OUTDOOR RECREATION ON STATE LANDS IN WASHINGTON

WHAT MOBILE DEVICE DATA REVEAL ABOUT VISITATION

EARTH ECONOMICS

AUTHORS

Earth Economics:

Alice Lin, GIS Manager

Ken Cousins, Research Principal and Ecological Economist

Angela Fletcher-Muñoz, Senior Researcher, Tools and Data Manager

Johnny Mojica, Project Director

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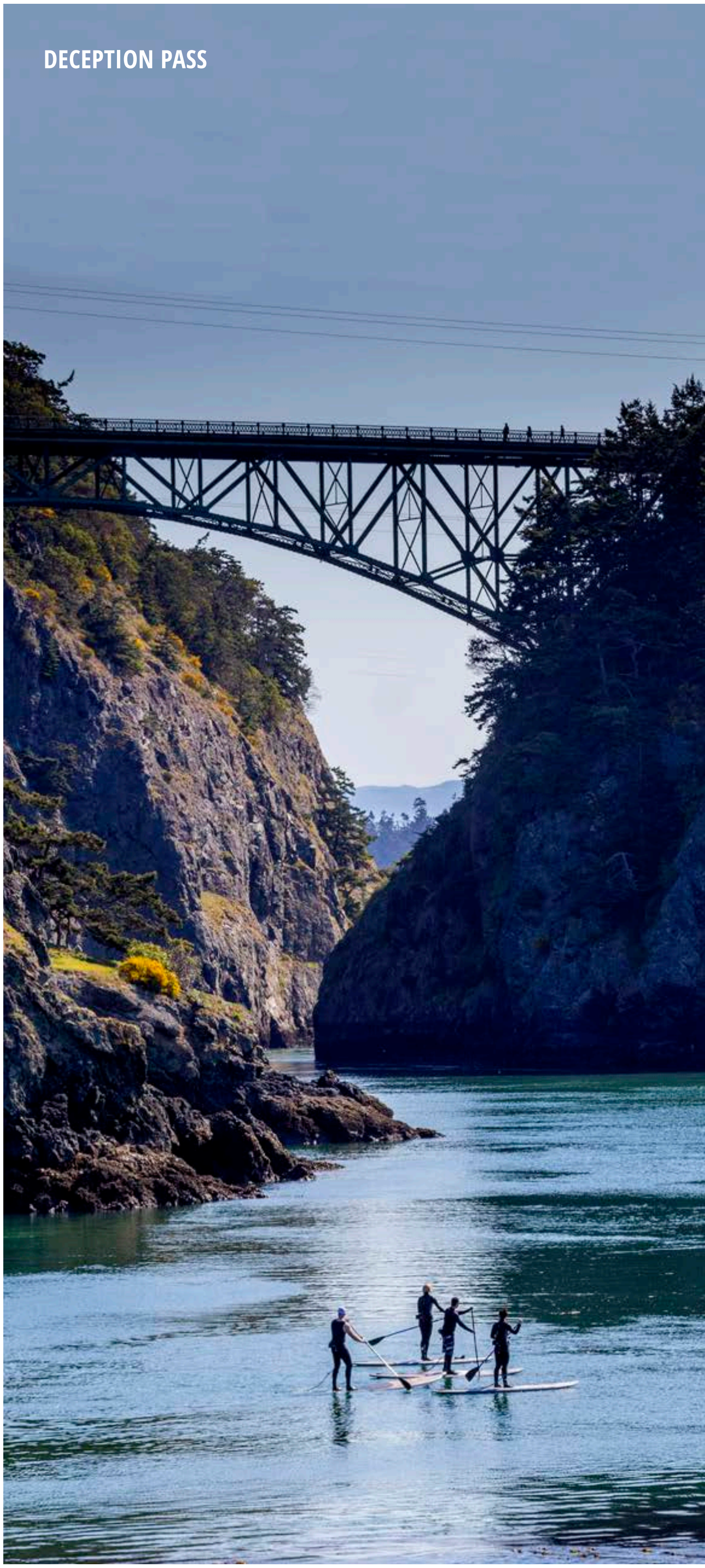
EARTH ECONOMICS

Earth Economics is a leader in ecological economics and has provided innovative analysis and recommendations to governments, tribes, organizations, private firms, and communities around the world. **eartheconomics.org**

Public land in Washington State totals 18.8 million acres, 6.5 million of which are managed by state agencies.[1] These lands allow both state residents and tourists to camp amongst old-growth forest, fish for wild salmon, hike to breathtaking lookouts, and ride ATVs on dirt roads. Effective recreation management relies on understanding the scale of visitation and benefits to local communities. Assessing the value of state lands to both recreationists and local economies also highlights the importance of maintaining these lands throughout the state.

In 2020, Earth Economics published the study "Economic Analysis of Outdoor Recreation in Washington State," which quantified the volume of visitors, spending, jobs, and tax contributions supported by outdoor recreation throughout Washington State. Subsequently, the Washington Department of Fish and Wildlife (WDFW), Washington State Department of Natural Resources (WDNR), Washington State Parks and Recreation Commission (Parks), and Washington State Recreation and Conservation Office (RCO) tasked Earth Economics with assessing the total visitation, consumer spending, and economic output associated with outdoor recreation on state-managed lands. This analysis improves significantly on earlier efforts by leveraging voluntarily provided mobile device locational data throughout 2019 and 2020 to generate data-driven estimates of the total economic contribution of visitors to state-managed recreation lands, detailed at more granular geographic and temporal scales than previous analyses.


DECEPTION PASS

One of the central tasks was to determine visitation more accurately at WDFW and WDNR lands. While visitation levels are regularly recorded for most state parks, visits to WDFW and WDNR lands are more difficult to track. Many of these properties have boundaries that can be difficult to identify on the ground, with multiple access points—location-enabled mobile device data offers a tractable means of estimating visitation for these lands. While individual user data have been anonymized to protect privacy, it is possible to track the general locations of unique devices throughout the state, including whether visitors travel to state recreation lands for day trips or overnight stays. By calibrating statistical models to on-site visitor counts (e.g., campground check-ins, road counters) and other locational data (e.g., site amenities, weather, air quality), it is possible to estimate total visitation across all state recreation lands.

We estimate that state lands supported 78 million visitor days[2] in 2019, increasing to 87 million visitor days the following year (see Table 1). Over that 2-year period, state parks supported 44 percent of all visitation, with WDFW lands 34 percent, and WDNR lands the remaining 22 percent. Visitation to state lands overall increased 12 percent in that time, with WDNR seeing the largest estimated increase in visitation—a 21 percent increase from 2019 to 2020. Again, these estimates were based on models calibrated to visitation counts from State Parks and a portion of WDFW Water Access Areas. While these estimates have been derived from the best-available data, we are unable to characterize the degree of error in these estimates across all state recreation lands. Accordingly, these estimates may not always align with previously published visitation reports.

This analysis also found that in 2019, 52 percent of trips were day trips, and in 2020 this number increased to 66 percent. This shift towards day trips was likely due to the COVID-19 pandemic. The anonymized locational data also allows us to understand how far people travelled to visit state lands, as these data include the Common Evening Locations of each device, reported by Census Tract. From this, we determined that about 30 percent of all visitors travelled more than 50 miles to visit state lands. Of those non-local visitors, nearly two-thirds stayed overnight within the management unit or the local area. The overall proportion of overnight stays declined during the pandemic, while day trips by both locals and nonlocals increased from 2019 to 2020.

TABLE 1: ESTIMATED VISITOR DAYS TO STATE RECREATION LANDS, 2019 TO 2020

AGENCY	2019	2020	CHANGE
Observed			
Parks	38,456,657	37,549,238	
Predicted			
WDFW	27,230,000	29,069,000	+7%
WDNR	16,572,000	20,080,000	+21%
Parks	34,239,000	37,991,000	+11%
All State Lands	**78,041,000**	**87,139,000**	**+12%**

1 Washington State Recreation and Conservation Office, 2020. Public Lands Inventory. Available at: https://rco.wa.gov/reports-and-studies/public-land-inventory/

2 Each visitor day represents one person present at a state recreation land for one day. Multi-day or multi-member trips translate to a higher number of visitor days. For example, two people visiting a wildlife area for two days is counted as four visitor days.

SUN LAKES STATE PARK

We combined these estimates with the results of the visitor spending survey from the 2020 analysis to estimate total visitor expenditures of about $3 billion from 2019 to 2020. Interestingly, not only was the pandemic associated with higher visitation overall, but it also skewed visitation toward higher local and day visitation relative to nonlocal and overnight visits. Because day visitors tend to spend less on their trips, we saw visitor spending decrease slightly in 2020.

We then used these expenditure estimates to model subsequent economic impacts—employment, wages, local and state taxes—as well as the effect on economic activity at both local and state levels (see Table 2). The total spending associated with outdoor recreation on state recreation lands supported goods and services (direct and indirect) worth a total of $5.9 billion. This means that for every $1 spent by recreational users, $1.80 in economic activity is generated within the state economy. Annual visitor expenditures and the economic activity they generate go on to support 37,600 full- and part-time jobs, and $1.65 billion in wages in the state. Finally, spending by visitors to state recreation lands contributes to more than $435 million in local and state tax revenue. State-managed recreation lands are of considerable importance to the state economy.

TABLE 2: ESTIMATED TOTAL OUTPUT DERIVED FROM SPENDING BY VISITORS TO STATE RECREATION LANDS, 2019 TO 2020

CONTRIBUTION TYPE	2019	2020
Employment	38,800	36,400
Labor Income	$1,705,205,000	$1,601,470,000
Output	$6,071,838,000	$5,855,285,000
Local and State Taxes	$445,118,000	$427,683,000

REPORT STRUCTURE

This report estimates visitation to state-owned recreation lands in Washington state and the effects of visitor spending on local and statewide economies.

CHAPTER 1: Background on outdoor recreation in Washington and new methods to estimate visitation

CHAPTER 2: A description of the study methodologies

CHAPTER 3: Reports estimated visitation to state lands and visitor spending, and the resulting jobs, wages, and tax revenues

CHAPTER 4: A summary of the report findings and areas for future research

INTRODUCTION

Effective management of outdoor recreation sites relies on allocating limited maintenance and operations resources to areas of relatively high recreation demand. Accomplishing this depends on understanding how many people visit, demographic characteristics of those visitors, and trip types (e.g. day trips or overnight stays), including seasonal shifts in visitation patterns.

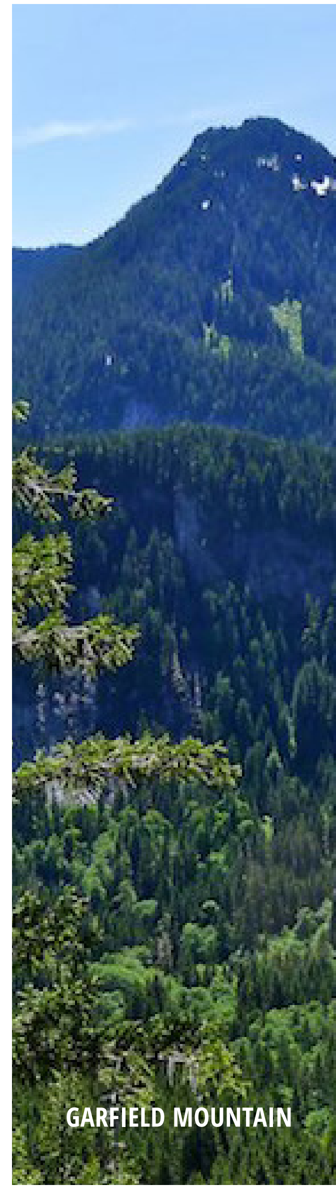
For recreation sites with limited access points (e.g., state parks), estimating visitation is accomplished through surveys, vehicle counts, or in-person observation. However, tracking visitation on millions of acres of recreation lands that often have multiple entry points (e.g., many sites managed by WDNR or WDFW) is a different challenge altogether. Deploying conventional visitor counts on these “porous” properties requires *significant* time and resources. This presents serious challenges to land managers tasked with comprehensively estimating the number of visitors to a given recreation area.

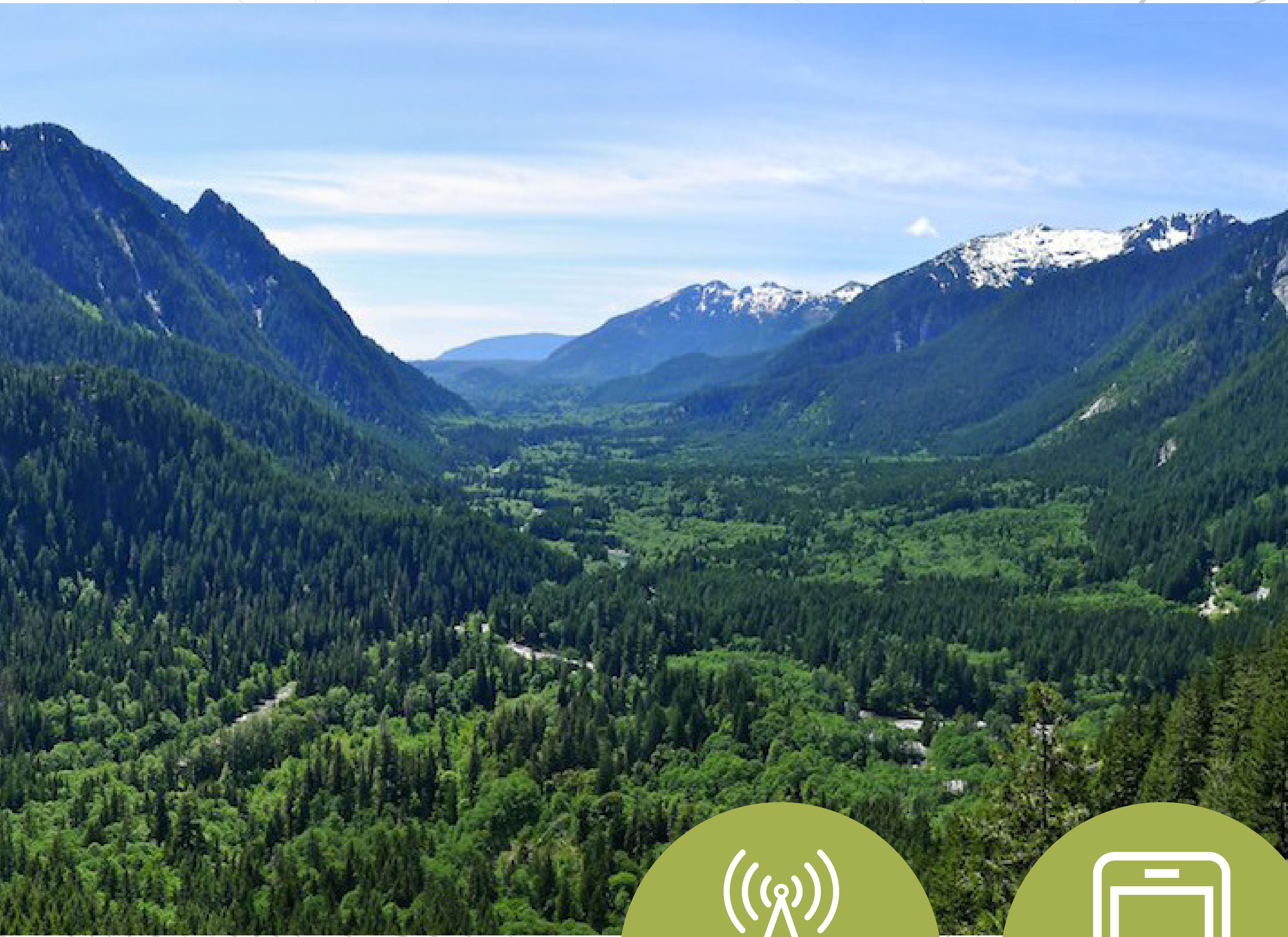
The widespread adoption of mobile cellular devices—especially applications that help users identify their location and nearby features—presents a new opportunity to understand the nature of visitation to all state recreation lands. While anonymized mobile locational data are unlikely to fully replace more conventional methods of visitor tracking, they can inform statistical models to estimate visitation—a particularly important approach for “porous” recreation sites.

By combining statewide mobile device locations for the 2019 and 2020 calendar years with select conventional visitor counts, we were able to produce monthly visitation estimates for almost all state-managed lands that offer public recreational access in Washington State. This level of spatial and temporal resolution can be particularly useful when attempting to monitor changes in visitation associated with factors such as public health, road work, or changed or expanded visitor amenities. Given sufficient cellular coverage, these data can even be used to map movement patterns within a given recreation area, effectively identifying the most popular recreational amenities. This project is timely, as state agencies have been interested in understanding how visitation may have changed throughout the COVID-19 pandemic as people sought out the relative safety and physical and mental benefits offered by recreating outdoors.

In 2020, we released the study “Economic Analysis of Outdoor Recreation in Washington State.” The study quantified the amount of spending, number of jobs, and tax contributions of outdoor recreation in Washington State. Following that study, several state agencies sought greater depth and breadth of visitation estimates and spending data for the recreation sites they manage. WDFW, WDNR, the Washington State Parks and Recreation Commission (Parks), and Washington State Recreation and Conservation Office (RCO) have contracted with Earth Economics to better understand the nature of the visitation to state-managed lands.

Visitation estimates matter from a management perspective, but they also enable estimates of the recreational expenditures and their economic effects on local and statewide economies. This project uses the visitation estimates to conduct an economic contribution analysis that estimates the total economic activity, wages, tax revenue, and jobs that are supported by recreationist spending. This analysis allows state land managers to quantify the economic value generated by recreation, in addition to the mental and physical wellbeing offered to recreationists.


GARFIELD MOUNTAIN



There are four major components of this analysis, each informing the other. First, there is spatial data. Spatial data allows us to assign geographic attributes to our other datasets. Second, we have site-specific visitation data, both observed and predicted. Third, through surveys and other data sources, we developed spatially explicit visitor spending estimates. Finally, we have the economic data used in input-output models. The process for gathering, cleaning, and employing each of these datasets is detailed below.

DATA SOURCES

Pairing management unit locations and related geospatial data (including mobile device locations) with county-level economic data allows us to represent on-the-ground transactions more accurately. This analysis leverages multiple sources of spatially explicit data (see Table 3).

MANAGEMENT UNIT FOOTPRINTS

Washington state lands that are available for outdoor recreation include parks, wildlife areas, natural resource lands, scenic highways, and more. The purpose of this analysis was to estimate the economic contribution of visitation to state lands for 2019 and 2020 using locational data provided by mobile cellular devices. The first step was to identify the footprint of all state lands that are open to the public, by managing agency. These include Washington state parks, as well as public access lands managed by WDNR, and wildlife areas and water access areas managed by WDFW. Green Dot roads—access roads maintained by either WDNR or WDFW—were also included. Each of these spatial datasets is managed separately, by agency. We refer to these individual locations as *management units.*

To avoid double counting, our analysts first created a single spatial dataset of non-overlapping management units. There were several instances of overlapping agency associations, especially where WDNR lands are actively managed by WDFW. In these instances, we associated those management units with the managing agency. There were also some cases where the current land use and lease data were clearly outdated (e.g., the presence of housing developments on "state" lands). To address these, we removed all parcels zoned residential, manufacturing, transportation, communications or utilities, trade, business services, or educational services.

Many state lands are managed for multiple uses. WDNR and WDFW lease more than a million acres for agricultural and grazing use. While some of these lands may also support some level of outdoor recreation, without some form of validation data (e.g., observed counts), it is not possible to identify recreationists and farm workers separately. To avoid overcounting recreation on these leased areas, we identified WDNR and WDFW parcels that intersect with agricultural footprints provided by the Washington Department of Agriculture (see Figure 1). Nearly half of these areas were farmed for grains, and 14 percent were used to grow hay or provide pasture. The remainder were farmed for perennials (e.g., orchards, vineyards), or other annuals (e.g., vegetables, oilseeds, turfgrass). A small fraction were identified as "developed" in the WSDA data.

FIGURE 1: CROPLANDS REMOVED FROM MANAGEMENT UNIT FOOTPRINTS

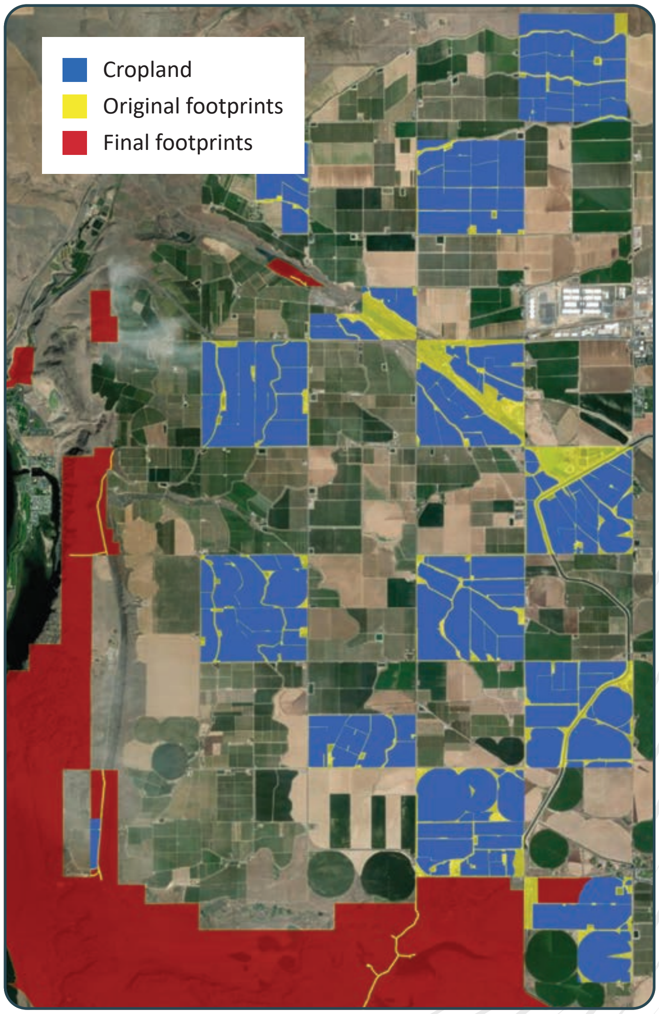


TABLE 3: DATA SOURCES

PURPOSE	FEATURES	DATA SOURCE
Management unit footprints	WA state parks	Parks
	WDNR public access lands	WDNR
	WDFW wildlife areas	WDFW
	WDFW water access areas	WDFW
	Green Dot roads	WDFW
Adjusting management unit footprints	Land-use zoning	Washington Geoservices
	Agricultural land use	Washington State Department of Agriculture (WSDA)
	Surface waters	U.S. Geological Survey (USGS)
	Satellite imagery	Satellite Imagery Basemap, via ArcGIS Pro
Local spending areas	Federal, state, and county roads	HERE Industries (via Hqgis API plugin)
	Forest access roads	WDNR
Device locations, common day/evening locations	Mobile device locations	Near (formerly UberMedia)
Mobile user demographics	Census demographics	U.S. Census' American Community Survey
Visitor spending patterns	"Point of Interest" business locations	SafeGraph
Visitation models	Broadband cellular coverage	Federal Communications Commission
	Total monthly precipitation	Daymet, National Aeronautics and Space Administration (NASA)
	Maximum daily temperature per month	Daymet (NASA)
	Maximum air quality index score per month	Air Quality Index Report, U.S. Environmental Protection Agency (EPA)
	Average elevation	Shuttle Radar Topography Mission (USGS)
	Proportion developed	National Landcover Dataset
	Total population within 5 miles	WorldPop Constrained Population Counts

While virtually all state lands are accessible by road, some roadways certainly carry traffic to other non-recreation destinations. As with agricultural lands, we lacked observation data to estimate the portion of mobile device users who are actively recreating while on these roads. Moreover, some management unit data (e.g., State Parks) already had most roadway features removed. To ensure that all management units were treated equally, and to avoid including incidental traffic (e.g., vehicles with a primary destination other than state lands), we compared multiple sources of road data against the State Parks footprints, including: the U.S. Census, U.S. Forest Service (USFS), Washington State Department of Transportation (WSDOT), WDNR, and Open Street Maps (OSM). We found that a combination of a subset[3] of OSM data and the WDNR Active Roads dataset offered the closest match to roadways that had been removed from State Parks footprints. To avoid over-estimating total visitation and apply a consistent methodology across all management unit types, we removed these roadways from all management units except Green Dot Roads. These were grouped into eight complexes, each analyzed as a separate management unit. Geospatial road data are commonly provided as line features, which have no width. To include all lanes and shoulders, we added linear buffers to each road type (e.g., highways, local roads) based on guidelines from the U.S. Department of Transportation's Federal Highway Administration. Although removing roadways sometimes split management units into separate polygons, we continued to analyze these fragments as single, multipart units.

WDNR lands are extensive, accounting for nearly three-quarters of all state lands and a total of more than 17,300 individual parcels. To simplify the analysis of WDNR lands, we first aggregated parcels by WDNR forest boundaries, and identified the counties where remaining WDNR parcels were located. We then grouped the remaining isolated WDNR parcels for separate analysis by county. This reduced the number of WDNR parcels to just 184 management units.

WDFW manages hundreds of water access areas that provide recreational access to fresh and marine surface waters throughout the state. While many of these are independent of larger wildlife areas, others are contained within these boundaries. However, spatial data are not available for all such areas; for these, estimated boundaries were provided by WDFW. To ensure that we identified all likely users of water access areas, we adjusted these boundaries to extend 15 feet into any adjacent surface waters (to allow for both tidal shifts and vessel loading and unloading). To validate the adjusted boundaries, we manually cross-checked all water access areas against recent satellite imagery. Clear errors (e.g., “parcel” fragments in the middle of a river) were manually adjusted, and parking

[3] We retained roadways identified as tracks or paths, as these tended to correspond with trails upon visual inspection. The roadways removed did not include parking areas.

TABLE 4: ADJUSTMENTS TO INITIAL MANAGEMENT UNIT FOOTPRINTS

		ACRES			
		GDOT	Parks	WDFW	WDNR
Initial management unit footprints			144,378	925,086	3,929,471
Buffered roadway centerlines		4,371			
Removed	**Overlaps**†	0	0	0	137,425
	Zoning	0	2,618	5,976	94,409
	Cropland‡	26	1,170	25,384	432,723
	Roadways	0	8,849	12,906	179,501
	GPS inaccuracy buffer (-15 feet)	0	2,559	11,178	201,795
Final management unit footprints		4,345	129,182	869,642	2,978,027
Proportion of initial area removed		0.6%	10.5%	6.0%	24.2%

†These lands are owned by WDNR, but managed by WDFW for recreation purposes. After consultation with agency staff, we attributed visitation and spending on these lands to WDFW.

‡Some portion of state lands leased for agricultural uses also support recreational opportunities (e.g., hunting, fishing, wildlife viewing). However, without observational data to validate our predictive models, we cannot estimate visitation for these lands. This may be addressed in subsequent research.

areas were included. Many water access areas are located within larger wildlife areas; because we wanted to identify visitors to each separately, we treated any overlaps as separate management units, and removed the water access area footprints from the surrounding wildlife areas.

One final challenge to account for is that mobile device locational data are imprecise—reported coordinates may vary ±15 feet from actual locations. Accordingly, we buffered all road features by an additional 15 feet to account for the limited spatial accuracy of mobile devices' Global Positioning Systems (GPS). To avoid overcounting mobile devices on adjacent parcels not owned or managed by state agencies, we also "shrank" the remaining management unit footprints by retracting their perimeters 15 feet inward. This process is known as buffering—essentially, redrawing feature boundaries a given distance (positive or negative) perpendicular to those boundaries. It is analogous to contracting or expanding the radius of a circle.

These adjustments reduced the overall spatial extent of state lands within our dataset by just over 20 percent (see Table 4). While these totals may appear considerable, all adjustments were made due to limitations within the source data—including generating Green Dot Road buffers from the original line data—or a lack of calibration data.

Aside from extending water access areas into adjacent surface waters, we consistently followed a conservative approach to defining the boundaries of state lands to avoid including non-visitors in our estimates. This moderate expansion in surface waters presents a very minimal risk of overcounting. Additional controls to limit the risk of overcounting recreational users were applied to the mobile device locational data, described below.

After these adjustments, our final state lands dataset contained 944 management units (see Table 5). This reduction in management units is largely the result of consolidating the disparate WDNR parcels, but locational data was lacking for some state lands. Our analysis does not capture recreation and associated economic effects for visitation to state lands not included within this dataset.

TABLE 5: MANAGEMENT UNITS BY AGENCY AND TYPE

STATE LANDS	MANAGEMENT UNITS
State Parks	208
WDFW Wildlife Areas	202
WDFW Water Access Areas	342
WDNR Forests	148
WDNR Isolated Parcels, grouped by county	36
Green Dot Road complexes	8
Total	**944**

MOBILE DEVICE LOCATIONAL DATA

Most estimates of outdoor recreation visitation are generated using resource-intensive approaches: visitor check-in stations, road counters, or in-person review by individual rangers or land managers.[4] While many of these are common for the more-developed state parks system, WDNR and WDFW properties tend to have fewer resources available for estimating visitation. Location-enabled mobile device data offer a new approach to assessing visitation for all state lands, at minimal cost. Installed applications on mobile devices are "opt-in," meaning that users determine whether to share their location with applications that provide services like routing software for roads and trails, the locations of nearby amenities (e.g., food and gasoline), identification of prominent landmarks, and more.[5] Locational data voluntarily provided by app users (who represent a subset of both state land visitors and mobile device owners) presents a unique opportunity to better understand visitation to state lands and the contribution of visitor spending to local economies.

The aggregators of mobile device data report the Common Evening Locations of users by ZIP code and census unit as an anonymized proxy for their home neighborhoods. Visitors who live within 50 miles of a given management unit are considered locals; all others are nonlocal. While the spatial precision of mobile device locational data is limited, it is sufficient for determining whether a mobile user stayed overnight within a management unit, or within 50 miles of that location. In this way, anonymized locational data support a more detailed understanding of visitation to state lands, especially for land managers that would otherwise be unable to comprehensively estimate visitation due to resource constraints or challenges with access, site infrastructure, and staffing.

U.S. Census data associated with these Common Evening Locations can provide general insights into the race, gender, age, and income of visitors, with some important caveats—we cannot be certain which members of any given census unit visit state lands. Accordingly, the demographics of a given census unit may not accurately represent those visitors, due to differences in the preferences or ability of individuals to visit state lands, use location-enabled mobile devices, or share locational data.[6] A more detailed understanding of the demographics of state lands visitors would require additional research (e.g., intercept surveys).

Mobile device data can also reveal the movement of state lands visitors as they travel to and from a management unit. This allows us to identify the businesses and industries that recreational visitors support during their trips to state lands. This information could inform potential partnerships

between state agencies and local businesses, or—as with visitation to state lands—to determine whether the pattern of businesses patronized by state land visitors is impacted by external factors like special events, road work, or public health measures, such as closures during the COVID-19 pandemic.

We initially acquired locational data for all available mobile devices throughout the state between January 2019 and June 2021. This dataset was quite large—over 21 million unique devices and 97 billion individual location records. Because our analysis focused on visits to state lands, significant data cleaning was necessary. We first removed data for any device that did not visit state lands during that period. To not count those who work or live (e.g., rangers, campground hosts) on specific management units for extended periods as recreational visitors, we excluded the records associated with those management units for any mobile devices where that unit was identified as either a common evening location or a common daytime location. In this way, we retain visitation data for any of those personnel or volunteers who visited other management units during the period of study.

The average amount each visitor spends is known to vary (detailed in Section 3.5), depending on whether they are local to the area, stay overnight within a management unit (i.e., camping), or stay overnight elsewhere within the local area (e.g., hotels, short-term rentals). To identify users who stayed overnight within a management unit, we identified devices appearing for consecutive days within management units that allow overnight stays. Locals who visited but then traveled within 0.25 miles of their common evening location neighborhood (before 3 a.m. of the following day) were assumed to have been local daytime visitors who returned home. All other local visitors were assumed to have stayed overnight within the local area. Nonlocals who visited a management unit but stayed within the local area (but not the management unit itself) were identified similarly.

The final mobile device dataset contains 3.6 million unique devices and 18 billion associated locational records.

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[4] Dagan, D.T., Brownlee, M.T.J., Henry, C., & Wood, S.A. (2020). Enhancing visitor estimation on National Wildlife Refuges: Phase one report. Technical report submitted to the U.S. Fish and Wildlife Service. In partial fulfillment of Research Work Order No. 104.

[5] Uber Media, 2020. Consumer Privacy Choices. Available at: https://covid19.ubermedia.com/consumer-privacy-choices/

[6] Curtis, D.S., Rigolon, A., Schmalz, D.L., Brown, B.B., 2021. Policy and Environmental Predictors of Park Visits During the First Months of the COVID-19 Pandemic: Getting Out While Staying in. Environment and Behavior 1–29. https://doi.org/10.1177/00139165211031199; Wang, J., McDonald, N., Cochran, A.L., Oluyede, L., Wolfe, M., Prunkl, L., 2021. Health care visits during the COVID-19 pandemic: A spatial and temporal analysis of mobile device data. Health & Place 72, 102679. https://doi.org/10.1016/j.healthplace.2021.102679

IDENTIFYING LOCAL AREAS

A primary goal of this analysis was to estimate the total economic activity supported by visitors to state lands, whose spending is particularly important for local economies. We defined local areas as those locations accessible by road within 50 miles of any road access point of each management unit, using the Hqgis plugin for QGIS (open-source geospatial software), which references roadway data provided by HERE Technologies. Management units in the San Juan Islands—accessible from the mainland via ferry—were associated with the local road networks of the nearest state parks, due to the complex interactions of road networks and ferry routes.

These road networks were not only used to define the local area for contribution analyses, but also to distinguish between local and nonlocal visitors, and to determine whether nonlocal visitors who did not stay overnight within a management unit chose to stay overnight within the local area. As previously noted, average spending varies by whether a visitor is local or nonlocal, visits only for a day before returning home, or stays overnight within a management unit or at another location outside their home neighborhood, but within the local spending area. These differences are explained below.

Visitation is partly correlated with the total population within 5 miles of each management unit, drawn from the WorldPop dataset, which maps population at a 100-meter resolution (significantly higher resolution than even the smallest Census unit). For management units in the San Juan Islands, we calculated the total population within a 5-mile radius.

KLICKITAT RIVER

VISITOR SPENDING

As people travel to and from state lands for recreation, they typically spend money across a range of industries: gasoline, convenience stores, sporting goods and other retailers, transportation, other recreation-related industries like guide services and ski resorts, hotels, motels, short-term rentals, restaurants (e.g., full service, casual dining, coffee shops), car repair, and more. This spending is known to vary, depending on whether a person lives nearby, stays overnight in a management unit (i.e., camping), or stays overnight elsewhere within the local area. There are six different visitor types, who spend money in different ways:

Local Day Visitors: Those who traveled less than 50 miles and did not stay in overnight accommodations in either the management unit or local area

Local Overnight Visitors in Management Unit: Those who traveled less than 50 miles and stayed overnight in the management unit

Local Overnight Visitors in Area: Those who traveled less than 50 miles and stayed in overnight accommodations in the area, but not overnight in the management unit

Nonlocal Day Visitor: Those who traveled 50 or more miles and did not stay overnight in the management unit or local area

Nonlocal Overnight Visitors in Management Unit: Those who traveled 50 or more miles and stayed overnight in the recreation management unit

Nonlocal Overnight Visitors in Area: Those who traveled 50 or more miles and stayed overnight in the area, but not overnight in the management unit

To estimate both the total spending per trip for an average person and in the industries (e.g., lodging, restaurants, grocery stores, fuel) where that spending occurred, we developed visitor spending profiles based on results of a 2020 survey conducted by Earth Economics that asked how visitors spent money on trips to specific state parks, and WDNR and WDFW lands generally. A methodology for developing, administering, and analyzing the survey is provided in Appendix A of Economic Analysis of Washington State Parks.[7]

Next, to estimate the total initial spending associated with all visitors to each management unit, we multiply the relevant regional industry spending for each visitor type by the total estimated visitors—reported as participant days—to each management unit per year.

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[7] Mojica, J., Cousins, K., Fletcher Munoz, A., 2021. Economic Analysis of Washington State Parks. Earth Economics. Tacoma, WA.

DEVELOPING A STATISTICAL MODEL

Currently, Parks is the only state agency with the resources to consistently monitor visitation to its lands. While trail counters, road counters, and other means of tracking visitation are conducted by WDNR and WDFW, these do not comprehensively estimate visitation across the lands they manage. WDNR and WDFW management units tend to be more "porous," meaning that they are characterized by having multiple access points and unmarked boundaries; this makes it more difficult to monitor visitation using these techniques than at single-entry sites like state parks.

While mobile data are unlikely to ever fully replace conventional means of visitor tracking, they can inform statistical models that estimate visitation to recreation sites lacking robust visitor counts. Many factors influence visitation, including the spatial extent of each management unit, site amenities, proximity to nearby communities, weather, and air quality. Mobile device data can be combined with such data to estimate visitation to sites that do not have other means of counting visitors. Additionally, given sufficient cellular signal coverage, movement within management units may also be mapped, revealing most visited locations within a given site.

We constructed a series of models that compared cell phone unique device days, site characteristics, and contextual factors (e.g., weather, air quality) with site visitor data collected by state agencies, reported as person visitor days (i.e., one person spending one day in a park). One set of models calibrated visitation estimates with counts collected by Parks; another set applied (TrafX) traffic counter data for WDFW-managed water access areas. These models were then used to estimate visitation at management units that lacked site-specific visitation data. A key assumption of this approach is that visitation models based on state parks and water access area data are applicable to other WDFW and WDNR management units.

These calibration models included control variables such as month and year, site amenities, mean monthly temperatures, air quality, 3G cellular coverage, and region. See Appendix C for a full list of variables included in each model.

Following recent literature,[8] we applied multiple statistical techniques to produce a "best fit" calibration model, including linear regression and a general random forest model. The latter is a non-parametric modeling approach common in machine learning, which has been shown to perform better than standard regression methods. We compared models based on their abilities to predict reported visitation levels at state parks. This was done by splitting the Parks visitation data into two datasets: training (70 percent of data points) and testing (30 percent of data points). In other words, we calibrated the visitation models based on statistical correlations to the training data, and estimated goodness-of-fit metrics based on how closely the visitation estimates produced by those models aligned with the testing data.

[8] 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.


COLUMBIA BASIN WILDLIFE AREA

HOW WE ALLOCATE SPENDING ACROSS COUNTIES

Economic contribution analyses rely on county-level data produced by the U.S. Bureau of Economic Analysis. Consistent with industry standards, we limited our impact area to businesses located within 50 driving miles of a given recreation area. In most instances, these road networks extend to two or more counties. Conventional practice is to define local spending regions as all counties within a 50-mile buffer of the center of a recreation site. However, this can skew spending analyses in two ways—one, not every location within a 50-mile linear distance will be accessible by road, and two, including all businesses in all counties that intersect a local area may include businesses located well outside a 50-mile distance (however that has been defined). To more accurately represent the opportunity to spend—the presence or absence of the industries identified in the spending profiles—it is necessary to determine where businesses are located within a local spending area and the intersecting counties. To do this, we acquired business location data from SafeGraph, which include the spatial footprints of businesses associated with each industry. By identifying the spatial distribution of businesses (i.e., total square footage by industry, by county) within local spending areas, we begin to approximate the relative importance of spending by visitors to a specific management unit to each county.

However, spatial relationships alone would not account for the relative productivity of each industry in each county, due to differences in the cost of variables including land, labor, and supplies. To address this, we divided the total economic output of each industry by the square footage of businesses within each industry in each county, to produce an estimate of dollars of economic output per square foot for each industry. This can be considered a proxy for county-level industry productivity, with the further assumption that businesses with larger footprints tend to generate more overall economic activity than smaller businesses.

Once we determined the county-level industry productivity, we then distributed spending based on the relative contribution to the entire local network. For example: the local spending network footprint of the widget industry is identical in counties A and B, but various factors lead that industry to be twice as productive (on a square footage basis) in county A. In this case, two-thirds of visitor expenditures for that industry would be allocated to county A, and a third to county B. Similarly, if the spatial productivity of the widget industry in both counties are equivalent, but the spatial extent of spending opportunities in the local network within county A is twice that of county B, two-thirds of expenditures would still be allocated to county A. This approach represents an improvement over simply combining all counties that intersect with the local spending network because it accounts for both the spatial extent of spending opportunities and the relative productivity of each industry in each county.

DECEPTION PASS

ECONOMIC CONTRIBUTION ANALYSIS

Total expenditures by industry are inputs for the economic contribution analysis (also known as input-output modeling), which models patterns of economic transfers (i.e., purchases) between industries based on real-world data. In addition to estimating the total economic activity spurred by the spending of visitors to state recreation lands, contribution analyses allow policy makers to compare that activity to the economic contributions of other industries (e.g., forestry, healthcare, construction).

Earth Economics uses the industry standard input-output software IMPLAN, which calculates the effect of spending on several economic factors, defined below:

Economic Output: Visitor spending on trips to state recreation lands leads to significant economic contributions in both the state and local economies. The value of all sales in industries that are directly and indirectly supported by recreation is known as total economic output. This is useful for understanding the size of one sector relative to others within the regional and state economy. Additionally, comparing total direct expenditures by recreationists against total economic output reveals how much economic activity is generated for every dollar spent by recreational users—its multiplier effect.

Value Added to Gross Domestic Product (GDP): The value of final goods and services sold is less than total economic activity, as it removes the value of intermediate inputs (e.g., raw materials, semi-finished goods, and business-to-business services) from the total economic activity.

Jobs: Visitor spending on trips to state recreation lands directly supports jobs in Washington by creating demand at restaurants, coffee shops, hotels, and other businesses, which meet the demand by hiring full- and part-time workers. Visitor expenditures also indirectly support employment in industries such as maintenance, government services, real estate, and medicine, which provide services to those who work in industries directly supported by recreation visitor spending.

Labor Income: The employees of the retail and hospitality sector businesses where recreation land visitors spend money are paid for their labor, and that spending also supports wages in the industries that provide services to those who work in directly impacted sectors. The total wages both directly and indirectly supported by visitor spending are referred to as labor income.

Tax Revenue: Visitor expenditures also generate revenue for state and local governments, through taxes on production and imports; these are commonly sales taxes or property taxes.

Apart from tax revenues, each category of the IMPLAN model is broken into direct and secondary economic effects. Direct effects measure the economic activity of industries directly supported by consumer spending, such as hotels, retail stores, recreation services, and restaurants. Secondary economic effects are the corresponding shifts in the economy due to the initial spending (i.e., the direct effect), and are further categorized as either indirect or induced effects.

Indirect effects are the impacts on the industries supporting those where consumers directly spend money. For example, restaurants are directly affected by consumer spending; ranchers and farmers supply the ingredients restaurants prepare into meals for their clientele. Increased restaurant spending leads to additional purchases from ranchers and farmers; in this way, the agricultural industry indirectly benefits from spending on outdoor recreation.

Induced effects measure the effects of employee spending. Those who work in the industries directly and indirectly affected by recreational expenditures also purchase goods and services for themselves. For example, a marina employee spends her paycheck on rent and groceries, benefiting local businesses and the regional economy—to the extent that such spending remains local. Depending on the internal connectivity of the state economy, this money can circulate multiple times before finally leaving the state.

IRON HORSE TRAIL

PREDICTING VISITATION

Variation in observed visitation data—whether this is state park visitation or road counter WDFW TrafX data—can be explained by models that combine mobile device data and other variables (e.g., weather, location, time of year, size of recreation asset). These data were assembled into statistical models—both linear and random forest models—where the variable of interest (i.e., the mobile device data) and the other variables are assessed for significance and the degree to which they explain the variance in visitation, holding the effect of the other variables in the model equal. These relationships are based on observed data and are represented by equations, which were then applied to predict visitation on recreation lands without observed data.

There are several ways to characterize the importance of individual explanatory variables in a model, or the ability of a model to accurately predict outcomes. For variables, a common statistical measure is known as the "p-value," which estimates the likelihood that the relationship between an explanatory variable (e.g., unique mobile devices) and the phenomenon the model is attempting to explain is due to random chance. The relationship between mobile device data and observed visitation is stronger for state park visitation than it is for WDFW TrafX data. In all linear models based on state park visitation data, the number of unique devices within a management unit was highly significant ($p < 0.001$), and provided most of the statistical explanatory power. In other words, the chance that the relationship between unique device days and observed visits was entirely random was less than 1-in-1,000.

A common statistical measure of model accuracy is known as R-square (R^2); which reflects the degree to which model output matches the data it is attempting to explain. A model with an R^2 of 1.0 explains all variation in the dependent variable; an R^2 of 0 indicates the model does not explain any variance of the dependent variable. Models with an R^2 of 0.5 are considered a moderately good fit; models with an R^2 of 0.85 and higher are usually considered to be robust. The linear model of unique device days (and no other covariates) produced an adjusted R^2 of 0.54, while a linear model including all variables resulted in an R^2 of 0.67. Similar linear models calibrated to the WDFW TrafX data produced an R^2 of 0.38 and 0.48, respectively. The random forest models produced far less error (i.e., were consistent with both state park visit and WDFW TrafX counts) and explained more of the variation in the visitation data. Our random forest model compared similarly to results reported in the literature,[9] but the linear model performed significantly worse. Linear and random forest models based on WDFW TrafX data performed similarly, although the latter produced estimates with slightly less error overall and which explained slightly more variation in observed visitation. Table 6 and 7 show the performance statistics for each model.

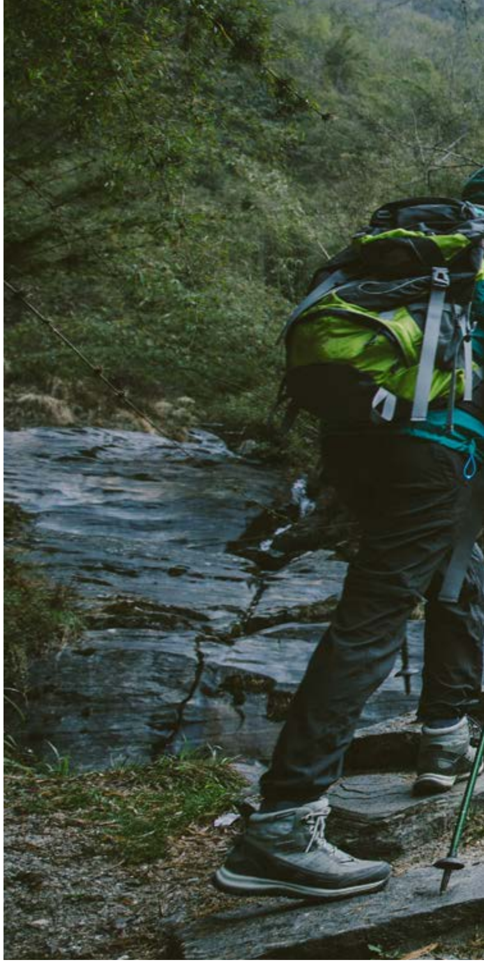


TABLE 6: AVERAGE MODEL PERFORMANCE AGAINST STATE PARKS COUNTS

	R^2	
MODEL	**DAY**	**OVERNIGHT**
Linear	0.67	0.67
Random Forest	0.86	0.78

TABLE 7: AVERAGE MODEL PERFORMANCE AGAINST WDFW TRAFX COUNTS

MODEL	**R^2**
Linear	0.48
Random Forest	0.51

9 ibid.

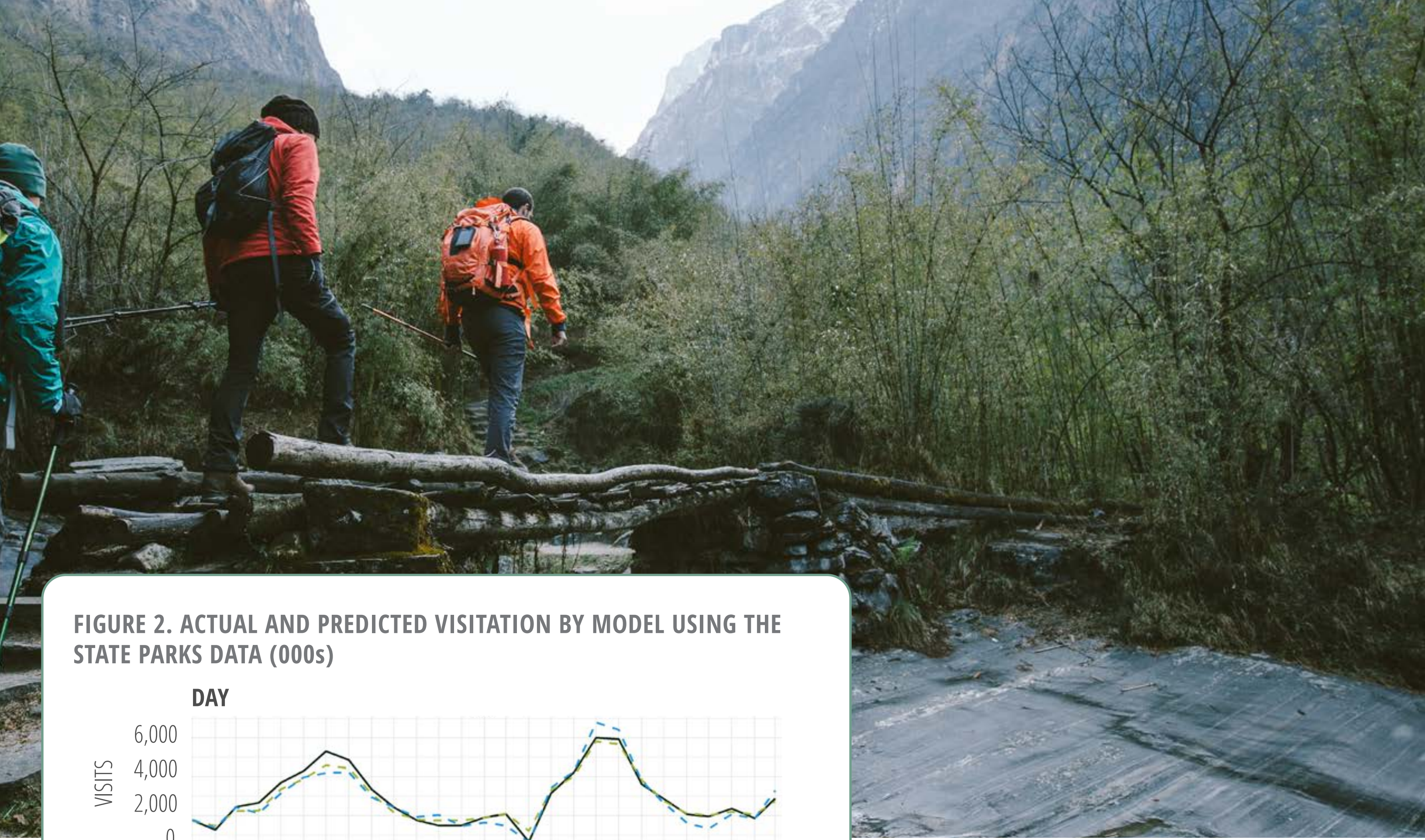


FIGURE 2. ACTUAL AND PREDICTED VISITATION BY MODEL USING THE STATE PARKS DATA (000s)

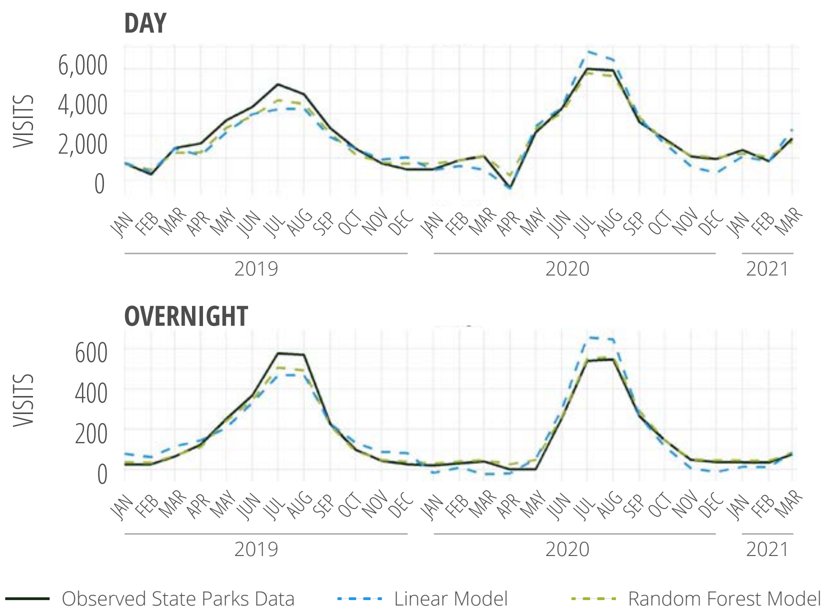
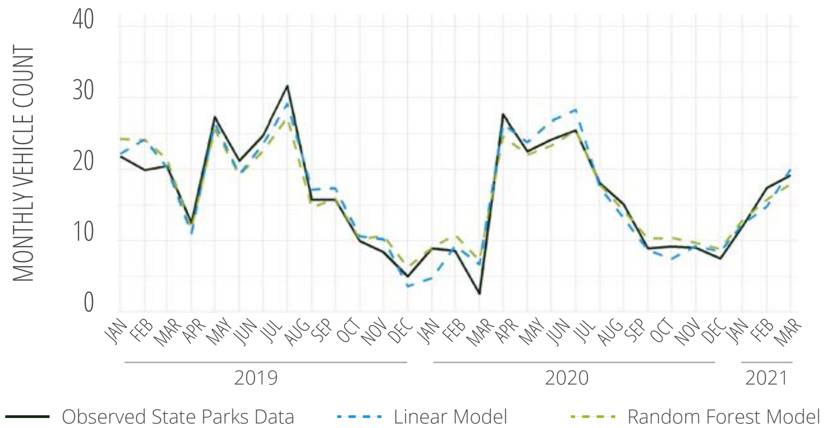


FIGURE 3. ACTUAL AND PREDICTED VISITATION BY MODEL USING WDFW TRAFX DATA (000s)



We prefer the random forest model for estimating recreation visitation for both the state parks and WDFW TrafX counts, as it outperformed the linear model for all performance statistics. We then used the random forest model to predict visitation on all state-owned recreation management units.

The substantive meaning of these statistics is perhaps best demonstrated by plotting model predictions (dashed lines) alongside actual State Parks visitation counts (solid lines) from State Parks (Figure 2) or WDFW TrafX vehicle counters at Water Access Areas (Figure 3).

Our research team also wanted to determine whether the models would perform in areas that lacked cellular coverage. Even when 3G coverage is not identified at a management unit, we are still able to use the limited mobile device data to estimate visitation, albeit with larger error bars. The performance of the different models in management units without 3G coverage is shown in Figure 4.

While the overall fit is weaker for these sites, the random forest model (green dashed line) continues to generate lower error than the linear model (blue dashed line) for predicting both day and overnight visits.

Another research question was to identify how these models would perform on the patchwork, dispersed WDNR parcels that were aggregated into larger management units. Because the areal extent of each management unit is positively correlated with visitation in our models, all models predicted unreasonably high visitation to these dispersed WDNR lands, which represent a very large proportion of all state recreation land area. Because the size of each management unit is a key factor in the calibration models, the estimates produced for WDNR dispersed parcels were believed to be substantially higher than actual visitation. After consultation with agency staff, we determined it would be necessary to acquire targeted validation data (i.e., observed visits) before sufficiently accurate visitation models for dispersed WDNR parcels could be developed. Accordingly, visitation to these dispersed parcels was not included in our final estimates.

FIGURE 4. ACTUAL AND PREDICTED VISITATION BY MODELS BASED ON STATE PARKS DATA FOR MANAGEMENT UNITS THAT HAVE NO 3G COVERAGE PRESENT ON SITE

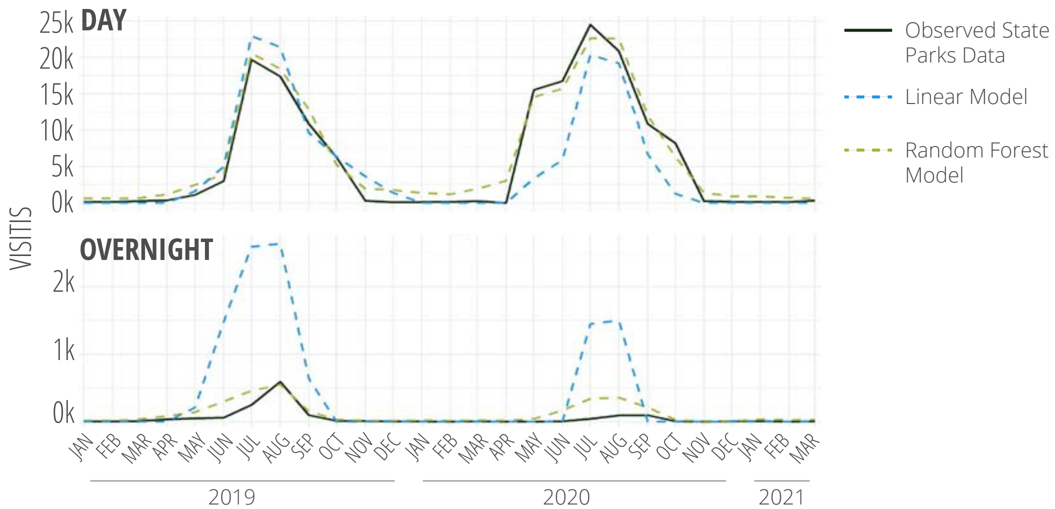
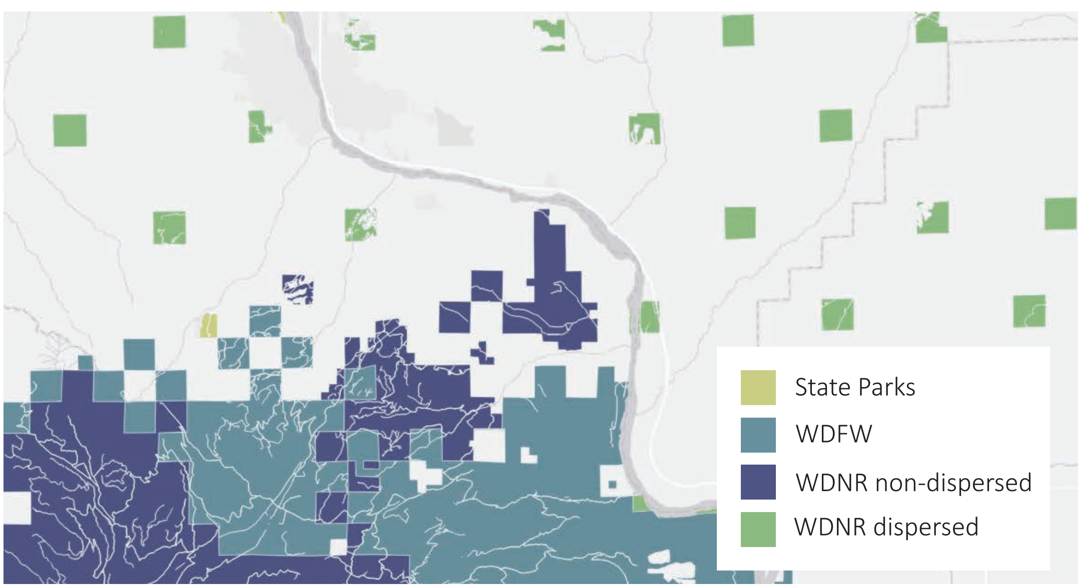
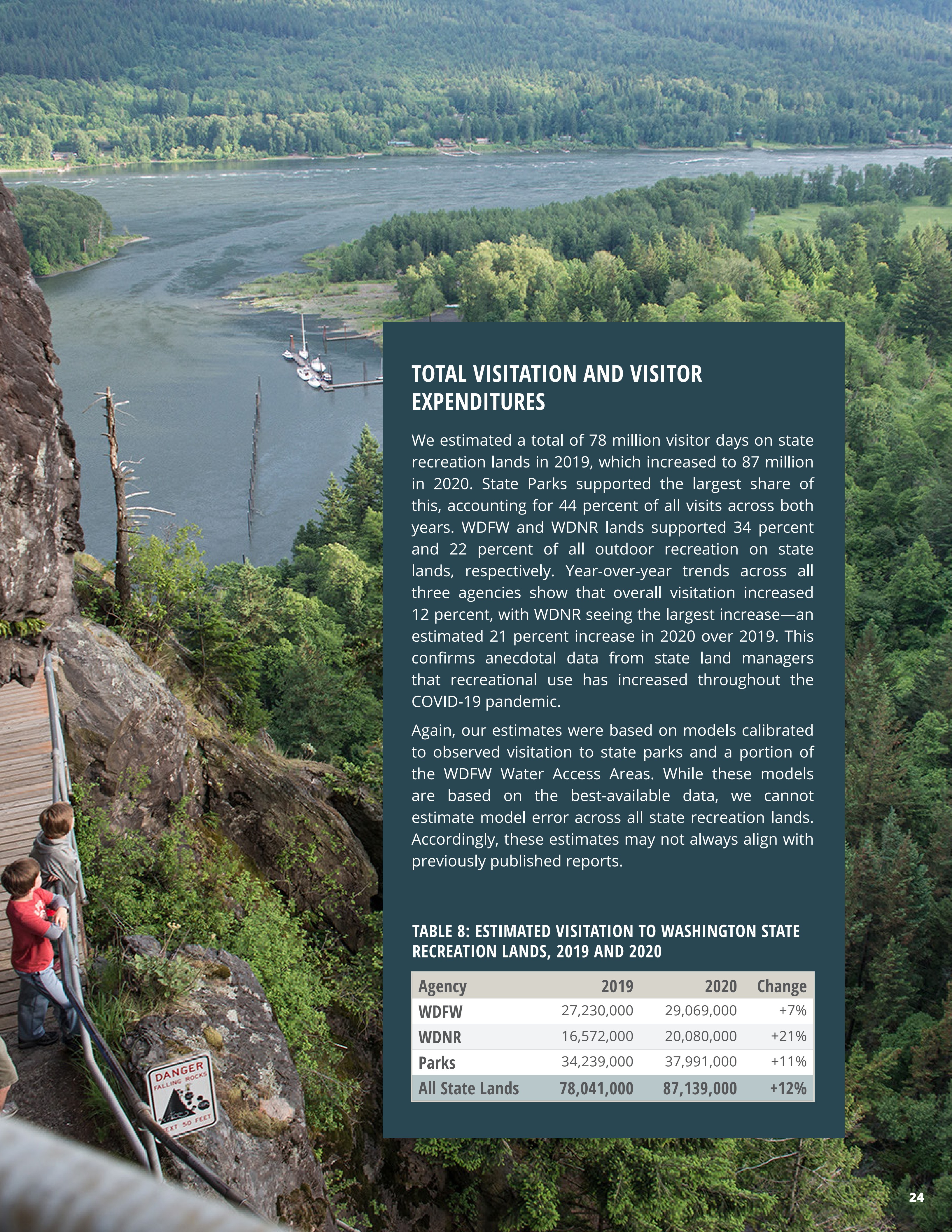


FIGURE 5: WDNR DISPERSED PARCELS CONTRASTED WITH OTHER MANAGEMENT UNIT TYPES



BEACON ROCK



TOTAL VISITATION AND VISITOR EXPENDITURES

We estimated a total of 78 million visitor days on state recreation lands in 2019, which increased to 87 million in 2020. State Parks supported the largest share of this, accounting for 44 percent of all visits across both years. WDFW and WDNR lands supported 34 percent and 22 percent of all outdoor recreation on state lands, respectively. Year-over-year trends across all three agencies show that overall visitation increased 12 percent, with WDNR seeing the largest increase—an estimated 21 percent increase in 2020 over 2019. This confirms anecdotal data from state land managers that recreational use has increased throughout the COVID-19 pandemic.

Again, our estimates were based on models calibrated to observed visitation to state parks and a portion of the WDFW Water Access Areas. While these models are based on the best-available data, we cannot estimate model error across all state recreation lands. Accordingly, these estimates may not always align with previously published reports.

TABLE 8: ESTIMATED VISITATION TO WASHINGTON STATE RECREATION LANDS, 2019 AND 2020

Agency	2019	2020	Change
WDFW	27,230,000	29,069,000	+7%
WDNR	16,572,000	20,080,000	+21%
Parks	34,239,000	37,991,000	+11%
All State Lands	**78,041,000**	**87,139,000**	**+12%**

FIGURE 6: ORIGIN OF IN-STATE MOBILE DEVICES THAT VISITED STATE RECREATION LANDS IN ISLAND COUNTY

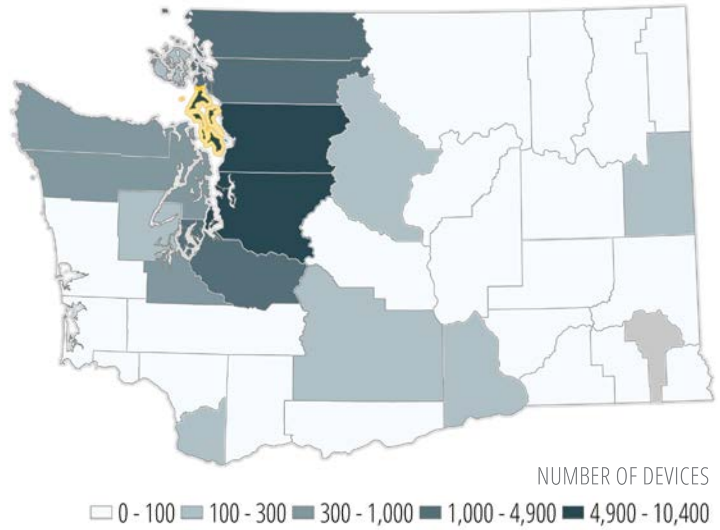


FIGURE 7: ORIGIN OF IN-STATE MOBILE DEVICES THAT VISITED STATE RECREATION LANDS IN GRAYS HARBOR COUNTY

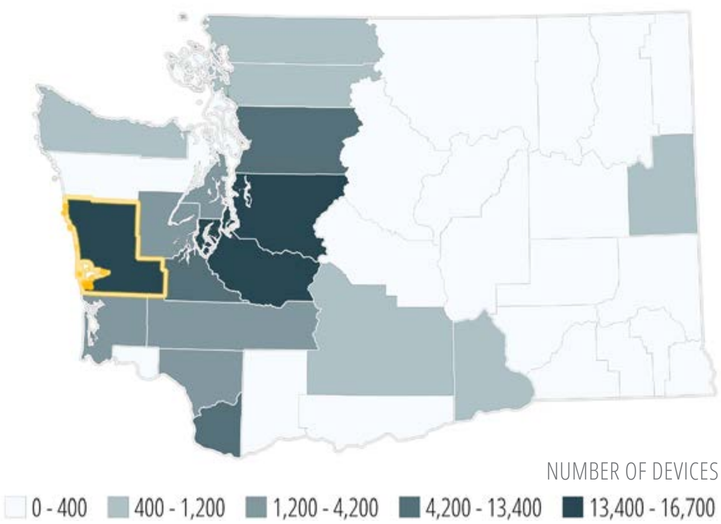
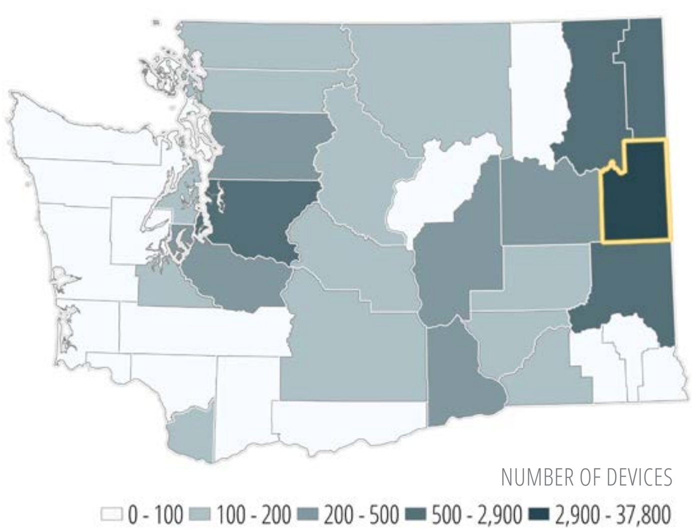


FIGURE 8: ORIGIN OF IN-STATE MOBILE DEVICES THAT VISITED STATE RECREATION LANDS IN SPOKANE COUNTY



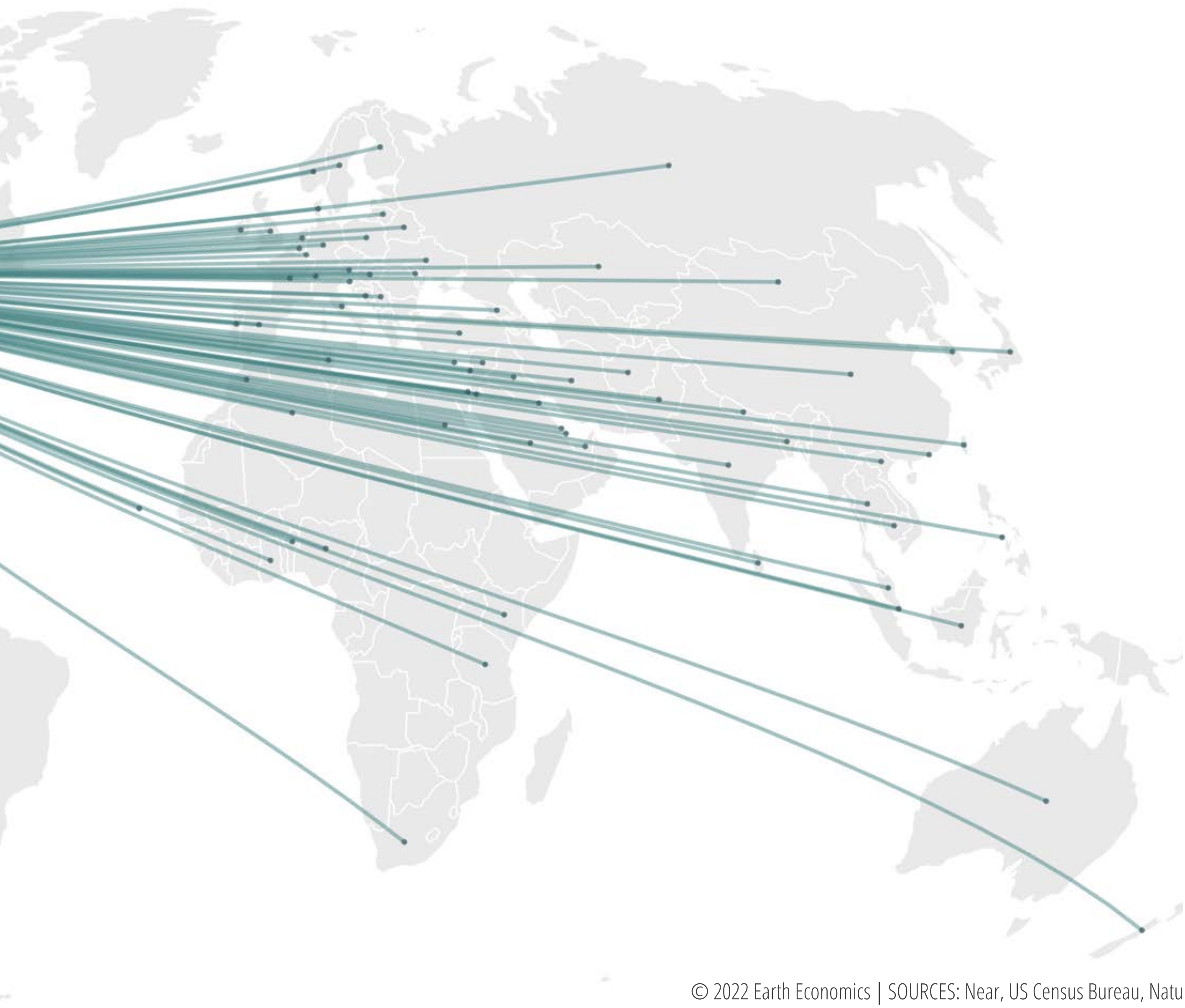
The Common Evening Locations of mobile devices identify users' home Census blocks, counties, or countries, informing how state lands at both the management unit level and by agency serve residents throughout the state. Figure 6, 8, and 9 highlight the home counties of device users who visited state lands in Island, Grays Harbor, and Spokane Counties, respectively. Unsurprisingly, a large proportion of device users originated from King County (the state's most populous county) across all three examples. The home nations of non-U.S. residents are presented in Figure 9. These figures highlight the power of this data.

FIGURE 9: ORIGIN COUNTRIES OF INTERNATIONAL MOBILE DEVICES THAT VISITED STATE RECREATION LANDS IN WASHINGTON STATE

Using the Common Evening Locations of mobile device users, we determined that across both years, two-thirds of all visitors returned home the day they visited state recreation lands. About 30 percent of visitors travel more than 50 miles to recreate on state lands, and of these, nearly two-thirds stay overnight, either within the management unit, or in the local area. Both local and nonlocal visitation increased from 2019 to 2020, while overnight stays declined. This may be related to safety concerns associated with the COVID-19 pandemic.

TABLE 9: VISITATION LEVELS BY TYPE, 2019 AND 2020

VISITOR TYPE	2019	2020
Local day use	42%	53%
Local overnight in area	25%	15%
Local overnight in management unit	1%	1%
Nonlocal day use	10%	13%
Nonlocal overnight in area	20%	15%
Nonlocal overnight in management unit	2%	2%



The anonymized mobile device data also allow us to understand shifts in the industries that visitors frequent within the local spending area of each management unit. Reviewing locational data from 2019 and 2020, we calculated the percentage of unique devices that visited businesses of each industry, each year. Most notable was a decline in the unique devices in restaurants and cafes, and an increase at grocery stores and gas stations. Hotels and motels also saw a decline in unique devices. These trends may be due to the relative increase in day use, pandemic restrictions that limited in-restaurant dining, or possibly a (temporary or permanent) shift towards vacation rentals and (vacation) home-cooked meals.

TABLE 10: PROPORTION OF MOBILE DEVICES VISITING STATE LANDS RECORDED AT INDUSTRY LOCATIONS, 2019 AND 2020

INDUSTRY	2019	2020	CHANGE
Grocery stores	30.2%	34.3%	13.9%
Gas stations	32.5%	40.6%	25.0%
Sporting goods stores	8.5%	7.2%	-14.6%
Misc. retail	7.1%	5.5%	-22.2%
Rentals	0.5%	0.4%	-16.9%
Other recreation	13.8%	8.5%	-38.1%
Hotels, motels	11.7%	9.8%	-16.6%
Full-service restaurants	38.1%	29.1%	-23.7%
Fast food restaurants	24.1%	20.2%	-16.1%
Cafes, coffee shops	22.6%	20.0%	-11.8%


MORAN STATE PARK

Reviewing the Common Evening Locations of devices recorded on state recreation lands, we developed approximate[10] visitor demographics, based on proportions of the U.S. Census block groups of users' home locations. Based on these proportions, we project that 77 percent of visitors were white, though 62 percent of the state's population identifies as such. Although 19 percent of state residents identify as Hispanic or Latino, we estimate that they represented 11 percent of visitors. Two percent of visitors are estimated to be black or African American, while 4 percent of Washington's population identifies as black or African American. These data, especially if corroborated with site-level surveys, can be used to inform future policy and outreach decisions about equitable availability, access, and use of state recreation lands.

FIGURE 10: MOBILE DEVICE COMMON EVENING LOCATIONS OF STATE LAND VISITORS, PER CAPITA, BY U.S. CENSUS TRACT

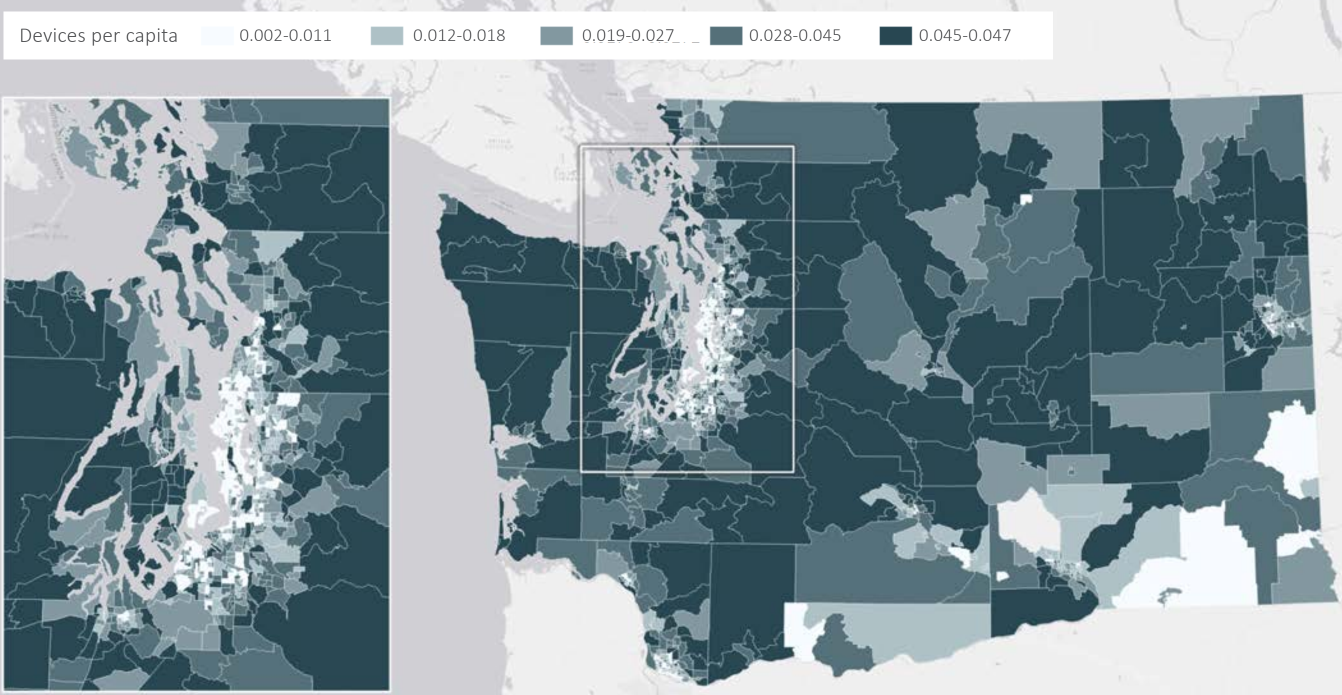


TABLE 11: DEMOGRAPHICS OF CENSUS BLOCKS ASSOCIATED WITH STATE LANDS VISITATION IN 2019 AND 2020

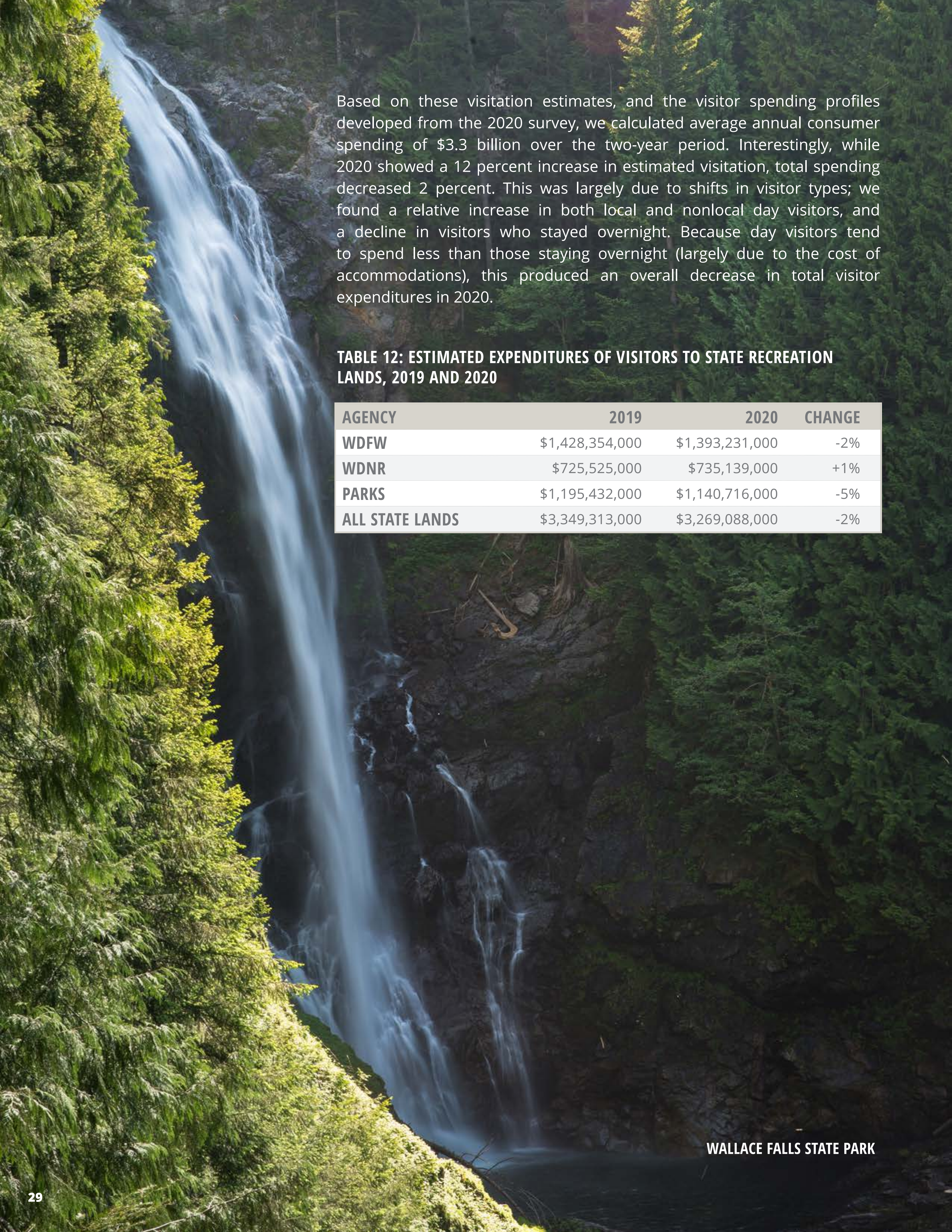
RACE AND ETHNICITY	PARKS	WDFW	WDNR	ALL STATE LANDS
White	76%	76%	79%	77%
Black or African American	3%	2%	2%	2%
Asian	7%	3%	4%	5%
Hispanic or Latino	10%	14%	9%	11%
American Indian and Alaska Native	1%	2%	2%	2%
Other	0.1%	0.1%	0.1%	0.1%
Multiracial	4%	4%	4%	4%

[10] These estimates should be interpreted with caution, as the portion of residents who enable locational tracking on their mobile devices is a subset of all mobile device users and the population as a whole. Moreover, we may expect that not all demographic segments within a Census unit are equally likely to own mobile devices and enable location tracking. Affluent residents may have a greater likelihood of appearing in the dataset than others, for instance.

Based on these visitation estimates, and the visitor spending profiles developed from the 2020 survey, we calculated average annual consumer spending of $3.3 billion over the two-year period. Interestingly, while 2020 showed a 12 percent increase in estimated visitation, total spending decreased 2 percent. This was largely due to shifts in visitor types; we found a relative increase in both local and nonlocal day visitors, and a decline in visitors who stayed overnight. Because day visitors tend to spend less than those staying overnight (largely due to the cost of accommodations), this produced an overall decrease in total visitor expenditures in 2020.

TABLE 12: ESTIMATED EXPENDITURES OF VISITORS TO STATE RECREATION LANDS, 2019 AND 2020

AGENCY	2019	2020	CHANGE
WDFW	$1,428,354,000	$1,393,231,000	-2%
WDNR	$725,525,000	$735,139,000	+1%
PARKS	$1,195,432,000	$1,140,716,000	-5%
ALL STATE LANDS	$3,349,313,000	$3,269,088,000	-2%



WALLACE FALLS STATE PARK

ECONOMIC CONTRIBUTION OF STATE LANDS

That initial $3.3 billion of annual visitor spending produces significant economic contributions in Washington State in terms of additional employment, wages, and taxes, increasing total output and GDP contributions to the state economy. Industries directly and indirectly supported by visitor spending produce goods and services valued at $5.9 billion. This is the total economic activity supported by outdoor recreation at state recreation lands. For every $1 spent by visitors, $1.80 in economic activity is generated in the state economy. This total value is useful for understanding the size of the recreation sector relative to other sectors (e.g., agriculture or higher education) at the state level.

Contributions to the state GDP—a subset of all economic activity—represents only the value of finished products and excludes intermediary transactions. In Washington, visitation to state recreation lands contributes $2.85 billion to the state's GDP each year; for reference, our 2019 study *Economic Analysis of Outdoor Recreation in Washington State*[11] found that all expenditures on outdoor recreation in Washington State contributed $20 billion to the state's GDP, though that figure included equipment purchases not directly tied to trips.

From 2019 to 2020, annual visitor expenditures supported an average of 37,600 full- and part-time jobs, paying $1.65 billion in wages. Jobs directly related to visitor spending are primarily service-related sectors (e.g., restaurants, coffee shops, hotels or other accommodations). Secondary employment effects are observed in industries such as real estate, maintenance, government services, and medicine.

Finally, spending by visitors to state recreation lands contributes significantly to local and state tax revenues—an average of more than $435 million a year. Taxes on production and imports are by far the largest contributors, mostly through sales taxes (see Figure 11).

FIGURE 11. ECONOMIC CONTRIBUTION OF OUTDOOR RECREATION (2020 DOLLARS)

AGENCY	EMPLOYMENT (FULL AND PART-TIME)		LABOR INCOME (000)		ECONOMIC OUTPUT (000)		LOCAL AND STATE TAXES (000)	
	2019	2020	2019	2020	2019	2020	2019	2020
WDFW								
DIRECT	9,300	8,900	$330,325	$311,507	$1,428,354	$1,393,231	$0	$0
INDIRECT	3,500	3,400	$213,821	$204,844	$663,128	$638,790	$0	$0
INDUCED	2,700	2,600	$148,528	$140,202	$466,340	$440,532	$0	$0
TOTAL EFFECT	**15,500**	**14,800**	**$692,674**	**$656,552**	**$2,557,822**	**$2,472,552**	**$184,362**	**$178,719**
WDNR								
DIRECT	4,900	4,600	$169,443	$160,036	$725,525	$735,139	$0	$0
INDIRECT	1,700	1,700	$105,118	$101,735	$324,351	$315,198	$0	$0
INDUCED	1,300	1,300	$74,199	$71,041	$232,846	$222,067	$0	$0
TOTAL EFFECT	**8,000**	**7,500**	**$348,759**	**$332,812**	**$1,282,722**	**$1,272,403**	**$91,916**	**$90,075**
PARKS								
DIRECT	9,400	8,700	$333,092	$303,537	$1,195,432	$1,140,716	$0	$0
INDIRECT	3,200	3,000	$191,720	$180,498	$591,637	$560,304	$0	$0
INDUCED	2,600	2,400	$138,960	$128,071	$444,225	$409,309	$0	$0
TOTAL EFFECT	**15,300**	**14,100**	**$663,772**	**$612,106**	**$2,231,293**	**$2,110,329**	**$168,840**	**$158,889**
ALL STATE LANDS	**38,800**	**36,400**	**$1,705,205**	**$1,601,470**	**$6,071,838**	**$5,855,285**	**$445,118**	**$427,683**

[11] Mojica, J., Fletcher, A., 2020, op. cit.

The central goals of this study were to better understand visitation to the state's recreational lands each year, including where visitors come from, how long they stay, and the overall economic effects of visitor spending. By leveraging mobile device data and powerful geospatial tools, we were able to generate defensible estimates of visitation across nearly 4 million acres, including state parks, natural resource lands, wildlife areas, Green Dot roads, and water access areas.

Our models estimated that state lands supported 78 million visitor days in 2019, which increased to 87 million visitor days in 2020. State Parks accounted for 44 percent of all visitation across the full period. We combined these estimates with spending profiles based on the 2020 visitor survey (see above) to estimate annual visitor expenditures of averaging about $3 billion in both 2019 and 2020. Visitors to WDFW lands accounted for 43 percent of total spending across both years, despite representing 34 percent of total visitation. This appears to derive from proportionally higher spending by birdwatchers, wildlife enthusiasts, hunters, and fishers.

The pandemic not only increased the number of people seeking outdoor recreational opportunities, it also changed the way they recreated. Mobile device data indicated an increase in day trips and a decrease in overnight visitation (both on-site and in the local area). This shift to day-use offset overall increases in visitation in terms of total visitor spending, which declined 2 percent in 2020.

Visitor spending produced goods and services, both direct and indirect, worth a total of $5.9 billion; for every $1 spent by recreational users, $1.80 in economic activity is generated in the regional economy. Annual visitor expenditures and the economic activity they generate go on to support 37,600 full- and part-time jobs, and $1.65 billion in wages in the state. Finally, spending by visitors to state recreation lands contributed more than $435 million in local and state tax revenue.

LESSONS LEARNED

Any approach to tracking visitation inevitably includes some element of error—visitors enter and leave off-hours, cars transport both individuals and

groups, and trail counters occasionally malfunction. This is also true of models that attempt to estimate visitation. However, the relatively recent availability of mobile device data offers the potential to advance analyses of outdoor recreation in several ways. While mobile device data alone predict about 50 percent of visitation to state parks, our estimates improved considerably with the addition of site-level contextual data that are easily gathered or generated (e.g., site amenities, weather and air conditions, spatial extent). Given sufficient cellular coverage, mobile device data can inform models to estimate visitation where more traditional monitoring data are unavailable or cost-prohibitive. Where such data exist, they can be combined with other contextual site data to calibrate mobile device models with a high degree of accuracy. Gaps in ground-level data could be addressed through a sampling approach in which a subset of all management units are tracked (i.e., entry surveys, road counters), and models are trained to those data before being used to estimate system-wide visitation.

That said, the scale of statewide, multi-year mobile device data is very large—the initial dataset included more than 21 million unique devices and 97 billion location records. While completing this project, we developed and tested several approaches to working with such data, which should make subsequent analyses more efficient. Identifying the local spending networks for each management unit was also a complex, large-scale process, as we had to generate 30,000 50-mile road networks from every point of access to all sites before merging these into one local network per site. While cloud data and automation greatly facilitated this process, these networks have now been defined for all state recreation lands, allowing future analyses to be executed with less time and effort.

While it may not be possible to fully correct for biases in the mobile device data (i.e., representativeness of both state land visitors, broadly), comparing devices per-capita across census units may offer some insights, including whether these patterns are different for mobile device users overall, versus those who visit state recreation lands. The nature of anonymized mobile device data limits our ability to conclusively address questions of equitable access, but it may be helpful to review relative differences across census units, even if it is impossible to identify the demographic attributes (e.g., age, race, gender, economic status) of individual visitors.


WENAS WILDLIFE AREA

FUTURE RESEARCH

TARGETED DATA COLLECTION

The visitation estimates presented here have been modeled from state park visitation data. Neither WDNR nor WDFW had commensurate data available, apart from road counters at WDFW water access areas. Future research could help WDFW and WDNR prioritize management units for targeted data collection to support agency-specific statistical models that could be used to generate visitation estimates for other (non-survey) sites.

While our 2020 survey of state park visitors also collected expenditure data for visits to WDFW and WDNR lands, these were not a central focus of the survey. The survey provided a general understanding of what visitors spent when visiting WDNR and WDFW lands, but we anticipate those profiles could be improved through agency-specific surveys.

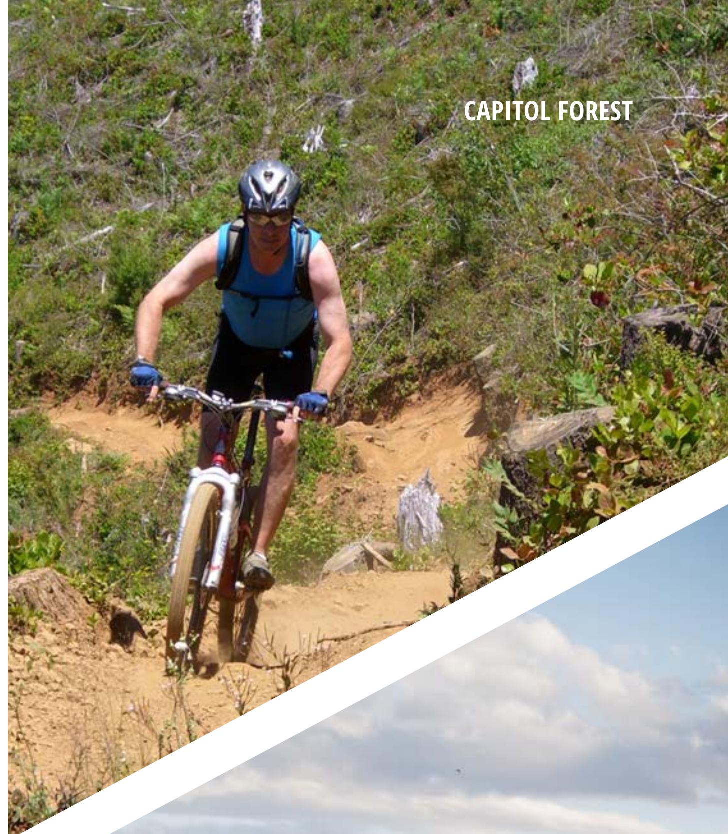
PATHWAYS AND GATEWAY COMMUNITIES

In 2018, Earth Economics completed a study of the economic impact of visitors to the Mount Baker-Snoqualmie National Forest. That study included an analysis of gateway communities—towns along access corridors to the forest that are believed to reap considerable benefits from outdoor recreation tourism. That analysis used entry surveys to identify the home ZIP Codes of visitors, from which “likely travel routes” were developed in ArcGIS, based on the time and distance to forest entry points. While this approach shed light on the importance of spending by urban visitors in these rural gateway communities, the distribution of visitor spending was based on the number of recreation industry businesses in each community along the probable (least-cost) routes between visitor ZIP Codes and forest entry points. Business locations for that analysis were drawn from ReferenceUSA, but since SafeGraph provides spatial footprints for individual businesses, it is now possible to adjust spending distributions by both square footage and county-scale industry productivity. It is also much easier to acquire business data at larger scales through SafeGraph. Finally, the availability of mobile device data presents the opportunity to identify locations where individual users travel, including changes to travel patterns associated with events such as road closures, inclement weather, and wildfires. Moreover, a more-nuanced gateway community analysis could be generated across all state recreation lands, rather than a single recreational unit (e.g., Mount Baker-Snoqualmie National Forest).

ACTIVE PLANNING

With sufficient preparation and processing power, mobile device data can be analyzed closer to “real time” than traditional approaches based on visitor surveys. This presents an opportunity to planners and the managers of state lands to better understand visitation to management units (at lower cost than traditional means), including the value of site amenities in attracting visitors, as well as the effect of disruptions on visitation. This could support more proactive approaches to managing state land visitation, anticipating disruptions due to road or site maintenance, or seasonal factors such as wildfire smoke.

LITTLE SI SUMMIT



CAPITOL FOREST

COLUMBIA PLATEAU TRAIL

STUDY LIMITATIONS

No analysis can be perfect—every effort to research complex, real world phenomena is limited by the scale and quality of the available data, as well as the tools to analyze such data. Mobile device data, like geospatial data and tools generally, presents a great opportunity to expand recreational analyses, producing faster, more detailed results at a larger scale. At the same time, the limitations and biases of these data and tools must be acknowledged to produce accurate and reliable results.

POTENTIAL BIAS IN MOBILE DEVICE DATA

Given that the use of mobile devices and location-enabled applications are not only based on individual preferences, but also economic constraints, mobile device data do not fully reflect state land visitors, in number or demographics.[vii] The "under-sampling" effect of this is clearly shown by plotting the number of unique devices located within State Park boundaries against visitor counts—the number of unique devices is often several orders of magnitude below actual visitation (see Figure 12 and Figure 13).

As described earlier, the availability of cellular carriers also impacts the accuracy of model estimates, although this effect is less significant for random forest models. Fortunately, relatively few management units fall entirely outside of cellular coverage, though this may change as the telecom industry shifts from 3G to more advanced technologies.

Less understood are the sociodemographic biases in mobile device data. Other research has shown these data to underrepresent poorer and elderly populations, as well as people of color. A direct comparison of mobile device users to the demographics of state parks visitors is not possible here, due to the anonymized nature of the mobile data. To the degree that equal access and representativeness of cellular data are concerns, future public lands surveys might include questions about the use of location-enabled mobile devices.

FIGURE 12. UNIQUE DEVICES PER MONTH VERSUS STATE PARKS VISITATION COUNTS, BY YEAR (000s)

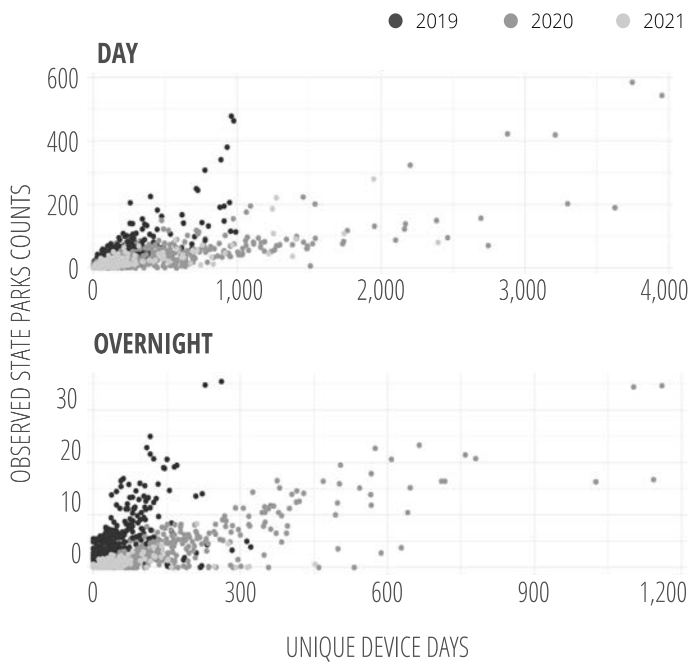


FIGURE 13. UNIQUE DEVICES PER MONTH VERSUS WDFW TRAFX CAR COUNTS, BY YEAR (000s)

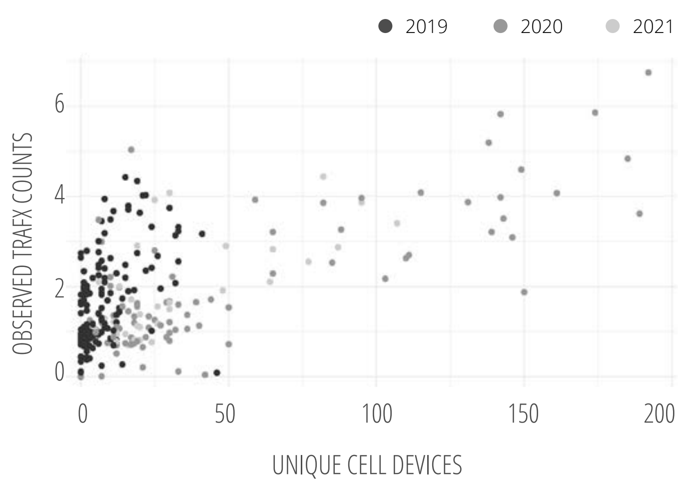
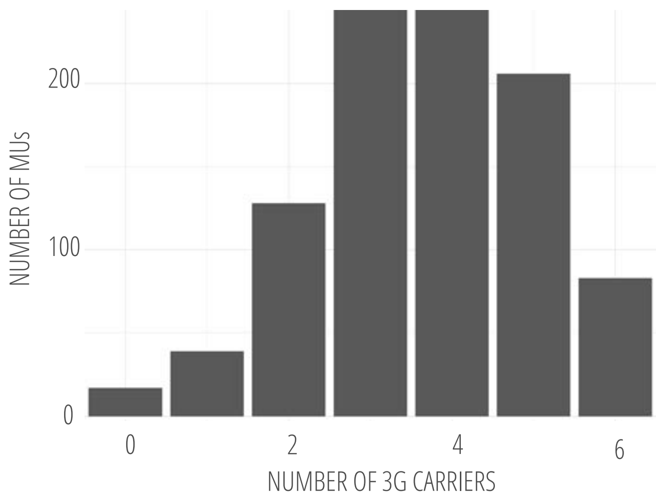


FIGURE 14. NUMBER OF MANAGEMENT UNITS WITH NON-ZERO UNIQUE DEVICE DAYS PER MONTH,BY THE AVERAGE NUMBER OF 3G CARRIERS AVAILABLE ON EACH SITE



LIMITATIONS OF INPUT-OUTPUT MODELS

While based on real-world data and updated regularly, IMPLAN is a static and linear I-O model. This means that industry-to-industry multipliers (the additional economic activity spurred by inter-industry transactions) are constant regardless of the level of spending. If $100,000 spent at restaurants results in employment of 2, $1 million employs 20, and $100 million employs 2,000. Similarly, IMPLAN does not address economies (or diseconomies) of scale. Also, the IMPLAN model does not reflect supply chain constraints, locally or globally.

Perhaps more importantly, our estimates of economic contributions are based on estimated spending across all visitor types per management unit, derived from the reported average spending by visitor type and modeled visitation levels. As discussed, visitation estimate errors terms for management units not managed by Parks are unknown; these estimates should be refined in future analyses. Any biases in either the spending profiles or the visitation models are reflected in the subsequent IMPLAN outputs.

SITE-LEVEL DATA

The visitation models assume that WDFW and WDNR recreation lands are comparable to State Parks in terms of the contextual variables included in the models. As comprehensive visitation is not tracked on WDFW or WDNR lands, we have no way of calculating the error of the estimates on lands other than the State Parks and WDFW water access areas. Deploying some means of counting visitors to these more "porous" lands would help to properly calibrate the visitation models and strengthen their predictive abilities.

In Washington, state-owned lands accessible to the public for outdoor recreation are vast—nearly 4 million acres statewide, larger than Connecticut and Rhode Island combined. While state agencies maintain extensive geospatial and relational data about the units they manage, these data are not always commensurate across agencies. For instance, geospatial data on State Parks usually omit roadways that pass fully through a park (e.g., sites "straddling" state or county highways), but this is less common within WDFW and WDNR data. Moreover, the boundaries of some management units overlap—especially where one agency owns a property but delegates management of that site to another agency. Though we took great care to ensure that all management units excluded (or included) similar roadway types, and corrected any boundary overlaps or management-ownership mismatches (we associated visitation with the managing agency, following guidance by agency staff), other analysts may generate somewhat different management unit boundaries. Similarly, while some site attributes were generated from state- or federal-level datasets (e.g., population distribution, proportion developed, air quality scores), others were produced from multiple agency-level data. Differences in agency definitions of amenity types may also introduce some variance in models based on such data.

Occasionally, management unit and business spatial boundaries were not clearly defined. A relatively small proportion of management units (e.g., water access sites) and Points of Interest (i.e., businesses) could not be clearly associated with parcel boundaries or building footprints. For these, "synthetic" footprints were generated, usually as buffers around point locations, with features such as roadways and surface waters removed. In these instances, we compared each against satellite imagery, correcting boundaries to align with relevant features in the landscape (e.g., parking areas or locations inaccessible by road). These alterations were reviewed by other Earth Economics analysts and agency staff.

That said, most site-level data limitations were addressed during this study, following extensive consultation with agency staff. This often entailed developing multiple approaches for comparison, before selecting the most-acceptable solution. The finalized management unit geospatial and attribute datasets represent a best-effort, empirically grounded approach, which should prove valuable for any future efforts.

VISITOR SPENDING PROFILES

Visitor spending while visiting Green Dot roads was associated with the agency managing lands adjacent to those roadways (i.e., WDNR or WDFW). All water access areas were associated with WDFW regional spending profiles.

TABLE 13: AVERAGE DAILY VISITOR SPENDING PER PERSON, BY REGION AND AGENCY

REGION	AGENCY	LOCAL DAY USE	LOCAL OVERNIGHT IN AREA	LOCAL OVERNIGHT IN MANAGEMENT UNIT	NONLOCAL DAY USE	NONLOCAL OVERNIGHT IN AREA	NONLOCAL OVERNIGHT IN MANAGEMENT UNIT
East	WDFW	$15.21	$30.41	$20.94	$34.46	$68.86	$47.39
	WDNR	$12.32	$30.05	$17.84	$27.88	$68.03	$40.42
	Parks	$17.87	$31.40	$28.53	$20.24	$67.83	$36.41
Northwest	WDFW	$31.34	$62.60	$43.10	$40.05	$80.01	$55.08
	WDNR	$25.42	$62.07	$36.86	$32.39	$79.08	$46.97
	Parks	$18.50	$51.13	$22.78	$24.40	$67.78	$30.56
Southwest	WDFW	$31.20	$62.33	$42.91	$36.73	$73.40	$50.53
	WDNR	$25.31	$61.76	$36.68	$29.73	$72.53	$43.06
	Parks	$18.41	$17.88	$18.58	$24.06	$79.28	$30.97

MODELS AND MODEL RESULTS

MODEL RESULTS USING STATE PARKS DATA

TABLE 14. VARIABLES INCLUDED IN THE LINEAR AND RANDOM FOREST MODELS AND THEIR DEFINITIONS

VARIABLE	DEFINITION
UDD	Unique device days per month
2020	1 if year is 2020; 0 otherwise
2021	1 if year is 2021; 0 otherwise
Jan	1 if month is January; 0 otherwise
Feb	1 if month is February; 0 otherwise
Mar	1 if month is March; 0 otherwise
Apr	1 if month is April; 0 otherwise
May	1 if month is May; 0 otherwise
Jun	1 if month is June; 0 otherwise
Jul	1 if month is July; 0 otherwise
Aug	1 if month is August; 0 otherwise
Sep	1 if month is September; 0 otherwise
Oct	1 if month is October; 0 otherwise
Nov	1 if month is November; 0 otherwise
LockDown	1 if Washington State was in a COVID-19 lockdown
Sum_pop	Total population within 5 miles of management unit
Prop_Dev	The proportion of the management unit area that is developed, according to NLCD definitions
Mean_elev	Mean elevation within a management unit
Max_aqi	Maximum daily air quality index score for a given month
precip	Total monthly precipitation
Tmax	Maximum daily temperature for a given month
Carr_3g	Average 3G cell phone networks present for a given month
Dev_camp	Developed campground present
Mot_boat	Motor boating allowed
ar_ctl	1 if management unit is in the Central Lakes area; 0 otherwise
ar_olv	1 if management unit is in the Olympic View area; 0 otherwise
ar_thg	1 if management unit is in the Tahoma Gateway area; 0 otherwise
ar_btg	1 if management unit is in the Battle Ground area; 0 otherwise
ar_slf	1 if management unit is in the Salish Foothills area; 0 otherwise
ar_ssD	1 if management unit is in the South Sound area; 0 otherwise
ar_Dcp	1 if management unit is in the Deception Pass area; 0 otherwise
ar_whb	1 if management unit is in the Whatcom Bays area; 0 otherwise
ar_kts	1 if management unit is in the Kitsap area; 0 otherwise
ar_sji	1 if management unit is in the San Juan area; 0 otherwise
ar_olp	1 if management unit is in the Olympic Peninsula area; 0 otherwise
ar_stb	1 if management unit is in the South Beach area; 0 otherwise
ar_csf	1 if management unit is in the Cascade Foothills area; 0 otherwise
ar_glD	1 if management unit is in the Goldendale area; 0 otherwise
ar_bmt	1 if management unit is in the Blue Mountain area; 0 otherwise
ar_lnb	1 if management unit is in the Long Beach area; 0 otherwise
ar_nos	1 if management unit is in the Northern Shores area; 0 otherwise
ar_ine	1 if management unit is in the Inland Northwest Empire; 0 otherwise
ar_okh	1 if management unit is in the Okanogan Highlands area; 0 otherwise
ar_clc	1 if management unit is in the Coulee Corridor area; 0 otherwise
ar_wvl	1 if management unit is in the Wenatchee Valley area; 0 otherwise
ar_cwb	1 if management unit is in the Central Whidbey area; 0 otherwise
ar_mlr	1 if management unit is in the Millersylvania area; 0 otherwise
ar_ccs	1 if management unit is in the Central Cascades area; 0 otherwise
ar_ucl	1 if management unit is in the Upper Cowlitz area; 0 otherwise

TABLE 15. LINEAR MODEL RESULTS USING THE PARKS VISITATION DATA

	DAY VISIT MODEL		NIGHT VISIT MODEL	
VARIABLE	COEFFICIENT	STD. ERROR	COEFFICIENT	STD. ERROR
Intercept	-2.34E+04***	4.40E+03	2.79E+02	4.91E+02
UDD	8.61E+01***	1.50E+00	2.11E+01***	5.27E-01
2020	-6.74E+03***	8.71E+02	-1.22E+03***	1.14E+02
2021	-6.60E+03***	1.16E+03	-5.57E+02***	1.35E+02
Jan	6.61E+02	1.48E+03	-2.94E+01	1.86E+02
Feb	2.82E+02	1.51E+03	9.77E+01	1.89E+02
Mar	1.84E+03	1.78E+03	1.17E+02	2.20E+02
Apr	2.24E+02	2.19E+03	1.07E+02	2.77E+02
May	1.78E+03	2.63E+03	2.44E+02	3.32E+02
Jun	4.85E+03*	2.84E+03	1.29E+03***	3.57E+02
Jul	5.38E+03*	3.06E+03	2.38E+03***	3.84E+02
Aug	5.08E+03	3.18E+03	2.40E+03***	3.98E+02
Sep	1.74E+03	2.63E+03	5.84E+02*	3.30E+02
Oct	2.25E+03	1.92E+03	1.68E+02	2.43E+02
Nov	1.07E+03	1.63E+03	7.50E+01	2.08E+02
Lockdown	-5.36E+03***	1.35E+03	-3.94E+02**	1.71E+02
Sum_pop	-1.02E-01***	8.80E-03	-1.07E-02***	1.15E-03
Prop_Dev	3.38E+04***	7.13E+03	3.47E+03***	1.06E+03
Mean_elev	1.63E+00	2.25E+00	-3.95E-02	2.86E-01
Max_aqi	1.34E+00	7.83E+00	1.63E-01	9.90E-01
precip	2.14E+00	4.85E+00	5.91E-01	6.06E-01
tmax	2.79E+02**	1.37E+02	5.28E+01***	1.73E+01
Carr_3g	1.36E+03***	2.91E+02	2.78E+01	3.94E+01
Dev_camp	6.94E+03***	7.40E+02	6.70E+02***	1.17E+02
Mot_boat	8.79E+03***	9.25E+02	2.32E+02**	1.09E+02
ar_ctl	3.92E+03	4.02E+03	-1.02E+03**	4.13E+02
ar_olv	1.36E+04***	4.12E+03	-6.33E+02	4.44E+02
ar_thg	1.87E+04***	4.13E+03	-6.93E+02	4.65E+02
ar_btg	5.81E+03	4.28E+03	-1.16E+03***	4.48E+02
ar_slf	1.55E+04***	4.22E+03	-4.42E+02	4.56E+02
ar_ssD	1.75E+04***	4.10E+03	-1.17E+03***	4.40E+02
ar_Dcp	6.58E+04***	4.40E+03	1.52E+03***	4.93E+02
ar_whb	2.43E+04***	4.27E+03	-4.63E+02	4.66E+02
ar_kts	1.71E+04***	4.16E+03	-1.40E+03***	4.50E+02
ar_sji	1.95E+04***	4.04E+03	-9.85E+02**	4.33E+02
ar_olp	1.37E+04***	4.09E+03	-9.29E+02**	4.49E+02
ar_stb	2.77E+04***	4.53E+03	4.76E+02	5.47E+02
ar_csf	2.16E+04***	4.15E+03	-9.22E+02*	4.83E+02

*** significant at 1%, ** significant at 5%, * significant at 10%

TABLE 15. LINEAR MODEL RESULTS USING THE PARKS VISITATION DATA (CONTINUED)

	DAY VISIT MODEL		NIGHT VISIT MODEL	
VARIABLE	COEFFICIENT	STD. ERROR	COEFFICIENT	STD. ERROR
ar_glD	9.58E+03**	3.99E+03	-1.41E+03***	4.28E+02
ar_bmt	1.69E+04***	3.95E+03	-1.15E+03***	4.36E+02
ar_lnb	1.54E+04***	4.23E+03	8.90E+02*	4.79E+02
ar_nos	1.73E+04***	4.28E+03	-5.09E+02	4.61E+02
ar_ine	1.43E+04***	4.15E+03	-2.14E+03***	4.76E+02
ar_okh	1.20E+04***	4.04E+03	-3.22E+02	4.25E+02
ar_clc	1.47E+04***	4.00E+03	-5.95E+02	4.29E+02
ar_wvl	8.74E+03**	3.96E+03	-1.08E+03**	4.20E+02
ar_cwb	1.45E+04***	4.20E+03	-1.04E+03**	4.78E+02
ar_mlr	1.65E+04***	4.30E+03	-5.42E+02	4.84E+02
ar_ccs	1.09E+04***	3.99E+03	-6.39E+02	4.31E+02
ar_ucl	1.06E+04***	4.10E+03	-6.96E+02	4.52E+02

*** significant at 1%, ** significant at 5%, * significant at 10%

MODEL RESULTS USING WDFW TRAFX DATA

TABLE 16. VARIABLES INCLUDED IN THE LINEAR AND RANDOM FOREST MODELS AND THEIR DEFINITIONS

VARIABLE	DEFINITION
UDD	Unique device days per month
2020	1 if year is 2020; 0 otherwise
2021	1 if year is 2021; 0 otherwise
Jan	1 if month is January; 0 otherwise
Feb	1 if month is February; 0 otherwise
Mar	1 if month is March; 0 otherwise
Apr	1 if month is April; 0 otherwise
May	1 if month is May; 0 otherwise
Jun	1 if month is June; 0 otherwise
Jul	1 if month is July; 0 otherwise
Aug	1 if month is August; 0 otherwise
Sep	1 if month is September; 0 otherwise
Oct	1 if month is October; 0 otherwise
Nov	1 if month is November; 0 otherwise
Camping	1 if camping allowed; 0 otherwise
Motorized	1 if motorized boating allowed; 0 otherwise
Restrooms	1 if restrooms present; 0 otherwise
Launch	1 if boat launch is present; 0 otherwise
ADAParking	1 if ADA-accessible parking is present; 0 otherwise
ADARestroom	1 if ADA-accessible restrooms are present; 0 otherwise
ADADock	1 if ADA-accessible dock is present; 0 otherwise
ADABoat-Launch	1 if ADA-accessible boat launch is present; 0 otherwise
Carriers	Number of 3G cell phone carriers in a given month

TABLE 17. LINEAR MODEL RESULTS USING THE WDFW TRAFX DATA

VARIABLE	COEFFICIENT	STD. ERROR
Intercept	587.961	521.307
UDD	16.046***	1.753
2020	-567.829***	136.028
2021	-68.98	168.389
Jan	-251.106	257.688
Feb	-471.377*	250.1
Mar	-105.421	258.418
Apr	-93.578	274.23
May	676.711**	274.434
Jun	602.532**	297.747
Jul	1154.679***	304.435
Aug	1189.439***	281.103
Sep	651.867**	286.335
Oct	536.407*	284.88
Nov	104.247	293.599
Camping	-507.76	338.69
Motorized	575.658**	290.508
Restrooms	-285.175	386.67
Launch	240.862	217.215
ADA Parking	-90.34	173.559
ADA Restrooms	48.325	197.342
ADA Dock	619.796**	270.056
ADA Boat Launch	26.372	282.035
Carriers	55.516	55.105

*** significant at 1%, ** significant at 5%, * significant at 10%

SUN LAKES STATE PARK

EARTH ECONOMICS