State-Level Estimates from 2016 National Survey: Final Evaluation Report for Modeled Estimates

In fulfillment of the AFWA proposal "Method to Derive State-Level Estimates from the 2016 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation" and FWS-Census IAA# FWS-7689019.

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Introduction

The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR) has been conducted on a repeating basis since 1955 and the 2016 FHWAR is the thirteenth National Survey. It is widely recognized as the most comprehensive ongoing source of data on participation and expenditures related to fishing, hunting, and other wildlife-related activities.

The survey is sponsored by the Association of Fish and Wildlife Agencies (AFWA). Data users turn to this survey to inform policy formation, planning, and funds allocation. The thirteen iterations of the National Surveys are used to reveal trends in the participation and economic impact of wildlife-related recreational activities over time. The 2016 FHWAR was the sixth National Survey that the U.S. Census Bureau has directly conducted under agreement with the U.S. Department of the Interior, U.S. Fish and Wildlife Service (FWS), and the eleventh National Survey that the U.S. Census Bureau has conducted as the data collection agent.

As with many surveys, FHWAR receives a fixed level of funding, and rising costs of data collection have necessitated changes to survey and sample design, limiting the scale of survey operations, and reducing the sample size. Furthermore, the detailed and lengthy nature of the survey proves to be a burden on respondents. In the 2011 survey, some state level estimates could not be released because of too few sample cases, and others were questioned as to their accuracy. As a result of these operational challenges, AFWA began exploring alternative ways to conduct the 2016 survey with the goal of attaining sufficient sample to produce estimates with adequate confidence at both the state and national levels. Consequently, the U.S. Census Bureau was tasked with conducting a national-level survey for 2016 using methods and techniques similar to those for previous National Surveys, from 1991 through 2011. The project was to provide national-level results and state results for Maine, Minnesota, Oklahoma, and Virginia that were directly comparable with the results from earlier National Surveys.

Additionally, the Census Bureau proposed a model-based approach to derive state-level estimates (and measures of uncertainty) based on response values from 2016 National Survey data. Specifically, the Census Bureau would produce estimates for three activity indicators: number of participants, days spent afield on the activity, and total annual expenditures by state-resident participants. These indicators would be produced at the state-level for each of the three major activities: fishing, hunting, and wildlife-associated recreation. The description below details the model specification, development, and evaluation of these proposed small area estimation methodologies.

This document is divided into five sections: Research Plan, Data Creation and Issues, General Methodology, Results and Discussion, and Conclusion. The conclusion includes a discussion of the feasibility of extending these methods to a breakout of fishing into saltwater vs. freshwater for coastal states. There are two appendices: Appendix 1 is a data dictionary for the accompanying final estimates spreadsheet and Appendix 2 is a detailed technical documentation for the estimates development.

Research Plan

The goal of this evaluation project was to produce publishable state-level estimates for three measures of activity (total count of participants, total number of days afield participating, and total expenditures) for each of three types of activities (hunting, fishing, and wildlife-watching). The basis of the modeling problem is that the sample was too small for direct state-level estimates of reasonable quality, with many states having insufficient participants for some model specifications (by reasonable quality, we mean general Census Bureau quality standards for publication, with the criterion being median standard error for the set of estimates being below 30% of the accompanying point estimate).

The general development of a research plan involves the iterative process of determining the type of model, specifying the structure of the model in detail, and planning the evaluation of the chosen model. By an iterative process, we mean that the eventual model type and specification chosen is determined by the evaluation, and thus there is some back and forth among these steps.

Given the relatively small size of the sample for the 2016 FHWAR survey, a model-based solution was the avenue chosen. A more design-based method, involving weight adjustments or post-calibration, does not generally produce substantial improvements in surveys with small sample sizes. Furthermore, the production of reasonable post-calibration estimates is limited by the lack of adequate administrative data for these activities.

By model-based method, we mean a conceptual two-stage model, which could be either jointly or hierarchically estimated. The first stage, generally referenced as the linking model, is a latent variable or random effects model, and the second stage is the sampling model. These are specified more exactly in the General Methodology section.

For 2016 FHWAR, the primary sampling units were selected partially on the basis of known hunting license counts. This procedure sets up a correlation between the unit-level respondents and the activity measures. Using appropriate adjustments to the survey weights, this provides no issues for direct sample-based estimates. This correlation does make it more problematic to construct a unit-level, model-based estimation strategy. Thus, for this study, we chose an area-level approach. By area-level, we mean the basic regression and “shrinkage” steps, which combines the regression estimate with the direct survey estimate based on each’s relative precision, are conducted for state-level estimates of both the sample-based estimates and the auxiliary data.

Three broad steps are required for an area-level, model-based strategy. First, the sample is re-weighted to be more representative of the target area, state-level in this case. This step is generally termed post-stratification. Other sample data issues are also addressed at this stage. Next, numerous specifications of the regression linking model are tested to determine the most reliable estimator. The term “linking model” is generally used to indicate how the regression formulation links the target concept to explanatory data. For this study, minimum mean-squared error (MSE) was the general criterion, accompanied by residual and outlier analysis. The MSE criterion was not followed exactly in every case. For example, if a specification resulted in coefficient estimates that did not appear sensible from a subject-matter perspective and only resulted in a very small improvement in MSE, then it was rejected. The final step is shrinkage to the direct estimate, with potential post-calibration to improve overall bias and/or skew. The remainder of this section is a discussion of the plan for the linking model specification. The post-stratification and calibration stages are addressed in subsequent sections.

The three different activities may have some degree of correlation, but with such low participant counts per state, it was decided to model each activity independently, rather than one model combining participation in all activities simultaneously. The one exception to this modeling framework is that it was found empirically that fishing license counts, which were publicly available at the state level (https://www.fws.gov/wsfrprograms/subpages/LicenseInfo/Fishing.htm), were a significant indicator for wildlife-watching activity. So implicitly we have set up some correlation between the models, even if we do not explicitly include it in the model specification. These results are highlighted in a later section.

Given the decision for independent models, the first step of the research plan is to precisely specify the concepts for estimation. Subject to the accepted proposal, the concepts were relatively easy to specify. First, the activity is geo-located by residence of the participant, not by location of the activity (same as in the published survey results – U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau). A fisherman from Fairfax, VA surf-fishing off the Delaware coast would be counted as a Virginia participant because of his residential location. Second, all days afield and expenses incurred for an activity are counted in the year they occur, even if the activity is planned for later. For example, an angler who only participated earlier in 2016 purchases a bass boat in October 2016, for use in the 2017 season, still counts as fishing activity expenditures for the 2016 estimates. Finally, the survey, and consequently the small area estimates based on the survey, are person-level, with no adjustment for household or other group activities. Large expenditures that might be used by the entire household, such as the bass boat previously mentioned, will all be tallied to the person making the expenditure, unless on the survey they reported a pro-rated share.

Table 1: General Specification Hierarchy for the 3 concepts for each activity (For aggregate state-level residents)

Indicator	**Function of…**
Participation count or rate	Demographics, geography, income, licensing
Days spent on activity	Demographics, geography, income
Expenditures per participant	Demographics, geography, income

There is a natural hierarchy to the three concepts describing each of the three activity areas. First, there is participation in the activity for the year, followed by number of days engaged during the year, and finally expenditures towards the activity. Expenditures could be separated into durable goods expenditures, which can be thought of as amortized over the useful life of the good, versus operating expenditures, like bait, rentals, etc., which have a closer causation with days spent in the activity.

However, to effectively amortize durable goods expenditures would require either a multi-year study, or a much larger sample allowing hedonic modeling. Since neither was available, total expenditures were modeled on an amount spent per participant basis. The resulting general specification plan for the regression estimate is shown below. The specific concepts on the right-hand side of the regression equation were determined empirically (i.e., by detailed specification testing that used mean squared error, normality testing, and reasonableness of the coefficients as the basic criteria).

Data Creation and Issues

The primary steps in preparing the sample and auxiliary data for modeling are first adjusting the sample-based direct estimates to represent state-level concepts, next creating reliable state-level sample variances, and finally identifying and adjusting outliers in the auxiliary data.

The first step for preparing the direct sample-based estimates is termed post-stratification. Basically, this consists of adjusting the individual-level survey weights such that they add up to state-level population estimates, rather than the division-level population totals to which the published estimates were benchmarked. A further complication was that the four individual states for which larger samples were obtained were benchmarked at the state-level for the published estimates, so in actuality, the post-stratification was performed for the division totals excluding these four states. Furthermore, the population benchmark used for the 2016 FHWAR was an estimate for May 1, 2016, rather than the usual July 1-based Census Bureau population estimates used for other surveys and publications.

A May 1, 2016 state-level estimate was obtained for the age 6-15 and 16-plus household population by interpolating between the available July 1, 2015 and July 1, 2016 estimates. Note that age 6-plus, and

16-plus individual residents within households is the universe for the 2016 FHWAR for the entire sample and the detailed questionnaire sample, respectively. Next, these state-level population estimates were adjusted to the division-level population estimates used for the survey. This adjustment was less than two percent for all divisions. Finally, the sum of survey weights within each state was adjusted such that they would add-up to the newly-benchmarked state-level population estimates; this adjustment averaged approximately five percent. There were some complications on whether to apply this adjustment equally across all states or omit the four high-sample states, and also on how to maintain consistency with division-level benchmarks. See Appendix 2 for more detail on this step.

The next major task in preparing the sample-based state-level estimates for use in modeling was to calculate reliable sampling variance estimates for each concept for each state. Sampling variance is an important component of the modeling stage, as it is used both to weight the influence of each state's direct estimate in the regressions, and for the final shrinkage step.

For the publication of survey estimates at the division-level, the survey team created estimates of the sampling variance using both a sample-based method similar to a bootstrap and also a functional approach, known as a generalized variance function (GVF). At the state-level, we explored both the sample-based and functional approach. The sample-based, or replicate weight, variances were designed to produce reliable estimates for the survey at the division-level, so were not always sufficiently stable at the state-level. The decision on which method to use was based on empirical evidence, primarily the mean-squared error of the regression estimates.

For participation, a standard form of the GVF for concept rates was used:

$$\log(SE\ of\ p) = \beta_0 + \beta_1 \log(ESS) + \beta_2 \log\big(P(1-P)\big) \qquad (1)$$

where *P* represents the true participation rate, *ESS* is an estimate of the effective sample size, and $SE\ of\ p$ is the standard error of the estimated participation rate. The parameters of the GVF are estimated twice, once using a regression estimate of *P* obtained by using the replicate weight variance for $SE\ of\ p$, and again using the regression estimate of *P* and the first stage estimate of $SE\ of\ p$. ESS is an aggregate survey weight calculation and is calculated separately for the sportsperson (fishing and hunting) sample vs. the non-consumptive (wildlife-watching) sample. The GVFs for days afield and expenditures are generally simpler constructs, modeling the relative variance on the log scale. Details of all the GVFs used in the final estimates are provided in Appendix 2.

The final step in data preparation is to examine the auxiliary data, in this case hunting and fishing license issuance by state, to determine if any values are unreasonable compared to expected issuance. As with the GVFs, this is a two-stage process where the regression estimates of hunting/fishing participation are created by including all un-adjusted license counts in 2016 as auxiliary data. Then, the ratio of licensing to predicted participants is examined by state relative to national and division averages. Very large differences (approximately 50% or more in either direction) are imputed using an instrumental-variable approach. There were very few adjustments needed, but individual states cannot be identified due to disclosure protections.

General Methodology

The general approach outlined in the Research Plan section, which is namely a single-concept, area-level model-based approach, is often termed the Fay-Herriot method after its first use by Census Bureau researchers (Fay and Herriot, 1979). It has been the primary modeling technique used in high-profile programs at the Census Bureau, including the Small Area Income and Poverty Estimates program (Bell, et al. 2007). As applied for the current project, it has four basic steps.

First an indirect, or regression, prediction is specified, evaluated, and produced. Next, a weighted average between the indirect and the direct sample-based prediction is calculated, with the weights derived from the relative variances of the two. This weighted average is termed the shrinkage estimate. This regression and shrinkage result is usually not in the original scale of the direct estimates. For example, to produce reasonable estimates of count data, like the number of participants, a log(count) model is usually best. Thus, the third step is to transform the shrinkage estimate back to the desired data scale, with an adjustment for mean differences in the two scales. Finally, it may be best to adjust the transformed shrinkage estimates such that the total participant counts (or days afield, etc.) are equal to the national survey results. This adjustment, or raking, step serves as a check against bias problems with the regression estimates, and provides consistency with the already-published estimates.

Let z_i represent the state-level sample-based direct estimate of a given activity by indicator combination, i.e. total state-level count of participants, total state-level days afield, or total state-level expenditures for any of the three activity concepts respectively. Then $r_i = z_i / d_i$ is the rate of activity, where d_i = total 16-plus population for participation rate, total participants for days afield per participant, or total participants for expenditures per participant. The four specifications tested for transformed data are below, where log() indicates the natural log, or log base *e*.

log-count transformation: $$y_i = \log(z_i) \tag{2}$$

naïve rate: $$y_i = r_i \tag{3}$$

log-rate transformation: $$y_i = \log(r_i) \tag{4}$$

logistic transformation: $$y_i = \log(r_i/(1 - r_i)) \tag{5}$$

The regression equation estimated is:

$$y_i = \mathrm{x}_i'\beta + u_i \tag{6}$$

where u_i is assumed normal with variance σ_u^2 and mean zero. The unknown parameters are estimated using either maximum likelihood (ML), or restricted maximum likelihood (REML). REML can provide a more reasonable estimate with state-level models, as it usually ensures the model error variance estimate is positive.

Evaluation details for each specification tested, and the accompanying list of auxiliary data, are provided in Appendix 2. The final specifications chosen are listed in the next section of results.

The second, or shrinkage, step is represented by the following equation.

$$\widehat{Y}_i = w_i\left(x_i'\hat{\beta}\right) + (1 - w_i)y_i \tag{7}$$

$$w_i = v_i/(v_i + \hat{\sigma}_u^2) \tag{8}$$

where v_i is the GVF estimate (or direct estimate) for the sampling variance of the state-level estimate y_i.

A raking adjustment was used for participant counts, but not days afield or expenditures. Intensity indicators like days afield and expenditures are highly skewed, with a few individuals spending amounts and time far above the median, so raking to national totals can create large non-normal adjustments. Such high skewness causes mean values, and thus totals, to be an unreliable indicator of typical behavior, and thus raking to national totals is not a good bias adjustment. This does mean that totals across all 50 states will not equal the national published total.

Results and Discussion

Detailed results for all nine estimates, 3 indicators by 3 activities, are reported in Appendix 2, with a table of contents leading that section. This section will give a summary of the specifications for each, plus a detailed interpretation of the results for hunting participation. Definitions of the auxiliary data concepts are also contained in Appendix 2.

As outlined in the Data Creation and Issues section, the GVF was derived in two steps. The first consisted of estimating model parameters using direct sampling variances and using the regression results to fit the GVF. The second step was to re-estimate the model parameters using the GVF predictions. This procedure only produced reliable estimates for some of the concepts. Table 2 below details the specification for final estimates for each concept. Each specification is labeled either “GVF” for the 2-stage GVF approach, or “no GVF” for first-stage direct estimates. When examining all diagnostics, the restricted maximum likelihood (REML) estimates performed best for all indicators. In some cases, ML had yielded lower mean CV, but did not perform as well in the normality test, or other diagnostics.

Table 2: Specification for Final Estimates, by Activity and Indicator

	Participation	Days Afield	Expenditures
Hunting	Log-count, REML GVF	Log-count, REML no GVF	Log-rate, REML no GVF
Fishing	Log-count, REML GVF	Log-count, REML no GVF	Log-rate, REML no GVF
Wildlife-Watching	Log-count, REML GVF	Log-count, REML no GVF	Log-rate, REML no GVF

Tests of the numerous specifications detailed in Appendix 2 are based on the following diagnostics, roughly in order of priority:

1) Mean Final Coefficient of Variation (CV = Standard Error/Regression Estimate)
2) Q-Q plot normality adherence
3) National raking factor
4) Reasonableness of parameter signs and T-stats
5) Mean Shrinkage

For the Appendix 2 results, the first-stage “no GVF” results are listed first for each indicator by activity, followed by the GVF-based results where appropriate. The tables below presented the GVF-based results for hunter participation only so that we can provide a detailed interpretation.

Table 3 below displays the CV comparison for the four different functional comparisons, based on the GVF estimate of the sampling variance, for both maximum likelihood estimation and restricted maximum likelihood estimation. The initial CVs are prior to transformation and raking, while the final CVs summarize the uncertainty in the final raked estimates in the original count scale. As seen from the table, the log-count specification has a slightly better CV distribution than the rate, log-rate, and logistic choices for both ML and REML.

Table 3: Hunting Participation Models CVs					
ML GVF					
Initial CVs	Model	Mean CV	Median CV	Max CV	Min CV
	Rate	0.5899	0.5231	1.994	0.1185
	Log-rate	0.534	0.442	1.748	0.1329
	Log-count	0.4914	0.4188	1.786	0.1407
	Logistic	0.5455	0.4537	1.824	0.1372
Final CVs	Rate	0.2392	0.1964	0.9642	0.1535
	Log-rate	0.2395	0.2333	0.3713	0.1619
	Log-count	0.2169	0.206	0.4249	0.1518
	Logistic	0.2469	0.2436	0.3549	0.1567
REML GVF					
Initial CVs	Rate	0.5884	0.5221	1.949	0.1189
	Log-rate	0.5359	0.4493	1.743	0.1321
	Log-count	0.4945	0.4311	1.776	0.1389
	Logistic	0.5479	0.4627	1.814	0.1365
Final CVs	Rate	0.2585	0.1989	1.192	0.1535
	Log-rate	0.2624	0.2581	0.3958	0.1661
	Log-count	0.2403	0.2332	0.4426	0.1589
	Logistic	0.2717	0.2766	0.3796	0.1625

Table 4 displays summaries of shrinkage weights (wt1), individual residual T-statistics (zres), and both the national raking factor and summaries of division raking factors. The national raking factor closest to one is for the log-count model. Thus, as with the CV comparison, the diagnostics in Table 4 favor the log-count model.

Table 4: Hunting Participation Models Diagnostics					
ML GVF					
	Model	**Mean**	**Median**	**Max**	**Min**
wt1	**Rate**	0.8191	0.9228	1	0.07804
	Log-rate	0.8398	0.8757	1	0.2621
	Log-count	0.911	0.9376	1	0.431
	Logistic	0.8355	0.8711	1	0.2484
zres	**Rate**	0.1595	0.1323	2.183	-2.673
	Log-rate	-0.01129	-0.1779	2.122	-2.276
	Log-count	-0.05087	-0.0682	2.393	-2.992
	Logistic	-0.009703	0.1308	2.304	-2.078
raking					
		Natl. Rk	**Mean Div Rk**	**Max. Div Rk**	**Min Div Rk**
	Rate	1.035	1.085	1.441	0.8238
	Log-rate	0.9768	1.003	1.292	0.7786
	Log-count	1.002	1.033	1.333	0.7648
	Logistic	0.9758	1.002	1.279	0.7933
REML GVF					
	Model	**Mean**	**Median**	**Max**	**Min**
wt1	**Rate**	0.7861	0.8957	1	0.05658
	Log-rate	0.7874	0.8266	1	0.1924
	Log-count	0.8525	0.8884	1	0.2848
	Logistic	0.7818	0.8157	1	0.1821
zres	**Rate**	0.1617	0.1312	2.202	-2.655
	Log-rate	-0.008165	-0.1851	2.113	-2.169
	Log-count	-0.04329	-0.06303	2.395	-2.86
	Logistic	-0.01396	0.0874	2.219	-2.063
raking					
		Natl. Rk	**Mean Div Rk**	**Max Div Rk**	**Min Div Rk**
	Rate	1.038	1.087	1.47	0.8246
	Log-rate	0.9772	1.003	1.277	0.7985
	Log-count	1.001	1.029	1.295	0.7909
	Logistic	0.9777	1.004	1.278	0.8172

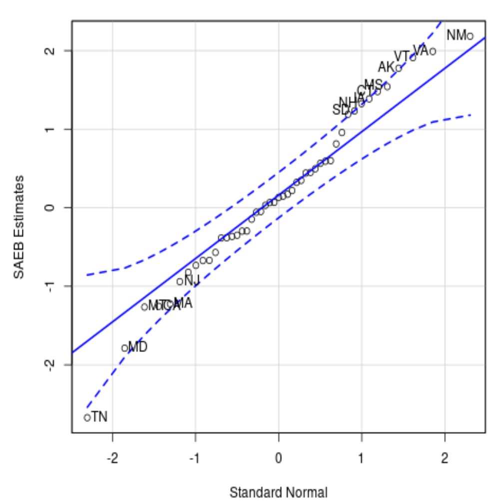
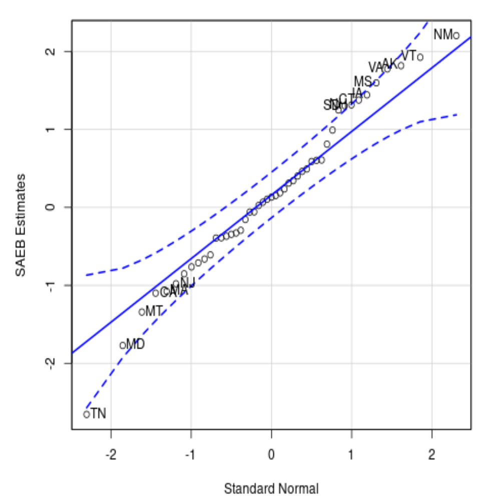
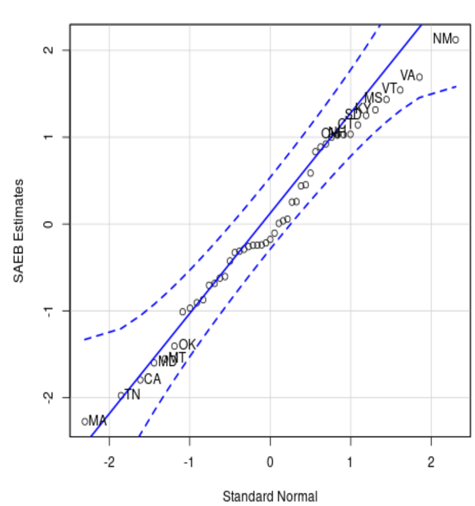
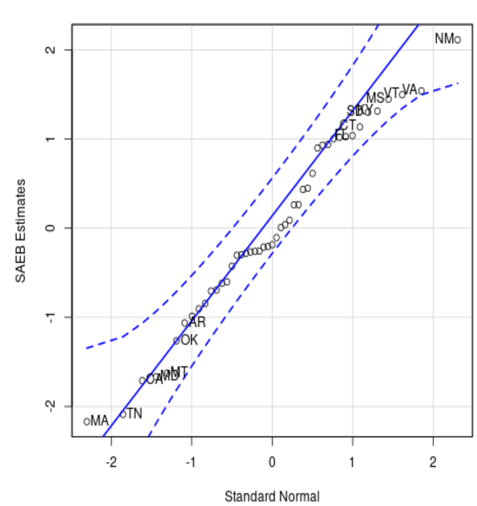
Table 5 reports the coefficients signs and T-statistics for the four specifications. There is not much difference among the eight specifications, with all having similar interpretations: strongly positive significance of hunting license issuance to residents with hunting activity, strongly positive significance for residence in Midwest and Gulf Coast states, and negative significance for residence in the northeast and southwest. Finally, the strongly negative significance of hours worked could be an indicator of increased hunting activity for under-employed persons.

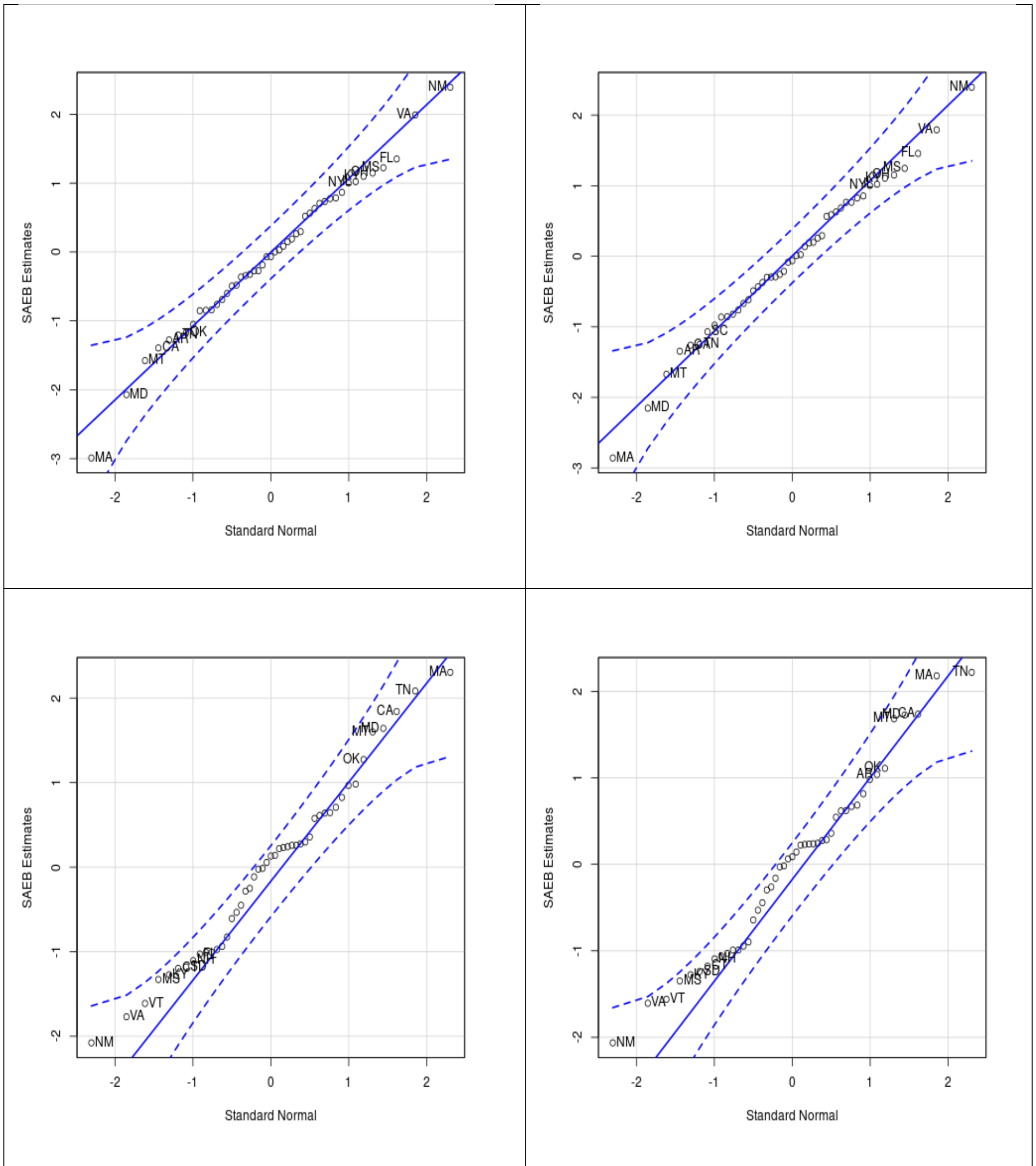
Table 5: Hunting R^2 Coefficient T-statistic Comparison				
ML GVF				
Variable	**Rate**	**Log-rate**	**Log-count**	**Logistic**
R^2	0.5847	0.7462	0.8282	0.7345
Hunters	4.847	6.877	3.852	6.794
MWGLF	4.609	3.709	4.259	3.774
NESW	-0.1293	-1.173	-2.755	-1.118
Hrs. Worked	-2.515	-3.095	-3.114	-2.775
Population			4.217	
REML GVF				
R^2	0.5794	0.7413	0.8254	0.727
Hunters	4.768	6.847	3.892	6.717
MWGLF	4.72	3.755	4.327	3.842
NESW	-0.08935	-1.063	-2.492	-0.9814
Hrs. Worked	-2.625	-3.133	-3.153	-2.832
Population			4.162	

The Q-Q plots below plot the standardized residuals for each specification on the y-axis against the predicted value given that point's percentile ranking. For the assumed normally distributed model error, the points should fall on the 45-degree line. Substantial deviations outside the confidence bands would indicate a problem with the specification.

The four functional specifications are displayed top-to-bottom, starting with rate, then log-rate, log-count, and logistic at the bottom. ML estimates are on the left, and REML on the right. As with the other diagnostics, the log-count specification performs the best for this test.

Figure 1: Q-Q plot for Normality Test of Regression Residuals
y-axis = standardized regression residual, x-axis = prediction from standard Normal table
Upper row charts are rate specification, followed by log-rate, log-count, and logistic

ML GVF	REML GVF
	
	



From top: Rate, Log-rate, Log-count, and Logistic models

The conclusion for hunting participation is a strong preference for the log-count model. Although ML produces a smaller mean CV, REML has a better raking factor (i.e., it is closer to 1) and a preferable residual plot. Both REML and ML have high mean shrinkages, but ML is higher so that the direct estimate accounts for less than 10 percent of the shrinkage estimate on average. For these reasons, the final specification chosen for hunting participation was the log-count model estimated using restricted maximum likelihood and GVF-based sampling variance estimates. The choice of specifications for final estimates of the other eight concepts proceed in the same way, using the output listed in Appendix 2.

Conclusion

Table 6 displays the mean CV for all final specifications of the three indicators by three activities. Participation and participation rates were well estimated, with mean CVs well under 30%. For days afield, mean CVs vary between 25% and 28%, so also reasonable. Expenditure estimate CVs vary between 31% and 36%, so outside the range of Census Bureau quality standards.

Table 6: Distribution of CVs for Final Estimates, by Activity and Indicator

	Participation			Days Afield			Expenditures		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Hunting	0.2406	0.1298	0.4729	0.2489	0.0891	0.4333	0.3078	0.1980	0.6111
Fishing	0.1939	0.0909	0.3549	0.2687	0.1199	0.6658	0.3556	0.2236	0.5338
Wildlife-Watching	0.1564	0.0891	0.2919	0.2796	0.1232	0.5543	0.3517	0.1637	0.5114

Breakout for finer categories of activities

Given that the results for the three top-line activities are marginal at best, modeling for even finer breakouts of hunting, fishing or wildlife-watching is unlikely to yield reliable results. This is likely to hold even for larger sub-activities that encompass sportsmen from nearly every state.

As an example, suppose we were to model these breakouts as proportions of the overlying activity. As a concrete example, suppose we were to divide hunters into waterfowl vs. all other hunting activities. Using fictitious data for a given state, suppose this state had a CV for the modeled hunting participation rate near the median of 25%, and a value for this hunting estimate of 10% participation. Suppose furthermore, we had an equivalently good model of the proportion of waterfowl hunters within all hunters, which also provided a CV of 25%, and a value of 50% waterfowl hunters within all hunters. Using a Taylor series expansion method for the SE, we would have an estimate of approximately 5% waterfowl hunters among the total population, and a CV of 30%. So even for the best modeled estimates (e.g., hunter participation), further breakout would generate marginal CV results.

It would be a similar case for each activity and each concept. As we make further subdivisions, the modeled results would be lower quality than the top-line activity estimates. So adequate top-line results would become marginal, and marginal results would become poor quality.

Breakout for Saltwater Fishing for Coastal state residents

For the specific breakout of resident anglers between saltwater and freshwater, beyond the limitation for general breakouts discussed above, there is an additional two factors limiting the likely performance of models. First, it is actually a four-way split of the population: zero fishing participation, saltwater-only fishing, freshwater-only fishing, and both types of fishing. So, for an accurate model, one may need to estimate these four smaller components and then add up the two containing saltwater anglers. The more problematic factor, however, is the limitation of the regression estimation to only the coastal states. Without more sample within these states, perhaps to facilitate individual-level modeling, the results would be substantially worse than reported in Table 6. An area-level model would have degrees of freedom only slightly above the number of auxiliary data columns, and thus would not be a practical data-set for maximum likelihood. Simpler estimation procedures could be attempted, but their performance would not necessarily be reasonable. As such, there does not appear to be a viable strategy for a saltwater fishing break-out given the 2016 sample size limitations.

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Appendix 1: Data Dictionary

The database of final estimates is delivered in spreadsheet form.

- Four spreadsheet tabs, one each for hunting, fishing and wildlife-watching. Plus, a data dictionary tab, which Is copied below for the hunter tab.
- All estimates are rounded to four significant digits as per current Census Bureau disclosure avoidance standards. Due to this rounding implied population totals are equivalent across the different activities to four significant digits only.

st	State postal abbreviation
hunt_part	Number residents aged 16 and above in a given state who hunt
hunt_part_rt	hunt_part divided by state population aged 16 and above
hunt_part_moe	Margin of error for hunt_part at a 90 percent confidence level
hunt_part_rt_moe	Margin of error for hunt_part_rt at a 90 percent confidence level
hunt_days	Estimated number of days spent hunting by state hunters aged 16 and above
hunt_days_rt	hunt_days divided by hunt_part
hunt_days_moe	Margin of error for hunt_days at a 90 percent confidence level
hunt_days_rt_moe	Margin of error for hunt_days_rt at a 90 percent confidence level
hunt_exp	Estimated expenditures on hunting by state hunters aged 16 and above
hunt_exp_rt	hunt_exp divided by hunt_part
hunt_exp_moe	Margin of error for hunt_exp at a 90 percent confidence level
hunt_exp_rt_moe	Margin of error for hunt_exp_rat at 90 percent confidence level

For the same concepts for anglers, replace prefix “hunt” with “fish”.

For the same concepts for wildlife-watchers, replace prefix “hunt” with “ww”.

Appendix 2: Technical Documentation

Contents for Appendix 2

Empirical Distributions

Sample Sizes

Of the 50 states, there is only one state with a total sample size less than 5. The following breaks down the sample size distribution of all 50 states and the 46 states not highly sampled (NHSS)

	Mean	Median	Max	Min	Std. Dev.
All States	400	200	3000	< 15	550
NHSS	300	200	2000	<15	400

The distribution of sample sizes across states are heavily skewed by outliers, indicating a small number of states contribute a large majority of respondents; this is true with and without the highly sampled states. In fact, the 4 most highly sampled states make up roughly 42 percent of all respondents.

Activity Sample Sizes

The sample sizes for individual activities (i.e., the number of participants in a given activity) are also heavily skewed. For hunting, the mean sample size drops from 9.6 for all 50 states to 6.91 with the four highly sampled states removed; there are 24 states which have five or fewer respondents who participated in hunting.

Activity Empirical Distributions

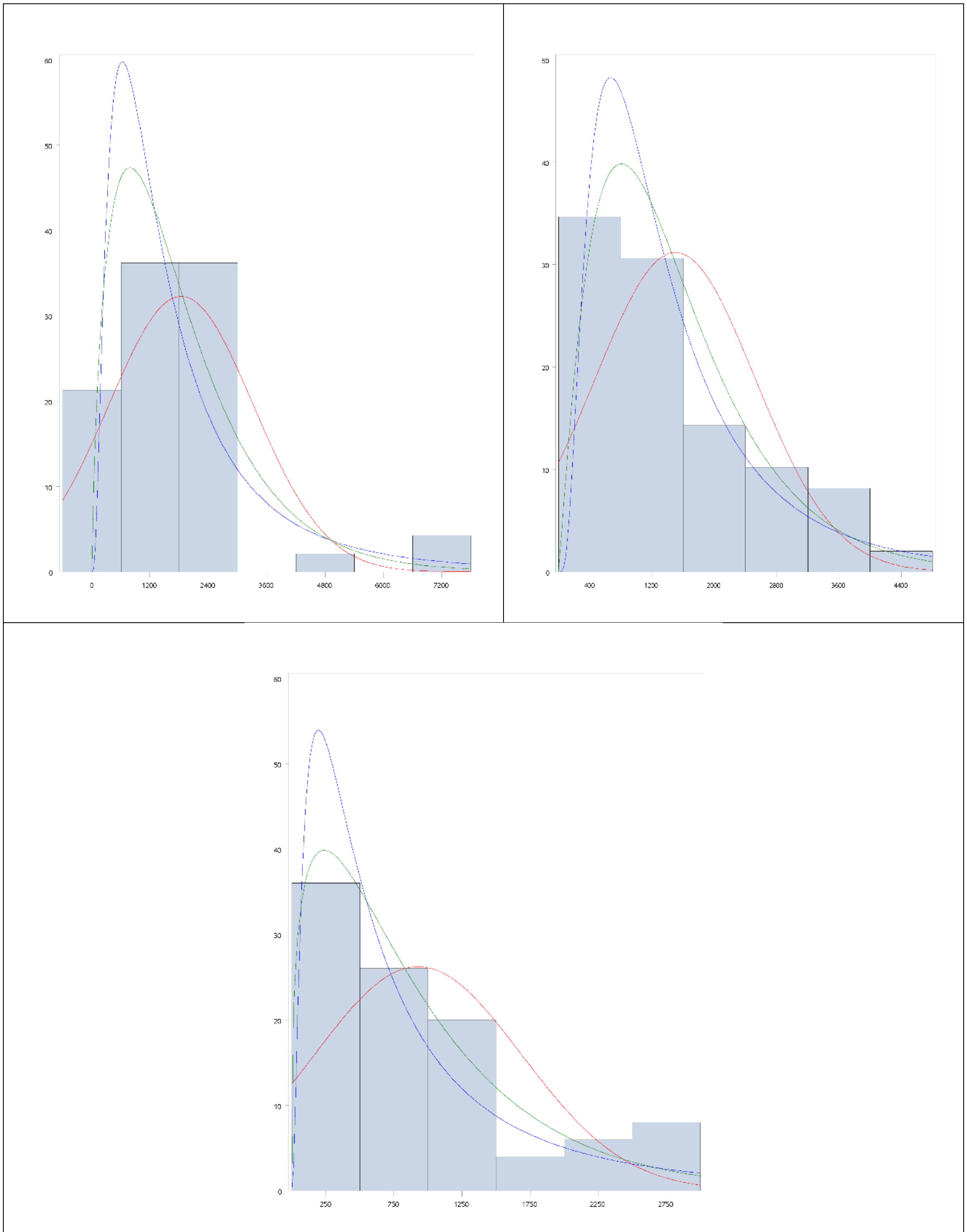
Outliers heavily influence the distributions of days afield and expenditures. This is true both nationally and across states. For instance, mean expenditures are approximately $3,000 but 1 percent spent over $27,000. These problems carry over to the weighted distributions as well, creating modelling issues that will be discussed later in the document.

National Expenditures, $/person (Zero Values Excluded)					
Activity	**Mean**	**Median**	**Max**	**Min**	**Std. Dev.**
Hunt	2200	700	>50000	< 15	5800
Fish	1800	350	>50000	< 15	5200
WW	1200	200	>90000	< 15	4900

The distribution of state means has a smaller range and smaller standard deviation than the national for all activities.

Average Expenditures Across States, Average $/person per state (Zero Values Excluded)					
Activity	**Mean**	**Median**	**Max**	**Min**	**Std. Dev.**
Hunt	1800	1700	7500	100	1500
Fish	1500	1400	4400	300	1000
WW	900	700	2900	30	750

All three activity distributions are fit by a normal (red line), lognormal (blue line), and gamma distribution below. Wildlife watching and fishing are best modelled by a gamma distribution (green line). The hunting is heavily influence by large values in the tail.



Counterclockwise from top: Hunting, Fishing, Wildlife-Watching

Post-Stratification

All survey weights had to be modified to produce state-level estimates. We explored 4 ways of performing the post-stratification. The procedural steps of each method are briefly outlined below.

- **Method 1**
  - First division and state populations are raked.
    - For each division i, sum the $perwgt$'s of all entries aged 16 and above to obtain $div\_pop\_16p_i$; these were compared to internal division populations, $internal\_div\_pop\_16p_i$ so that $div\_rake\_16p_i = \frac{div\_pop\_16p_i}{internal\_div\_pop\_16p_i}$.
    - For division i and state j within division i, $sae\_pop\_16p_{ij} = div\_rake\_16p_i * internal\_st\_pop\_16p_{ij}$
  - Within each state i, the $perwgt$'s were summed to obtain $st\_pop\_16p_{ij}$; the state raking factor is then $st\_rake\_16p_{ij} = \frac{sae\_pop\_16p_{ij}}{st\_pop\_16p_{ij}}$. It is assumed that this state population is fixed, so all replicate state population totals are raked to it.
    - The final population weights for the 16 and above population are the $perwgt$'s multiplied by the state raking factor. This method is repeated to obtain $st\_pop\_615_{ij}$ for the aged 6-15 and population.
  - Now we consider the sporting weights $spwgt$ and non-consumptive weights $ncwgt$. For each state i within division j, identify a screener population, $st\_screener\_pop_{ij}$ and pre-screener population which is the complement:
    $st\_screener\_pop_{ij} = sae\_pop\_16p_{ij} - st\_prescreener\_pop_{ij}$
  - The state sporting and non-consumptive raking factors are

$$st\_sport\_rake_{ij} = \frac{sae\_pop\_16p_{ij} - st\_prescreener\_pop_{ij}}{st\_sport\_pop_{ij}}$$

$$st\_nc\_rake_{ij} = \frac{sae\_pop\_16p_{ij} - st\_prescreener\_pop_{ij}}{st\_nc\_pop_{ij}}$$

where $st\_sport\_pop_{ij}$ and $st\_nc\_pop_{ij}$ denote the sum of the $spwgt$'s times $st\_rake\_16p_{ij}$ and the sum of the $ncwgt$'s times $st\_rake\_16p_{ij}$. Final sporting weights and non-consumptive weights are

$$fhwar\_spwgt = st\_sp\_rake_{ij} * st\_rake_{ij} * spwgt$$

$$fhwar\_ncwgt = st\_nc\_rake_{ij} * st\_rake_{ij} * ncwgt$$

- **Method 2**
  - This is similar to Method 1 but with a small modification. For a selected PSU k, the probability a household was from a particular state j, within division i can be estimated as $psu\_st\_select\_prob_{ijk} = \frac{PSU\ VHUs\ in\ state\ j}{Total\ PSU\ VHUs}$.
  - Now continue as in Method 1 but with $perwgt$'s replaced by $\frac{perwgt}{psu\_st\_select\_prob_{ijk}}$ and the final sporting and non-consumptive weights defined as

$$fhwar\_spwgt = \frac{st\_rake_{ij} * st\_sp\_rake_{ij} * spwgt}{psu\_st\_select\_prob_{ijk}}$$

$$fhwar\_ncwgt = \frac{st\_rake_{ij} * st\_nc\_rake_{ij} * ncwgt}{psu\_st\_select\_prob_{ijk}}$$

- **Method 3**
  - The division and state populations are raked as before and the final sporting and non-consumptive weights, for a respondent in state j and division i, are defined as

$$fhwar\_spwgt = st\_rake_{ij} * spwgt$$

$$fhwar\_ncwgt = st\_rake_{ij} * ncwgt$$

- **Method 4**
  - Apply Method 1 uniformly, i.e. we allow the final sporting and non-consumptive weights for ME, OK, VA, and MN to change slightly.

The raking factors for both the 16p and 6-15 population have a wide range of values. There are eight states which have a raking factor above two for the 6-15 population across all methods; there are three such states for the 16p population. Removing the states with raking factors above two from the analysis aligns the mean more closely with the median. Note that there is not a large difference between Method 2 and the other three.

State Population Raking Factors Comparison 6-15					
Method	**Mean**	**Median**	**Max**	**Min**	**Std**
1	1.5990	1.0220	13.9600	0.5028	1.5990
2	1.5740	1.0080	13.9600	0.5028	1.5740
3	1.5990	1.0220	13.9600	0.5028	1.5990
4	1.5980	1.0220	13.9500	0.5028	1.5980
State Population Raking Factors Comparison 16p					
Method	**Mean**	**Median**	**Max**	**Min**	**Std**
1	1.1590	1.0010	3.8330	0.6656	1.1590
2	1.1300	1.0000	3.8330	0.6174	1.1300
3	1.1590	1.0010	3.8330	0.6656	1.1590
4	1.1590	1.0030	3.8330	0.6656	1.1590

State Population Raking Factors Comparison 6-15 Rake < 2					
Method	**Mean**	**Median**	**Max**	**Min**	**Std**
1	1.0220	1.0000	1.9030	0.5028	1.0220
2	0.9926	1.0000	1.9030	0.5028	0.9926
3	1.0220	1.0000	1.9030	0.5028	1.0220
4	1.0220	1.0000	1.9030	0.5028	1.0220

State Population Raking Factors Comparison 16p Rake < 2					
Method	**Mean**	**Median**	**Max**	**Min**	**Std**
1	1.0490	1.0000	1.9520	0.6656	1.0490
2	1.0180	1.0000	1.9520	0.6174	1.0180
3	1.0490	1.0000	1.9520	0.6656	1.0490
4	1.0490	1.0010	1.9520	0.6656	1.0490

In terms of activity x indicator estimates, with respect to hunting, Method 1 is closer to national estimates but is more volatile across divisions than Method 3. For the other activities, Method 3 tends to be closer to the original survey estimates than Method 1.

Hunting			
Method	**Participation Total**	**Days Afield Total**	**Expenditures Total**
Survey	11450000	184000000	26190000000
1	11490000	184000000	25230000000
2	11870000	224600000	26370000000
3	11530000	188700000	25890000000
4	11480000	184000000	25220000000

Hunt Participation Estimate and Survey Estimate Difference Comparison by Division								
	Mean by Method				Std. Deviation by Method			
Div.	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1	-5646	-7352	640	-5634	9872	13030	8412	9888
2	-24190	-53940	-6493	-24190	109100	92460	44260	109100
3	-11350	91440	-13240	-11350	256700	351000	89040	256700
4	4149	2281	1340	4093	56670	56540	41080	56650
5	3240	6121	178	3239	62900	47230	26650	62900
6	5275	-4834	7661	5275	80900	77730	141700	80900
7	6673	6635	1530	6692	37090	37100	28810	37010
8	-5664	-5664	5543	-5664	35900	35900	26640	35900
9	27510	27510	12330	27510	57050	57050	23740	57050

Hunting National Total Divided by Survey National Total			
Method	**Participation**	**Days Afield Total**	**Expenditures Total**
1	1.003	1.000	0.963
2	1.037	1.221	1.007
3	1.007	1.026	0.989
4	1.003	1.000	0.963

Fishing National Total Divided by Survey National Total			
Method	**Participation**	**Days Afield Total**	**Expenditures Total**
1	1.021	0.9488	0.9709
2	1.014	0.9451	0.963
3	1.005	0.9928	1.002
4	1.021	0.9488	0.9709

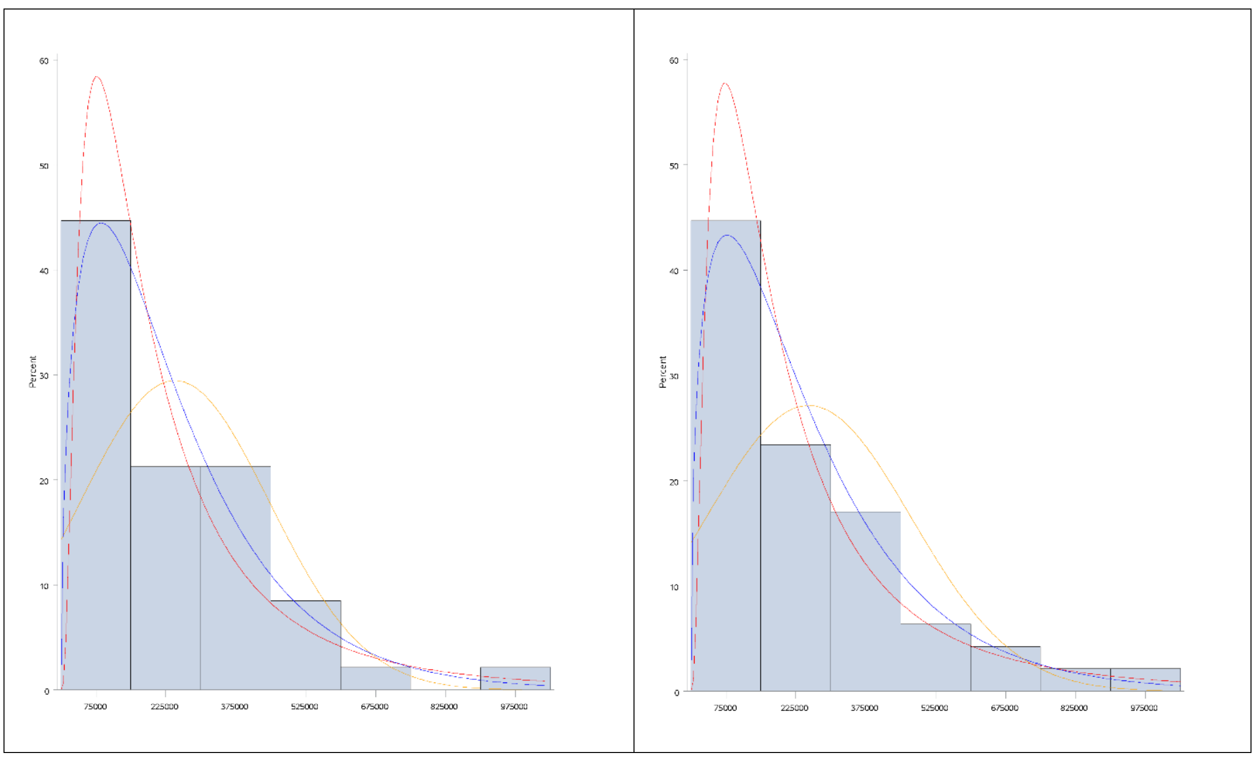
WW National Total Divided by Survey National Total			
Method	**Participation Total**	**Days Afield Total**	**Expenditures Total**
1	1.011	0.9602	1.159
2	1.026	0.9709	1.149
3	0.9929	0.9644	1.05
4	1.011	0.9603	1.159

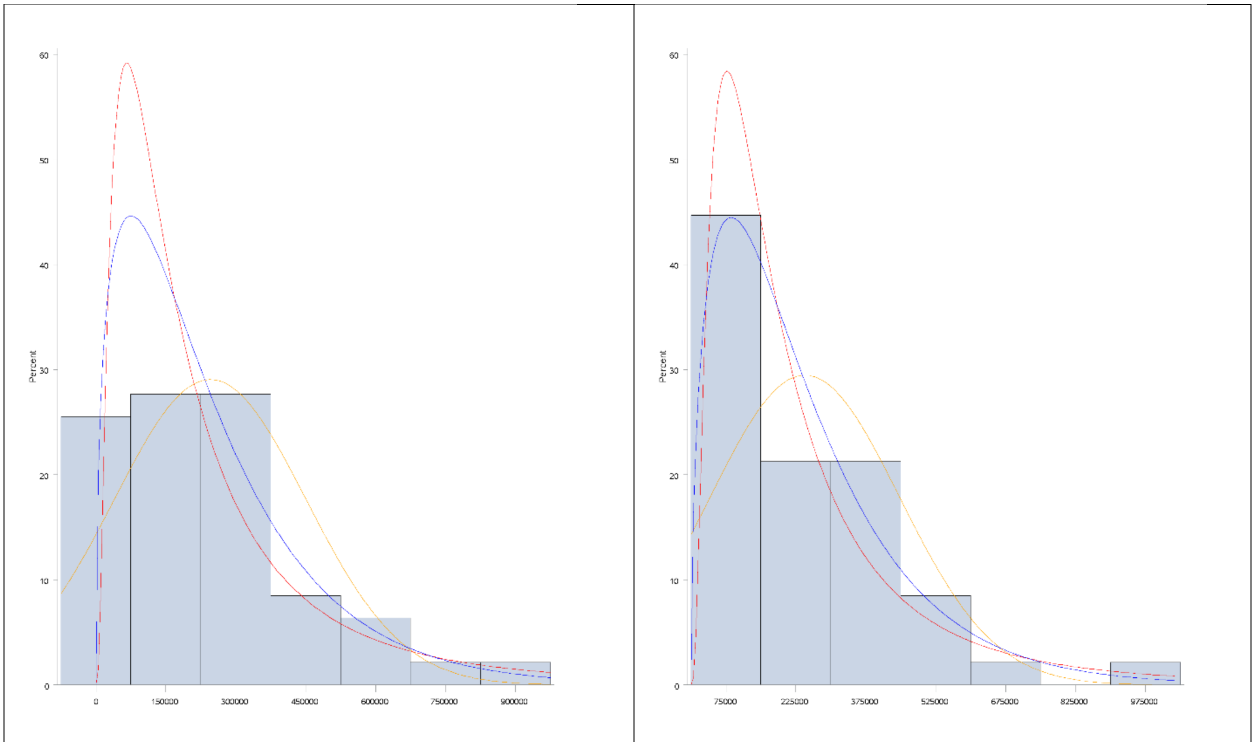
All methods produce lower CVs than the original survey estimates because of population raking. Methods 1, 2, and 4 have mean CVs which are generally higher and closer to the initial mean CVs produced by the survey estimates than Method 3.

	Participation Mean CVs			Days Afield Mean CVs		
Method	**Hunt**	**Fish**	**WW**	**Hunt**	**Fish**	**WW**
Survey	0.5279	0.4733	0.4532	0.6195	0.5364	0.6692
1	0.4866	0.3841	0.3413	0.5837	0.4698	0.6353
2	0.485	0.3858	0.3157	0.58	0.4648	0.6137
3	0.467	0.377	0.3516	0.5617	0.453	0.6087
4	0.4866	0.3841	0.3413	0.5837	0.4698	0.6353

	Expenditures Mean CVs		
Method	**Hunt**	**Fish**	**WW**
Survey	0.7039	0.6234	0.6198
1	0.6607	0.5509	0.5725
2	0.662	0.5438	0.5704
3	0.6474	0.5351	0.5378
4	0.6607	0.5509	0.5725

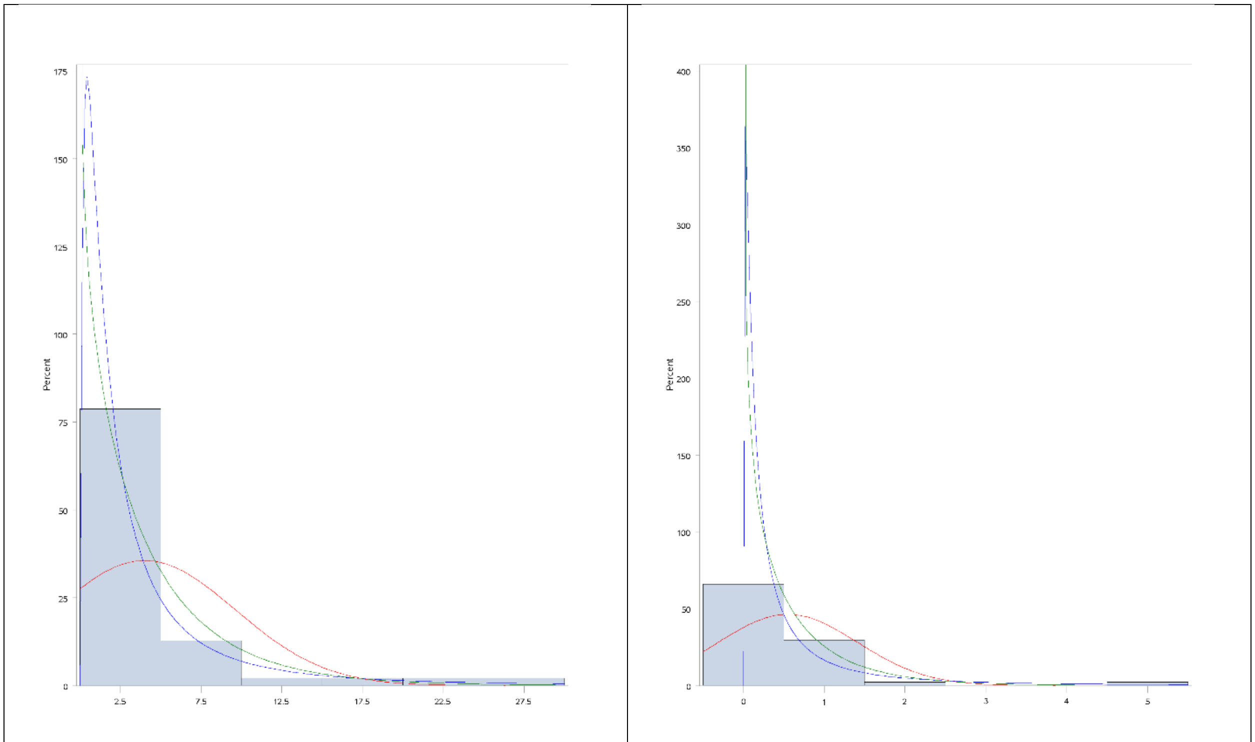
Below we fit a lognormal, gamma, and normal distribution to the state hunting participation estimates for each of the methods. Method 3 has a poorer fit than Method 1 and Method 4 with respect to the normal and lognormal distributions, which we will later model.





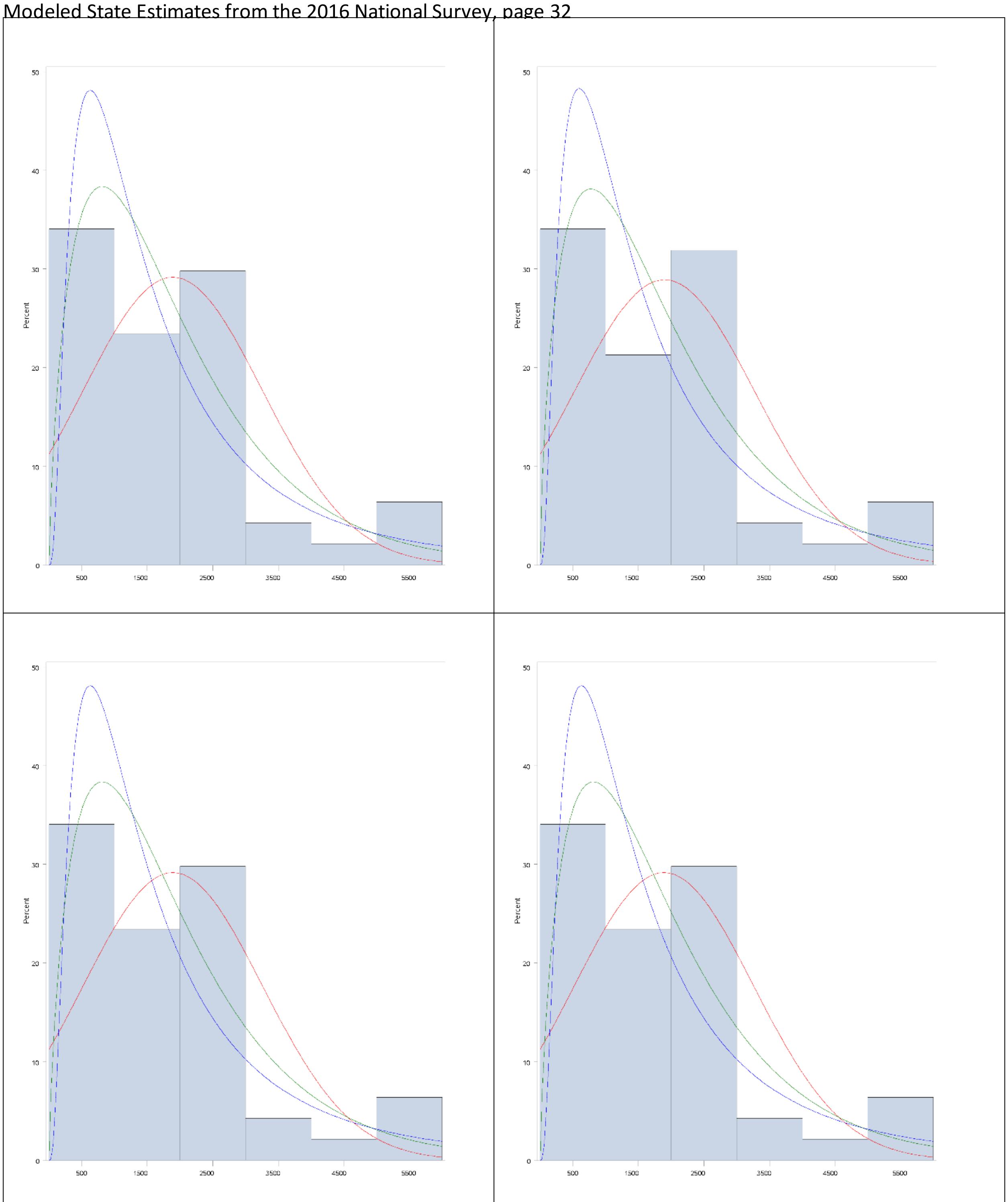
From Upper Left Clockwise: Participation calculated by Method 1, Method 2, Method 4, Method 3
Lognormal shown in red, gamma in blue, and normal in yellow

Weighting segments or clusters total days afield and total expenditures around relatively small values; it tends to amplify outliers. This is typified by the histograms below.



Total Days afield and Total Expenditures Calculated using Method 3 weights

The corresponding rates for days afield and expenditures are less affected by weighting, being similar to the original empirical distributions. Curve fits for Normal distribution in red, log-normal in blue and gamma in green.



From Upper Left Clockwise: Expenditures per hunter calculated by Method 1, Method 2, Method 4, Method 3

Above chart displays expenditures per hunter state-level weighted estimates for the four different methods of post-stratification. Fitted curves for the empirical distribution are overlaid, with normal distribution in red, log-nomal in blue and gamma in green. Method 2 is too volatile to use in the models;

it can produce estimates that are very different from published totals. There is not a large difference between Methods 1, 3, and 4. Method 1 is to be preferred over Method 4, since there is little reason to modify the highly sampled areas other than consistency. The choice for which method to use comes down to Method 1 versus Method 3. As shown above, Method 3 can produce estimates which are difficult to model and Method 1 has preferable CV distributions so what follows will use Method 1's weights for all estimates.

Models

- **Overview**
  - **Fay Herriot Model**

For each state i we assume

y_i	=	$Y_i + u_i$
Y_i	=	$\mathbf{x}_i'\beta + e_i$

where y_i is the direct survey estimate of a (transformed) response variable, $\mathbf{x}_i$ is a set of covariates and the errors, e_i and u_i are independent such that $e_i \sim N(0, \sigma^2)$ and $u_i \sim N(0, v_i)$. The empirical best predictor $\widehat{Y_i}$ of Y_i is

$$\widehat{Y_i} = w_i\left(x_i'\hat{\beta}\right) + (1 - w_i)y_i$$

where $w_i = \frac{v_i}{\hat{\sigma}^2 + v_i}$ and best refers to the unbiased linear estimator of least variance. $\widehat{Y_i}$ is a convex combination of the original survey estimate y_i and the regression estimate $x_i'\hat{\beta}$. Notice that large values of w_i give more weight to the regression estimate, while smaller values give more weight to the survey estimate. Since w_i is a decreasing function of $\frac{\hat{\sigma}^2}{v_i}$, smaller values of $\hat{\sigma}^2$ produce larger weight values, i.e. as the variance of the regression becomes smaller the regression estimate is weighted more, as v_i becomes smaller the survey estimate is given more weight.

- **Transformations and Nomenclature**

The estimate $\widehat{Y_i}$, is transformed back to its native scale to obtain $\widehat{Z_i}$.
The transformations used for each activity are summarized in the following table:

Activity	Transformations Used
Participation	identity, logarithm, logit
Days afield	identity, logarithm
Expenditures	Identity, logarithm

If y_i an initial estimate of the participation in an activity for state i and p_i the state's total population, we use the term naïve rate in reference to modeling $r_i = \frac{y_i}{p_i}$; log-rate in reference to modeling $\log r_i$; log-count in reference to modeling $\log y_i$; and logistic in reference to modeling $\log \frac{r_i}{1 - r_i}$. Similarly if z_i is an estimate of expenditures or days afield for a given activity and y_i the corresponding participation, then the naïve rate is used in reference to modeling $r_i = \frac{z_i}{y_i}$; log-rate in reference to modelling $\log r_i$; log-count in reference to modelling $\log z_i$.

- **Raking**

  For a given activity x indicator combination, the sum of the $\widehat{Z}_i$ does not necessarily match published national totals. In the case of participation, we use stochastic Taylor series expansions to rake the sum of the $\widehat{Z}_i$ to published totals. Specifically, if *P* corresponds to the published total, then we define

rk	=	$\frac{P}{\widehat{P}}$
$\widehat{P}$	=	$\sum_i \widehat{Z}_i$
SAE_i	=	$rk\widehat{Z}_i$

  and use the following formulas to estimate the variances of rk and SAE_i,

$V_{x/y}$	≈	$\frac{V_x}{{y_0}^2} + \frac{V_y {x_0}^2}{{y_0}^4}$
V_{xy}	≈	$V_x V_y + {x_0}^2 V_y + {y_0}^2 V_x$

  where $V_{x/y}$ and V_{xy} are the variances of $\frac{x}{y}$ and xy.The final estimate in the case of participation is SAE_i. The same process is omitted for days afield and expenditures so that our final estimates in these cases are the $\widehat{Z}_i$. We do this for two reasons. First, the estimates for expenditures and days afield tend to be skewed by a few outliers (e.g., in the case of expenditures a handful of respondents who make large purchases) which can make the raking factors large. Secondly, the variances of the published estimates for expenditures and days afield have large variances; as a result, the variance of SAE_i is much larger than the variance of $\widehat{Z}_i$.

- **Implementation**

We optimize the log-likelihood and restricted log-likelihood using numerical programs in SAS; these are defined below using the same notation as in the previous section:

$l(\beta,\sigma)$	=	$-\frac{1}{2}\sum_{i=1}^{m}\log(\sigma^2+v_i) - \frac{1}{2}\sum_{i=1}^{m}\frac{(\mathbf{x}_i'\beta - y_i)^2}{\sigma^2+v_i} + c$
$rl(\beta,\sigma)$	=	$-\frac{1}{2}\sum_{i=1}^{m}\log(\sigma^2+v_i) - \frac{1}{2}\sum_{i=1}^{m}\frac{(\mathbf{x}_i'\beta - y_i)^2}{\sigma^2+v_i} - \frac{1}{2}\log\left\lvert\sum_{i=1}^{m}\frac{\mathbf{x}_i\mathbf{x}_i'}{\sigma^2+v_i}\right\rvert + c$

We allow the naïve rate model to iteratively update the sampling variances, for the others we leave the sampling variances unchanged through the iteration. By iteratively updating, we mean that we estimate $\beta^{(k)}$, $\sigma^{2(k)}$, and

$$v_i^{(k)} = \frac{\mathbf{x}_i'\beta^{(k)}(1-\mathbf{x}_i'\beta^{(k)})}{y_i(1-y_i)} v_i^{(0)}$$

until convergence. For $v_i^{(0)}$ we use the replicate weight variance; note also that this is based off of the GVF $Variance(\hat{X}) = a\hat{X} + b\,\hat{X}^2$, with $a = 1$ and $b = -1$ and keeps $\frac{v_i^{(k)}}{\mathbf{x}_i'\beta^{(k)}(1-\mathbf{x}_i'\beta^{(k)})}$ constant. This scheme does not work well for expenditures and days afield (which do not fit the GVF $Variance(\hat{X}) = a\hat{X} + b\,\hat{X}^2$ very well) so we use an update scheme based off a logarithmic GVF, i.e. $\log\left(Variance(\hat{X})\right) = a + b\log(\hat{X})$. For these indicators, we update $\beta^{(k)}$, $\sigma^{2(k)}$, and

$$v_i^{(k)} = \left(\frac{\mathbf{x}_i'\beta^{(k)}}{y_i}\right)^q v_i^{(0)}$$

for a suitable exponent q (≈1.84) chosen by examination. The result of updating is to make the model behave more like the others.

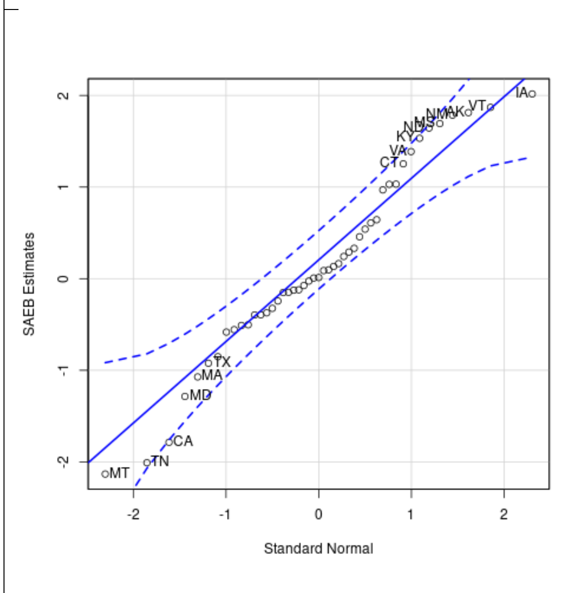
- **Participation**

Hunting Participation Models CVs					
ML no GVF					
	Model	**Mean CV**	**Median CV**	**Max CV**	**Min CV**
Initial CVs	**Rate**	0.5831	0.4973	2.175	0.09518
	Log-rate	0.5636	0.4602	2.12	0.1329
	Log-count	0.5232	0.4056	2.17	0.1443
	Logistic	0.573	0.4679	2.209	0.1304
Final CVs	**Rate**	0.2315	0.1947	0.8354	0.1553
	Log-rate	0.245	0.2446	0.3847	0.1647
	Log-count	0.2121	0.2036	0.4085	0.1546
	Logistic	0.2488	0.2483	0.37	0.1568
REML no GVF					
	Model	**Mean CV**	**Median CV**	**Max CV**	**Min CV**
Initial CVs	**Rate**	0.5803	0.4945	2.134	0.09414
	Log-rate	0.5605	0.4671	2.076	0.1331
	Log-count	0.5229	0.416	2.128	0.1476
	Logistic	0.5694	0.4751	2.158	0.1304
Final CVs	**Rate**	0.2453	0.1966	0.9803	0.1555
	Log-rate	0.2694	0.2709	0.411	0.1675
	Log-count	0.2349	0.2314	0.4245	0.1624
	Logistic	0.2744	0.2797	0.3998	0.1619

Hunting Participation Models Diagnostics					
ML no GVF					
	Model	**Mean**	**Median**	**Max**	**Min**
Wt1	**Rate**	0.833	0.9292	1	0.1317
	Log-rate	0.836	0.8615	1	0.2652
	Log-count	0.9217	0.9413	1	0.4821
	Logistic	0.8399	0.8696	1	0.2615
Zres	**Rate**	0.15	0.0123	2.016	-2.132
	Log-rate	0.02464	-0.06143	1.684	-2.334
	Log-count	-0.02296	-0.003148	2.049	-2.601
	Logistic	-0.04038	0.05175	2.384	-1.725
Raking					
		Natl. Rk	**Mean Div Rk**	**Max. Div Rk**	**Min Div Rk**
	Rate	1.019	1.07	1.334	0.7955
	Log-rate	1.004	1.043	1.278	0.7822
	Log-count	1.027	1.068	1.394	0.807
	Logistic	1.027	1.035	1.253	0.784
REML no GVF					
	Model	**Mean**	**Median**	**Max**	**Min**
Wt1	**Rate**	0.8016	0.9047	1	0.09977
	Log-rate	0.7779	0.8003	1	0.1887
	Log-count	0.8628	0.8879	1	0.3149
	Logistic	0.7841	0.8122	1	0.1868
Zres	**Rate**	0.1485	0.003443	1.993	-2.195
	Log-rate	0.02251	-0.05898	1.678	-2.23
	Log-count	-0.01499	-0.008842	1.814	-2.556
	Logistic	-0.03851	0.05164	2.294	-1.713
Raking					
		Natl. Rk	**Mean Div Rk**	**Max. Div Rk**	**Min Div Rk**
	Rate	1.019	1.07	1.345	0.794
	Log-rate	0.9998	1.036	1.261	0.7972
	Log-count	1.024	1.061	1.356	0.8288
	Logistic	0.9936	1.029	1.237	0.8014

Hunting R^2 and Coefficient T-statistic Comparison				
ML no GVF				
Variable	**Rate**	**Log-rate**	**Log-count**	**Logistic**
R^2	0.5785	0.7247	0.8339	0.7108
Hunters	4.772	6.829	4.388	6.688
MWGLF	3.702	3.152	3.9	3.153
NESW	-1.003	-1.992	-3.15	-1.944
Hrs. Worked	-1.961	-2.468	-2.054	-2.172
Population			4.498	
REML no GVF				
Variable	**Rate**	**Log-rate**	**Log-count**	**Logistic**
R^2	0.5684	0.7188	0.8329	0.7041
Hunters	4.645	6.71	4.315	6.556
MWGLF	3.765	3.218	4.039	3.224
NESW	-0.9441	-1.869	-2.914	-1.815
Hrs. Worked	-2.033	-2.585	-2.178	-2.291
Population			4.46	

ML No GVF



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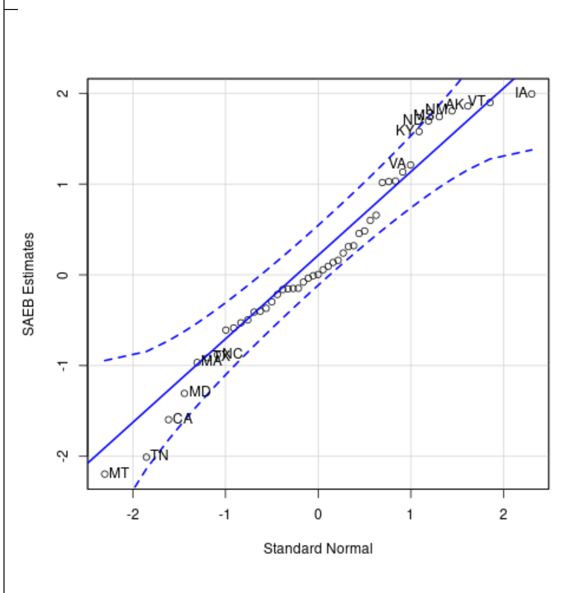

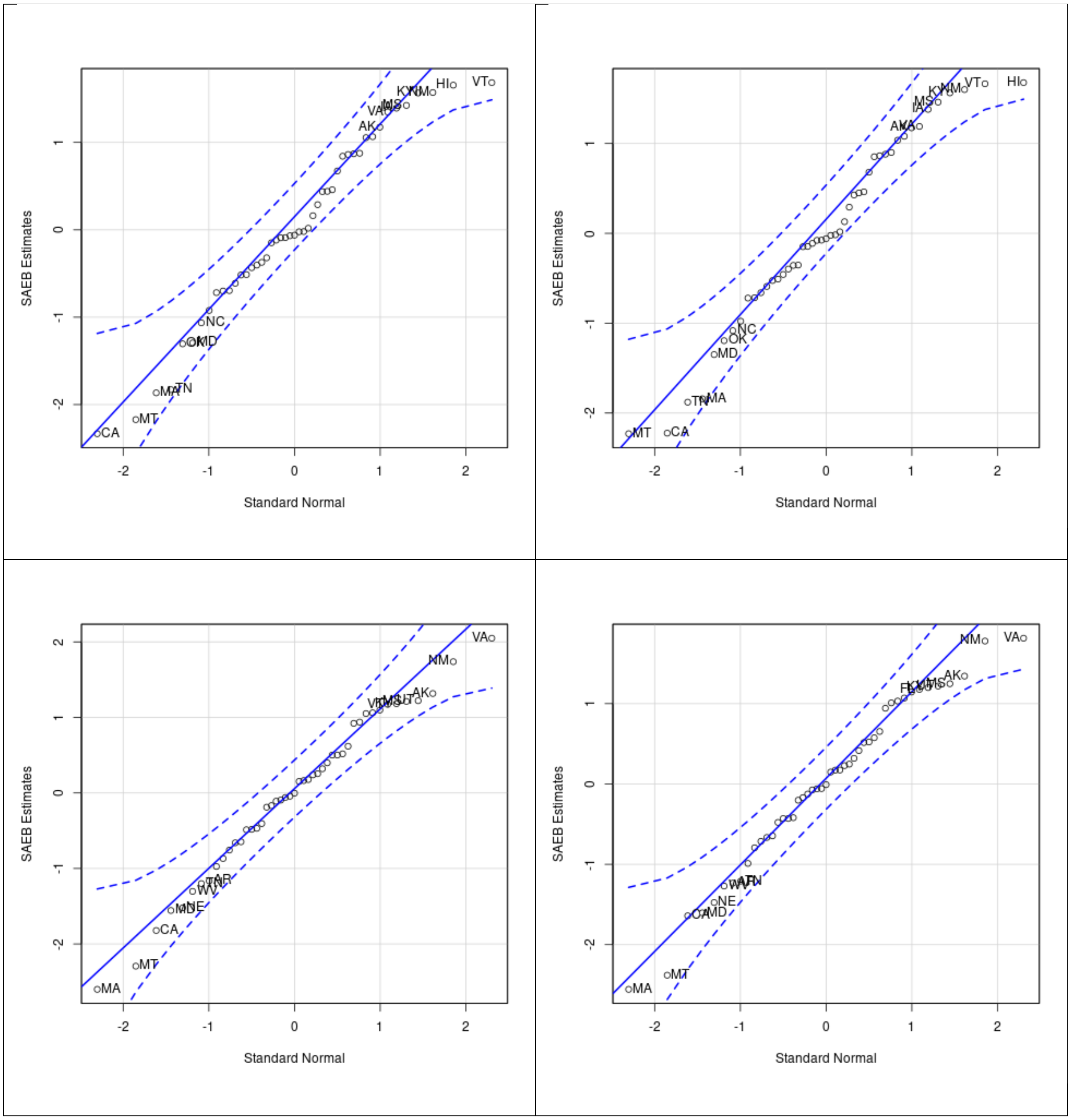
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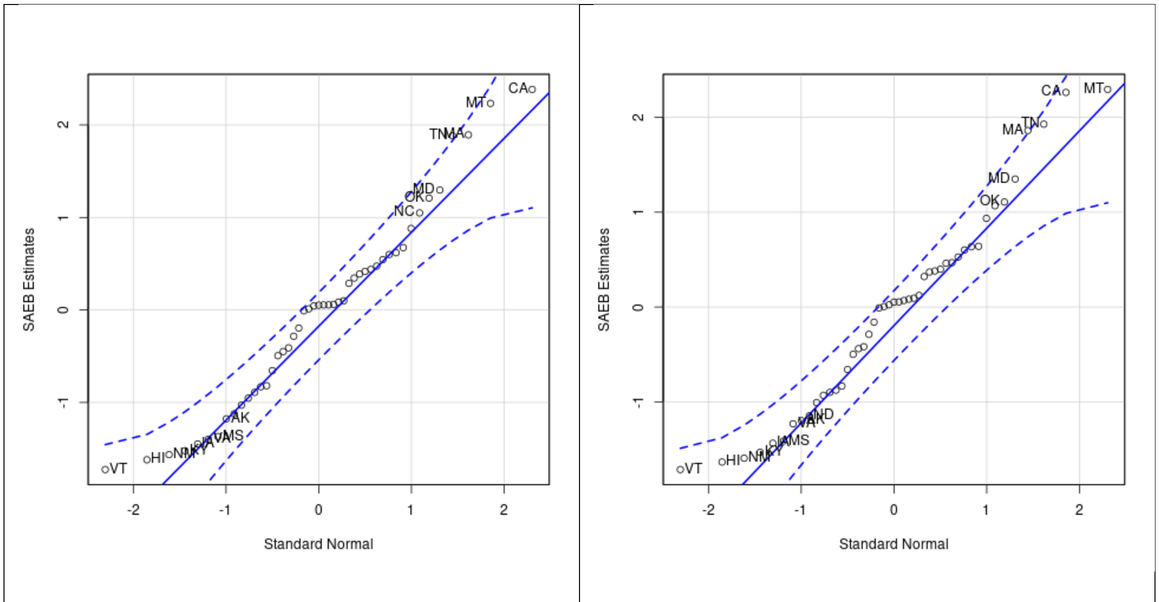


From top: Rate, Log-rate, Log-count, and Logistic models

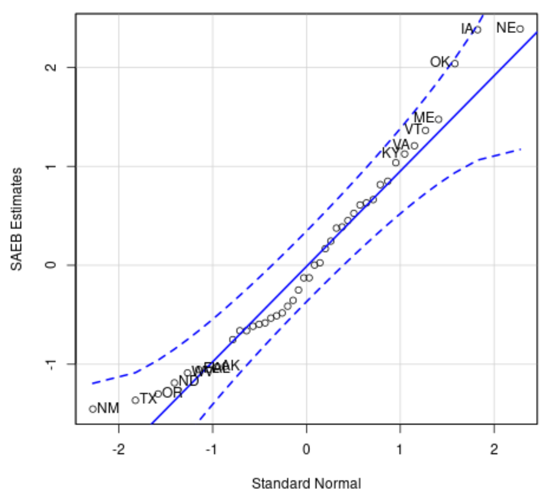
- **Days Afield**

Hunting Days Afield Models CVs					
ML no GVF					
Initial CVs	**Model**	**Mean CV**	**Median CV**	**Max CV**	**Min CV**
	Rate	0.6164	0.4655	2.616	0.09578
	Log-rate	0.6557	0.5126	2.947	0.1071
	Log-count	0.6763	0.6046	2.166	0.1022
Final CVs	**Rate**	0.4308	0.386	2.031	0.1215
	Log-rate	0.5347	0.4376	3.338	0.08544
	Log-count	0.3281	0.3219	0.4702	0.2158
REML no GVF					
Initial CVs	**Model**	**Mean CV**	**Median CV**	**Max CV**	**Min CV**
	Rate	0.6129	0.4908	2.607	0.09489
	Log-rate	0.6545	0.5127	2.93	0.1066
	Log-count	0.6747	0.6043	2.127	0.1019
Final CVs	**Rate**	0.4045	0.3516	1.65	0.1414
	Log-rate	0.5451	0.4441	2.92	0.1047
	Log-count	0.3383	0.3325	0.4793	0.2156

Hunting Days Afield Models Diagnostics					
ML no GVF					
	Model	**Mean**	**Median**	**Max**	**Min**
Wt1	**Rate**	0.8727	0.901	1	0.41
	Log-rate	0.5184	0.5122	1	0.03546
	Log-count	0.8587	0.8939	1	0.318
Zres	**Rate**	0.03527	-0.127	2.389	-1.453
	Log-rate	0.01533	-0.04923	2.126	-2.948
	Log-count	0.02468	0.1085	2.889	-2.598
Raking					
		Natl. Rk	**Mean Div Rk**	**Max. Div Rk**	**Min Div Rk**
	Rate	1.034	1.072	1.694	0.6064
	Log-rate	1.052	1.079	1.65	0.691
	Log-count	1.033	1.034	1.402	0.7462
REML no GVF					
	Model	**Mean**	**Median**	**Max**	**Min**
Wt1	**Rate**	0.8597	0.8886	1	0.3788
	Log-rate	0.4947	0.4789	1	0.03116
	Log-count	0.8397	0.8758	1	0.2805
Zres	**Rate**	0.03657	-0.1269	2.404	-1.457
	Log-rate	0.01476	-0.06125	2.144	-2.931
	Log-count	0.02506	0.1077	2.781	-2.596
Raking					
		Natl. Rk	**Mean Div Rk**	**Max. Div Rk**	**Min Div Rk**
	Rate	1.008	1.047	1.715	0.5822
	Log-rate	1.052	1.062	1.57	0.7102
	Log-count	1.021	1.032	1.395	0.7526

Hunting R^2 and Coefficient T-statistic Comparison			
ML no GVF			
Variable	**Rate**	**Log-rate**	**Log-count**
R^2	0.2826	0.403	0.8781
Hunters	2.615	2.575	15.37
Cluster 1	2.1	3.557	4.736
Cluster 2	-2.666	-2.152	-7.719
REML no GVF			
R^2	0.2814	0.4049	0.8794
Hunters	2.58	2.58	15.40
Cluster 1	2.12	3.596	4.848
Cluster 2	-2.646	-2.646	-7.766

ML No GVF



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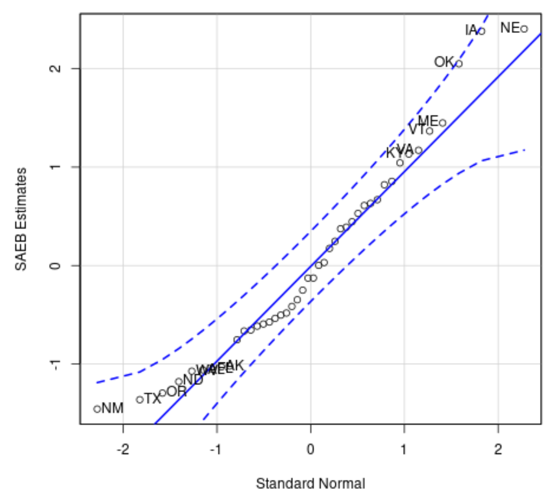

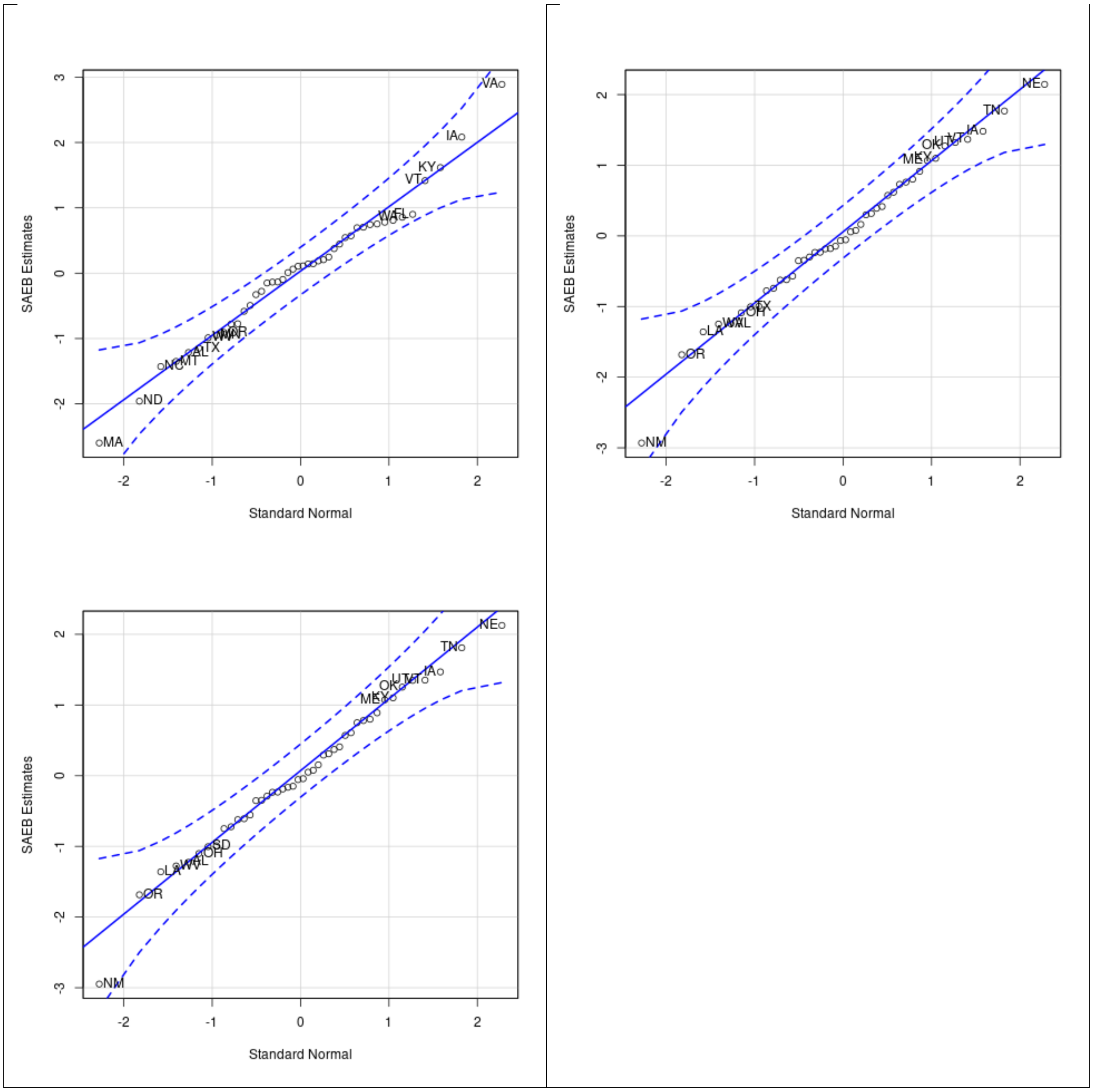
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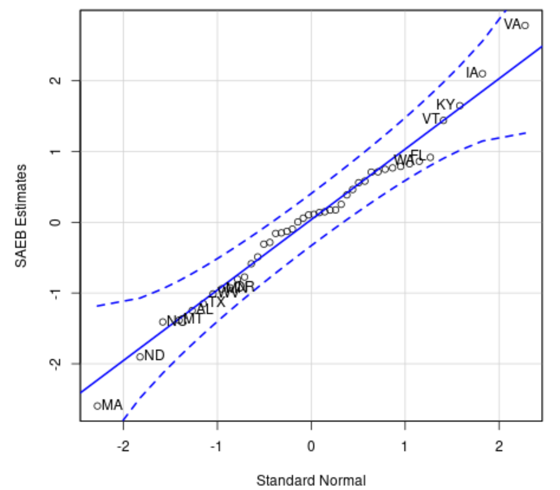


From top: Rate, Log-rate, and Log-count models

- **Expenditures**

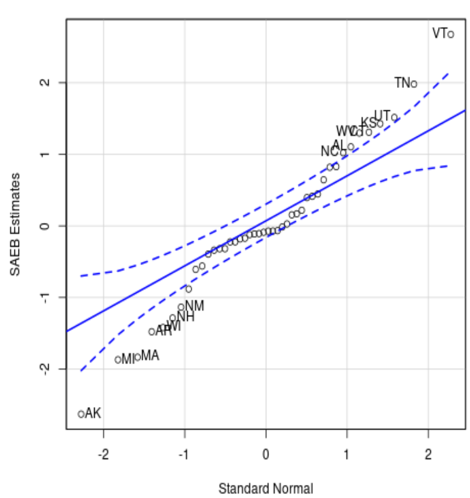
Hunting Expenditures Models CVs

	Model	Mean CV	Median CV	Max CV	Min CV
ML no GVF					
Initial CVs	**Rate**	0.6852	0.4842	4.366	0.01572
	Log-rate	0.7064	0.5444	4.675	0.02879
	Log-count	0.7753	0.6265	4.849	0.08013
Final CVs	**Rate**	0.3723	0.3633	0.5812	0.2981
	Log-rate	0.4013	0.3828	0.7148	0.2999
	Log-count	0.4126	0.4028	0.6377	0.3178
REML no GVF					
	Model	**Mean CV**	**Median CV**	**Max CV**	**Min CV**
Initial CVs	**Rate**	0.6867	0.485	4.401	0.01575
	Log-rate	0.7188	0.5581	4.871	0.02887
	Log-count	0.7733	0.6414	4.718	0.07918
Final CVs	**Rate**	0.3957	0.3717	0.7045	0.2951
	Log-rate	0.4224	0.4068	0.7424	0.3108
	Log-count	0.4626	0.4604	0.6816	0.3253

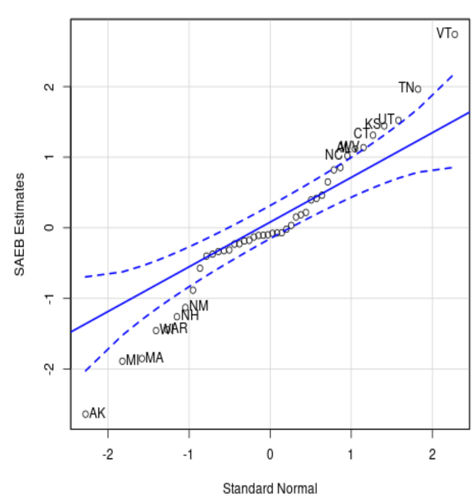
Hunting Expenditures Models Diagnostics					
ML no GVF					
	Model	**Mean**	**Median**	**Max**	**Min**
Wt1	**Rate**	1	1	1	1
	Log-rate	0.9000	0.9459	1	0.3289
	Log-count	0.8897	0.9196	1	0.4644
Zres	**Rate**	-0.002513	-0.08137	-0.002513	-0.08137
	Log-rate	-0.04935	-0.08004	2.243	-3.142
	Log-count	0.004873	-0.0001009	2.872	-2.961
Raking					
		Natl. Rk	**Mean Div Rk**	**Max. Div Rk**	**Min Div Rk**
	Rate	1.073	1.112	1.544	0.6842
	Log-rate	1.013	1.117	1.628	0.8551
	Log-count	0.9937	1.083	1.445	0.7352
REML no GVF					
	Model	**Mean**	**Median**	**Max**	**Min**
Wt1	**Rate**	0.9674	0.9921	1	0.5898
	Log-rate	0.8206	0.8833	1	0.175
	Log-count	0.8146	0.8495	1	0.2996
Zres	**Rate**	0.001873	-0.08754	2.738	-2.637
	Log-rate	-0.02311	-0.03965	1.958	-3.059
	Log-count	0.009162	0.02239	2.775	-2.846
Raking					
		Natl. Rk	**Mean Div Rk**	**Max. Div Rk**	**Min Div Rk**
	Rate	1.063	1.112	1.544	0.6842
	Log-rate	1.022	1.121	1.628	0.8551
	Log-count	0.9937	1.083	1.445	0.7352

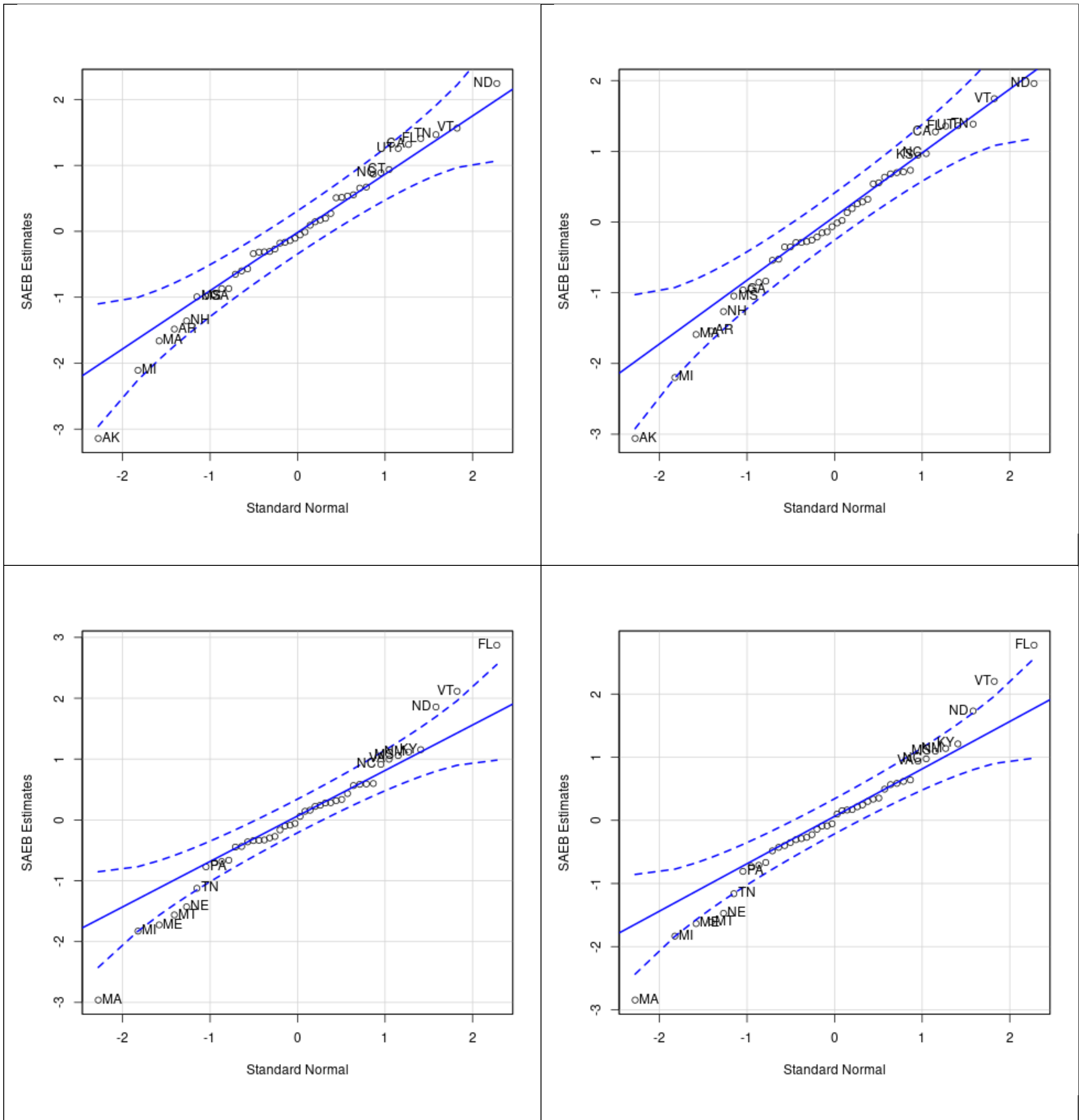
Hunting Coefficient T-statistic and R^2 Comparison			
ML no GVF			
Variable	**Rate**	**Log-rate**	**Log-count**
R^2	0.8865	0.8474	0.8418
Economic Indicator	5.223	7.348	9.001
Cluster 1	-7.681	-7.446	-4.286
Cluster 2	8.464	9.252	5.054
Cluster 3	1.213	2.224	3.252
Hunters	3.582	4.29	6.753
REML no GVF			
R^2	0.8737	0.837	0.8323
Economic Indicator	5.224	7.473	8.555
Cluster 1	-7.601	-7.267	-4.153
Cluster 2	8.504	9.115	5.154
Cluster 3	1.178	2.074	3.277
Hunters	3.621	4.313	6.748

ML No GVF



REML No GVF





From top: Rate, Log-rate, and Log-count models

GVFs

- **GVF for Participation**
  - We use a standard form of the GVF for concept rates. The formula (where *ESS* denotes effective sample size),

$$\mathbf{log}(\boldsymbol{SE\ of\ p}) = \boldsymbol{\beta_0} + \boldsymbol{\beta_1}\,\mathbf{log}(\boldsymbol{ESS}) + \boldsymbol{\beta_2}\,\mathbf{log}\big(\boldsymbol{P}(\mathbf{1}-\boldsymbol{P})\big) \qquad (1)$$

  - We define ESS for both the non-consumptive weights and the sportsperson weights separately. The formulas for sportspersons are below, the ones for non-consumptive weights are the same with $fhwar\_ncwgt_{ij}$ replacing $fhwar\_spwgt_{ij}$.

H_j	=	$\sum_{i \in household\ j} fhwar\_spwgt_{ij}$
ST_HH_k	=	$\sum_{j \in in\ state\ k} {H_j}^2$
ST_HH2_k	=	$\left(\sum_{j \in in\ state\ k} H_j\right)^2$
ESS	=	$\frac{ST\_HH2_k}{ST\_HH_k}$

  - We remove the highly sampled states from the GVF and do not change their variances at all. We only use states with an effective sample size greater than or equal to 5 to estimate β_0, β_1, and β_2. Then we use these betas to calculate variances for all states outside of the four highly sampled ones.

We run the model twice. The first run uses the replicate weight variances. The model output from the first run is used for *P* in **(1)** and the second run uses the GVF variances.

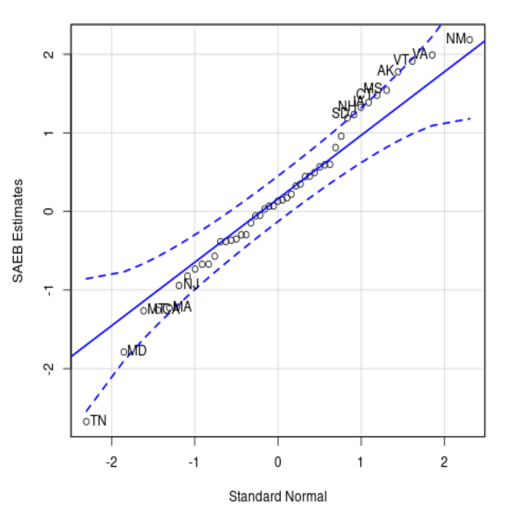
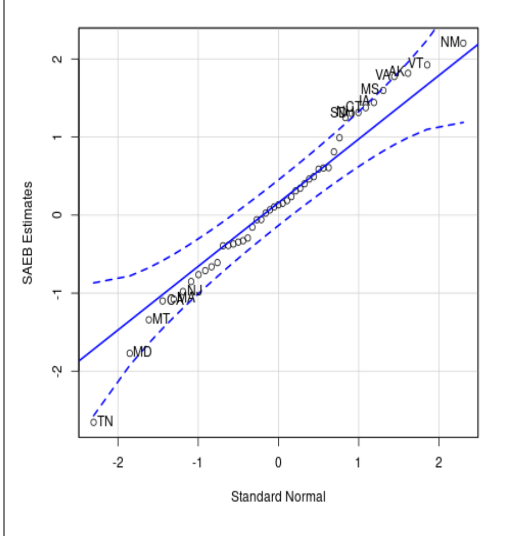
Hunting Participation GVF Count SE Comparison Among Non-Zero Values				
ML GVF				
	Mean SE	**Median SE**	**Max SE**	**Min SE**
Original	115500	87960	392800	11390
Rate	118700	87960	365300	11390
Log-rate	115000	91520	326100	8789
Log-count	115100	91120	327100	9782
Logistic	114600	91490	328300	10060
REML GVF				
Rate	118500	91140	366000	8722
Log-rate	114200	90060	328100	9548
Log-count	115000	91040	328400	9913
Logistic	113800	89450	330700	9315

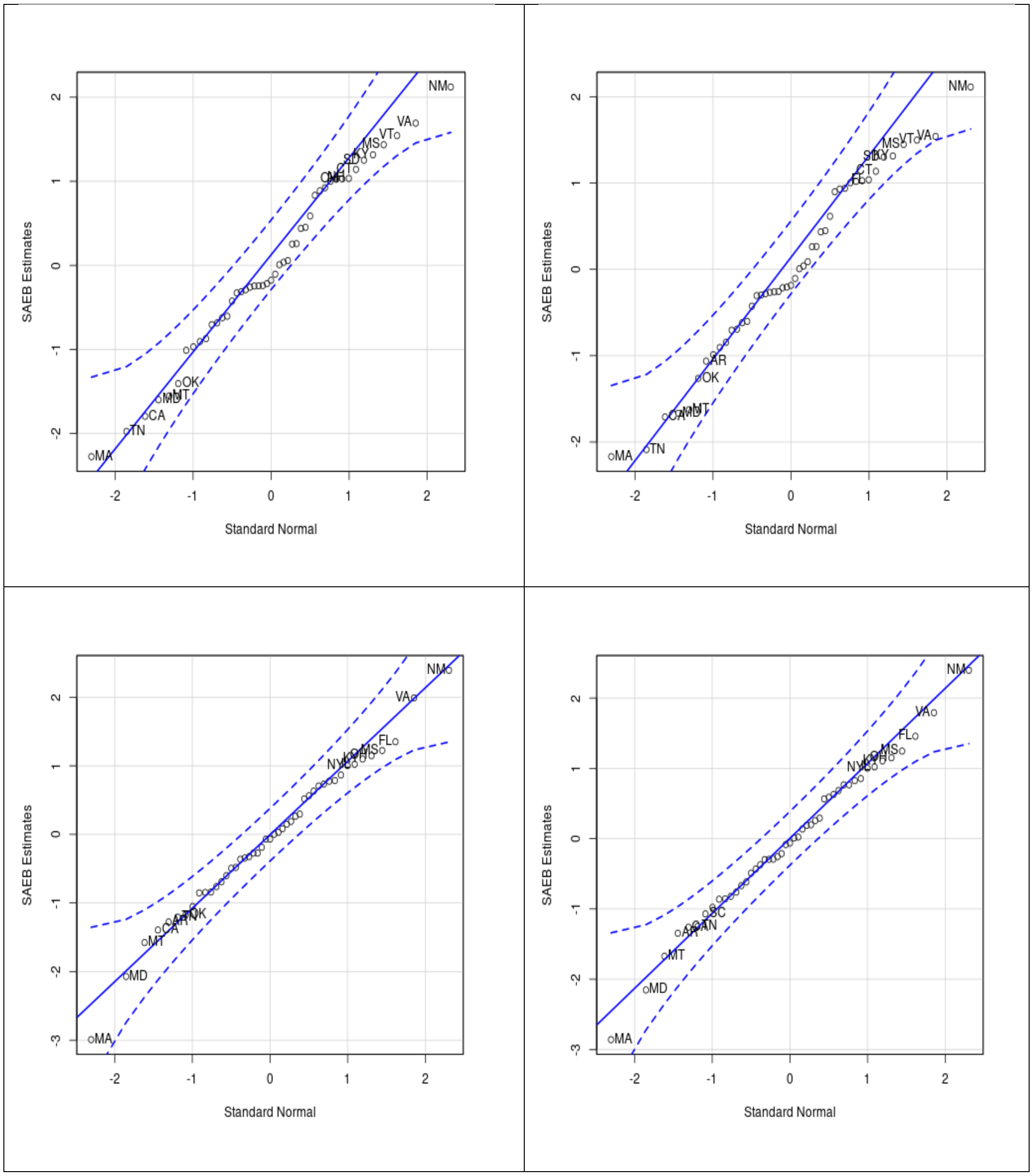
Hunting Participation GVF Rate SE Comparison Among Non-Zero Values				
ML GVF				
	Mean SE	**Median SE**	**Max SE**	**Min SE**
Original	0.03746	0.02383	0.192	0.002
Rate	0.04354	0.02772	0.2102	0.001583
Log-rate	0.04139	0.02813	0.1837	0.001762
Log-count	0.04118	0.0282	0.1809	0.001813
Logistic	0.04139	0.02808	0.1853	0.001723
REML GVF				
Rate	0.03746	0.02383	0.192	0.002
Log-rate	0.04344	0.02748	0.2109	0.001571
Log-count	0.04113	0.02789	0.1856	0.00172
Logistic	0.04115	0.02825	0.1829	0.001786

Hunting Participation Models CVs for Reporting					
ML GVF					
Initial CVs	Model	Mean CV	Median CV	Max CV	Min CV
	Rate	0.5899	0.5231	1.994	0.1185
	Log-rate	0.534	0.442	1.748	0.1329
	Log-count	0.4914	0.4188	1.786	0.1407
	Logistic	0.5455	0.4537	1.824	0.1372
Final CVs	Rate	0.2392	0.1964	0.9642	0.1535
	Log-rate	0.2395	0.2333	0.3713	0.1619
	Log-count	0.2169	0.206	0.4249	0.1518
	Logistic	0.2469	0.2436	0.3549	0.1567
REML GVF					
Initial CVs	Rate	0.5884	0.5221	1.949	0.1189
	Log-rate	0.5359	0.4493	1.743	0.1321
	Log-count	0.4945	0.4311	1.776	0.1389
	Logistic	0.5479	0.4627	1.814	0.1365
Final CVs	Rate	0.2585	0.1989	1.192	0.1535
	Log-rate	0.2624	0.2581	0.3958	0.1661
	Log-count	0.2403	0.2332	0.4426	0.1589
	Logistic	0.2717	0.2766	0.3796	0.1625

Hunting Participation Models Diagnostics					
ML GVF					
	Model	**Mean**	**Median**	**Max**	**Min**
Wt1	**Rate**	0.8191	0.9228	1	0.07804
	Log-rate	0.8398	0.8757	1	0.2621
	Log-count	0.911	0.9376	1	0.431
	Logistic	0.8355	0.8711	1	0.2484
Zres	**Rate**	0.1595	0.1323	2.183	-2.673
	Log-rate	-0.01129	-0.1779	2.122	-2.276
	Log-count	-0.05087	-0.0682	2.393	-2.992
	Logistic	-0.009703	0.1308	2.304	-2.078
Raking					
		Natl. Rk	**Mean Div Rk**	**Max. Div Rk**	**Min Div Rk**
	Rate	1.035	1.085	1.441	0.8238
	Log-rate	0.9768	1.003	1.292	0.7786
	Log-count	1.002	1.033	1.333	0.7648
	Logistic	0.9758	1.002	1.279	0.7933
REML GVF					
	Model	**Mean**	**Median**	**Max**	**Min**
Wt1	**Rate**	0.7861	0.8957	1	0.05658
	Log-rate	0.7874	0.8266	1	0.1924
	Log-count	0.8525	0.8884	1	0.2848
	Logistic	0.7818	0.8157	1	0.1821
Zres	**Rate**	0.1617	0.1312	2.202	-2.655
	Log-rate	-0.008165	-0.1851	2.113	-2.169
	Log-count	-0.04329	-0.06303	2.395	-2.86
	Logistic	-0.01396	0.0874	2.219	-2.063
Raking					
		Natl. Rk	**Mean Div Rk**	**Max Div Rk**	**Min Div Rk**
	Rate	1.038	1.087	1.47	0.8246
	Log-rate	0.9772	1.003	1.277	0.7985
	Log-count	1.001	1.029	1.295	0.7909
	Logistic	0.9777	1.004	1.278	0.8172

Hunting R^2 Coefficient T-statistic Comparison				
ML GVF				
Variable	**Rate**	**Log-rate**	**Log-count**	**Logistic**
R^2	0.5847	0.7462	0.8282	0.7345
Hunters	4.847	6.877	3.852	6.794
MWGLF	4.609	3.709	4.259	3.774
NESW	-0.1293	-1.173	-2.755	-1.118
Hrs. Worked	-2.515	-3.095	-3.114	-2.775
Population			4.217	
REML GVF				
R^2	0.5794	0.7413	0.8254	0.727
Hunters	4.768	6.847	3.892	6.717
MWGLF	4.72	3.755	4.327	3.842
NESW	-0.08935	-1.063	-2.492	-0.9814
Hrs. Worked	-2.625	-3.133	-3.153	-2.832
Population			4.162	

ML GVF	REML GVF
	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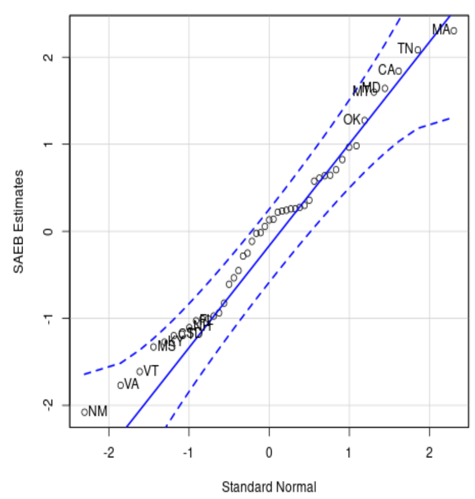
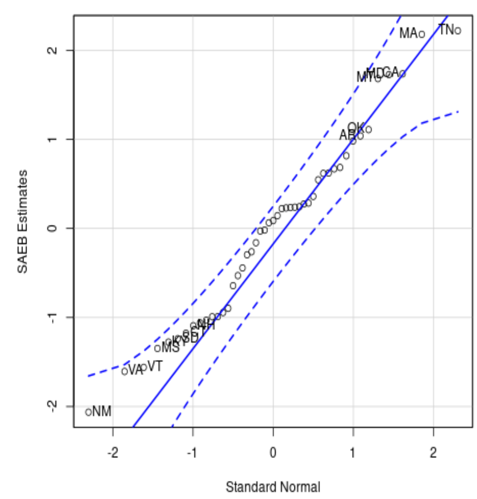




From top: Rate, Log-rate, Log-count, and Logistic models

- **GVFs for Days afield and Expenditures: Specification**
  - We consider the following two GVF specifications,

$$\log(relvar(\hat{X})) = a + b\log(ESS)$$

GVF 1

$$\log(relvar(\hat{X})) = a + b\log(\hat{X})$$

GVF 2

for the days afield and expenditures models. GVF 1 is used for all models except the expenditures naïve rate, where GVF 2 is fit.

  - For either indicator, $\hat{X}$ represents a count or a rate estimated using a Taylor series.
  - Here *ESS* is calculated using only respondents that participated in a given activity, e.g. for hunting we have

H_j	=	$\sum_{\substack{i \in household\ j \\ i\ hunted}} fhwar\_spwgt_{ij}$
ST_HH_k	=	$\sum_{j \in in\ state\ k} H_j^2$
ST_HH2_k	=	$\left(\sum_{j \in in\ state\ k} H_j\right)^2$
ESS	=	$\frac{ST\_HH2_k}{ST\_HH_k}$

  - We run the model twice for days and expenditures. Replicate weight variances are used in the regression for the first model run; for the second run we use the regression estimates to calculate $relvar(\hat{X})$ and use the resulting GVF variances in the model.

- **GVF for Days Afield: Results**

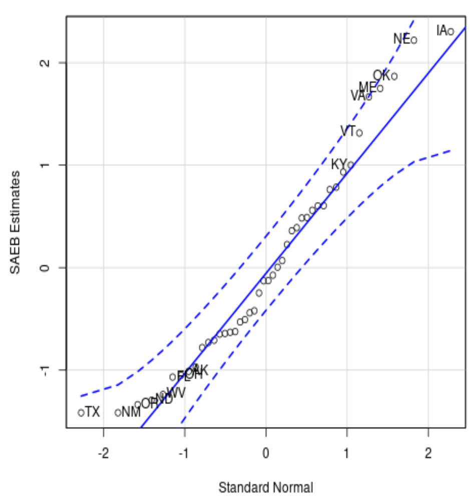
Hunting Days Afield GVF Count SE Comparison Among Non-Zero Values				
ML GVF				
	Mean SE	**Median SE**	**Max SE**	**Min SE**
Original	2679000	1228000	21480000	86060
Rate	2097000	894800	14240000	165500
Log-rate	2225000	950400	15240000	174600
Log-count	2402000	1025000	16310000	189600
REML GVF				
Rate	2098000	894900	14240000	165600
Log-rate	2222000	949100	15200000	174600
Log-count	2399000	1023000	16270000	189600
Hunting Days Afield GVF Rate SE Comparison Among Non-Zero Values				
ML GVF				
	Mean SE	**Median SE**	**Max SE**	**Min SE**
Original	4.991	3.724	18.77	0.4709
Rate	11.26	7.889	36.51	3.253
Log-rate	11	7.892	33.05	2.983
Log-count	11.07	8.069	37.49	3.059
REML GVF				
Rate	11.26	7.891	36.54	3.256
Log-rate	11	7.874	33.23	2.999
Log-count	11.07	8.064	37.47	3.069

Hunting Days Afield Models CVs					
ML GVF					
Initial CVs	**Model**	**Mean CV**	**Median CV**	**Max CV**	**Min CV**
	Rate	0.6129	0.4908	2.607	0.09489
	Log-rate	0.4788	0.3817	1.815	0.06982
	Log-count	0.5915	0.5393	1.282	0.08351
Final CVs	**Rate**	0.4028	0.3636	1.894	0.1213
	Log-rate	0.3467	0.3117	1.673	0.106
	Log-count	0.2561	0.2430	0.4207	0.2290
REML GVF					
Initial CVs	**Model**	**Mean CV**	**Median CV**	**Max CV**	**Min CV**
	Rate	0.6129	0.4908	2.607	0.09489
	Log-rate	0.4788	0.3817	1.814	0.06981
	Log-count	0.5956	0.5393	1.3	0.08458
Final CVs	**Rate**	0.4028	0.3636	1.894	0.1213
	Log-rate	0.3465	0.3115	1.673	0.106
	Log-count	0.2661	0.2539	0.4267	0.2393

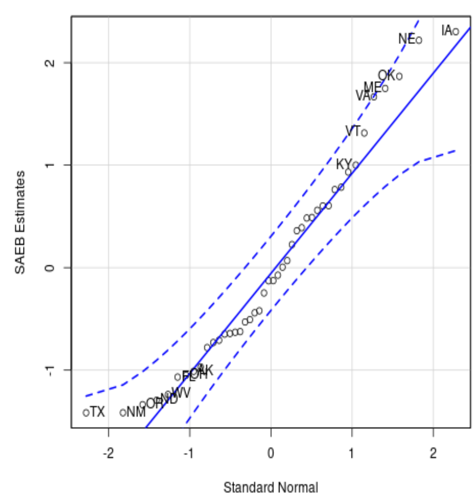
Hunting Days Afield Models CVs					
ML GVF					
Wt1	**Model**	**Mean**	**Median**	**Max**	**Min**
	Rate	1	1	1	1
	Log-rate	1	1	1	1
	Log-count	0.9516	0.9605	1	0.5948
Zres	**Rate**	0.007876	-0.1276	2.303	-1.416
	Log-rate	-0.2657	-0.4345	2.229	-2.358
	Log-count	-0.120	-0.2976	3.153	-2.180
Raking					
		Natl. Rk	**Mean Div Rk**	**Max Div Rk**	**Min Div Rk**
	Rate	1.007	1.062	1.764	0.5703
	Log-rate	0.8905	0.8788	1.294	0.4543
	Log-count	0.9902	0.96	1.145	0.7573
REML GVF					
Wt1	**Model**	**Mean**	**Median**	**Max**	**Min**
	Rate	1	1	1	1
	Log-rate	1	1	1	1
	Log-count	0.9355	0.946	1	0.514
Zres	**Rate**	0.007876	-0.1276	2.303	-1.416
	Log-rate	-0.2659	-0.4362	2.228	-2.354
	Log-count	-0.1085	-0.2771	3.039	-2.170
Raking					
		Natl. Rk	**Mean Div Rk**	**Max Div Rk**	**Min Div Rk**
	Rate	1.007	1.062	1.764	0.5703
	Log-rate	0.8906	0.8788	1.294	0.4542
	Log-count	0.9939	0.9655	1.144	0.767

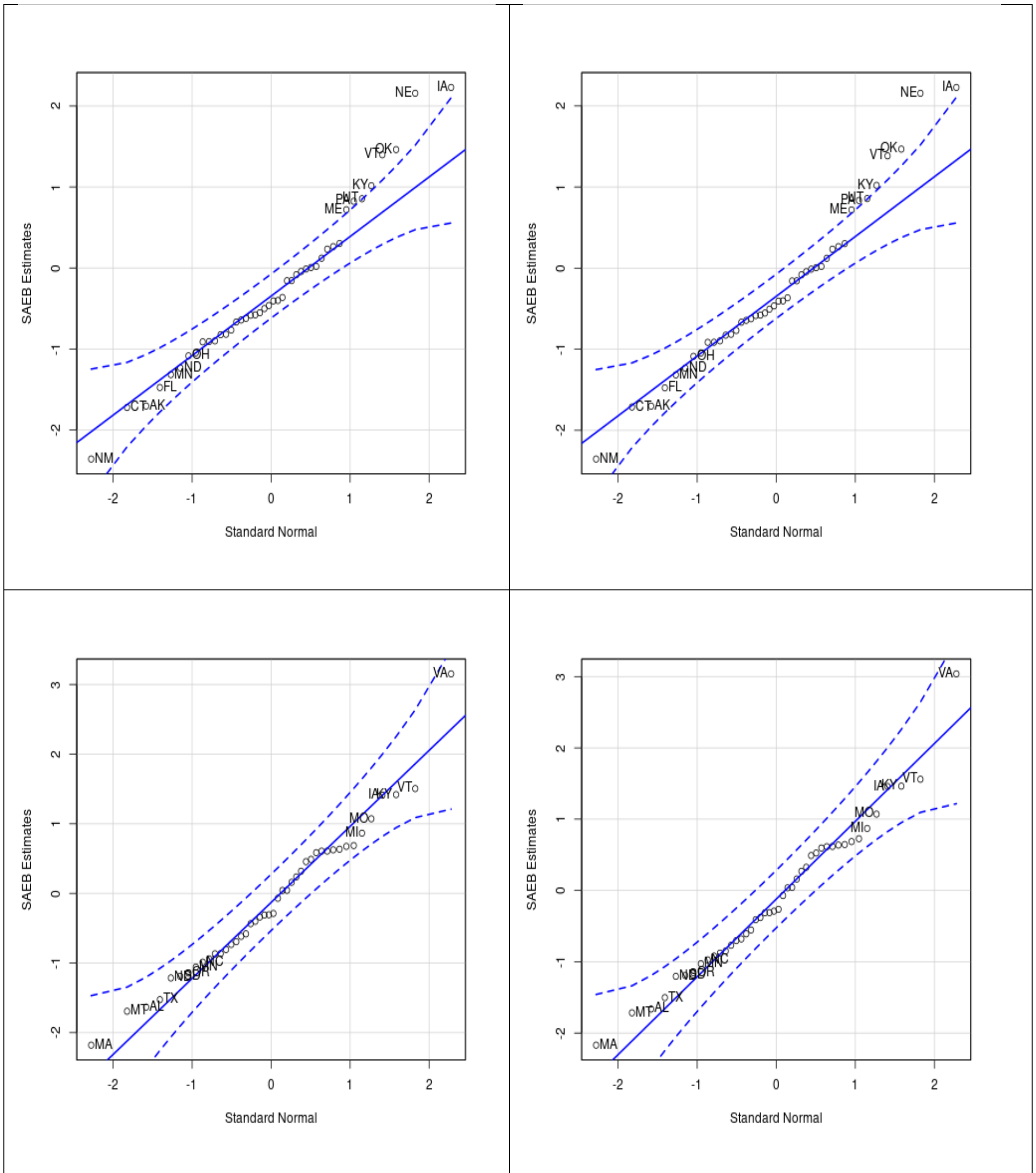
Hunting R^2 and Coefficient T-statistic Comparison			
ML GVF			
Variable	**Rate**	**Log-rate**	**Log-count**
R^2	0.3096	0.3965	0.8741
Hunters	3.03	0.3847	13.64
Cluster 1	1.916	4.078	5.764
Cluster 2	-3.012	-2.49	-8.843
REML GVF			
R^2	0.3096	0.3984	0.8762
Hunters	3.03	0.3778	13.79
Cluster 1	1.916	4.096	5.885
Cluster 2	-3.012	-2.497	-8.781

ML GVF



REML GVF





From top: Rate, Log-rate, and Log-count models

- **GVF for Expenditures: Results**

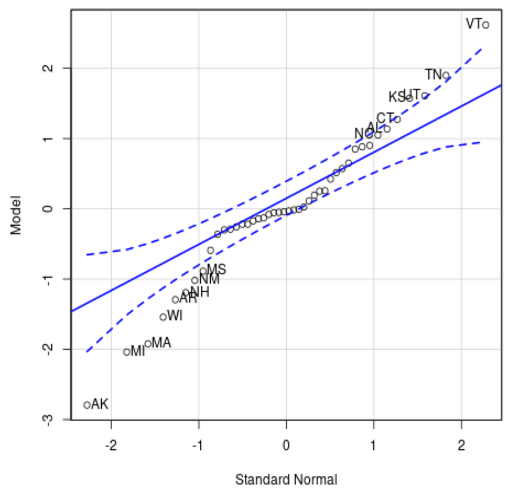
Hunting Expenditures GVF Count SE Comparison Among Non-Zero Values				
	Mean SE	**Median SE**	**Max SE**	**Min SE**
Original	391900000	189500000	3270000000	8609000
Rate	299800000	123000000	2501000000	20350000
Log-rate	313700000	125500000	2846000000	20460000
Log-count	302300000	120900000	2693000000	19920000
Hunting Expenditures GVF Rate SE Comparison Among Non-Zero Values				
	Mean SE	**Median SE**	**Max SE**	**Min SE**
Original	925.7	594.9	4647	96.18
Rate	977.1	828.2	2739	113.4
Log-rate	1001	906.4	2458	114.7
Log-count	975	870.8	2454	114.9

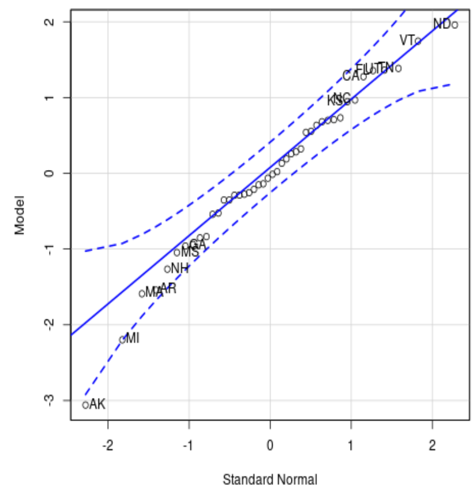
Hunting Expenditures Models CVs, GVF REML					
Initial CVs	**Model**	**Mean CV**	**Median CV**	**Max CV**	**Min CV**
	Rate	0.6203	0.5063	2.787	0.0118
	Log-rate	0.7006	0.5483	4.151	0.01863
	Log-count	0.7581	0.6653	3.765	0.0506
Final CVs	**Model**	**Mean CV**	**Median CV**	**Max CV**	**Min CV**
	Rate	0.3902	0.3704	0.6726	0.2943
	Log-rate	0.4151	0.392	0.7734	0.3154
	Log-count	0.4	0.3884	0.6495	0.3325

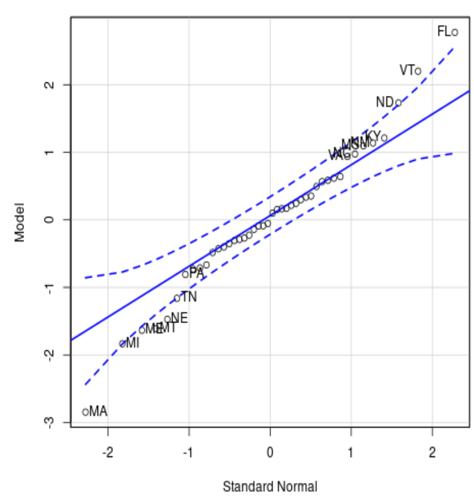
Hunting Expenditures Models Diagnostics, GVF REML					
Wt1	**Model**	**Mean**	**Median**	**Max**	**Min**
	Rate	1	1	1	1
	Log-rate	1	1	1	1
	Log-count	0.9262	0.9357	1	0.6584
Zres	**Rate**	-0.02455	-0.1589	4.965	-1.447
	Log-rate	0.01646	0.02397	3.749	-2.499
	Log-count	0.01392	0.088	2.935	-2.415
Raking					
		Natl Rk	**Mean Div Rk**	**Max Div Rk**	**Min Div Rk**
	Rate	1.029	1.035	1.302	0.6638
	Log-rate	1.027	1.12	1.57	0.8503
	Log-count	0.9977	1.111	1.443	0.8761

Hunting Coefficient T-statistic Comparison, GVF REML			
Variable	**Rate**	**Log-rate**	**Log-count**
R^2	0.8432	0.837	0.8323
Economic Indicator	4.448	6.704	8.121
Cluster 1	-5.82	-6.821	-4.74
Cluster 2	5.852	8.908	6.057
Cluster 3	2.201	1.933	3.539
Hunters	0.5294	2.184	6.095

REML GVF







From top: Rate, Log-rate, Log-count

- **Variable Definitions**

Activity x Indicator	Variable	Definition
Hunting Participation	**Hunters**	State licensed hunters
	MWGLF	Indicator for AL, AR, GA, IL, IN, KY, LA, MI, MN, MO, MS, NC, OH, SC, TX, WI
	NESW	Indicator for AZ, CO, CT, ID, MA, ME, MT, NH, NJ, NM, NV, NY, PA, RI, UT, VT, WY
	Hrs. Worked	Estimated number of hours worked by a state resident
	Population	Total 16p state population
Fishing Participation	**Fishers**	State licensed fishers
	Low License Cluster	Indicator for AZ, CA, CT, DC, HI, MA, MD, NJ, NV, NY, RI
	Population	Total 16p state population
Wildlife-Watching Participation	**Fishers**	State licensed fishers
	Div4	Indicator for IA, KS, MN, MO, ND, NE, SD
	Cluster 1	Indicator for IA, ME, MS, ND, NE, OK, UT, VT, WV
	Cluster 2	Indicator for AK, AR, IA, IL, VT, WV
	Population	Total 16p state population
Hunting Days Afield	**Hunters**	State licensed hunters
	Cluster 1	Indicator for AL, IL, IN, MS
	Cluster 2	Indicator for AR, AZ, CO, ID, KS, LA, ME, MI, MO, MT, OR, PA, TN, WA, WV
	Fishers	State licensed fishers
	Cluster 1	Indicator for AK, AL, FL, GA, IL, IN, KY, LA, MO, MS, NC, ND, NM, NV, OH, SC, SD, TX, WI

Fishing Days Afield	**Cluster 2**	Indicator for AR, AZ, CO, GA, MD, MT, NC, NE, NM, SD, TX, WV
	Cluster 3	Indicator for AR, DE, HI, IL, KY, MA, MD, MS, NJ, NM, RI, WI
	Cluster 4	Indicator for AZ, CO, KS, ME, ND, NM, NV
	Population	Total 16p state population
Wildlife-Watching Days Afield	**Econ. Indicator**	State durable goods expenditures
	Cluster 1	Indicator for AZ, CT, IA, ME, MO, NC, NV, WI
	Cluster 2	Indicator for AL, DE, GA, HI, NC, NE, SD, TN, WV, WY
	Cluster 3	Indicator AL, AR, GA, NE, NM, RI, TN, VT
	Population	Total 16p state population
Hunting Expenditures	**Economic Indicator**	Mean/Sum of durable goods expenditures, recreational expenditures, food/beverages expenditures and farm livestock receipts
	Cluster 1	Indicator for AL, AR, AZ, CA, CO, CT, FL, KS, KY, MD, ME, MI, MS, NM, NY, OR, PA, SC, TX, WI, WV
	Cluster 2	Indicator for AL, CO, CT, NM, PA, TX, WI
	Cluster 3	Indicator for AK, AL, GA, IA, IL, IN, KS, MI, MN, MO, MT, ND, NE, NM, OH, SD, TX, UT, VT
	Hunters	State licensed hunters
Fishing Expenditures	**Economic Indicator**	Mean/Sum of durable goods expenditures, recreational expenditures, food/beverages expenditures and farm livestock receipts
	Cluster 1	Indicator for AK, AL, CA, CT, DC, DE, FL, GA, HI, LA, MA, MD, ME, MS, NC, NH, NJ, NY, OR, RI, SC, TX, VA, WA

	Cluster 2	Indicator for AR, AZ, CO, IA, ID, IL, IN, KS, LA, MI, MN, MO, MT, ND, NE, NM, NV, OH, OK, SD, TX, UT, WI, WY
	Cluster 3	Indicator for AK, AZ, CO, CT, GA, ID, IN, KS, KY, MA, MD, MT, ND, NH, NV, OH, SC, SD, VT, WV
	Cluster 4	Indicator for AZ, GA, ID, ME, MT, NV, TN, TX, WY
Wildlife-Watching Expenditures	**Economic Indicator**	Mean/Sum of durable goods expenditures, recreational expenditures, food/beverages expenditures and farm livestock receipts
	Number Pub. Coll.	Number of public universities
	Cluster 1	Indicator for AZ, GA, ID, ME, MT, NV, TN, TX, WY
	Cluster 2	Indicator for AL, AR, GA, ID, IL, IN, MD, NH, NM, TN, VT
	Cluster 3	Indicator for AL, AR, GA, IL, IN, KY, LA, MI, MN, MO, MS, NC, OH, SC, TN, TX, WI

- **Fishing Participation**

Fishing Participation Models CVs, GVF REML					
		Mean CV	**Median CV**	**Max CV**	**Min CV**
Initial CVs	**Rate**	0.4175	0.3311	1.331	0.07042
	Log-rate	0.4099	0.3077	1.412	0.06744
	Log-count	0.399	0.3136	1.363	0.06764
	Logistic	0.4197	0.3186	1.38	0.07002
Final CVs	**Rate**	0.1298	0.1121	0.256	0.08829
	Log-rate	0.1893	0.1903	0.3017	0.08559
	Log-count	0.1959	0.1939	0.3669	0.08696
	Logistic	0.189	0.1849	0.3735	0.08057

Fishing Participation Raking Information				
	Nat. Rk	**Mean Div Rk**	**Max Div Rk**	**Min Div Rk**
Rate	1.071	1.078	1.248	0.9304
Log-rate	0.9956	1.008	1.113	0.8778
Log-count	1.006	1.013	1.116	0.895
Logistic	1.021	1.033	1.17	0.896

Fishing Participation Shrinkage Information				
	Mean Wt1	**Median Wt1**	**Max Wt1**	**Min Wt1**
Rate	0.8165	0.8785	1	0.2763
Log-rate	0.6768	0.7005	1	0.1109
Log-count	0.6782	0.702	1	0.1116
Logistic	0.712	0.7419	1	0.1357

Fishing R^2 and Coefficient T-statistic Comparison, GVF REML				
Variable	**Rate**	**Log-rate**	**Log-Count**	**Logistic**
R^2	0.5151	0.4634	0.8592	0.4661
Fishers	2.214	1.443	0.8665	1.358
Low Lic Clus	-3.821	-3.488	-3.564	-3.644
Population			9.155	

- **Wildlife-Watching Participation Models**

Wildlife-Watching Participation Models CVs, GVF REML					
		Mean CV	**Median CV**	**Max CV**	**Min CV**
Initial CVs	**Rate**	0.2763	0.249	0.6222	0.04143
	Log-rate	0.2663	0.2286	1.049	0.04121
	Log-count	0.2507	0.2299	0.6783	0.03336
	Logistic	0.2881	0.2453	1.085	0.04507
Final CVs	**Rate**	0.1539	0.1377	0.4022	0.07711
	Log-rate	0.1512	0.1478	0.234	0.08979
	Log-count	0.1445	0.1396	0.2694	0.08881
	Logistic	0.1916	0.1757	0.46	0.06736

Wildlife-Watching Participation Raking Information				
	Nat. Rk	**Mean Div Rk**	**Max Div Rk**	**Min Div Rk**
Rate	0.9661	0.9601	1.065	0.8263
Log-rate	0.9537	0.8975	1.057	0.7182
Log-count	0.9262	0.9129	1.107	0.7299
Logistic	0.9596	0.9537	1.083	0.8197

WW Participation Shrinkage Information				
	Mean Wt1	**Median Wt1**	**Max Wt1**	**Min Wt1**
Rate	0.6734	0.7124	1	0.1927
Log-rate	0.7107	0.7455	1	0.245
Log-count	0.7675	0.8078	1	0.3178
Logistic	0.64	0.6815	1	0.1633

Wildlife-Watching R^2 Coefficient T-statistic Comparison, GVF REML				
Variable	**Rate**	**Log-rate**	**Log-Count**	**Logistic**
R^2	0.4026	0.4247	0.9271	0.3405
Fishers	4.07	4.592	3.242	3.489
Div4	-1.534	-1.964	-2.065	-1.422
Clus. 1	-3.593	-3.07	-3.961	-3.681
Clus. 2	1.285	1.617	1.193	1.412
Population			10.88	

- **Fishing Days Afield Models**

Fishing Days Afield Models CVs for Reporting, no GVF REML					
Initial CVs		**Mean CV**	**Median CV**	**Max CV**	**Min CV**
	Rate	0.4763	0.4191	1.712	0.06535
	Log-rate	0.5051	0.413	1.982	0.06169
	Log-count	0.5342	0.4105	4.744	0.03643
Final CVs	**Rate**	0.3888	0.3149	1.343	0.06391
	Log-rate	0.448	0.3907	1.287	0.1031
	Log-count	0.3284	0.3215	0.643	0.2285

Fishing Days Afield Models Raking Information, no GVF REML				
	Nat. Rk	**Mean Div Rk**	**Max Div Rk**	**Min Div Rk**
Rate	1.172	1.12	1.7	0.7462
Log-rate	1.081	1.053	1.347	0.8601
Log-count	1.075	1.06	1.364	0.7679

Fishing Days Afield Models Shrinkage Information, no GVF REML				
	Mean Wt1	**Median Wt1**	**Max Wt1**	**Min Wt1**
Rate	0.7748	0.8204	1	0.1708
Log-rate	0.4509	0.3802	1	0.005006
Log-count	0.7731	0.8249	1	0.345

Fishing R^2 and Coefficient T-statistic Comparison, no GVF REML			
Variable	**Rate**	**Log-rate**	**Log-Count**
R^2	0.456	0.5306	0.8058
Fishers	2.29	3.14	5.301
Clus. 1	0.1885	1.054	2.583
Clus. 2	-2.769	-3.194	-4.124
Clus. 3	2.593	3.539	3.609
Clus. 4	-1.127	-1.795	-1.341
Population	-2.962	-3.723	2.21

- **Wildlife-Watching Days Afield Models**

Wildlife-Watching Days Afield Models CVs for Reporting, no GVF REML					
		Mean CV	**Median CV**	**Max CV**	**Min CV**
Initial CVs	**Rate**	**NA**	**NA**	**NA**	**NA**
	Log-rate	1.046	0.5638	13.6	0.151
	Log-count	0.6553	0.4542	2.453	0.1619
Final CVs	**Rate**	**NA**	**NA**	**NA**	**NA**
	Log-rate	0.7463	0.3143	18.37	0.2008
	Log-count	0.3139	0.2887	0.5439	0.2103

Wildlife-Watching Days Afield Models Raking Information, no GVF REML				
	Nat. Rk	**Mean Div Rk**	**Max Div Rk**	**Min Div Rk**
Rate	**NA**	**NA**	**NA**	**NA**
Log-rate	1.07	1.05	1.47	0.6277
Log-count	1.058	1.01	1.33	0.7146

Wildlife-Watching Days Afield Models Shrinkage Information, no GVF REML				
	Mean Wt1	**Median Wt1**	**Max Wt1**	**Min Wt1**
Rate	**NA**	**NA**	**NA**	**NA**
Log-rate	0.7536	0.848	1	0.001983
Log-count	0.9066	0.9516	1	0.08259

Wildlife-Watching R^2 and Coefficient T-statistic Comparison, no GVF REML			
Variable	**Rate**	**Log-rate**	**Log-Count**
R^2	**NA**	0.8461	0.8705
Econ. Indicator	**NA**	8.409	7.466
Clus. 1	**NA**	7.885	6.704
Clus. 2	**NA**	-8.798	-7.469
Clus. 3	**NA**	3.666	2.617
Population	**NA**	-8.379	-6.171

- **Fishing Expenditures Models**

Fishing Expenditures Models CVs for Reporting, no GVF REML					
		Mean CV	**Median CV**	**Max CV**	**Min CV**
Initial CVs	**Rate**	0.6506	0.3488	5.702	0.09345
	Log-rate	0.7176	0.3814	7.069	0.1272
	Log-count	0.7652	0.4706	5.631	0.06957
Final CVs	**Rate**	0.3878	0.3036	1.302	0.2341
	Log-rate	0.3902	0.4041	0.5105	0.2593
	Log-count	0.3374	0.3347	0.4362	0.2692

Fishing Expenditures Models Raking Information, no GVF REML				
	Nat. Rk	**Mean Div Rk**	**Max Div Rk**	**Min Div Rk**
Rate	0.9802	1.077	1.759	0.7668
Log-rate	0.9995	1.136	2.113	0.7982
Log-count	1.131	1.235	2.2	0.7323

Fishing Expenditures Models Shrinkage Information, no GVF REML				
	Mean Wt1	**Median Wt1**	**Max Wt1**	**Min Wt1**
Rate	0.7102	0.8009	1	0.006551
Log-rate	0.6421	0.675	1	0.02101
Log-count	0.8938	0.924	1	0.5837

Fishing R^2 and Coefficient T-statistic Comparison, no GVF REML			
Variable	**Rate**	**Log-rate**	**Log-Count**
R^2	0.4367	0.6041	0.8403
Economic Indicator	1.467	2.812	8.171
Cluster 1	2.808	3.958	3.505
Cluster 2	2.476	3.225	3.406
Cluster 3	-2.68	-3.519	-5.501
Cluster 4	-2.791	-3.09	-3.865

- **Wildlife-Watching Expenditures Models**

Wildlife-Watching Expenditures Models CVs for Reporting, no GVF REML					
		Mean CV	**Median CV**	**Max CV**	**Min CV**
Initial CVs	**Rate**	0.4748	0.3163	2.857	0.03459
	Log-rate	0.4655	0.3846	1.897	0.04764
	Log-count	0.4661	0.3744	2.202	0.04913
Final CVs	**Rate**	0.5143	0.3133	8.141	0.1646
	Log-rate	0.3805	0.3596	0.7092	0.1784
	Log-count	0.3195	0.3166	0.4081	0.26

Wildlife-Watching Expenditures Models Raking Information, no GVF REML				
	Nat. Rk	**Mean Div Rk**	**Max Div Rk**	**Min Div Rk**
Rate	1.039	0.9493	1.9	0.5132
Log-rate	0.9158	0.8997	1.223	0.5415
Log-count	0.9227	0.8869	1.131	0.5599

Wildlife-Watching Expenditures Models Shrinkage Information, no GVF REML				
	Mean Wt1	**Median Wt1**	**Max Wt1**	**Min Wt1**
Rate	0.8015	0.8698	1	0.2153
Log-rate	0.6923	0.7216	1	0.2509
Log-count	0.8255	0.8701	1	0.4306

Wildlife-Watching R^2 and Coefficient T-statistic Comparison, no GVF REML			
Variable	**Rate**	**Log-rate**	**Log-Count**
R^2	0.4927	0.7151	0.8903
Economic Indicator	0.8704	1.011	5.606
Number Pub. Coll.	3.706	4.855	4.117
Cluster 1	4.035	7.45	7.376
Cluster 2	2.548	4.416	5.083
Cluster 3	-1.058	-1.051	-0.269