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An Analysis of the Sampling Frame for the Chemical Use and Farm Finance Survey

Susan Cowles
Susan Hicks

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ABSTRACT

The National Agricultural Statistics Service (NASS) plans to reduce respondent burden and improve data quality by combining the Objective Yield Cropping Practices Survey (Form H) and the Cost of Production Survey (COPS) versions of the Farm Cost and Returns Survey (FCRS) to form the Chemical Use and Farm Finance Survey (CUFFS). A pilot survey for CUFFS was conducted in 1991 in Minnesota and both Minnesota and Louisiana in 1992. Most NASS surveys utilize a multiple frame design -- a combination of list and area frames. To evaluate the necessity of a multiple frame sample for this survey, each State's Form H data for selected commodities was partitioned into overlap (OL) and nonoverlap (NOL) domains. Multiple frame (MF) and OL estimates of percent of acres treated and rate of application were compared. Comparisons were then made between the multiple frame components--OL and NOL domains. Significant differences were found but they were not consistent across commodity, chemical, State or time.

KEY WORDS

Sample frame; Bootstrap-t confidence intervals; Overlap; Nonoverlap.

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SUMMARY

The National Agricultural Statistics Service has developed a survey which consists of three phases: screening for a given commodity, collecting chemical use data, and collecting economic data. Pilot studies for this Chemical Use and Farm Finance Survey (CUFFS) have begun. However, the sampling frame is still in question. The proposed sample design consists of a list only sample. This paper examines the need for a multiple frame sample that would cover the entire population--made up of both area and list frames--versus a list only sample.

Pilot studies were conducted in Minnesota in 1991 and 1992 and Louisiana in 1992. These pilot surveys used the proposed list only sample. Because the CUFFS data did not have both list and area components to compare, Cropping Practices (Form H) data was used to evaluate the sampling frame. Each data set was divided into list (OL) and area (NOL) domains and then the Form H summary was run for each domain separately as well as the combined data set.

Multiple frame (MF) and OL estimates of percent of acres treated and rate of application for common commodity/chemical combinations were tested for significant statistical differences. Thirteen statistical differences were found from the seventy-four tests performed using a 90% confidence level.

The same commodity/chemical combinations were tested for differences between the OL and NOL percents of acres treated and mean rates of application. Of the seventy-four tests performed, fifteen statistical differences were found. Eight of these differences occurred between OL and NOL percent of acres treated and the remaining seven differences were between mean rates of application. Two differences between percent of acres treated in Minnesota were consistent across 1991 and 1992. Because a 90% confidence level was used in the tests, seven or eight statistical differences could have been found strictly by chance when no true difference exists and when the tests are independent.

Although the data suggest some differences between OL and NOL characteristics, the differences are not consistent over commodity, chemical, State or time. Also, many of the differences, although statistical, may not be of operational or practical importance. If the CUFFS continues to be conducted with a list only sampling frame and becomes operational nationally, quality control checks such as periodic reviews to determine if OL and NOL differences continue to exist need to be conducted.

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INTRODUCTION

In 1991 the National Agricultural Statistics Service (NASS) began pilot studies of a Chemical Use and Farm Finance Survey (CUFFS) which integrates collection of field level chemical use, farm level crop-specific chemical use and farm finance information. That information is currently collected using the Objective Yield Cropping Practices Survey (Form H) and the Farm Costs and Returns Surveys' Cost of Production Survey (FCRS-COPS). When, or if, CUFFS becomes operational, it would replace Form H and COPS would be shortened for crops being targeted by CUFFS.

Pilot surveys for CUFFS were conducted in Minnesota in 1991 and in both Minnesota and Louisiana in 1992. These pilot surveys collected data on barley, corn, oats, soybeans and spring wheat in Minnesota and rice, cotton and soybeans in Louisiana.

The CUFFS design consists of three phases. In the first phase operations are contacted to determine if they have the commodity of interest. In the second phase pesticide and fertilizer use information is collected in the fall from operations that reported having the commodity. Finally, those same operations are recontacted the following spring to obtain economic data.

CUFFS was developed by NASS in an effort to reduce respondent burden, improve data quality and improve response rates. Respondent burden is expected to be reduced as Objective Yield and FCRS-COPS interviews are shortened substantially. Data quality improvement is expected as a result of collecting information closely following harvest. Currently the COPS versions of the FCRS collect data six months after harvest is complete. A better response rate is predicted for the economic data due to its association with chemical use data, which farmers are willing to provide as a result of widespread public concern for farming's effect on water quality and the environment.

This paper investigates whether a list frame only sample is adequate for this survey, or if an additional area frame representation is necessary to estimate percent acres treated and application rates. The list frame is a list of known farm operators in a state, which can never be complete, while the area frame covers completely the farming operations in a specific geographic location. Farm operators found in the area frame that are not represented on the list comprise the NonOverlap sample or NOL. NASS usually uses multiple frame samples to provide complete coverage of the population. The three major advantages to using a list only sample are a reduction in respondent burden for the NOL, cost savings and reduction in variances.

Respondent burden reduction is a major advantage of a list only sample. The NOL domain is relatively small due to small area frame sample sizes and more complete list frames. However, the relatively small population of NOL operators must be spread across many NASS surveys, with the result that some NOL operators must be interviewed for multiple surveys.

The cost savings due to a list only sample are small compared to total survey costs. However, for less common commodities the NOL produces few if any positive operations. In those cases, the cost per positive record is high. If the NOL domain is included, this cost could be reduced by screening operations by telephone for the commodity of interest prior to interview.

At the U.S. level, the NOL contributes about 15% to total planted acres for major commodities such as corn and soybeans, but contributes about 40% to the total variance. For most commodities, the CV for a list only sample would be smaller than the multiple frame CV. However, the decrease in variance comes at a cost and that cost is bias. A list only sample introduces an inherent bias into the estimate by excluding some members of the population from the sample universe. However, if farm operators in the NOL domain are similar to farm operators on the list frame, then the bias may be minimal. Typically, farms on the list frame are larger in size than those not on the list frame, but that may not affect the variables under consideration.

The CUFFS pilot studies used the proposed list only sample design. Therefore, each state's Form H data was examined as a proxy to provide a NOL domain. Since all comparisons were made using a single survey's results, the study essentially controlled for differences between survey methodologies. Corn, soybeans and spring wheat were studied for Minnesota, while rice, cotton and soybeans were used for Louisiana. The available data (which came from the area frame) were divided into overlap (OL) and nonoverlap (NOL) domains in order to analyze differences in chemical usage between those domains.

To simulate OL and NOL characteristics, the data were divided into operations that were OL and NOL to FCRS for the given year. The OL to FCRS group was further divided into groups determined by whether or not they were in a strata being sampled for CUFFS. If an operation was OL to FCRS <u>and</u> in a CUFFS strata, it was OL to CUFFS. All others were considered NOL to CUFFS.

The Form H summary was run for the complete data set as well as the component domains to obtain each active ingredient's percent of acres treated and mean rate of application per treatment. Multiple frame estimates were compared to OL estimates to determine if the list only sample would result in estimates equivalent to those found using the more complete multiple frame. Twelve commodity/chemical combinations were studied for Minnesota and thirteen were selected for Louisiana. Percents and rates from the same commodity/chemical combinations were then compared between OL and NOL to examine causes for any differences.

METHODS

Percent acres treated is estimated as:

$$\hat{p}_d = \frac{n_d}{u_d}$$

where:

d = MF, OL or NOL domain

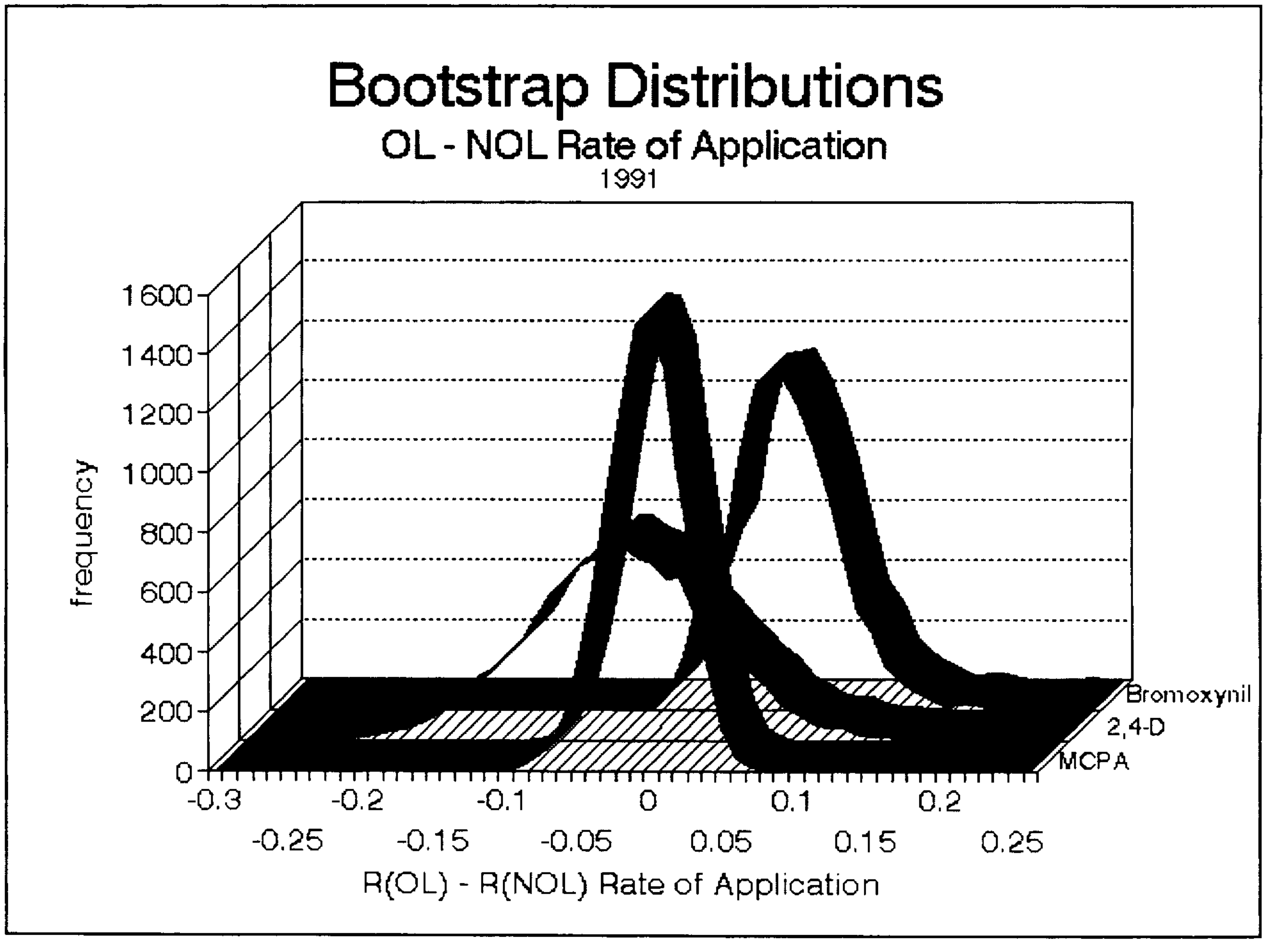
n_d = number of positive responses in domain d

u_d = number of usable responses in domain d

The variances were calculated using the usual formulas for the variance of a proportion when data are obtained by a simple random sample. In actuality, the sample design was more complicated than a SRS. We assumed that the effect of the design's clustering and stratification on the variance was ignorable.

The t-test was used to determine whether or not differences existed between domain

Figure 1. Frequency of OL-NOL Differences for Rate of Application (Spring Wheat)



estimates of percent acres treated. The critical t-value used was 1.645, corresponding to a 90% confidence level.

Mean rate of application is estimated as:

$$\hat{R}_d = \frac{\bar{z}_d}{\bar{y}_d}$$

where:

$\bar{z}_d$ = *average rate of application for each commodity/chemical combination in domain d*

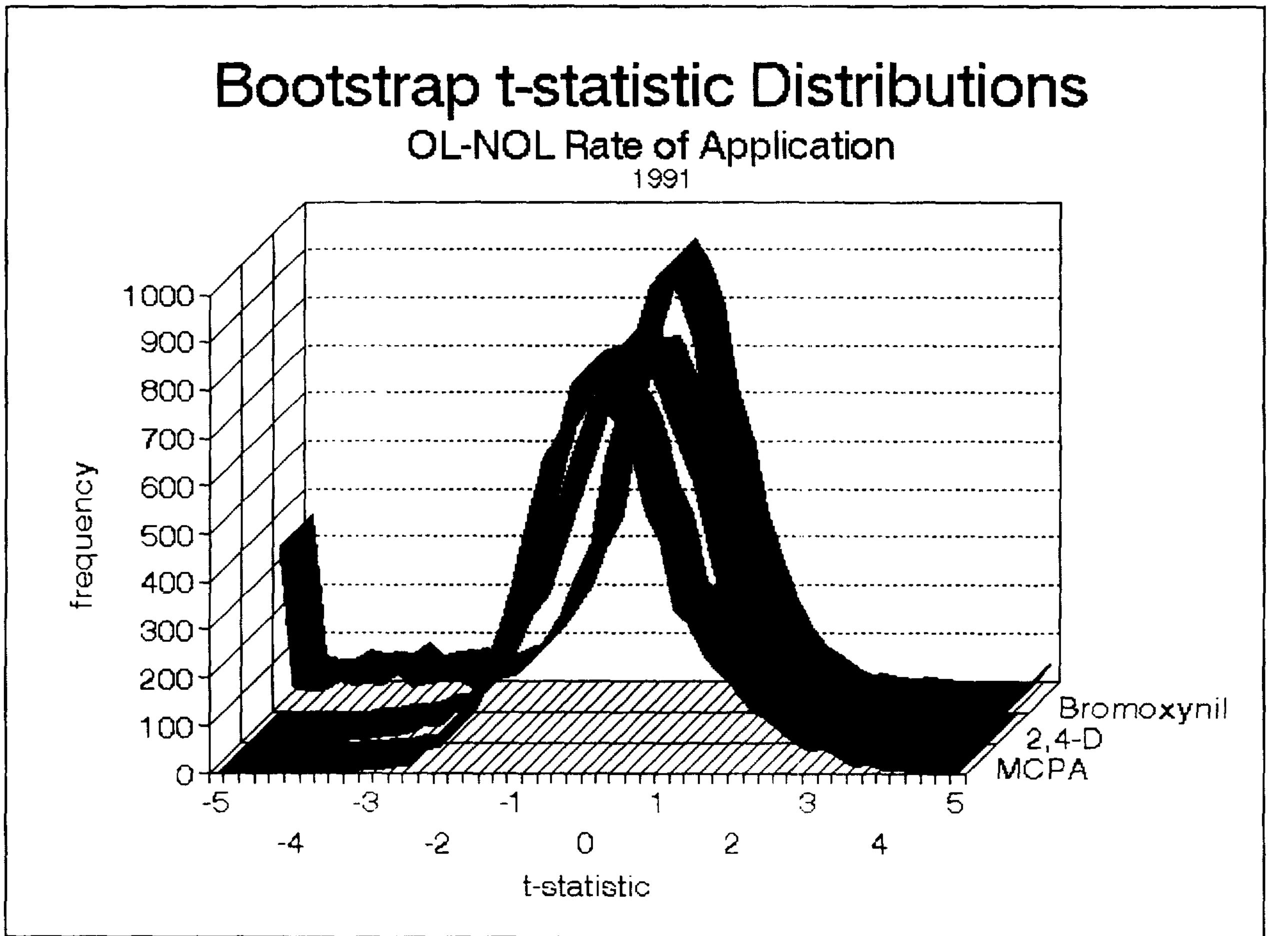
$\bar{y}_d$ = *average number of treatments for each commodity/chemical combination in domain d*

The t-test was also used for MF vs OL domain comparisons for estimates of rate of application per treatment. The correlation between the two estimates was accounted for in the variance estimate of the difference.

When OL and NOL estimates of mean rate of application per treatment were tested for differences, bootstrap-t confidence intervals were calculated instead of the usual t-tests because of concerns about the normality of the statistic being tested. (Rao & Wu, 1988)

Histograms constructed using bootstrap methodology suggested departures from

Figure 2. Bootstrap t-statistics for OL-NOL Rate of Application (Spring Wheat)



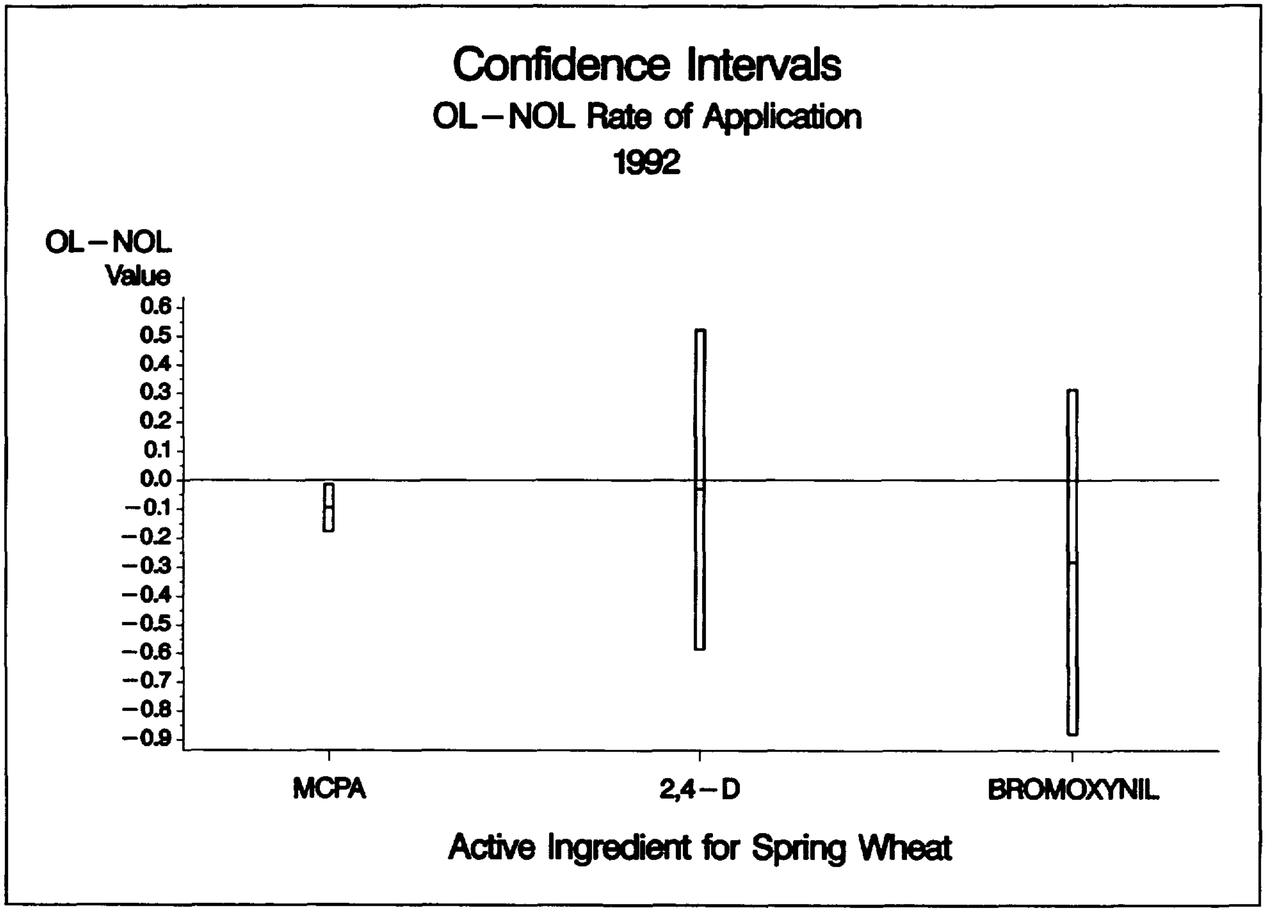
normality in the distribution of some of the mean rate of application per treatment statistics. The bootstrap confidence intervals should perform as well as the normal confidence intervals when the data are normal and better when the data are not normal. However, using bootstrap methodology does not guarantee all deviations from normality were accomodated.

Figure 1 (page 3) shows the bootstrap distributions of the rate of application differences between OL and NOL estimates for spring wheat. Although they are nearly symmetric for MCPA and 2-4D, the distributions are not necessarily normal. MCPA has a narrow spiked distribution while 2,4-D has a shorter and wider distribution.

The effects of the distributions of the OL-NOL differences are reflected in the distributions of the t-statistics shown in Figure 2 (preceding page). The ribbon representing Bromoxynil goes up at the tails to illustrate the continuation of the distribution outside the bounds of the graph. Bromoxynil is skewed left with bootstrap t-statistics going as low as -18. Although differences between the distributions for each chemical are not as pronounced as those in Figure 1, they are visible.

From the combined OL and NOL sample,

Figure 3. Confidence Intervals for Spring Wheat Rate of Application (1992)



10,000 bootstrap samples of size m=n-1 were drawn with replacement from the parent sample of size n. For each bootstrap sample, b, the following were calculated:

$$\hat{R}_{OL,b} = \bar{z}_{OL,b} / \bar{y}_{OL,b}$$

$$\hat{R}_{NOL,b} = \bar{z}_{NOL,b} / \bar{y}_{NOL,b}$$

$$\theta_b = \hat{R}_{OL,b} - \hat{R}_{NOL,b}$$

$$Var(\theta_b) = Var(\hat{R}_{OL,b}) + Var(\hat{R}_{NOL,b})$$

Then for each bootstrap sample the usual t-statistic for a difference was calculated.

$$\hat{t}_b = \frac{\theta_b - \theta}{SE(\theta_b)}$$

where:

$$\theta = \frac{\Sigma\theta_b}{B}$$

B = *total number of bootstrap samples drawn*

Based on the distribution of the bootstrap t-statistics, the 5[th] and 95[th] percentiles of the t-distribution were estimated for each commodity/chemical combination. These bootstrap-t percentiles were used to create 90% confidence intervals around the difference in the rates of application between OL and NOL domains.

The confidence interval is defined as:

$$\{ \hat{D} - t_{.95}\hat{\sigma}(\hat{D}),\ \hat{D} - t_{.05}\hat{\sigma}(\hat{D}) \}$$

where:

$\hat{D} = \hat{R}_{OL} - \hat{R}_{NOL}$ -- *from the original sample*

$\hat{\sigma}(\hat{D})$ = *standard error of difference*

$t_{.05}, t_{.95}$ = *percentiles of the bootstrap t distribution*

If the confidence interval did not contain zero, a statistical difference was found between the OL and NOL mean rates of application per treatment. Figure 3 (preceding page) shows graphically the bootstrap-t confidence intervals found for Minnesota's 1992 spring wheat rate of application. MCPA showed a significant difference between OL and NOL rates of application (the confidence interval does not include zero).

All of the test statistics and confidence intervals were found using unrounded numbers. Percents and rates given in this paper have been rounded as are standard published estimates.

RESULTS

Note: Complete tables of results, including t-statistics and Bootstrap-t confidence intervals are in Appendix A.

PERCENT ACRES TREATED

Table 1 (page 7) contains MF and the component OL and NOL estimates for percent acres treated for both Minnesota and Louisiana. Three statistical differences between MF and OL estimates were found in Minnesota in 1991 (12 differences were tested) and four differences were found in Minnesota and Louisiana in 1992 (25 differences were tested).

Table 1. Multiple Frame and Component (OL and NOL) Estimates for Percent of Acres Treated in Minnesota and Louisiana.

		Percent Acres Treated 1991			Percent Acres Treated 1992		
Commodity	Active Ingredient	MF	OL	NOL	MF	OL	NOL
MINNESOTA							
Corn	Nitrogen	97	97	98	96	96	94
	Dicamba	30	31	27	**47**	**45★**	**55***
	Atrazine	32	32	29	39	38	44
	Alachlor	25	26	19	21	22	21
	Metolachlor	25	25	27	28	28	29
Soybeans	Trifluralin	**43**	**47★**	**37***	**53**	**55★**	**44***
	Imazethapyr	54	56	51	67	66	70
	Alachlor	11	10	12	6	5	6
	Bentazon	12	12	10	14	14	16
Spring Wheat	MCPA	64	68	52	64	66	59
	2,4-D	**33**	**28★**	**52***	36	40	24
	Bromoxynil	**33**	**37★**	**21***	33	**38**	**18***
LOUISIANA							
Rice	Nitrogen	DATA NOT AVAILABLE			100	100	100
	Propanil				58	57	63
	Molinate				58	60	42
	Carbofuran				28	27	36
Cotton	Nitrogen				97	97	100
	Fluometuron				**66**	**63★**	**84***
	MSMA				58	56	69
	Norflurazon				46	43	61
Soybeans	Trifluralin				**23**	**20★**	**32***
	Acifluorfen				25	26	21
	Metribuzin				26	26	27
	Clomazone				17	15	23
	Imazequin				26	26	25

★ Significant difference between MF and OL estimates at a 90% confidence level.
* Significant difference between OL and NOL estimates at a 90% confidence level.

Trifluralin applied to soybeans showed a statistical difference between domains for both years and states. However, in Louisiana the OL domain treated a smaller percentage than the MF while in Minnesota the OL domain treated a greater percentage of acres.

In addition to those differences between MF and OL estimates which were significant ($|t| > 1.645$), three other commodity/chemical combinations were very close. In 1991 in Minnesota, Alachlor applied to corn and MCPA applied to spring wheat nearly showed statistical differences between MF and OL percents of acres treated.

In 1992, Bromoxynil applied to spring wheat had a t-value near the critical value when testing for a difference between MF and OL estimates. Bromoxynil's MF and OL estimates of percent of acres treated were found to be statistically different the previous year. A statistical difference between OL and NOL estimates was found both years. In 1991 and 1992 the OL domain applied Bromoxynil to a greater percentage of acres than the total sample.

More statistical differences than could be expected by chance were found. Therefore, the data suggest there can be significant differences between percent of acres treated in the MF and OL domains. Nearly one-third of the MF and OL estimates of percent acres treated are equivalent. MF and OL estimates of percent acres treated differ by only 0-5 percentage points. If that margin of error is acceptable, then list only estimates of percent acres treated can be used instead of multiple frame estimates.

RATE PER TREATMENT

Differences between mean rates per treatment for MF and OL domains were harder to interpret. (Table 2, following page.) For example, in Minnesota, Imazethapyr applied to soybeans showed a <u>statistical</u> difference in both years while the published rates are equivalent. (States publish rates with two digits following the decimal point.) If the numbers are carried out further, MF=0.0543 and OL=0.0533 in 1991 and in 1992, MF=0.0537 and OL=0.0529. This particular commodity/chemical combination has an extremely narrow distribution resulting in a statistical difference when there is no practical operational difference.

The rates of application for Bentazon and MCPA to their respective commodities rose in the NOL domain and shrank in the OL domain between 1991 and 1992. These changes resulted in the detection of statistical differences in 1992.

In Louisiana three differences were found between OL and NOL rate per treatment. However, only Metribuzin applied to soybeans showed a difference between MF and OL rates so the NOL domain was overshadowed by the OL domain.

OL rate estimates range from 8% below MF estimates to 17% above MF estimates. However, neither of those extremes was statistically significant. Over half of the thirty-seven (37) OL estimates varied 1% or less from their corresponding MF mean rate of application per treatment estimates.

These results are based on some very small sample sizes. (See Appendix B.) The number of usable records in Louisiana was small for each commodity/chemical

Table 2. Multiple Frame and Component (OL and NOL) Estimates for Rate per Treatment in Minnesota and Louisiana.

		Rate per Treatment (pounds) 1991			Rate per Treatment (pounds) 1992		
Commodity	Active Ingredient	MF	OL	NOL	MF	OL	NOL
MINNESOTA							
Corn	Nitrogen	66.50	67.25	63.07	65.68	66.30	63.30
	Dicamba	**0.31**	**0.32★**	**0.25***	0.34	0.34	0.35
	Atrazine	0.80	0.80	0.82	0.77	0.78	0.74
	Alachlor	2.29	2.24	2.63	2.22	2.16	2.44
	Metolachlor	2.17	2.14	2.31	2.28	2.32	2.13
Soybeans	Trifluralin	0.78	0.77	0.81	0.81	0.79	0.87
	Imazethapyr	**0.05**	**0.05★**	0.06	**0.05**	**0.05★**	**0.06***
	Alachlor	2.58	2.60	2.54	2.33	2.46	2.00
	Bentazon	0.71	0.69	0.76	**0.68**	**0.64★**	**0.80***
Spring Wheat	MCPA	0.29	0.29	0.30	**0.28**	**0.26★**	**0.35***
	2,4-D	0.28	0.26	0.31	0.27	0.26	0.29
	Bromoxynil	0.23	0.24	0.19	0.23	0.23	0.23
LOUISIANA							
Rice	Nitrogen	DATA NOT AVAILABLE			49.99	50.13	49.04
	Propanil				3.37	3.36	3.51
	Molinate				2.82	2.80	3.09
	Carbofuran				0.51	**0.52**	**0.49***
Cotton	Nitrogen				57.26	**61.26**	**39.24***
	Fluometuron				0.61	0.62	0.55
	MSMA				0.90	0.88	0.95
	Norflurazon				0.55	0.54	0.60
Soybeans	Trifluralin				1.19	1.19	1.20
	Acifluorfen				0.21	0.21	0.23
	Metribuzin				**0.33**	**0.35★**	**0.26***
	Clomazone				0.73	0.67	0.85
	Imazequin				0.06	0.07	0.06

★ Significant difference between MF and OL estimates at a 90% confidence level.

* Significant difference between OL and NOL estimates at a 90% confidence level.

combination, especially for the NOL domain. In 1992, as few as three observations were present for NOL commodity/chemical combinations.

The Minnesota commodity/chemical combinations with less than ten observations were studied because their sample sizes were larger in 1991 and we were interested in changes over time. The Louisiana commodity/chemical combinations with less than ten observations were studied because they were the most common combinations.

CONCLUSIONS

Percent acres treated and rate of application per treatment were examined for Minnesota and Louisiana for a wide range of commodity/chemical combinations to determine the necessity of a multiple frame sample. Some differences were found between MF and list estimates for percent of acres treated and rate of application per treatment.

The purpose of this study was to determine whether the CUFFS should be a multiple frame survey or a list only survey. The results indicate some statistical differences exist, but as they are not consistent across commodities, chemicals, time or states, modelling for the differences would be difficult.

OL estimates of percent acres treated are within five percentage points of corresponding MF estimates. OL and NOL estimates differed by as much as 24 percentage points, but 65% differed by less than 10 percentage points. Most of those differences are not significant due to variability in the estimates. The fact that a difference was significant one year did not indicate a significant difference the other year. However, the MF and OL estimates of the percent of soybean acres treated with Trifluralin in Minnesota were significantly different in both 1991 and 1992, indicating a potential real difference, although the differences were small at four and two percentage points respectively.

OL mean rate of application per treatment estimates varied from 8% below the corresponding MF estimate to 17% above the MF estimate. OL estimates differed 1% or less from MF estimates in over half of the commodity/chemical combinations examined. When comparing OL to NOL mean rates of application per treatment, OL estimates ranged from 26% below corresponding NOL estimates to 56% above NOL estimates. Due to small NOL domain sizes, these large differences do not translate into similarly large differences between OL and MF estimates. As with percent acres treated estimates, significant differences one year did not imply significant differences in other years.

RECOMMENDATIONS

Using a list only sampling frame will produce some estimates that would be significantly different from multiple frame estimates. Percent acres treated varied five percentage points above or below the MF estimates. List only estimates of rate of application per treatment ranged 10% below and above the MF estimate. If this level of accuracy is acceptable, list only sampling can be used for these two States. However, these two States are not necessarily representative of all States. Cropping practices vary by region and State, making generalizations difficult.

If list only sampling is used operationally, periodic quality control checks to insure that important differences between MF and OL estimates do not develop would be necessary.

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APPENDIX A

Table 3. Minnesota Multiple Frame (MF) and OL Percent Acres Treated and t Values

		Percent Acres Treated 1991			Percent Acres Treated 1992		
Commodity	Active Ingredient	MF	OL	t	MF	OL	t
Corn	Nitrogen	97	97	-0.902	96	96	-1.083
	Dicamba	30	31	0.894	**47**	**45**	**1.973***
	Atrazine	32	32	0.643	39	38	1.161
	Alachlor	25	26	1.636	21	22	-0.262
	Metolachlor	25	25	-0.381	28	28	0.283
Soybeans	Trifluralin	**43**	**47**	**-1.938***	**53**	**55**	**-1.697***
	Imazethapyr	54	56	-0.845	67	66	0.729
	Alachlor	11	10	0.732	6	5	0.354
	Bentazon	12	12	-0.645	14	14	0.414
Spring Wheat	MCPA	64	68	-1.582	64	66	-0.515
	2,4-D	**33**	**28**	**2.288***	36	40	-1.262
	Bromoxynil	**33**	**37**	**-1.784***	33	38	-1.635

Table 4. Louisiana Multiple Frame (MF) and OL Percent Acres Treated and t Values

		Percent Acres Treated 1992		
Commodity	Active Ingredient	MF	OL	t
Rice	Nitrogen	100	100	0.000
	Propanil	58	57	0.490
	Molinate	58	60	-1.433
	Carbofuran	28	27	0.852
Cotton	Nitrogen	97	97	1.323
	Fluometuron	**66**	**63**	**1.683***
	MSMA	58	56	0.923
	Norflurazon	46	43	1.197
Soybeans	Trifluralin	**23**	**20**	**1.696***
	Acifluorfen	25	26	-0.737
	Metribuzin	26	26	0.169
	Clomazone	17	15	1.283
	Imazaquin	26	26	-0.184

APPENDIX A (continued)

Table 5. Minnesota Multiple Frame (MF) and OL Rate per Treatment and t Values

Commodity	Active Ingredient	Rate per Treatment 1991 (pounds)			Rate per Treatment 1992 (pounds)		
		MF	OL	t	MF	OL	t
Corn	Nitrogen	66.50	67.25	-1.139	65.68	66.30	-1.048
	Dicamba	**0.31**	**0.32**	**-3.691***	0.34	0.34	0.290
	Atrazine	0.80	0.80	0.219	0.77	0.78	-0.669
	Alachlor	2.29	2.24	1.185	2.22	2.16	1.139
	Metolachlor	2.17	2.14	1.242	2.28	2.32	-1.409
Soybeans	Trifluralin	0.78	0.77	0.956	0.81	0.79	1.645
	Imazethapyr	**0.05**	**0.05**	**1.789***	**0.05**	**0.05**	**1.907***
	Alachlor	2.58	2.60	-0.315	2.33	2.46	-1.187
	Bentazon	0.71	0.69	1.127	**0.68**	**0.64**	**2.074***
Spring Wheat	MCPA	0.29	0.29	0.418	**0.28**	**0.26**	**1.757***
	2,4-D	0.28	0.26	0.757	0.27	0.26	0.247
	Bromoxynil	0.23	0.24	-1.174	0.23	0.23	0.034

Table 6. Louisiana Multiple Frame (MF) and OL Rate per Treatment and t Values

Commodity	Active Ingredient	Rate per Treatment 1992 (pounds)		
		MF	OL	t
Rice	Nitrogen	49.99	50.13	-0.405
	Propanil	3.37	3.36	0.561
	Molinate	2.82	2.80	1.455
	Carbofuran	0.51	0.52	-1.617
Cotton	Nitrogen	57.26	61.26	-0.838
	Fluometuron	0.61	0.62	-0.810
	MSMA	0.90	0.88	0.632
	Norflurazon	0.55	0.54	0.477
Soybeans	Trifluralin	1.19	1.19	0.126
	Acifluorfen	0.21	0.21	0.538
	Metribuzin	**0.33**	**0.35**	**-2.115***
	Clomazone	0.73	0.67	1.523
	Imazaquin	0.06	0.07	-0.943

APPENDIX A (continued)

Table 7. Minnesota OL and NOL Percent Acres Treated and t Values

Commodity	Active Ingredient	Percent Acres Treated 1991			Percent Acres Treated 1992		
		OL	NOL	t	OL	NOL	t
Corn	Nitrogen	97	98	-0.900	96	94	1.081
	Dicamba	31	27	0.892	**45**	**55**	**-1.991***
	Atrazine	32	29	0.640	38	44	-1.160
	Alachlor	26	19	1.643	22	21	0.260
	Metolachlor	25	27	-0.379	28	29	-0.281
Soybeans	Trifluralin	**47**	**37**	**1.950***	**55**	**44**	**1.710***
	Imazethapyr	56	51	0.844	66	70	-0.726
	Alachlor	10	12	-0.731	5	6	-0.352
	Bentazon	12	10	0.644	14	16	-0.412
Spring Wheat	MCPA	68	52	1.602	66	59	0.502
	2,4-D	**28**	**52**	**-2.400***	40	24	1.275
	Bromoxynil	**37**	**21**	**1.828***	**38**	**18**	**1.700***

Table 8. Louisiana OL and NOL Percent Acres Treated and t Values

Commodity	Active Ingredient	Percent Acres Treated 1992		
		OL	NOL	t
Rice	Nitrogen	100	100	0.000
	Propanil	57	63	-0.473
	Molinate	60	42	1.447
	Carbofuran	27	36	-0.831
Cotton	Nitrogen	97	100	-1.430
	Fluometuron	**63**	**84**	**-1.824***
	MSMA	56	69	-0.925
	Norflurazon	43	61	-1.218
Soybeans	Trifluralin	**20**	**32**	**-1.713***
	Acifluorfen	26	21	0.733
	Metribuzin	26	27	-0.167
	Clomazone	15	23	-1.285
	Imazaquin	26	25	0.183

APPENDIX A (continued)

Table 9. Minnesota OL and NOL Rate per Treatment, 1991, and Bootstrap-t Confidence Intervals

Commodity	Active Ingredient	Rate per Treatment 1991 (pounds)		Bootstrap CI	
		OL	NOL	LL	UL
Corn	Nitrogen	67.25	63.07	-2.110	9.888
	Dicamba	**0.32**	**0.25**	**0.047**	**0.098***
	Atrazine	0.80	0.82	-0.232	0.134
	Alachlor	2.24	2.63	-0.900	0.176
	Metolachlor	2.14	2.31	-0.381	0.067
Soybeans	Trifluralin	0.77	0.81	-0.126	0.030
	Imazethapyr	0.05	0.06	-0.006	0.000
	Alachlor	2.60	2.54	-0.229	0.414
	Bentazon	0.69	0.76	-0.182	0.048
Spring Wheat	MCPA	0.29	0.30	-0.066	0.030
	2,4-D	0.26	0.31	-0.149	0.059
	Bromoxynil	0.24	0.19	-0.007	0.202

Table 10. Minnesota OL and NOL Rate per Treatment, 1992, and Bootstrap-t Confidence Intervals

Commodity	Active Ingredient	Rate per Treatment 1992 (pounds)		Bootstrap CI	
		OL	NOL	LL	UL
Corn	Nitrogen	66.30	63.30	-1.472	7.426
	Dicamba	0.34	0.35	-0.034	0.024
	Atrazine	0.78	0.74	-0.077	0.149
	Alachlor	2.16	2.44	-0.666	0.117
	Metolachlor	2.32	2.13	-0.025	0.398
Soybeans	Trifluralin	0.79	0.87	-0.144	0.009
	Imazethapyr	**0.05**	**0.06**	**-0.006**	**-0.0003***
	Alachlor	2.46	2.00	-0.398	0.997
	Bentazon	**0.64**	**0.80**	**-0.258**	**-0.049***
Spring Wheat	MCPA	**0.26**	**0.35**	**-0.178**	**-0.014***
	2,4-D	0.26	0.29	-0.587	0.524
	Bromoxynil	0.23	0.23	-0.880	0.313

Table 11. Louisiana OL and NOL Rate per Treatment and Bootstrap-t Confidence Intervals

		Rate per Treatment (pounds) 1992		Bootstrap CI	
Commodity	Active Ingredient	OL	NOL	LL	UL
Rice	Nitrogen	50.13	49.04	-3.145	5.700
	Propanil	3.36	3.51	-1.000	0.281
	Molinate	2.80	3.09	-0.662	0.037
	Carbofuran	**0.52**	**0.49**	**0.001**	**0.095***
Cotton	Nitrogen	**61.26**	**39.24**	**10.790**	**30.967***
	Fluometuron	0.62	0.55	-0.098	0.200
	MSMA	0.88	0.95	-0.300	0.086
	Norflurazon	0.54	0.60	-0.319	0.106
Soybeans	Trifluralin	1.19	1.20	-0.251	0.173
	Acifluorfen	0.21	0.23	-0.087	0.040
	Metribuzin	**0.35**	**0.26**	**0.039**	**0.166***
	Clomazone	0.67	0.85	-0.356	0.046
	Imazequin	0.07	0.06	-0.006	0.022

APPENDIX B

Table 12. 1992 Minnesota and Louisiana Response Rates and OL and NOL Domain Sizes

Commodity	Response Rate	Active Ingredient	Number of Responses Reporting Active Ingredient	
			OL	NOL
MINNESOTA				
Corn	87.3%	Nitrogen	405	105
		Dicamba	188	62
		Atrazine	158	49
		Alachlor	91	23
		Metolachlor	118	33
Soybeans	87.0%	Trifluralin	134	34
		Imazethapyr	158	54
		Alachlor	13	5
		Bentazon	33	11
Spring Wheat	83.8%	MCPA	33	10
		2,4-D	20	4
		Bromoxynil	19	3
LOUISIANA				
Rice	87.9%	Nitrogen	124	19
		Propanil	71	12
		Molinate	75	8
		Carbofuran	33	7
Cotton	63.8%	Nitrogen	68	13
		Fluometuron	44	11
		MSMA	39	9
		Norflurazon	30	8
Soybeans	74.0%	Trifluralin	32	18
		Acifluorfen	42	12
		Metribuzin	41	15
		Clomazone	24	13
		Imazequin	42	14