Good, Better, Best: A Revealed Preference Ranking of US National Park System Units

PRELIMINARY DRAFT

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January 2022

Abstract

The US National Park System attracts over 300 million visitors each year, significant interest in popular media, and recently, increased attention from policy makers. Despite this, there have been few recreation demand studies that analyze a broad range of National Park System units. I build a random-utility maximization travel cost model of recreation demand for over 130 National Park Service units across the contiguous United States. Combining a nationally representative telephone survey and unit-level visitation counts, I estimate each unit's amenity appeal for every month between January 2000 and December 2019, which provides a revealed preference ranking. Over the survey period, between January 2008 and December 2009, Golden Gate NRA, Yellowstone, and Glacier top the ranking. Allowing units' amenity appeal to vary throughout time reveals that groups are willing to pay a $1,300 premium to visit Yellowstone in July rather than November of 2008. This dramatic seasonal variation in willingness to pay has not been explored by previous travel cost studies. In second stage regressions of amenity appeal on unit characteristics, I find that a new national park designation increases groups' willingness to pay for a visit by approximately $9 but that this relationship is not statistically significant. The outlined approach provides a valuable tool that could be applied to study numerous challenges facing the National Park System. It could also be used to improve travel cost models in other settings.

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I am grateful for support from the Property and Environment Research Center. I thank Leslie Richardson for providing data, and Soren Anderson, Frank Lupi, Nick Parker, Randy Rucker, Margaret Walls, Arthur Wardle, and seminar participants from Michigan State University and PERC for their helpful comments.

1 Introduction

In 1916, the National Park Service was created to conserve the United States' most significant scenery, natural and historic objects, and wildlife for the enjoyment of present and future generations ("Organic Act of 1916"). More than 100 years later, the National Park System includes over 400 units, which collectively receive more than 300 million visits each year. Visitation has grown in recent years, increasing 15% between 2000 and 2019, and 2021 visitation set all-time records at many units. At the same time, national parks have received attention in popular media through documentaries, like Ken Burns' *The National Parks: America's Best Idea*, and websites that rank national parks based on personal opinions or annual visitation (Rothschild 2021).

The National Park System has recently garnered more attention from policy makers as well. The Great American Outdoors Act, enacted in 2020, provides up to $9.5 billion to address deferred maintenance on federal land and guarantees $900 million annually for the Land and Water Conservation Fund, which helps fund land acquisitions for the National Park System. Additionally, Congress has redesignated five National Park System units as national parks since 2013.[1]

The increased popularity and legislative attention make this an important time to study recreation demand for the National Park System, especially given that there are important gaps in the research on the topic. The National Park Service conducts surveys to learn about visitor experiences and preferences, but these studies tend to be unit-specific rather than system-wide. Environmental economics boasts an extensive recreation demand literature, but these studies have traditionally focused on sites in the same region. Additionally, they often rely on cross-sectional variation to estimate the value of environmental amenities, so

[1] The National Park System specifies official designations for each of its units. While every unit in the system is commonly referred to as a national park, only 64 units have the official national park designation. The National Park Service also manages National Recreation Areas (18), Seashores (10), Lakeshores (4), Preserves and Reserves (21), Battlefields (25), Historic Sites and Parks (129), some National Monuments (80), and various other units (*The National Parks: Index 1916-2016* 2016). I refer to sites as "units" unless they are specifically designated as national parks.

results may be biased by unobservable site characteristics.

This paper conducts the most extensive analysis of recreation demand for the US National Park System (NPS) to date by modeling recreation demand for over 130 NPS units.[2] I construct a random utility maximization model, where individuals repeatedly choose which unit to visit and whether to drive or fly given the travel costs for each alternative. I combine three sources of data to estimate the model: a nationally representative telephone survey of NPS visitation conducted between 2008 and 2009, a long-term monthly panel of unit-level visitation counts, and on-site surveys conducted by the National Park Service.

Estimating the model yields a monthly panel of unit fixed effects between January 2000 and December 2019. I call these terms amenity appeals, and they are commonly known as alternative-specific constants, or site-specific constants, in the travel cost literature. If a unit is highly visited despite having a remote location and many high quality substitutes, then it will have a high amenity appeal estimate for that month. If a unit receives few visits despite having a convenient location and few substitutes, then it will have a low amenity appeal estimate. Thus, amenity appeals provide an intuitive revealed preference ranking of NPS units. Less formally, they rank NPS units by their awesomeness. Unit rankings based on raw visitation counts are affected by units' locations and the characteristics of its substitutes. The travel cost model isolates amenity appeal by calculating travel costs and modeling alternatives.

The estimation procedure combines micro-level and macro-level data sources, leveraging the contraction mapping introduced by Berry (1994) and first applied to travel cost models by Murdock (2006). Given parameter values describing the disutility of travel cost, the contraction mapping finds the unique set of unit amenity appeals that match visitation shares predicted by the model to the true visitation shares observed in the data. With assumptions on how the parameters describing the disutility of travel cost evolve over time,

[2] I define an individual's choice set to include all units designated as National Parks, Recreation Areas, Seashores, Lakeshores, Preserves, and Reserves, plus all National Monuments larger than 150 acres. This restricts the set of NPS units to roughly all naturally significant units, whereas the entire system also includes units protected for their historical significance that offer fewer outdoor recreation opportunities.

this calibration can be repeated month-by-month to obtain high frequency amenity appeal estimates both inside and outside of the survey period.

After estimating the panel of amenity appeals, I regress them on unit characteristics to recover estimates of willingness to pay for a national park designation and marginal increases in unit size. The panel structure allows me to control for all time-invariant factors using fixed effects. Time-varying factors correlated with amenity changes still pose threats to identification.

I find that Golden Gate National Recreation Area, Yellowstone National Park, and Glacier National Park have the highest amenity appeal of all naturally significant NPS units. By calibrating the model on a monthly level, I uncover rich, seasonal variation in amenity appeal that is averaged out when estimating a single amenity appeal for the entire survey period. This seasonal variation is particularly apparent for units like Yellowstone and Glacier, which each have harsh winters that alter recreation possibilities. Groups were willing to pay a roughly \$1,300 premium to visit Yellowstone in July rather than November of 2008.

Regressing the panel of amenity appeal estimates on unit characteristics and fixed effects reveals that a new national park designation increases groups' willingness to pay to visit a unit by approximately \$9. This relationship is not statistically significant, but the sign is consistent with recent reduced form work by Szabó and Ujhelyi (2021). Marginal changes in unit size have no significant impact on willingness to pay. I also find that the number of animal species and carnivore species are positively correlated with amenity appeal in a cross-sectional regression.

Several previous studies have analyzed recreation demand for the National Park System. Neher, Duffield, and Patterson (2013) employ a count data model to study visitation to 58 National Park System units and estimate the average willingness to pay to visit each unit. They regress willingness to pay on unit characteristics, finding willingness to pay is positively correlated with national park designation, historic site designation, remoteness, and location in the National Park Service's Pacific region. By estimating a panel of amenity values, I can use fixed effects to control for time-invariant omitted variables that may bias Neher and Duffield's estimates. Henrickson and Johnson (2013) use annual visitor counts and a reduced form spatial econometric approach to study visitation to 56 national parks. They conclude that a 5 percent increase in gas prices would decrease visitation by 1.96 million and a 2°F increase in average temperature would increase visitation by 3.42 million. This paper differs from Henrickson and Johnson by structurally modeling individual decisions, which allows me to conduct estimate willingness to pay. I also exploit monthly, rather than annual, variation in visitation.

This study builds on a broader environmental economics literature applying random utility maximization models to analyze recreation demand. These studies typically estimate the value of recreation sites or environmental characteristics (Parsons et al. 2021, 2013; Egan et al. 2009). Methodologically, this paper relates closely to Murdock (2006), which introduces a contraction mapping technique to estimate a full cross-section of site fixed effects. Murdock's approach eliminates bias from omitted site characteristics when estimating the disutility of travel cost. My approach also estimates a full set of site fixed effects, obtaining the benefits of Murdock's procedure. It also goes further by repetitively applying the contraction mapping to obtain a monthly panel of site fixed effects, rather than one fixed effect for the entire survey period. I also extend the contraction mapping beyond the survey period. With assumptions on how preferences other than unit amenity appeals change over time, I show how to estimate an extended panel of amenity appeals. The panel structure allows for causal inference techniques to be used to recover willingness to pay estimates, a recent point of emphasis in the travel cost literature (Lupi, Phaneuf, and von Haefen 2020).

This paper also relates closely to English et al. (2018), which quantifies the value of recreation lost due to the Deepwater Horizon oil spill at beaches throughout the entire Gulf Region. The authors use an extensive nationally representative survey with over 41,000 respondents and calculate travel costs on a national scale. They also estimate how the amenity value of sites change over time in response to the spill by calibrating the model to visitor count data. In addition to studying a different setting, my approach differs in two main ways. First, I explicitly apply panel data econometric methods to study changes in amenity values, whereas English et al. estimate all parameters in a single stage with maximum likelihood estimation. Second, I leverage a long-term panel of visitor counts to estimate amenity appeals outside the survey period and at a monthly level, while English et al. focus on a single difference between spill and non-spill conditions. The panel of visitor counts also greatly reduces, but does not eliminate, the need for costly mail or telephone surveys.

Section 2 describes the nationally representative telephone survey, monthly visitor counts, and on-site surveys employed in this analysis. Section 3 outlines how travel costs are calculated for both driving and flying travel modes. Section 4 outlines the repeated random utility model. Section 5 explains the process for estimating monthly amenity appeals and the model's other parameters. Section 6 describes the results and provides context for interpreting them, and Section 7 concludes.

2 Data

I combine a nationally representative telephone survey and a monthly panel of unit-level visitation counts to estimate my model. I augment this data with separate on-site surveys that provide statistics on re-entry, group size, and the proportion of international visitors at many units. I incorporate airfare data from the Consumer Airfare Report (2015) to calculate the travel cost of flying to a unit. Finally, I consolidate a variety of data sources describing unit characteristics including acreage, designation, and species presence.

2.1 Comprehensive Survey of the American Public

The National Park Service administered an individual-level national telephone survey, the Comprehensive Survey of the American Public (CSAP), between April 2008 and March 2009 (2011). The survey was executed by the Wyoming Survey & Analysis Center, and it aimed to gauge public opinion regarding the National Park Service and collect information describing visitation and recreational preferences. It is the second of three similar surveys conducted by the National Park Service. Unfortunately, the first survey, conducted in 2000, does not contain any information describing respondents' home location. The third survey, conducted in 2018, does contains respondents' state of residence, but I have not incorporated it into the analysis at this stage.

The second iteration of the CSAP contains both respondents' state of residence and area code, which allows me to compute respondents' travel costs of accessing each unit. The CSAP also contains the location of each respondent's most recent visit to the NPS, if their most recent visit was within two years of the interview, and the number of times each respondent visited the NPS over the previous two years. A randomly chosen subset of respondents was also asked about their mode of travel on their most recent visit.

The CSAP used a regionally stratified sample of landline telephones and a sample of cell-phone users to obtain a nationally representative sample of US individuals. From each of the seven National Park Service administrative regions, interviewers randomly selected landline telephone number and then randomly selected individuals within the sampled households. Roughly 500 landline interviews were conducted in each region. The landline interviews were augmented by an additional 553 cell-phone interviews, which were not regionally stratified.

The survey data contains weights, which match sample demographics to demographics in the general population to help ensure the sample is representative. I use the weights for all of my analyses unless otherwise specified. In total, 4,103 respondents completed the approximately 15-minute telephone interview, and the response rate was 12.5%.

Table 1 shows summary statistics for the CSAP with and without weighting. When possible, I include US population statistics from the 2010 Census to assess the validity of the sample weights and the representativeness of the sample. After weighting, the average age, sex, and regional distribution of respondents matches the general population closely. Although, respondents tend to be more wealthy and are slightly more likely to be white and non-Hispanic than the general population.

Table 1: CSAP Summary Statistics

	Unweighted	Weighted	Population
Mean Age	51.3	46.1	46.2
Male	46.5%	48.4%	48.5%
Median HH Income	$62,500	$62,500	$49,445
White, non-Hispanic	76.0%	68.5%	63.7%
Alaska	13.4%	0.2%	0.2%
DC	12.0%	0.2%	0.2%
Intermountain	15.0%	14.7%	14.6%
Midwest	14.9%	23.7%	22.6%
Northeast	15.2%	22.7%	23.8%
Pacific	14.7%	16.5%	17.2%
Southeast	14.9%	21.9%	21.4%
Visited within 2 years	67.8%	60.7%	–
Recent Visit In-Sample	27.8%	29.7%	–
Avg # of NPS Unit Visits	7.9	3.8	1.1
Flew to Recent Visit (N=568)	13.6%	12.7%	–
Most Visited NPS Unit	Yellowstone	Yosemite	Golden Gate RA

Note: The table shows summary statistics from the CSAP telephone survey, conducted by the National Park Service between April 2008 and March 2009.

Table 2 splits the sample into visitors and non-visitors. Both groups have similar average age and number of children, but visitors are more likely to be white, college graduates, married, and male. The visitor group also has a $20,000 higher average household income.

2.2 NPS Visitor Use Statistics

I calibrate my model using unit-level, monthly visitation counts. These counts, known as the NPS Visitor Use Statistics (VUS), track how many people enter a National Park System unit each month. The dataset is an unbalanced panel of monthly counts for 383 NPS units.

Table 2: Visitors vs. Non-visitors

	Mean	Std Dev	Min	Max
Non-visitors (39.3%)				
Age	45.1	18.6	18.0	96.0
Male	0.45	0.50	0.00	1.00
White Non-Hispanic	0.57	0.50	0.00	1.00
College Grad	0.30	0.46	0.00	1.00
Single	0.47	0.50	0.00	1.00
HH Income ($)	54,893	36,488	0	150,000
N Kids	0.7	1.1	0.0	6.0
Visitors (60.7%)				
Age	46.7	16.3	18.0	103.0
Male	0.51	0.50	0.00	1.00
White Non-Hispanic	0.76	0.43	0.00	1.00
College Grad	0.51	0.50	0.00	1.00
Single	0.34	0.47	0.00	1.00
HH Income ($)	75,827	41,583	0	150,000
N Kids	0.7	1.0	0.0	7.0

The counts begin approximately when a unit is added to the National Park System, and they start in 1904 for several of the oldest units. Typically, counts are tallied by NPS rangers at unit entrances or by traffic counters with assumptions on the number of visitors per vehicle.

The nearly comprehensive nature of the VUS makes the dataset a powerful complement to the telephone survey, but it has one main shortcoming for studying recreation demand. It tallies entries rather than visits. Visits are often the primary unit of measurement for recreation demand studies, because travel costs are incurred when groups travel between their residence and the recreation site. The group may enter a site multiple times on each visit. I attempt to control for this using on-site surveys conducted by the NPS.

2.3 On-Site Surveys

The NPS conducted roughly 105 on-site surveys between 1995 and 2017 as part of its Visitor Services Project initiative. Each survey constitutes a random sample of a unit's visitors. While the surveys differ by unit, most include a core set of questions describing visitors' group size, number of entries, and state or country of residence. Less standardized questions gather more information about visits, often focusing on the perceived quality of infrastructure and programs or the activities visitors engaged in while visiting.

The on-site survey information describing re-entry, group size, and country of residence is particularly useful for combining the telephone survey and visitor count data. The estimation procedure matches predicted visitation shares of telephone survey respondents to the visitation shares observed in the visitor count data, but without adjustments, these shares actually should not be equal. They would have different geographic scopes, the telephone survey does not include international visitors, and I model group travel costs for telephone survey respondents, while the visitor counts individual entries. To reconcile these differences, I adjust the visitor counts using re-entry, group size, and country of residence information from the on-site surveys.

To construct these adjusted visitation shares, I begin with the number of entries at each unit for each month. This is the statistic provided in the raw VUS data. I divide by the average number of entries at the unit to obtain the number of individual visits. Then, I divide by the average group size at each unit to obtain the number of group visits. Finally, I multiply by the fraction of domestic visits at each site. The final adjusted visitation count represents the number of domestic group visits, and dividing by the market size yields adjusted visitation shares directly comparable to model predicted visitation shares.

Many units have never conducted an on-site survey, and none conduct a survey every month. Therefore, re-entry, group size, and international visitation statistics are not available for all units in every month. When necessary, I impute these statistics using linear regressions. For units that conducted a survey at another time period, then I use unit fixed effects and seasonal dummy variables as explanatory variables. If a unit never conducted a survey, then I use designation fixed effects, a flexible function of unit acreage, and seasonal dummy variables.

2.4 Unit Characteristics

I collect a variety of data describing NPS unit characteristics to estimate willingness to pay for different amenities. I obtain official unit designations and redesignation dates from the *The National Parks: Index 1916-2016*, annual unit acreage measurements from National Park Service Acreage reports from 2000 to 2019, and species presence and abundance data from NPSpecies. In future work, I plan to include variables describing units' climate and weather, topography, hydrography, land cover, and infrastructure.

3 The Travel Cost Variable

A fundamental part of disentangling the effects of amenities, substitutes, and location on visitation is calculating travel costs. These include both monetary costs, such as gasoline, vehicle deterioration, or airfare, as well as the cost of time. NPS units attract visitors from across the country, and my model allows individuals to choose whether to drive or fly to a unit. Thus, I compute each CSAP respondent's cost of driving and flying to each NPS unit. In most similar studies, travel costs are calculated for each individual-unit pair only once, but because my estimation procedure allows me to estimate units' amenity appeal outside the survey period, I compute respondents' travel costs to each NPS unit for every quarter between January 2000 and December 2019.[3]

To compute driving travel costs, I use PC*Miler to obtain the driving mileage and time from each respondent's home city to each NPS unit.[4] I multiply mileage by the variable cost of driving, provided by annual AAA reports. For every 12 hours of driving, I add a lodging cost equal to the average US hotel rate for that quarter. I also make the standard

[3]The visitation counts allow me to estimate amenity appeals at a monthly level, but I observe airfare on a quarterly basis. I assume travel costs are constant across months within a quarter.

[4]The CSAP contains respondents area code and self-reported state of residence. For landline interviews, I assign respondents' home city as the largest city in their area code. For cell-phone interviews, I assign respondents home city as the largest city in their area code if their area code is in their state of residence. If their area code is not in their state of residence, I assign their home city as the largest city in their state of residence.

assumption that the cost of one hour's time equals one-third of a respondent's hourly wage rate - their annual household income divided by 2080 hours worked per year.

To compute the travel cost of flying, I use the US Department of Transportation's Consumer Airfare Report. This dataset contains the average airfare for both the carrier with the largest market share and the lowest cost on every airline route within the contiguous United States that averages at least 10 passengers per day, and I drop units and respondents outside the contiguous United States from the analysis. Average airfare is calculated on a quarterly basis, and routes are identified by city markets, not individual airports.

I calculate flying cost for a variety of possible origin and destination airports, where flying cost consists of the driving costs to and from origin and destination airports, plus airfare and the cost of approximate flight time. I assign the flying travel cost for a respondent-unit pair as the flying cost of cheapest possible route with one or fewer layovers.

4 Model

I specify a repeated random utility maximization model where individuals choose which NPS unit to visit, whether to drive of fly, or to forego a visit to any NPS unit, which I define as the outside option. In future work, I plan to incorporate observable heterogeneity by interacting demographic variables with unit characteristics and experiment with nesting alternatives.

Suppose an individual chooses which unit to visit from the set $\mathcal{J} = \{0, 1, 2, ...J\}$ and which travel mode to use from the set $\mathcal{M} = \{D, F\}$, where D and F indicate driving and flying, respectively. Let $j = 0$ denote the outside option, which can be thought of as an individuals' best way of spending their month that does not involve visiting an NPS unit. Let $j \in 1, 2, ..., J-1$ denote each of the NPS units included in the sample and $j = J$ denote a composite alternative of NPS units not explicitly included in the sample. This includes mainly historically significant units like National Battlefields or Historic Parks. I make a simplifying assumption that the travel cost of accessing the composite NPS unit equals zero to reduce the required travel cost calculations. I also make an arbitrary assumption that individuals face one choice occasion each month. Let U_{ijmt} denote the utility individual i receives from visiting unit j using travel mode m at choice occasion t, where

$$U_{ijmt} = \begin{cases} \delta_{0t} + \epsilon_{i0t} & j = 0 \\ \delta_{jt} + \phi_m + \beta TC_{ijt} + \epsilon_{ijmt} & j \in \{1, ...J-1\}, m \in \{D, F\} \\ \delta_{Jt} + \epsilon_{iJt} & j = J \end{cases} \tag{1}$$

$$\equiv \begin{cases} V_{0t} + \epsilon_{i0t} & j = 0 \\ V_{ijmt} + \epsilon_{ijmt} & j \in \{1, ...J-1\}, m \in \{D, F\} \\ V_{Jt} + \epsilon_{iJt} & j = J \end{cases}$$

In equation (1), β represents the marginal disutility of travel costs, and ϕ_m represents the fixed cost associated with driving or flying to an NPS unit. For $j \in \{1, ..., J-1\}$, δ_{jt} are unit by choice occasion fixed effects that represent a units' amenity appeal at a given time. They can be interpreted as the mean utility received from accessing NPS unit j at choice occasion t after accounting for the disutility from traveling to the unit. I decompose these amenity appeals to explicitly describe preferences for unit characteristics.

$$\delta_{jt} = X_{jt}\alpha + \gamma_{j,month} + \xi_t + \nu_{jt} \tag{2}$$

In this decomposition, I include unit-month fixed effects, $\gamma_{j,month}$, to control for variation in unobserved unit characteristics that vary by month but remain constant from one year to the next. I also include choice occasion fixed effects, ξ_t, to control for system-wide visitation trends.

Suppose that individual i chooses alternative j and travel mode m at choice occasion t if $U_{ijmt} > U_{iknt} \;\; \forall (k, n) \neq (j, m)$ and that y_{ijmt} describes this choice such that

$$y_{ijmt} = \begin{cases} 1 & \text{if } \; U_{ijmt} > U_{iknt} \;\; \forall (k,n) \neq (j,m) \\ \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

Under the assumption that ϵ_{ijmt} follows a Type I Generalized Extreme Value distribution that it is independent and identically distributed across individuals, units, travel modes, and choice occasions, the probability that individual i chooses unit j and travel mode m at choice occasion t is

$$P_{ijmt} = \begin{cases} \frac{exp(V_{0t})}{exp(V_{0t})+exp(V_{Jt})+(\sum_{k=1}^{J}\sum_{n\in\mathcal{M}} exp(V_{iknt}))} & \text{if } \; j=0 \\ \frac{exp(V_{ijmt})}{exp(V_{0t})+exp(V_{Jt})+(\sum_{k=1}^{J}\sum_{n\in\mathcal{M}} exp(V_{iknt}))} & \text{if } \; j\in\{1,...j-1\} \\ \frac{exp(V_{Jt})}{exp(V_{0t})+exp(V_{Jt})+(\sum_{k=1}^{J}\sum_{n\in\mathcal{M}} exp(V_{iknt}))} & \text{if } \; j=J \end{cases} \tag{4}$$

Combining these choice probabilities and respondents' visitation histories yields a likelihood function with three terms.

$$L_i(\beta,\phi,\delta) = \underbrace{(\Pi_{j=0}^{J}\Pi_{m\in\mathcal{M}}P_{ijm}^{y_{ijm}})}_{(1)}\underbrace{(1-P_{i0})^{v_i}}_{(2)}\underbrace{(P_{i0})^{24-1-v_i}}_{(3)} \tag{5}$$

The first term describes the likelihood that individual i visits unit j with travel mode m on their most recent visit. The second describes the likelihood that individual i made v_i visits to NPS units over the two years prior to their interview, in addition to their most recent visit, and the third term describes the likelihood that individual i chose the outside option $24-1-v_i$ times over the two years prior to their interview aside from the most recent occasion.

By including information about the most recent visit and the number of visits in the past two years, I use all the CSAP telephone survey data describing respondents' location and number of visits to NPS units. The CSAP telephone survey did not collect the dates when visits occurred. Therefore, I drop the choice occasion subscript when forming the log-likelihood equation. Section 5 describes the procedure used to recover monthly amenity appeals, but this step occurs after the initial log-likelihood estimation.

5 Estimation

The estimation procedure uses three steps. In the first, I estimate both unit amenity appeals and disutility of travel cost parameters, but I average travel costs and market shares across the survey period to obtain a single amenity appeal estimate for each unit. In the second step, I assume the disutility of travel cost parameters remain constant across time, and I repeatedly apply a contraction mapping to identify the unique amenity appeals that match predicted and observed visitation shares. This process yields monthly estimates of unit amenity appeals that vary flexibly across time and could theoretically be extended across the entire time span of the VUS visitor count data. If the data described when respondents' visits occurred, these first two steps could be combined. In the third and final step, I regress the monthly unit amenity appeal estimates on unit characteristics.

5.1 Estimation for the 2008-2009 Time Period

I begin by estimating a single amenity appeal parameter for each unit and disutility of travel cost parameters for the survey period. I maximize equation (5) with respect to β, the marginal disutility of travel cost, ϕ_D, the fixed cost of driving to a unit, and ϕ_F, the fixed cost of flying to a unit. As the optimization routine iterates over values of β, ϕ_D, and ϕ_F, I apply the contraction mapping to calibrate the unit amenity appeals. The contraction mapping is a computationally efficient way to solve a system of equations. It finds the unique value of the amenity appeals that match predicted and observed visitation shares for each unit. In this step, applying the contraction mapping has two main benefits. First, it combines information from both the telephone survey and the visitor counts when estimating the model's parameters. Second, the optimization routine must only search over three parameters, because amenity appeals are calibrated. This greatly reduces the computational burden. The classic demand estimation paper, Berry, Levinsohn, and Pakes (1995), estimates all model parameters using the same contraction mapping without individual-level data. In a travel cost model, travel costs, in essence the price of accessing a unit, vary across individuals, which differs from their setting. This means individual-level data is necessary to recover estimates of the disutility of travel cost parameters, β, ϕ_D, and ϕ_F.

Denote the observed market share for unit j as s_j. I assume the market size equals the product of the number of US households, the fraction of CSAP respondents who report that they plan to visit an NPS unit in the next 12 months, 71.6 percent, and the number of choice occasions, months, over survey period, 24. Denote the model predicted market share of unit j as $\hat{s}_j$. Taking the expectation of the sample average of y_{ijm} for each alternative yields the predicted market share for each NPS unit,

$$\hat{s}_j(\delta, \phi, \beta) = \frac{1}{N} \sum_{i=1}^{N} \sum_{m \in \mathcal{M}} P_{ijm}(\delta, \phi, \beta) \tag{6}$$

Using these predicted visitation shares, I apply the contraction mapping

$$\delta_j^{n+1} = \delta_j^n + ln(s_j) - ln(\hat{s}_j(\delta^n, \phi, \beta)) \tag{7}$$

The optimization routine evaluates the likelihood function at different values of β, ϕ_D, and ϕ_F, and each time, it solves for the unique vector of amenity appeals, δ, that matches predicted and observed visitation shares. The resulting estimates maximize the likelihood function subject to the constraint that predicted visitation shares equal observed visitation.

5.2 Monthly Amenity Appeal Estimates

This subsection outlines a method to recover a monthly panel of amenity appeal estimates using the monthly visitor count data. The key to this approach is that predicted visitation shares depend on respondents' probability of choosing unit each unit but not their choices directly. Thus, with estimates of the disutility of travel cost parameters from the previous subsection, amenity appeals can be calibrated using only aggregate data.

First, I take $\hat{\beta}$, $\hat{\phi}_D$, and $\hat{\phi}_F$ from the previous subsection. For each month between January 2000 and December 2019, I calculate observed and predicted visitation shares. Starting with January 2000, I apply the contraction mapping to find the $\delta_{\cdot t}$ vector that matches the observed and predicted visitation shares given $\hat{\beta}$, $\hat{\phi}_D$, and $\hat{\phi}_F$. I repeat this process for every month, assuming that β, ϕ_D, and ϕ_F remain constant over the entire time period

Note that these estimates depend critically on assumptions about how the fixed costs of each travel mode and the marginal disutility of travel cost parameters change over time. For now, I assume they are constant, but this is not necessary. Previous work exploring how the disutility of travel cost evolves over time is scarce. One exception is Dundas and von Haefen (2020), who specify a model that allows the marginal disutility of travel cost to vary annually. Their parameter estimates are stable between 2004 and 2009, but they do exhibit significant differences between regions along the Atlantic Coast. In future work, I plan to incorporate the most recent NPS telephone survey to inform these assumptions.

5.3 Explaining Amenity Appeal with Unit Characteristics

In the last step of the estimation procedure, I estimate equation (2) using OLS. The panel structure of the amenity appeal estimates allows me to include a variety of fixed effects when estimating the marginal willingness to pay for different unit characteristics.

Table 3: Parameter Estimates from CL Model

Rank	Variable	Estimate	Std Error
–	Driving FC	-1.03	(0.07)
–	Flying FC	-3.75	(0.08)
–	Travel Cost	-0.29	(0.02)
Amenity Appeal Estimates			
1	Golden Gate RA	-2.77	(0.09)
2	Olympic	-3.89	(0.10)
3	Lake Mead RA	-3.93	(0.10)
4	Cape Cod SS	-4.04	(0.10)
5	Grand Canyon	-4.07	(0.11)
6	Yellowstone	-4.09	(0.14)
7	Gateway RA	-4.13	(0.09)
8	Grand Teton	-4.18	(0.14)
9	Point Reyes SS	-4.24	(0.09)
10	Glacier	-4.29	(0.15)
–	Other NPS	-3.43	(0.00)

6 Results

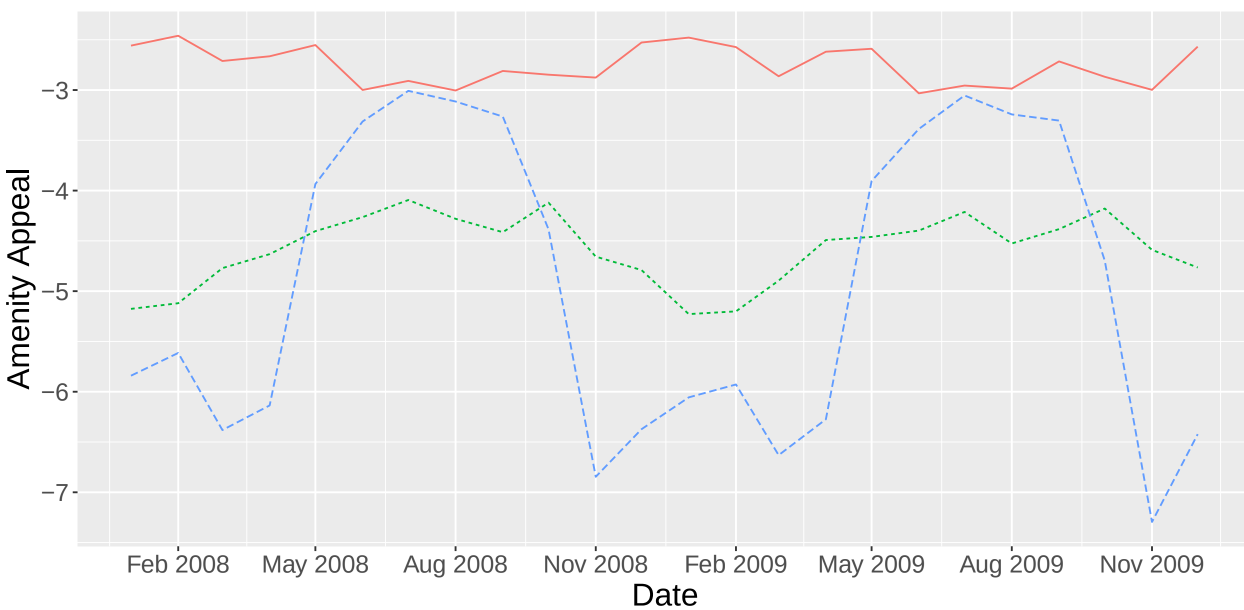
Table 3 contains estimates from the conditional logit model calibrated to match average observed and predicted visitation shares over the 2008 to 2009 survey period. It shows the siutility of travel cost parameters and the top ten National Park System units ranked by their amenity appeal estimates. The travel cost coefficient allows other estimates to be interpreted in terms of 2015 US dollars. Travel costs are scaled to hundreds of dollars, so a roughly three tenths difference in utility is equivalent to $100. The fixed cost of flying is approximately $940 greater on average than the fixed cost of driving. This difference could be driven by non-monetary costs like reduced flexibility or unobserved monetary costs like airport parking fees.

The top three units are Golden Gate National Recreation Area, Olympic National Park, and Lake Mead, another National Recreation Area. While national parks are typically thought of as the most treasured and impressive units in the NPS, table 3 suggests recreation areas are among the most appealing. This finding is partially due to the fact that recreation areas are very highly visited. Golden Gate NRA received 2.3 million group visits over the survey period, the most of any unit, and Gateway NRA, Lake Mead NRA, and Delaware Water Gap NRA were also among the top ten most visited units. This could be because recreation areas typically have fewer restrictions on recreational activities. Golden Gate touts itself as the most dog friendly NPS unit, and Lake Mead allows hunting and ATV riding, which are not allowed in most national parks.

Another factor affecting these rankings is the ability to visit units as side destinations on a larger trip. Both Golden Gate and Lake Mead can be easily visited from other destinations. Golden Gate is across the bay from San Francisco, while Lake Mead, home of the Hoover Dam, is roughly 45 minutes from Las Vegas. The on-site surveys include information about whether a respondent's visit was the primary purpose of their trip. Here, I do not adjust visitation counts to account for the primary purpose of visits, because the CSAP does not include information about primary purpose visits. Therefore, the convenience of adding units as a side trip is one component of location that does influence amenity appeal estimates. This should be taken into account when interpreting the NPS unit rankings.

One surprising feature of these results is that every unit has a negative amenity appeal estimate. I follow convention and normalize the mean utility of the outside option to zero; a normalization is required to apply the contraction mapping. Thus, negative amenity appeal estimates indicate that, on average, individuals prefer the outside option to visiting an NPS unit, where the outside option consists of any way of spending a month that does not involve an NPS visit. Based on these estimates, individuals would only choose to visit an NPS unit if they have a large positive shock in the idiosyncratic error term. The negative amenity appeals are also partially the result of the market size definition, because market size directly affects observed visitation shares. If I specify a smaller market size, the visitation shares of units will rise and their amenity appeal estimates will as well.

Seasonal variation is an important factor affecting the amenity appeal estimates in table 3, and it has traditionally been ignored by recreation demand studies. Figure 1 shows how amenity appeal varies across the survey period at Golden Gate NRA, Great Smoky Mountains, and Yellowstone. Yellowstone's amenity appeal changes dramatically between seasons, likely because of its harsh winters. Groups' average willingness to pay for a visit to Yellowstone is $1,300 greater in July 2008 than November 2008. Great Smoky Mountains' amenity appeal also decreases in the winter, but not as drastically. Meanwhile, Golden Gate NRA's amenity appeal is relatively stable. When estimating one amenity appeal value for the entire survey period, this seasonal variation is averaged out. This has broad implications for recreation demand models, even in settings with more geographically concentrated choice sets. For example, the amenity appeal of a site with a quality swimming area would likely be much higher in summer than winter, while sites popular for hiking trails may have more consistent amenity appeals. Even in this simple example, using one amenity appeal value would not accurately characterize individuals' choice problem.



Note: The plot shows seasonal variation in amenity appeal for three different NPS units: Golden Gate NRA (red−solid), Great Smoky Mountains (green−dotted), and Yellowstone NP (blue−dashed). The three units have dramatically different seasonal patterns. Yellowstone's appeal drops dramatically in its harsh winter season. Golden Gate's remains relatively stable year−round, and Great Smoky Mountains has an autumn surge, possibly for fall foilage viewing.

Figure 1: Monthly Variation in Amenity Appeal

Table 4 ranks units by their maximum amenity appeal over the survey period. Many of the units with high average amenity appeals also have high maximum amenity appeals,

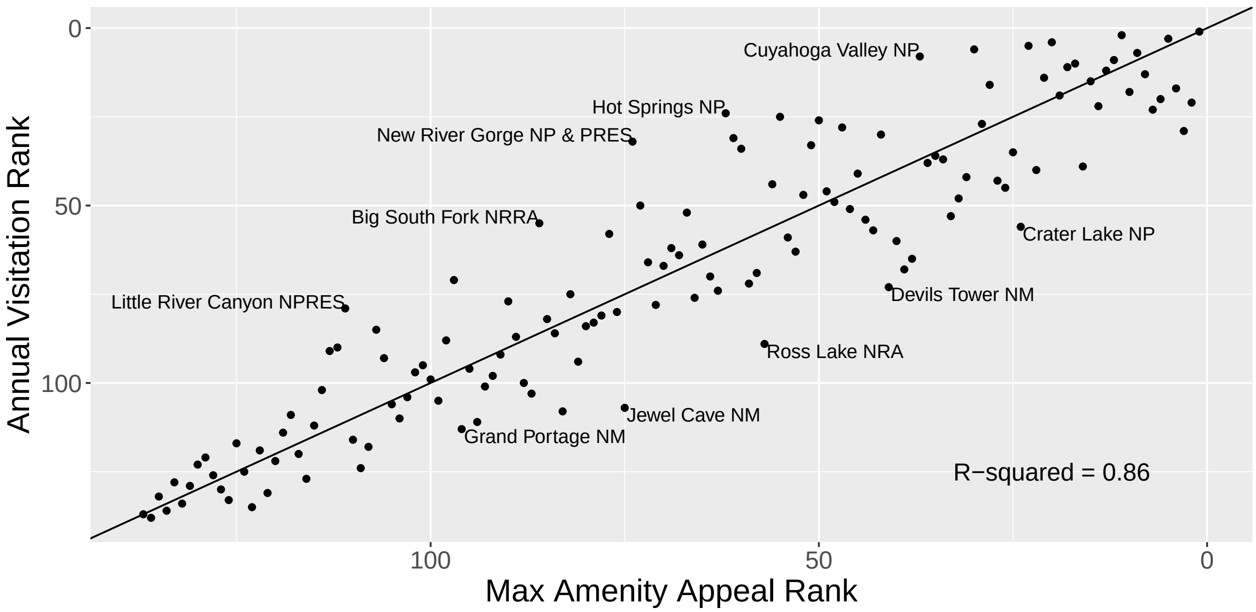
Table 4: Unit Ranking by Maximum Amenity Appeal

Rank	Unit	Max Amenity Appeal
1	Golden Gate RA	-2.46
2	Yellowstone	-3.01
3	Glacier	-3.17
4	Olympic	-3.17
5	Cape Cod SS	-3.20
6	Grand Teton	-3.29
7	Mount Rainier	-3.43
8	Rocky Mountain	-3.50
9	Lake Mead RA	-3.54
10	Acadia	-3.59

but there are significant differences in the ranking. Units with tourism off-seasons that drag down their average amenity appeal tend to move up the ranking. The largest mover is Sleeping Bear Dunes in northern Michigan, which rises twenty-three spots. It is followed by Jewel Cave National Monument in South Dakota and Saint Croix National Scenic River in Wisconsin, which both rise twenty-two spots.

Figure 2 displays how the revealed preference ranking from the model compares to the ranking implied by annual visitation counts in 2008, which is similar to rankings typically published in the popular media. The fundamental contribution of the travel cost framework is that it disentangles the joint effect of travel costs and amenity appeal on visitation. Using the maximum amenity appeal ranking also accounts for seasonal variation. Units above the 45 degree line like Biscayne, Hot Springs, and Chattahoochee River NRA, all in the Southeast, rank higher in visitation than in maximum amenity appeal. They are relatively convenient and have more pleasant climates year-round. Units beneath the 45 degree line, like Grand Portage NM on the shores of Lake Superior and Devil's Tower NM in northeast Wyoming, are more remote and have climates that limit tourism during parts of the year. Thus, they rank higher in terms of maximum amenity appeal than annual visitation.

Table 5 presents preliminary results from regressions of amenity appeal estimates on unit characteristics. Column (1) shows results from a cross-sectional regression of the single



Note: This figure compares the amenity ranking of NPS units implied by the model to units' 2008 adjusted visitation ranking. Points below the 45 degree line indicate units that have a higher amenity rank than visitation rank, suggesting they are more remote and/or have more seasonal amenity appeal. Points above the 45 degree indicate units with a higher visitation rank than amenity rank, suggesting they have convenient locations and/or consistent amenity appeal.

Figure 2: Comparing Model Rankings to Annual Visitation

Table 5: Amenity Appeal Estimates on Unit Characteristics

Dependent Variables:	Survey Period Amenity Appeal	Monthly Amenity Appeal
Model:	(1)	(2)
Variables		
NP Designation	0.3434	0.0260
	(0.2514)	(0.0647)
N Carnivore Species	0.0399	
	(0.0306)	
N Species	0.0005*	
	(0.0003)	
Acreage	0.0004**	-9.04×10^{-5}
	(0.0002)	(0.0003)
Fixed-effects		
Unit-Month		Yes
Time		Yes
Fit statistics		
Standard-Errors	Heteroskedasticity-robust	Unit
Observations	116	32,748

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1* survey period amenity appeal estimate on the number of species, number of carnivore species, a dummy for national park designation, and acreage. Column (2) displays results from a panel regression of monthly amenity appeals on unit characteristics. I include both unit-month and month-year fixed effects to control for unit specific factors that are consistent across time or change similarly each year, as well as contemporaneous system-wide factors. In the panel data specification, groups are willing to pay roughly $9 more to visit a national park rather than another type of unit, but this result is not statistically significant. This estimate uses variation from changes in unit designations rather than comparing national parks to all other units. Although, redesignations have become increasingly common, there were only six units redesignated as national parks between 2000 and 2019, which is a small treated group. There could also be significant heterogeneity that is not captured by this specification.

The effect of acreage on amenity appeal is also not statistically significant, and it is too small to be economically meaningful. Thus, there is no evidence that increasing the acreage of an NPS unit makes it a more appealing. In the cross-section, both the number of species and the number of carnivore species exhibit statistically insignificant positive correlations with amenity appeal. I do not have panel data on species presence, but with data on species reintroductions this model could be used to obtain rigorously identified estimates of the willingness to pay for species presence.

7 Conclusion

This paper describes recreation demand for the US National Park System. It offers a revealed preference ranking of NPS units that improves on widespread annual visitation rankings by controlling for individuals' travel costs, the availability of substitute units, and seasonal changes in amenity appeal. The data, model, and results presented can be used as a tool to study a variety of challenges facing the National Park Service, such as quantifying the monetary damages due to wildfires or the social costs of congestion and crowding.

The introduced estimation procedure combines a nationally representative survey and monthly visitor counts to construct a panel of amenity appeal estimates. This approach reveals significant seasonal variation both within and between units. This variation has been ignored by previous recreation demand studies but should be considered in future research. The estimation procedure also allows panel data econometric techniques to be applied inside a structural model, which helps control for unobserved site characteristics when estimating willingness to pay.

Appendix

Table 6: Ranking by Max Amenity Appeal 2008-2009

Rank	Unit	Max Amenity Appeal
1	Golden Gate NRA	-2.46
2	Yellowstone NP	-3.01
3	Glacier NP	-3.17
4	Olympic NP	-3.17
5	Cape Cod NS	-3.20
6	Grand Teton NP	-3.29
7	Mount Rainier NP	-3.43
8	Rocky Mountain NP	-3.50
9	Lake Mead NRA	-3.54
10	Acadia NP	-3.59
11	Gateway NRA	-3.62
12	Grand Canyon NP	-3.68
13	Gulf Islands NS	-3.74
14	Amistad NRA	-3.79
15	Yosemite NP	-3.80
16	Lake Roosevelt NRA	-3.85
17	Point Reyes NS	-3.88
18	Gateway Arch NP	-4.07
19	Zion NP	-4.09
20	Great Smoky Mountains NP	-4.09
21	Cape Hatteras NS	-4.22
22	Badlands NP	-4.25
23	Chattahoochee River NRA	-4.28
24	Crater Lake NP	-4.31
25	Curecanti NRA	-4.33
26	Bryce Canyon NP	-4.33
27	Mesa Verde NP	-4.39
28	Assateague Island NS	-4.39
29	Joshua Tree NP	-4.40
30	Delaware Water Gap NRA	-4.44
31	Arches NP	-4.44
32	Wind Cave NP	-4.45
33	Cedar Breaks NM	-4.46
34	Mojave NPRES	-4.52
35	Glen Canyon NRA	-4.57
36	Saguaro NP	-4.58
37	Cuyahoga Valley NP	-4.60
38	Theodore Roosevelt NP	-4.60
39	Craters of the Moon NM & PRES	-4.62
40	Whiskeytown NRA	-4.65
41	Devils Tower NM	-4.70
42	Canyon de Chelly NM	-4.74
43	Capitol Reef NP	-4.75
44	Sleeping Bear Dunes NL	-4.79
45	Montezuma Castle NM	-4.83
46	Everglades NP	-4.83

Table 6: Ranking by Max Amenity Appeal 2008-2009 *(continued)*

Rank	Unit	Max Amenity Appeal
47	Muir Woods NM	-4.84
48	Big Cypress NPRES	-4.87
49	Sequoia NP	-4.90
50	Canaveral NS	-4.94
51	Cabrillo NM	-5.01
52	Padre Island NS	-5.02
53	Colorado NM	-5.10
54	White Sands NP	-5.10
55	Indiana Dunes NP	-5.16
56	Lake Meredith NRA	-5.18
57	Ross Lake NRA	-5.19
58	Organ Pipe Cactus NM	-5.19
59	Saint Croix NSR	-5.20
60	Ozark NSR	-5.21
61	Shenandoah NP	-5.22
62	Hot Springs NP	-5.26
63	Canyonlands NP	-5.28
64	Redwood NP	-5.29
65	Biscayne NP	-5.30
66	Lassen Volcanic NP	-5.31
67	Fire Island NS	-5.35
68	Death Valley NP	-5.36
69	Petrified Forest NP	-5.40
70	Carlsbad Caverns NP	-5.43
71	Great Sand Dunes NP & PRES	-5.46
72	Kings Canyon NP	-5.49
73	Chickasaw NRA	-5.52
74	New River Gorge NP & PRES	-5.57
75	Jewel Cave NM	-5.57
76	Big Bend NP	-5.57
77	Cape Lookout NS	-5.58
78	Pictured Rocks NL	-5.67
79	Bandelier NM	-5.69
80	Dinosaur NM	-5.71
81	John Day Fossil Beds NM	-5.75
82	Santa Monica Mountains NRA	-5.85
83	Rainbow Bridge NM	-5.86
84	Voyageurs NP	-5.87
85	Sunset Crater Volcano NM	-5.93
86	Big South Fork NRRA	-5.94
87	Natural Bridges NM	-6.03
88	Devils Postpile NM	-6.06
89	Pinnacles NP	-6.06
90	Channel Islands NP	-6.07
91	Black Canyon of the Gunnison NP	-6.12
92	Bighorn Canyon NRA	-6.12
93	Oregon Caves NM & PRES	-6.13
94	Timpanogos Cave NM	-6.16
95	Lava Beds NM	-6.31

Table 6: Ranking by Max Amenity Appeal 2008-2009 *(continued)*

Rank	Unit	Max Amenity Appeal
96	Grand Portage NM	-6.32
97	Mammoth Cave NP	-6.32
98	Guadalupe Mountains NP	-6.35
99	Casa Grande Ruins NM	-6.36
100	Missouri NRR	-6.39
101	El Malpais NM	-6.41
102	Scotts Bluff NM	-6.42
103	Pipestone NM	-6.54
104	Tonto NM	-6.60
105	Apostle Islands NL	-6.61
106	Petroglyph NM	-6.62
107	Upper Delaware S&RR	-6.62
108	City of Rocks NRES	-6.82
109	Hagerman Fossil Beds NM	-6.88
110	Great Basin NP	-6.88
111	Little River Canyon NPRES	-6.88
112	Congaree NP	-7.01
113	Big Thicket NPRES	-7.01
114	Effigy Mounds NM	-7.08
115	Gauley River NRA	-7.09
116	Niobrara NSR	-7.11
117	Capulin Volcano NM	-7.15
118	Cumberland Island NS	-7.16
119	Florissant Fossil Beds NM	-7.17
120	Gila Cliff Dwellings NM	-7.30
121	Fossil Butte NM	-7.33
122	El Morro NM	-7.36
123	North Cascades NP	-7.37
124	Aztec Ruins NM	-7.37
125	Dry Tortugas NP	-7.48
126	Lake Chelan NRA	-7.48
127	Hovenweep NM	-7.52
128	Salinas Pueblo Missions NM	-7.73
129	Russell Cave NM	-7.87
130	George Washington Carver NM	-8.05
131	Tallgrass Prairie NPRES	-8.18
132	Agate Fossil Beds NM	-8.50
133	Bluestone NSR	-8.53
134	Isle Royale NP	-8.65
135	Booker T. Washington NM	-9.09
136	Rio Grande W&SR	-9.35
137	Alibates Flint Quarries NM	-9.56

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