Appendix A. Calibration

In this Appendix we describe three different calibration exercises for awareness bias, internal hypothetical bias, and external hypothetical bias. These three adjustments are done sequentially – first we adjust for awareness of the pass, then we calibrate for estimated hypothetical bias using internal sample data, and finally we adjust for any residual hypothetical bias using external information on recent pass revenues. In Table A3, we show the size of each adjustment. Protest households (i.e., those that refuse the pass for free) are excluded from the analysis.

A.1 Calibration for Awareness Bias

Both the unconditional and conditional revenue projections for the RDD and NPF populations are adjusted for "pass awareness". Approximately 50% of the RDD sample and 4% of the NPF sample[1] were unaware of both the NPP and GEP. Assuming the NRP is marketed in a similar manner, we should expect that similar fractions of the respective populations will not purchase the NRP simply because they will not learn of its existence. To account for this in our population revenue projections, we calculate NRP revenues in the sample by summing NRP revenues only for those who were aware of either the NPP or the GEP and have a maximum WTP that is higher than the proposed NRP price. We then scale that amount up to the appropriate population. Estimated gate revenues, on the other hand, include households that were unaware of either the NPP or GEP, under the assumption that such households will continue to visit federal recreation sites and pay gate fees.

A.2 Internal Calibration for Hypothetical Bias

Next, we calibrate estimated WTP to be consistent with stated rates of GEP purchases from within our survey sample. We specifically designed our valuation experiment to account for hypothetical bias by comparing hypothetical decisions to buy the NRP (at a bid equal to $65) with decisions to purchase the existing Golden Eagle Passport (GEP), which is currently sold for $65 in the marketplace. Assuming households are accurately stating whether or not they purchased the GEP within the previous year, this internal calibration should result in WTP and revenue estimates that reflect the actual purchasing behavior of households in the general U.S. population.

[1] The NPF sample consisted of telephone numbers that had belonged to households purchasing the NPP from one to two years before the survey was conducted. Some of those telephone numbers may no longer have belonged to the households that bought the pass, and hence respondents reached at those numbers might have been unaware of both the NPP and the GEP.

A.2.1 Probit Model to Estimate Probability Measure of Hypothetical Bias

To estimate the potential degree of hypothetical bias in the survey data, we specify a probit model with a dummy variable to capture the difference between hypothetical and actual purchasing decisions.[2] We analyze the RDD and NPF samples separately. Within each of these samples, we pool data from two distinct subsamples—the *stated preference* and the *revealed preference* subsamples. The revealed preference subsample includes every household who knew of the $65 GEP. The stated preference subsample includes every household that received an initial bid of $65 and was unaware of the GEP.[3] The underlying economic model is

$$WTP_i = \exp(X_i'\beta + \delta \cdot SP_i + \varepsilon_i) = \exp(\delta \cdot SP_i)\exp(X_i'\beta_i + \varepsilon_i)\,, \tag{A1}$$

where WTP_i is unobserved willingness to pay for either the GEP or the NRP; X_i is a vector of explanatory variables; β is a vector of coefficients; SP_i is a dummy variable equal to one for the stated preference subsample and zero for the revealed preference subsample; δ is the hypothetical bias coefficient; ε_i is a mean-zero normal error term with variance σ^2; and $i = 1,..,N$ is the sample size. We form the probability (P_i) that the i[th] household purchases the pass at price of $65:

$$P_i = \Pr(WTP_i \geq \$65) = \Phi(\frac{1}{\sigma}(X_i'\beta + \delta \cdot SP_i - \ln(\$65)))\,, \tag{A2}$$

where Φ is the standard normal cumulative distribution function. Let $y_i = 1$ indicate that the household purchased the pass (either hypothetical or real), and $y_i = 0$ indicate that the household did not purchase the pass. This is a probit model with (log) likelihood function

$$\ln L(\beta, \delta \mid y, X) = \sum_{i=1}^{N} \left[y_i \ln(P_i) + (1 - y_i) \ln(1 - P_i) \right]. \tag{A3}$$

The coefficients β and δ are only identifiable up to the scale factor (1/σ). That is, because β and δ only show up in the likelihood function as a ratio with σ (i.e., (β/σ) and (δ/σ)) and the price is fixed at $65, it is

[2] The design for estimating the degree of hypothetical bias follows Aadland and Caplan (2003).
[3] We also excluded 61 and 336 revealed-preference households in the RDD and NPF samples who were aware of the policy that allows receipts from recent entrance fees to federal recreation sites to be applied toward the cost of the NPP or GEP. This was done to level the playing field because the "receipt policy" may alter the value of a pass and was not described to our survey respondents.

impossible to disentangle the ratios and obtain individual estimates of β, δ and σ. However, the *marginal effects*, which measure the change in probability for a one unit change in the explanatory variables (X or SP), only depend on the identifiable ratios. For the average household, the marginal effect for hypothetical bias is

$$\begin{aligned}\Delta &= \Pr(y=1\mid \overline{X}, SP=1) - \Pr(y=1\mid \overline{X}, SP=0)\\ &= \Phi\left(\overline{X}'(\beta/\sigma) + (\delta/\sigma)\right) - \Phi\left(\overline{X}'(\beta/\sigma)\right).\end{aligned} \tag{A4}$$

This coefficient is defined in terms of increased (or decreased) probability of pass purchase. In the next section, we describe how to translate Δ into a WTP scale factor using the baseline Double Bounded Discrete Choice (DBDC) model.

A.2.2 Transforming Δ into a Hypothetical Bias Scale Factor

The coefficient of hypothetical bias Δ in expression (A4) is measured in terms of probability that the pass is purchased. Although this provides evidence of hypothetical bias, it does not allow household WTP and welfare measures to be directly adjusted to reflect revealed preferences. Furthermore, the probit model shown in expression (A2) does not identify a dollar amount of hypothetical bias because the bids are not varied (i.e., the bid is fixed at $65). Fortunately, the DBDC model described in the body of our report uses the entire bid vector and allows us to identify household WTP.

We use the normal distribution along with estimates of β and σ to back out the WTP hypothetical bias scale factor that is consistent with Δ for the average household. This is accomplished by solving for *δ* (given estimates of β, σ and Δ) from the following equation:

$$\begin{aligned}\Delta &= \Pr(\overline{WTP}_{SP} > \$65) - \Pr(\overline{WTP}_{RP} > \$65)\\ &= \Pr(\overline{X}'\beta + \delta + \varepsilon > \ln(\$65)) - \Pr(\overline{X}'\beta + \varepsilon > \ln(\$65))\\ &= \Phi(\frac{1}{\sigma}(\overline{X}'\beta + \delta - \ln(\$65))) - \Phi(\frac{1}{\sigma}(\overline{X}'\beta - \ln(\$65))),\end{aligned} \tag{A5}$$

where a bar over the variable represents its average value. Figure A1 illustrates the procedure for identifying exp(δ), the WTP scale factor for hypothetical bias. The procedure is straightforward. We start with our estimate of hypothetical bias, Δ, which is measured in terms of the increased probability that the NRP is purchased. This value is estimated using the method outlined in Section A.2.1 and is represented by the etched area in Figure A1. We then calculate the value of exp(δ) that is consistent with Δ assuming a normal distribution with standard deviation σ. Finally, we use the resulting WTP scale factor, exp(δ), to form the *calibrated* WTP estimates [WTP_i / exp(δ)] that more accurately reflect actual purchasing decisions of households.

A.2.3 Estimation Results for Hypothetical Bias Model

We now turn our attention to the estimation results from the hypothetical bias model outlined above. We estimate the hypothetical-bias model separately for the RDD and NPF samples.

The first row of Table A1 presents the estimates of (δ/σ) under the coefficient heading and estimates of Δ under the marginal effect (ME) heading. In both samples, the hypothetical bias coefficients are positive and statistically significant. Furthermore, the ME estimates indicate that, all else equal, the average RDD and NPF stated-preference households are 13.6 and 12.6 percentage points more likely to purchase a $65 pass than similar revealed-preference households. The control variables include respondent and household demographics such as age, gender, education, race and region of residence.

As discussed above, the estimates of Δ need to be translated from a probability into a WTP scale factor (i.e., we need to map our estimates of Δ into estimates of exp(δ)) for the purpose of calibrating the WTP estimates for hypothetical bias. To accomplish this, we use the baseline DBDC estimates reported in the body of our report. The estimated value for the hypothetical bias calibration factor, exp(δ), is approximately 1.4 and 1.3 for the RDD and NPF samples. Additional details for this calculation are reported in Table A2. Put differently, the RDD and NPF WTP values would need to be reduced by 40% and 30% to be consistent with the fact that stated-preference households are 13.6 and 12.6 percentage points more likely than revealed-preference households to purchase the pass at $65. The revenue functions reported in the Sections 5 and 6 of our report are scaled by exp(δ) to more accurately reflect the actual purchasing decisions of households. We turn next to the final step in the calibration process.

A.3 External Calibration for Hypothetical Bias

The external calibration uses outside information on recent NPP/GEP revenues to project future NPP/GEP revenues and then matches them to projected NRP revenues. As a consequence, the external calibration process adjusts for any remaining hypothetical bias not addressed by the awareness or internal hypothetical bias adjustments.

The external calibration exercise is straightforward. Based on recent NPP and GEP revenue figures (see Table 3 in the benchmarking report from this study), we project that at a price equal to $65, NRP revenues should be approximately $30 million and $1 million for the RDD and NPF populations based on revenues from the year 2005. After adjustments have been made to WTP for awareness bias (Section A.1) and internal hypothetical bias (Section A.2), we then scale the corresponding NRP revenues to match these figures. Because gate and net revenues are calculated from NRP revenues, they are automatically calibrated in a similar fashion.

Table A3 presents the magnitudes of all three types of calibration factors. Panel A presents the projected NRP revenues based on various assumptions about awareness and hypothetical bias in the relevant populations. Panel B presents total scaling factors and their decomposition into awareness bias, internal hypothetical bias and external hypothetical bias. In calculating the total bias, the decomposed terms are multiplied together, rather than added, to be consistent with the multiplicative hypothetical bias term in equation A1. By decomposing the total bias in a multiplicative fashion, each individual bias term maintains the interpretation of a 'scaling factor' (i.e., "NRP revenues should be divided by a factor of __").

The scaling factors in Panel B are calculated in a sequential fashion using the revenue projections in Panel A. First, the scaling factors for awareness bias are calculated by taking the ratio of predicted NRP revenues at $65 (assuming that all households in the population will be made aware of the NRP) to the predicted NRP revenues at $65 (assuming that households in the population will be aware of the NRP at the same rate as our sample was aware of the GEP). Second, maintaining the correction for awareness bias, the internal hypothetical bias scaling factor is calculated by taking the ratio of predicted NRP revenues at $65 (without a correction for internal hypothetical bias) to predicted NRP revenues at $65 (after scaling WTP by $\exp(\delta)$). Finally, the external bias factor is calculated by taking the ratio of projected revenues at $65 (with adjustments for awareness and internal hypothetical bias) to the benchmark revenues ($30 million and $1 million for the RDD and NPF populations, respectively).

The total degree of awareness and hypothetical bias using the RDD sample and the unconditional forecasts implies that NRP revenues taken directly from survey responses are approximately 16 times higher than the actual data suggest. The total bias using the NPF sample is much lower and even slightly negative in the unconditional case. This suggests the overall hypothetical bias for the general public RDD sample is greater than the bias for the more pass-experienced NPF sample.

References

Aadland, D. and A.J. Caplan. 2003. "Willingness to pay for curbside recycling with detection and mitigation of hypothetical bias." *American Journal of Agricultural Economics*, 85(2), 492–502.

Table A1. Hypothetical Bias Probit Model

Explanatory Variables	RDD Sample				NPF Sample			
	Mean	Coefficient	P –Value	ME	Mean	Coefficient	P –Value	ME
Hypothetical	0.082	1.362***	0.001	0.136	0.039	0.348**	0.034	0.126
All Revenue	0.628	-0.177	0.395	-0.007	0.636	0.030	0.376	0.012
Low Visits	0.803	-1.329***	0.002	-0.131	0.453	-0.409***	0.000	-0.157
Young	0.149	0.580	0.163	0.038	0.138	-0.055	0.346	-0.021
Old	0.242	-0.400	0.206	-0.014	0.300	0.177**	0.043	0.067
Male	0.433	-0.517	0.106	-0.022	0.477	0.062	0.252	0.024
BS degree	0.357	0.537	0.140	0.026	0.394	0.093	0.210	0.036
Professional degree	0.236	0.068	0.452	0.003	0.353	0.129	0.144	0.049
Low Income	0.312	-0.400	0.204	-0.019	0.255	0.054	0.361	0.020
White	0.846	-0.577	0.156	-0.038	0.877	0.224*	0.080	0.087
NE	0.048	0.168	0.438	0.008	0.079	-0.475***	0.008	-0.187
ENC	0.113	0.178	0.383	0.008	0.117	-0.297**	0.038	-0.117
WNC	0.160	0.117	0.427	0.005	0.155	-0.375**	0.012	-0.147
GP	0.071	0.122	0.433	0.005	0.082	-0.730***	0.000	-0.285
SE	0.165	-0.187	0.383	-0.007	0.177	-0.307**	0.018	-0.120
WSC	0.065	-3.832	0.461	-0.032	0.025	-0.471**	0.046	-0.186
SW	0.067	-1.256	0.084	-0.020	0.071	-0.353**	0.039	-0.139
RM	0.097	-1.114	0.133	-0.022	0.109	-0.171	0.147	-0.067
Constant	1.000	-0.639	0.235	--	1.000	0.435**	0.037	--
Sample Size	180				830			
Hypothetical Bias Scaling Factor (e^{δ})	1.43				1.30			

Notes. (***), (**), and (*) refer to statistical significance at the 1, 5 and 10 percent levels. The estimation was carried out using the Constrained Maximum Likelihood (CML 2.0) package in Gauss version 3.5. The nonlinear optimization routine was Newton-Raphson with a convergence criterion of 1×10^{-5} for the gradient of the coefficients. The estimates for "don't know" and "missing" dummy variables are not shown. ME = Marginal Effect. 26 and 17 protest households (those that would not be interested in the NRP even if it were offered free of charge) were removed from the RDD and NPF samples.

Table A2. Information Used in Solving for the Internal Hypothetical Bias Factor from Equation (A5)

Estimate	RDD Sample	NPF Sample
Δ	0.136	0.126
σ	1.014	0.561
$\bar{X}'\beta$	3.748	4.536
Equation (A5): $\Delta = \Phi(\frac{1}{\sigma}(\bar{X}'\beta + \delta - \ln(\$65))) - \Phi(\frac{1}{\sigma}(\bar{X}'\beta - \ln(\$65)))$		
δ	0.357	0.261
exp(δ)	1.430	1.298

Notes. Φ ≡ standard normal cumulative distribution function.

Table A3. Awareness, Internal Hypothetical Bias and External Hypothetical Bias Calibration Factors

Panel A. NRP Revenue Predictions

Revenue Type	Predicted NRP Revenue ($65 × Millions of Households Purchasing NRP)			
	RDD Sample		NPF Sample	
	Unconditional	Conditional	Unconditional	Conditional
w/out Awareness Correction	491.14	254.63	0.88	1.40
w/ Awareness Correction	187.63	102.75	0.85	1.35
w/ Awareness & IHB Correction	143.48	22.34	0.54	1.03
w/ EHB Correction	30.00	30.00	1.00	1.00

Panel B. Scaling Factors

Calibration Type	Scaling Factor: "NRP Revenues are Divided by a Factor of __"			
	RDD Sample		NPF Sample	
	Unconditional	Conditional	Unconditional	Conditional
Awareness Bias	2.62	2.48	1.04	1.04
Internal Hypothetical Bias	1.31	4.60	1.57	1.31
External Hypothetical Bias	4.78	0.74	0.54	1.03
Total Bias	16.41	8.44	0.88	1.40

Notes. IHB = Internal Hypothetical Bias; EHB = External Hypothetical Bias.

Figure A1. Illustration of the Procedure to Identify a Dollar-Valued Hypothetical Bias Estimate