Transactions of Illinois Academy of Sciences
(1982), Volume 75, 3 and 4, pp. 239-246

AREA MEASUREMENTS IN ILLINOIS

Folke Dovring
Department of Agricultural Economics
University of Illinois at Urbana-Champaign

ABSTRACT

Comparison is made of Illinois area data from three sources: the Census Bureau's township, county, and state data; acreage data in plat books; and data computed from the ILLIMAP system of digitized rectangular coordinates (with correction for curvature) of the Illinois State Geological Survey. The ILLIMAP-based data are shown to differ systematically from those of the Census, and they agree better with those of the plat books than do the Census area data. The conclusion is reached that the Census Bureau's figures for areas in Illinois are biased upward by about 1.1 percent. Consequently, a near average county of 400,000 acres is smaller by about 4,400 acres, and the state's area is about 400,000 acres less than shown in current official Census statistics. The bias appears to follow from the way the Census Bureau adjusted area data to state and national totals, and may therefore not be the same in all states.

INTRODUCTION

Areas in Illinois need to be measured with more precision than has been the case until now. One reason is the increased interest in land use research and planning. Another is that the most recent Census of Agriculture (1978) has substantially over estimated land in farms in Illinois (Dovring 1981, 1982). Moreover, comparison between census area data (Bureau of the Census 1940, 1960, 1980) and recent county plat books reveal systematic discrepancies which need to be resolved.

MATERIALS AND METHODS

Until recently, the two main sources of area data were in the Census of Agriculture (Bureau of the Census 1940, 1960) obtained from map measurements, and the county plat books reflecting the results of rectangular survey and subsequent remeasurements. Both have built-in sources of error. A systematic disagreement between these two sources was discovered by arranging Census data for townships in bar diagram form. On such a diagram, one would expect a mode at the township size of 36 square miles, because this was the statutory normal size of a rectangular township. In Illinois, a clear mode instead emerges at 36.3 - 36.4 square miles, indicating that one of the two sources is biased, to the extent of about 1 percent. Which of the sources has the bias cannot be concluded directly from this comparison. The same analysis in other states does not always give the same extent

of bias or even the same direction. In Iowa, the modal township size is also larger than 36 square miles, but somewhat less so than in Illinois. In Minnesota, by contrast, the modal township size comes out somewhat smaller than 36 square miles. If the Census is at fault, its reconciliation of state data with the national total may have had different effects in different states, depending on how faulty the state measurements were to begin with. If the rectangular survey results, as reflected in plat books, were the carrier of the bias, we would have to assume that the surveyors not only used faulty measure but also that it was systematically faulty to a different degree in different areas.

A more recent source is in the ILLIMAP system of digitized rectangular coordinates, corrected for curvature (Swann, DuMontelle, Mast and Van Dyke). This system dates to the years around 1970. It gives coordinates for all county, township, and section corners in Illinois (Illinois State Geological Survey, ISGS, Urbana; computer printouts available on a loan basis). Data are in feet, and at the level of individual sections the error margin does not allow precise area estimates, even though the coordinates are precise enough for many purposes, such as for identifying resource sites, for instance. At the level of townships and counties, the error margin is insignificant for our purpose.

The ILLIMAP data were used to test the accuracy of the Census data (drawn from maps) and of plat book data (reflecting rectangular survey) in two ways. First, rectangular county areas were computed from the ISGS coordinates. Thereafter, linear measures of longitude and latitude across Illinois were computed from the ILLIMAP coordinates and compared with measurements on a topographic map.

For the first of these tests, only counties with near-rectangular configurations were tried, as those with irregular boundary lines would be more complicated. For instance, Boone County was investigated by noting X and Y coordinates in the four corners of its near-rectangular configuration, as follows:

	X			Y	
3,151,456	3,150,433		3,319,594	3,320,515	
	3,214,574	3,212,987		3,443,888	3,443,816
ΔX	63,118	62,554	ΔY	124,294	123,301
Average ΔX	62,836		Average ΔY	123,798	

$$\frac{\text{Average } \Delta X \text{ times average } \Delta Y}{43{,}560 \text{ (= square feet in an acre)}} = 178{,}581 \text{ acres}$$

This is an approximation technique acceptable when the configuration differs only slightly from a true rectangle. A more precise but more time consuming calculation, based on two triangles, was also tried for Boone County (by R. Herendeen) and revealed an error term of .006 percent (about 11 acres, in this case)—clearly far below the other sources of error in this kind of data.

The second comparison is of longitude and latitude lines across Illinois. For this, a topographic map in the scale of 1:1 million with the boundaries of all survey townships, was used. This map, like most other geological and topographic maps of Illinois, belongs to the same cartographic system as that used by the Census Bureau

Geography Division. Its identification as to the location of longitude and latitude lines in relation to the topographic facts of Illinois reflect the adjustment of quadrangles that was performed in order to adjust the area of the state to that of the country. Consequently, the map may be expected to embody whatever measurement bias that may have been introduced by this adjustment.

From this map, estimates were made of the linear distance between points (township corners) near the edge of the state, and in the immediate vicinity of longitude and latitude lines shown on the map (which are in whole degrees). The linear length of abscissas of developed parallel (longitude intervals) and of meridional distance (at indicated latitude) were computed from the U.S. Geological Survey Topographic instructions of 1964. Thus, only fractions of degrees were estimated from the map by millimeter measurement, estimating to the nearest 1/10 millimeter. Because of this approach, any shrinkage (or swelling) of paper would have no consequence, since the degree fractions were measured as fractions of whole degrees, the latter being taken from the tabulated values in the Topographic instructions just cited. The millimeter scale used is one engraved on the edge of a slide rule, and any scale error here would also be eliminated by the measuring of whole and fractional degrees in the same scale. The scale is finely enough engraved to permit eye estimates to 1/10 of the millimeter interval, similarly as on the slide rule itself. Thus, the error term here is of a few hundred feet, in each case. The meridian and parallel lines, and the boundaries of survey townships, are also printed finely enough to allow estimates at this level.

For instance, longitude 89 degrees was followed from Pulaski County in the south, Township 14S2E, the southwest corner, to Winnebago County in the north, Township 46N2E, the northwest corner. The Y coordinate distance between these two points was found to be (3,444,193 − 1,539,947 =) 1,904,246 feet, while the X variation was only 13,482 feet. The map distance includes four whole latitude degrees; measuring the fractions of two other degrees from the map, the total north-south distance was found to be 5.2605 degrees, or 315,633 minutes, which comes to 22,997,623 inches (at 728.62 inches to the minute, in scale 1:1 million, at the average of the latitudes involved) or 1,916,468 feet. Thus the proportion of this map over the ISGS coordinate measurements is 1.00641 in length measure or 1.0129 in square measure, the latter being comparable with the proportions discovered in the acreage data above.

RESULTS

Tables 1, 2 and 3 show results from the measurements described above.

Table 1 has acreage estimates for 20 counties and compares these with those computed by the Bureau of the Census (its 1980 figures). The ratio of Census/ISGS is always over 1, meaning that the bias is consistent. Three of the counties (Effingham, Marion and Stephenson) are close to 1, however. This need only mean that the Census estimates are of somewhat varying quality, depending on the quality of the maps used. Most of the ratios are close to both the averages of the twenty, and the weighted and unweighted averages are close together.

Table 2 shows results from measurement of four longitude and five latitude lines across Illinois. Again, the weighted and unweighted averages for each group (longitudes and latitudes taken separately) are close to each other, and both groups of averages are close (in area measure) to those of Table 1.

The findings concur to suggest a bias of 1.1 percent in the Census area estimates. Accordingly, the area of the state appears to be about 400,000 acres less than usually shown in official statistics, and a typical county of 400,000 acres is smaller by about 4,400 acres.

Table 3 shows comparison of the same results as in Table 1, for selected counties, and including also area estimates from detailed scanning of plat books. The Census data are shown also as reduced by a factor of .9891 (1/1.011). In all seven cases, the reduced Census data are closer to the plat book figures than were the unreduced Census data. The plat book figures are also shown to be close to the data computed from ISGS coordinates in five of the seven counties.

DISCUSSION

The main finding of this inquiry, that the Census measurements (and the maps on which they are based) in Illinois are biased upward to the extent of about 1.1 percent, is convincing because the same result was obtained from two kinds of analysis, by county areas and by longitude and latitude lines. Any errors in the ILLIMAP coordinates must be assumed to be small and at random, symmetrically distributed, and thus could not have generated the systematic bias which the analyses revealed. The same goes for the measurements on the 1:1 million map: errors in reading down to 1/10 millimeter would also be without systematic bias.

The plat books, and the rectangular surveys which they reflect, stand acquitted of major bias. No doubt they contain numerous errors, some of them quite serious as established now and then through resurveys by modern precision methods. But these errors are not systematically slanted one way or the other, as far as the state as a whole is concerned. There may still be systematic errors in some counties (or groups of county components, the counties being generally established after the original surveys, and often containing bits of more than one original survey installment), and such errors must be explored for localized land use analysis to become more precise.

This finding on the rectangular survey data is of some consequence, for it dispenses with any need to subject current acreage data in land deeds, tax rolls, and Census returns to systematic recalculation as would have been desirable if the bias had been inherent in the rectangular survey system. Not that such recalculation would be of much importance to farmers, landowners, or tax officials; to them each parcel has its value because of the inputs and outputs used in production, and if these are divided through by a slightly larger or smaller acreage it would not mean much to the economic and fiscal results. But for land use analysis and planning the matter is different. If the plat book figures (and the tax rolls, deeds, and Census replies based on them) can be trusted, on the whole, then the downward revision of county (and state) totals means that there is less "other land" to be expected when the bulk of farm, forest and urban use land had been accounted for. Specifically, the downward revision of county totals places in sharper relief the fact of overcount of land in farms in the 1978 Census of Agriculture (to a lesser extent also in the previous mail censuses of 1974 and 1969), and renders more urgent an explanation and rectification. (Dovring, 1982).

The conclusions are specific to Illinois. In other states, the matter must be taken up independently of the Illinois findings, but the statement of the problem is likely to be valid in many of the states.

SUMMARY

State and county areas in Illinois were found to be somewhat incorrectly measured in Census area data and in the maps on which they are based. Probably due to the adjustment of state areas to the total for the country (and of county areas to that of the state, so established), the Census area figures are too large by about 1.1 percent. By contrast, plat books (and the rectangular surveys on which they are based) were found to be free of major or consistent bias, even though there are likely to be many detailed errors.

The findings are of consequence for land use analysis and planning, rather than for the day-to-day affairs of farmers, landowners, and tax officials.

ACKNOWLEDGMENTS

Thanks are due to Mr. Paul DuMontelle of the Illinois State Geological Survey for helping in interpreting the ILLIMAP coordinate data, to Dr. James Bier of the University of Illinois Department of Geography for observations on an earlier draft of this paper, and to Professor R. Hereudeen of the University of Illinois Department of Forestry, for suggesting and carrying out the test of accuracy in the area calculation for Boone County.

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Table 1. County Areas, According to Census Bureau (1980) Estimates, and Estimates Made from ISGS Coordinate Data.
Data in Acres, and Ratios Census/ISGS.

County	Acreage Census	Estimates ISGS Coordinates	Ratio Census/ ISGS
Boone	180,493	178,580	1.0107
Champaign	638,861	630,887	1.0126
Cumberland	221,619	219,891	1.0079
Effingham	307,219	306,336	1.0029
Grundy	275,354	273,099	1.0083
Hamilton	279,072	275,653	1.0124
Jasper	319,104	311,977	1.0228
Jefferson	373,523	369,384	1.0112
Knox	461,677	454,527	1.0157
LaSalle	735,642	727,126	1.0117
Livingston	669,619	663,882	1.0086
McDonough	377,754	373,859	1.0104
McHenry	391,219	387,232	1.0103
Macoupin	555,251	550,347	1.0089
Marion	368,685	368,257	1.0012
Saline	247,398	244,998	1.0098
Stephenson	361,389	360,941	1.0012
Warren	348,096	342,884	1.0152
Wayne	457,779	451,634	1.0136
Williamson	284,365	280,137	1.0151
Sums and weighted average:	7,854,119	7,771,631	1.0106
Unweighted average, 20 counties			1.0105

Table 2. Results of Linear Measurements Along Longitude and Latitude Lines On a Topographic Map in Scale 1:1 Million, and Corresponding Distance Readings From ISGS Coordinate Data. Data in Feet.

Locations	Distance Readings		Proportion, Map/ISGS	
	Map	ISGS	Length	Area
a) Longitudes				
Longitude 88°, from White Co., T6S10E, S.E. corner, to Cook Co., T41N10E, S.W. corner	1,474,038	1,464,609	1.0064	1.0129
Longitude 89°, Pulaski Co., T14S2E, S.W. corner, to Winnebago Co., T46N2E, N.W. corner	1,916,468	1,904,246	1.0064	1.0129
Longitude 90°, Randolph Co., T6S6W, S.W. corner, to Carroll Co., T23N5E, N.W. corner	1,480,619	1,473,213	1.0050	1.0101
Longitude 91°, Pike Co., T6S5W, S.W. corner, to Rock Island Co., T16N5W, S.W. corner	671,363	666,963	1.0066	1.0132
Sums and weighted averages	5,542,488	5,509,031	1.0061	1.0122
Unweighted averages of 4 north-south lines			1.0061	1.0123
b) Latitudes				
Latitudes 38°, from Randolph Co., T6S6W, S.W. corner, to White Co., T6S10E, S.E. corner	511,995	508,578	1.0067	1.0135
Latitude 39°, from Jersey Co., T7N12W, S.W. corner, to Crawford Co., T7N13W, S.E. corner	763,672	759,136	1.0060	1.0120
Latitude 40°, from Adams Co., T1N8W, S.W. corner, to Vermilion Co., T18N10W, S.W. corner	1,075,231	1,069,960	1.0049	1.0099
Latitude 41°, from Henderson Co., T12N4W, S.W. corner, to Kankakee Co., T30N10W, S.W. corner	926,821	922,464	1.0047	1.0095
Latitude 42°, from Carroll Co., T24N5E, S.W. corner, to Cook Co., T41N9E, S.E. corner	498,539	496,099	1.0049	1.0099
Sums and weighted averages	3,776,258	3,756,237	1.0053	1.0107
Unweighted averages of 5 east-west lines			1.0055	1.0109

Table 3. Comparison of County Area Totals from Census Bureau 1980, the Same Reduced by .9891, and From Platbooks and From Computations Based on ISGS Coordinates. Data in Acres.

State County	Census 1980	Same, times .9891	Platbook	ISGS Coordinates
Illinois	36,060,838	35,667,775	. . .	. . .
Champaign	638,861	631,897	631,900	630,887
Cumberland	221,619	219,203	219,550	219,891
Effingham	307,219	303,870	300,600	306,336
Livingston	669,619	662,320	663,800	663,882
McDonough	377,754	373,636	365,900	373,859
Macoupin	555,251	549,199	550,450	550,347
Stephenson	361,389	357,450	358,850	360,941