Appendix A. Farmer Sample Selection

A.1 Background

This survey was a collaborative effort between the Climate and Corn-based Cropping Systems CAP (CSCAP) and the Useful-to-Usable (U2U) project. The original sampling plan for both the CSCAP and U2U projects called for state-level selection of random samples of farmers in several Corn Belt states. Once the project teams decided to pool resources, the possibility of using hydrological, ecological, or other criteria to stratify the Corn Belt study area was explored. We stratified by watershed because: 1) agricultural systems are influenced by ecological conditions that vary by hydrological unit; 2) the impacts of climate change are predicted to be in large part hydrological; and, 3) the National Agricultural Statistics Service (NASS) could sample by HUC6 watershed.

We limited our geographic scope to "major crop areas" for corn and soybeans as defined by the USDA (USDA 1994). Corn Belt counties that comprise the "major crop areas" for corn and soybeans span 25 HUC6 watersheds. These watersheds represent nearly 65 percent of all corn acres and 55 percent of soybean acres in the U.S.

A.2 Watershed selection

There are 25 HUC6 watersheds that comprise the area that USDA defines as "major crop areas" for corn and soybeans (USDA 1994). These watersheds cover some or all of 11 states:

Illinois	Missouri
Indiana	Nebraska
Iowa	Ohio
Kansas	South Dakota
Michigan	Wisconsin
Minnesota	

Initial calculations were conducted to determine the number of farms that must be surveyed in order to have a representative sample from which to generalize to the population of each watershed 1) at the 95% confidence level assuming a margin of error of 2.5% and 2) assuming a 40% response rate. It was estimated that approximately 900 farmers per watershed would need to be surveyed, depending on the population of farms within each watershed. Thus, the combined initial survey budget would cover only 16 watersheds. It was therefore necessary to develop decision criteria to determine which watersheds would be included/excluded. Between the two projects we were able to secure additional funding which allowed us to survey 22 watersheds.

Two main criteria were identified for determining watershed selection within the major crop areas:

(1) the proportion of total cropland that is planted to corn/soybeans within a HUC6 watershed; and

(2) the proportion of total cropland that is irrigated.

The 25 proposed HUC6 watersheds were ranked according to the two criteria. Fifteen watersheds were then selected: 1) the top ten watersheds based on corn/soybean production intensity, and 2) the top five watersheds based on irrigation acreage. All data on cropland and acreage were taken from the 2007 Census of Agriculture (NASS 2009).

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The top 15 watersheds, in ranked order by criteria are:

- Top ten by percent of cropland planted to corn and soy:
    1. 071300 — Lower Illinois
    2. 102300 — Missouri–Little Sioux
    3. 051201 — Wabash
    4. 071200 — Upper Illinois
    5. 070802 — Iowa
    6. 071402 — Kaskaskia
    7. 051202 — Patoka–White
    8. 070801 — Upper Mississippi Skunk Wapsipinicon
    9. 071000 — Des Moines
    10. 102002 — Lower Platte

- Top five by percent of cropland irrigated:
    11. 102001 — Middle Platte
    12. 102100 — Loup
    13. 102702 — Big Blue
    14. 102200 — Elkhorn
    15. 040500[1] — Southeastern Lake Michigan

[1]Because watershed 102002 was ranked 10th in corn and soy and 5th in irrigated acres, 040500 was selected as the fifth intensively irrigated watershed.

Selection of the next watersheds for inclusion followed a less rigid logic. Climatological, ecological, political, and other reasons were all considered and discussed, and decisions were made through team consensus. The following was the order proposed for inclusion of additional watersheds as funding became available.

- Next 10 watersheds by key selection criteria:
    16. 041000 — Western Lake Erie
    17. 070200 — Minnesota
    18. 070600 — Upper Mississippi Maquoketa Plum
    19. 102400 — Missouri–Nishnabotna
    20. 070900 — Rock
    21. 101702 — Big Sioux
    22. 070400 — Upper Mississippi Black Root

Detailed explanations of the ordering process were:

16. Watershed 041000 in Indiana, Michigan, and Ohio. This watershed was designated 16 because 1) it is the easternmost watershed and expands the east-west gradient substantially, 2) it is a critical

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watershed for the CSCAP project because watershed groups and research sites are located within it, and 3) it is a major crop production watershed (9th in the region in total corn and soybean acres).

17. Watershed 070200 in Iowa, Minnesota, and South Dakota. This watershed was included at 17 because 1) it is the northernmost watershed, expanding the north-south gradient substantially, 2) it comprises parts of two ecoregions that would otherwise not be covered sufficiently, and 3) it is a major crop production area (3rd in the region in total acres of corn and soybeans).

18. Watershed 070600 in Iowa, Illinois, Minnesota, and Wisconsin. This watershed was included at 18 because 1) it contains a unique ecological zone, the driftless area, 2) it is a critical watershed for the CSCAP project because watershed groups and are located within it, 3) it is a priority area for Iowa NRCS, and 4) it has substantial corn and soybean acreage (18th in total acres).

19. Watershed 102400 in Iowa, Kansas, Missouri, and Nebraska. This watershed was included at 19 because 1) it contains a unique ecological zone, the loess hills area, which is ecologically sensitive/highly erosive, 2) it is a priority area for Iowa NRCS, and 3) it has substantial corn and soybean acreage (6th in total acres).

20. Watershed 070900 in Illinois, Wisconsin. This watershed was included at 20 because 1) it contains an ecological zone that would not otherwise be represented, 2) it stretches the north-south gradient in the center of the Corn Belt, and 3) it has substantial corn and soybean acreage (10th in total acres).

21. Watershed 101702 in Iowa, Minnesota, Nebraska, and South Dakota. This watershed was included at 21 because 1) it extends the northwestern boundary of our survey zone, 2) it expands coverage of an ecoregion that is present in only one other watershed, and 3) it may be the site of a watershed group.

22. Watershed 070400 in Minnesota, Wisconsin. This watershed was included at 22 because 1) it contains a major portion of the driftless ecological zone, 2) it stretches the north gradient toward the center of the Corn Belt, and 3) it may be the site of a watershed group.

The 22 watersheds are represented in Map 71.

A.3 Farmer sample selection

The potential sample frame was the population of farmers in the study area. The sample was drawn from the National Agricultural Statistics Service (NASS) “Master List,” which is the most comprehensive and up-to-date list of U.S. farmers available.

The USDA defines a farm as “as any place from which $1,000 or more of agricultural products (crops and livestock) were sold or normally would have been sold during the year under consideration” (Hoppe and Banker 2010, 1). This low revenue threshold necessitates inclusion of “farms” that do not contribute substantial amounts of income (if any) to household income nor do they produce a significant percentage of grain. For example, farms categorized as retirement and residential/lifestyle represent 18.4 and 45.1 percent of farms, respectively, yet together produce only 5.8 percent of overall sales. Further, 98 percent of farms in these two categories on average generate less than $100,000 in gross sales annually (Hoppe and Banker 2010, 8). A simple random sample of the overall farm population would be largely comprised of retirement and residential/lifestyle farmers and would not be representative of the farms that produce the bulk of the U.S. grain crop.

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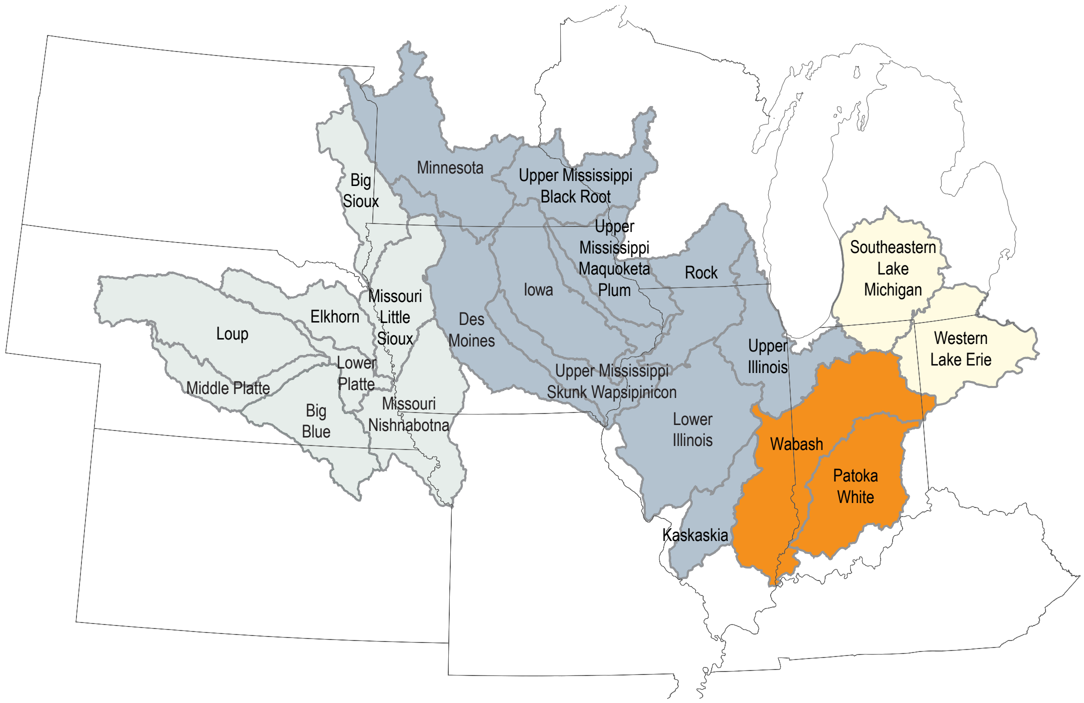

Map 71. Study watersheds.

Thus the challenge that the project faced was to define the population of farmers of interest. Given that our project focuses on long-term sustainability of corn (and soybean) production, our sampling approach is designed to allow us to generalize to farmers who produce a substantial proportion of corn (and soybean) acres in the Corn Belt.

A.4 Farmer selection criteria

The primary selection criteria were 1) farm size and, 2) amount of corn production.

To ensure that our sample was representative of farmers who produce substantial amounts of corn, the following thresholds were used to select farmers into the sample frame:

1) A Calculated Farm Value Sales of $100,000 or more, which would capture medium-sales farms and above. While these farms represent fewer than 17 percent of all farms nationally, they generate of 90 percent of overall value of sales (Hoppe and Banker 2010, 8).

2) A minimum of 80 acres of corn production. Setting 80 acres as the minimum threshold will ensure that the farmers in the sample produce a substantial amount of corn.

The NASS master list sampling frame was used to identify operations in the 11 states that met these two criteria. There were a total of 103,126 farms within the 22-watershed sample area (Map 71) that meet these two criteria. The number of farms that met the criteria within each watershed ranged from 1,454 to 8,881 and those farms represented between 11 percent and 44 percent of the total number of farms in the watersheds (Table 16). Calculations were conducted to determine the number of farms that must be surveyed in order to have a representative sample from which to generalize to the population of each watershed 1) at the 95% confidence level assuming a margin of error of 2.5% and 2) assuming

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Table 16. Sample size context and calculation

	HUC 6 Watershed	States	Farms in major crop area watersheds	Corn farms > $100K/ 80ac corn	Sample pop as percentage of all farms	Mailed (eligible)	Returned	Percent Response
1	071300	IL	22,862	7,955	35%	895	244	27.3%
2	102300	IA MN NE	12,571	5,341	42%	892	223	25.0%
3	051201	IL IN OH	31,868	7,899	25%	875	239	27.3
4	071200	IL IN WI	13,622	3,578	26%	837	234	28.0%
5	070802	IA MN	23,063	7,686	33%	895	248	27.7%
6	071402	IL	9,508	2,378	25%	801	197	24.6%
7	051202	IN	19,264	3,048	16%	804	201	25.0%
8	070801	IA IL MN	17,386	5,652	33%	880	233	26.5%
9	071000	IA MN	22,112	7,444	34%	890	259	29.1%
10	102002	NE	4,689	1,454	31%	753	161	21.4%
11	102001	NE	3,722	1,539	41%	760	151	19.9%
12	102100	NE	5,862	1,954	33%	795	154	19.4%
13	102702	KS NE	9,929	4,136	42%	877	185	21.%
14	102200	NE	6,693	2,923	44%	846	164	19.4%
15	040500	IN MI	26,079	2,986	11%	794	231	29.1%
16	041000	IN MI OH	25,857	4,698	18%	861	254	29.5%
17	070200	IA MN SD	23,520	8,881	38%	896	237	26.5%
18	070600	IA IL MN WI	17,301	4,688	27%	874	255	29.2%
19	102400	IA KS MO NE	19,223	5,558	29%	887	224	25.3%
20	070900	IL WI	21,737	5,040	23%	877	259	29.5%
21	101702	IA MN NE SD	10,652	4,230	40%	850	183	21.5%
22	070400	MN WI	20,509	4,058	20%	868	242	27.9%
		Totals	395,461	103,126	33%	18,707	4,778	25.5%

a 40% response rate. It was estimated that an average of approximately 875 farmers per watershed would need to be surveyed. A random sample of farmers was drawn from each watershed.

Once the stratified sample was drawn, the list was crosschecked with a NASS "do not contact" list. It was determined that some names were on that list, and these were removed from the sample. The survey was mailed to 18,813 farmers. A total of 106 of those were deemed ineligible, for a final sample size of 18,707.

A.5 Response rate and non-response bias analysis

Of the 18,707 selected farmers, 4,778 responded to the survey resulting in an overall unweighted response rate of 26%. To facilitate tests for non-response bias, NASS provided data for 28 variables measuring farm enterprise (e.g., farm size, crops and livestock produced) and farmer (e.g., age, sex)

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characteristics for both respondents and non-respondents. Statistical tests at the watershed level detected no meaningful differences between respondents and non-respondents, indicating that our sample is representative of the target population and statistics calculated for respondents will lead to unbiased estimates of the population parameters of interest.

A.6 Sampling weights

Because our random sample of farmers is stratified by watershed, it was necessary to assess potential differences in response probability between watersheds prior to calculating statistics for the region as a whole. Response rates differed between watersheds, ranging from 19% to 29%. In addition, selection probabilities within each watershed differed due to variation in the ratio of the sample size drawn to the overall population of farmers in each watershed. Because watershed-level sample sizes were calculated to assure generalizability at the 95% confidence level with a margin of error of 2.5%, selection probability ranged from 10% (sample size of 923 out of 8881 farmers) to 52% (sample size of 763 out of 1454 farmers). Thus, it was necessary to calculate sampling weights that account for differences in both probability of selection and response at the watershed level by

$$w_{i,h} = \frac{1/n_h^*}{1/N_h} = \frac{N_h}{n_h^*} \qquad (1)$$

where N_h is the population size of watershed h, and is the number of respondents in watershed h. The resulting weights are applied in the regional-level analyses that are discussed by Arbuckle et al. (2013).

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