

## *New Rural Area Sampling Frame Being Developed*

BY WILLIAM E. KIBLER

*Statistical Reporting Service, U.S. Department of Agriculture*

### *Background*

As a part of its program for improving crop and livestock estimates the Statistical Reporting Service (SRS) of the Department of Agriculture has developed new area sampling frames for 11 Western States and 13 Eastern States based on current land uses. The frame for the Western States was developed to reflect the concentrations of cropland located near sources of irrigation and the extensive public and private areas used for grazing.<sup>1</sup> For Eastern States the frame identified areas intensively farmed and those developed for business, industrial and residential purposes. These frames have been very effective in reducing variability between sampling units within the various strata and have enabled SRS to reduce the cost and sampling errors for surveys using area sampling. Emphasis is now being given to developing a new frame to replace the Master Sample<sup>2</sup> materials that are still used in Midwestern and Southern States. Work for the new frame for Iowa has been completed by the Statistical Laboratory of Iowa State University under contract with SRS. Similar frames are under construction for Missouri and Nebraska, and will be developed for other Midwestern and Southern States as funds permit.

### *Characteristics of the Frame*

The new frame combines features of the Master Sample materials developed in 1943 at Iowa State and the SRS Land Use Frame developed for Western and Eastern States in 1963 and 1964. However, it provides considerably more flexibility for assigning sampling units and developing sample designs for collecting data on farms

<sup>1</sup> Huddleston, Harold F., "A New Area Sampling Frame and Its Use," *Journal of Farm Economics*, Vol. 47, No. 5, December 1965.

<sup>2</sup> King, A. J. and Jessen, R. J., "The Master Sample of Agriculture," *Journal of the American Statistical Association*, Vol. 40, p. 38-56, March 1945.

or rural households. The new frame (1) updates changes that have occurred in roads since 1943, (2) utilizes latest boundaries for cities and incorporated and unincorporated towns, and (3) provides data required for assigning sampling units to count units<sup>3</sup> on the basis of three possible criteria (farms, households—farm and nonfarm, and land area). Boundaries for counties, cities and incorporated or unincorporated towns of all sizes are maintained in the frame so it can be used for selecting samples for county or multi-county areas or specified sizes of cities and towns. It is anticipated this will be important with the governmentwide emphasis being placed on rural development in such areas as housing, environment and community services.

### *Stratification*

The frame was developed for individual counties, making geographic stratification for individual counties or groups of counties possible. Minor civil division boundaries within counties were disregarded since they do not follow readily identifiable boundaries in many states. Within counties, land was stratified on the basis of its current use. Two primary strata were delineated: (1) non open country areas (sometimes referred to as built-up or developed areas for cities or towns and adjacent areas), and (2) open country areas.

The nonopen country area consists of all incorporated or unincorporated towns or cities plus other adjoining areas with a housing density of more than 20 dwellings per square mile. It was subdivided into "urban" and "agri-urban" depending upon the housing density and the presence or absence of agricultural activity. The "urban" and "agri-urban" substrata do not add to urban territory as defined for census purposes but rather to the

<sup>3</sup> To eliminate the detailed task of delineating individual sampling units of the size desired, larger areas of about 10 square miles were delineated and counts of the indicated number of farms and dwellings made along with measures of area.

nonopen country stratum. However, within the nonopen country areas boundaries for cities and towns were maintained so they could be sampled independently if desired. The agri-urban substratum includes all areas with some agricultural activity, one quarter square mile or more in size, having five or more dwellings but no definite subdivision, business, commercial or developed residential (built-up) areas. These areas have different characteristics as they include small specialty farms producing vegetables, fruit or nursery stock with the operator generally working off the farm, from open country and highly developed areas. The urban substratum is made up of developed residential, business, and commercial areas of approximately one-half square mile or more in size. It is generally confined to the larger cities or towns, and the suburban areas adjacent to these, where there is little probability of finding agricultural activity.

The open country stratum is all the area remaining after delineating the nonopen country areas described. Within this area three general substrata are defined. These are (1) intensively farmed land, (2) extensively farmed land, and (3) nonagricultural land. Intensively farmed land represents areas used primarily for the production of field, fruit or vegetable crops with relatively small portions of the land in pasture or forest. Land used mostly for grazing or the production of hay with some small woodland areas is classified as extensively farmed. Desert areas, large forests, military installations and recreation areas of eight or more square miles, where no agricultural activity is permitted, make up the nonagricultural substratum. All the open country areas for Iowa were in the intensively farmed substratum since about 94% of the total land is in farms. The other two substrata will be more important in the frame for the Plains States where significant portions of the land are used for purposes other than agriculture.

#### *Basic Materials and Procedures Used*

County highway maps, Agricultural Stabilization and Conservation Service (ASCS) photo index sheets, and Farm and Ranch Directories<sup>4</sup> were obtained for all counties of Iowa. For larger cities and towns or built-up areas, U.S. Geological Survey quadrangle maps and ASCS contact prints (9 x 9 photos scaled approximately 3 inches per mile) were assembled for reference and for recording refined boundaries. The 1960 Population and Housing Census provided data on number of households for all cities and towns of 1,000 or more and for all counties.

<sup>4</sup> Published annually by Directory Service Company, Algona, Iowa.

Nonopen country areas were identified on photo index sheets and boundaries determined. Boundaries for incorporated and unincorporated cities or towns were transferred from county highway maps to USGS maps or contact print and identified. Adjoining and within agri-urban areas were delineated on these materials along with the urban developed areas. These portions of the incorporated and unincorporated cities and towns falling in each of the substrata were clearly identified so the households associated with these could be linked with census or other information for developing sample designs or analyzing survey data for groups of cities or towns by population. Census data on number of dwelling units within the cities and incorporated and unincorporated towns were listed for places with 1,000 or more population. For cities and towns with populations under 1,000 the number of dwellings was estimated by dividing the population by the average number of people per occupied unit, 3.04. Dwelling units counted from photos within the agri-urban areas were deducted from these totals to arrive at the number of indicated dwellings within each urban area. In each county the individual nonopen country areas were assigned identification codes and the total area for each planimetered and recorded. There were about 11 of these areas per county that averaged 1.2 square miles in size and accounted for about 2.5% of the total land area.

The areas remaining after delineation of the nonopen country stratum were classified as open country. This stratum represented about 97.5% of the total land area of the State. Within counties the open country areas were divided into blocks averaging about 61 square miles in size. Improved and major roads as well as county lines were used as boundaries for blocks. Blocks within the counties were numbered in a serpentine manner and broken into count units, using major roads as boundaries. For each count unit three measures of size were recorded: Area in square miles, number of farms, and number of occupied dwellings. The count units ranged from 8 to 15 square miles in size and averaged 10.1 square miles, contained about 31 farm dwellings and 33 occupied dwellings. The dwelling and farm counts for each count unit were obtained from the Farm & Ranch Directories. A planimeter was used to determine the area covered by each count unit rounded to the nearest 0.1 square mile.

Only the identification of blocks and count units was recorded on the county highway maps. All other information was listed on a summary sheet and converted to ADP cards or tape. Shown opposite is a portion of a county map that illustrates the stratification, blocks, and count units used in the frame construction.

Data recorded for the various strata and substrata in the frame, shown in Table 1, check closely with Census

TABLE 1. Approximate number of farms, households, and land area, by stratum and substratum, Iowa

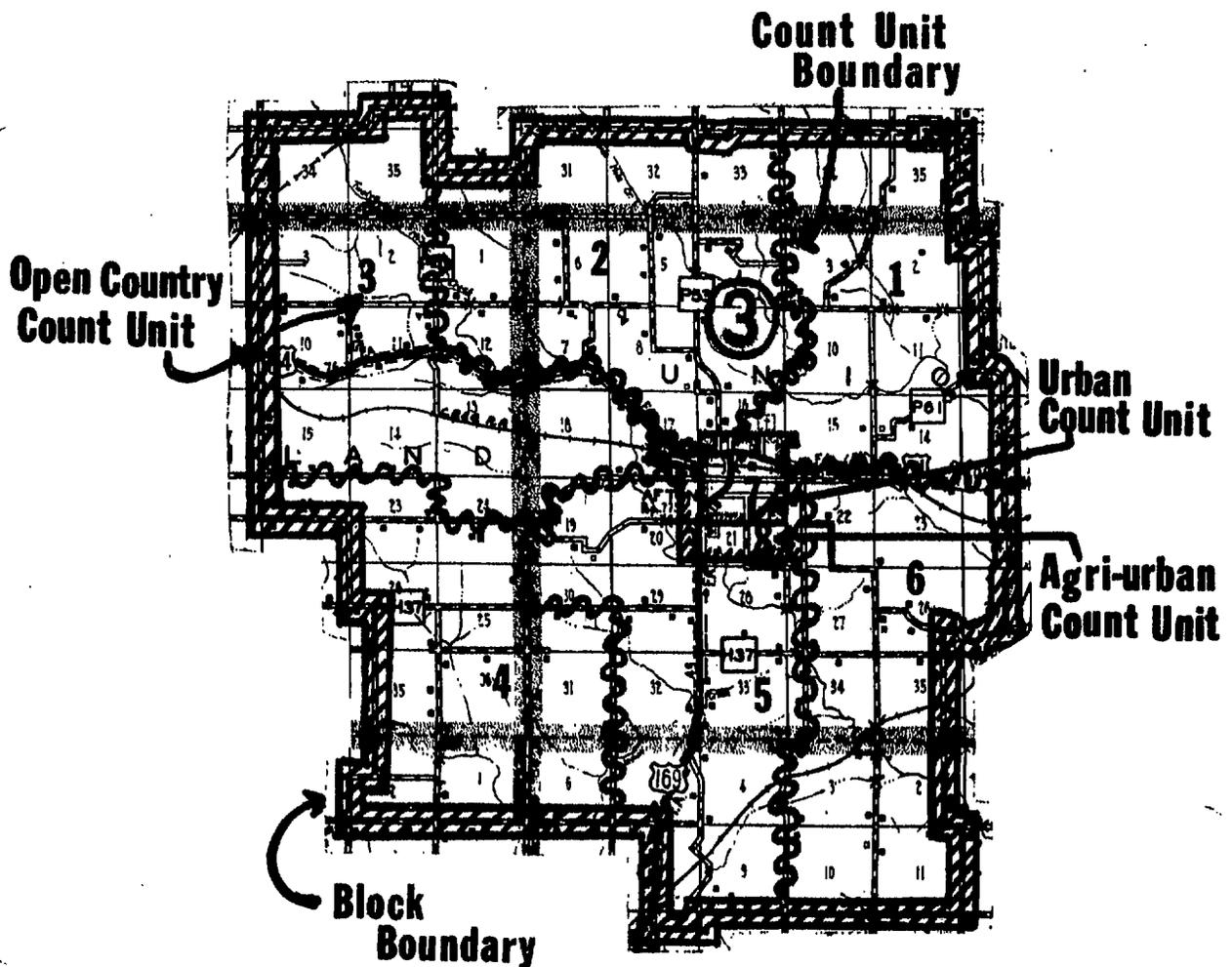
Stratum and substratum	Square mile area	Number of farm dwellings	Total number of occupied dwellings
<b>Nonopen country:</b>			
Urban .....	308	—	482,000
Agri-urban .....	1,050	3,400	175,200
<b>Open country:</b>			
Intensively farmed .....	54,437	165,300	177,600
Extensively farmed .....	—	—	—
Nonagricultural .....	—	—	—
<b>Total .....</b>	<b>55,795</b>	<b>168,700</b>	<b>824,800</b>

State totals. The total area recorded was 55,795 square miles or almost exactly the 56,032 listed by the Census Area Measurement Reports. The indicated number of dwellings is only about two % below the total number shown by the 1960 Census of Housing. The number of farm dwellings is slightly above the estimated number

of farms in the state. This is expected since it includes farm operator households as well as households for tenants, renters, and others associated with the farms. For the open country stratum the number of occupied dwellings, 177,600, counted from maps agrees rather closely with the rural farm household total of 179,599 listed by the 1960 Census of Housing.

### Factors Considered in Preparing Frame

Many factors were taken into consideration in developing the new frame. It needed to be flexible enough to accommodate any definition of rural areas that might be adopted. By maintaining the identity of all boundaries for incorporated or unincorporated places this can be accomplished. The frame can also be easily updated for changes in city or town limits. Boundaries for the principal strata had to coincide with recognizable ground features (minor civil division boundaries do not meet this criterion in many States). Areas likely to have any agri-



cultural activity had to be identified along with some measure of the level of agricultural activity. In Iowa this was accomplished by using the intensive open country and the agri-urban country substrata. For other States the general stratification could include irrigated and nonirrigated lands for intensively farmed "cropland" areas, rangeland areas and agri-urban areas. It will be tailored to meet the needs of individual States.

In designing sample surveys it is often desirable to have some flexibility in choosing the size of primary sampling units. The counties, blocks within counties and the count units used for all the strata, provided a technique for obtaining different sized PSU's. The count units within these blocks, designed with rigid controls on size, also provide a small unit of very uniform size (area), that could be used as a sampling unit, for screening to identify eligible respondents in sample surveys.

Control data (shown in Table 1) for each count unit were provided so that sampling units (SU's) could be defined on the basis of land area, number of farms, number of occupied dwellings or some combination of these. The control data were assembled so they could be easily updated; permitting revised SU's to be assigned as new data become available.

### First Operational Survey

The frame was used for the first time in 1971 to select a sample of 360 segments for the Iowa SRS June Enumerative Survey. This survey provides information on crop acreages planted and to be planted, livestock inventories and other general farm characteristics. Previous research had indicated that sampling units of about one-half square mile and containing about 1.5 farms are optimum sized units in the open country intensively farmed area for the close segment (sampling unit) survey technique<sup>a</sup> (accounting for all crops and livestock physically within a given sample unit). For the agri-urban substratum the most efficient sized unit is about a one-fourth square mile area containing about 40 dwellings.

Sampling units were assigned to the open country count units on the basis of area and indicated number of occupied dwellings. Rigid restrictions were placed on the land area to reduce sampling errors for the closed

<sup>a</sup> Experimental Program Using Area Sampling Method, Agricultural Marketing Service, U.S. Department of Agriculture, May 1954.

segment technique. Within count units the number of segments assigned had to be such that the average size was between .5 and .6 square miles. Count units were assigned one sampling unit for each .6 square mile area plus one additional unit for each 15 more occupied dwellings over three per square mile, with the restriction that no count unit could have more than two sample units for each square mile area. The following are examples of the assignment procedure.

Count unit	Square mile area	Number of occupied dwellings	Number of sampling units assigned
1	8.2	23	14
2	8.2	37	15
3	8.2	60	16
4	10.5	30	18
5	10.5	46	19
6	10.5	100	21

For the nonopen country stratum sampling units were assigned on the basis of area only. For the agri-urban substratum one sampling unit was assigned for each one-fourth square mile area. In the urban substratum one sampling unit was assigned for each one-tenth square mile area.

Stratum or substratum	Number of sampling units assigned	Average square mile size
Nonopen country:		
Urban	3,082	.10
Agri-urban	4,214	.25
Open country	100,603	.54

An optimum allocation of 360 segments assigned to Iowa using "convex programming" was made to the two strata. This technique makes use of variability and costs in reaching optimal allocation. The 350 segments allocated to the open country stratum were further distributed to nine geographic substrata within the State using the same technique. This allocation by geographic areas was essentially the same as that which had been used in previous surveys.

Survey results indicate the sampling variance in land area of segments was reduced more than 50% using the new frame. Sampling errors, for items closely related to area, such as corn planted, soybeans planted and hay harvested, were reduced by 20 to 30% using the same size sample. For agricultural items more closely associated with the farm headquarters, such as livestock inventories, farm count and farm labor, little or no change in sampling errors occurred.