counts.
Keywords	Visitor use estimation; Big data; Dispersed area

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Li, J., Xu, L., Tang, L., Wang, S., & Li, L. (2018). Big data in tourism research: A literature review. *Tourism management*, *68*, 301–323.
Study Purpose	Provide a comprehensive literature review on the application of big data in tourism research.
Study Area	N/A
Managing Agency/Organization	N/A
Recreation activity types	N/A
Method	Collected full-length articles from online academic databases; Identified types of big data in the existing research; Investigated research focuses, data characteristics, and analytic techniques for each of different types of big data sources; Discussed challenges and opportunities of using big data in tourism research.
Results	Big data fall into three categories: user-generated content (UGC) data (including online textual/photo data), device data (including passive mobile data, Bluetooth data, etc.), and transaction data (web search data). Each has a specialized analysis focus: (1) Online photo data (covering geo-information) and various device data were specialized in modeling tourist spatial-temporal behavior; (2) Web search data have excellent performance in predicting tourism demand. For analyzing geo-located photo data and device data, two steps appear common: (1) Data preprocessing step includes tasks of data filtering, map matching, and stay point detection; (2) Movement pattern mining utilizes techniques like statistical analysis, clustering, frequent pattern generalization, and movement prediction.
Conclusions	In terms of data quality, online photo data and mobile roaming data were only applicable to the macro level due to their accuracy limitations, while other tracking data with higher precision (e.g., GPS data, RFID data, Bluetooth data, and Wi-Fi data) can be used to model tourist movement at the micro level. Bluetooth can be used in indoor places or in the proximity of tall structures where GPS connectivity cannot be guaranteed.
Keywords	Big data; Tourism research

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Merrill, N. H., Atkinson, S. F., Mulvaney, K. K., Mazzotta, M. J., & Bousquin, J. (2020). Using data derived from cellular phone locations to estimate visitation to natural areas: An application to water recreation in New England, USA. *PloS one*, *15*(4), e0231863.
Study Purpose	Use AirSage cellular device locations to estimate visitation to water recreation areas.
Study Area	464 water recreation areas in Cape Cod, Barnstable County, Massachusetts, and 113 beaches in greater New England
Managing Agency/Organization	Multiple
Recreation activity types	Swimming, fishing, boating, water skiing, kayaking and rafting, etc.
Method	Created a 100-meter buffer around each recreation area to capture the use at sites; Based on the spatial extent, acquired aggregated hourly summaries of visitation by recreation site and estimates of the visitor's census block-group geographies from AirSage; Assuming a three-hour average stay, aggregated the hourly-level cell data to visitor-use-days totals by calculating a moving average of visitation for each hourly visitation estimate and summing the moving average from 8 a.m. to 4 p.m.; Estimated several calibration models of different functional forms that estimated the observed visits using cell data-derived visitation estimates along with other explanatory factors; Evaluated candidate models based on out-of-sample predictive performance.
Results	Daily visitation to 577 water recreation areas in New England for the four summer months of 2017
Conclusions	The locational accuracy of reported locations varies depending on source device and the smartphone application: The accuracy varies with ranges of 1–10 meters (GPS), 20–200 meters (Wi-Fi), and 100–2,000 meters (cell tower-based) based on the methods used to locate each device. Their regression models have strong explanatory power. The author also finds that cell data were by far the most useful in modeling visitation. Cellphone data may be better at predicting visitation to larger areas with more daily visitation, therefore, calibration is needed to match the scale of the observed visitation.
Keywords	Visitor use estimation; Passive mobile data; Water recreation; Porous PPA; Calibration

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Monz, C., Mitrovich, M., D'Antonio, A., & Sisneros-Kidd, A. (2019). Using mobile device data to estimate visitation in parks and protected areas: an example from the nature reserve of orange County, California. *Journal of Park and Recreation Administration*, *37*(4), 92–109.
Study Purpose	Estimate recreation visitation using geolocation data from GPS-enabled mobile devices and with calibration.
Study Area	High-use, porous, urban-proximate park management units (11) within the Nature Reserve of Orange County, California
Managing Agency/Organization	Multiple
Recreation activity types	Hiking, running, mountain biking, beach recreation, nature appreciation
Method	Delineated 24 formal and informal access locations in geographic information systems (GIS) polygons based on field-based site scoping; used StreetLight InSight model to estimate total number of vehicle trips from any origin ending at each access point (StL Index); calibrated StL Index values using annual average daily traffic (AADT) from proximate permanent traffic count station and applied correction factor (multiplier) to scale StL Index estimates of visitor use at access points to estimate total visitor use at access points; validated results using multiple sources of ground-truth data.
Results	Average daily visitation across 24 formal and informal entrances for a four-year period (2014–2018).
Conclusions	Currently available mobile device data provide easy and convenient comparisons of *relative visitation levels*. Proper scaling (calibration) needed to be developed to estimate *absolute visitation levels*.
Keywords	Visitor use estimation; Porous parks; Mobile device data; Calibration

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Nettles, J. M., Brownlee, M. T., Sharp, R. L., & Verbos, R. I. (2022). The utilization distribution: Wildlife research methods as a tool for understanding visitor use in remote parks and protected areas. *Human Dimensions of Wildlife,* 27(2), 151–163.
Study Purpose	Demonstrate the use of a common wildlife analysis method and utilization distribution (UD) for understanding visitor use in remote parks and protected areas.
Study Area	Case study approach at Katmai (KATM) and Lake Clark National Parks and Preserves (LACL)
Managing Agency/Organization	Park Solutions Lab at the Clemson University Institute for Parks; other university entities
Recreation activity types	Human presence
Methods	The U.S. National Park Service's mandate is to protect and maintain the natural and scientific values of parks while providing for public enjoyment, education, and inspiration. The study focuses on two parks in Alaska, KATM and LACL, both of which have vast wild landscapes and low visitor numbers. The study analyzes visitor use and identifies distinct visitor use monitoring areas. The study uses a 99% UD to map the distributions of visitors' activities and compares trends across months, years, and activity types within each park.
Results	The results show the potential benefits of incorporating wildlife methods into social science practices to better manage parks and protected areas. The conclusion provides information on the relative intensity of visitor use in different areas of the park, the changes in use across different months, and the primary activity types of commercial visitors. It also provides links to additional resources for accessing 3D figures and animations of the utilization distribution.
Conclusions	The paper demonstrates the potential of using wildlife research methods, such as UDs, to understand visitor use in large and remote parks and other protected areas. UDs display the relative intensity of use across a region and can help managers understand and visualize trends in visitor use. UDs can also help to identify areas with higher potential for user group conflict and can incorporate spatial data to highlight sites with high potential for visitor crowding. However, there are limitations to the UD approach, including reliance on Commercial Use Authorization (CUA) reporting and the need for visitor surveys to evaluate the quality of experiences within certain monitoring areas. The paper encourages future research to apply and enhance these techniques, which could increase understanding of visitor use and develop connections between social and wildlife sciences for achieving positive human-wildlife coexistence.
Keywords	Visitor use estimation; remote parks; utilization distributions; human dimensions of wildlife

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Reif, J., & Schmücker, D. (2020). Exploring new ways of visitor tracking using big data sources: Opportunities and limits of passive mobile data for tourism. *Journal of Destination Marketing & Management*, *18*, 100481.
Study Purpose	Describe three ways of identifying tourists from non-tourist activities using passive mobile data and correctly estimating the tourism volumes.
Study Area	Urban study area of Hamburg, Germany; Seaside resorts at St. Peter-Ording and Büsum, located on the North Sea coast of Germany
Managing Agency/Organization	Multiple
Recreation activity types	Various tourism activities
Method	Along with the baselines to identify tourists, the authors propose three ways: (1) Identify the home and work locations for a device. Tourists are those who travel outside of their home and work locations; (2) Use discriminant variables to separate visitors from commuters to derive the receiver operating characteristic (ROC) curve. A great discriminant should be the point on the upper left corner of ROC curve; (3) If the place of residence is known for a portion of the data, use this portion to train a classification model that will be applied to all the data.
Results	Implications for future research: (1) Develop methods that can classify mobile signals as touristic or non-touristic; (2) Utilize various data sources to validate and calibrate passive mobile data (PMD); (3) Define key metrics to help management agencies monitor findings over time and compare with other destinations.
Conclusions	Two good ways to apply passive mobile data are to (1) identify inter- and intra-destination movement patterns and (2) analyze the seasonality and structure of tourist demand. Nevertheless, PMD cannot define tourism on its own.
Keywords	Visitor use estimation; Movement patterns; Passive mobile data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Rice, W. & Pan, B. (2021). Understanding changes in park visitation during the COVID-19 pandemic: A spatial application of big data. *Wellbeing, Space and Society*, 2.
Study Purpose	During the 2020 COVID-19 pandemic, park and recreation managers experienced an influx of use. However, it was not clear to what extent these changes occurred. The purpose of this study was to use mobile location data to answer the following questions: R1: What factors influenced changes in park visitation in the western United States during the spring of 2020 in the midst of the COVID-19 pandemic? R2: To what degree are Google's data on changes in park visitation attributable to the COVID-19 pandemic?
Study Area	97 counties in Arizona, California, Nevada, Oregon, and Washington
Managing Agency/Organization	Various
Recreation activity types	Various
Methods	Google COVID-19 mobility reports
Results	Results identified that elevation and latitude were positively related to change in visitation. Median age and duration at "safer-at-home" orders were negatively related to a change in visitation. No other variables were found to have a significant impact on visitation. These results directly tie to an understanding that few variables predicted increased visitation at parks. In fact, the climate is more of a driving factor than COVID-19 issues.
Conclusions	The study showed that elevation and latitude were the two primary predictors of park visitation increases during COVID-19. However, stay-at-home orders did have a negative effect on park visitation, despite being usually a safely promoted option during the pandemic. Overall, Google's mobility reports were found to have limitations for park visitation as it generally did not show true change in visitation due to COVID-19 reasons.
Keywords	Visitor use estimation; COVID-19; Big data; Google; Spatial Analysis

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Sessions, C., Wood, S. A., Rabotyagov, S., & Fisher, D. M. (2016). Measuring recreational visitation at U.S. national parks with crowdsourced photographs. *Journal of Environmental Management*, *183*, 703–711.
Study Purpose	Compare geotagged Flickr photos with monthly counts of recreational visitors to each park published by the National Park Service.
Study Area	38 national parks in the western United States excluding Hawai‘i
Managing Agency/Organization	National Park Service (NPS)
Recreation activity types	Diverse recreation activities, including hiking, wildlife viewing; scenic driving, water activities, etc.
Method	Accessed Flickr geo-tagged photos within the boundary of each national park through Application Programming Interfaces (APIs); Counted unique combinations of users and dates per month—monthly “photo-user-days” (PUDs); Collected posted home locations from Flickr users’ public profiles; Performed regression models that regress monthly visitation on monthly PUD for each park and evaluated the model’s predictive accuracy via cross-validation.
Results	Proxy for monthly visitation to U.S. national parks from 2007–2012
Conclusions	Regression result suggests that PUD is a statistically significant predictor of NPS visitation. The models’ fit get worse at lower visitation rates. Flickr photos estimate a similar proportion of in-state visitors to the NPS surveys, although they tend to underestimate the proportion of out-of-state visitors and overestimate international visitors. Having surveyed visitor-count data against which to calibrate the Flickr data can improve the accuracy of predicted visitation rates.
Keywords	Visitor use estimation; Visitor profile; Social media data; U.S. National Parks

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Sonter, L. J., Watson, K. B., Wood, S. A., & Ricketts, T. H. (2016). Spatial and temporal dynamics and value of nature-based recreation, estimated via social media. *PloS one*, *11*(9), e0162372.
Study Purpose	Explore the use of social media data to estimate the spatial and temporal dynamics and value of nature-based recreation.
Study Area	Conserved lands in Vermont (n = 998)
Managing Agency/Organization	Multiple
Recreation activity types	Various forest recreation activities including swimming, camping, hiking, hunting and fishing, fall foliage viewing, and snow sports
Method	Obtain conserved lands map from The Nature Conservancy and aggregated parcels into 998 entities; Queries Flickr geotagged images taken from 2007–2014 within conserved land; Estimated the number of unique photo-use-days (PUDs) per parcel of conserved land; Averaged across the eight years to derive an average annual PUDs.
Results	A proxy for annual visitation to Vermont's conserved lands
Conclusions	The study found a significant and positive relationship between annual PUDs and survey user days (SUDs) to Vermont's state parks. Despite the significant relationship between PUDs and SUDs, their model has weak explanatory power. Social media data can be used to predict visits to data-sparse recreational sites. Future analyses will need to include information on *specific visitor groups* (e.g., in- vs. out-of-state visitors) and *recreational activities* (e.g., camping vs. day-use visits), since these factors influenced relationships between PUDs and SUDs in Vermont
Keywords	Visitor use estimation; Social media data; Geotagged photographs; Temporal dynamics

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Tenkanen, H., Di Minin, E., Heikinheimo, V., Hausmann, A., Herbst, M., Kajala, L., & Toivonen, T. (2017). Instagram, Flickr, or Twitter: Assessing the usability of social media data for visitor monitoring in protected areas. *Scientific Reports*, *7*(1), 17615.
Study Purpose	Compare social media data from Instagram, Twitter, and Flicker and assess how well these data correlate with visitation to national parks.
Study Area	21 national parks in South Africa; 35 parks in Finland
Managing Agency/Organization	South African National Parks; Metsähallitus Parks & Wildlife Finland
Recreation activity types	Wildlife-viewing; skiing, hiking, camping, fishing, etc.
Method	Created 10-kilometer buffer area around the parks to ensure that the surrounding area was included; Use Application Programming Interfaces (APIs) to query a global database of Instagram, Twitter, and Flickr posts; Selected posts within the buffered polygon for each national park; Calculated the number of active social media users per day and aggregated daily users to the monthly user level.
Results	Proxy for monthly visitation to national parks in South Africa and Finland in 2014
Conclusions	The correlation between the number of active social media users and official visitor statistics ranges from weak to moderate for different parks. Instagram outperforms Twitter and Flickr in representing monthly visitor patterns. Social media data tend to match the monthly visitation patterns better in more visited parks (higher visitor numbers) and in parks with higher quantity of social media content (and users). Other explanations for differences between social media and the official visitor statistics include the geography and location of the park, the park profile, visitor profiles, and sudden events.
Keywords	Visitor use estimation; Social media data; South African National Parks

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Volenec, Z. M., Abraham, J. O., Becker, A. D., & Dobson, A. P. (2021). Public parks and the pandemic: How park usage has been affected by COVID-19 policies. *PloS one*, *16*(5), e0251799.
Study Purpose	Use geotagged Instagram posts to examine the impact of COVID-19 policies on park visitation.
Study Area	98 parks in northern and central New Jersey, including 13 state parks, five wildlife management areas, 14 county parks, and 66 local parks
Managing Agency/Organization	Multiple
Recreation activity types	Diverse recreation activities
Method	Matched the parks with their corresponding Instagram location tags and visually verified all location tags using Google Maps; Webscraped Instagram posts tagged at each of the 98 parks using location tags; Inspected the photos to ensure no photos from parks in other locations were accidentally included in the dataset; Aggregated data for parks with several different location tags; Performed data cleaning to remove irrelevant photos; Calculated the photo-user-days (PUDs) for each park; Compiled annual data on total number of United States Instagram users to detrend PUD data.
Results	Proxy for park visitation during four periods of spring 2020
Conclusions	The methods used have two limitations: (1) Geotagged photos are from public accounts, which may introduce preferential bias; (2) Instagram stories are not included in the visitation estimation, which may lead to underestimating park visitation. Park visitation increased significantly with the onset of the pandemic. The subsequent park shutdown order significantly decreased park visitation to closed parks, while parks that remained open continued to experience elevated visitation levels. Visitation then returned to elevated pre-shutdown levels when closed parks were allowed to reopen.
Keywords	Visitor use estimation; Social media data; COVID-19

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Wood, S. A., Guerry, A. D., Silver, J. M., & Lacayo, M. (2013). Using social media to quantify nature-based tourism and recreation. *Scientific Reports*, *3*(1), 2976.
Study Purpose	Estimate recreation visitation using geotagged photographs and derive visitors' origin using profiles of the photographers.
Study Area	836 various recreation sites in 31 countries (including amusement parks, national parks, historic battlefields, urban attractions, etc.)
Managing Agency/Organization	Multiple
Recreation activity types	Various tourism activities
Method	Defined the "user days" (PUD) as the total number of days, across all users, that each person took at least one Flickr photograph within the bounds of each site; Collected total annual visitor user-days (EUD) from public statistics; Calculated average annual PUD and EUD across all years and fitted a log-log model in which the average PUD, is regressed against the average EUD and attributes of the study sites. Calculated the proportion of origin countries (POC) of flicker users (with location profiles); Collected data on proportion of visitors per each country (EOC) from visitor survey; Tested the relationships between POC and EOC.
Results	Annual visitor user-days at each recreation site from 2005–2011. User days are defined as one person spending a portion of one day within one site.
Conclusions	The 0.7 multiplying factor between empirical and photograph-based visitation is consistent across attraction types, while the absolute adjustment factor varies. Geotagged photos can be better used to estimate marginal changes in visitation in response to acute changes and the economic valuation of recreation sites, such as using a travel cost model.
Keywords	Visitor use estimation; Social media data; Geotagged photographs; Calibration

Conclusions Pertaining to Publications on Visitor Use Estimation

Key insights from the literature reviewed relevant to visitor use estimation are as follows:

- Conventional methods for visitor use estimation generally focused on direct observational counts, surveys, and physical counting devices such as trail or traffic counters. In many cases, these tools and techniques may be combined to assist in further calibrating and triangulating visitor use estimates.

- Trail or traffic counters can be challenging to use to ensure visitors are being properly counted and that multiple counts are corrected where feasible. Direct observation at the site of where automated counters are placed can be used to create adjustment factors to create more accurate estimates. Researchers stress that trained personnel are an important part of accurate visitor use estimation even when relying on automated counts.

- Visitor use studies frequently use survey data to gauge behavioral patterns not feasible to collect using counting equipment such as psychological elements of the experience, detailed trip patterns, and true behavior along trail systems. Surveys paired with robust count mechanisms can be used to extrapolate results to additional sites not captured in the original study area.

- Conventional use estimation methods generally have a higher degree of accuracy than most emerging sources; however, there is a much higher degree of labor required, and covering multiple sites at once is challenging and expensive. Therefore, joining multiple methodologies together (e.g., conventional and emerging) may create efficiencies and may provide acceptable levels of accuracy in some contexts.

- Emerging forms of data are best suited for complementing, not completely replacing, the traditional counting methods and must be calibrated to on-site counts. The visitation estimates derived from emerging data have better precision on an annual, quarterly, or monthly scale, and are less accurate on a weekly or daily level. Emerging data are better suited for estimating visitor use in busier and denser parks and protected areas (PPAs) with relatively high recreation activity.

- The three primary types of emerging data used for PPA applications to date include: (1) passive mobile data, (2) GPS-based app tracking data, and (3) social media and search engine data.

- Passive mobile data may be a suitable option to estimate visitor use in porous and dispersed recreation areas where conventional methods are difficult. Compared to app-tracking and social media data, it has three advantages:

    - Collecting passive mobile data does not require active participation, which reduces cost for data collection.

    - Passive mobile data can be used to identify the locations where visitors entered the park from surrounding neighborhoods and secondary entrances.
    - Passive mobile data have been widely used in transportation research with examples of origin-destination analysis, which can illustrate relationships with PPAs and surrounding communities, and intra-destination mobility analysis.

- GPS-based app tracking data appear particularly practicable to measure trail use:
    - App tracking is particularly useful to view visitor flow networks and patterns into, through, and out of PPAs.
    - App tracking data programs also have the ability to differentiate user groups (i.e., pedestrian and bicycle use).

- Social media data perform better when applied to a broader spatial scale, such as an entire park unit instead of high-resolution individual trails. Although much of the existing research leverages social media geotagged photos, photo-based methods have several limitations: (1) Social media data are not representative of the visitor population, and with some platforms losing popularity (e.g., Facebook), there are concerns about whether social media sites are considered consistent and reliable data sources for this purpose; (2) spatial accuracy is questionable, especially when users may manually assign the photo's location; (3) crowdsourced photographs are susceptible to poor weather and seasonality. Compared to social media data, search engine data may be better suited as a predictor for tourism demand, which has relatively fewer applications in PPAs.

- More recent studies rely on statical relationships rather than correlation analysis to estimate visitation. These studies tend to build a statistical model to relate visitation proxies derived from emerging data and ground-based visitation measures at representative locations, and then use this model to calibrate the visitation proxies for other locations. The most popular type of statistical model is specified in log-log form. Additional explanatory variables are commonly added into the statistical model to improve the predictive accuracy, including socio-economic variables, meteorological data, and time fixed effects. The use of statistical methods further motivated the need to collect more accurate, consistent, and unbiased observations of visitation using traditional methods.

- The reviewed papers also highlight several factors that might affect the precision of visitation estimates based on emerging data methods:
    - Emerging data are not specifically intended for visitor use estimation in recreation settings; a particular challenge is distinguishing park visits/visitors from non-recreation travel in some study locations.

- Emerging data samples may not be representative of visitor populations. The magnitude of this bias likely depends on the type of site, recreational activity, and data types. Unrepresentative demographics can be adjusted using weighting derived from surveys in conjunction with statistics of the number of users and demographic profile from the data providers.
- The precision of visitation estimates derived from emerging data varies among different visitor groups. Proper segmentation of visitors may improve the accuracy of the visitation estimate.
- Uncertainty resulting from spatial accuracy can be a concern when leveraging emerging data. The accuracy of locational information depends on types of data and techniques used to assign the locational information. For passive mobile data, the spatial accuracy can range from 10 meters to several kilometers.
- The accuracy and representativeness of emerging data will vary in response to user settings, user privacy protection concerns, proprietary algorithms, and market demands that change over time.

- In summary, there are relatively few published studies using emerging data to estimate visitation in parks and protected areas generally, and for long-distance trails and rivers specifically. Pilot studies and related research are needed to further evaluate the suitability and best methods for estimating visitation using emerging data. These efforts should include scaling and validation using conventional data methods to calibrate and "ground truth" estimates using emerging data.

Visitor Profiles

This subsection of the report provides a systematic review of conventional and emerging methods for understanding profiles (i.e., characteristics) of tourists and/or visitors to various regions or outdoor areas in tabular summaries. This subsection also includes a conclusion with key insights based on the literature reviewed.

Tabular Summaries

Conventional Methods

This subsection contains tabular summaries of the literature reviewed relevant to conventional methods for understanding visitor profiles.

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Anderson, D. M., Scott, M. J., Bunn, A. L., Fowler, R. A., Prendergast, E. L., Miley, T. B., ... & Jaksch, J. A. (2002). 2001 Columbia River recreation survey—implications for Hanford Site Integrated Assessment (No. PNNL-13840). Pacific Northwest National Lab (PNNL), Richland, WA (United States).
Study Purpose	Document the current recreation use levels in these areas of the river, and elicit information on recreation-related expenditure from visitors. Economic and environmental models use this information to measure the economic and environmental risk posed by possible, but unlikely, releases of contaminants from the Hanford Site into the Columbia River.
Study Area	Columbia River
Managing Agency/Organization	Pacific Northwest National Laboratory for the United States Department of Energy
Recreation activity types	River recreation
Methods	During the summer of 2001, the United States Department of Energy (DOE) commissioned a survey of Columbia River recreationists. The survey was conducted in two parts. First, trained 2-person teams of interviewers conducted personal on-site interviews with parties of recreationists to gather information concerning time on site, activity participation, visitation habits, and trip expenditures. Second, field observations were recorded on standardized forms at the various survey points to record general conditions, person counts, and other data. Sampling for the survey interview and the field observations followed a maximum-effort approach. Surveyors entered predetermined recreation sites and attempted to survey as many parties as time and cooperation would allow. They also made field observations during 15 minutes of each hour spent on site. Each team was given a route consisting of various river access points/parks to investigate during their shift. The study also intended to collect data on the broadest array of river-based recreation activities possible. This effort was constrained by the availability of the data collection team, as they were limited to the July–August period previously indicated. As a result, traditional summer activities, like boating, swimming, water skiing, and some fishing, were well

STUDY COMPONENT	DETAILED DESCRIPTION
	sampled. However, the river hosts significant levels of recreation during other times of the year. In particular, various fishing and waterfowl hunting seasons occur outside the data collection window of this study. Though not represented in this report, those activities are acknowledged as significant in the total river-based recreation picture.
Results	The average summer river visitor spends more than $32 per river trip, of which about $18 is spent in the local economy. These numbers vary widely based on the activity set of the visitor. Boaters and water-skiers spend much more per person, while sightseers and swimmers spend much less. The average summer river recreation party consists of three adults and two children. Summer river recreationists take an average of more than 47 trips to the river each year. Summer visitors spend an average of 5.6 hours on a trip to the river. This time is composed of 1.5 hours of swimming, 0.9 hour of boating, 0.8 hour of water skiing, 0.7 hour of fishing, and 1.6 hours of other activities, including picnicking, walking, and sightseeing.
Conclusions	The survey, complemented by field observations, successfully accomplished the objectives outlined with some caveats. The study provides a thorough description of summer river recreation participation, activities, trip characteristics and duration, and trip expenditures. If a goal of the Groundwater/Vadose Zone Integration Project System Assessment Capability (SAC) approach is to model based on a complete picture of river recreation on the Columbia, an obvious limitation of this study is the focus on the summer season. This region of the Columbia Basin is well known for salmon fishing and waterfowl hunting. Primary data about these river-based activities could not be collected because these activities occur principally in the Spring and Fall. As becomes apparent from statistical results, the uncertainty bands tend to be quite wide for most survey means reported. Small sample sizes lead to these results in most cases. However, the survey, in concert with the field observations, documents the variability of recreation participation on the Columbia. Considering the tremendous range in valid responses about trip duration, trip activities, days per year spent in river recreation, and trip expenditures discovered in this study, much larger sample sizes are recommended in future data collection efforts. In the case of wide-ranging valid responses, significantly increasing sample sizes is the most effective way to tighten uncertainty bands needed for SAC modeling efforts. Uncertainty in the responses could also be mitigated to some lesser degree by using follow-up questions to probe for valid responses. That approach is more conducive to a mail survey data collection method.
Keywords	Visitor profiles; Visitor demographics; Expenditures; Visitor surveys; River recreation

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Begly, A., Eury, D., Cook, P., Le, Y. (2012). Big South Fork National River and Recreation Area visitor study. National Park Service & University of Idaho.
Study Purpose	Profile a sample of visitors to the Big South Fork National River and Recreation Area during a specific period, including their demographics, visitation behavior, expenditure, and preferences for park facilities and services. The study also aimed to gather feedback from visitors on the quality of park facilities, services, and recreational opportunities, as well as identify the most commonly visited attractions and activities in the park. Finally, the study sought to determine visitor groups' awareness of and compliance with food storage regulations in bear country.
Study Area	Big South Fork National River and Recreation Area (NRRA)
Managing Agency/Organization	National Park Service
Recreation activity types	Human presence, rafting, river activities
Methods	The methods of the visitor study involved profiling a systematic random sample of visitors to the Big South Fork NRRA during two periods between September 4–10, 2012. A total of 751 questionnaires were distributed to visitor groups, and 474 were returned, resulting in a 63.1% response rate. The questionnaires collected information on visitor demographics, park visitation history, information sources, primary reasons for visiting, length of stay, activities, expenditures, and opinions on park facilities and services. The study also included on-site interviews and observations to assess visitor behavior, satisfaction, and perceptions of park resources and services.
Results	The study found that most visitors to Big South Fork NRRA were from the United States and primarily from Tennessee. The majority of visitors were white and aged 46–65 years. The most common reasons for visiting were the scenery and the park's proximity to their home. The park's website was the preferred source of information for future visits. Visitors' expenditures averaged $204 per group and $88 per person. The study also found that most visitors rated the park's facilities, services, and recreational opportunities as "very good" or "good."
Conclusions	The study found that visitors were knowledgeable about food storage regulations in bear country at Big South Fork NRRA, and that most visitors preferred to obtain information about the park through the park's website. Finally, the study found that visitors' primary concerns were related to protecting park resources and experiences, such as clean water and scenic views.
Keywords	Visitor profiles; Visitor demographics; Expenditure; Visitor services; Visitor surveys

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Begly, A., Manni, M. F., Eury, D., Le, Y., (2012). Obed Wild and Scenic River visitor study. National Park Service & University of Idaho.
Study Purpose	Profile a sample of visitors to the Obed Wild and Scenic River during a specific period in 2012. The study gathered information on visitor demographics, behaviors, and preferences, as well as their ratings of the park's facilities, services, and recreational opportunities.
Study Area	Obed Wild and Scenic River (WSR)
Managing Agency/Organization	National Park Service
Recreation activity types	Human presence, rafting, river activities
Methods	The study used a systematic random sample of visitors to Obed WSR during a specific time period (September 11–October 4, 2012). A total of 334 questionnaires were distributed to visitor groups, with a response rate of 53%. The study collected information on visitor demographics, trip characteristics, activities, spending, preferences, and opinions through on-site questionnaires. Data were analyzed using descriptive statistics.
Results	The study found that most visitors were from the United States, primarily Tennessee, and visited the park for its scenery and climbing opportunities. Visitors were primarily interested in hiking, walking, and stopping at scenic overlooks on future visits. The study also found that visitors generally rated the park's facilities and services as very good or good and were interested in learning about the park through self-guided materials and ranger-led programs.
Conclusions	The study report provides a profile of visitors to the Obed Wild and Scenic River during a specific time period. The results provide information on visitor characteristics, trip characteristics, visitation patterns, activity participation, and preferences. Overall, visitors to the park were primarily white, male, from the United States, and visited the park to enjoy its scenery and for rock climbing opportunities. Visitors were generally satisfied with the facilities and services offered at the park. The study provides valuable information that can inform management decisions and resource allocation for the park.
Keywords	Visitor profile; Visitor demographics; Expenditures; Visitor services; Visitor surveys; Wild and Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Blotkamp, A., W. F. Boyd, G. A. Vander Stoep, S. Hollenhorst. 2011. Curecanti National Recreation Area: Summer 2011. Natural Resource Report NPS/NRPC/SSD/NRR—2011/616/107287. National Park Service, Fort Collins, Colorado.
Study Purpose	Curecanti National Recreation Area Visitor Study
Study Area	Curecanti National Recreation Area (NRA)
Managing Agency/Organization	National Park Service–U.S. Department of the Interior Natural Resource Program Center
Recreation activity types	Sightseeing, fishing
Methods	All Visitor Services Project (VSP) questionnaires follow design principles outlined in Don A. Dillman's book Mail and Internet Surveys: The Tailored Design Method (2007). Brief interviews were conducted with a systematic, random sample of visitor groups that arrived at various sites during July 3–July 11, 2010. Visitors were surveyed between the hours of 6 a.m. and 7 p.m. The Curecanti NRA questionnaire was developed at a workshop held with park staff to design and prioritize the questions. No pilot study was conducted. Visitors were greeted, surveyed, and provided a pre-addressed envelope to return the complete survey after their visit. Reminder postcards were sent two, four, and seven weeks after respondent's visits. Returned questionnaires were coded and the visitor responses were processed using custom and standard statistical software applications—Statistical Analysis Software® (SAS), and a custom designed FileMaker Pro® application. Non-response bias was also checked.
Results	This visitor study report profiles a systematic random sample of Curecanti NRA visitors during July 3–11, 2010. Thirty-eight percent of visitor groups were in groups of two and 29% were in groups of five or more. Sixty-three percent of visitor groups were in family groups. Ninety-nine percent of visitation came from U.S. residents. Forty-four percent of visitors visit Curecanti NRA one to eleven times per year. Ten percent of visitor groups had members with physical conditions that made it difficult to access or participate in activities or services. Hiking, using stairs, and walking were the services/activities most commonly listed as difficult to access or participate in. The average length of stay in the park was 53.3 hours, or 2.2 days. The highest combined proportions of "extremely important" and "very important" ratings of protecting park attributes, resources, and experiences included clean water (97%), clean air (95%), and scenic views (89%). Most visitor groups (85%) rated the overall quality of facilities, services, and recreational opportunities at Curecanti NRA as "very good" or "good." Less than 2% of groups rated the overall quality as "very poor" or "poor."

STUDY COMPONENT	DETAILED DESCRIPTION
Conclusions	This report profiles a systematic random sample of Curecanti NRRA visitors, which aimed to profile visitors and understand their behavior and opinions about the park's facilities and services. Visitors predominantly used the area's trails during their visits and rated ranger-led programs as "extremely important." Most groups rated facilities well, and in conjunction with the other results have good perceptions of the Curecanti NRA.
Keywords	Visitor profiles; Visitor demographics; Visitor services; Visitor surveys

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Blotkamp, A., N. C. Holmes, W. Morse, S. J. Hollenhorst. 2011. Chattahoochee River National Recreation Area: Summer 2011. Natural Resource Report NPS/NRPC/SSD/NRR—2011/636/106766. National Park Service, Fort Collins, Colorado.
Study Purpose	Chattahoochee River National Recreation Area Visitor Study
Study Area	Chattahoochee River National Recreation Area (NRA)
Managing Agency/Organization	National Park Service–U.S. Department of the Interior Natural Resource Program Center
Recreation activity types	Walking, hiking, running, jogging, enjoying solitude/quiet, general exercise
Methods	All Visitor Services Project (VSP) questionnaires follow design principles outlined in Don A. Dillman's book Mail and Internet Surveys: The Tailored Design Method (2007). Brief interviews were conducted with a systematic, random sample of visitor groups that arrived at selected locations in Chattahoochee River NRA during June 15–24, 2010. Visitors were surveyed between the hours of 7 a.m. and 7 p.m. The Chattahoochee River NRA questionnaire was developed at a workshop held with park staff to design and prioritize the questions. Some of the questions were comparable with VSP studies conducted at other parks while others were customized for Chattahoochee River NRA. No pilot study was conducted to test the Chattahoochee River NRA questionnaire. However, all questions followed Office of Management and Budget (OMB) guidelines and/or were used in previous surveys, thus the clarity and consistency of the survey instrument have been tested and supported. Visitors were greeted, surveyed, and provided a pre-addressed envelope to return the complete survey after their visit. Reminder postcards were sent two, four, seven, and twelve weeks after respondent's visits due to low response rates. Returned questionnaires were coded and the visitor responses were processed using custom and standard statistical software applications—Statistical Analysis Software® (SAS), and a custom designed FileMaker Pro® application. Non-response bias was also checked.
Results	This report profiles a systematic random sample of Chattahoochee River NRA visitors. Thirty-five percent of visitor groups were alone and 34% were in groups of two. United States visitors comprised 99.8% of total visitation during the survey period, with international visitors from two countries. Thirty-six percent of visitors were ages 36–55 years, 14% were ages 15 years or younger, and 5% were ages 66 or older. Thirty-one percent of visitors visit the park occasionally during the year and 28% visit every week. Thirty-nine percent of visitor groups spent up to one hour visiting the park, and the average length of visit was 2.1 hours. The most common activities among visitor groups were walking/hiking (54%), exercising/running/ jogging (41%), and enjoying solitude/quiet (33%). The most common units visited/used on this visit were Columns Drive (27%) and Interstate North Parkway (21%). The information service most commonly used by visitor groups was the directional signs (58%). The information service that

STUDY COMPONENT	DETAILED DESCRIPTION
	received the highest combined proportion of "extremely important" and "very important" ratings was ranger-led programs (78%, N=37). The visitor services and facilities most commonly used by visitor groups were the trails (75%) and restrooms (53%). The visitor service/facility that received the highest combined proportion of "extremely important" and "very important" ratings was the trails (97%, N=383). Most visitor groups (90%) rated the overall quality of facilities, services, and recreational opportunities at Chattahoochee River NRA as "very good" or "good." One percent of visitor groups rated the overall quality as "very poor" or "poor."
Conclusions	This report profiles a systematic random sample of Chattahoochee River NRA visitors, which aimed to profile visitors and understand their behavior and opinions about the park's facilities and services. Visitors predominantly used the area's trails during their visit and rated ranger-led programs as "extremely important." Most groups rated facilities well, and in conjunction with the other results have good perceptions of the Chattahoochee River NRA.
Keywords	Visitor study, Chattahoochee River National Recreation Area, demographics, interpretive services, visitor services, overall quality

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Blotkamp, A., Le, Y., Hollenhorst, S. J., (2010). Niobrara National Scenic River visitor study. National Park Service & University of Idaho.
Study Purpose	Profile a systematic random sample of Niobrara National Scenic River visitors during a specific time period and gather information on visitor characteristics, behaviors, and preferences, as well as their ratings of the park's facilities and services. The study also aimed to assess visitor satisfaction and identify opportunities for improvement in visitor services and resource management.
Study Area	Niobrara National Scenic River
Managing Agency/Organization	National Park Service
Recreation activity types	Human presence, rafting, river activities
Methods	The study distributed 526 questionnaires to a systematic random sample of visitors at Niobrara National Scenic River during July 30–August 7, 2010. Of those, 317 questionnaires were returned resulting in a 60.3% response rate. The questionnaire asked visitors about their demographics, previous visits, length of stay, activities, and satisfaction with facilities and services. The data were analyzed to determine visitor characteristics, preferences, and behaviors.
Results	The majority of visitors were from the United States, with 70% from Nebraska and 29 other states represented. Most visitors were white and 97% of visitors were from the U.S. Family groups made up the majority of visitor groups, and the most common reason for visiting was to enjoy recreation in the park, with canoeing/kayaking/rafting being the most common activity. The park was a primary destination for most visitors, and the average length of stay was 1.7 days. Visitors obtained information about the park primarily through friends, relatives, and word of mouth. The park website was the most commonly preferred method of obtaining information for a future visit.
Conclusions	According to the visitor study report, the most common activities that visitors participated in at Niobrara National Scenic River were canoeing/kayaking/rafting and tubing. Visitors also enjoyed natural quiet and scenic views. The most important activity to visitors was tubing. Visitors obtained information about the park prior to their visit through friends/relatives/word of mouth, and the park's website was the most common source of information for future visits. The most commonly visited location was Smith Falls State Park, and the most common location visited first was Fort Niobrara National Wildlife Refuge Launch Site, while the most common location visited last was Brewer Bridge Landing.
Keywords	Visitor profiles; Visitor demographics; Expenditures; Visitor services; Visitor surveys; National Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Blotkamp, A., Morse, W., Hollenhorst, S. J., (2010). Little River Canyon National Preserve visitor study. National Park Service & University of Idaho.
Study Purpose	Profile a sample of visitors to Little River Canyon National Preserve from June 6–12, 2010, and provide information on their activities, interests, sources of information, and commonly visited locations. The study aimed to understand visitor behavior and preferences in order to inform park management decisions.
Study Area	Little River Canyon National Preserve
Managing Agency/Organization	National Park Service
Recreation activity types	Human presence, rafting, river activities
Methods	This report describes the results of a visitor study at Little River Canyon National Preserve during June 6–12, 2010. A total of 488 questionnaires were distributed to visitor groups. Of those, 210 questionnaires were returned resulting in a 43% response rate.
Results	The results of the study showed that most visitors to Little River Canyon National Preserve during the survey period were from the United States, with the majority from Alabama and Georgia. The visitors were mostly in family groups, with 39% in groups of two and 34% in groups of three or four. General sightseeing and touring/driving Little River Canyon scenic drive were the most common activities during the visit. The most commonly used visitor services and facilities were the Canyon Center restrooms and picnic areas. Visitors rated the overall quality of facilities, services, and recreational opportunities at the preserve as “very good” or “good.”
Conclusions	The report notes that the results provide insight into the characteristics and behavior of visitors to Little River Canyon National Preserve, which can inform future management and decision-making at the park.
Keywords	Visitor profiles; Visitor demographics; Expenditures; Visitor services; Visitor surveys

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Bowker, J.M., Bergstrom, J. C., Gill, J., Lemanski, U. (2004). The Washington & Old Dominion Trail: An assessment of user demographics, preferences, and economics. USDA Forest Service, University of Georgia, and the National Park Service.
Study Purpose	Quantify trail use, user demographics and preferences, the economic benefit to trail users, and the economic impacts to local communities to recreational trail use across the Washington and old Dominion Trail of Virginia.
Study Area	Washington and Old Dominion Trail (W&OD), a 45-mile-long transportation and recreation corridor running from Arlington, Virginia, west to Purcellville, Virginia
Managing Agency/Organization	USDA Forest Service and the University of Georgia
Recreation activity types	Equestrians, mountain biking, running, walking
Methods	The W&OD Trail study was conducted in 2003–2004, with data collection occurring between May 2003 and April 2004. The study took place on the trail, through a self-administered two-page survey, made available to trail users by volunteers and Northern Virginia Regional Park Authority (NVRPA) personnel. A quota sampling approach was used with a goal of 1,500 survey respondents. Data collection was done via guidelines set by the project planning team and implemented on the dates of surveyor availability, which were representative of typical trail use. Two different questionnaires were administered for locals and non-locals.
Results	Information from completed questionnaires was combined with on-site summer visitor counts at various trail segments to arrive at an annual estimate of adult visits (aged 16 and older) of 1,707,353. Of this number 5.24% or 89,807 of the visits, amounting to 33,262 group trips were from users living outside the Northern Virginia area. The remainder of the visits, 1,617,546, were from local residents. Trail users were primarily white (85%) and evenly split along gender lines. The largest two age cohorts were those aged 36–45 and 46–55. Average annual household income for users was just under $100,000. The average user group size for all visitors was 1.7, but more than 57% of visitors were using the trail alone. Nonlocals traveled from an average distance of just under 200 miles. Summer accounted for 40% of the share of annual use for locals, with spring and fall at almost 30% each and winter use accounting for just over 10%. Most users (85%) claimed that recreation and fitness was the main reason for their use of the trail. Among users, biking (66%), walking (16%), and jogging (16%) were the main observed activities. Among the benefits received by users, health, a safe place to recreate, and nature were the most highly ranked. An estimated 1.7 million adult W&OD users spent in total about $12 million annually related to their recreational use of the trail. Of this amount, about $7 million was spent directly in the Northern Virginia economy by locals and nonlocals using the trail. The estimated 1.6 million local visits accounted for about $5.3 million of spending directly related to the use of the W&OD. Nonlocal visitors spent about $199 per group trip and $74 per person to visit the

STUDY COMPONENT	DETAILED DESCRIPTION
	W&OD. Of this amount, $41.50 per group and $15 per person was spent in the Northern Virginia economy directly related to trail use. Overall, the estimated $1.4 million in nonlocal spending generated about $1.8 million in local economic impacts and supported 34 full time job equivalents, and about $642 thousand of personal income.
Conclusions	While access to the trail is "free," there is nevertheless considerable economic value that accrues to W&OD users. This net economic value or consumer surplus is a dollar measure of the amount of welfare that users would lose if the trail were unavailable. Using conventional economic methods, it was determined that, on average, a trip to the W&OD was worth between $9 and $14 dollars per person more than the average cost to use the trail. Extrapolating this net economic benefit across 1.7 million adult visits, of which 93% were for the primary purpose of visiting the W&OD, leads to an annual net economic benefit of trail access to users of between $14.4 and $21.6 million. Because the W&OD is primarily a local resource (95% of visits are by locals) rather than a destination trail, the vast majority of these net economic benefits accrue to Northern Virginia residents.
Keywords	Visitor profiles; Visitor demographics; Expenditures; Visitor services; Visitor surveys; Economic benefit

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Daigle, J. J., & Cooper, A. (2004). Allagash Wilderness Waterway visitor survey.
Study Purpose	Present findings of visitor use and experiences on the Allagash Wilderness Waterway, which were designed to re-assess the visitor experiences identified as being important in the previous 2003 visitor survey, and collect new information such as trip expenses as well as transportation information from visitors. The report aims to help the Bureau of Parks and Lands and others interested in the management of the Allagash Wilderness Waterway by providing insights into the different types of visitors, their needs and expectations, and the different levels of importance they place on recreation opportunities and conditions.
Study Area	Allagash Wilderness Waterway (AWW)
Managing Agency/Organization	Maine Agricultural and Forest Experiment Station
Recreation activity types	Human presence
Methods	To collect information from visitors, two survey instruments were used: a short visitor survey card and a more extensive self-administered online questionnaire. Visitors were greeted in person at one of three checkpoints near the AWW and were asked to participate in the study. Rangers also mentioned the study and asked visitors if they were interested in participating. The visitor contacts were made from June to October, with most contacts made at the Telos, Six Mile, and Allagash checkpoints by employees for North Maine Woods. However, some visitors were missed during the study period due to staff changes at the checkpoints, limited access points to the watercourse, and the fact that rangers do not connect with all visitors.
Results	The report analyzed data collected from a short visitor survey card and a more extensive online questionnaire to better understand the social and resource conditions important to the visitor experience on the AWW. The data were organized into five categories: visitor use characteristics, visitor experiences, visitor preferences for resource and social conditions, travel modes and experiences, and visitor trip expenses. The report's conclusion emphasizes the importance of understanding the different types of visitors to the AWW and their needs and expectations to maximize the quality of their experiences while protecting the unique natural setting.
Conclusions	This report presents the findings of a visitor survey conducted to better understand the social and resource conditions important to the visitor experience on the AWW. The study collected information from visitors using two survey instruments: a short visitor survey card and a more extensive self-administered online questionnaire. Information was collected from visitors between June and October 2019, using a sampling approach at three checkpoints near the AWW, as well as through rangers initiating contact with visitors about the study. The study found that protecting the backcountry experiences of AWW visitors is key to maximizing the quality

STUDY COMPONENT	DETAILED DESCRIPTION
	of the visitor experiences while protecting the unique natural setting. The report is organized into five broad categories involving visitor use characteristics, visitor experiences, visitor preferences for resource and social conditions, travel modes and experiences, and visitor trip expenses. The study provides visitor management implications and suggests further research focus on the diversity of use of the AWW.
Keywords	Visitor profiles; Visitor demographics; Expenditures; Visitor experiences; Visitor preferences; Visitor surveys

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	English, D. B., White, E. M., Bowker, J. M., & Winter, S. A. (2020). A review of the Forest Service's national visitor use monitoring (NVUM) program. *Agricultural and Resource Economics Review, 49*(1), 64–90.
Study Purpose	Document the Forest Service's nationwide effort to collect information on visitors to sites across the country. The program serves as a model for estimating demographics across a wide landscape of units.
Study Area	U.S.
Managing Agency/Organization	US Forest Service (USFS)
Recreation activity types	All
Methods	Surveys, Counts
Results	Through the lifecycle of this project, the USFS has been able to systematically sample forests across the country to help estimate visits and responses from those visitors. Overall, the data have remained relatively consistent for estimating topics such as visitor spending, trip types, demographics, and more. Throughout the years, improvements have been made to better sustain needed sample sizes, reduce confusion among respondents, and address new topics.
Conclusions	The program has led to numerous improvements in the USFS' use of data across the agency. Identifying activity participation and spending has allowed for future planning to accommodate expansions in these offerings. Furthermore, the program sets up a framework for other similar agencies to take on a large-scale visitor use effort.
Keywords	Visitor profiles; Visitor demographics; Expenditures; Visitor surveys; US Forest Service National Visitor Use Monitoring Program

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Manni, M., Hollenhorst, S. J. (2005). Chickasaw National Recreation Area: Summer 2005. Visitor Services Project Report 166. National Park Service, Fort Collins, Colorado.[1]
Study Purpose	Chickasaw National Recreation Area Visitor Study
Study Area	Chickasaw National Recreation Area (NRA)
Managing Agency/Organization	National Park Service–U.S. Department of the Interior Natural Resource Program Center
Recreation activity types	Swimming, walking, hiking, picnicking
Methods	All VSP questionnaires follow design principles outlined in Don A. Dillman's book Mail and Internet Surveys: The Tailored Design Method (2000). Brief interviews were conducted with visitor groups, and 883 questionnaires were distributed to a random sample of visitor groups who arrived at Chickasaw NRA during the period from July 1–10, 2005. No pilot study was conducted, and all questions followed Office of Management and Budget (OMB) guidelines. Visitors were greeted, surveyed, and provided a pre-addressed envelope to return the complete survey after their visit. Reminder postcards were sent seven weeks after respondent's visits. Returned questionnaires were coded and the information was entered into a computer using standard statistical software packages—Statistical Analysis System (SAS) and Statistical Package for the Social Sciences (SPSS). Non-response bias was also checked.
Results	This report describes the results of a visitor study at Chickasaw NRA during July 1–10, 2005. Twenty-five percent of visitor groups were in groups of seven or more, 21% were in groups of two, and 20% were groups of three. Fifty-eight percent of the visitor groups were family groups. Forty-nine percent of visitors were ages 26–55 years and 26% were ages 15 or younger. United States visitors were from Oklahoma (39%), Texas (15%), and 15 other states. International visitors, comprising 1% of the total visitation, were from China (54%), Japan (23%), and Mexico (23%). Twenty-one percent of visitors visited Chickasaw NRA for the first time in their life and 38% visited once in the past 12 months. The most used visitor services/facilities by the 435 visitor groups included parking (85%) and restrooms (80%). The visitor services/facilities that received the highest combined proportions of "extremely important" and "very important" ratings included campgrounds (97%, N=138), restrooms (96%, N=332), and boat launches (96%, N=167). The visitor services/facilities that received the highest combined proportions of "very good" and "good" quality ratings included boat launches (91%, N=163) and campgrounds (91%, N=135). The average of total expenditures in and

[1] This study is part of a larger series of studies titled the "Visitor Services Project" (VSP), which was administered by NPS from the mid-1980s to the mid-2010s. This and other VSP studies were not specifically studies of long-distance trails or rivers, but they provide an example of conventional methods to understand visitor characteristics.

STUDY COMPONENT	DETAILED DESCRIPTION
	outside the park (within 50 miles of park) per visitor group was $243. The median visitor group expenditure (50% of groups spent more, 50% of group spent less) was $114. The average per capita expenditure was $50. Most visitor groups (90%) rated the overall quality of services, facilities, and recreational opportunities at Chickasaw NRA as “very good” or “good.” One percent of groups rated the overall quality as “very poor” or “poor.”
Conclusions	This report profiles a systematic random sample of Chickasaw NRA visitors, which aimed to profile visitors and understand their behavior and opinions about the park’s facilities and services. Visitors predominantly used the area’s trails during their visit and rated ranger-led programs as “extremely important.” Most groups rated facilities well, and in conjunction with the other results have good perceptions of the Chickasaw NRA.
Keywords	Visitor profiles; Visitor demographics; Expenditures; Visitor services; Visitor surveys

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Coleman, Sevylor, Stearns, & The Outdoor Foundation (2015). 2015 Special Report on Paddlesports. www.outdoorfoundation.org
Study Purpose	Special report on paddlesports
Study Area	United States of America
Managing Agency/Organization	Partnership Project of Coleman, Sevylor, Stearns, and the Outdoor Foundation
Recreation activity types	Paddlesports
Methods	Each year the Physical Activity Council (PAC) carries out the largest sports participation study in the USA. During January and February of 2014, a total of 10,778 online interviews were carried out with a nationwide sample of individuals and households from the U.S. Online Panel of over 1 million people operated by Synovate/IPSOS. A total of 5,067 individual and 5,711 household surveys were completed. The total panel is maintained to be representative of the U.S. population for people ages 6 and older. Over sampling of ethnic groups took place to boost response from typically under responding groups. All interviews of children under 13 were carried out following the guidelines set out in the Children's Online Privacy Protection Act of 1998 (COPPA). No children were contacted directly. The panel is a balanced sample of households with children in each age group, but contact is always made through designated adult panelists. The adult panelist receives the survey invitation on behalf of a specified child, age 6 to 12, and they are asked to complete the survey together. Respondents ages 13 to 17 are contacted in a manner similar to respondents at age 6 to 12, but they are asked to complete the survey themselves.
Results	Kayaking is the most popular form of paddling, increasing from 3% of Americans participating in 2010 to 4.4% in 2014. Kayakers are the most avid paddlers, averaging 8.1 outings. Overall, kayaking is most popular among young adults, ages 18 to 24. Interestingly, a majority of participants in this age group—62%—are female. Canoeing participation slightly decreased in 2014 but the sport remains the second most popular paddlesport. Consistent with previous years, canoeing participants are the least ethnically diverse. Eighty-two percent are Caucasian, and only 18% come from other ethnic groups. Canoeing participants tend to live in the East North Central region, which includes the five states bordering the Great Lakes. Participation in rafting, the third most popular type of paddlesport, has remained stagnant at 1.3% for the past four years. The sport is most popular among teens, ages 13 to 17. This group is 67% male. In fact, rafting is the only paddlesport that is more popular among males than females in every age group. Stand up paddling continues to increase in popularity. In 2014, 2.8 million Americans, almost 1% of the population, participated in stand-up paddling. These participants averaged five annual outings each, making a total of 13.7 million outings last year. Participation increased among all age groups. The majority of paddlers (all types) are motivated to

STUDY COMPONENT	DETAILED DESCRIPTION
	get outside to exercise. Adult paddlers, ages 25 to 44, are the most likely participants to describe themselves as paddling fanatics. That age group is also the most likely to say they are "hooked" on paddlesports. When comparing genders, female participants are the most likely to describe themselves as fanatics, while males are the most likely to describe themselves as hooked on the sport.
Conclusions	The fifth annual Special Report on Paddlesports shows that paddlesports are on the rise, again setting a record for the number of participants. In 2014, 21.7 million Americans—7.4% of the population—enjoyed paddling. This represents an increase of more than 3 million participants since the study began in 2010. Paddlers averaged seven annual outings in 2014, up from 6.8 the year before. Collectively, paddling participants made nearly 216 million outings. Though paddling participation is rising, there is significant growth potential among minorities, which are underrepresented in the sport.
Keywords	Visitor profiles; Visitor demographics; Visitor surveys

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Manni, M. F., Le, Y., Hollenhorst, S. J. (2012). Missouri National Recreational River visitor study. National Park Service & University of Idaho.
Study Purpose	Profile visitors to the Missouri National Recreation River (NRR) during a specific time period, including their demographics, visitation patterns, preferred activities, use of information sources, and opinions on park attributes and resources.
Study Area	Missouri National Recreational River
Managing Agency/Organization	National Park Service
Recreation activity types	Human presence, rafting, river activities
Methods	The study used a systematic random sampling method to survey visitors to the Missouri National Recreational River during a specific period in July 19–25, 2012. A total of 467 questionnaires were distributed to visitor groups, and 256 questionnaires were returned, resulting in a 54.8% response rate. The survey collected data on visitor demographics, trip characteristics, park awareness, information sources, activities, interests, and satisfaction with park facilities, services, and recreational opportunities. The data were analyzed to provide insights into visitor preferences, behavior, and attitudes towards the park.
Results	The study found that most visitors were from the United States, with a majority visiting as family groups and preferring to use English for communication. Visitors were most commonly interested in natural quiet, swimming/playing in the water, and hiking, and rated park facilities and services as “very good” or “good.” The study also identified areas of interest for visitors, including attending extended and ranger-led programs and learning about topics such as wildlife, early exploration, and Native American cultures.
Conclusions	Overall, most visitors were U.S. citizens, and many were repeat visitors who visited the park for natural, cultural, and recreational activities. Visitors preferred the Lewis & Clark Visitor Center, Riverside Park, Ponca State Park, and Chief White Crane Campground. Most visitors found the quality of facilities, services, and recreational opportunities to be “very good” or “good.” The report provides insights into visitor interests, motivations, and preferences that can inform park management decisions and help enhance visitor experiences.
Keywords	Visitor profiles; Visitor demographics; Expenditures; Visitor services; Visitor surveys; Recreational River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Manni, M. F., Le, Y., Littlejohn, M. A., Hollenhorst, S. J. (2004). New River Gorge National River Visitor Services Project report 153. National Park Service & University of Idaho.
Study Purpose	Describe the results of a visitor study conducted at New River Gorge National River (NR) during June 19–27, 2004. The report provides a profile of the visitors, including their demographics, information sources, and reasons for visiting, as well as their use and satisfaction with park services and facilities. The report also includes visitors' comments about their visit. The study aimed to provide information to park managers and policymakers to enhance visitor experiences and to identify areas for improvement in the park.
Study Area	New River Gorge
Managing Agency/Organization	National Park Service
Recreation activity types	Human presence, rafting, river activities
Methods	The New River Gorge NR questionnaire was developed based on design principles outlined in Don A. Dillman's book and customized for the park. The survey was distributed to a sample of visitor groups who arrived at the park and visitors were asked to complete the questionnaire after their visit and return it by mail. Reminder/thank you postcards and replacement questionnaires were sent to those who did not respond. The data were coded and entered into a computer using a statistical software package, and frequency distribution and cross-tabulations were calculated for the coded data. The sample size varies depending on the figure, and missing data and reporting errors may occur due to unanswered questions or mistakes by respondents.
Results	This report presents the results of a visitor study at New River Gorge National River during June 19–27, 2004. The study shows that the majority of visitors were family groups and aged between 26–60 years. The most common reasons for visiting were to participate in recreation and visit New River Gorge NR. Visitors obtained information about the park mainly through previous visits and word of mouth. The average visitor group expenditure in and outside the park was $403, and the most used interpretive services were the park brochure/map and visitor center exhibits. Most visitor groups rated the overall quality of visitor services as "very good" or "good."
Conclusions	The report describes the results of a visitor study at New River Gorge National River, which aimed to profile visitors and understand their behavior and opinions about the park's facilities and services. The conclusion of the study is that the park is meeting visitors' needs and expectations, and that efforts to maintain and improve services should continue.
Keywords	Visitor profiles; Visitor demographics; Expenditures; Visitor services; Visitor surveys

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Tuck, B., & Linscheid, N. (2016). Profile of Mesabi Trail visitors: People traveling more than 50 miles or staying overnight to use the trail.
Study Purpose	Club Mesabi is an organization that promotes and supports the Mesabi Trail through education and advocacy, encouraging its use as part of a healthy lifestyle. Club Mesabi also organizes and hosts the annual Great River Energy Mesabi Trail Tour. Club Mesabi is interested in learning more about trail users, particularly those traveling to the region with the purpose of recreating on the trail. In order to understand visitors, Club Mesabi, with support from its partners, commissioned University of Minnesota Extension to conduct a visitor profile.
Study Area	The Mesabi Trail (Minnesota)
Managing Agency/Organization	St. Louis & Lake County Regional Railroad Authority
Recreation activity types	Hiking, biking, walking, in-line skating
Method	Intercept Survey
Results	The study reported the following statistics: "More than 90% of visitors report staying overnight in the region while visiting the trail, spending three nights on average. The majority of visitors patronize local lodging establishments or otherwise pays for accommodations. Fifty-three percent stayed in a hotel, motel, inn, bed and breakfast, or hotel; 17% stayed at a private or public campground; and 9% stayed in a rental home, cabin, or resort. Less than one-quarter (24%) stayed in non-paid accommodations (own vacation home or with friends/family). Mesabi Trail visitors spend an average of $143.90 per person per day during their visit to the region. Major per person expenditures per day include lodging ($56.60), prepared food and beverage ($30.40), transportation alternatives in the region, such as shuttles, rentals, and tours ($11.80), and gasoline ($11.50). Given that the average person stays three days, total spending during the trip is $431.70. The average party size is four, translating into average trip party spending of more than $1,700. A party of four Mesabi Trail visitors generates an estimated $2,762.10 in economic activity during their three-day trip. An increase in trail visitors could have implications for regional tourism."
Conclusions	The article discusses potential ways to increase the influence of the Mesabi Trail. One suggestion is to extend the trail to Ely, which could attract more visitors to the city. Targeting millennials may also open up new markets for the trail. Collaboration between local recreational and tourism attractions and the trail is seen as a way to increase visitor numbers for both. A survey was conducted, in which participants were asked about their engagement in other activities during their trail visit, such as visiting a state park, museum, or participating in other recreational activities. The results showed that over 70% of respondents did not engage in such activities. Therefore, increasing collaboration between tourism destinations and the trail could offer opportunities to increase trail ridership and participation in other activities.
Keywords	Visitor profiles; Expenditures; Visitor surveys; Long-distance trail

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Tyson, B., Thorson, J., & Maliar, D., (2009). Use and economic importance of the Lower Farmington River and Salmon Brook. The Center for Public Policy and Social Research. Central Connecticut State University.
Study Purpose	Conduct four different surveys to assess the recreational use and values attached to the Farmington River and Salmon Brook, the impact of proximity to the river and brook on real estate values in the area, and support for watershed protection measures among residents and business owners in the area. The surveys were conducted between May and October 2008, and data were collected through in-person and mail surveys, as well as a review of real estate sales data.
Study Area	The Farmington River and Salmon Brook
Managing Agency/Organization	The Center for Public Policy and Social Research & Central Connecticut State University
Recreation activity types	A variety of outdoor recreation activities
Methods	The study conducted four separate surveys to assess the value and impact of the lower segment of the Farmington River, Salmon Brook, and lands that border it. A brief in-person survey was first conducted at 15 recreation access points, with 566 intercept interviews completed over 60 days. Total recreation use estimates were used for economic impact calculations. A mail survey was conducted of the 566 respondents to assess recreational use and values. A mail survey was also conducted of 600 residents living close to the river/brook and 30 owners/managers of nearby businesses to assess their values and support for watershed protection measures. Lastly, the impact of proximity to the river/brook on real estate values in the 10-town study area was assessed using a hedonic price model based on data from 700 residential property sales.
Results	Respondents in the survey are predominantly white (95.6%), in their mid-50s, with about 60/40 female/male, and about two-thirds having graduated college. About 40% of respondents have a household income of less than $60,000, and about another 40% have a household income between $60,000 and $120,000. The majority of respondents (84.4%) live in single-family homes, which they own, with an average household size of 2.42 people. Most (71.3%) say the Lower Farmington River defines where their home is located. The top five motivations for engaging in recreational activities in the area are to enjoy the view along the water, to be close to nature, to relax, to get exercise, and to experience solitude. Over two-thirds of respondents rate the Lower Farmington River/Salmon Brook area above the scale mid-point of 3.0 when evaluating the area's recreational opportunities, and nearly half believe that the quality of the area has improved in recent years.

STUDY COMPONENT	DETAILED DESCRIPTION
Conclusions	The report describes the findings of a survey on the recreational use and value of the Lower Farmington River and Salmon Brook area in Connecticut. The results indicate that the river and brook contribute to the residents' sense of place and positively affect how they feel about where they live. Recreational activities such as walking, jogging, kayaking, and picnicking are popular, and the top motivations for engaging in these activities are to enjoy the view, be close to nature, and relax. Respondents rate the area's recreational opportunities highly, and few perceive negative impacts. The economic impact of recreation in the area is moderate, and the quality of the river and bordering lands is perceived to have improved or remained the same in recent years.
Keywords	Visitor profiles; Visitor demographics; Expenditures; Visitor surveys

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Wenatchee Valley Planning, LLC (2020). River recreation survey: Wenatchee River and Icicle Creek near Leavenworth. Chelan County Natural Resources Department, 1–19.
Study Purpose	Gather data on users of this particular river to aid the county in developing management plans and addressing usage. Additionally, characterize boating recreation within stream reaches that pass through Leavenworth, describe existing conditions, estimate river users, and identify issues on the river.
Study Area	Wenatchee River and Icicle Creek, Washington
Managing Agency/Organization	Chelan County Natural Resources Department
Recreation activity types	River recreation
Methods	Community survey, inventory analysis, counts, environmental monitoring
Results	Survey results identified that users are concerned about how recreation impacts the environment. River safety, river rescue, and the cost to the community were listed as important topics to consider. River estimates found that Fridays and weekend days are most popular on the river.
Conclusions	Results were used in community meetings to address parking fines, possible impacts to river use, and overall spending to the region. The authors suggest landowners at launch and/or take out facilities could improve infrastructure. Enforcement of laws are needed. A permit system may regulate total users, and seasonal closures may be necessary to maintain environmental quality.
Keywords	Visitor profiles; Visitor surveys

Emerging Methods

This subsection contains tabular summaries of the literature reviewed relevant to emerging methods for understanding visitor profiles.

STUDY COMPONENT	**DETAILED DESCRIPTION**
Citation	Fisher, D. M., Wood, S. A., Roh, Y. H., & Kim, C. K. (2019). The geographic spread and preferences of tourists revealed by user-generated information on Jeju Island, South Korea. *Land, 8*(5), 73.
Study Purpose	Advance the science of measuring and mapping recreation demand at landscape scales using user-generated content (e.g., Flickr photos, tweets, and mobile phone traffic) for continuous planning and management of recreation opportunities.
Study Area	Jeju Island, South Korea
Managing Agency/Organization	Multiple
Recreation activity types	Hiking, running, mountain biking, beach recreation, nature appreciation
Method	The authors compared the number of unique photographers (from Flickr photos), tweeters (from Twitter), and mobile phone customers (using the Sun Kyung Telecom network) per day against visitation counts from ticket sales or gate entries at 36 tourist sites (e.g., parks/protected areas, museums, cultural attractions, etc.)
Results	They found that densities of social media posts (from Flickr and Twitter) and mobile phone traffic are all positively correlated with ticket sales and counts of gate entries at tourist sites. They also found that Flickr and Twitter visitation-based estimates typically undercount the actual number of visits, but mobile traffic-based estimates sometimes exceed on-site visits reported by ticket sales or entry-gate counts due to the aggregate form in which the mobile data were received from the provider.
Conclusions	Visitation data provided by user-generated content open the door for statistical models that can quantify recreation demand. Managers and practitioners could combine these flexible and relatively inexpensive user-generated data with more traditional survey data to inform sustainable tourism development plans and policy decisions.
Keywords	User-generated geographic content; social media data; tourism; cultural ecosystem services; revealed preferences

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Hausmann, A., Toivonen, T., Slotow, R., Tenkanen, H., Moilanen, A., Heikinheimo, V., & Di Minin, E. (2018). Social media data can be used to understand tourists' preferences for nature-based experiences in protected areas. *Conservation Letters, 11*(1), e12343.
Study Purpose	Explore whether social media data can be used as an alternative to traditional surveys to understand tourists' preferences for nature-based experiences in protected areas.
Study Area	Kruger National Park, South Africa
Managing Agency/Organization	Multiple
Recreation activity types	Biodiversity (animals and plants as main subject of photo); human activity (biking, driving); dining
Method	The authors explored whether social media data can be used as an alternative to traditional surveys by comparing preferences for biodiversity obtained from a traditional survey conducted in Kruger National Park, South Africa, with observed preferences assessed from over 13,600 pictures shared on Instagram and Flickr by tourists visiting the park in the same time period. In more detail, social media users' observed preferences for biodiversity were measured by looking at the representation (i.e., number of pictures posted), and the proportion of likes (average like/picture/group).
Results	The authors found that the distribution (of both the number of pictures and likes) of preferences observed on social media was similar to the distribution of preferences expressed by tourists during the survey, and that combining data from different social media platforms can better assess the heterogeneous preferences of ecotourists for biodiversity. They also found that amongst the survey population, 72.5% of respondents reported actively using social media to share their nature-based experiences while visiting protected areas, which suggests that a majority of park visitors engage with social media during their visit. They found that biodiversity pictures were more frequent on Flickr than they were on Instagram. Meanwhile, pictures including people, such as human activity (e.g., biking, driving) and posing (e.g., "selfie") were more frequent on Instagram than they were on Flickr.
Conclusions	Social media content can be used as a cost-efficient way to explore, and continuously monitor preferences for biodiversity and human activities in protected areas. Instagram specifically may be the better option for studying human activity alone in protected areas.
Keywords	Visitor profiles; Visitor preferences; Social media data; Visitor surveys

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Liang, Y., Yin, J., Pan, B., Lin, M. S., Miller, L., Taff, B. D., & Chi, G. (2022). Assessing the validity of mobile device data for estimating visitor demographics and visitation patterns in Yellowstone National Park. *Journal of Environmental Management, 317*, 115410.
Study Purpose	Validate mobile data by comparing Points-of-Interest (POIs), visitor demographics, and temporal visitation patterns from mobile device data with traditional visitor surveys and count data in a national park context.
Study Area	Yellowstone National Park (YNP)
Managing Agency/Organization	Multiple
Recreation activity types	Hiking, driving, sight-seeing at points of interest
Method	To compare Points-of-Interest between mobile data and survey data, the authors performed a point in polygon geospatial analysis of the SafeGraph mobile device data coordinates to locate the top nine POIs within the boundary of the park from May through September 2018. These were compared with 2018 YNP Visitor Use Survey data results. SafeGraph and America Community Survey (ACS) data share formatting for geographical information, so the datasets were merged together, and the authors were able to extract ACS demographic and socioeconomic variables including gender, age, race, education, income, and home state to compare against the visitor survey. SafeGraph data and the count data from NPS Stats were normalized and compared using a linear regressions and Pearson's correlations.
Results	Only 40 POIs matched their location names and geographical locations among 80 POIs inside YNP as reported in SafeGraph data. The majority of those valid POIs are service facilities that fall into YNP cellular coverage areas while attractions or trails were invalid or not represented likely due to poor signal coverage. Mobile device data results revealed statistically significant differences from results in the visitor use survey regarding education levels and income levels, likely because mobile device data exclude the international visitors and include park staff (who are not technically visitors). No statistically significant differences existed between the two in terms of visitor gender distribution, and only two sub-groups of age had statistically significant differences. Mobile device data generally had strong correlations with count data regarding monthly and daily visitation patterns.

STUDY COMPONENT	DETAILED DESCRIPTION
Conclusions	The results suggest mobile device data may not be suitable for estimating visitor demographics. Compared to traditional visitor surveys, mobile device data likely have greater sampling bias, which can skew accurate portrayals of visitor demographic profiles. In addition, with mobile device data, demographics can only be analyzed with respect to Census block statistics, not at the individual level. Further research may be warranted to assess the suitability of mobile device data for estimating visitor demographics, but with these limitations in mind.
Keywords	Visitor profiles; Visitor demographics; Visitor use patterns; Mobile device data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Monz, C., Mitrovich, M., D'Antonio, A., & Sisneros-Kidd, A. (2019). Using mobile device data to estimate visitation in parks and protected areas: An example from the nature reserve of orange County, California. *Journal of Park and Recreation Administration, 37*(4), 92–109.
Study Purpose	Show that mobile device data can be used to determine basic park visitor demographic information rather than having to rely on field-based assessments (i.e., surveys).
Study Area	Three parks from The Nature Reserve of Orange County, California: Peters Canyon Regional Park (PECA), Whiting Ranch Wilderness Park (WHRA), and Top of the World/Aliso and Wood Canyons Wilderness Park (ALWO)
Managing Agency/Organization	Natural Communities Coalition; Department of Environment and Society, Utah State University
Recreation activity types	Hiking, running, mountain biking, beach recreation, and nature appreciation
Method	The authors' approach compared mobile device data on three demographic variables (race/ethnicity, average household income, and level of education) purchased from the mobile data vendor StreetLight and on-site trailhead survey data. For a most robust comparison, StreetLight pulled data from the month the on-site survey was administered (i.e., May 2017) and from polygonal geographic areas corresponding to the exact entrance areas where visitors were intercepted for the on-site survey.
Results	The authors found that StreetLight demographic estimates were, for the most part, consistent with the sample from the 2017 survey for race/ethnicity and income for two of the three parks in this analysis. However, visitors' level of education was significantly different between the survey and StreetLight dataset for the three parks. Where differences occurred between the StreetLight and survey data, they note that StreetLight data include visitors who entered from informal entrances, whereas the survey was only administered at formal parking entrances. This suggests a strength of StreetLight for visitor use monitoring in parks with porous boundaries, as sampling these visitors with traditional visitor intercept surveys may introduce systematic biases in the sample population.
Conclusions	The mobile device strategy is likely more accurate in situations where visitors enter parks from multiple, sometimes informal entry locations, but is also somewhat limited in the types of data available
Keywords	Visitor profiles; Visitor demographics; Mobile device data

Conclusions Pertaining to Publications on Understanding Visitor Profiles

Key insights from the literature reviewed relevant to understanding visitor profiles are as follows:

- Visitor profiles help to understand the people who use recreation areas, including rivers and trails. Unfortunately, both rivers and long-distance trails pose difficulties for conducting these types of surveys due to their length and users' ability to navigate on and off the site as they see fit. Many locations require multiple sampling periods to capture a large geography and ensure the data represent the entire site.

- River and trail user profiles tend to vary depending on the location along the trail or river. Certain activity classifications (e.g., class 4 or 5 rapids vs. class 1 or 2 rapids) may impact the profile at a given site. Therefore, systematic sampling is needed to fully represent the user profile.

- Conventional methods (e.g., surveys) are the prominent method for collecting data on visitor profiles, especially when it comes to collecting data on visit-specific characteristics (e.g., visitor group size). Emerging methods for understanding visitor profiles are not as prominent in the field of research because there are few ways to understand their characteristics when not intercepting them on the rivers and trails. Mobility data allow for cross-referencing Census Block demographics with visitation; however, obtaining these data at the more granular household level is not feasible. Therefore, accurate estimates of demographics from a wide geography are difficult to obtain.

- Visitor surveys could be used as an initial case study, capturing a smaller period of time to understand the typical visitor profile for a given season/year. Then, through the use of mobile device data, it would be possible to apply visitor profiles from the survey data to understand broader trends throughout the season/year.

- Mobile device data may be useful for pinpointing the best sampling locations for surveys. Understanding visitor movement patterns and temporal tracking may be helpful in designing effective sampling plans.

- Some mobility data vendors offer products to estimate characteristics of visitors, such as race and ethnicity, which can be used to help identify visitor profiles. However, there is still a consistent need for a survey to better understand the demographics and to verify the estimates available through mobility data providers.

- Preferences for outdoor recreation subjects and areas can be better understood by examining geo-tagged coordinates of photos on photo-sharing social media sites, such as Instagram, Flickr, or Twitter. A popular unit for measuring this is the "photo-user-day."

- In summary, conventional methods are required to understand demographic characteristics of visitors. Emerging data are reliable for estimating domestic visitors' state or ZIP code of residence.

Visitor Use Patterns

This subsection of the report provides a systematic review of conventional and emerging methods for understanding visitor use patterns (i.e., mobility or movement patterns) in tabular summaries. This subsection also includes a conclusion with key insights based on the literature reviewed.

Tabular Summaries

Conventional Methods

This subsection contains tabular summaries of the literature review relevant to conventional methods for understanding visitor use patterns.

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Vogel, J. J., & Chilman, K. C. (1996). A study of water-based recreation on the Upper Mississippi River (Pools 7 and 8). Army Engineer Waterways Experimental Station Vicksburg MS Environmental Lab.
Study Purpose	Test and adapt management information-gathering procedures that could be applied systematically to each pool in the Upper Mississippi River system.
Study Area	Pools 7 and 8 of the Upper Mississippi River, Wisconsin
Managing Agency/Organization	Multiple
Recreation activity types	Boating, fishing, hunting, hiking and camping, etc.
Method	The method of this paper involves a two-week reconnaissance visit to the area, during which they identified and described boater access points such as public launch ramps, marinas, and privately owned docks. The research team also pre-tested an exit interview questionnaire similar to that used in previous studies at Corps Lakes. The aerial boat count was conducted between 1:00 and 4:00 p.m., which is the busiest time of day on the river, in order to obtain data primarily for those times. The technician conducting this observation sat behind or next to the pilot (on right-hand side) and marked the locations of boats on a map with Xs/arrows indicating stationary and moving boats respectively. For trailer counts, interviewers counted the number of boat trailers present at the beginning, two hours into the interview, and at the end of the interview period.
Results	Boaters generally did not regard commercial traffic (tows) or physical hazards common to the river boating environment as significant threats to their safety or enjoyment. However, they reported some negative effects on their boating due to changes in social and resource conditions, such as a simple loss of enjoyment in fishing and pleasure boating in the area, using the river less often, or abandoning certain activities altogether. The survey also revealed that 71% were passing through Pools 7 and 8 while only 29% said it was their primary destination. The results from boat and trailer counts suggested that there was a higher proportion of boats originating at public launch ramps compared to marinas or private docks. This suggests that access points such as public launch ramps are important for recreational use in this area.

STUDY COMPONENT	DETAILED DESCRIPTION
Conclusions	Management actions are needed to protect and improve recreational experiences for visitors by targeting management efforts towards maintaining historical conditions where possible, providing access points like public launch ramps, which are important for recreational use in this area, and marking physical hazards such as wing dams appropriately.
Keywords	Visitor use patterns; Visitor perceptions; Recreational boating

Emerging Methods

This subsection contains tabular summaries of the literature review relevant to emerging methods for understand visitor use patterns.

STUDY COMPONENT	**DETAILED DESCRIPTION**
Citation	Ahas, R., Aasa, A., Roose, A., Mark, Ü., & Silm, S. (2008). Evaluating passive mobile positioning data for tourism surveys: An Estonian case study. *Tourism Management, 29*(3), 469–486.
Study Purpose	Introduce and evaluate the applicability of the passive mobile positioning data in studying tourism and assess the strengths and weaknesses of the method.
Study Area	Estonia Mobile Telephone users that are tourists (i.e., out of country) to Estonia
Managing Agency/Organization	Multiple
Recreation activity types	Tourism
Method	Use passive mobile data (i.e., the location, time, ID, and country of origin of active mobile phone usage, such as calls, incoming/outgoing text messages, internet or GPS service, etc.) of Estonian Mobile Telephone (EMT) users. To validate the mobile positioning data's ability to estimate counts of tourists, the authors compared the mobile data against the number of accommodation nights in Estonia from the Statistical Office of Estonia.
Results	From the mobile positioning data, the authors were able to extract the following: (1) the movement of a unique tourist during their stay, where movements can be sequenced in chronological order by timestamp, in both populated and remote areas; and (2) visitor origin (e.g., from which countries are people most frequently visiting Estonia). These movement and characteristic patterns can be compared across weeks/months/seasons/years, depending on the availability of data. The average monthly number of call activities from the Statistical Office accommodation data was roughly 2x higher than seen in mobile data from EMT, and percent share in positioning data vs. accommodation data varied by country (e.g., Latvian share in positioning data was 8% for positioning data but only 3% for accommodation data, whereas German share in positioning data was 3.9% but 7.3% for accommodation data).

STUDY COMPONENT	DETAILED DESCRIPTION
Conclusions	The results show that passive mobile positioning data have advantages: (1) data can be collected for larger spatial units and in less visited areas; (2) spatial and temporal preciseness is higher than for regular tourism statistics; (3) Random IDs allow one to study tourists' movements, for example to study typical routes of tourists of certain nationalities. The weaknesses of data are related to problems with accessing data, as operators do not wish to share data and because of privacy protection and surveillance concerns, and that it is a quantitative dataset with limited features. Additionally, the sample of cases in the positioning data does not capture all tourists, and therefore may not be fully representative, especially as it relates to count estimates.
Keywords	Visitor use patterns; Passive mobile data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Baird, T., Stinger, P., Cole, E., & Collins, R. (2022). Mobile device data for parks and public lands transportation planning: A framework for evaluation and applications. *Transportation Research Record, 2676*(8), 490–500.
Study Purpose	Investigate how mobile device data can enhance regional and park-level transportation planning efforts by better answering questions such as how visitors utilize park transportation networks across time and space, how visitors to National Park Service units enter and move through the state of Colorado, how behavior differs between local and non-local visitors, and the duration of time visitors stay at locations of interest.
Study Area	National Park Service (NPS) units and gateway communities in the state of Colorado
Managing Agency/Organization	Fehr & Peers; Multimodal Program, Washington Transportation Office, National Park Service; Planning Division, Denver Service Center, National Park Service
Recreation activity types	Driving, tourism, travel, park visitation
Method	The study team developed a selection and evaluation framework for selecting suitable third-party data providers, selecting StreetLight as their primary data vendor, and then acquired and processed mobile device data from the selected vendor to characterize visitor movements to, from, and within NPS units and gateway communities (e.g., inter- and intra-park movements) in the state of Colorado.
Results	They explored a variety of results, including (1) park entries and visitor centers tended to be observed as a first stop within the park, whereas destinations along Bear Lake Road were most likely to be visited as the third, fourth, or a higher-order stop within a longer trip sequence; (2) the largest share of roadway congestion was heaviest on US 36 from Estes Park to Beaver Meadows, experiencing speeds at nearly half that of free flow periods; and (3) Estes Park visitors tended to stay for longer periods, with over 70% of visitors staying for 6+ hours, probably indicating an all-day or overnight stay.
Conclusions	The StreetLight visitor data sample provides detailed historical data for understanding the relationships between gateway communities and parks, internal traffic/visitor flows, dwell times at internal park destinations, and speeds on roadways in and around the NPS units. The application of StreetLight data allows for a more systematic assessment of where and when issues occur in and around a park, however, traditional data gathering methods, such as permanent or rotating counts, should also be used to ensure robust and accurate data on long-term trends remain available.
Keywords	Visitor use patterns; Passive mobile data; Recreational travel

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	e Silva, F. B., Herrera, M. A. M., Rosina, K., Barranco, R. R., Freire, S., & Schiavina, M. (2018). Analysing spatio-temporal patterns of tourism in Europe at high-resolution with conventional and big data sources. *Tourism Management, 68*, 101–115.
Study Purpose	Improve the existing knowledge base of current spatiotemporal distributions of tourism in the EU-28 to enable new insights relevant to tourism management and policy.
Study Area	European Union (EU) countries
Managing Agency/Organization	European Commission, Joint Research Centre, Italy
Recreation activity types	Travel, overnight accommodations, tourism
Method	The authors assembled big data from official European statistical bodies about nights spent at or arrivals to tourist accommodation establishments per quarter/month and per region, and from online booking services (i.e., a big data source) about geographic coordinates and other descriptors of tourist stays at accommodation establishments. The data were combined to produce multi-temporal grid maps of tourist density.
Results	Spatially, the dataset reveals significant differences in the spatial distribution of tourism, including sprawled patterns (London and Paris), clustered (Santorini), concentrated (Venice) and linear (Rimini). Temporally, tourist density is generally the highest in August and summer is the most popular tourist season for almost every region in Europe as measured by the number of overnight tourists. Alpine areas display high tourist densities in both summer and winter but are comparatively less dense in mid-season (spring and fall), and coastal areas and islands peak significantly in summer months.
Conclusions	Statistical data from the EU on tourism, by itself, does not provide fine resolutions of spatial and temporal patterns, skewing analyses relevant for tourism management and policy. Likewise, big data, by itself, is limited in terms of incomplete penetration rates leading to selection biases. However, the patterns outlined in the results of this study are generally acknowledged amongst tourism researchers, showing that statistical data combined with big data sources have the potential to accurately summarize spatial, density, and temporal patterns at high resolutions.
Keywords	Visitor use patterns; Big data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	García-Palomares, J. C., Gutiérrez, J., & Mínguez, C. (2015). Identification of tourist hot spots based on social networks: A comparative analysis of European metropolises using photo-sharing services and GIS. *Applied Geography, 63*, 408–417.
Study Purpose	Demonstrate the potential of photo-sharing services for identifying and analyzing the main tourist attractions in eight major European cities.
Study Area	Athens, Barcelona, Berlin, London, Madrid, Paris, Rome, and Rotterdam
Managing Agency/Organization	Departamento de Geografía Humana, Universidad Complutense de Madrid
Recreation activity types	Tourism, sight-seeing, museums, ancient architecture
Method	Geotagged photographs on the Panoramio website, a photo sharing website with an emphasis on geotagging unlike Flickr and Instagram, were differentiated according to whether they had been taken by tourists or local residents, and then their spatial distribution patterns were analyzed using spatial statistical techniques in geographical information systems (GIS), for example, the number of photographs observed in spatial polygons.
Results	The results indicated the concentration and dispersion of photographs in each city and their main hot spots and revealed marked differences between tourists' and residents' photographs. London and Paris presented the highest densities of tourists' photographs. Barcelona and Rome presented a strong spatial concentration of photographs.
Conclusions	Geotagged photographs taken by tourists make it possible to identify and analyze the main visual tourist attraction areas in a city and to perform comparisons between cities. However, it's important to note that the information is biased because not all tourists make use of these photo-sharing networks, and those who do, do so with varying degrees of intensity. Additionally, the photo data commonly refer to aesthetically attractive places visited by most tourists, and does not fully reflect the attraction of other, less "photogenic" sites.
Keywords	Visitor use patterns; Big data; Social media data; Spatial analysis

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Juhasz, L., & Hochmair, H. H. (2020). Studying spatial and temporal visitation patterns of points of interest using SafeGraph data in Florida.
Study Purpose	Grow the body of literature related to analysis of spatial and temporal visitation patterns of Points-of-Interest (POIs) data.
Study Area	Miami, Orlando, and Jacksonville, Florida
Managing Agency/Organization	Florida International University; University of Florida
Recreation activity types	Travel, tourism, sightseeing
Method	Using three major Florida cities, the authors explore how temporal patterns of daily and monthly visitation numbers are correlated between various POI categories (e.g., amusement parks, grocery stores, restaurants, etc.) using correlation matrices. They also explore the effect of a short event (Hurricane Irma) on daily visitation numbers using SafeGraph data. The authors also compare travel distances from home locations to POIs between different POI categories, and Ordinary Least Squares (OLS) regression models are used to identify factors associated with increased or decreased distance between home and a specific POI category.
Results	The authors find that in Orlando, monthly and daily visitation to the POI category of universities, colleges, and professional schools do not show the same monthly visitation patterns as other POI categories (e.g., because visitation to schools decrease during vacation times when other tourists and locals are recreating in the area). However, for the most part, POI categories have positive correlation coefficients between POI categories (e.g., when stops to gas stations rise, so do visits to stores, restaurants, and other recreation opportunities). The authors find that grocery shopping is a more localized activity than restaurant dining (i.e., people living close to the POI tend to visit more grocery stores than people whose homes are far from home).
Conclusions	The research demonstrated that the SafeGraph dataset analyzed is a viable source of information for several analysis tasks related to travel patterns in spatial and temporal domains, although only check-in data but not travel trajectory data are provided.
Keywords	Visitor use patterns; Passive mobile data; Travel behavior

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Kim, J., Thapa, B., Jang, S., & Yang, E. (2018). Seasonal spatial activity patterns of visitors with a mobile exercise application at Seoraksan National Park, South Korea. *Sustainability, 10*(7), 2263.
Study Purpose	Explore the seasonal spatial patterns of visitors' activities using a mobile exercise application within the context of Seoraksan National Park in South Korea.
Study Area	Seoraksan National Park in South Korea
Managing Agency/Organization	Department of Tourism, Recreation and Sport Management, University of Florida; Cardiff Business School, College of Arts, Humanities & Social Sciences, Cardiff University
Recreation activity types	Hiking, walking
Method	A dataset composed of 5,142 starting and ending points of 2,639 activities (hiking and walking) created by 1,206 mobile exercise application users (January–December 2015) were collected from a leading mobile exercise application operator in South Korea: Tranggle. Geographic information systems (GIS)-based spatial analytical techniques were used to analyze the spatial patterns of activity points across seasons and day-of-week type (weekdays/weekends).
Results	The authors found considerable seasonal and day-of-week type variations in activity distribution (e.g., the largest number of activity points occurred in the fall season (September–November), while the smallest during the winter (December–February). They also found variations in hot spots (i.e., locations of potential congestion or crowding) when comparing by season and by day-of-week type.
Conclusions	The findings enable park managers to mitigate negative impacts to natural resources as well as enhance visitors' experiences and allows potential visitors to decide when to visit certain sites to ensure optimal conditions. The Tranggle GPS-based exercise mobile application can be used as a new methodological approach to understand spatiotemporal patterns of visitors' behavior within national parks and other natural protected areas. Limitations to the data from the Tranggle exercise mobile application are that (1) it does not include information about visitor preferences for recreational activities, and (2) only start and end points were available which excludes the possibility for a full-on mobility study within the activity journey.
Keywords	Visitor use patterns; Mobile exercise application; Spatial analysis

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Kim, J., Thapa, B., & Jang, S. (2019). GPS-based mobile exercise application: An alternative tool to assess spatio-temporal patterns of visitors' activities in a national park. *Journal of Park and Recreation Administration, 37*(1).
Study Purpose	Explore the spatiotemporal patterns of visitors' activities across four segments of hours—dawn, morning, afternoon, and evening—based on a GPS-based mobile exercise application dataset related to Seoraksan National Park, South Korea, using a GPS-based mobile exercise application dataset to help mitigate impacts to natural resources as well as manage experiences.
Study Area	Seoraksan National Park, South Korea
Managing Agency/Organization	Multiple
Recreation activity types	hiking, walking, bicycling, jogging
Method	1,206 anonymous Tranggle (the most popular outdoor mobile exercise app in South Korea) users and their 2,571 activity start points were acquired for January 2015 to December 2015. The start point is assumed to be representative of the point of activity interest. This dataset was exported into a GIS point shape file, and the study area region was divided into 69 sub-cells in GIS for a hot spot analysis.
Results	The majority of activity start points observed occurred at dawn (00:01–06:00) and in the morning (06:01–12:00), while a relatively small number of activity start points occurred in the afternoon (12:01–18:00) and in the evening (18:01–24:00), and this pattern was relatively constant across all four seasons. The authors were also able to identify hot spots (i.e., the most congested areas in the park) by time of day.
Conclusions	GPS-based mobile exercise application can be used as an alternative tool to assess spatiotemporal use of visitors in national parks, which can in turn assist park staff in managing visitors on an hourly basis across seasons to minimize environmental impacts, allocate resources, and enhance visitor experiences and safety. Limitations to using GPS-based mobile exercise data are that (1) the data are more robust when paired with survey data to understand more of the "why" of the patterns observed; and (2) the results summarize use patterns of only Tranggle users which results in sampling bias, and the data could be more robust if including data from other exercise apps and also data of non-app users.
Keywords	Visitor use patterns; Mobile exercise application; Spatial analysis

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Kim, Y., Kim, C. K., Lee, D. K., Lee, H. W., & Andrada, R. I. T. (2019). Quantifying nature-based tourism in protected areas in developing countries by using social big data. *Tourism Management, 72*, 249–256.
Study Purpose	Identify spatial patterns of 'where people visit' and 'why people visit' nature-based tourist locations using social big data.
Study Area	ASEAN Heritage Park
Managing Agency/Organization	Multiple
Recreation activity types	Tourism, travel, sightseeing
Method	Spatial visitation patterns were identified by quantifying the proxy 'photo-user-day' (PUD) in 1 km-by-1 km squares based on coordinates of geo-tagged Flickr photos over 10 years in ASEAN Heritage Park. The authors offer the example that if PUD is quantified as 10, it indicates that the site has an average of 10 visitors a day over the course of a year. To analyze characteristics of preference, the authors ran a geographically weighted regression relationship between PUDs and the distribution of attributes (e.g., natural and cultural attractions and tourism-supporting artifacts).
Results	Tarutao National Marine Park was determined to be the most preferred visiting spot (i.e., maximum PUD). At a more granular level, results also showed that preferred hot-spots within this park were Ko Lipe Island and Ko Tarutao Island. It should be noted that the authors conducted focus group interviews with locals and park managers to validate the identified spatial visitation pattern's applicability, and they checked out. The geographically weighted regression showed that the highest regression coefficient was observed for the natural attractions (β=6.5), while the lowest was detected for the tourism supporting artifacts (β=−0.3), which in other words means that tourists are most drawn to/prefer visiting natural attractions.
Conclusions	The authors proposed and applied an innovative modeling approach that uses social big data (i.e., Flickr) to reveal spatial visitation patterns of outdoor recreation tourists, and their results were confirmed by focus group interviews and other observed data (e.g., tourism revenue). The authors also present a method (i.e., the geographically weighted regression evaluating PUDs against attraction sites) to assess the "why" of visiting specific parks or areas using big data. Most big data sources struggle to answer the "why" and surveys are typically the proposed strategy. Limitations to these methods included biases (e.g., who takes photos), and the accuracy of geo-tagged coordinates.
Keywords	Visitor use patterns; Social media data; Spatial analysis

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Kim, Y. J., Lee, D. K., & Kim, C. K. (2020). Spatial tradeoff between biodiversity and nature-based tourism: Considering mobile phone-driven visitation pattern. *Global Ecology and Conservation, 21*, e00899.
Study Purpose	Use mobile phone information to identify place-based information on frequently visited hotspots and examine the trade-off between visitation preference and biodiversity importance in protected areas.
Study Area	Protected areas on Jeju Island (Republic of Korea)
Managing Agency/Organization	Multiple
Recreation activity types	Tourism
Method	The study team used mobile phone data from Korea's largest telecommunications company, SKT, to identify visitation density in certain protected areas, and compared that against various measures of biodiversity (e.g., total number of endangered species, average forest age, years elapsed after designations, etc.) using a Bayesian network approach to reflect causality relationships (e.g., more visitation causes fewer endangered species). The visitor density data were validated against observed/survey data.
Results	In a comparison of mobile phone data with the observed number of visitors, an overall correlation of 0.64 was observed ($p < 0.01$). The monthly trends in the observed number of visitors and mobile phone visitor data showed general agreement on seasonal visitation fluctuations. The Bayesian network indicated that a low level of biodiversity in protected areas was associated with a high visitation density, and that the number of endangered bird species and the size of the protected area showed the highest conditional density with frequently visited areas. Species diversity also tended to increase at higher visitation densities. The number of artifacts (e.g., restaurants, convenience/shopping stores, and accommodations facilities) was directly related to higher visitation density.
Conclusions	By identifying the major biodiversity features associated with locations of highest visitation density, this method offered insights for biodiversity conservation policies. Even though mobile phone data sources cannot provide the exact number of visitors (i.e., only provide moderate accuracy, with a correlation of 0.64), they can effectively illustrate overall spatial visitation tendencies and identify areas with high visitation preference.
Keywords	Visitor use patterns; Mobile device data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Kupfer, J. A., Li, Z., Ning, H., & Huang, X. (2021). Using mobile device data to track the effects of the COVID-19 pandemic on spatiotemporal patterns of national park visitation. *Sustainability*, *13*(16), 9366.
Study Purpose	Use SafeGraph mobile device data to visualize the spatiotemporal patterns of visitation and examine the impact of COVID-19 on visitor use patterns.
Study Area	Six national parks in the western U.S. including Glacier National Park, Grand Canyon National Park, Rocky Mountain National Park. Yellowstone National Park, Yosemite National Park, and Zion National Park
Managing Agency/Organization	National Park Service (NPS)
Recreation activity types	Diverse recreation activities
Method	Acquired SafeGraph's Social Distancing Metric data, which are a daily dataset including device's 'home' location in census block groups, and record daily flows between census block groups; Extracted origin-destination (OD) daily flows from Social Distancing Metric data; Extracted daily flow data for each national park according to census block group IDs if the majority of the block group intersected the park boundary; Measured the correlation between the monthly NPS visitation and estimates derived from SafeGraph data; Calculate the visitor change rate between 2019 and 2020 at the state-level for each park and produce flow maps using Kepler.gl.
Results	There is strong correlation between monthly NPS visitation and estimates derived from SafeGraph data (R-squared above 0.8). With travel restriction in places, parks initially saw the greatest increases in visitation coming from nearby states, as compared to 2019 levels.
Conclusions	SafeGraph data provided greater temporal resolution and additional spatial information on visitation and visitors' origin. The method used in this study are meant only to complement existing methods for estimating park visitation.
Keywords	Visitor use patterns; Passive mobile data; Origin-Destination Analysis; COVID-19

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Korpilo, S., Virtanen, T., & Lehavirta, S. (2017). Smartphone GPS tracking—inexpensive and efficient data collection on recreational movement. *Landscape and Urban Planning, 157,* 608–617.
Study Purpose	Demonstrate the use of smartphone GPS tracking (SGT) for examining spatial patterns and density of recreational movement, and outline the potential and limitations of the method based on pilot data.
Study Area	Keskuspuisto, Finland (multiple-use urban forest)
Managing Agency/Organization	City of Helsinki
Recreation activity types	Walking, jogging, cycling, horse-riding
Method	GPS route data collected via smartphone. Participants sent in their own GPS routes for analysis. Participants sent in socio-economic data with their routes.
Results	Fifty-five tracks were evaluated and mapped for hotspots and movement patterns. Runners mostly followed structured trails with 21% being off-trail. Forty-six percent of mountain biking tracks were located outside of a formal trail network. Fieldwork confirmed that the hotspot analysis correctly identified off-trail access with mountain bikers. Heavy wear focused on main paths, cold spots displayed little or no visitable effects of wear.
Conclusions	The study confirmed the benefits of using SGT to measure use and patterns among recreation users. Benefits include reduced fieldwork efforts, lower costs, and detailed route data. However, participant behavior may change when they are personally uploading the routes.
Keywords	Visitor use patterns; Mobile device data; Spatial analysis

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Levin, N., Lechner, A. M., & Brown, G. (2017). An evaluation of crowdsourced information for assessing the visitation and perceived importance of protected areas. *Applied Geography, 79*, 115–126.
Study Purpose	Assess (1) how strongly correlated various sources of crowdsourced data and visitation statistics are; (2) whether the type of protected area influences the utility of crowdsourced information; (3) which categories of perceived protected area are best represented in crowdsourced data, and (4) if crowdsourced data will be used to build a predictive model of protected area visitation.
Study Area	Victoria, Australia
Managing Agency/Organization	Multiple
Recreation activity types	Parks and protected area visitation; tourism; travel
Method	The study team drew spatial polygons around protected area boundaries and then, leveraging a spatial analysis, identified the number of spatial observations where crowdsourced data were available. This number of observations was compared with visitor count statistics. The crowdsourced data sources included Flickr, OpenStreetMap, Wikipedia, and from Public Participation GIS data.
Results	The study team found that OpenStreetMap had the highest data completeness rate (e.g., the percent of protected area represented in the data), followed by Flickr, PPGIS, visitation counts, and finally Wikipedia articles. They also found that official visitation statistics were significantly correlated with all crowdsourcing variables; however, Wikipedia was not significantly correlated with the other three crowdsourcing data types.
Conclusions	While previous studies have shown that Flickr photo density is correlated with visitation statistics, this is the first study to demonstrate the potential utility of both Flickr and OSM crowdsourced data for this task (Wikipedia less likely). However, it must be noted that the coverage of crowdsourced data can be spotty and therefore incomplete or non-representative of true visitation counts.
Keywords	Visitor use patterns; Social media data; Search engine data; Spatial analysis; Public participation GIS (PPGIS)

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Levin, N., Lechner, A. M., & Brown, G. (2017). An evaluation of crowdsourced information for assessing the visitation and perceived importance of protected areas. *Applied Geography, 79*, 115–126.
Study Purpose	Develop a novel approach to conservation prioritization at large scales, which combines social media "big data" and remote sensing tools to identify areas that people use for recreation outside of urban centers. The study aims to address the challenge of quantifying human presence in conservation efforts, which is critical but often unquantified. The approach is an attempt to incorporate human-related factors into conservation efforts and provides a solution to a gap in applied ecology and conservation. The article offers a valuable contribution to the field of conservation and provides new insights into how technology can be used to enhance conservation prioritization.
Study Area	Global reach, Yellowstone and Yosemite National Parks
Managing Agency/Organization	Hebrew University of Jerusalem; other university entities
Recreation activity types	Human presence
Method	Night-light Brightness Mapping, Flickr Data Analysis, GIS Hotspot Layers
Results	The study found that 11% of all total geo-tagged photos were taken in protected areas, with nearly 5% originating from non-lit coastal areas outside urban centers and 6.4% in non-lit protected areas. Furthermore, within protected areas, 16.3% of all Flickr photos were taken in non-lit areas. The analysis revealed a non-uniform distribution of highly photographed protected areas, with a power law distribution and an exponent of 1.7. Interestingly, half of all Flickr photos taken in protected areas (10.3 million photos) originated from only 250 of the 27,000 protected areas worldwide, representing just 0.1% of the total number of protected areas. Overall, the study demonstrates the potential of using Flickr-based visitation statistics to identify and refine wilderness areas and dynamically redefine them over time using user-based information.
Conclusions	The article's analysis concludes that internationally recognized protected areas are popular among visitors, and that such conservation efforts generate tourism activity. The study highlights remote wilderness areas, also known as "Last of the Wild," as a target for conservation efforts. By utilizing Flickr-based visitation statistics, the definition of wilderness areas can be refined dynamically over time with user-based information. This approach enables the identification of regions with low visitor rates and minimal light pollution resulting from urban and industrial activities.
Keywords	Visitor use patterns; Social media data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Miller, Z. D., Freimund, W., Dalenberg, D., & Vega, M. (2021). Observing COVID-19 related behaviors in a high visitor use area of Arches National Park. *PloS one, 16*(2), e0247315.
Study Purpose	Determine whether it is possible to socially distance in a busy national park that has been designed to concentrate use.
Study Area	Visitor Center of Arches National Park
Managing Agency/Organization	Multiple
Recreation activity types	Visitor center, walking
Method	An observational study was conducted in July 2020 at the outside foyer of the Visitor Center of Arches National Park. Motion sensor cameras were placed to record one-minute videos when a person entered the field of view. Number of groups, group size, facial coverings, and encounters within six feet (1.83 meters) of other groups were recorded.
Results	The authors find that groups were smaller on average than recorded in previous studies. Approximately 61% of visitors wore masks. Most groups (69%) were able to experience the visitor center with no intergroup encounters. With four groups present, the probability of one or more inter-group encounters ranged from 19% to 40%, while if eight groups are present, the probability of one or more encounters increased from 34% to 64%.
Conclusions	Under conditions in which park visitors have the physical space to avoid close encounters with other groups, they are taking advantage of the opportunity. However, encounters increase as the number or the size of the groups increases. In other areas of the parks this ability to avoid encounters may not be as possible.
Keywords	Visitor use patterns; Motion sensor cameras; COVID-19

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Oksanen, J., Bergman, C., Sainio, J., & Westerholm, J. (2015). Methods for deriving and calibrating privacy-preserving heat maps from mobile sports tracking application data. *Journal of Transport Geography, 48*, 135–144.
Study Purpose	Develop various methods to enrich workout data from a mobile sports tracking application to create privacy-preserving information about the most popular places to do sports.
Study Area	Region of Helsinki
Managing Agency/Organization	Department of Geoinformatics and Cartography, Finnish Geospatial Research Institute/National Land Survey of Finland; Faculty of Science and Engineering, Åbo Akademi University
Recreation activity types	Cycling
Method	The data used for this study was obtained from Sports Tracking Technologies Ltd., a mobile sports tracking and sharing application that tracks coordinates of users. The coordinate data were used to estimate use densities of bikers using three different methods. In the first and simplest method for deriving heat maps, density along road segments was apparent, but a road segment with 100 workouts recorded by 10 users received the same heat map score as a segment with 10 workouts recorded by 10 users. In a second method, the density of trajectories by users was accounted for, but overestimates in route segment density attributed to a single very active user were not accounted for. In the third and most robust method, both the density of the workout trajectories and the diversity of users was taken into account so as to not suffer from the bias introduced by very active application users.
Results	In general, the three methods for deriving heat maps produced similar looking results, but when focusing on the details, some major differences could be found. The third method offers the most neutral view on the popularity of cycling and hides the bias issues related to very active application users. Additionally, when comparing heat maps to real-world data, all methods for deriving heat maps performed almost equally well.
Conclusions	Heat maps and real-world counting data had connections, especially when accounting for biases if possible. There are some biases that can never be accounted for, such as selected groups of cyclists not tracking their workouts and participation inequality.
Keywords	Visitor use patterns; Mobile device data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Qin, S., Man, J., Wang, X., Li, C., Dong, H., & Ge, X. (2019). Applying big data analytics to monitor tourist flow for the scenic area operation management. *Discrete Dynamics in Nature and Society, 2019*.
Study Purpose	Analyze tourist flows from and to popular scenic spots in Beijing using Call Detail Record (CDR) data and travel Origin-Destination (OD) Analysis.
Study Area	20 main scenic spots in Beijing, China, including the Forbidden City, the Summer Palace, and the Olympic Forest Park
Managing Agency/Organization	Multiple
Recreation activity types	Various tourism activities (mainly sightseeing)
Method	Filtered the data to obtain an efficient sample; Calculated the tourist flow statistics of the scenic spots (total flow, stagnant flow, influx, outflow, net increment, and variation); Performed traffic zone division of the study area; Convert the trajectory data into an OD matrix by determining which traffic zone they originate from and where they finally arrive.
Results	The zone-level OD matrix that summarizes the spatial distribution of tourists who visit a given scenic spot and depart from it for other places.
Conclusions	Travel OD analysis of the scenic spot can provide the spatial origin and destination distribution of tourists. Though the macroscopic tourist flow analysis used in this paper has already met the accuracy requirement for location information, future research should further improve positioning accuracy and the calculation accuracy for the attractions.
Keywords	Visitor use patterns; Call detail record data; Origin-Destination Analysis

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Raun, J., Ahas, R., & Tiru, M. (2016). Measuring tourism destinations using mobile tracking data. *Tourism Management, 57*, 202–212.
Study Purpose	Develop a methodology for measuring spatial, temporal, and compositional patterns of visitor flows to destinations in Estonia using space-time tracking data.
Study Area	Estonia at the whole country level and at the county-level
Managing Agency/Organization	Department of Geography, University of Tartu; Positium LBS
Recreation activity types	Travel, tourism
Method	This study analyzed spatial, temporal, and compositional (e.g., where the visitor is from) dimensions of visitor flows using the mobile positioning data (pinged from phone calls, text messages, or internet/data usage) from Estonia's largest mobile phone operator EMT. The authors look only at data from foreign visitor mobile phone use in Estonia from 2011 to 2013.
Results	Spatially, almost half of the visits made to Estonia are made only to one county. The most visited county in Estonia is Harju (40.7%). The average number of counties visited is 2.03. Temporally, the proportion of visits is highest in July and lowest in the winter months. One-day trips account for the largest share of the total visits to Estonia, but the duration of visit length ranged from one to 14 days. Composition-wise, a majority of visitors were from Russia, Latvia, and Finland.
Conclusions	Results show that using big data, smaller destination areas can be differentiated inside the whole country by the geographical, temporal, and compositional parameters of the visits. A strength of passive mobile positioning datasets is that it is very easy and cost-effective to analyze such data on a longitudinal basis. However, major cons include data access and privacy protection concerns
Keywords	Visitor use patterns; Passive mobile positioning data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Raun, J., Shoval, N., & Tiru, M. (2020). Gateways for intra-national tourism flows: Measured using two types of tracking technologies. *International Journal of Tourism Cities, 2020*.
Study Purpose	Illustrate the impact of major gateways on national tourism flows by using tracking data; demonstrate and compare the use and applicability of tracking data on a national scale.
Study Area	Estonia and Israel
Managing Agency/Organization	Multiple
Recreation activity types	Tourism, travel
Method	The authors analyze foreign tourists' movements using two spatially and temporally precise tracking data sets—call detail records from passive mobile positioning data and GPS data from smartphones—in two countries, Estonia and Israel. The movements of international tourists entering the countries via main gateways (e.g., main entry/exit points) are studied, with a focus on the impact of gateways on intra-national tourism flows.
Results	The results show the impact of gateways on the concentration of tourists. More specifically, in both Estonia and Israel, the critical mass of time was spent in close proximity to the gateway and, due to distance decay, a dramatic decrease was seen in visitation to areas that were distanced from both countries' core areas. In Estonia, 57% of the trips are recorded by a first call activity in Tallinn and almost 80% of those trips never leave Tallinn. In Israel, Ben Gurion Airport sees almost 90% of all the visitors arriving in Israel.
Conclusions	GPS data are typically more precise than mobile positioning data since passive mobile data (PMD) depends on usage of the phone itself. However, PMD enable researchers to analyze tourist behaviors for an extended period of time, rather than a fixed period of time.
Keywords	Visitor use patterns; Passive mobile data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Rice, W. L., Mueller, J. T., Graefe, A. R., & Taff, B. D. (2019). Detailing an approach for cost-effective visitor-use monitoring using crowdsourced activity data. *Journal of Park and Recreation Administration, 37*(2).
Study Purpose	Use Strava crowdsourced heatmaps to visualize visitor use patterns and identify off-trail use in protected areas.
Study Area	Barton Creek Greenbelt and Wilderness Park, Austin, Texas; City of Boulder Open Space & Mountain Parks, Boulder, Colorado; Pennsylvania State Game Lands No. 176, Warriors Mark, Pennsylvania
Managing Agency/Organization	Multiple
Recreation activity types	A mixed use of hiking, biking, swimming or dog walking; running; biking
Method	Took screenshots of heat map images from Strava web platform; Produced maps that overlayed heat-map images with trail and road layers.
Results	Strava data have the ability to determine the level and location of off-trail travel and to understand the main networks into, through, and out of a park.
Conclusions	Using Strava heatmaps to visualize visitor use is cost-efficient for monitoring visitor use, particularly in *urban-proximate protected areas*. Heatmap data are likely skewed by commuters and dense use of road systems.
Keywords	Visitor use patterns; Location-based services data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Roten, L. (2019). Using location-based data in regional parks visitors research. Twin Cities Research Group.
Study Purpose	Use location-based data to estimate visitor use and demographics of regional parks in Minnesota.
Study Area	Twin Cities Metropolitan Council Regional Parks System
Managing Agency/Organization	Twin Cities Metropolitan Council
Recreation activity types	Walking, leisure, sightseeing, urban park activities
Methods	Purchase and analysis of StreetLight Data, using "trip" characteristics. A trip is any movement over 500 meters lasting longer than three minutes. Trips can be normalized with the StreetLight Traffic Index and are limited to Bike and Pedestrian uses. Demographics are inferred from the census block of origin.
Results	Various visitation patterns of the Metropolitan Council's regional parks.
Conclusions	There is no consistent way to define who counts as a visitor across all regional parks and each park requires detailed review of the data to ensure accuracy. The Metropolitan Council also needs to implement stronger sampling plans, target resources to different areas over the year, and avoid placing survey staff where there are few people in response to the mobility data findings. Location-based data challenges traditional thinking about regional parks visitors, and can be applied to: • Examine disparities in park use • Differentiate passthrough and non-passthrough visitors • Locate busy areas within parks • Allow low-cost park-level analysis • Open the door for advanced research
Keywords	Visitor use patterns; Location-based services data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Shoval, N., & Ahas, R. (2016). The use of tracking technologies in tourism research: The first decade. *Tourism Geographies*, *18*(5), 587–606.
Study Purpose	Review existing literature that utilizes mobile tracking data in tourism research.
Study Area	Various study areas ranging from a small and confined area to regional, national, or global scales
Managing Agency/Organization	N/A
Recreation activity types	Multiple
Method	The authors conducted a search of existing literature that discussed the use of tracking technologies in tourism research using Web of Science and Google Scholar. Only peer-reviewed journal papers are selected. They generated tabular and graphic summaries of the basic information (e.g., year of study, country, and methods).
Results	Studies that use GPS tracking and Bluetooth data tend to focus on small, bounded study sites with defined entry and exit points. On the other hand, the studies using passive mobile data, geocoded photos, and social media messages are larger-scale analyses. It's considered generally impossible to characterize subjective experiences and social-economic variables from passive mobile data. Passive mobile data can be supplemented using sensors and online questionnaires on smart devices to collect such information.
Conclusions	The analysis of big data can help uncover unknown or underrated visitor patterns in the wilderness, where traditional visitation statistics are not readily available. The authors predict that future improvements on various sensors and off-the-shelf applications on smartphones will facilitate gathering information about visitor activities and visitor profiles.
Keywords	Visitor use patterns; GPS tracking; Bluetooth tracking; Passive mobile data; Social media data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Walden-Schreiner, C., Rossi, S. D., Barros, A., Pickering, C., & Leung, Y. F. (2018). Using crowdsourced photos to assess seasonal patterns of visitor use in mountain-protected areas. *Ambio, 47*, 781–793.
Study Purpose	Use geotagged photos to determine spatial and temporal visitation patterns in remote mountain protected areas.
Study Area	Aconcagua Provincial Park, Argentina and Kosciuszko National Park, Australia
Managing Agency/Organization	Multiple
Recreation activity types	Hiking, camping, mountaineering, rock climbing, skiing, etc.
Method	Queried Flickr geotagged images within the boundaries of the park; Inspected the photos to determine whether they are correctly geotagged; Performed Maximum Entropy modeling to examine the associations between environmental and infrastructure factors and the spatial distribution of Flicker-derived visitation patterns.
Results	The correlation between number of Flicker photos and on-ground visitation is significant, but somewhat weak. Flicker photos are 97% correctly geotagged. Formal and hardened trails are the top explanatory factors to predict spatial distribution of visitor use.
Conclusions	Geotagged social media data can complement on-ground visitor use in mountain protected areas. Spatial accuracy can be a concern when leveraging volunteered geographic information, especially geotagged photos where users may manually assign the photo's location.
Keywords	Visitor use patterns; Social media data; Remote protected areas

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Xu, F., Nash, N., & Whitmarsh, L. (2020). Big data or small data? A methodological review of sustainable tourism. *Journal of Sustainable Tourism, 28*(2), 144–163.
Study Purpose	Identify novel methodological areas for sustainable tourism studies in relation to big data and small data approaches. Identify developments outside sustainable tourism and discuss how innovative approaches could be utilized to open new methodological pathways and sources of knowledge.
Study Area	N/A
Managing Agency/Organization	University of Bath, Southeast University (China)
Recreation activity types	Travel, tourism
Method	The authors present the pros and cons of big data collection (i.e., typically quantitative) methods and small data collection (i.e., typically qualitative) methods as they relate to sustainable tourism research, analysis, and management.
Results	Big data methods are more data-driven than theory-driven and allow for analysis at a macro-level (e.g., examining cross-country, trans-national, or globally). Big data also capture data from a longer span of time so that change over years can be evaluated. Additionally, a variety of topics can be explored with big data, from tourist densities and flow (geospatial data) to human relationships with place (social media). However, big data are limited and may not accurately represent an entire sample, due to selective users and privacy protection concerns, and in that it does not explain causality of behaviors and patterns. While small data research (i.e., surveys, focus groups, etc.) does not cover the same sample size as big data, it can fill in the gaps discussed. As such, the two approaches offer different insights to sustainable tourism and should both be explored to gain the most comprehensive understanding of sustainable tourism patterns and best management practices.
Conclusions	The authors conclude that there is a complementary relationship between big data and small data approaches. In more detail, qualitative processes are needed to interpret and flesh out the micro-processes that enable the vast amounts of more quantitative-focused big data.
Keywords	Big data; Small data; Sustainable tourism; Mobility

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Xu, Y., Li, J., Belyi, A., & Park, S. (2021). Characterizing destination networks through mobility traces of international tourists—a case study using a nationwide mobile positioning dataset. *Tourism Management, 82*, 104195.
Study Purpose	Investigate the inter-destination movement patterns of foreign tourists to South Korea using passive mobile data and network analysis approaches.
Study Area	South Korea
Managing Agency/Organization	Multiple
Recreation activity types	Various tourism activities
Method	Mobile devices with a time span of less than 12 hours filtered from passive mobile data that records dwell time at each stay; Aggregated the record-level data to city level trajectories; Extracted tourist flows between cities and constructed destination networks; Compared the attractiveness of destinations by analyzing the distribution of node strength in the networks; Performed a hierarchical clustering over different originating countries to reveal heterogeneity in the mobility preferences of different nationalities; Applied the community detection algorithm to partition the destination cities into tourism regions, each of which covers a set of destinations that are densely connected by tourist flows
Results	The number of inbound tourists to a city is generally nonlinear, i.e., a few cities attract a large number of visits while many cities attract few tourists. Heterogeneous travel mobility is found among travelers originated from different continents.
Conclusions	The community detection algorithm can be applied over similar long-term datasets to partition a study area into districts. Clustering methods can be used to help uncover the similarity between travelers that are divided into distinct group.
Keywords	Visitor use patterns; Passive mobile data; Network analysis

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Zaragozi, B., Trilles, S., & Gutierrez, A. (2021). Passive mobile data for studying seasonal tourism mobilities: An application in a Mediterranean coastal destination. *ISPRS International Journal of Geo-Information, 10*(2), 98.
Study Purpose	Use passive mobile data to analyze the complex mobilities that occur in a Spanish coastal region characterized by seasonal patterns of tourism activity.
Study Area	Municipalities of Spain, including Tarragona, Reus, Cambrils, Salou, and Vila-seca
Managing Agency/Organization	Departament de Geografia, Universitat Rovira i Virgili; Institute of New Imaging Technologies (INIT), Universitat Jaume I
Recreation activity types	Travel, tourism
Method	Data generated by mobile phone users containing records for two summer days and two winter days were selected and aggregated spatially and temporally. The authors also differentiated trips by local residents, national tourists, and international tourists. Then origin destination matrices were developed, and graph-based visualizations were created to provide insights on the mobilities affecting the study area.
Results	They find that (1) locals predominate in terms of inter-urban mobility; (2) the predominant trips in winter are inter-urban (and mainly carried out by locals), whereas, in summer, intra-urban trips are clearly higher due to the predominance of short-distance urban tourism mobilities; (3) In the morning, the number of trips is lower at weekends than on weekdays, while the number of trips at night is higher at weekends; (4) The Spanish have a certain preference for visiting the park at the weekend, while international tourists visit the park more during the week.
Conclusions	The analysis of passive mobile data (PMD) can be useful to study the effects of tourism seasonality in local mobility patterns. It is important to note that PMD is most effective when evaluating mobility in very populated urban areas where the mobile phone network is denser. Limitations of PMD include the variability in data availability, depending on the mobile phone network and study area, and that researchers cannot be guarantee that the owner of the phone is a real user in the study area (e.g., the user could be an employee or a relative, among other possibilities). Lastly, privacy protection concerns can be a limiting factor of PMD.
Keywords	Visitor use patterns; Passive mobile data

Conclusions Pertaining to Publications on Understanding Visitor Use Patterns

Key insights from the literature reviewed relevant to understanding visitor use patterns are as follows:

- Passive mobile data providers used to understand visitor use patterns throughout the literature reviewed include those that use location-based services data.
- Some U.S.-based GPS tracking and fitness apps have been used to understand visitor use patterns.
- Gaps in understanding visitor use patterns attributed to biases that are presented with emerging data methods (i.e., big data sources) could be filled by collecting information about visitor use patterns through conventional methods (such as route surveys, GPS tracking studies, and observations of visitor locations).
- It may be important to differentiate visitor travel patterns from local travel patterns when assessing visitation patterns using geo-tagged photo, GPS tracking app, or mobile device data. It may also be important to parse out patterns by time of day, day of week, and season of year.
- Limitations to data collected via emerging methods include:
    - Like other data sources (e.g., visitor surveys, self-reports), passive mobile data are subject to sampling bias. For example, not all visitors carry mobile devices with them during their visits and these visitors are systematically excluded from passive mobile data sources. In addition, not all visitors who carry mobile devices with them during their visits use them as frequently and for the same purposes. Consequently, not all visitors with mobile devices are represented equally with passive mobile data.
    - Protecting privacy is an important consideration in managing passive mobile data (and also influences the selection of data vendors and data products).
- There are no known published studies using conventional or emerging data methods to measure and analyze visitor use patterns for long-distance trails or rivers. As such, any efforts to assess visitor use patterns for National Trails and National Wild and Scenic Rivers will require pilot testing of novel approaches adapted from other contexts.

Planning Documents

This subsection of the report provides a systematic review of planning documents that guide the management of units within the NTS and NWSRS. Many of these documents include comprehensive management plans, capacity and visitor use studies, economic impact studies, resource assessments, environmental assessments, and atlases. The plans and studies provide information on socioeconomic conditions, visitor use, visitation estimates, and visitor capacity estimates. As multiple agencies are responsible for administering and/or managing rivers and trails, the planning documents present different methods, available data sources, and techniques for collecting data, performing analysis, and managing resources. The review of these documents is presented in tabular summaries followed by a conclusion section with key insights.

Tabular Summaries

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	BBC Research & Consulting (2022). Health, social equity, and economic impact of the Potomac Heritage National Scenic Trail in Northern Virginia. https://www.novaregion.org/1533/Equity-and-Economic-Study
Study Purpose	Assess the public health and community-related impacts associated with use of the Potomac Heritage National Scenic Trail and provide recommendations to maximize those impacts and help justify the investment of public funds.
Study Area	The Potomac Heritage National Scenic Trail (PHNST) includes 900 miles of multi-use trails across Virginia, Washington D.C., Pennsylvania, and Maryland. This study focused on 140 miles of trail network in Northern Virginia that passes through the towns of Dumfries, Occoquan, Leesburg, Alexandria, and the Counties of Loudoun, Fairfax, Arlington, and Prince William.
Managing Agency/Organization	The Northern Virginia trails are managed by multiple federal, state, and local entities. The Northern Virginia Regional Commission (NVRC) created a memorandum of understanding in 2014 to promote coordination among land managers and improve the network.
Recreation activity types	Walking and biking. Additionally, many residents commute on the trail and use it for transportation.
Method	A literature review was conducted to identify benefits and economic impacts of long-distance trails. Trail use data were also used to estimate visitor use of the trail by pedestrians and bicyclists. Data sources included StreetLight location-based data (gathered from cell phones, GPS devices, and navigation tools), Strava Metro Data (counts of trail users, activity times, and distances), and walking and biking counters. These data were used to develop a model based on average annual daily traffic (AADT) counts for each segment. Estimated visitor use was used to analyze health benefits related to the use of the trail. The study also utilized GIS data, crash data, demographic data, interviews with key stakeholders, and focus groups to inform the process. An economic development analysis, a transportation analysis, an equity analysis, and a gap analysis were conducted for the trail.

STUDY COMPONENT	DETAILED DESCRIPTION
Results	Results showed that trail users walked a total of 13.6 million miles annually and biked 45 million miles annually. This represented 100,000 miles of walking and 300,000 miles of biking for each mile of completed trail. The study also found that regional residents saw $349 million in annual health benefits due to decreased mortality and reduced healthcare costs. The community experiences high economic benefits from the trail, and the average tourist to the region spends more than $300 during their stay. Benefits from commuting on the trail represent savings in environmental and personal vehicle costs. However, the study did find that benefits of the trail are not equally distributed, and there are equity issues related to trail access and safety.
Conclusions	This study utilized a wide array of data sources and methods to assess public health and community impacts of the Potomac Heritage National Scenic Trail. It's combined use of location-based data from StreetLight and Strava, as well as data from existing counters, provided a site specific and detailed method for estimating visitation for the trail, and developing separate use estimate for walkers and bicyclists.
Keywords	Visitor use estimates; Economic impacts; Public health; Mobile device data; National Scenic Trail

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Helvoigt, T., Neculae, C., Josephson, A., & Charlton, D. (2009). Review of regional economic impacts of recreation on the Wild and Scenic Rogue River. ECONorthwest. https://www.americanwhitewater.org/content/Document/view/id/513
Study Purpose	Analyze the economic impacts that recreation related spending on the Wild & Scenic Rogue River has on the Josephine County and Oregon economy.
Study Area	The Wild and Scenic Rogue River is located in the southwestern corner of Oregon. The designated corridor flows for 84 miles, and includes Recreation, Wild, and Scenic segments.
Managing Agency/Organization	Bureau of Land Management (BLM) and the US Forest Service (USFS)
Recreation activity types	Whitewater rafting, fishing, boating, hiking on the Rogue River Trail, commercial jetboat tours
Method	Surveys were conducted of commercial rafting outfitters and local lodging establishments to gather data on the river's impact on the economy and culture of Josephine County. Past studies on economic impacts of river recreation on local economies were reviewed, including previous economic studies on the Rogue River. An economic impact analysis of river-recreation activities was conducted using an input-output modeling approach. This analysis used the IMPLAN (for IMpact analysis for PLANning) framework. Using BLM data, the study estimated the number of rafters and fisherman who floated the Rogue River in 2007.
Results	The results of the economic impact analysis and the surveys show that Josephine County and the state of Oregon enjoy direct economic benefits from recreational activities on the Rogue River. Key findings include: • River-based recreation on the Rogue River accounted for $30 million in total economic output, including $15.4 million in personal income and 445 full and part time jobs. • Oregon-based outfitters were responsible for 91% of commercial activity on the river. • About 93% of guests on commercial rafting and fishing trips came from outside of southwestern Oregon, and 72% came from outside of Oregon. • Visitors to the Rogue Wild and Scenic River accounted for three out of every four lodging guests in the local area during the permit season. • The designation of the river has contributed to the long-run economic growth of the local area. • Increased federal protection of other tributaries of the Wild Rogue would likely have short-term and long-term economic benefits to the County and State of Oregon.

STUDY COMPONENT	DETAILED DESCRIPTION
Conclusions	Using multiple methods including surveys, literature reviews, an IMPLAN economic analysis, and visitation estimation, the study demonstrated the significant positive impact that the Wild and Scenic Rogue River has on Oregon's economy.
Keywords	Economic benefits; Wild and Scenic River; Surveys; IMPLAN modeling

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Maine Department of Agriculture, Conservation, and Forestry, & Division of Parks and Public Lands (2012). Allagash Wilderness Waterway. https://www.rivers.gov
Study Purpose	Describe existing resource conditions and outstandingly remarkable values, define goals and desired conditions, address user capacities, address water quality issues, recognize opportunities for partnership, identify regulatory agencies, and provide a monitoring strategy.
Study Area	The Allagash Wilderness Waterway stretches for 92 miles and is surrounded by a privately owned commercial forest in Maine.
Managing Agency/Organization	Maine Department of Agriculture, Conservation, and Forestry, and the Division of Parks and Public Lands
Recreation activity types	Hiking, camping, boating, canoeing, and snowmobiling
Method	User demographics, visit characteristics, and relevant outdoor recreation trends were described as part of the plan. Information on user demographics came from the 2003 Allagash Wilderness Waterway Survey. Information on visit characteristics including camping nights group size, and entry and exit points is presented. Winter recreation was more difficult to estimate due to staffing and operation limitations. Winter angler counts taken by the Maine Department of Inland Fisheries and Wildlife were used from 1980 to 2012. Snowmobile use, snowshoeing, and cross-country skiing also has limited data to track visitation.
Results	Survey data from 2003 showed that Maine residents accounted for 58% of non-winter visitation. About a quarter of groups included a child under 16, and most groups were composed of families or families and friends. Sixty percent of visitors had visited a remote or undeveloped river before they were 20 years old. The most popular reported activities were camping, taking pictures, and fishing. Camping nights were studied from 1995 to 2010. In 2010, 18,860 camper nights were recorded, a steep reduction from 1995. Visitation records showed that the average number of nights camped between 2005 and 2008 was 3.7. This was a reduction from the five-night average reported by the 2003 survey. Winter angler counts showed that there have been recent drops in winter angler use.
Conclusions	Comparing visitation and overnight use data from 2012 to the results of a 2003 survey allowed managers to evaluate trends in use over time. Also, utilizing data sources from other agency helps to estimate visitation in seasons when data are not regularly collected.
Keywords	Visitor profiles; Visitor demographics; Overnight use; Surveys

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	McKendry, J. (2009). A socioeconomic atlas for the Chesapeake Bay watershed and its region. https://d38c6ppuviqmfp.cloudfront.net/content/publications/cbp_46698.pdf
Study Purpose	Atlas provides park managers and communities with socioeconomic data about the regions surrounding the Captain John Smith Chesapeake National Historic Trail. For this trail, the atlas includes the entire Chesapeake Bay Watershed.
Study Area	The Captain John Smith Chesapeake National Historic Trail extends for nearly 3,000 miles across the Chesapeake Bay and its rivers. Designated in 2006, the trail crosses six states, including Virginia, Delaware, West Virginia, Maryland, Pennsylvania, and New York.
Managing Agency/Organization	National Park Service
Recreation activity types	Paddling, sailing, boating, scenic driving, viewing wildlife, geocaching, biking, and learning about history
Method	The NPS atlas provides information on key indicators including population, economy, social and cultural characteristics, recreation and tourism, administration and government, and land use for counties surrounding a NPS park unit. For the Captain John Smith Chesapeake National Historic Trail, the region includes the Chesapeake Bay Watershed in Virginia, Maryland, District of Columbia, Delaware, Pennsylvania, and New York. Each indicator includes table of county-level data, a map of patterns, and a description of the indicator and how it is measured.
Results	The information presented in the atlas provides a robust suite of data that can be used for decision making for the Captain John Smith Chesapeake National Historic Trail. Results such as recent population change along the trail, employment and economic data by county, recreation and tourism establishments, and recreation and tourism employment and revenue can all be used to support the planning and management process for the trail.
Conclusions	The large scope and detail of the NPS atlas provides a valuable tool for understanding site conditions and making management decisions for a trail system. Using data from multiple available atlases could be used to provide a high-level overview of trail conditions for systems across the country.
Keywords	Demographics; Socioeconomic data; Tourism economy; National Historic Trail

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Moore, R. L., Barthlow, K. (1998). The economic impacts and uses of long-distance trails: featuring a case study of the Overmountain Victory National Historic Trail. North Carolina State University. https://rosap.ntl.bts.gov/view/dot/15003
Study Purpose	Investigate use patterns and economic impacts of long-distance trails.
Study Area	Overmountain Victory National Historic Trail, a 300-mile-long route that includes a marked motor route, historic sites, and visitor centers operated by multiple public and private agencies. The route crosses parts of Virginia, Tennessee, North Carolina, and South Carolina.
Managing Agency/Organization	National Park Service. Some historic sites and visitor centers are managed by other agencies.
Recreation activity types	Visiting historic sites, learning about American history, auto touring, hiking, and learning about natural history
Method	A visitor survey was conducted over 12 sample sites in Tennessee, North Carolina, and South Carolina. These included historic sites, and off-highway trail segments. A combination of brief on-site contacts and mailed follow-up questionnaires was used at each sample site. To establish the total regional expenditures related to the trail, average use expenditures were multiplied by the total number of visits for 1995. Estimates of total numbers of visitors for 1995 were based on site managers ongoing visitor counts, including traffic counts, visitor registers, or direct counts. Economic analysis was conducted using IMPLAN, and statistical software program STATA. A literature review was also conducted to identify benefits and economic impacts of long-distance trails.
Results	The literature review concluded that there are many techniques for estimating economic impacts, that each carry advantages and disadvantages. The more accurate and detailed information is needed, the more expensive and time-consuming the data collection will usually be. Methods should be selected after considering the level of accuracy needed, and the resources available. When a high level of detail is needed, the best approach appears to be brief on-site interviews followed by a more detailed mail-back questionnaire. The survey results showed that most visitors came from the states where the trail was located, also there was a large number of non-local users and some international visitation. Many of the demographic and trip characteristics of trail users were very similar to those found for visitors in the Nez Perce National Historic Park, which includes the Lewis and Clark National Historic Trails. This may be due to the historic nature of both trails. For the economic impact, the study showed that trail-related direct spending in trail counties by non-resident users was about $5.4 million in 1995, with a total economic impact of $7.5 million.

STUDY COMPONENT	DETAILED DESCRIPTION
Conclusions	The mixed methods approach of conducting a literature review and a visitor survey allowed the investigators to identify the most appropriate method for collecting data that would be useful for analyzing visitor patterns and economic impact. Though resource intensive, the survey resulted in a large quantity of detailed data that could be used for the economic analysis.
Keywords	Visitor use estimation; Visitor use patterns; Visitor surveys; Literature review; Economic impact; IMPLAN modeling; National Historic Trail

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	National Park Service, U.S. Department of Interior (2011). El Camino Real de Los Tejas National Historic Trail comprehensive management plan/environmental assessment. Nps.gov. https://parkplanning.nps.gov/document.cfm?documentID=44443
Study Purpose	Provide objectives, policies, processes, and management guidelines for El Camino Real de los Tejas National Historic Trail. The plan provides a framework for administering the trail, a vision for the trail's future, and a programmatic environmental assessment that considers impacts of proposed alternatives.
Study Area	El Camino Real de los Tejas National Historic Trail includes 2,580 miles of trail that extends from southwestern Texas to Natchitoches, Louisiana. The trail was designated in 2004, and commemorates historic routes developed between 1680 and 1845 that significantly contributed to U.S. history.
Managing Agency/Organization	The trail is administered by the National Trails intermountain Region. However, less than 1% of the corridor is owned by the federal government. A large amount of trail resources are managed by private entities, and it is difficult to coordinate trail management among many jurisdictions and stakeholders.
Recreation activity types	Recreation activities are envisioned to highlight the historical significance of the trail and educate visitors. This includes trail retracement, in which visitors would travel roads that closely follow the designated trail, engage with interpretive materials, and experience what travel may have been like during the historic era. Other activities include recreation at National Park Service sites, state parks, and other open spaces along the trail. These sites provide opportunities for walking, hiking, cycling, equestrian use, camping, and scenic driving along the trail corridor.
Method	County and parish level census data from the year 2000 were used to derive information to describe the socioeconomic conditions of the affected environment of the trail. Population growth data were based on returns for 1990 and 2000. The authors acknowledge that there is a gap in data between 2000 and 2009 that is not provided by this plan. Additionally, data were not able to be extrapolated at the state level.
Results	The analysis provided information on population growth, income, employment, education, ethnicity, and land ownership. Between 1990 and 2000, all counties and parishes except for two, experienced population growth with several areas experiencing significant change. Census data showed significant inequality in income and poverty among different counties and parishes. Only nine counties/parishes reported median household incomes above their state averages. Most counties/parishes crossing the trail were below the average reported poverty rates for their state. Employment data also showed harsh economic circumstances along the trail corridor. High school graduation rates vary across the corridor, ranging from 40% to 80%. Land ownership is mostly private along the trail

STUDY COMPONENT	DETAILED DESCRIPTION
	corridor. Only 1% of land crossing the trail in each state is owned by the federal or state government.
Conclusions	Using county and parish level census data provided key outcomes on socioeconomic conditions surrounding the trail corridor. Additional State data would allow for a more robust analysis and contribute to the planning and management of the trail.
Keywords	Visitor demographics; Census data; Trail users; National Historic Trail

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	National Park Service (2020). Delaware Water Gap National Recreation Area visitor use management plan. https://parkplanning.nps.gov/document.cfm?parkID=220&projectID=55912&documentID=108093
Study Purpose	Maximize the ability of the National Park Service to encourage access, improve visitor experiences, and protect the natural and cultural resources of Delaware Water GAP National Recreation Area, and Middle Delaware National Scenic and Recreational River.
Study Area	The Middle Delaware National Scenic and Recreational River flows for 40 miles through Pennsylvania and New Jersey. This segment is completely included within Delaware Water Gap National Recreation Area.
Managing Agency/Organization	National Park Service (NPS)
Recreation activity types	Boating, swimming, hiking, hunting, fishing, picnicking, biking, scenic driving, birdwatching, rock climbing, and cross-country skiing
Method	The plan uses the visitor use management framework developed by the Interagency Visitor Use Management Council (IVUMC). To summarize existing conditions, regional recreation and socioeconomic context was studied. Data sources included census data, the Pennsylvania Department of Community and Economic Development, New Jersey Division of Travel and Tourism, 2010 Visitor Services Project (VSP) data, a 2015 NPS Visitor Spending Effects study, a 2015 National Parks Conservation Association study.
Results	The data showed that tourism and recreation are important economic drivers for the five-county region surrounding the park. Between 1998 and 2014 travel and tourism employment grew by 42.1%. By 2014, one in every five private jobs in the region was in travel and tourism. 2010 VSP survey data showed that the average river visitor group expenditure for day trips was $61 by locals and $102 by nonlocals. The 2015 NPS Visitor Spending Effects study estimated that visitors spent a total of $125 million. For visitation, data show that Delaware Water Gap National Recreation Area receives an average of 3.8 million recreational visitors. Visitation is highest in June, July, and August. In 2015, the park's visitation was about 4 million visitors.
Conclusions	The Middle Delaware National Scenic and Recreational River is in the unique position of sitting completely within the boundaries of National Recreation Area. Therefore, a rich amount of data related to visitation, visitor patterns and preferences, and socioeconomic conditions is available. However, the visitor use management plan does not appear to specifically estimate visitation for the river corridor itself, vs. the recreation area. This study shows that existing data sources from agencies like NPS should be leveraged to estimate visitation for river and trail systems, where available.
Keywords	Socioeconomic data; Interagency Visitor Use Management Framework; Scenic and Recreational River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	US Forest Service (2017). Fossil Creek Wild and Scenic River Resource Assessment. Rivers.gov. February 27, 2017. https://www.rivers.gov/documents/plans/fossil-creek-resource-assessment.pdf
Study Purpose	Determine and document which river values meet the standard for "Outstandingly Remarkable" in the Fossil Creek Wild and Scenic River Corridor.
Study Area	Fossil Creek is located in Arizona, north of Phoenix; 16.8 miles are designated as a wild and scenic river, including wild and recreational segments.
Managing Agency/Organization	US Forest Service
Recreation activity types	Sightseeing, wildlife observation, camping, photography, hiking, fishing, hunting, and boating
Method	The resource assessment uses criteria developed by the Interagency Wild and Scenic Rivers Coordinating Council. As part of the evaluation of recreational value, existing recreation conditions were summarized. This included a description of existing recreation opportunities and an analysis of visitor demographics. To study the impact of recreation on aquatic habitat, People at One Time (PAOT) was studied. Data from a 2012 Visitor Use Data Collection project were used to evaluate PAOT.
Results	Data gathered in 2013 showed that 79% of visitors came to the river from the Phoenix-Metro area. Residents from the local community made up only 11% of visitors, and very few visitors (3%) came from out of state. Data from the 2012 Visitor Use Data Collection Project indicated that 56% of visitors to the Wild and Scenic corridor go to the river to swim. Based on available parking, the number of people that are able to access the corridor is estimated at 1,100 people at one time (PAOT). Based on current conditions, this means that 616 people could potentially be swimming in Fossil Creek at one time. This large amount of swimming activity has negative impacts on native fish.
Conclusions	This report used available parking as the main factor to estimate PAOT on the river corridor, and further extrapolated that data using results on river use from a data collection project. This was used to identify impacts to river resources. A subsequent Comprehensive River Management Plan specified a user capacity of 212 vehicles and approximately 1,120 PAOT per day for Fossil Creek Wild and Scenic River.
Keywords	Visitor demographics; Resource assessment; Wild and Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Research Center University of Wisconsin-Whitewater (2020). Review of an analysis of ice age trail users. Ice Age Trail Alliance. https://www.iceagetrail.org/economic-impact-ice-age-trail/
Study Purpose	Measure the annual economic impact of the Ice Age Trail to the State of Wisconsin and the local communities along the Trail. This was done by determining the annual number of users who utilize the Trail.
Study Area	The Ice Age National Scenic Trail is a 1,000-mile footpath that extends across the state of Wisconsin. The trail highlights the scenic landscape features resulting from glaciation. The trail has an estimated annual visitation of 2.3 million, which has increased by 50,000 visitors since a 2011 survey.
Managing Agency/Organization	Managed by a partnership between the National Park Service, the Wisconsin Department of Natural Resources, and the Ice Age Trail Alliance.
Recreation activity types	Hiking, backpacking, snowshoeing, cross-country skiing, camping, fishing, and bird watching
Method	More than 4,000 surveys were conducted to quantify the monetary impact on the local and state economies by analyzing the average expenditures of trail users. Addition methods included the Impact Analysis for Planning (IMPLAN) input/output technique and statistical analyses. IMPLAN is an economic analysis software system that analyzes average survey responses. It was used to measure the following effects: • *Direct effect*—spending at businesses near the Trail. • *Indirect effect*—the indirect demand that businesses have for locally produced materials. The success of businesses on the Trail affects the suppliers. • *Induced effect*—changes in household spending due to additional employment generated by the Trail. The survey collected demographic data on visitors including level of education, age, income, and residency. Other data collected included information on group sizes, trail activities, overnight stays, number of visits, and spending. The study also identified two main visitor groups, high intensity and low intensity, and reported spending data for each group to see how user behaviors differed.
Results	The study concluded that the Ice Age Trail generated 3,616 full-time jobs, $27 million in state and local taxes, $335 million in annual economic impact, and over $106 million in total wages. Other key economic information was reported from the study. The survey identified that 82% of visitors were willing to travel from out of town to visit the Trail. Additionally, almost half of visitors stayed overnight along the trail, with most users staying at campsites, and a smaller group using hotels and motels. The survey identified that most visitors are willing to spend discretionary income on Trail experiences.

STUDY COMPONENT	DETAILED DESCRIPTION
Conclusions	One of the main results of this study was the difference in user characteristics between high intensity and low intensity Trail visitors. High intensity visitors used the trail more than three to four more times on average than other groups and spent more on average than low intensity users. However, low intensity users were more willing to pay for leisure experiences, souvenirs, shopping, and entertainment.
Keywords	Visitor use estimation; Economic impact; Visitor survey; IMPLAN modeling; National Scenic Trail

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	The Shimoda Group, LLC (2021). Lower Delaware Wild and Scenic River recreational use and capacity. https://www.lowerdelawarewildandscenic.org/index.php/resources/presentations/river-use-capacity-study/river-use-capacity-study-final-report
Study Purpose	Due to increased use of the Lower Delaware Wild and Scenic River since its designation in 2000, there was a need to develop metrics to monitor and manage recreational use. This study aimed to identify priority issues based on a site inventory and input from the community.
Study Area	The Lower Delaware Wild and Scenic River is designated for a total of 67.3 miles that flow through Pennsylvania and New Jersey.
Managing Agency/Organization	Lower Delaware Wild and Scenic River; Management Council
Recreation activity types	Paddling, fishing, floating/tubing, water play, motorized boating, viewing wildlife, non-motorized boating
Method	The framework developed by the Interagency Wild and Scenic Rivers Coordinating Council was used to conduct an analysis of the Lower Delaware Wild and Scenic River. To describe baseline conditions, an inventory was conducted of the 30 river launch sites. This included fee/permit information, launch managers, and parking capacity. A process was outlined to conduct counts of vehicle traffic, parking spaces, boaters, and recreationists at launch sites. A combination of manual counts and density estimates can be used to establish a visitor use estimate. To continue developing current conditions and desired conditions, a public survey questionnaire was developed and shared with visitors online and through newsletters. Two hundred thirty-nine questionnaires were completed. Key stakeholders including management agencies and businesses were also interviewed. The survey included questions about primary access locations, visitor activities, over-utilization of the river, factors contributing to increased river popularity, and negative impacts of river popularity.
Results	The survey results showed that the most popular river activities included paddling, fishing, floating/tubing, and swimming. When asked to describe recreation use, 32% of visitors said that the river is “over-utilized” and “in need of dramatic management improvement.” However, a similar percentage indicated that use is “appropriate,” and 24% described it as “over-utilized but manageable.” The majority of visitors stated that river tubing has contributed to the increased popularity of the river. Sixty-three percent of visitors also believe that increased popularity had increased user awareness of the need to protect river values. Conversely, 50% stated that there were negative impacts to the popularity, including litter, parking issues, and human waste. Forty-six percent believed fish habitat had been negatively impacted by recreation, and 46% stated that jurisdictions could not effectively manage river-related traffic.

STUDY COMPONENT	DETAILED DESCRIPTION
Conclusions	One of the key quantifiable limiting factors this study identified for visitor capacity was parking capacity at launch sites. The study presented a plan to compare visitor counts to parking capacity to analyze crowding. To establish existing conditions and desired conditions, this study utilized community outreach to gather data through surveys, interviews, and town hall meetings. Through this approach, valuable data were collected about visitor use, experience, and perceptions of river utilization.
Keywords	Recreational use; User capacity; Existing conditions; Desired conditions; Visitor survey; Stakeholder interviews; Wild and Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	National Park Service, U.S. Department of Interior (1982). Review of comprehensive plan for management and use: North Country Trail. https://etic2.nps.gov/Documentum/00021085/80/1e/a4/7d.pdf
Study Purpose	Provide guidance on routing, developing, and managing the North Country National Scenic Trail for public agencies and private entities that are interest groups for the trail.
Study Area	North Country National Scenic Trail was designated as part of the National Trails System in 1980. As of the 1986 plan, the trail is planned to extend 3,200 miles from Crown Point, New York, to Lake Sakakawea in North Dakota. The proposed trail travels through seven states, including New York, Pennsylvania, Ohio, Michigan, Wisconsin, Minnesota, and North Dakota.
Managing Agency/Organization	National Park Service is the overall administrating agency and is supported by the North Country National Scenic Trail Advisory Council. Many potential trail segments are managed by State and local agencies, as well as private interests, and require a memorandum of agreement to develop and maintain the trail.
Recreation activity types	Hiking, backpacking, camping, birdwatching, cycling, and equestrian use
Method	The plan provides information about the expected amount of use on the trail. Due to the spectrum of use and the incremental development of the trail, it was determined to be very difficult to estimate the projected use of the entire North Country Trail, or individual segments. The plan provides description for which segments are expected to receive the most use, based on current patterns. Managing authorities are directed to consult State Comprehensive Outdoor Recreation plans (SCORP) to estimate the level of use on specific segments.
Results	It is predicted that most trail use will be by short-term hikers including day hikers, weekenders, and those hiking for a week or two. This is based on the pattern of use at the Appalachian National Scenic Trail. The importance of balancing the needs of more casual hikers with those of long-distance hikers is emphasized. The plan concludes that the heaviest use will occur on segments near major population centers, near popular recreation areas such as national parks and state parks, and areas with vehicle access.
Conclusions	Due to the large scope of the trail and early stages of trail development, the plan acknowledged the limitation of trying to estimate visitor use. Instead, it provided information on expected use, and factors which could increase the use of trail segments to predict trail popularity.
Keywords	Visitor use estimation; Long-distance trail recreation; National Scenic Trail

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	National Park Service, U.S. Department of Interior (1999). Comprehensive management and use plan: California National Historic Trail and Pony Express Trail. Nps.gov. https://www.nps.gov/cali/learn/management/upload/Comprehensive_Management_Plan-508.pdf
Study Purpose	Propose a comprehensive management and use plan for the California and Pony Express National Historic Trails and update the 1981 Oregon and Mormon Pioneer Comprehensive Management and Use Plans.
Study Area	The Oregon, California, Mormon Pioneer, and Pony Express National Historic Trails. These trails commemorate the settlement of the American West, and its impact on the development of the United States. The four trails cover land in 12 states, including Washington, Oregon, California, Idaho, Nevada, Utah, Wyoming, Colorado, Nebraska, Kansas, Iowa, and Missouri.
Managing Agency/Organization	The Long Distance Trails Office in Salt Lake City, Utah,[2] administers the Oregon, the California, the Mormon Pioneer, and the Pony Express National Historic Trails. Individual trail resources are managed by various management jurisdictions, and federal, state, local, and private agencies.
Recreation activity types	Diverse recreation opportunities, including camping, hiking, visiting historic and cultural sites, auto touring, and visiting museums
Method	As part of the comprehensive management and use plans, socioeconomic conditions along the four trails were reported. This information includes landownership and uses, population, income, and state economic conditions.
Results	Results of the socioeconomic analysis was provided for each of the 12 states. For land ownership, it was identified what percentage of landownership in each state was managed by BLM, USFS, or other federal managers. It also identified the amount of State, private, and Tribal lands. It was recognized that GIS mapping revealed that much of the information is incomplete and needs to be updated. Land uses were also provided for each state and categorized as agriculture, forest land, rangeland, urban development, and ungrazed (desert shrubland). Information on population growth, income, and employment was provided for each state. It was shown that Nevada had increased the greatest average population growth rate per year with 3.5%, followed by California (2.3%) and Utah (2.0%). Nebraska experienced the greatest average growth in per capita income with 9% between 1980 and 1994, followed by Kansas (8.8%) and Iowa (7.9%).

[2] The National Trails Office administering Regions 6, 7, 8, is now headquartered in Santa Fe, New Mexico.

STUDY COMPONENT	DETAILED DESCRIPTION
Conclusions	Though there were some limitations in available data, this plan was able to provide a large amount of information on land ownership, land use, and socioeconomic conditions for the 12 states that the trails pass through. This method of analyzing data for multiple state or large regions is useful when planning or managing other long distance trail systems.
Keywords	Socioeconomic analysis; Census data; Long-distance trail recreation: National Historic Trail

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	US Forest Service, U.S. Department of Agriculture (2001). Big Sur River comprehensive river management plan. https://www.rivers.gov/documents/plans/big-sur-plan.pdf
Study Purpose	Describe existing resource conditions and outstandingly remarkable values, define goals and desired conditions, address user capacities, address water quality issues, recognize opportunities for partnership, identify regulatory agencies, and provide a monitoring strategy.
Study Area	The Big Sur Wild and Scenic River is located entirely in the Ventana Wilderness, about 200 miles south of San Francisco.
Managing Agency/Organization	US Forest Service
Recreation activity types	Hiking, primitive camping, swimming, fishing, picnicking, and nature study
Method	To summarize resource values, existing recreation conditions were assessed and described. Data on recreation usage were provided from information on wilderness permits, the Los Padres National Forest Resource Management Plan, and wilderness ranger observations. The Recreation Opportunity Spectrum (ROS) was used to classify areas based on the recreation experiences they provide. The Limits of Acceptable Change (LAC) concept was also used to develop strategies for managing to maintain the desired ROSs. LAC, does not focus on capacity, but can provide an estimate of desired level of use.
Results	Recreation usage estimated that the Pine Ridge Trail accounted for 67% of total wilderness permits issued in the Monterey Ranger District in 1979. In 1981, 57,300 Recreation Visitor Days (RVDs) were recorded for the Big Sur River Corridor. In 2002, 29,838 RVDs were recorded for the Pine Ridge Trail out of the Big Sur Station. Use levels for 2002 were down from 1979 and 1981. This was likely due to a reduction in parking spaces and the Pine Ridge trailhead. Observations from wilderness rangers estimated that 75% of use in the river corridor is overnight use, 25% is day use, and 98–100% of users are on foot.
Conclusions	Several of the data sources used to estimate river use were outdated or based on informal observation. However, RVD data presented by the Los padres National Forest Resource Management Plan provided quantitative data on visitor use that could be used to manage the desired level of use.
Keywords	Visitor use estimation; Recreation opportunity spectrum; Recreation Visitor Day data; Wild and Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	US Forest Service, U.S. Department of Agriculture (2021). Eleven Point Wild and Scenic River comprehensive river management plan. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd973213.docx
Study Purpose	Guide development, management, and restoration activities in the Wild and Scenic River Corridor. Include desired conditions, a visitor use management strategy, and a monitoring plan.
Study Area	The Eleven Point Wild and Scenic River is located in the Mark Twain National Forest in Missouri. It includes 44.4 miles that have been designated as scenic.
Managing Agency/Organization	Administered by the US Forest Service; 6,427 acres of private land are within the Scenic Corridor.
Recreation activity types	Paddling, fishing, floating/tubing, water play, motorized boating, viewing wildlife, non-motorized boating
Method	To protect river values, visitor use capacity was analyzed. The plan used the capacity analysis framework outlined by the Interagency Wild and Scenic Rivers Coordinating Council. It also utilized the Recreation Opportunity Spectrum (ROS) to classify and describe a range of available recreation opportunities. Very little information on the exact number of river users was available, but some estimates could be made. Data used to inform the estimates include desired conditions from the Forest Plan, visitor preferences from past surveys in 2019 and 2004, current and expected impacts to river values, and the Recreation Opportunity Spectrum Classes. Capacity had previously been estimated in the 1975 comprehensive river management plan and was measured in number of canoes per day. Based on technical knowledge, public input, and data on river values, the main limiting attribute on the river was determined to be encounters with other groups. Off the river, parking availability was identified as the main limiting attribute.
Results	The analysis identifies separate capacities for day use and overnight use. Day use includes river floating activities, and overnight use focuses on float camp and gravel bar availability. The following capacities were identified for five uses on the Eleven Point River: • Day Use, above Greer Springs–320 people per day • Day river use, below Greer Springs–560 people per day • Overnight use at float camps–180 people per night • Overnight use on gravel bars–125 people per night • Dispersed on-shore use (not floating related)–508 to 1075 people per day

STUDY COMPONENT	DETAILED DESCRIPTION
Conclusions	Using data from surveys, Forest Plans, and Recreation Opportunity Spectrum classes allowed visitation estimates to be made, which were used to identify visitor capacities for river uses in key locations.
Keywords	Visitor use estimation; User capacity; Existing conditions; Desired conditions; Visitor surveys; Stakeholder interviews; Wild and Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	US Forest Service, U.S. Department of Agriculture, & Bureau of Land Management (2022). Cottonwood Creek comprehensive river management plan. https://usfs-public.app.box.com/v/PinyonPublic/file/1184262024896
Study Purpose	Establish management direction for Cottonwood Creek, a Wild and Scenic River. This includes addressing user capacities.
Study Area	21.5 miles of Cottonwood Creek are designated as a Wild and Scenic River. Cottonwood Creek flows through Mono County and Inyo County, California. A 17.1-mile segment flows through Inyo National Forest, and a 41-mile segment flows through BLM land.
Managing Agency/Organization	Administered jointly by the US Forest Service (USFS) and the Bureau of Land Management.
Recreation activity types	Hiking, dispersed camping, trout fishing, bird watching, four-wheel drive exploration, hunting, mountain biking, and equestrian use
Method	Current daily use was estimated to develop user capacity estimates for Cottonwood Creek. For the wild segment (USFS managed), current daily use was estimated based on daily visitor volume data collected by a trail counter for 94 days on the Cottonwood Creek Trail between August and November 2020. Daily and average intergroup encounter raters per hour were used to compare to estimated user capacity for the segment. For the recreational segment (BLM managed), counts were conducted for daily vehicle use on the access road, and for campground occupancy in dispersed campsites. Vehicle data were collected using two traffic counters and a camera for 94 days between August and November 2020. Estimates of current daily use were used to compare to estimated user capacity.
Results	For both segments, higher levels of recreation may adversely impact river values. Therefore, existing site capacities were determined to be limiting factors for user capacity. In the wild segment, trail use was shown to be very low, dispersed, and often off-trail. The quantity of dispersed camping was determined to be a limiting factor for this segment. Numeric user capacity was estimated as the maximum number of visitors that can be accommodated per day without the number of camping groups exceeding the capacity of existing campsites. The estimated numeric daily user capacity was calculated by multiplying the number of dispersed campsites by the number of visitors per campsite. Total daily user capacity was estimated as 30 visitors per day. In the recreational segment, results show that current overnight and day use is very low. The existing footprint of dispersed campsites and the day use parking areas were determined to be a limiting factor for this segment. Based on the data collected, the capacity of campsites was determined to be a greater limiting factor than day use parking. Therefore, the numeric user capacity was estimated as the maximum number of visitors that can be accommodated in the area per day without the number of camping groups exceeding the physical capacity of the dispersed campsites. Based on the relationship between the vehicle traffic and campground occupancy data,

STUDY COMPONENT	DETAILED DESCRIPTION
	30 vehicles per day and 75 visitors per day were estimated as numeric user capacities.
Conclusions	The use of trail counters and traffic counters to collect data to estimate current daily use was effective for the smaller scale of this Wild and Scenic River system, due to the limited access points and recreation sites. This provided a strong foundation to develop numeric user capacities for each segment.
Keywords	Visitor use estimation; User capacity; Wild and Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	US Forest Service, U.S. Department of Agriculture (2022). Owen's River Headwater comprehensive river management plan. https://usfs-public.app.box.com/v/PinyonPublic/file/1184264721989
Study Purpose	Protect and enhance river values by providing desired conditions, management direction, and a monitoring plan for the Owens River Headwaters Wild and Scenic River. To help guide decisions about visitor use management, visitor capacity was analyzed for the river.
Study Area	The Owens River Headwaters are located in the Sierra Nevada Mountains in Mono County, California, in the Inyo National Forest. The boundaries of the river corridor are about 0.25 mile from each side of the river. A total of 19.1 miles of the Owens River Headwaters are designated as a wild, scenic, or recreational river.
Managing Agency/Organization	The USDA Forest Service is responsible for the administration of the Owens River Headwaters.
Recreation activity types	Hiking, horseback riding, camping, fishing, birding, backcountry skiing, and snowshoeing, OHV riding, and hunting
Method	In order to determine potential effects of recreation use on river values (scenery, wildlife, recreation, geologic/hydrologic, botany), current daily use was estimated for the both the scenic and recreational segments, and the wild segment of the Owens River Headwaters. In the recreational and scenic segments, daily visitor use was estimated based on campground occupancy data collected at two major campgrounds. Data were collected for 69 days at Big Springs Campground and 79 days at Glass Campground between July and October 2020. Due to a lack of staffing and a shortage of volunteers, data were not collected for dispersed camping and day use sites. In the wild segment, counts of daily visitor use and intergroup encounters per hour were conducted over 80 and 10 days, respectively, between August and November 2020. Data were collected on the Glass Creek Meadow Trail, the primary public access for the wild segment.
Results	In the recreational and scenic segments, estimated current daily use of the campgrounds was compared to the existing campground capacity. Daily user capacity was calculated by multiplying the number of available campsites by the number of visitors per campsite. The data suggested that the two main campgrounds reach capacity less than 5% of days during the visitor use season, but they approach capacity often during the peak summer season. In the wild segment, current visitor use was shown to generally be very low. A threshold of no more than two encounters with groups per hour was developed by USFS and used to estimate the numeric user capacity. Daily visitor use and intergroup encounter rate data were used to develop a regression model to estimate a numeric user capacity for the maximum number of people who can hike the trail per day without exceeding the threshold of no more than two encounters with groups per hour. The results

STUDY COMPONENT	DETAILED DESCRIPTION
	showed that the numeric user capacity for the wild segment is estimated as a total of 18 people per day.
Conclusions	Two different counting methods were used to estimate current daily use in the two river segments, based on the differing conditions and recreation opportunities of each segment. Campground occupancy data were collected in the recreational setting, due to the high use of campgrounds and dispersed campsites. In the wild section, trail counts of daily visitor use and intergroup encounters were used, based on the segment's main visitor access being by trail. Additionally, data collection was limited by lack of staffing, a shortage of volunteers due to the COVID-19 pandemic, and fire closures. These factors present risks for many studies on remote river and trail systems.
Keywords	Visitor use estimation; User capacity; Wild and Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	US Forest Service, U.S. Department of Agriculture, & Bureau of Land Management (2022). Wasson and Franklin Creeks comprehensive river management plan. https://usfs-public.app.box.com/v/PinyonPublic/file/982845001792
Study Purpose	Establish management direction to protect and enhance the values of Wasson Creek and Franklin Creek. This includes establishing user capacities.
Study Area	Wasson Creek and Franklin Creek Wild and Scenic Rivers are located near the coast of Oregon, about 70 miles southwest of Eugene. The designated segment of Wasson Creek is 10.1 miles long and managed by both the Forest Service and the BLM. The designated segment of Franklin Creek is 4.5 miles long and managed by the Forest Service.
Managing Agency/Organization	Administered jointly by the US Forest Service and the Bureau of Land Management under a multiple use mandate.
Recreation activity types	Backcountry use, sightseeing, wildlife observation, camping, photography, hiking, fishing, hunting, mushroom hunting, and non-motorized boating along the river corridors
Method	A capacity analysis was conducted using the nine-step process outlined by the Interagency Wild and Scenic Rivers Coordinating Council. The steps are: 1. Describe the baseline and current conditions and uses for the Wild and Scenic River 2. Identify desired conditions for the river's values and classifications 3. Identify the kinds of use that the Wild and Scenic River Corridor can accommodate 4. Identify measurable indicators for the desired conditions 5. Establish thresholds for each indicator 6. Identify triggers that elicit management response 7. Identify management actions to take when triggers are reached 8. Determine the Wild and Scenic River Corridor's user capacity 9. Establish a monitoring and adaptive management approach Wasson Creek was divided into three geographic river management areas (GRMAs) based on differences in recreation access, recreation use, infrastructure, and desired conditions. A numerical visitor capacity was estimated for each GRMA. Franklin Creek was assessed as a single GRMA. Data sources used include online resources about hiker access points and visitor experience, information from field visits by staff, vehicle use data from a road counter, information for external parties (advocacy groups and local individuals, and National Visitor Use Monitoring (NVUM) data from 2016.

STUDY COMPONENT	DETAILED DESCRIPTION
Results	Capacity was determined for each GRMA. For each area, capacity was measured in people per day. For two of the segments, a separate capacity was determined for overnight use and visitor use, while the other two segments provided a capacity for combined day and overnight use. Key rationale and assumptions were provided for each estimate, including factors such as: • Size and layout of campsites • Estimate of maximum group size • Average group size • Length of stay • Length of day use • Presence of social trails • Visitor sensitivity to crowding • Occupancy of recreation sites • Desired conditions
Conclusions	Using the nine-step process outlined by the Interagency Wild and Scenic Rivers Coordinating Council provided a robust framework for determining visitor capacity. Estimating visitor capacity for smaller geographic river management areas allowed for more detailed analysis of study area. However, quantitative data sources for this river were limited, and the analysis relied heavily on anecdotal or qualitative data.
Keywords	Visitor use estimation; User capacity; US Forest Service National Visitor Use Monitoring Program; Wild and Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	US Forest Service, U.S. Department of Agriculture (2022). Middle Fork Snoqualmie and Pratt comprehensive river management plan. https://usfs-public.app.box.com/v/PinyonPublic/file/1026651696634
Study Purpose	Establish management direction of the Middle Fork Snoqualmie and Pratt Wild and Scenic Rivers. This management plan includes a visitor use management strategy.
Study Area	The Middle Fork Snoqualmie and Pratt Wild and Scenic Rivers. The rivers include a total of 41.2 miles located in King County, Washington.
Managing Agency/Organization	The US Forest Service administers the Middle Fork Snoqualmie and Pratt Wild and Scenic Rivers. Several state and local agencies also have management responsibilities for the rivers.
Recreation activity types	Catch and release fishing, whitewater rafting, equestrian use, hot springs, camping, hiking, tribal hunting
Method	In order to provide opportunities for visitor recreation while protecting and enhancing river values, visitor use capacity was estimated for the river corridors. The following data were used to assess current conditions and estimate visitation numbers: • Campsite monitoring data—evaluation of ground disturbance, human waste and litter, and damage to vegetation in campsites and recreation areas. • Visitor use monitoring—estimated using car counter data, vehicle counts at trailhead parking lots, and findings from a 2015 visitor use monitoring effort. • Visitor use surveys—a 2018 survey of 192 visitors collected information on their activities, motivations, likes and dislikes, and experiences in the corridors. • Trail use modeling—a statistical random effect model was developed to estimate visitation of trails in the river corridor. It related on-site visitation to social media data, calendar (time of year, holidays), weather, and estimate use-level variables. It was developed through a partnership with University of Washington Outdoor Recreation and Data Lab, Mt. Baker-Snoqualmie National Forest, the US Forest Service Pacific Northwest Research Station, and Washington Trails Association. • Human-wildlife conflicts and impacts information • Field ranger observations—data related to trail and overnight use, visitor behavior, presence of campfire rings, off-leash dogs, and litter. • Satellite imagery—analyzed for presence of social trails. • Road and trail buffers—GIS mapping showed 100-meter and 500-meter buffers of roads, trails, and well-used portions of the river to analyze impacts on wildlife habitats. • Habitat modeling

STUDY COMPONENT	DETAILED DESCRIPTION
Results	Visitor use analysis was conducted for five distinct visitor use areas, based on desired conditions for each section. Current annual visitation was calculated using one or both of the following data sources, depending on the river section: • The average of five years of modelled visitation data for trail use. • The 3-year average of cars driving on key access roads. The number of vehicles was multiplied by 2.5, the average number of people per vehicle for the Mt. Baker–Snoqualmie National Forest. Estimated annual visitation and estimated capacity for each section was calculated as: • Pratt River Corridor: Visitation = 9,428 annual visitors; Estimated capacity = 10,000 annual visitors. • Middle Fork Snoqualmie River Wild Section: Visitation = 1,128 annual visitors; estimated capacity = 1,200 annual visitors. • Middle Fork Snoqualmie Scenic Section #1: Visitation = 16,104 annual visitors; estimated capacity = 16,500 annual visitors. • Middle Fork Snoqualmie Section #2: Visitation = 26,685 annual visitors; estimated capacity = 29,00 annual visitors. • Section #3: Visitation = 97,968 annual visitors; estimated capacity = 117,562 annual visitors.
Conclusions	The visitor use capacity study used a comprehensive set of data sources to estimate visitation and user capacity. Specifically, vehicle count data and the results of the statistical random effect model of trail use provided valuable data on estimating existing annual visitation.
Keywords	Visitor use estimation; User capacity; Wild and Scenic River

Conclusions Pertaining to Planning Documents and Publications

Key insights from the planning documents reviewed are as follows:

- The Wild and Scenic Rivers Act mandates that each designation's free flowing condition, water quality, and outstandingly remarkable values (collectively known as "river values") be protected and enhanced. Federal river administering agencies for congressionally designated wild and scenic rivers are required to "address user capacities" within each comprehensive river management plan. Such plans typically analyze visitor use data and identify a visitor use management approach that will protect and enhance the baseline and desired conditions for each identified river value. To achieve this, many systems have derived current visitor use estimates with limited data sources. Common data sources include campground occupancy, visitor use counts, intergroup encounter observations, vehicle and trail counters, visitor surveys, and parking counts.

- River corridors are often divided into segments or geographic river management areas to estimate use and user capacities more accurately.

- There is variation in the metrics used to measure visitation. Some plans differentiate between day use and overnight use, while others combine those categories. Some studies present visitation estimates based on annual visitor use, while others use visitors per day. Though many visitation estimates exist for river and trail systems, units and categories are often not consistent.

- Multiple frameworks are used to analyze user capacities across agencies, including the Interagency Wild and Scenic Rivers Coordinating Council (IWSRCC) Framework, the Interagency Visitor Use Management Council Framework, and the Recreation Opportunity Spectrum, and Limits of Acceptable Change. No guidance documents for addressing user capacities have been developed by the Interagency National Trails System Council.

- Due to the expansive and porous nature of National Historic, Recreational, and Scenic Trails, most planning documents do not include precise and accurate estimates of visitation. However, more quantitative use descriptions have been established and documented in some plans.

- National Trail System planning documents provide information on socioeconomic conditions surrounding trail corridors. These descriptions often include multiple states and provide a model for identifying characteristics across long distances.

- National Park Service atlases provide a model for analyzing a large area and providing detailed data related to planning indicators.

- Different agencies including the US Forest Service, the Bureau of Land Management, the National Park Service, and others have differing levels of data availability. Where possible, it is beneficial to coordinate data sources across multiple agencies.

- Please note that the project team is aware of several ongoing studies that have not yet been published for the following trails (see the sub-bulleted list below). Though these studies were not included as part of the literature review, the project team will continue to monitor their progress and incorporate any relevant outcomes into this research.
    - Pacific Crest National Scenic Trail
    - Appalachian National Scenic Trail
    - Overmountain Victory National Historic Trail
    - Appalachian National Scenic Trail
    - Pacific Crest National Scenic Trail
    - Continental Divide National Scenic Trail
    - Lewis and Clark National Historic Trail
    - Washington-Rochambeau Revolutionary Route National Historic Trail

Economic and Other Benefits

This subsection of the report provides a systematic review of the benefits related to rivers and trails in tabular summaries. This subsection also includes a conclusion with key insights based on the literature reviewed.

Tabular Summaries

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	American Whitewater (2014). The economic impacts of river recreation. 1–5.
Study Purpose	Document the various studies on economic impacts of river recreation since the early 2000s. The goal of this study is to highlight the various findings and how river recreation impacts the communities around rivers.
Study Area	Various
Managing Agency/Organization	Various
Recreation activity types	River recreation, paddling
Methods	Secondary analysis
Results	American Whitewater was able to find a variety of studies across the past 15 years that have measured the economic output of river recreation in various areas. Overall, results found that river recreation can be quite beneficial to local areas, but the total output ranges. Depending on the number of users, economic output can range from ~ $500 thousand to $14.3 million in economic output.
Conclusions	Specific studies to understand how visitors spent money during their river recreation can assist management in proving the usefulness of maintaining their rivers. Economic impacts are broad and positively impact the local community where visitors spend their time after rafting. They encourage other water managers of places such as whitewater parks and local rivers to consider measuring economic impact to understand their users' contribution.
Keywords	Economic impact; River recreation

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	BBC Research & Consulting (2018). Economic and health benefits of bicycling in Northwest Arkansas. https://www.bbcresearch.com
Study Purpose	Estimate economic and health benefits of bicycling in Northwest Arkansas.
Study Area	Northwest Arkansas (Areas surrounding Bentonville, Fayetteville, Rogers, & Springdale)
Managing Agency/Organization	BBC Research & Consulting, Walton Family Foundation, and PeopleForBikes
Recreation activity types	Bicycling
Method	Economic Benefit Analysis: BBC utilized surveys and interviews of Northwest Arkansas residents, businesses, bicyclists, skilled workers, and hiring managers, as well as secondary data (Strava data on trail usage) to determine economic impact. This was based upon a comprehensive literature review of economic impact studies of bicycling. Included quantitative and qualitative analyses were hedonic regressions, and analyses of business/residential development and worker attraction/retention. Health Benefits: This methodology was split into determining benefits of reduced mortality and avoided healthcare costs. The mortality analysis was conducted using data collected from the Household Survey, the standard value of a statistical life as determined by the United States Department of Transportation, and the World Health Organization's Health Economic Assessment Tool to calculate the annual benefit of reduced mortality due to bicycling. The morbidity analysis (avoided healthcare costs) used data from the household survey to provide a conservative estimate of residents in the region who realize lower health care costs due to physical activity associated with bicycling. For those residents, BBC used Arkansas-specific cost estimates for treatment of the top five chronic health conditions linked to physical inactivity: heart disease, stroke, diabetes, cancer, and poor mental health. Health care and lost productivity costs related to bicycling injuries were also considered. Health care costs were tailored to Northwest Arkansas by accounting for differences in regional household income, heath care costs, and the proportion of off-street riding. Bicycle Participation: The study used a telephone and online panel survey to gather information regarding bicycling behavior, in collaboration with Davis Research, PeopleForBikes, the Walton Family Foundation, and BikeNWA.

STUDY COMPONENT	DETAILED DESCRIPTION
Results	Key Results: • Bicycling in Northwest Arkansas provides $137 million in benefits to the economy annually • Bike tourism is a significant economic driver with tourists spending more than $25 million at local businesses each year • Investment in soft-surface mountain bike trails is a key driver of tourism with at least 55% of mountain bikers traveling to Northwest Arkansas from outside the region • Bicycling in Northwest Arkansas generates $85 million annually in health related benefits • Residents of Northwest Arkansas spend more than $20 million on bicycling annually BBC • Houses within .25 miles of the Razorback Greenway sell for an average of nearly $15,000 more than those two miles from the trail On a per-capita basis, results for Northwest Arkansas are very similar to those found for Colorado. The role of bicycling in the Northwest Arkansas economy is comparable to other areas throughout the country. Overall, approximately $51 million (37%) of total economic benefits are business benefits and approximately $86 million (63%) are health benefits.
Conclusions	Bicycling has a definitive economic impact to Northwest Arkansas and community sentiments towards bicycling were positive. The Razorback Regional Greenway (and the related trail system) have driven demonstrated beneficial impacts to Northwest Arkansas that are on par with other well-known bicycling destinations, per-capita.
Keywords	Economic Impact; Health benefit

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Bergstrom, J. C., & Loomis, J. B. (2017). Economic valuation of river restoration: An analysis of the valuation literature and its uses in decision-making. *Water Resources and Economics, 17*, 9–19.
Study Purpose	Analyze the existing non-market valuations of river restoration in the U.S. and Europe, identify the goals of the river restoration and the valuation methods used. The study found that stated preference methods were commonly used, and the economic value of river restoration increased with the number of river miles restored.
Study Area	38 Rivers across the U.S. and Europe
Managing Agency/Organization	University of Georgia & Colorado State University
Recreation activity types	River recreation
Method	The paper used a literature review to analyze existing non-market valuations of river restoration primarily in the United States and Europe. The paper identified the goals of the river restoration in terms of ecosystem services, as well as the valuation methods used. The paper reviewed 38 river restorations and examined whether they involved benefit-cost analyses or environmental assessments or equivalent decision documents.
Results	The paper analyzed the use of revealed preference and stated preference methods for valuing river restorations. The paper estimated a willingness-to-pay (WTP) function to examine the relationship between the economic value of river restoration and the number of river miles restored. Finally, the paper discussed the potential for meta-analysis of river restoration values to allow for benefit function transfer and the international transferability of resulting benefit functions.
Conclusions	The conclusion suggests that meta-analysis of these studies will become increasingly reliable and feasible, and benefit transfer based on the studies reviewed in the paper would likely be most applicable to valuing U.S. river restoration policies and projects.
Keywords	Economic benefit; Ecosystem goods and services; Revealed preference; Stated preference

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Bowker, J. M., & Bergstrom, J. C. (2017). Wild and Scenic Rivers: An economic perspective. *International Journal of Wilderness, 23*(2).
Study Purpose	Assess the economic benefits of the National Wild and Scenic Rivers System (NWSRS) by providing a conceptual taxonomy of economic benefits associated with individual rivers and the system as a whole. The paper reviews the empirical literature on economic valuation of wild and scenic rivers, summarizes the results, and assesses the economic impacts of the NWSRS on local communities. The paper also identifies the shortcomings in the existing economic literature and research needs to better understand the economics of wild and scenic rivers.
Study Area	Wild and Scenic Rivers Meta-Analysis
Managing Agency/Organization	US Forest Service & University of Georgia
Recreation activity types	River recreation
Method	A review of the empirical studies and valuation results for scenic rivers, with a qualitative and quantitative summary and assessment of each report's results and an assessment of the economic impacts of wild and scenic rivers on local communities.
Results	The study recommends that future studies should attempt to disaggregate values categorically and account for the full suite of benefits derived from natural riverine ecosystems and the likely consequences to those benefit flows from alternative development options. This will help set priorities such that healthy river ecosystems and appropriate visitor services are maintained.
Conclusions	The study provides evidence that the economic benefits of protecting rivers in the National Wild and Scenic Rivers System (NWSRS) outweigh the costs associated with designation, and that future research should focus on better accounting for the full suite of benefits derived from natural riverine ecosystems to help ensure that priorities are set such that healthy river ecosystems and appropriate visitor services are maintained.
Keywords	Economic benefit; Economic impact; Ecosystem services; Literature review; Wild and Scenic Rivers

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Binod P. Chapagain, Neelam C. Poudyal, J.M. Bowker, Ashley E. Askew, Donald B.K. English, and Donald G. Hodges (2021). Demand for and economic value of nonmotorized boating access in rivers at U.S. National Forests. *Journal of Forestry, 119*(3), 275–290.
Study Purpose	Explore the significance of non-motorized boating (NMB) activities and the benefits they bring in the National Forest System. Present economic benefits of NMB access, which will help in characterizing the value of maintaining these resources for public use, and justify the investment and costs involved in their management.
Study Area	National forests in the U.S. with a focus on non-motorized boating (NMB) trips to rivers within the national forests
Managing Agency/Organization	USDA Forest Service
Recreation activity types	Non-motorized boating
Method	Analyzing data from the Forest Service National Visitor Use Monitoring (NVUM) program to estimate the demand for NMB trips to rivers on national forests. A negative binomial regression model used as the likelihood ratio test of overdispersion, rejected the null hypothesis that the mean and variance of the dependent variable are equal. The variables included in the model were travel cost, substitute cost, age, gender, group size, number of children, boat ramp availability, rapid class, velocity, designation, days spent on the trip, recession, and round of data collection.
Results	Net economic benefit of NMB access was estimated to be in the range of $56 to $73 per trip, depending on the modeling assumptions used. When aggregated across visits over the country, the total annual economic value of NMB access in National Forest System ranged from $92 million to $120 million.
Conclusions	The value of nonmotorized boating in national forests is significant and trip demand for nonmotorized boating is responsive to site and river characteristics such as ramp availability, rapid class difficulty level, and flow velocity. This information is useful for resource managers and planners in characterizing the public value of nonmotorized boating opportunities, comparing the benefits with costs, and prioritizing programs to meet recreationists' needs.
Keywords	Economic benefit; Non-motorized boating; US Forest Service National Visitor Use Monitoring Program

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Colby, B., & Smith-Incer, E. (2005). Visitor values and local economic impacts of riparian habitat preservation: California's Kern River Preserve 1. *JAWRA Journal of the American Water Resources Association, 41*(3), 709–717.
Study Purpose	Examine the economic aspects of preserving a riparian birding area in Southern California, including visitor willingness to pay for habitat restoration and visitor expenditures in the local economy.
Study Area	Kern River Preserve
Managing Agency/Organization	American Water Resources Association
Recreation activity types	Birding
Method	A survey was conducted to elicit maximum willingness to pay (WTP) to prevent the degradation of stream flows and riparian habitat in a hypothetical scenario. The survey used a payment card presenting annual donation amounts from $0 to $1,000, followed by follow-up questions for positive and zero bids. The socio-economic information necessary to estimate a WTP function was collected. A Tobit model was used to analyze the data, and the results showed that income, level of education, and the number of previous trips to the area have positive effects on expected WTP.
Results	The study found that visitors are willing to pay an annual fee of $77 to preserve the habitat, and their expenditures generate approximately $1.3 million in increased local business activity. The study suggests that dedicating water to maintain riparian habitat deserves serious consideration and may generate positive net benefits for the local economy.
Conclusions	This study found that preserving the KRP riparian habitat is valuable and may generate positive net benefits, with visitors spending an estimated $648,000 to $860,000 per year on lodging, meals, and retail purchases. Businesses dependent on nature tourism should ensure the preservation of the riparian habitat to maintain and enhance nature-based tourism revenues. The study also indicates that continued preservation of the riparian habitat of the Kern River Preserve is important to the local economy, and visitors value continued protection of the riparian habitat.
Keywords	Economic benefit; Willingness to pay

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Cook, P.S. (2012). Impacts of visitor spending on the local economy: Obed Wild and Scenic River. National Park Service & University of Idaho.
Study Purpose	Analyze the economic impact of visitors to the Obed Wild and Scenic River in 2012.
Study Area	Obed Wild and Scenic River
Managing Agency/Organization	National Park Service
Recreation activity types	Human presence, rafting, river activities
Methods	The economic impact estimates for Obed WSR were produced using the Money Generation Model 2 (MGM2), which combines information on park use, spending, and regional multipliers to calculate changes in sales, labor income, jobs, and value added in the region. Inputs for the model included the number of visits by lodging-based segments, spending averages for each segment, and economic multipliers for the local region. The visitor survey conducted at Obed WSR provided data on visitor demographics, activities, and travel expenditures, which were used to estimate spending and economic impact. The MGM2 model divided visitors into four segments based on reported trip characteristics and lodging expenditures: local, day trip, paid overnight, and unpaid overnight.
Results	On average, visitor groups spent $47 per trip, and the spending of visitor groups staying in paid lodging was estimated at $156, while unpaid lodging spending was $131. The direct spending attributed to the park visit was estimated at $2.4 million. Visitor spending generated $0.73 in secondary sales through indirect and induced effects, and the tourism output sales multiplier for the region is 1.73.
Conclusions	The study found that visitors spent a total of $3.75 million, with 80% of visitor groups indicating that their visit to the park was the primary reason for their trip to the area. The study estimated that the $2.35 million in visitor spending attributed to the park generated $2.82 million in direct sales in the region, which supported 35 jobs. The paper also includes a separate study that estimated the local impacts of the park employee payroll in FY 2010.
Keywords	Economic impact; Visitor demographics; Expenditures; Visitor services; Wild and Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Deller, S. C., Lledo, V., & Marcouiller, D. W. (2008). Modeling regional economic growth with a focus on amenities. In *Review of Urban & Regional Development Studies: Journal of the Applied Regional Science Conference, 20*(1).
Study Purpose	Employ a Bayesian Modeling Average (BMA) approach to address the problem of model specification and provide new insights into the role of amenities, broadly defined, on regional economic growth.
Study Area	Data for U.S. counties
Managing Agency/Organization	University of Wisconsin–Madison
Recreation activity types	River recreation
Method	The study used a Bayesian Modeling Average (BMA) approach to address the problem of model specification. The authors estimated a neoclassical growth model using data for U.S. counties, while looking at growth over the 1990s. They looked at three separate ways of measuring amenities and recreational opportunities that build on those amenities.
Results	The results suggest that counties that have high levels of natural amenities are not ensured higher levels of growth, rather, there must be recreational sites available that build opportunities to access and use of these resources. The report also highlights the need for more work to develop specific indicators of development and to provide clear evidence of the latent input structure that characterizes recreation and tourism's supply-side.
Conclusions	The results show that higher levels of natural amenities do not necessarily result in higher growth rates, and that value-added development may be required to realize growth. The study provides new insights into the role of amenities on regional economic growth and suggests that there needs to be more work done to develop specific indicators of development rather than simplistic measures of economic growth. From a policy perspective, the interpretation of the results needs to be done with care, and more work is needed to provide clear evidence of the latent input structure that characterizes recreation and tourism's supply-side.
Keywords	Economic impact; Bayesian Modeling Average

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	ECONorthwest. n.d. The economic and social importance of Deschutes National Forest Trails.
Study Purpose	The Economic and Social Importance of Deschutes National Forest (DNF) Trails
Study Area	Deschutes National Forest
Managing Agency/Organization	US Forest Service, Deschutes Trails Coalition
Recreation activity types	Hiking/walking, horseback riding, bicycling, skiing, snowmobiling, ATV
Methods	This report compiles the best available information on the state of the trail network from a supply perspective, as well as the uses and users from a demand perspective. In conjunction, this information supports analysis of the benefits, spending, and economic impacts of DNF trails for the regional community and businesses. It also helps to highlight where and how investment is needed to keep pace with growing demand, while ensuring equitable access and opportunity.
Results	Hiking is the most common trail-based trip on the DNF, followed by biking. When considering the proportion of trail miles by activity type to annual trips for that activity type, hiking, biking, and non-motorized snow-based trail activities see the scarcest supply of primary dedicated trail availability. These are also the activities experiencing the most increase in use and participation, including among members of the growing Hispanic population. The direct economic benefit to users was estimated to be $82.5 million from trail activities in the DNF. Locals are responsible for over half the trail-related trips although non-locals spend more in total than locals do on these trips. These expenditures support over 800 jobs in Central Oregon and engage several industry sectors, not counting all those who choose to live in the area because of the amenities available to them.
Conclusions	• Visits are up, but funding is down: While national forests in the Pacific Northwest are seeing increasing recreation demand, available funds to operate and maintain the trail infrastructure are in decline, as timber revenues stay below historical levels and costs for wildfire fuel treatment and restoration efforts increase. • Trail funding does not match the benefit they provide: An important emerging trend is local stewardship and support of forests, such as the "$1 for Trails" program of Deschutes Trails Coalition. The $1 for Trails program allows local businesses to collect $1 from patrons to go towards local trail maintenance. This report was tasked with describing the social benefits of trails, calculating the measurable benefits that trails bring to the community, and demonstrating that existing trail funding did not match the level of benefits these trails provide. • Trails provide value to visitors, jobs for locals, and an influx of money to the local economy: this analysis of the over 800,000 annual trail-based visits to Deschutes National Forest found over

STUDY COMPONENT	DETAILED DESCRIPTION
	$80 million in annual value to visitors, and separately over $80 million in annual spending, supporting over 800 jobs. Using these numbers, this report calculated that visitors contributed $81 million annually to the local economy (via food, lift tickets, and hotel accommodations) in addition to the value they enjoy from their trips. • Trails cannot be maintained with the current level of funding: this report looked at the Deschutes National Forest's trail maintenance costs and found that at their current level, funds could not keep up with the level of use the trails support. Under-maintenance could lead to fewer trails open at a given time, or a less enjoyable experience for visitors as open trails are overwhelmed and facilities are stressed.
Keywords	Economic Impact; Social Impact; Trail recreation

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	ECONSULT SOLUTIONS INC., & Capital Trails Coalition. n.d. The economic, health, and environmental benefits of completing the Capital Trails Network. https://www.capitaltrailscoalition.org/wp-content/uploads/2021/04/CTC-Impact-Report-Web-4.28.pdf
Study Purpose	Determine the economic, health, and environmental benefits of completing the Capital Trails Network.
Study Area	Capital Trails Network
Managing Agency/Organization	Capital Trails Coalition, Washington Area Bicyclist Association, Rails to Trails Conservancy
Recreation activity types	Walking, running, cycling
Methods	IMPLAN modeling, commuter pattern analysis within two miles of existing and proposed trails, ecosystem services analysis based on land cover, and a public health analysis using Rail to Trail Conservancy, Census, and CDC information.
Results	This study found the $1.09 Billion investment in network expansion would yield increased trail access for 3.9 million area residents and add 930,000+ regular trail users. This would generate $2.05 billion from construction over 25 years and support 16,100 jobs, $941 million in local annual spending (supporting 8,200) jobs, result in $9.9 billion in property value premium benefits in 25 years and save $517 million in annual health savings. Environmental Benefits were estimated at $433 million for carbon storage and a decrease of 49 million vehicle miles traveled each year.
Conclusions	This study emphasizes the positive economic, social, and environmental externalities gleaned from the investment in completing the Capitol Trails Network. As the Capital Trails Network becomes increasingly more connected, the region will benefit from improved mobility opportunities, better recreation and safe bicycle commuting access for residents, increased access to low-cost recreation options and the health effects it provides, increased property values, as well as generating economic growth.
Keywords	Economic Impact; Health Impact; Trails network; IMPLAN modeling

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	EY (2020). Economic and social benefits of completing the Baltimore Greenway Trails Network. Greater Washington Partnership. 1–13.
Study Purpose	Understand the economic and social benefits of a $28 million plan to expand and connect existing trails in Baltimore to create the Baltimore Greenway Trails Network.
Study Area	Baltimore, Maryland
Managing Agency/Organization	Greater Washington Partnership
Recreation activity types	Hiking/walking, biking, other trail activities, greenspace activities
Methods	Literature review/project report
Results	The potential economic benefit of completing the greenway trail within Baltimore was estimated at $84 million to $113 million including 863–1,163 jobs. For health benefits, an estimated $1,600 annual health care savings is estimated per user on the trail. This accounts to nearly $2.4 million in annual health care costs.
Conclusions	The benefits associated with completing and further creating the Baltimore Greenway far outweigh the costs of $28 million in in building trails. Additionally, active transportation options reduce congestion and crowding on roads, provide value to nearby businesses, and lower environmental emissions. Through these estimates, the partnership can help position the Greenway to benefit the most amount of people.
Keywords	Economic benefit; Trails network

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Headwaters Economics (2018). The economic impact of outdoor recreation and the Whitefish Trail in Whitefish, Montana. https://www.headwaterseconomics.org
Study Purpose	The Economic Impact of Outdoor Recreation and the Whitefish Trail in Whitefish, Montana
Study Area	The Whitefish Trail and area of Whitefish, Montana
Managing Agency/Organization	Headwater Economics, Kendeda Fund, Whitefish Legacy Partners, and the Whitefish Convention and Visitors Bureau
Recreation activity types	Hiking, mountain biking, cycling, equestrian, general outdoor recreation
Methods	This study collected primary data from counts of trail users, in-person interviews at trailheads, and in-person interviews in downtown Whitefish. Secondary data were collected from Strava (a fitness tracking app) to estimate trail uses at Whitefish Mountain Resort and other areas outside the Whitefish Trail network. Infrared trail counters were used to identify the trail usage of the four most popular trailheads of the area over six months, which then determined the interviewing schedule and allocation of time spend at each trailhead from May to October. Verification of the trail counter accuracy and adjustments for non-human trail counts were done through hour-long manual counts. User surveys then delineated users into locals (Flathead County residents) and visitors to the area, along with collecting additional information for the study. This information fed into an IMPLAN model that generated the economic impact numbers for the study.
Results	Trail Use: Trail use peaked in summer months, with the local use max occurring in May. While use drops by about half in the winter, the four studied trailheads average 100 uses per day in the lowest use months. Foot traffic predominates but decreases in share compared to bicycle use in the winter. Role of Outdoor Recreation: Outdoor recreation is essential to the community character, quality of life, and economy of Whitefish. Fifty-one percent of locals stated that they recreate more since the Whitefish Trail was built and when asked why they use the Whitefish Trail, “health” was identified by 43% of respondents. Outdoor recreation is the main driver bringing visitors to Whitefish, and the Whitefish Trail plays an important role in attracting people. According to the study, 65% of all visitors who travel to Whitefish indicate that outdoor recreation is the primary purpose for their visit while 72% of first-time visitors to Whitefish indicated that outdoor recreation was their primary purpose for visiting. Visitor Makeup: 46% of visitors to Whitefish are from Montana, the Pacific Northwest, and Alberta (see Map 2). Nearly one-third of visitors are from Montana and Alberta alone. After Montana and Alberta, California is the third-largest source of visitors, accounting for 8% of visitors interviewed.

STUDY COMPONENT	DETAILED DESCRIPTION
	Economic Impacts of Outdoor Recreation: The Whitefish Trail contributes $6.4 million in annual spending by visitors who come to enjoy the trail and by locals who purchase or rent outdoor gear at local stores. Spending by visitors who use the Whitefish Trail translates to 68 additional jobs and $1.9 million in labor income in Whitefish. Spending by people visiting Whitefish mainly for outdoor recreation in the area amounts to approximately $101 million, 1,460 jobs, and $41.1 million in labor income annually.
Conclusions	Outdoor recreation is essential to the economy and quality of life in Whitefish. In just more than 10 years since the first section of the Whitefish Trail was constructed, the trail has become an essential component of summer and winter recreation offerings in the area. Visitors engaged in outdoor recreation stay longer and spend more per day, on average, than those who are not participating in outdoor recreation. For local residents, summer and winter recreation are what brings them to Whitefish and keeps them there. This helps businesses recruit and retain employees and sustains school enrollment. Locals most appreciate the trail's proximity to town, and this proximity has led to more than half of locals interviewed exercising more because of the trail. The trail's success in becoming an attraction for visitors in a short time is likely due, in part, because visitors are drawn first to the other, larger well-known destinations of the area. The Whitefish Trail appears to play a part in bringing back visitors for another trip; playing an important role in 21% of repeat visitors' decision to return to town. As the trail's size and reputation continue to spread, its impact will continue to grow. The Whitefish Trail's economic contribution builds on the broader economic foundation created by the collective destinations in the area that support approximately $101 million in spending annually.
Keywords	Economic Impact; Visitor use estimation; Mobile device data; IMPLAN modeling; Visitor interviews

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Holmes, T. P., Bergstrom, J. C., Huszar, E., Kask, S. B., Orr, F. (2004). Contingent valuation, net marginal benefits, and the scale of riparian ecosystem restoration. *Ecological Economics, 49,* 19–30.
Study Purpose	Estimate the benefits and costs of riparian restoration projects along the Little Tennessee River in western North Carolina, and determine whether restoration is an economically feasible investment of public funds.
Study Area	Little Tennessee River
Managing Agency/Organization	USDA Forest Service
Recreation activity types	River recreation
Method	The study identified and assigned generalized categories to several ecosystem services, such as habitat for fish and wildlife, erosion control, and water purification. The research conducted iterative referendum voting scenarios using a computerized survey instrument to determine the impact of program scale on marginal economic benefits. The survey was designed to facilitate communication of information about the sources of riparian ecosystem degradation and the various restoration activities that could be implemented. Bid amounts for the restoration programs were conditional on the response to the prior referendum question, and respondents were presented with bids for each of the four programs.
Results	The study found that respondents were willing to pay a premium for total restoration of the ecosystem compared to partial restoration, and the benefits of ecosystem restoration were super-additive, meaning the value of total restoration was greater than the sum of benefits measured for partial restoration programs.
Conclusions	The study found that the benefits of ecosystem restoration were a non-linear function of restoration scale and that the benefits of full restoration were super-additive. The conclusion suggests that future research on the economics of ecosystem restoration is needed to improve methods for communicating complex ecological dynamics in the context of economic valuation studies. It also recommends conducting more rigorous external scale tests and investigating how WTP is affected by the number of restoration programs. Finally, the paper highlights that human populations living in many different and diverse watersheds may benefit from riparian restoration activities.
Keywords	Economic impact; Economic benefit; Ecosystem services

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	James, T., Evans, A., Madly, E., & Kelly, C. (2014). The economic importance of the Colorado River to the basin region. L. William Seidman Research Institute, Arizona State Univ, 1.
Study Purpose	Examine the economic importance of the Colorado River for the Upper and Lower Basin regions in one calendar year (2012). The study uses Modified IMPLAN input-output models to estimate the Colorado River's economic importance to six states (Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming) and seven contiguous Southern California counties.
Study Area	Six states (Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming) and seven contiguous Southern California counties
Managing Agency/Organization	Arizona State University
Recreation activity types	River activities
Method	The study examines the economic importance of the Colorado River for the Upper and Lower Basin Regions for one calendar year (2012) using Modified IMPLAN input-output models to estimate the economic impacts of the non-availability of Colorado River water. The study assumes that no other sources of water are available to compensate for the loss of Colorado River water deliveries for the study year.
Results	The study assesses gross state product, employment, and labor income for each geographical area studied. The study estimates the total economic impacts of Colorado River water loss by Basin Region geography for one full calendar year. Over 16 million public and private sector jobs in the Basin Region rely on the availability of Colorado River water each year, with a total labor income of $871 billion (2014 $).
Conclusions	The study concludes that approximately 64.4% of the Basin Region's annual GSP could be lost if the Colorado River water is no longer available to residents, businesses, industry, and agriculture, and over 16 million public and private sector jobs in the Basin Region rely on the availability of Colorado River water each year, and $871 billion (2014 $) labor income. The availability and delivery of Colorado River water to municipal, industrial, and agricultural customers have a crucial impact on the economic development of the region.
Keywords	Economic impact; IMPLAN modeling

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Keith, J., Jakus, P., and Larsen, J. (2008). Impacts of Wild and Scenic River designation. Utah Governor's Public Lands Policy Coordination Office, 1–64.
Study Purpose	Review and understand existing impacts from Wild and Scenic River designation.
Study Area	U.S.
Managing Agency/Organization	Utah State University
Recreation activity types	River recreation
Methods	Literature review
Results	The study identified a variety of key findings, some of which are summarized below: 1. No significant trends were found between home values and designation. 2. No evidence was found to support a "designation effect" of rivers who went through the process. 3. Visitors' knowledge of WSR designation varied widely, but most knew that it preserved the quality of the environment. 4. Various considerations such as condemnation and other land management strategies have been used to successfully and unsuccessfully designate WSRs.
Conclusions	The primary conclusion from the researchers highlighted that local citizens and officials need to be involved in the designation plans for it to be successful. Providing committees to help oversee and review the pros and cons of designation is critical to gain support from the community and users. The authors state further that more research needs to be done to understand designation's impact on the economy. Setting up levels of use pre-and-post designation would be an important factor to understand the impacts of designation.
Keywords	Economic benefit; Wild and Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Lawson, M. (2022). Great American Rail-Trail: Economic potential of the Great American Rail-Trail. Headwaters Economics. https://headwaterseconomics.org/outdoor-recreation/great-american-rail-trail
Study Purpose	Estimate the economic potential of the Great American Rail-Trail.
Study Area	Washington, Idaho, Montana, Wyoming, Nebraska, Iowa, Illinois, Indiana, Ohio, West Virginia, Pennsylvania, Maryland, and the District of Columbia
Managing Agency/Organization	Headwaters Economics
Recreation activity types	Cycling, walking, running
Methods	The analysis was conducted in 2021–2022 using four data elements: (1) existing trail count data; (2) original statistical models to estimate trail users; (3) a literature review of spending estimates and trail use characteristics; and (4) economic impact estimates from the IMPLAN economic modeling program. Economic benefits then based on the following assumptions: that communities will capitalize on the trail with tourism-focused businesses, that the increase in outdoor recreation observed during the pandemic will persist, and that the route in this assessment will be built and maintained at a level of quality that is connected to other segments.
Results	The Great American Rail Trail could generate an annual impact of 25.6 million trips, 2,500 new jobs, $229.4 million in spending, $22.8 million in new tax revenue, $104 million in labor income, and $161 million in GDP contribution once completed. These metrics vary state to state based on length of trail, the total trail usage in the area, population density, and wealth. The strongest industries supported by the trail are lodging (3,980 jobs), retail (4,990 jobs), and restaurants (8,650 jobs).
Conclusions	The completion of the Great American Rail-Trail® will help amplify the benefits, on a mass scale, that trails provide. In addition to offering places for physical activity and recreation, connecting diverse communities with safe walking and biking routes, and promoting a closer connection to nature, the Great American will help communities along the route realize new economic potential. The cross-country route will serve as a catalyst for economic growth. Hundreds of communities along the route will experience new opportunities for business development and tourism thanks to the Great American Rail-Trail, all while contributing to the growth of the country's burgeoning outdoor economy—one of the fastest-growing sectors in the United States. To fully realize the economic opportunity of the Great American Rail-Trail, communities will need to plan for and invest in the trail. Eighty-eight gaps remain to be completed and infrastructure like trailheads and signage are needed. States and communities can support tourism-ready businesses along the route. Such investments could generate more than $229.4 million in visitor spending, $104 million in labor income, and $22.8 million in new tax revenue
Keywords	Economic impact; Trail recreation; Long-distance trail; IMPLAN modeling

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Loomis, J. (2003). Travel cost demand model based river recreation benefit estimates with on-site and household surveys: Comparative results and a correction procedure. *Water Resources Research, 39*(4).
Study Purpose	Examine the impact of endogenous stratification on recreation benefit estimates and compare benefit estimates from on-site and household surveys.
Study Area	River economic estimation
Managing Agency/Organization	Department of Agricultural and Resource Economics, Colorado State University
Recreation activity types	River recreation
Method	The article discusses the use of travel cost models to estimate consumer surplus for recreational trips. The dependent variable in most models is the number of trips, which can be modeled using a Poisson process. On-site sampling can lead to biased estimates if not corrected for, but Englin and Shonkwiler (1995) suggest a correction method by subtracting one trip from all observations.
Results	The study found that the on-site survey over-sampled avid users, resulting in higher benefit estimates than those derived from the household survey. Correcting for endogenous stratification using econometric methods eliminated the avidity bias and produced estimates similar to those from the household survey. Ignoring endogenous stratification can lead to overvaluing recreational uses of water resources and under-allocating water to other project purposes.
Conclusions	The conclusion is that correcting for endogenous stratification is important in determining the benefits of recreation provided by water resources. Ignoring this stratification can lead to overestimating the benefits of recreational uses of water, undervaluing other project purposes such as irrigation, hydropower or navigation, and producing biased results. The econometric procedures proposed by Shaw (1988) and Englin and Shonkwiler (1995) have been found to be effective in eliminating the bias from endogenous stratification in on-site samples, and the results should be replicated at other sites.
Keywords	Economic benefit; Visitor surveys; River recreation

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Moore, R. L., & Siderelis, C. (2002). Use and economic importance of the West Branch of the Farmington River. American Rivers & National Park Service.
Study Purpose	Examine the recreation users, economic benefits, and effects on nearby property values of the Wild and Scenic segment of the West Branch of the Farmington River in Connecticut. The study found that fishing, tubing, and boating were the most common activities, and users tended to be well-educated, middle-aged males on day trips. The segment receives 77,400 recreation visitors annually and generates an estimated annual economic impact of $3.63 million for the five river towns.
Study Area	The Farmington River
Managing Agency/Organization	Farmington River Coordinating Committee
Recreation activity types	Fishing, tubing, and boating
Method	This study collected two sets of data, one from recreation visitors to the river and the other related to the value of residential property near the river. The methods for sampling recreation users involved field personnel trained by the principal investigators who sampled users weekly from late April to late September 2001 using a systematic sampling schedule. Users were approached on site and handed a self-administered questionnaire or read the questions if more convenient. Follow-up mail questionnaires were sent to those agreeing, with up to three mailings employed to maximize response rates.
Results	The total economic benefits to recreational users were estimated to be $9.45 million. The river's effect on residential land values was found to be $3.76 per foot at a one-mile distance and $0.63 per foot at a six-mile distance. The study recommends maintaining the quality of the river resources and natural environment to keep river benefits high.
Conclusions	The river is primarily used by anglers, tubers, and boaters and generates a large economic impact in the five river towns. The total economic benefits to visitors were over $9.45 million in 2001, with anglers receiving the majority of the total benefits. Maintaining the high quality of river resources is the most important aspect of recreational demand for visits to the West Branch. The river users tend to be well-educated, middle-aged males with relatively high household incomes, and newcomers to the river represent both a challenge and an opportunity for managers. Overall, the river appears to be providing the intended nature-oriented setting and experiences.
Keywords	Economic benefits; Economic impact; Visitor survey; Wild and Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Patton, D., Bergstrom, J. C., Moore, R., & Covich, A. P. (2015). Economic value of carbon storage in U.S. National Wildlife Refuge wetland ecosystems. *Ecosystem Services, 16*, 94–104.
Study Purpose	Report on the quantity and economic value of carbon stored in wetland ecosystems found in four U.S. National Wildlife Refuges. The economic benefits of these wetlands, as carbon sinks, can be weighed against the economic costs of managing and perhaps expanding National Wildlife Refuge wetlands areas.
Study Area	Four U.S. National Wildlife Refuges
Managing Agency/Organization	U.S. Department of the Interior, Athens Technical College, and University of Georgia
Recreation activity types	River recreation
Method	Due to budget and time limitations, the authors used secondary data for both economic value and quantity. The chosen case-study refuges represent a diverse range of ecosystems, and issues of current interest to the U.S. Fish and Wildlife Service were considered. The study is a unique application of the third approach to carbon storage valuation, using secondary data for both the economic value and quantity of carbon stored.
Results	The results suggest that wetlands in National Wildlife Refuges provide substantial carbon storage benefits to the U.S. and the world. The study also found that different types of National Wildlife Refuge wetlands have varying capacity for carbon storage, and coastal and inland marsh ecosystems have a high capacity to store carbon. The economic benefits of wetlands as a carbon sink, along with other ecosystem services supported by these wetlands, should be weighed against the economic costs of managing and perhaps expanding National Wildlife Refuge wetland areas.
Conclusions	The authors suggest that wetlands in National Wildlife Refuges represent an economically valuable carbon sink, and that the economic benefits of these wetlands as a carbon sink, along with other ecosystem services supported by these wetlands, should be considered in planning for adaptation to global climate change.
Keywords	Economic benefits; Ecosystem services; U.S. National Wildlife Refuges

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Rutgers (2011). Route 66 economic impact study–Route 66. https://ncptt.nps.gov/rt66/economic-impact-studies/
Study Purpose	N/A
Study Area	Route 66
Managing Agency/Organization	National Park Service, Route 66 Corridor Preservation Program, and World Monuments Fund
Recreation activity types	Vehicular travel, tourism
Methods	Visitor Surveys, Case Studies
Results	The total annual, direct economic activity related to Route 66 from various sources amount conservatively to about $132 million annually. Rutgers applies an input-output (I-O) model to this direct spending and finds millions of additional dollars in multiplier benefits. These include $262 million in overall (direct and multiplier) economic output, $126 million in wealth creation (or gross domestic product), and $37 million in public tax revenues.
Conclusions	While the economic results are clearly important in their own right, the yet more significant contribution of Route 66 is at a local level. As documented in the case studies, in many smaller communities along Route 66, tourism related to the Mother Road is one of the most significant, if not the only, "economic game in town." Some of the most significant federal incentive programs in the United States today are not fully utilized along Route 66 and present exciting opportunities for advancing historic preservation and economic development on the Mother Road. The study also finds numerous economic challenges to the Mother Road. Slightly more than one-seventh of the population in the Route 66 Corridor are considered officially impoverished. Further, the Rutgers Museum survey and case studies point to the vulnerable economic situation of at least some of these resources: a bad tourist season, loss of a generous donor, death of a founding principal, or a dampening of enthusiasm by area volunteers could all prove devastating. Related is the challenge of fostering strong and sensitively presented heritage preservation and tourism. It is hoped that this study serves as a catalyst for a new era of cooperation and revitalization in the preservation of this iconic American landscape. In sum, the Mother Road provides both spiritual and economic nurturing.
Keywords	Economic impact; Vehicle travel

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Sage, J. L., Nickerson, N. (2018). Trail usage and value: A Helena case study. University of Montana Institute for Tourism & Recreation Research. http://www.itrr.umt.edu
Study Purpose	Trail Usage and Value of the Helena, Montana, trail system
Study Area	The Whitefish Trail and area of Whitefish, Montana
Managing Agency/Organization	University of Montana Institute for Tourism & Recreation Research
Recreation activity types	Hiking, mountain biking, running, walking
Methods	Trail User Intercept Survey: This study used a four month intercept survey at popular locations in addition to periodic hour-long proportion counts of trail user types (visitor/local, children present, group size, foot/bike traffic, and presence of dogs). TRAFx infrared and mountain bike specific trail counters to determine total trail use volumes (these were also multidirectional counters allowing for entry and exit estimations). Trail counters were in place the entirety of the summer survey period and added to addition trail counter data collected in 2016. User volume estimates were also supplemented with Strava data when needed/applicable. Helena Community Surveys: In-person intercept surveys at fueling-locations. A second online survey was also used, distributed via a social media push.
Results	Trail User Intercept Survey: Trail users tended to be male, in their mid-40s, recipients of undergraduate degrees, and of middle income ($40k-$119k annually). Eighty-one percent of trail users were Montana residents, of which 87% are from the local area. Nonresidents were mostly U.S. residents from out of state. Thirty-nine percent of nonresident trail users were in Helena for the first time. Trail users, independent of their residency, averaged 1.88 people per group. Roughly one in five respondents indicated they had a dog with them during their trail use the day they were surveyed, 88% of which were local trail users. Ninety percent of local users surveyed report that they use the trails network at least once a week between April and October, and over 70% say they do so at least three times a week during this period. Over half of all users, 55%, utilize some form of fitness tracking mobile app or device. Largely driven by foot traffic at the main Mt. Helena trailhead, trail use on foot exceeds that of bike use by nearly a three to one margin across the entirety of the trail system. Most trailheads served as round trip entry/exit points, while prime shuttle trailheads serve as primary entry points with users exiting elsewhere in the trail network. Shuttle use has risen and peaks in the summer, while also contributing strongly to the mountain bike use of particular trailhead entries. The desire to use the Helena trail network was a large motivator to purchasing outdoor gear in the last year. Two-thirds of all users indicated they have purchased gear in the last year in Helena. More than eight in 10 local trail users have purchased gear, while 28% of nonlocal Montanans and

STUDY COMPONENT	DETAILED DESCRIPTION
	33% of nonresidents have done so. Estimated visitor volumes yield a total spending estimate of $4.03 million by all nonlocal visitors who used the trail system in the summer of 2017. $3.64 million of the total is generated by nonresidents of Montana. The reported spending yields an impact of $4.3 million dollars in economic output, 60 jobs, and $185,211 in state and local tax generation. Helena Community Surveys: The vast majority of survey respondents were from the immediate Helena vicinity and had lived in the area for 30 years on average. The intercept survey collected data from older, longer-term residents than the social media survey, who were also more likely to be women. More than half, 55%, of the respondents indicated they use the trails and paths at least occasionally. Three in 10 respondents however, indicated they never use the trails or paths. Women were 4% more likely to indicate that they frequently use the trails, while men were 4% more likely to say they never use the trails. More variability may be found when partitioning the data by age with respondents in their 30s and 40s were the most likely to indicate they frequently use the trail system. The rate at which an age group indicated they never use the trails increased with age, peaking out at nearly 50% of those over age 60 indicating they never use the trails. While access to open space and lands was ranked of highest importance among community amenities available to Helena residents, the importance of trails on the decision to live and stay in Helena was less. This was less important to longer-term Helena residents than newer ones. For local business, the value of the trail system was more in sectors tied to the tourism economy than less tourism-specific industries.
Conclusions	Outdoor recreation is a major driver of tourism in many parts of Montana. Combining the survey information collected with both manual and electronic counts of users entering the trail system, this study estimated that over 63,000 users took part in outdoor recreation on these trails between May and September of 2017. Of these numbers, 17,438 were on mountain bikes, and 45,602 were on foot. Just over a quarter of all mountain bike activity was from users outside the local area, and one in five users on foot were nonlocal. In total, these nonlocal users spent $4.03 million on goods and services in the local area, $1.3 million of which came from mountain bike users. $4.3 million in economic activity and 60 jobs can be attributed to spending by visitors to the area who recreate in the South Hills. Over half of respondents rated the trail system as ‘very important’ to the quality of life in Helena. Additionally, 55% of Helena residents indicated they use the trails at least occasionally. Lastly, while there appears to be a broad attraction to the trail across visitors and locals alike, as well as across many age cohorts, there does appear to be a substantial drop off in use among those over the age of 60. Nearly 50% of survey respondents in this age group indicated they never use the trails, compared with only 3% of those adults under 30. While the surveys in this report do not contain enough information to identify why this low rate of usage might be, it does spark an opportunity for further evaluation, especially given the average age of survey respondents was nearly 53 years. It is well known that mobility declines with age and

STUDY COMPONENT	DETAILED DESCRIPTION
	thus accessibility of recreation opportunities becomes a concern. This study found that social media on-line 'push' surveys provide results skewed to the interested parties. They are not random and do not reflect the population; therefore, these should be used sparingly for decision making.
Keywords	Economic impact; Visitor use estimation; Trail use; Visitor surveys; Mobile device data

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Schultz, C. L., Layton, R., Edwards, M. B., Bocarro, J. N., Moore, R. L., Tepperberg, S., Bality, A., & Floyd, M. F. (2016). Potential measures for linking park and trail systems to public health. *Journal of Park and Recreation Administration, 34*(1).
Study Purpose	Identify potential health measures associated with public parks and trails and recommend measures that are both valid and feasible for practitioner and planning use.
Study Area	Meta-analysis of NPS River & Trails Health Benefits
Managing Agency/Organization	National Park Service (NPS), Rivers, Trails, and Conservation Assistance Program (RTCA), and North Carolina State University (NCSU)
Recreation activity types	Nature appreciation
Method	NPS, NCSU, and Centers for Disease Control and Prevention (CDC) conducted a collaborative study to identify potential health measures related to public parks and trails. The study included a comprehensive literature review through multiple electronic databases and libraries. The search criteria were articles that collected data on health or well-being related to natural spaces, greenspaces, parks, and trails and had to be peer-reviewed in English. A total of 210 articles were found that were related to the impact of parks and trails on health and well-being.
Results	Results from this research have four important implications for professionals and advocates in the fields of parks, recreation, trails, greenways, open space, and health: (1) to help make the case for public health goals related to park and trail system planning; (2) guide practitioners in their efforts to provide health-related recreation opportunities; (3) support community recreation and conservation projects; and (4) encourage more productive conversations among planners, advocates, managers, and researchers.
Conclusions	There is growing evidence of the connection between parks and trails and public health, but specific metrics are needed to assess this connection. Current planning practices are outdated and inadequate for promoting both social and ecological health outcomes. Recent research is exploring the evidence of healthy park and trail planning and will help refine measures for informed decisions to improve park and trail systems for community health.
Keywords	Health benefits; Literature review

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	Smith, J. W., & Moore, R. (2011). Perceptions of community benefits from two Wild and Scenic Rivers. *Environmental Management, 47*: 814–827.
Study Purpose	Examine the perceptions of benefits provided by Wild and Scenic Rivers to local communities, focusing on two specific rivers. The study aims to determine similarities and differences in perceived benefits based on proximity to the river, prior recreation experience, sociodemographic characteristics, and resource area.
Study Area	West Branch of the Farmington River & Chattooga River
Managing Agency/Organization	US Forest Service
Recreation activity types	River recreation
Method	The surveys asked respondents about their perceived importance of 10 potential community benefits of the river to local communities, proximity to the river, and frequency of river use. Data were also collected on socio-demographic characteristics. The West Branch of the Farmington River survey was conducted in person, with a total of 483 river users contacted, and 247 questionnaires were returned. The Chattooga River survey was conducted through mail-back questionnaires, with a total of 982 questionnaires sent to guided boaters, 942 to self-guided boaters, and 180 to annual pass holders. The survey response rate was 43.4%, with 841 questionnaires returned. The surveys were administered using a modified Dillman method. Data analysis was conducted to test several hypotheses.
Results	The findings suggest that there are similar patterns of perceived community benefits across distinct resource areas, and that resource managers should take these desired management outcomes into account when developing policies and practices. User characteristics, such as proximity to the resource and prior use history, can significantly affect perceptions of community benefits.
Conclusions	Local communities have a complex relationship with wildland recreation areas and their management, but the users of those areas tend to perceive community benefits in very similar ways. The findings imply that similar patterns of perceived community benefits exist across distinct resource areas and that the relationships between user characteristics and perceived benefits are also similar across the study rivers. Understanding these desired management outcomes can aid in the development of successful and sustainable resource management practices and policies, and managing agencies need to be aware of how these perceptions vary among resource users.
Keywords	Community benefits; Surveys; Wild and Scenic River

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	University of Connecticut Extension (2022). Trails impact series: Trails support economies, 1–2.
Study Purpose	Understand the economic benefits of trails on locations across the U.S. A case study from Canton, Connecticut Trail Town on the Farmington Canal Trail is presented as an example.
Study Area	Varied, and Canton, Connecticut
Managing Agency/Organization	NPS/others
Recreation activity types	All trail activities
Methods	Literature review/summary analysis
Results	The authors looked at various economic impact effects from trail systems across the United States along with an example from Canton, Connecticut. Results found that trails are important amenities for real estate buyers, a most desired activity. Trails provide jobs, tax revenue, and monetized value of quality of life. Trails may impact property values and impact crime. Furthermore, trails lead to users spending money at local businesses. An example in Canton, Connecticut found that the city has captured over $1.7 million grants to support construction of a new trail.
Conclusions	The authors recommend that trail managers take a systems approach to explore benefits at a wide scale. Connecting trails to downtown amenities is also recommended. Finally, engaging and involving anchor institution and local property owners in trail development.
Keywords	Economic benefits; Trail recreation

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	U.S. Department of Transportation, & Federal Highway Administration (2021). Recreation Trails Program Annual Report, 1–30.
Study Purpose	Document the successes and challenges of the Recreational Trails Program (RTP) for 2021 for the Federal Highway Administration.
Study Area	U.S.
Managing Agency/Organization	Federal Highway Administration (FHWA)
Recreation activity types	Hiking, biking, snowsports, pedestrian activities, aquatic or water activities, motorized vehicles, and more
Methods	N/A—Summary report
Results	In 2020, the RTP successfully funded over $1.5 billion (with an additional $1.1 billion in matched funding) to support trail maintenance, trailside facilities, equipment, construction, and acquisition of trail corridors. Overall, the program saw efficiencies in youth conservation and service corps working with private contractors and other agencies. The RTP has become an essential element of managing trails across the country. Over 26,000 projects occurred in 2021.
Conclusions	The RTP has become essential to fund thousands of trail programs, especially where deferred maintenance costs are expensive to mitigate. Managers should continue to look to the RTP to help with important projects that benefit the communities they serve.
Keywords	Recreational Trails Program

STUDY COMPONENT	DETAILED DESCRIPTION
Citation	White, E. M., & Stynes, D. J. (2008). National Forest visitor spending averages and the influence of trip-type and recreation activity. *Journal of Forestry, Jan/Feb: 17–24*.
Study Purpose	Examine the effectiveness of trip-type segmentation compared to segmentation based on recreation activity in estimating national forest recreation visitor spending. The results suggest that spending averages for trip types are more useful in estimating local economic impacts than those based on activity alone.
Study Area	US Forest Service National Visitor Use Monitoring program data (NVUM)
Managing Agency/Organization	US Forest Service
Recreation activity types	National Forest visitation
Method	This study used the NVUM Program and Survey Instrument to analyze data collected during the first round of the program from 2000 to 2003, to develop visitor spending averages and to examine the influence of activity and trip type on visitor spending. The NVUM program used a sampling protocol that included traffic counts and visitor surveys conducted at specific locations and days within a national forest. The survey instrument included a basic survey and an economic supplemental questionnaire that gathered information on the spending of the travel party within 50 miles of the interview site during the current recreation trip to the national forest.
Results	The study recommends that managers and planners estimate activity-specific spending averages within the trip-type framework to account for differences in spending between local and nonlocal and day and overnight trips. The study also suggests that spending averages for trip types are more generalizable across forests than those based on activity alone.
Conclusions	The authors propose a trip-type segmentation approach that better facilitates estimation of local economic impacts and contribution of national forest recreation than a segmentation based on activity alone. They recommend that activity-specific spending averages still be estimated within the trip-type framework. The study also discusses the importance of distinguishing local visitors from nonlocal visitors and the use of spending averages for trip types rather than activities for estimating spending and local economic impacts.
Keywords	Economic impact; US Forest Service National Visitor Use Monitoring Program

Conclusions Pertaining to Publications on Economic and Other Benefits

Key insights from the literature reviewed relevant to economic and other benefits related to rivers and trails are as follows:

- Wild, scenic, and recreational rivers and trails have been shown to contribute in many ways to local economies. Various studies have used surveys to assess spending associated with recreational use of rivers and trails and to what extent they contributed to the local economy. Spending totals vary greatly, especially depending on the type of river/trail and the type of users. It can be challenging to understand the impact in more remote areas, however.

- The complexities of developing accurate estimates of visitor use of rivers and trails make economic impacts and other benefit-related analyses challenging. Economic impact studies rely on estimating a total population of users to calculate the overall output. Without accurate population estimates, economic outputs can be inflated/deflated depending on direction. In most cases, the methods used to estimate visitor use are not detailed in reports. However, the most common methods include using existing visitor use statistics for similar areas or approximations based on professional judgement.

- Secondary data can be used to estimate economic benefits to varying degrees of accuracy. One method that has had varying degrees of success is examining the relationship between housing prices and natural amenities.

- Measuring health benefits can be challenging due to many confounding factors that make it difficult to understand the benefits attributable directly to recreational use of rivers and trails. Currently, standardized metrics to consistently measure health benefits are lacking.

- Few emerging methods have been identified in this topic. Conventional surveys, sometimes coupled with economic models of visitor spending, are still the predominant approach for estimating economic benefits.

- As noted, there are no established methods for reliably estimating visitation for long-distance trails and rivers. Pilot studies and related research are needed to evaluate the suitability and best methods for estimating visitation using a mix of conventional and emerging data methods.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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