

Applying a Family Equalization Adjustment to Weighting for the Current Population Survey

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1. Introduction*

The Current Population Survey (CPS) is the primary source of labor force data for the United States. The Bureau of Labor Statistics and the Census Bureau sponsor it. Although the main purpose of the CPS is to produce estimates of employment status and other personal characteristics for the civilian noninstitutional population, it also produces estimates for householders and housing units. The householder is the person or one of the persons who owns or rents the unit occupied by the household. The estimates of households and householders should agree by definition, in that there is one householder for every household.¹ But there are large discrepancies in these estimates within the CPS. Other surveys conducted by the Census Bureau use a family equalization adjustment to reduce this discrepancy, and create consistent estimates of people in married and unmarried partner households.

This paper discusses the application of a family equalization adjustment for estimating households, householders and people in the basic CPS. I compare estimates of household, householder and population characteristics using the current CPS weighting and the family equalization method. I also examine variances of the estimates from these methods.

2. An Overview of the CPS

The CPS is conducted monthly on a sample of approximately 70,000 households, resulting in approximately 55,000 interviewed households. The United States monthly unemployment rate is probably the best-known statistic from the CPS.

CPS sample households are divided into eight groups of approximately equal size, called rotation groups, because they rotate in and out of the sample. Six of the eight groups are the same in any pair of consecutive months, and four of the eight groups are the same from year to year (i.e., identical months 1 year apart). The rotation of the groups is commonly referred to as the 4-8-4 pattern, in that all households in a given rotation group are in the CPS sample for four consecutive months, out of the sample for the next eight months, and back in sample for the following four months.

* This report is released to inform interested parties of ongoing research and to encourage discussion of work in progress. The views expressed are those of the author and not necessarily those of the Census Bureau.

The author wishes to acknowledge Lindsay McMillan and Reid Rottach for computations and statistical consultation.

¹ A household includes all individuals residing in a sample housing unit.

3. Nature of the CPS Weighting

The first two CPS weighting adjustments are based on households or occupied housing units, and are applied to all members of a household. These are the weighting control factor and the noninterview factor. The base weight is the initial weight or estimate for each CPS person. It is simply the inverse of the probability of selection for all persons in the civilian noninstitutional population in a geographic area, usually a state. The weighting control factor is applied when it is necessary to subsample in the field, when there are many more housing units than expected. In most cases, where no subsampling occurs, the factor has a value of one. The noninterview factor accounts for nonresponse, when an eligible household does not complete an interview.

The remaining steps of the CPS weighting are applied to persons within each household. These are the first-stage factor, the national and state coverage adjustment factors, and the second-stage factor. The first-stage factor is intended to reduce the variance that results from sampling of primary sampling units (i.e., the first stage of CPS sample selection). The national and state coverage adjustments and the second-stage adjustment apply independent population controls to adjust the CPS sample estimates, based on age, race/ethnicity and sex (note that members of the same household will frequently have different values for these factors). The result is that every civilian person who is a member of an eligible, interviewed sample CPS household receives a weight for each step of the CPS weighting and estimation. For the discussion in this paper, the ‘second-stage’ weight can be considered the final person weight². See Tupek (2004) and U.S. Census Bureau (2006) for more detail on the CPS weighting.

The CPS household weight is derived from the second-stage weight of a designated person in the household, and it is here that the discrepancy in the estimates of households and householders arises. In married-couple households, the second-stage weight of the wife is typically used as the household weight, even when the husband is designated as the householder. This is because the CPS coverage ratios³ for women are usually higher and less variable, from month to month, than for men.

4. Background for Weighting Research

The discrepancy in estimates of households and householders has occurred in other surveys conducted by the Census Bureau. A housing unit control working group was formed at the Census Bureau to examine this problem and make recommendations. This group recommended that all current surveys that produce housing-based estimates⁴ use the same set of independent housing estimates, provided by the Census Bureau’s Population Division, as controls. But for surveys that produce both population-based and housing-based estimates, like the CPS, the working group recommended research on alternative weighting methods, and noted that housing unit estimates could be affected considerably, depending on how the weighting methods were changed. In particular, the CPS currently uses “population-based” estimates of housing units or households, as

² This paper doesn’t discuss the composite weighting that follows second-stage weighting.

³ The coverage ratio measures how well the survey covers the target population. It is the ratio of estimates after the first-stage adjustment to independent population controls.

⁴ These include the American Housing Survey, the New York City Housing and Vacancy Survey, and the Housing Vacancy Survey.

indicated in section 3 above, and controlling these estimates to independent housing unit controls could result in large changes. See Love (2002) and Love (2003) for more details on the discussion and recommendations of this housing unit control working group.

In previous research and analysis, Zbikowski and Letourneau (2006) applied some of the recommendations from the working group. This previous analysis looked at ratios of household to householder weights for demographic groups and household types (e.g., married couple and other households, with or without children under 18). We found that the ratios were close to 1 for female-headed households, but tended to be under 1 for male-headed households. This was consistent with the current CPS methodology, in which the final weight of a civilian adult female (i.e., the householder) is commonly assigned as the household weight.

We also compared household and labor force characteristics based on the current CPS household weight, with two other weights: the CPS noninterview weight and the current weight adjusted by independent regional housing unit estimates. We found that the current and adjusted household weights provided similar distributions of characteristics like householder race/ethnicity, householder labor force status and household type. On the other hand, the noninterview weight provided smaller percentages of Black and Asian householders, and householders not in the labor force.

In the discussion concluding that paper, we noted that the CPS Annual Social and Economic Supplement uses a family equalization adjustment to reduce discrepancies in estimates of households and householders, and could be considered for application to the basic CPS. That is the focus of the remainder of this paper.

5. Application of the Family Equalization Adjustment

The family equalization adjustment (FEA) used for this research was adapted from the FEA already being used in the CPS Annual Social and Economic Supplement (ASEC). The FEA uses a series of assignments and calculations, after the second stage or final person weights have been derived, to assign a family equalization weight.

The family equalization weight (FEW) is created for every person in the CPS sample, but for practical purposes is relevant for those 15 years and older. All children under 15 have their second-stage weights assigned as their FEW. Next, adults (15 years and older) are classified into seven groups, based on sex and household type:

1. Females in female/female unmarried partner households.
2. All other females.
3. Males in male/female married partner households with spouse present.
4. Males in male/female unmarried partner households.
5. Other male heads of household.
6. Male partners in male/male unmarried partner households.
7. All other males.

Note that for weighting purposes, in married and unmarried partner households, one member of the couple is identified as the householder or reference person, and the other is identified as the partner. The members of each group are identified and assigned the FEW in the order listed above. Thus, females in same-sex unmarried partner households are assigned an FEW before other females. Similarly for males in groups 3-7, those in

opposite-sex married and unmarried partner households receive an FEW first, followed by other heads of household, partners in same-sex unmarried partner households, and finally all other males. Note that this order gives precedence to married and unmarried couples, and women. This is consistent with the main purpose of the FEA, which is to achieve consistent estimates of people in couple households. It also reflects historically better coverage of women.

The females in group 1 are unique in that the FEW is computed by averaging the second-stage weights of the members of the couple. For all other females, the second-stage weight is simply assigned as the FEW. Note that groups 3 and 4 (males in male-female married and unmarried partner households, respectively) receive the FEW of their spouses or partners, in group 2. For September 2009 CPS data, males and females in male-female married and unmarried couple households accounted for 57% of the sample 15 years and older.

For other male heads of household in group 5, a ratio adjustment factor, based on the FEW and second stage weights of males in male-female married and unmarried partner households, is computed and applied to their second-stage weights to obtain the FEW. The ratio adjustment factor is computed for separate groups or cells, defined by age and race/ethnicity. The FEW for other male heads of household is:

$$FEW_{omh} = SS_{omh} * R_{omh} \quad (1)$$

Where SS_{omh} is the second stage weight for that person, and R_{omh} is the adjustment factor:

$$R_{omh} = \frac{Group\ 3(FEW) + Group\ 4(FEW)}{Group\ 3(SS) + Group\ 4(SS)} \quad (2)$$

where group 3 is males in male-female married couple households, and group 4 is males in male-female unmarried partner households. The numerator is the cell total of family equalization weights for groups 3 and 4, and the denominator is the cell total of second-stage weights for groups 3 and 4.

A similar ratio adjustment is applied to the second-stage weights for group 7, all other males, to obtain the FEW. As for other male heads, the FEW is computed for separate groups defined by age and race/ethnicity :

$$FEW_{aom} = SS_{aom} * R_{aom} \quad (3)$$

Where SS_{aom} is the second stage weight for that person, and R_{aom} is the adjustment factor:

$$R_{aom} = \frac{Control - Group\ 3(FEW) - Group\ 4(FEW) - Group\ 5(FEW)}{Control - Group\ 3(SS) - Group\ 4(SS) - Group\ 5(SS)} \quad (4)$$

where the Control is the population control for a specific age/race/ethnicity group. The cell total of family equalization weights for groups 3-5 is subtracted from the control total in the numerator, while the corresponding cell total of second-stage weights is subtracted in the denominator.

The remaining group, male partners in male/male unmarried partner households, receive the FEW of their partners, who are part of group 5, other male heads of household. For more detail on the application of the family equalization adjustment in the CPS ASEC, see Tupek (2007).

6. Comparison of Survey Estimates

In this section, I present some estimates using the current householder (or final person) weights and the FEW. I have grouped the results into subsections, to highlight some of the different implications of using the FEW. I used September 2009 CPS data for these analyses, unless noted otherwise.

6.1 Estimates of Married and Unmarried Partner Households

As described in section 5, the FEW is assigned in an order that gives priority to people in married and unmarried couple households. The FEW produces consistent estimates of people in married and unmarried couple households (e.g., equal estimates of males and females in male/female unmarried couple households). This is not the case when using the CPS final person weight. Table 1 illustrates this for male-female couple households.

Type of Household	CPS Householder Weight		Family Equalization Weight	
	Males	Females	Males	Females
Married Partner	61,585	59,772	59,772	59,772
Unmarried Partner	5,865	5,613	5,613	5,613
Total	67,450	65,385	65,385	65,385

Table 2 provides FEW estimates of married and unmarried partner households for July-September 2009. The estimates of both opposite-sex and same-sex unmarried partner households from the CPS are low, compared to those from other data sources. Since the primary purpose of the CPS is the collection of labor force data, it is likely that the CPS estimates of these household types are ‘depressed’. Among other choices in the CPS questionnaire to identify the relationship, a respondent may indicate that another household member is a 1. partner/roommate, 2. housemate/roommate, 3. roomer/boarder or 4. non-relative. Other research (e.g., O’Connell and Lofquist (2009)) has indicated that these categories may overlap with the category of unmarried partner. But the important result for this paper is the consistency of estimates of people in these households. For example, the estimates of males and females in male/female unmarried partner households are equal.

Household Type	Estimated Number of Households		
	July 2009	August 2009	September 2009
Married, Spouse Present	60,085	59,754	59,772
Male/Female UMP	5,741	5,650	5,613
Male/Male UMP	168	158	149
Female/Female UMP	169	189	200

6.2 Estimates of Household and Householder Characteristics

The tables in this section compare household and householder characteristics, based on the current CPS householder/final person weight, with those based on the FEW. The FEW produces an estimate of householders much closer to the current CPS household estimate. Table 3 compares estimates of households and householders, based on these old and new weights, for July-September 2009 CPS data. As we noted previously, the current household estimate is lower than the householder estimate, and the FEW estimates are lower still.⁵

Estimate	Month and Year of Estimate		
	July 2009	August 2009	September 2009
CPS Householder	119,176	119,513	119,916
CPS Household	118,369	118,558	118,914
Family Equalization	117,712	117,808	118,077

Next, I looked at how the FEW affects distributions of household and householder characteristics, particularly the labor force status and unemployment rates. It would be problematic to add the FEW to basic monthly weighting if it results in drastic changes to distributions of characteristics.

Table 4 presents labor force data for householders. In comparing the labor force estimates based on the current householder and FEW weights, we do find one significant difference⁶: the percentage of householders not in the labor force is higher for the FEW estimate at 33.5%, compared to 33.2% for the current householder weight. However, the householder unemployment rates of 8.5% and 8.4% are not significantly different⁷. Table 5 presents data on householder race/ethnicity, and table 6 presents data on the educational

⁵ Unlike the person weights, the FEW and household weights are not controlled to a common set of independent estimates, so we would not expect them to be equal.

⁶ All comparisons presented and discussed in this paper were tested for statistical significance at the 90-percent confidence interval. When we report significant differences in this paper, they are at the 90-percent confidence level.

⁷ These unemployment rates will not be the same as the seasonally adjusted rates released by BLS.

attainment of the householder. The percentage of White householders is about a point higher using the FEW, and the percentage of Hispanic householders is almost a point lower with the FEW; both of these FEW-householder differences in table 5 are significant. In addition, the differences for Black and Other householders are significant. From Table 6, a lower percentage of householders were not high school graduates, based on the FEW estimates, but none of the other differences in householder educational attainment are significant.

Householder Labor Force Status	CPS Householder Weight		Family Equalization Weight	
	N	%	N	%
Employed	72,990	61.1 (0.2)	71,602	60.9 (0.2)
Unemployed	6,771	5.7 (0.1)	6,605	5.6 (0.1)
Not in Labor Force	39,724	*33.2 (0.2)	39,439	*33.5 (0.2)
Total	119,485	100.0	117,646	100.0
Unemployment Rate (%)		8.5 (0.2)		8.4 (0.2)

* Percentages are significantly different.

Householder Status	CPS Householder Weight		Family Equalization Weight	
	N	%	N	%
White NonHisp	83,657	*69.8 (0.2)	83,517	*70.7 (0.2)
Black NonHisp	14,993	*12.5 (0.2)	14,486	*12.3 (0.2)
Hispanic	14,440	*12.0 (0.2)	13,359	*11.3 (0.2)
Asian	4,615	3.8 (0.1)	4,517	3.8 (0.1)
Other	2,210	*1.8 (0.1)	2,198	*1.9 (0.1)
Total	119,916	100.0	118,077	100.0

* Percentages are significantly different.

Householder Educational Attainment	CPS Householder Weight		Family Equalization Weight	
	N	%	N	%
Less than HSG	14,278	*12.6 (0.2)	13,792	*12.4 (0.2)
High School Grad	33,143	29.3 (0.2)	32,678	29.3 (0.2)
Some College	31,151	27.5 (0.2)	30,773	27.6 (0.2)
Bachelor's	22,421	19.8 (0.2)	22,148	19.8 (0.2)
Master's +	12,325	10.9 (0.2)	12,220	11.0 (0.2)
Total	113,320	100.0	111,610	100.0

* Percentages are significantly different.

The last of the householder characteristics discussed here are householder age and number of persons in the household. Table 7 shows the householder estimates by age group; these are very consistent for the two weighting methods. The largest difference in percentages is for the 25-34 year-old age group; based on the current householder weight, 16.7 % of householders are in this group, compared to 16.4% based on the FEW. This is the only statistically significant difference in Table 7. The household size estimates, provided in Table 8, are even more consistent: comparing the current householder and FEW estimates, none of the percentages differ by more than 0.1 points, although the difference for householders with 6 or more persons is statistically significant.

Age of Householder	CPS Householder Weight		Family Equalization Weight	
	N	%	N	%
15-24	6,597	5.5 (0.1)	6,465	5.5 (0.1)
25-34	20,032	*16.7 (0.2)	19,384	*16.4 (0.2)
35-44	22,455	18.7 (0.2)	22,117	18.7 (0.2)
45-54	25,290	21.1 (0.2)	24,792	21.0 (0.2)
55-64	20,711	17.3 (0.2)	20,617	17.5 (0.2)
65+	24,831	20.7 (0.2)	24,701	20.9 (0.2)
Total	119,916	100.0	118,077	100.0

* Percentages are significantly different.

Number of Persons in Household	CPS Householder Weight		Family Equalization Weight	
	N	%	N	%
1	32,911	27.4 (0.2)	32,474	27.5 (0.2)
2	40,230	33.6 (0.2)	39,757	33.7 (0.2)
3	18,972	15.8 (0.2)	18,677	15.8 (0.2)
4	15,987	13.3 (0.2)	15,668	13.3 (0.2)
5	7,367	6.1 (0.1)	7,210	6.1 (0.1)
6 or more	4,448	*3.7 (0.1)	4,291	*3.6 (0.1)
Total	119,916	100.0	118,077	100.0

* Percentages are significantly different.

6.3 Estimates of Population Characteristics

In addition to estimates of householders and households, the FEW can be used to obtain estimates of characteristics for the civilian noninstitutional population (CNP). This section includes comparisons of CNP estimates based on the final person weight (i.e., the second stage weight) and the FEW.

These two weights use the same estimates of the CNP as controls. Thus, the total CNP estimates based on the final person weight and the FEW will be equal, although the distribution of demographic and labor force characteristics may be different. Again, the most important of these characteristics in the CPS are estimates of employed and unemployed people, and the unemployment rate.

Table 9 presents data on labor force characteristics. The estimated number of employed people is slightly lower for the FEW, compared to the final person weight, but the FEW provides a slightly higher percentage for people who are not in the labor force. Both differences are statistically significant. The unemployment rates of 9.6% (from the FEW) and 9.5% (for the current final person weight) are not statistically different. I also examined the unemployment rates for July and August 2009, using the final person weight and the FEW, and found no statistical differences.⁸

CNP Labor Force Status	CPS Final Person Weight		Family Equalization Weight	
	N	%	N	%
Employed	139,440	*58.0 (0.2)	138,920	*57.8 (0.2)
Unemployed	14,641	6.1 (0.1)	14,748	6.1 (0.1)
Not in Labor Force	86,295	*35.9 (0.2)	86,705	*36.1 (0.2)
Total	240,380	100.0	240,380	100.0

⁸ These unemployment rates will not be the same as the seasonally adjusted rates released by BLS.

Unemployment Rate (%)		9.5 (0.1)		9.6 (0.1)
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* Percentages are significantly different.

The remaining tables in this section present estimates on race/ethnicity (Table 10), educational attainment (Table 11, for people aged 25 and over) and age (Table 12), for the CNP. Although there are small differences in estimates based on the final person weight and the FEW, there is also a high level of consistency in the two sets of estimates. None of the percentages for characteristics (e.g., percent of the CNP aged 25 and over who have some college, from Table 11) differ more than a tenth of a percentage point, and none are statistically significant.

Table 10. Race/Ethnicity of Civilian Noninstitutional Population (CNP), Using CPS Final Person Weights and Family Equalization Weights, September 2009 (estimates in thousands, standard errors in parentheses)				
CNP Race/Ethnicity	CPS Final Person Weight		Family Equalization Weight	
	N	%	N	%
White NonHispanic	196,880	65.1 (0.2)	197,040	65.2 (0.2)
Black NonHispanic	36,779	12.2 (0.1)	36,777	12.2 (0.1)
Hispanic	48,195	15.9 (0.1)	48,195	15.9 (0.1)
Asian	13,314	4.4 (0.1)	13,170	4.4 (0.1)
Other	7,220	2.4 (0.1)	7,202	2.4 (0.1)
Total	302,390	100.0	302,390	100.0

Table 11. Educational Attainment of Civilian Noninstitutional Population (25 and over), Using CPS Final Person Weights and Family Equalization Weights, September 2009 (estimates in thousands, standard errors in parentheses)				
CNP Educational Attainment	CPS Final Person Weight		Family Equalization Weight	
	N	%	N	%
Less than HSG	26,027	13.1 (0.1)	26,141	13.1 (0.1)
High School Grad	61,442	30.9 (0.2)	61,553	30.9 (0.2)
Some College	52,131	26.2 (0.2)	52,087	26.2 (0.2)
Bachelor's	38,839	19.5 (0.2)	38,740	19.5 (0.2)
Master's +	20,639	10.4 (0.1)	20,558	10.3 (0.1)
Total	199,080	100.0	199,080	100.0

Age of Householder	CPS Final Person Weight		Family Equalization Weight	
	N	%	N	%
Under 15	61,580	20.4 (0.1)	61,580	20.4 (0.1)
15-24	41,728	13.8 (0.1)	41,726	13.8 (0.1)
25-34	40,566	13.4 (0.1)	40,565	13.4 (0.1)
35-44	40,939	13.5 (0.1)	40,939	13.5 (0.1)
45-54	44,476	14.7 (0.1)	44,478	14.7 (0.1)
55-64	34,940	11.6 (0.1)	34,917	11.5 (0.1)
65+	38,157	12.6 (0.1)	38,181	12.6 (0.1)
Total	302,390	100.0	302,390	100.0

7. Variance Estimation

In section 6, I presented and discussed data on how the current and FEW estimates differed, or resembled each other. There is considerable evidence that the estimates, including the critical labor force estimates, are not statistically different. But we also want to compare the estimates of variance from the two methods. If we find, for example, that estimates of characteristics based on the FEW had much larger estimates of variance and standard errors than did estimates based on the current householder/final person weights, it would be problematic, since the CPS sample design is based on achieving a required level of reliability in unemployment rate estimates.

Historically, the CPS has used the replication method for estimating variance. Replicates are modified samples from the full survey sample; prior to 1970, the CPS used 40 replicates for variance estimation, but with improvements in computer capacity, the CPS currently uses 160 replicates for most variance computation. The variance of an estimate, Y_0 , can be represented in the following equation:

$$\text{Var}(Y_0) = \frac{4}{160} \sum_{r=1}^{160} (Y_r - Y_0)^2 \quad (5)$$

where Y_r is the estimate for the r th replicate sample, and Y_0 is the estimate for the full sample. The “4” in the equation results from the replicate factors we use. See U.S. Census Bureau (2006) for more details on variance estimation in the CPS.

The coefficient of variation (CV) is a relative measure of the sample error, and is a common way to present and compare variances of different estimates, given the wide range in the size of estimates (e.g., employed vs unemployed, or 2-person households vs. 5-person households). The CV is computed as the ratio of the standard error of an estimate to the estimate itself:

$$\text{CV}(Y) = \frac{\text{SE}(Y)}{Y} \quad (6)$$

We computed estimates of variance, using replicate weights as illustrated in (5), and then the corresponding CVs, as in (6). We did this for a variety of householder and CNP characteristics. We find that most of the CVs are larger for FEW estimates, although a few (6 of 43 estimates) were smaller for the FEW, and some were not different. When we compared the variance estimates with a chi-square statistic, we find support for concluding that the FEW results in larger CVs than the current householder/final person weight. But given the extra constraints imposed by the FEW (e.g., making householder and partner weights equal in married and unmarried couple households), it is reasonable to expect larger variances and CVs.

Table 13 provides the average CV for groups of characteristics on which we computed this statistic, for household/householder and CNP estimates.

Characteristic Groups	Mean CV of Estimates Based On:	
	Householder/Final Person Weight	Family Equalization Weight
Householder Labor Force Status	.0104	.0106
Householder Race/Ethnicity	.0115	.0128
Householder Education	.0118	.0119
Householder Age	.0080	.0097
Household Size	.0136	.0136
CNP Labor Force Status	.0070	.0070
CNP Race/Ethnicity	.0030	.0039
CNP Education	.0097	.0098

8. Discussion and Recommendations

The earlier discussion in this paper described the FEW and its application to weighting for the basic monthly CPS, and compared estimates using the FEW with those based on the current weights. The two weighting methods showed a great deal of consistency in the householder and CNP estimates they produced; differences in the distribution of labor force status and other characteristics, such as age and educational attainment, are mostly not statistically significant. We note that when we examined the variance estimates for these characteristics, we found somewhat higher CVs for many FEW estimates, compared to the current estimates. But as described in section 6, the FEW provides estimates of employment and the unemployment rate that are not significantly different from those provided by the current weight.

The FEW provides lower estimates of households than the current method, and these are closer to those obtained from other Census Bureau surveys. The FEW

could be used to represent both household and householder estimates, and thus resolve the household-householder discrepancy found in current CPS weights. As an alternative to the final person weight, it uses the same set of population controls; thus the total population estimate will not change, although there will be slight redistributions of subcategories for characteristics. In addition, although the CPS is not primarily concerned with estimates by household type, the FEW does provide consistent estimates of persons within married and unmarried partner households (e.g., equal estimates of males and females in male-female unmarried partner households).

The CPS could consider using the FEW as an additional weighting stage, following the current final person weight. As part of the process of considering such a change, the CPS may want to examine FEW estimates at the state level. Given the state-based design of the CPS, and the use of CPS data for annual average state unemployment rates, this would be a sensible area for further research. We may also want to examine more closely the definitions of groups used for computing the ratio adjustment factors for other male householders, in equation (2), and all other males, in equation (4).

Perhaps the biggest implication of implementing the FEW would be the change in estimates of households (i.e., an abrupt rather than a smooth decrease, representing the change). We would need to consider the experiences of other survey programs, in implementing such a change, as we move forward.

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