Measuring the Value of Outdoor Recreation for National Environmental-Economic Statistics

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Abstract

Accurately measuring welfare changes from outdoor recreation requires accounting for both market expenditures and household-produced services, yet current U.S. satellite accounts capture only market transactions. Ignoring the value of recreation under the household production accounting boundary can create a measurement gap for benefit-cost analyses of environmental protection or infrastructure investments, where recreation benefits would be systematically understated. We find that outdoor recreation is primarily a household-produced service that combines purchased inputs (gasoline, equipment) with travel time: the major welfare-relevant cost. Using detailed U.S. coastal recreation data, we partition travel costs across the System of National Accounts boundary (market expenses) and the household production boundary (travel time) to quantify this measurement gap. We find that market expenditures represent only one-third of total recreation costs, while household production of recreation services through travel time comprises two-thirds. This means current assessments using only market expenditures underestimate outdoor recreation's welfare-relevant value by approximately threefold. Including travel time would increase the Household Production Satellite Account by 4-5 percent nationally, corresponding to $12.4 billion in the U.S. Gulf Region or 0.7 percent of regional GDP. For benefit-cost analysis, jointly considering both the SNA and household production boundaries is essential for accurately measuring welfare-relevant expenditure changes over time and properly valuing natural assets that enable outdoor recreation.

Keywords: Recreation, Household Production, Accounting Boundaries, Satellite Accounts
JEL Classification Numbers: Q51, Q56, E01

*We are greatful to [insert roger and other ppl who talked on phone with us about data, and camp resources for the idea]

1 Introduction

Evaluating progress toward sustainable development requires measuring changes in welfare through time, but traditional economic statistics omit ecosystem services such as outdoor recreation that contribute to welfare and natural capital assets that contribute to wealth (Nordhaus and Tobin, 1973; Arrow et al., 2004; Nordhaus, 2006; Dasgupta and HM Treasury, 2021). This measurement gap has consequences for policy analysis. Incomplete valuation of outdoor recreation benefits can lead to systematically suboptimal decisions around environmental protection and infrastructure investments due to underestimation of its benefit. Although the Bureau of Economic Analysis has developed satellite accounts extending beyond GDP boundaries (Landefeld et al., 2009; Highfill et al., 2018), these measures remain incomplete. The Household Production Satellite Account excludes outdoor recreation despite recreation being a household-produced service **(cite chapt 2)**, and the Outdoor Recreation Satellite Account captures only market expenditures and omits marginal spending for local trips. Our analysis reveals that assessments based only on market expenditures underestimate outdoor recreation's welfare-relevant value by approximately threefold, which may create errors in benefit-cost analyses where recreation benefits are used to justify environmental protection or public investments.

This paper addresses the question of how outdoor recreation should be valued across national accounting boundaries, and estimates the magnitude of current measurement gaps in U.S. satellite accounts. Ecosystem services like outdoor recreation generate value across multiple accounting boundaries, requiring careful partitioning for comprehensive measurement (National Research Council, 2005; Office of Science and Technology Policy et al., 2023; Fenichel et al., 2024). We focus on two key boundaries: the System of National Accounts (SNA) boundary capturing market transactions, and the household production boundary measuring non-market services produced for own consumption. We demonstrate that outdoor recreation is primarily a household-produced service where travel time, not market purchases, represents the major welfare-relevant expenditure, yet current satellite accounts ignore this household production component entirely.

Three streams of prior research inform our approach. First, ecosystem service valuation literature has established frameworks for measuring natural resource benefits (Boyd and Banzhaf, 2007; Barbier, 2013; Fenichel and Abbott, 2014), but these frameworks do not partition estimated values across accounting boundaries, as is needed for populating national accounts. Second, travel cost models provide well-established methods for estimating recreation values using both market expenditures and travel time (Freeman et al., 2014; Parsons, 2017; Lupi et al., 2020). However, this literature estimates welfare changes (consumer surplus) rather than expenditure measures appropriate for satellite accounts, and it has not systematically addressed how to partition travel costs across SNA versus household production boundaries. Third, recent work has clarified conceptual linkages between non-market valuation and national accounting frameworks (Fenichel et al., 2024; Office of Science and Technology Policy et al., 2023), but demonstrating how to partition the value of outdoor recreation for existing satellite accounts that correspond with welfare-relevant accounting boundaries is still needed. These gaps are consequential. Without clear partitioning methods, existing satellite accounts either omit recreation's household production value entirely or risk double-counting when recreation values span multiple boundaries.

This paper makes two contributions. First, we provide a conceptual framework for partitioning outdoor recreation expenditures across accounting boundaries, clarifying that the combined SNA and household production boundary is the relevant framework for welfare assessment and benefit-cost analysis. Second, we estimate these boundary-specific values using travel cost data, demonstrating how to value household production of recreation services using time expenditures consistent with BEA satellite account methodology.

We provide estimates of outdoor recreation's contribution to household production accounts. Using detailed data from 7,621 recreation trips to Gulf Coast shoreline sites, we find that including recreation travel time would increase household production account values by 4-5% ($12.4 billion in the Gulf Region, or 0.7% of regional GDP), while including local market expenditures increases ORSA by only 1%. This confirms that outdoor recreation is primarily a household-produced service. Current analyses of recreation's benefit that only rely on market expenditures undervalue recreation by approximately threefold.

The remainder of the paper proceeds as follows. Section 2 provides background on U.S. satellite accounts and how they currently measure outdoor recreation. Section 3 presents our conceptual framework for partitioning recreation value across accounting boundaries. Section 4 describes our data and the characteristics of Gulf Coast recreation patterns. Section 5 details our empirical methods for estimating values under each boundary. Section 6 presents results demonstrating the threefold underestimation when household production is ignored. Section 7 discusses implications for benefit-cost analysis and environmental-economic accounting.

2 Background on U.S. Satellite Accounts

Understanding current measurement gaps requires context about how U.S. satellite accounts operate and what they currently capture for outdoor recreation.

2.1 Outdoor Recreation Satellite Account

The ORSA was created in 2018 to measure economic activity generated by outdoor recreation that otherwise would be attributed to other industries (Highfill et al., 2018). Available from 2017 onward, the ORSA finds that approximately 2 percent of GDP annually can be attributed to outdoor recreation, ranging from 1.4 percent in Connecticut to 5.6 percent in Hawaii (Bureau of Economic Analysis, 2023). The ORSA's methodology follows the BEA's Travel and Tourism Satellite Account and international standards (Highfill et al., 2018; United Nations Department of Economic and Social Affairs and Statistics Division, 2010). It measures both fixed expenditures (apparel and gear) and marginal expenditures (gasoline and accommodations required for individual trips). However, following travel and tourism standards, ORSA only tracks marginal expenditures on trips occurring at least 50 miles from a participant's home, excluding local recreation's marginal expenditures. We find that local trips comprise 77 percent of all recreation trips.

2.2 Household Production Satellite Account

The U.S. Household Production Satellite Account operates under different principles, tracking non-market services outside the SNA boundary but part of consumers' consumption (Landefeld et al., 2009). Unlike the ORSA, which reorganize existing market transactions, the household production account measures value not captured in traditional economic statistics like GDP because no market transaction occurs. The Household Production Satellite Account uses the American Time Use Survey to track time spent cooking, cleaning, childcare, and household maintenance, including travel time related to these activities. Time is valued using wages of general-purpose domestic workers rather than individual wage-based valuations typically used in travel cost models, because this wage-replacement approach captures the market price for household production time (Landefeld et al., 2009). The value of non-market services was 14.7 percent of GDP in 2020

(Bridgman et al., 2022). However, this substantial account excludes outdoor recreation entirely, despite travel time being a well-established component of recreation value estimation (Lupi et al., 2020).

3 Conceptual Framework

To understand how current U.S. satellite accounts omit the value of recreation, it is useful to consider how this value should be partitioned across welfare-relevant accounting boundaries. We partition non-market and market expenditure spent on outdoor recreation because it is more readily observable than welfare. While expenditure flows are not welfare per se, tracking comprehensive expenditure across all welfare-relevant accounting boundaries provides a more complete measure of resource use and can support welfare assessment (Nordhaus and Tobin, 1973; Arrow et al., 2004).

Consider how a beach ecosystem. The beach drives economic activity through market expenditures at seaside businesses like restaurants, hotels, and equipment rentals that support recreation (Zhuang et al., 2024). These expenditures fall under the SNA boundary and are partially captured by ORSA. The beach also provides a place for individuals to enjoy leisure such as swimming, sunbathing, or walking. Because individuals must spend time traveling to the beach, this travel time represents the expenditure of time to produce a leisure service for oneself. Additionally, beaches with healthy dune systems provide storm surge protection that can mitigate hurricane and tropical storm damage (Addicott, 2024). Spending to conserve the beach and its dunes can be classified under defensive expenditure boundaries. These are all welfare-relevant expenditures that can approximate the benefits of the beach's recreational and protective services.

This example illustrates the broader challenge facing national environmental-economic accounts: systematic tracking of ecosystem service values across accounting boundaries to avoid double counting while ensuring comprehensive measurement. Because outdoor recreation expenditures span multiple boundaries, they create measurement challenges for existing satellite accounts. However, when comprehensive expenditures are partitioned across accounting boundaries correctly, the union of the three boundaries (market spending, household production, defensive expenditure) can be used to measure changes in welfare-relevant expenditure. In this paper, we focus on partitioning travel cost expenditures across the SNA boundary and the household production boundary. Current satellite accounts inadequately capture this partitioning, meaning they cannot approximate national welfare.

3.1 The Accounting Boundary Problem

Consider total recreation expenditure as $E_{total} = E_{market} + E_{time}$. Market expenditures E_{market} include gasoline, accommodation, and equipment purchases that fall under the SNA boundary. Time expenditures E_{time} represent household production of recreation services via travel time.

Current satellite accounts face a fundamental partitioning problem. The Outdoor Recreation Satellite Account (ORSA) captures E_{market} for trips exceeding 50 miles from home but systematically excludes local recreation trips, which we find comprise 77 percent of all trips. The Household Production Satellite Account excludes E_{time} for recreation entirely, despite outdoor recreation being primarily produced through travel time. This creates measurement gaps in both accounts despite recreation representing a major component of household production and economic activity.

3.2 Expenditure-Based Measurement Approach

Rather than estimating welfare changes through traditional travel cost demand models, we measure realized expenditures under each accounting boundary using observed travel behavior. This expenditure-based approach directly addresses the national accounting need for consistent boundary measurement while avoiding the complexities of welfare estimation across time periods.

Our approach partitions observed recreation expenditures by calculating adjustment parameters that scale existing satellite account values to include currently excluded components. First, α is the ratio of total recreation market expenditures to expenditures on distant trips (>50 miles), allowing ORSA scaling to include local recreation. Second, γ is the ratio of travel time expenditures to market expenditures, enabling estimation of household-produced recreation services.

This framework provides a systematic method for connecting travel cost data to national accounting frameworks without requiring repeated demand model estimation or welfare calculations. The expenditure approach focuses on measuring what households actually spend on recreation inputs, which aligns with how other satellite accounts track economic activity.

3.3 Connection to Intertemporal Assessment

While our primary contribution addresses national accounts measurement, the expenditure-based approach also supports intertemporal welfare assessment for sustainable development goals. The key insight is that consistent tracking of expenditure changes across accounting boundaries over time provides a foundation for measuring welfare changes without requiring repeated demand estimation.

Under duality theory, changes in the expenditure function evaluated while holding prices constant using superlative index numbers provide ex-post equivalent variation up to a second-order approximation (Fenichel et al., 2024; Diewert, 1992). By establishing systematic expenditure measurement across SNA and household production boundaries, our approach enables tracking how recreation expenditure patterns evolve over time. These expenditure changes, when properly indexed, can serve as proxies for welfare changes. This enables answering questions concerning sustainable development, such as whether households are better or worse off in their recreation opportunities compared to previous periods.

This approach treats the current period relative to the prior period as the relevant counterfactual, which is appropriate for measuring sustainable development. Traditional travel cost models estimate welfare relative to zero recreation trips, requiring complex repeated estimation across time periods with significant identification challenges when time series variation is needed for both parameter identification and change measurement. The expenditure approach sidesteps these complications by focusing on observed spending patterns that can be consistently tracked through existing national accounting systems, creating the measurement infrastructure necessary for intertemporal welfare assessment.

4 Data

To implement our expenditure-based approach for adjusting existing satellite accounts, we use publicly available survey data that were collected by the National Ocean and Atmospheric Agency (NOAA) and partners on trips to coastal recreation sites in Texas, Louisiana, Mississippi, Alabama, Florida, and Georgia (hereout referred to as the Gulf region) from 2012-2013. These data were used to estimate recreational losses due to the 2010 Deepwater Horizon oil spill in the Gulf of Mexico (English et al., 2018). The original data

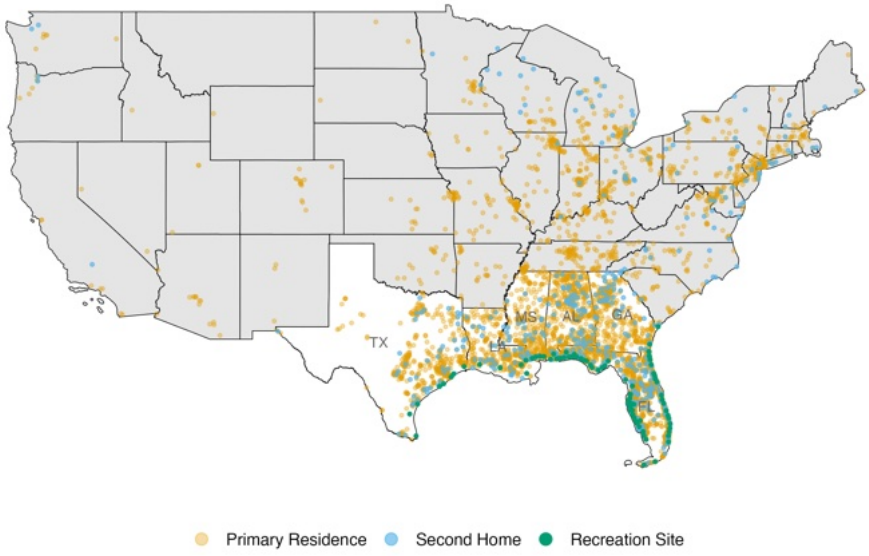

Figure 1: Recreation Origins and Destinations in the Gulf Coast Region. Map shows primary residences, second homes, and the 83 shoreline recreation sites from the Deep Water Horizon survey data. Gulf Coast states (TX, LA, MS, AL, FL, GA) are highlighted with state abbreviations.

collection effort surveyed 41,708 people. Respondents provided their demographic characteristics and the number of trips taken to each of 83 shoreline recreation sites in the Gulf Coast region. Weights were applied to the choice occasion to account for the sampling strata to reflect annual shoreline trip-taking behavior for the adult population of the lower 48 states (Figure 4).

We use the final dataset used by the Deepwater Horizon (DWH) team for their shoreline model, which includes local and national trips for 6,383 unique individuals who take 7,747 trips. We observe total travel costs, one-way distance, market expenditure, and round-trip travel time for 7,621 of these trips (Figure 2). For the NOAA project, travel costs combined driving and flying expenses, weighted by the observed share of respondents who chose each travel mode. Both driving and flying cost calculations included market expenditures and the value of travel time (English et al., 2018). We partition the expenditure on market goods and the travel time using additional data from the DWH team. Due to data availability, we cannot use the weighted average of driving and flying expenditure. Instead, we use the costs associated with driving, which include out-of-pocket driving costs (gasoline, maintenance, and depreciation of average vehicle) and hotel stays. We partition the total cost of a trip into market expenditures and travel time expenditure by subtracting the travel time expenditure associated with driving from the total cost of a trip and thus constructing the market expenditure for a trip. This calculation assumes the value of travel time is one-third the wage rate, as was assumed by English et al. (2018). This leads to underestimating the market expenditure and overestimating travel time for the few far trips when flying may be faster than driving.

We also consider different values of travel time than one-third of the wage rate. The household produc-

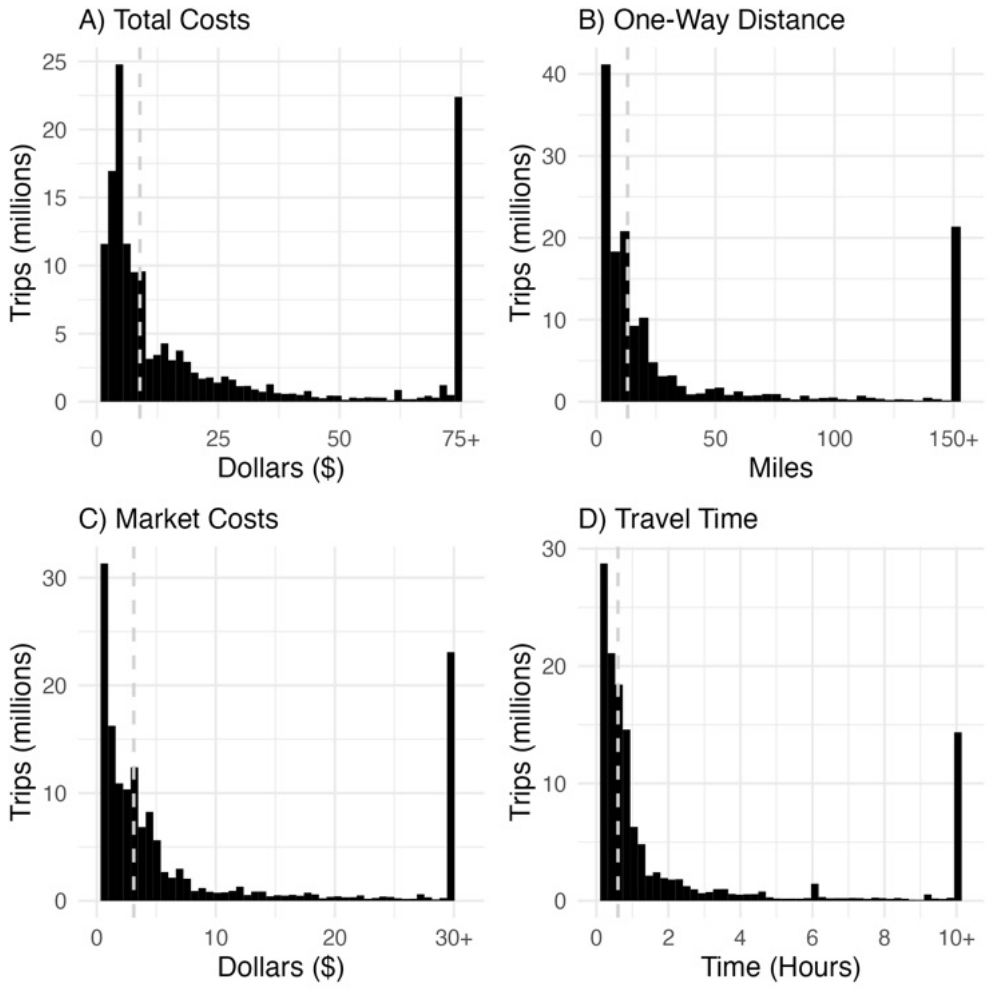

Figure 2: Distribution of Trip Characteristics for Gulf Coast Shoreline Recreation. Panel A shows total costs (market costs plus value of travel time) with a median of $8.88 (average $119). Panel B displays one-way distance traveled with a median of 13.1 miles (average 133 miles), highlighting that 77% of trips are local (within 50 miles of home). Panel C presents market expenditures (excluding travel time value) with a median of $3.11 (average $39). Panel D shows round-trip travel time with a median of 36 minutes (average 4 hours 17 minutes). The difference between medians and averages shows that while most recreation trips are low-cost, high-impact trips influence the averages. Dashed vertical lines indicate weighted medians. Sample includes 7,621 trips from the Deep Water Horizon shoreline recreation survey. Histograms are weighted by trip frequency and truncated at the 95th percentile for clarity.

tion accounts recommend against using the opportunity cost of time (Landefeld et al., 2009). We use the average hourly wage of and general-purpose domestic workers ($14.66 in 2022 dollars), to calculate outdoor recreation's contribution to the household production satellite account if included.

We use the ORSA reports by state provided by the Bureau of Economic Analysis (BEA) from 2022 to scale our results. The ORSA is available by state. It is broken down by industry and activity at the national level and, to a lesser degree, at the state level. We also use the BEA's reported GDP by state from 2022.

For estimating household production values, we use the aggregate national values from the Household

Production Satellite Account, which report that household-produced services equaled 14.7 percent of GDP in 2020 (Bridgman et al., 2022). Unlike the ORSA, which is tracked by state and region, the Household Production Satellite Account is only available at the national level. To generate regional household production estimates, we estimate the ratio of household production value (travel time) to market expenditure value using our DWH data. We then apply this ratio to the regional ORSA market expenditure values to estimate regional household production values for outdoor recreation. This approach allows us to scale household production estimates to the state and regional level using the observed relationship between market and time expenditures in our recreation data.

5 Estimation Methods

We implement our expenditure-based approach to estimate outdoor recreation expenditure across both SNA and household production accounting boundaries. Building on our conceptual framework, we use Deep Water Horizon recreation data to estimate adjustment parameters α and γ that allow us to quantify the measurement gaps in the ORSA and Household Production Satellite Account. Using these parameters, we scale existing ORSA expenditure data to calculate adjusted satellite account values that include local recreation (using α) and to estimate corresponding household production account values for travel time devoted to outdoor recreation trips (using γ).

We partition total recreation expenditure into two components: market expenditures on gasoline and accommodations (captured under the SNA boundary) and travel time expenditures (valued under household production boundaries). The parameter α measures how much total market expenditures exceed expenditures on distant trips (>50 miles), allowing us to scale ORSA values upward to include currently excluded local recreation. The parameter γ captures the ratio of travel cost to market expenditures, enabling us to estimate household production values using ORSA market expenditures. This approach provides a systematic method for adjusting satellite accounts to reflect recreation expenditure across different accounting boundaries by using a sample of recreations trips.

5.1 Estimating Expenditures Under SNA Boundary

To estimate the α parameter, we first calculate total market expenditure on driving costs and accommodations for outdoor recreation at shoreline sites in the Gulf region using the Deepwater Horizon dataset,

$$E_{DWH} = \sum_i \sum_s w_i p_{is} x_{is} \tag{1}$$

where we sum over individuals i and sites s. Here, p_{is} represents per-trip market expenditure for individual i visiting site s, x_{is} is the number of trips, and w_i are sampling weights that scale the data to represent the contiguous U.S. adult population. We reweight observations from the original DWH dataset due to losing 126 observations because of missing data, scaling weights so that the total number of trips in our dataset matches the original 156 million trips taken to the 83 sites. We estimate standard errors for E_{DWH} using the nonparametric bootstrap method with 10,000 replications.

Our goal is to determine how much the ORSA's gasoline and accommodation expenditures would need to be scaled up to include local recreation trips within 50 miles of home, the value currently excluded because the ORSA follows travel and tourism standards that focus on distant trips. We focus on scaled gasoline and accommodation expenditure recorded in the ORSA because the expenditures in the DWH dataset consist

of driving expenses and hotel stays. We use our shoreline recreation data as a representative sample of Gulf region recreation patterns, acknowledging that broader satellite account adjustments would require more comprehensive data across recreation types.

To estimate α which can adjust the ORSA to include the market expenditure for local trips under 50 miles (see Section 3.2), we separate Equation (1) into expenditure on local and other recreation trips

$$E_{DWH} = \sum_i \sum_s \mathbf{1}(l_{is} < 50) \cdot w_i p_{is} x_{si} + \sum_i \sum_s \mathbf{1}(l_{is} \geq 50) \cdot w_i p_{is} x_{si} \tag{2}$$

where $\mathbf{1}(\cdot)$ are indicator functions for whether the one-way travel distance of a trip l is within 50 miles of home or not.

Equation 2 can be relabelled as the expenditure on local trips and the expenditure on far trips, $E = L+F$. We assume that F can be scaled to find E, introducing the adjustment parameter α where $E = \alpha F$. This defines our adjustment parameter as $\alpha = E/F$. We estimate the adjustment parameter using the DWH dataset,

$$\hat{\alpha} = \frac{E_{DWH}}{\sum_i \sum_s \mathbf{1}(l_{is} \geq 50) \cdot w_i p_{is} x_{si}} \tag{3}$$

We find the standard errors for $\hat{\alpha}$ using the non-parametric bootstrap method, resampling our dataset with replacement 10,000 times.

Having estimated $\hat{\alpha}$ from the DWH data, we can now adjust ORSA expenditure values state by state to include local recreation trips. The ORSA provides total state recreation expenditure, but our α parameter applies specifically to gasoline and accommodation expenditures which are the components we observe in the DWH dataset. To isolate the relevant ORSA expenditure baseline, we use national-level data showing that "petroleum and coal products" and "accommodation" represent 13 percent of total ORSA expenditure in most years (12 percent in 2017, 11 percent in 2020). We assume this share applies across states and define $F^r_{ORSA} = 0.13 \times \text{Total ORSA}^r$ as our baseline distant-trip expenditure for gasoline and accommodations in region or state r.

This F^r_{ORSA} corresponds to the denominator in Equation 3, allowing us to use the estimated scaling parameter $\hat{\alpha}$ to calculate total gasoline and accommodation expenditure that includes both local and distant trips. This estimates what ORSA gasoline and accommodation expenditure would be if it included the currently excluded local recreation within 50 miles of home. We calculate the regional expenditure on out-of-pocket driving costs and accommodation for recreation – now including local recreation – as

$$\hat{E^r} = \hat{\alpha} \cdot F^r_{ORSA}. \tag{4}$$

We calculate the share of GDP contributed by this expenditure, including local recreation,

$$\hat{S^r} = E^r / GDP^r \tag{5}$$

We calculate the standard error for E^r and S^r using the delta method.

5.2 Estimating Value under Household-Production Boundary

The household production boundary is responsible for the larger measurement gap from outdoor recreation. While the ORSA at least partially measures market expenditures (excluding only local trips), household production satellite accounts currently exclude outdoor recreation entirely. The γ parameter enables us to

estimate what household production account values would be if recreation travel time were included, by providing the ratio needed to convert observable market expenditures (available through ORSA) into travel time values that belong under the household production boundary. We calculate the total value of travel time for outdoor recreation, estimate the γ scaling parameter, and apply it to generate regional household production account estimates.

To estimate the ratio of travel time expenditure to market expenditure, γ, we calculate the total value of travel time spent on outdoor recreation using the DWH data. This represents the time households invest in "producing" recreation trips to the 83 shoreline sites, which we refer to as the total travel time expenditure,

$$\Theta_{DWH} = \sum_i \sum_s w_i \rho_i t_{is} x_{is} \tag{6}$$

where ρ_i is the monetary value of time for individual i, t_{is} is round-trip travel time to site s, and x_{is} is the number of trips. We use sampling weights w_i so that Θ_{DWH} represents the total value of travel time to the 83 sites for the contiguous U.S. We estimate standard errors using the nonparametric bootstrap method with 10,000 replications.

To scale these results to the regional level, we again use the ORSA, building on our approach to adjusting the ORSA to include local trips. We estimate γ as the ratio of travel time expenditure (now converted to a monetary unit) to market expenditures, allowing us to use ORSA's gasoline and accommodation expenditure as the scalable market expenditure. This approach is necessary because household production satellite accounts are only available at the national level, preventing direct regional adjustments. Additionally, there is no existing non-market value of recreation in the household production satellite account, because it is currently excluded.

The relationship $\gamma E = \Theta$ assumes that market expenditures on gasoline and accommodations, E, can be scaled to equal travel time expenditure. This assumption is supported by the strong correlation between travel distance, market costs, and travel time costs. We estimate this scaling parameter using our DWH data,

$$\hat{\gamma} = \frac{\Theta_{DWH}}{E_{DWH}} \tag{7}$$

where E_{DWH} is the total market expenditure on driving costs and accommodations (Equation 1) and Θ_{DWH} is the total travel time expenditure measured in a monetary unit (Equation 6). We estimate standard errors for $\hat{\gamma}$ using the delta method.

Having estimated both $\hat{\gamma}$ and the adjusted regional expenditure on out-of-pocket driving costs and accommodation for recreation $\hat{E}^r$ from Equation 4 (which now includes local recreation) we can calculate regional household production values for travel time,

$$\hat{H}^r = \hat{\gamma} \cdot \hat{E}^r. \tag{8}$$

This household production value is expressed a share of regional GDP,

$$\hat{V}^r = \hat{H}^r / GDP^r. \tag{9}$$

The standard errors for $\hat{H}^r$ and $\hat{V}^r$ are calculated using the delta method.

We estimate $\hat{\gamma}$ using two different approaches to valuing time, reflecting different methodological perspectives. We use one-third of the wage rate as the opportunity cost of time, which is standard in the travel

cost literature and used by the DWH research team (Lupi et al., 2020; English et al., 2018). Additionally, we estimate $\hat{\gamma}$ using a wage-replacement rates of $14.99 per hour for general-purpose domestic workers (in 2022 dollars, sourced from ONet data). This replacement wage represents the recommended approach for populating household production accounts as they capture the market cost of replacing household time with hired services.

These different time valuations allow us to assess the sensitivity of our household production estimates to alternative approaches for converting time to monetary values. The opportunity cost approach reflects forgone earnings, while the replacement cost approaches reflect the market value of household time in production activities. We use the general-purpose domestic workers' wage because it is what is currently used in the Household Production Satellite Account.

We calculate all results for the Gulf region and each state within. We extrapolate our estimates for the whole country as a demonstrative exercise to benchmark the orders of magnitude of our estimates. However, the country-wide extrapolation is only externally valid if the Gulf region were representative of the country.

6 Results

We estimate measurement gaps in current U.S. satellite accounts for outdoor recreation, demonstrating that market-only approaches substantially underestimate recreation's welfare-relevant value. As established in our conceptual framework, comprehensively measuring outdoor recreation requires accounting across two boundaries: the System of National Accounts (SNA) boundary capturing market transactions, and the household production boundary measuring non-market time expenditures. Current satellite accounts capture only a fraction of this total value. The ORSA tracks market expenditures for distant trips (over 50 miles), while the Household Production Satellite Account excludes recreation entirely.

Our empirical results reveal why this omission matters for policy analysis. We estimate adjustment parameters α and γ that quantify the gaps in current accounts: α measures how much ORSA underestimates market expenditures by excluding local trips, while γ measures how much larger household production values are compared to market expenditures. We find a large asymmetry in measurement gaps across boundaries. While including local recreation increases market expenditure estimates modestly (a 1% adjustment to ORSA), household production values are twice that of market expenditures. This demonstrates that outdoor recreation is primarily a household-produced service where travel time, not market purchases, represents the major welfare-relevant expenditure.

We present results at regional, state, and national levels for both accounting boundaries. Section 6.1 estimates market expenditure adjustments under the SNA boundary using the α parameter, quantifying the gap created by ORSA's exclusion of local trips. Section 6.2 estimates household production values using the γ parameter, revealing the substantially larger measurement gap from ignoring travel time for recreation entirely.

Our Gulf Coast recreation data illustrates why both boundaries matter. Seventy-seven percent of trips occur within 50 miles of home—the "local" recreation that ORSA excludes due to its travel and tourism focus (Figure 2). These local trips exhibit the low market expenditures characteristic of most outdoor recreation: median spending is only $3.11 per trip (average $39), comparable to Berry et al. (2018)'s findings for the value of a recreation trip. However, these same low-expenditure trips require substantial travel time investment (median 36 minutes round-trip). This creates the foundation for significant household production values despite minimal market transactions, highlighting that market expenditures alone provide an incomplete

Table 1: SNA Boundary Results: Market Expenditure Adjustment Parameters

Region	E^r (Mill. $)	SE	$\hat{\alpha}$	SE	Local Expend. (Mill. $)	SE	Orig. S^r (%)	Adjusted S^r (%)	Change (%)	SE	N
Gulf Region	6127.71	326.33	1.08	0.01	1454.53	137.99	2.49	2.52	1.10	0.10	7621.00
AL	263.64	51.70	1.03	0.01	24.96	7.59	1.96	1.97	0.45	0.14	639.00
FL	5196.09	312.96	1.08	0.01	552.89	54.49	3.64	3.68	1.06	0.10	5563.00
GA	18.18	2.89	1.37	0.15	749.51	300.45	2.05	2.15	4.76	1.91	179.00
LA	125.02	30.13	1.05	0.02	54.67	20.76	2.71	2.72	0.69	0.26	216.00
MS	113.60	36.80	1.07	0.03	32.57	15.03	2.41	2.43	0.97	0.45	454.00
TX	411.17	57.49	1.17	0.07	1032.89	416.23	1.98	2.03	2.17	0.87	570.00
United States			1.08	0.01	6171.24	585.47	2.21	2.24	1.10	0.10	7621.00

Notes: E^r represents regional expenditure on gasoline and accommodation for recreation including local trips (Equation 4). S^r is the share of regional GDP contributed by this expenditure (Equation 5). "Orig. S^r" shows ORSA's current value excluding local trips; "Adjusted S^r" includes local recreation expenditure. Standard errors calculated using the delta method.

picture of recreation's economic contribution.

6.1 Expenditure under SNA Boundary

Results for market expenditure that falls under the SNA boundary are reported in Table 1. We find that market expenditure for the 83 sites observed equals $6 billion for the Gulf Region. The $\hat{\alpha}$ multiplier for gas and accommodation expenditure in the ORSA is 1.08 and is significantly different from 1.00 at the 99 percent confidence level. After scaling using marginal expenditures on gas and accommodations in the ORSA, we estimate that local recreation drives an additional $1.5 billion in spending on gas and accommodations in the Gulf region that is not included in the ORSA. Including this additional local recreation value in the ORSA would cause a one percent increase in its regional value, from 2.49 percent of regional GDP to 2.52 percent. The percent change increase is significantly different from zero at the 99 percent confidence level.

The results for the adjustment parameter for states in the Gulf region vary from 1.03 in Alabama to 1.37 in Georgia. All are statistically different from one at the 99 percent confidence level. Maintaining our assumption that shoreline recreation behavior can scale to represent the ratio of local trips for all recreation, we estimate that local recreation by state contributes between $25 million in spending on gas and accommodations in Alabama and $1 billion in Texas. Including expenditure on gas and accommodations for local recreation increases the value of the ORSA between 0.45 percent in Alabama and 4.76 percent in Georgia. All percent increases are significantly different from zero at the 99 percent confidence level.

If we extrapolate our results to the entire U.S., we find that local outdoor recreation may be responsible for the order of $6 billion in spending on gasoline and accommodations, raising the contribution of outdoor recreation from 2.21 percent to 2.24 percent of GDP when local recreation is included.

6.2 Expenditure under Household-Production Boundary

The results for the expenditure of travel time when using one-third of the wage rate as the VOTT are presented in Table 2. We find that the travel time expenditure to the 83 sites is $12 billion for the Gulf Region. If we use the expenditure on gas and accommodations in the ORSA to scale this result from the 83 sites to all recreation sites in the region, we find that the expenditure of travel time for all recreation sites in the Gulf Region is $38 billion, which is equivalent to 0.71 percent of regional GDP. If household-produced services are equivalent to the same percent of the Gulf region's GDP as the United States, including the expenditure of travel time in the household-produced services satellite account would increase its value by 4.85 percent in 2020 and 5.40 percent in 2017. Both percent increases in the value of the household-produced services account are significantly different from zero at the 99 percent significance level.

Table 2: Household Production Boundary Results: Travel Time Expenditure (1/3 Wage Rate)

Region	Cost Type (ρ)	Θ^r (Mill. $)	SE	$\hat{\gamma}$	SE	H^r (Mill. $)	SE	V^r (%)	SE	Δ Sat. Acct. 2020 (%)	SE	Δ Sat. Acct. 2017 (%)	SE	N
Gulf Region	opp. cost	12417.26	1180.69	2.03	0.13	37925.57	2463.39	0.71	0.05	4.85	0.31	5.40	0.35	7621.00
AL	opp. cost	569.54	163.34	2.16	0.41	1603.05	308.43	0.57	0.11	3.87	0.75	4.31	0.83	639.00
FL	opp. cost	10582.52	1168.71	2.04	0.15	15013.12	1102.17	1.04	0.08	7.10	0.52	7.90	0.58	5563.00
GA	opp. cost	37.09	7.15	2.04	0.23	5704.87	890.50	0.74	0.12	5.06	0.79	5.63	0.88	179.00
LA	opp. cost	204.84	61.14	1.64	0.30	1774.00	329.52	0.61	0.11	4.13	0.77	4.60	0.86	216.00
MS	opp. cost	177.97	43.20	1.57	0.34	738.96	159.43	0.53	0.11	3.59	0.77	4.00	0.86	454.00
TX	opp. cost	845.31	142.04	2.06	0.23	14883.72	1895.67	0.62	0.08	4.21	0.54	4.69	0.60	570.00
United States	opp. cost			2.03	0.13	160910.12	10451.65	0.63	0.04	4.30	0.28	4.79	0.31	7621.00

Notes: ρ is the value-of-travel-time approach used. Θ^r is travel time expenditure to the 83 DWH sites (Equation 6). $\hat{\gamma}$ is the scaling parameter converting market expenditures to household production values (Equation 7). H^r represents scaled regional household production value for all recreation (Equation 8). V^r is recreation's household production value as share of regional GDP (Equation 9). Δ Sat. Acct. shows the percent increase in the Household Production Satellite Account if recreation were included, calculated for 2020 and 2017.

The expenditure of travel time is equivalent to approximately twice the expenditure on market goods for all states in the Gulf region. After using the ORSA expenditure on gas and accommodations to scale results, we estimate that the expenditure on travel time to recreation sites in each individual state is between 0.57 percent of state GDP in Alabama, and 1.04 percent in Florida. If the value of household-produced services in each state is equivalent to the same percent of state GDP as for the U.S., including the travel time required to produce an outdoor recreation trip would increase the value of household-produced non-market services by between 3.59 percent in Mississippi and 7.1 percent in Florida in 2020. In 2017, this increase would be between 4.0 percent and 7.9 percent. All percent increases in the value of the household-produced non-market services account are significantly different from zero at the 99 percent confidence level.

The national implications of our household production estimates are substantial. Extrapolating our Gulf Coast results to the entire U.S., we estimate total household production value for outdoor recreation at $161 billion annually (0.6% of national GDP). To put this in perspective, including this previously unmeasured recreation activity would increase the Household Production Satellite Account by 4.3% in 2020 and 4.8% in 2017. Both increases are statistically significant at the 99% confidence level.

These findings highlight a fundamental measurement gap in current national accounts. The Household Production Satellite Account, designed to capture non-market economic activity, currently omits a major household production activities: the time investment required to access outdoor recreation. Our estimates suggest that this omission substantially understates the economic contribution of household production to national welfare, with implications for policy decisions about infrastructure investment, environmental protection, and sustainable development planning.

In alternative analyses, we use the wage rate of a general-purpose domestic worker for the VOTT (Table 3). For comparison, the average value of one-third of an individual's wage rate is $15.72, and the median value is $10.85. This implies that most individuals in our dataset earn approximately twice as much as a general-purpose domestic worker and, on average, earn three times the wage rate. The wage-replacement rates lead to smaller estimates of the value of travel time under the household production boundary for the Gulf region when compared to one-third of the wage rate. When using the general-purpose domestic worker wage replacement rate, travel time expenditure is equivalent to 0.56 percent of GDP in the Gulf Region. Including this travel time expenditure in the household-production satellite account would increase its value for non-market services by approximately 4 percent in 2020 and 2017. Apart from Florida, for which the wage replacement rate lowers the value of travel time expended, using these VOTTs does not lead to significantly different estimates for individual states.

Table 3: Household Production Boundary Results: Travel Time Expenditure (general-purpose domestic worker)

Region	Cost Type (ρ)	Θ^r (Mill. $)	SE	$\hat{\gamma}$	SE	H^r (Mill. $)	SE	V^r (%)	SE	Δ Sat. Acct. 2020 (%)	SE	Δ Sat. Acct. 2017 (%)	SE	N
Gulf Region	dom. wrkr	9814.94	481.31	1.60	0.01	29892.07	342.28	0.56	0.01	3.82	0.04	4.26	0.05	7621.00
AL	dom. wrkr	439.35	78.72	1.67	0.04	1239.39	34.34	0.44	0.01	2.99	0.08	3.33	0.09	639.00
FL	dom. wrkr	8139.90	455.13	1.57	0.01	11554.21	128.35	0.80	0.01	5.46	0.06	6.08	0.07	5563.00
GA	dom. wrkr	40.75	6.20	2.24	0.05	6264.18	686.27	0.82	0.09	5.55	0.61	6.18	0.68	179.00
LA	dom. wrkr	205.34	46.75	1.64	0.04	1774.00	53.37	0.61	0.02	4.13	0.12	4.60	0.14	216.00
MS	dom. wrkr	200.89	52.67	1.77	0.11	833.09	59.04	0.60	0.04	4.05	0.29	4.51	0.32	454.00
TX	dom. wrkr	788.71	115.29	1.92	0.07	13872.20	930.62	0.58	0.04	3.93	0.26	4.37	0.29	570.00
United States	dom. wrkr			1.60	0.01	126825.71	1452.24	0.50	0.01	3.39	0.04	3.78	0.04	7621.00

Notes: ρ is the value-of-travel-time approach used (general-purpose domestic worker wage: \$14.99/hour). Θ^r is travel time expenditure to the 83 DWH sites (Equation 6). $\hat{\gamma}$ is the scaling parameter converting market expenditures to household production values (Equation 7). H^r represents scaled regional household production value for all recreation (Equation 8). V^r is household production value as share of regional GDP (Equation 9). ΔH^r shows the percent increase in the Household Production Satellite Account if recreation were included, calculated for 2020 and 2017 baseline values. Standard errors calculated using the delta method.

7 Discussion

Using Gulf Coast recreation data, we demonstrate that outdoor recreation generates substantial economic value across multiple accounting boundaries. However, current U.S. satellite accounts systematically understate this value due to excluding outdoor recreation for the Household Production Satellite Account.

Our key finding is a striking asymmetry in measurement gaps across accounting boundaries. While including local recreation in the Outdoor Recreation Satellite Account requires only modest adjustments (1% increase in regional value of ORSA), the household production boundary reveals larger unmeasured welfare-relevant expenditure. Nationally, we estimate \$12.4 billion in household-produced recreation services for the Gulf Region. This equivalent to 0.7% of regional GDP, which would increase the Household Production Satellite Account by nearly 5%. In comparison, the market expenditure (including for local trips) is \$6.1 billion. This difference underscores the importance of accounting for welfare-relevant time expenditure for recreation under the household production accounting boundary. Travel time, not market purchases, represents the primary welfare-relevant expenditure for outdoor recreation trips.

These findings address the welfare measurement challenges highlighted in our introduction. As Nordhaus and Tobin (1973) and Arrow et al. (2004) emphasized, measuring true national welfare requires accounting for both market and non-market economic activity. Our results demonstrate that current satellite accounts provide incomplete measures of recreation's economic contribution precisely because they fail to partition required travel cost expenditure – consisting of market spending and travel time – across the SNA and household production accounting boundaries.

The policy implications extend beyond national accounting methodology. If economic accounts are to support sustainable development evaluation, they must jointly consider SNA and household production boundaries to estimate real national income and its connection to underlying natural assets. Our estimates suggest that policy decisions affecting outdoor recreation access (e.g., infrastructure investments, environmental protection) have economic impacts roughly three times larger than current ORSA-based assessments would suggest. This measurement gap is particularly relevant for budget decisions regarding public natural assets that serve as inputs into household-produced recreation activities.

7.1 Adjustments to the Outdoor Recreation Satellite Account

Despite 77% of recreation trips occurring within 50 miles of home including these trips increases the Gulf region's ORSA value by only 0.03 percentage points of GDP (from 2.49% to 2.52%). This modest impact re-

flects the fundamental characteristic of local recreation: high trip frequency but minimal market expenditures per trip (median $3.11).

The small magnitude of this adjustment does mean that the current ORSA provides a reasonable approximation of market recreation expenditures despite its methodological exclusion of local trips. Local recreation's low marginal costs mean that the 77% of excluded trips contribute proportionally little to total market expenditure, even though they represent the majority of recreation activity by trip count.

However, this finding reveals a more fundamental measurement challenge within the SNA boundary itself. ORSA already captures substantial fixed-cost expenditures (*e.g.,* outdoor gear, apparel, and equipment) that are used for local recreation trips, even while excluding the marginal costs of those same trips. Given that 77% of trips occur locally, a significant portion of gear purchases presumably supports local recreation sites. This creates an internal inconsistency within ORSA. It includes the durable goods used for local recreation while excluding the variable costs of accessing recreation sites.

This measurement inconsistency poses challenges for natural capital accounting, which requires linking service flows to their enabling assets. ORSA's current structure captures market expenditures without geographic attribution, preventing the linkage between recreation spending and the specific natural assets that support recreational activities. We can measure total outdoor recreation expenditure under the SNA boundary, but we cannot determine which natural assets generate which expenditure flows – a critical requirement for asset-based environmental accounting.

The prevalence of local recreation also highlights additional SNA boundary expenditures that current accounts may miss. Our finding that 77% of trips occur within 50 miles suggests substantial residential sorting toward recreation amenities. Households seeking recreation access may pay housing premiums for proximity to outdoor recreation sites, representing additional market expenditures under the SNA boundary that are conceptually distinct from both marginal trip costs and household production time expenditure.

Comprehensive natural capital accounting would need to capture these location-based premiums alongside travel costs and household production time to fully represent recreation's economic footprint. This points toward an integration of travel cost and hedonic approaches, but such integration requires careful partitioning to avoid double-counting expenditures across model types.

7.2 Adjustments to the Household Production Satellite Account

The magnitude of household production adjustments confirms that travel time represents the primary economic input for outdoor recreation. Using the welfare-theoretic opportunity cost approach (one-third the wage rate), we estimate household production values of $12.4 for the Gulf region GDP – two times larger than the regional market expenditure measured by the SNA boundary of $6.1 billion. This dramatic difference highlights that outdoor recreation is fundamentally a household production activity where time investment, not market purchases, drives welfare-relevant expenditure.

In the Gulf region, these estimates suggest including outdoor recreation would increase the Household Production Satellite Account by 4.9% (2020) to 5.4% (2017). Unlike the minimal ORSA adjustment (0.03 percentage points, 1 percent increase), these represent economically significant changes that would substantially alter how national accounts capture non-market economic activity. The current exclusion of outdoor recreation from household production accounts thus represents a major measurement gap in capturing household-produced services.

However, incorporating outdoor recreation into household production accounts requires resolving a fundamental methodological tension. The welfare economics literature typically values recreation travel time

using opportunity cost approaches. Most commonly, one-third the wage rate is used to capture forgone earnings (Lupi et al., 2020). However, there is ongoing debate about whether this is the "correct" value of travel time to use (Lloyd-Smith et al., 2019; Fezzi et al., 2014; Wolff, 2014). The one-third the average wage rate approach also conflicts with household production accounting methodology, which requires replacement wages approaches for consistency with other non-market activities (Landefeld et al., 2009; National Research Council, 2005).

The Household Production Satellite Account follows the principle that household time should be valued using comparable market services (Nordhaus, 2006). Currently, it uses the wage of general-purpose domestic workers ($14.99/hour) as the replacement cost for household production time. This creates a methodological choice for recreation: use the welfare-theoretic opportunity cost that aligns with recreation demand literature, or use the replacement cost approach that ensures internal consistency within household production accounts.

Using the replacement wage approach yields somewhat smaller but still substantial estimates: 0.56% of regional GDP, representing a 3.8% to 4.3% increase in household production accounts in the Gulf region. Importantly, both approaches produce estimates within the same order of magnitude, suggesting that methodological choice, while consequential, does not fundamentally alter the conclusion that outdoor recreation represents a major unmeasured component of household production.

This methodological choice has broader implications for integrating environmental economics with national accounting. Adopting replacement cost approaches for recreation time valuation would align travel cost methods with existing household production accounting standards, potentially facilitating more systematic integration of environmental services into national accounts. However, it would require recreation economists to adopt accounting consistency over welfare-theoretic measures, which is a trade-off that merits careful consideration as environmental accounting frameworks continue to develop.

8 Conclusion

This paper addresses a fundamental gap in measuring national welfare: the systematic exclusion of outdoor recreation from household production accounts despite its substantial non-market contribution. Our expenditure-based approach demonstrates how to partition recreation costs across accounting boundaries, revealing that current satellite accounts dramatically understate the economic significance of outdoor recreation by capturing market transactions while ignoring the household production of recreation services.

The empirical evidence shows that outdoor recreation is primarily a household production activity. While including local recreation's market expenditures in the ORSA require only modest adjustments ($1.5 billion of missing expenditure in the Gulf region), household production represents a major unmeasured economic component, equivalent to $12 billion in the Gulf region, or 4-5% of the entire Household Production Satellite Account. This finding has immediate consequences for policy evaluation, because analyses that only consider market activity will severely underestimate welfare-relevant expenditure on outdoor recreation and thus may underestimate its benefit.

Looking forward, comprehensive environmental accounting will require expanding this boundary-based approach beyond outdoor recreation to other ecosystem services that span market and non-market domains. This paper underscores the importance of household production accounts in capturing the true contribution of natural assets to national welfare. Until these measurement gaps are addressed, national accounts will provide incomplete guidance for policies affecting environmental quality and sustainable development.

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