National Mapping Program

Using an Acreage Sampling Template With U.S. Geological Survey 1:250,000-Scale Land Use and Land Cover Maps

Open-File Report 85-303
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Department of the Interior
U.S. Geological Survey
National Mapping Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

USING AN ACREAGE SAMPLING TEMPLATE WITH U.S. GEOLOGICAL SURVEY 1:250,000-SCALE LAND USE AND LAND COVER MAPS

By Eddie L. Schwertz, Jr., and George L. Loelkes, Jr.

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USING AN ACREAGE SAMPLING TEMPLATE WITH U.S. GEOLOGICAL SURVEY 1:250,000-SCALE LAND USE AND LAND COVER MAPS

By Eddie L. Schwertz, Jr.[1], and George L. Loelkes, Jr.[1]

INTRODUCTION

The U.S. Geological Survey (USGS) has prepared 1:250,000- and 1:100,000-scale land use and land cover maps since 1975. While the preparation of the graphic products has progressed to the point where 85 percent of the land use and land cover maps for the United States, except Alaska, are now available as open-file maps, only slightly more than 50 percent of the country is currently available in a digital format. The USGS has used the Geographic Retrieval and Analysis System (GIRAS) software to convert the graphic products to a digital format and subsequently to prepare acreage statistics (Fegeas and others, 1983). Land use and land cover acreage statistics for those areas which have been digitized by counties, census county subdivisions, and hydrologic cataloging units are available on microfiche through the National Cartographic Information Center. Statistics are also available on microfiche for selected States and quadrangle maps for Federal and(or) State land ownership.

Present production plans call for the remainder of the graphic products to be completed for the country by 1986 and for the digital products to be completed by 1990.

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1 Mid-Continent Mapping Center, U.S. Geological Survey, Rolla, Missouri. Publication authorized by the Director, U.S. Geological Survey on May 28, 1985. Any use of trade names and trademarks in this publication is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

Until such time as the graphic open-file maps are converted to a digital format, users must await the conversion process or take steps to measure or estimate their own land use and land cover acreage statistics. Because not all users have available the area measurement equipment needed to precisely determine the acreage values, and not all users require the precise values obtained through the use of measurement techniques, a research project was initiated to develop a sampling technique for use with USGS 1:250,000-scale land use and land cover open-file maps. Results of that research are described in the report, "Determination of County-Level Land Use Acreage Statistics from Open-File Maps Using Sampling Procedures," prepared by the Mid-Continent Mapping Center in 1982.

The purpose of this open-file report is to document when and how best to use the sampling templates.

ALTERNATIVES TO OBTAINING ACREAGE VALUES

There are two basic techniques which can be used to obtain acreage values from thematic maps: (1) enumeration techniques, and (2) sampling techniques. Enumeration techniques are generally more accurate than sampling techniques, but they tend to be more costly both in man-hours and in equipment needs. Sampling techniques can produce acceptable results at a fraction of the cost required to undertake an enumeration technique and in much less time. Table 1 identifies various enumeration and sampling techniques that can be used to obtain area measurements, along with brief comments about the speed of data capture, data turnaround, accuracy, and suitability for use with small polygons (homogeneous areas of land use) and large projects.

DEVELOPING THE LAND USE ACREAGE SAMPLING TEMPLATE

Drawing from previous USGS land use map accuracy sampling research (Rosenfield, May 1982, p. 793-801; Latham, 1979), a stratified systematic sampling procedure was employed for use with Level II USGS land use and land cover maps (table 2) (Anderson and others, 1976, p. 8). The number of sample points (225) required for an administrative unit area was determined from Tortora's (1978) formula for estimating the sample size for multinomial proportions based on the approximate large sample equations for simultaneous confidence limits.[2] A USGS software program used in testing land use map accuracy was modified to generate the positions of the sampling points for a square-shaped template suitable for use with 1:250,000-scale land use and land

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[2] For the statistical parameters used in developing N=225, refer to Mid-Continent Mapping Center report, "Determination of County-Level Land Use Acreage Statistics from Open-File Maps Using Sampling Procedures," p. 7-10.

Table 1.--Area measurement techniques

Technique	Speed of data capture	Data turnaround	Suitability for use with small polygons	Suitability for use with large projects	Accuracy
A. Enumeration techniques					
1. Manual					
a. Cut and wight	Very slow	Moderate	Very poor	Poor	Fair
b. Planimeters (manual)	Slow	Good	Very poor	Poor	Very poor
c. Electronic planimeters	Slow	Good	Good	Poor	Good
2. Automated digitizing					
a. Raster	Moderate	Slow	Fair	Very good	Good
b. Vector	Slow	Slow	Excellent	Excellent	Very good
B. Sampling techniques					
1. Transects	Fast	Good	Poor	Poor	Poor
2. Square grids	Fast	Good	Poor	Fair	Fair
3. Dot grids	Moderate	Good	Fair	Fair	Good to very good
4. Stratified systematic unaligned sampling	Fast	Very good	Fair to good	Good	Good

TABLE 2--Land use and land cover classification system for use with remote sensor data

Level I	Level II
1 Urban or Built-up Land	11 Residential.
	12 Commercial and Services.
	13 Industrial.
	14 Transportation, Communications, and Utilities.
	15 Industrial and Commercial Complexes.
	16 Mixed Urban or Built-up Land.
	17 Other Urban or Built-up Land.
2 Agricultural Land	21 Cropland and Pasture.
	22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas.
	23 Confined Feeding Operations.
	24 Other Agricultural Land.
3 Rangeland	31 Herbaceous Rangeland.
	32 Shrub and Brush Rangeland.
	33 Mixed Rangeland.
4 Forest Land	41 Deciduous Forest Land.
	42 Evergreen Forest Land.
	43 Mixed Forest Land.
5 Water	51 Streams and Canals.
	52 Lakes.
	53 Reservoirs.
	54 Bays and Estuaries.
6 Wetland	61 Forested Wetland.
	62 Nonforested Wetland.
7 Barren Land	71 Dry Salt Flats.
	72 Beaches.
	73 Sandy Areas other Than Beaches.
	74 Bare Exposed Rock.
	75 Strip Mines, Quarries, and Gravel Pits.
	76 Transitional Areas.
	77 Mixed Barren Land.
8 Tundra	81 Shrub and Brush Tundra.
	82 Herbaceous Tundra.
	83 Bare Ground Tundra.
	84 Wet Tundra.
	85 Mixed Tundra.
9 Perennial Snow or Ice	91 Perennial Snowfields.
	92 Glaciers.

[Anderson and others, 1976]

cover maps. The sample points were hand plotted and acreage estimates obtained for several counties for which USGS digital land use and land cover acreage statistics existed. The results proved very satisfactory.

Because the minimum number of sample points (225) required to obtain reliable acreage estimation values remains constant for an administrative unit, but the size of counties or other administrative unit areas vary, it was necessary to develop a series of various sized templates. It was believed that most users would be interested in obtaining acreage estimates at the county administrative unit where digital statistical data did not already exist. Accordingly, administrative unit area ranges for counties were identified from area figures contained in the U.S. Bureau of the Census "County Area Measurement File Including Population Counts" for 1980. Nine county area ranges, listed in table 3, were selected for template development. It was observed that the hand-drafted template had to be repositioned frequently for rectangular or elongated counties. It was therefore decided to prepare square-shaped sampling templates at twice the size (four times the area) of the original templates but at the same sampling density (not less than 225 sampling points per administrative unit). A software plotting program was written to plot the nine square-shaped templates.

Table 3.--County size intervals*

County size in square miles	Template letter designation	Sample cell size values in feet	Frequency of occurrence Number	Percent
Less than 64	A	1,991.213	124	3.87
64 - 127	B	2,816.000	35	1.09
128 - 255	C	3,982.425	181	5.65
256 - 511	D	5,631.999	849	26.48
512 - 1,023	E	7,964.851	1,393	43.45
1,024 - 2,047	F	11,264.000	374	11.66
2,048 - 4,095	G	15,929.702	157	4.90
4,096 - 8,191	H	22,528.000	73	2.28
More than 8,192	I	31,859.403	20	0.62

*Does not include Alaska.

It was realized that counties with denser land use patterns require a greater number of sample points to obtain more reliable acreage estimates. Generally, denser land use patterns are easily identified by visual inspection.

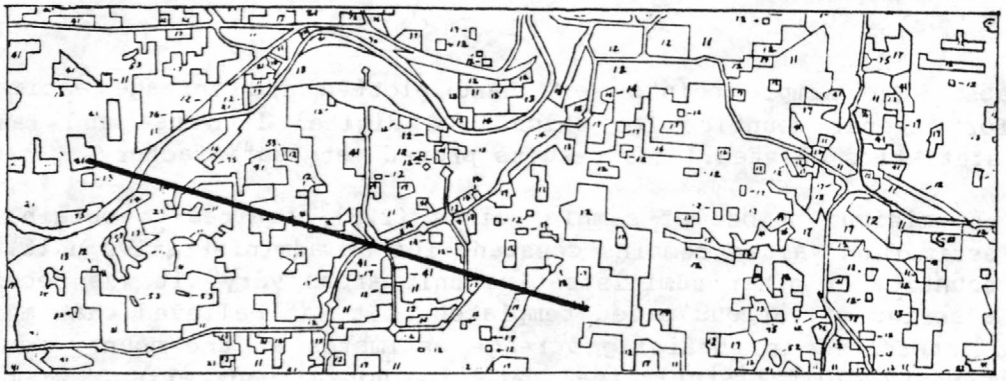


Figure 1.--Transect line on land use map.

Empirical analysis revealed that such areas were characterized by more than 10 polygon boundary line changes per inch. In other words, a transect line intersected by 10 or more land use polygon boundary changes in an inch was identified as a dynamic land use area. Figure 1 further illustrates the transect concept. A straight line is drawn on the land use map. The number of lines crossing the straight line per inch are recorded over a 2- or 3-inch distance. The land use polygon boundary changes per inch are then calculated.

As one becomes more accustomed to using the sampling template, it is no longer necessary to perform transect measurements to identify dynamic land use areas. Again, through empirical analysis, transect change values were related to the appropriate use of specific sampling templates. Table 4 presents the changes per inch and the appropriate templates to use.

Table 4.--Land use density selection criteria

Changes per inch*	Template selection
More than 10.5	A
5.2-10.4	B
3.6-5.1	C
Less than 3.6	D

* Calculated from observation of the number of times the land use changes along a straight line by the length, in inches, of that line.

Procedures were developed to record the number of sampling points falling within each land use type. A land use acreage tabulation worksheet (fig. 2) was designed to facilitate the recording procedure.

County land use acreage values were prepared for Texas County, Missouri, using the land use sampling template, a dot grid template, a polar planimeter, and an electronic planimeter. The acreage results were compared to the USGS digital land use acreage values and the time required to complete the acreage

LAND USE ACREAGE TABULATION WORKSHEET

Administrative Unit Name _____ Approximate Area (in square miles) _____

Template: _____ Acres per sample point: _____				Template: _____ Acres per sample point: _____				
(1) LAND USE TYPE	(2) SAMPLE POINTS	(3) TOTAL NUMBER SAMPLE POINTS	(4) ACREAGE SUBTOTAL FOR THIS TEMPLATE*	(5) LAND USE TYPE	(6) SAMPLE POINTS	(7) TOTAL NUMBER SAMPLE POINTS	(8) ACREAGE SUBTOTAL FOR THIS TEMPLATE*	(9) TOTAL LAND USE FOR THIS CATEGORY (4) - (8)
11				11				
12				12				
13				13				
14				14				
15				15				
16				16				
17				17				
21				21				
22				22				
23				23				
24				24				
31				31				
32				32				
33				33				
41				41				
42				42				
43				43				
51				51				
52				52				
53				53				
54				54				
61				61				
62				62				
71				71				
73				73				
74				74				
75				75				
76				76				
77				77				
	TOTALS				TOTALS			

* Acreage value equals sample points times acres per sample point value shown on land use acreage estimation template and noted above.

Figure 2--Land use acreage tabulation worksheet.

estimates were recorded. For Texas County (1,175 square miles), it took only 27 minutes with the F land use sampling template, 75 minutes with the dot grid template, and approximately 10 hours with either the manual or electronic planimeters to obtain land use acreage values.

Eighty-six counties were examined using the land use sampling templates. Six of the counties were also examined using the dot grid template. The 86 counties were in Missouri, Kansas, Louisiana, and Florida. The acreage results were compared to the USGS digital statistics and the percentage differences noted. The average time required to obtain land use acreage estimates for a 500-square-mile county was 15 minutes. The comparisons between the sampling template results and the USGS digital statistics revealed that more than 88 percent of the sampling template estimates were within 1 percent of the USGS digital statistical values. Only 0.6 percent of the sampling template estimates deviated by more than 5 to 7 percent from the USGS digital statistical values.

USING THE SAMPLING TEMPLATES

Various template marking experiments were performed using grease pencils, felt-tip pens, and similar marking devices to obtain the acreage estimation values for the 86 counties. Based on the experience gained from the various combinations of equipment and procedures, the following steps are recommended for achieving the best results with the sampling templates. The steps presented assume that the user desires to obtain county-level acreage values from USGS 1:250,000-scale open-file land use and land cover maps.

1. Determine the approximate area of the county.

If the size of the county to be measured is not known, refer to table 2 in U.S. Bureau of the Census publication "Number of Inhabitants: 1980 Census of Population" for each State. The table contains the value of the land area for each county, parish, or independent city. If you wish to obtain an acreage estimation figure for an administrative or natural resource area other than a county, estimate the area of the administrative unit. The simplest procedure is to estimate the area in square inches for the administrative unit and convert this value to square miles using the appropriate scale conversion factor.

2. Determine the appropriate template to use for the county.

Refer to table 3, "County Size Intervals," to determine the appropriate template (A through I) to use for the county. If the county size is at the lower end of the county size range and you wish to ensure greater accuracy, select the next lowest template. For example, assume the county is 259 square miles in size; use template C rather than D to obtain the more accurate results. Caution must be taken to never use a higher letter template than the template specified in table 3 for county size interval. This could result in fewer than 225 sample points for the county and less than desirable acreage estimation results.

3. Prepare the map for acreage estimation.

Place the 1:250,000-scale USGS land use and land cover map on a flat surface. (The templates are not designed for use at any other scale). If using transparent or semitransparent film copies of the open-file land use and land cover maps, first outline the county boundaries from the political units map on the land use map. A suitable felt-tip pen for this purpose is a green or orange Sanford's "Sharpie." The ink dries rapidly but can be easily removed with rubber cement thinner if removed within 8 hours. If using a printed L-series black over green paper map, it is best to highlight the county boundaries with a red or blue pencil. Not only does the county boundary set the bounds for acreage estimation, but the boundary is used in assigning sample points in a later step.

4. Identify areas of denser land use patterns.

Note the areas of denser land use patterns on the map. Draw a boundary line around each area with the felt-tip pen. If desired, the transect method described earlier can be used with table 4 to select the appropriate sampling template for use in these areas. However, it was very efficient to use template A for all of the denser land use patterns. The larger, less dense, template identified in step 2 is used for the outlying county or more rural areas.

5. Prepare the land use tabulation worksheet.

It is recommended that photocopies of figure 2, "Land Use Acreage Tabulation Worksheet," be used in recording the frequency of land use types. Write the name of the county or administrative unit for which the acreage estimations are being tabulated in the space provided on the worksheet. Write the approximate size of the administrative unit in square miles in the blank set aside for that purpose. The land use tabulation worksheet is designed to accommodate the use of two templates. Although the choice is not critical, sample point counts for the denser template were placed in the right-hand column, and sample point counts for the outlying (rural) county areas were placed in the left-hand column. Since template A is most often used to record land use acreage estimates for the denser land use areas, the letter "A" should be written in the blank following the word "Template" in the right-hand column. Note in the appendix that the "acres per sample point" values are indicated in the lower right-hand corner of each template. The acres per sample point value for template A is 91.022 acres. Write 91.022 in the blank provided on the land use tabulation workshop for that purpose. In the left-hand column, write the identity of the less dense template that will be used for the rest of the county and the acres per sample point values in the appropriate blanks.

The user should decide on a notation system that best suits individual preferences. During the empirical phase of the research, the use of numerical values for groups of 50 sample points and tally marks to represent 10 sample points was found to be most effective.

Also note in figure 2 that the acreage subtotals (columns 4 and 8) will be summed to obtain the individual land use category acreage totals in column 9.

6. Record the number of sample points falling within the more dense land use areas in the left-hand column.

Place template A over one of the denser land use areas. Secure the template to the map with four small pieces of masking tape. Select a felt-tip pen to mark through each sample point as you proceed through the recording process. The best approach is to start with sample points falling within land use polygons 11. (See table 2 for a complete listing of the land use codes.) The empirical research revealed that the best procedure is to mark through 50 sample points at a time. When it is felt that there will not be 50 or more sample points within a land use category, use tally marks to denote groups of 10 sample points. Do not include sample points falling directly on the boundary line that was drawn to define the limits of denser land use patterns. These points will be accounted for later. In practice, several sample points will often be overlooked. These points are easily marked through and noted on the land use acreage tabulation worksheet as they are noticed. The same procedure is used to record the number of sample points falling within each remaining land use category.

Once the process is complete, the next step is to account for the sample points that fall on the boundary line. This is accomplished by recording the land use type for every other sample point falling on the line. The same procedure should be used when using the less dense template to record land use acreages in the more rural portions of the county.

If another area of dynamic land use falls beneath template A, repeat the procedure noted above for that area. If other dynamic land use areas exist but are not beneath template A as presently positioned, reposition the template to record the land use acreages for these areas.

7. Record the number of sample points falling in the rural areas of the county.

Position the template selected in step 2 over the county. Secure the template over the land use map with four small pieces of masking tape. If the template does not cover the entire county, it will be necessary to mark the area which is covered so that the remaining area may be measured following the repositioning of the template. The recommended procedure is to place small tick marks on the land use map directly beneath the border of the template. After the sample points have been recorded, the template can be removed and a line drawn to connect the tick marks. This line will serve as a boundary for the area yet to be measured.

As with the recording of the sample points for the dynamic land use areas, the same procedure is used to record the number of sample points falling within each of the land use categories, beginning with land use category 11.

8. Compute the acreage totals on the land use tabulation worksheet.

If you have not already done so, convert the numeric values and tally marks to a total for the number of sample points for each template in columns 3 and 7, respectively. Next, multiply the values in column 3 by the areas per sample point for that template. The same procedure should be used to arrive at the acreage subtotal values for column 8. Finally, add the subtotal values from columns 4 and 8 to obtain the total land use acreage values for each land use category in column 9.

9. Prorate land use acreage values to the county area figure which will be used.

Seldom do county area figures agree from one publication to another. In step 1, it was recommended that the U.S. Bureau of the Census land area figures from the number of inhabitants reports be used for an approximate county area size. Note that this figure does not include water bodies over 40 acres in size. Accordingly, the figures obtained when using the sampling template will often be higher when converted from acres to square miles than the figures shown in the Census reports.

A recommended corrective procedure is to convert the land use acreage totals obtained through the use of the sampling templates to a percentage value and then multiply these figures by the county or administrative area value, that will be used for the particular study or project. The procedure produces prorated land use acreage figures that total the desired county or administrative unit area size.

10. Remove the felt-tip pen markings from the template and the film copies of the open-file land use and land cover maps.

If a felt-tip pen was used to mark through the sample points during the recording process or to mark or highlight county or administrative unit boundaries, time should be taken to remove these markings with a solvent such as rubber cement thinner, and a soft rag. Because of the high cost of film materials, it is wise to give proper care to the templates and open-file land use and land cover map films.

ACQUIRING FILM COPIES OF THE TEMPLATES

Printed copies of the templates are included in the appendix to this report. If desired, viewgraph copies of the templates may be produced on a photocopy machine to obtain rough estimates of land use acreage statistics. If more accurate estimates are desired, users should contact any of the National Cartographic Information Centers (NCIC) listed below to order the template(s) needed. The cost for a page-size template as of June 1985 was $3.25. Users should refer to open-file materials LU/LCT-100, A through I, as appropriate.

National Headquarters

National Cartographic Information Center
U.S. Geological Survey
507 National Center
Reston, VA 22092
703-860-6045/FTS 928-6045

Regional Offices

Eastern Mapping Center-NCIC
U.S. Geological Survey
536 National Center
Reston, VA 22092
703-860-6336/FTS 928-6336

Mid-Continent Mapping Center-NCIC
U.S. Geological Survey
1400 Independence Road
Rolla, MO 65401
314-341-0851/FTS 277-0851

National Cartographic Information Center
U.S. Geological Survey
National Space Technology Laboratories
NSTL Station, MS 39529
601-688-3544/FTS 494-3544

Rocky Mountain Mapping Center-NCIC
U.S. Geological Survey
Box 25046, Stop 504 Federal Center
Denver, CO 80225
303-324-2326/FTS 234-2326

Western Mapping Center-NCIC
U.S. Geological Survey
345 Middlefield Road
Menlo Park, CA 94025
415-323-8111, ext. 2427
FTS 467/2427

National Cartographic Information Center
U.S. Geological Survey
9230 University Drive
Anchorage, AK 99508-4664

USING THE TEMPLATES FOR ADMINISTRATIVE UNITS NOT INCLUDED AMONG THE LAND USE AND LAND COVER AND ASSOCIATED MAPS

If a user needs to obtain acreage estimates for land use and land cover data other than by counties, census county subdivisions, hydrologic units, or Federal or State land ownership, all that needs to be known is the approximate size of the administrative unit(s). For example, if a user requires land use and land cover acreage estimates for watersheds, this information is not available from the USGS digital data files. However, by knowing or estimating the approximate size of watersheds, the user can identify the appropriate sampling template to use to obtain the acreage statistics desired. The procedures in steps 3 through 10 are then followed.

USING THE SAMPLING TEMPLATES FOR VERY LARGE COUNTIES OR ADMINISTRATIVE UNITS

As originally designed, templates A through F were prepared to cover four times the area of the upper limit of the county or administrative unit size for that template. While templates A through D fit nicely on a piece of film measuring 8 1/2 by 11 inches, templates E and F measure 12 by 13 inches and 20 by 22 inches, respectively. Templates G, H, and I measure 14 by 12 inches, 19 by 17 inches, and 27 by 24 inches. At 1985 film costs, template G would cost approximately $6, H would cost $11, and I would cost about $20.

A less expensive approach is to produce a page-size template for use with larger areas. Of course this requires more frequent repositioning of the template. Accordingly, the printed templates for templates E through I in the appendix of this report may have to be repositioned more frequently to obtain land use acreage estimates for larger counties or administrative areas.

MODIFYING THE TEMPLATES FOR USE AT OTHER MAP SCALES AND WITH OTHER LAND USE CLASSIFICATION SYSTEMS

The sampling templates have been prepared for use with USGS land use and land cover maps at a scale of 1:250,000. Approximately 46 USGS land use and land cover maps have been prepared at the 1:100,000 scale. If a user desires to apply the templates to maps at the 1:100,000 scale, the templates must first be enlarged by a factor of 2.5. It is not recommended that the templates be used with land use and land classification systems other than the USGS Level II classification system outlined in table 2. The reason for this caution is that the template design was based on an average of 25 land use and land cover Level II categories per 1:250,000-scale quadrangle map. Users interested in designing their own template should obtain a copy of the Mid-Continent Mapping Center technical research report mentioned previously and follow the design procedures for template development in that report to ensure appropriate template design for other land use classification systems.

REFERENCES

Anderson, J.R., Hardy, E.E., Roach, J.R., and Witmer, R.E., 1976, A land use and land cover classification system for use with remote sensor data: U.S. Geological Survey Professional Paper 964, 28 p.

Fegeas, R.G., Claire, R. W., Guptill, S. C., Anderson, K. E., and Hallam, C. A., 1983, Land use and land cover digital data, USGS digital cartographic data standards: U.S. Geological Survey Circular 895-E, 21 p.

Latham, J.P., 1979, Land use change analysis from archival and current remotely sensed patterns in Pennsylvania: Paper presented at annual meeting of American Society of Photogrammetry, Washington, D.C., March 23. [Copies available from American Society of Photogrammetry, 210 Little Falls Street, Falls Church, Virginia 22046.]

Mid-Continent Mapping Center, 1982 Determination of county-level land use acreage statistics from open-file maps using sampling procedures: U.S. Geological Survey, National Mapping Division, MCMC-24 Final Research Report. [Copies available from Office of Geographic and Cartographic Research, National Mapping Division, U.S. Geological Survey, 519 National Center, Reston, Virginia 22092.]

Rosenfield, G.H., 1981, Sample design for estimating change in land use and land cover: Photogrammetric Engineering and Remote Sensing, v. 48, no. 5, p. 793-801.

Tortora, R.D., 1978, A note on sample size estimation for multinomial populations: The American Statistician, v. 32, no. 3, p. 100-102.

U.S. Bureau of the Census, 1981, Number of inhabitants: 1980 census of population: U.S. Bureau of the Census Reports PC80-1-A1 through PC80-1-A51 [one volume for each State and the District of Columbia].

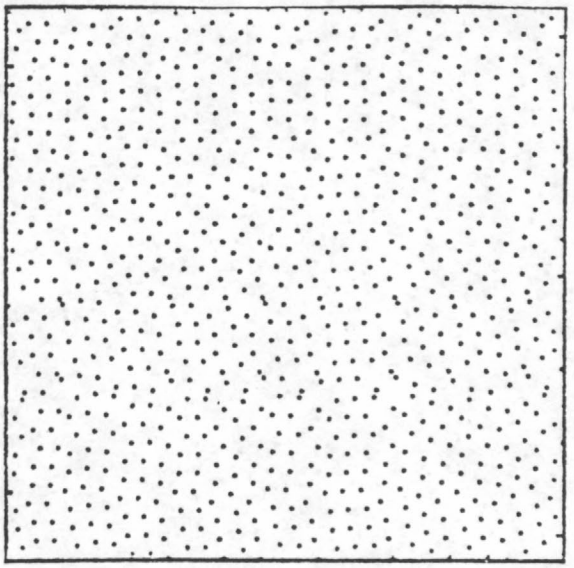
_____ 1982, County area measurement file including population counts: U.S. Dept. of Commerce, Bureau of the Census, magnetic tape file. [Copies available from Public Information Office, Bureau of the Census, Department of Commerce, Washington, D.C. 20233.]

APPENDIX

APPENDIX

LAND USE ESTIMATION TEMPLATES

Photocopies of land use estimation templates are included primarily to illustrate the sampling density of each template. Users are advised to obtain stable base film copies of the templates to ensure reliable acreage estimation results.

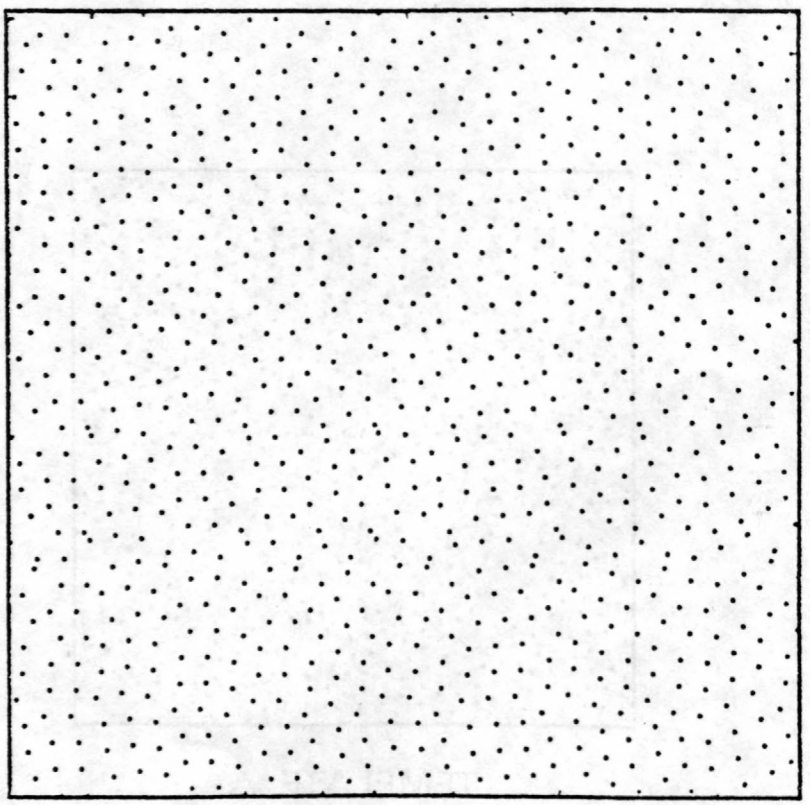


TEMPLATE A

Optimal Administrative Area Sizes: 0-63 square miles

Map Scale: 1:250,000

Acres/Sample Point: 91.022

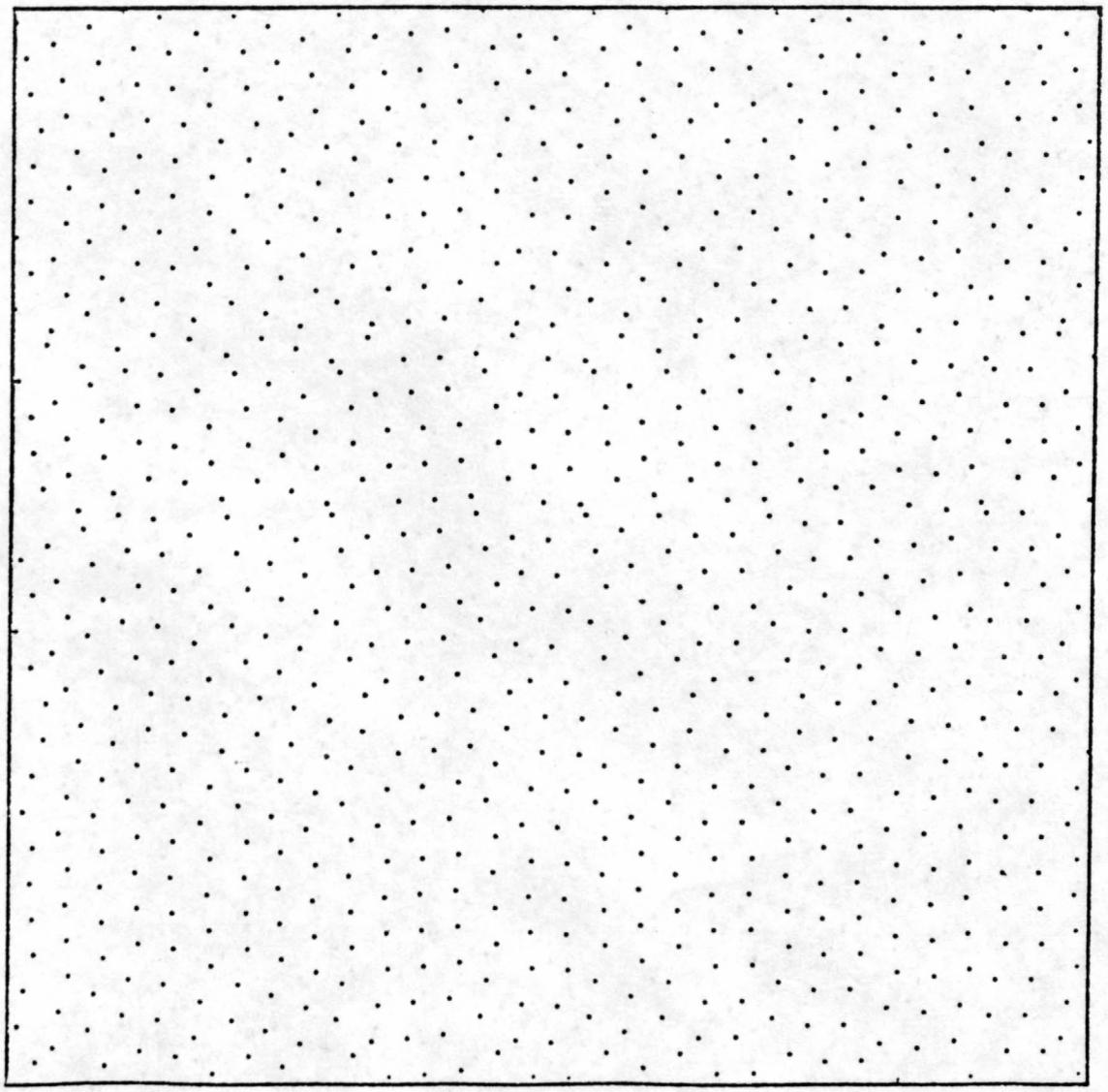


TEMPLATE B

Optimal Administrative Area
Sizes: 64-127 square miles

Map Scale: 1:250,000

Acres/Sample Point: 182.044

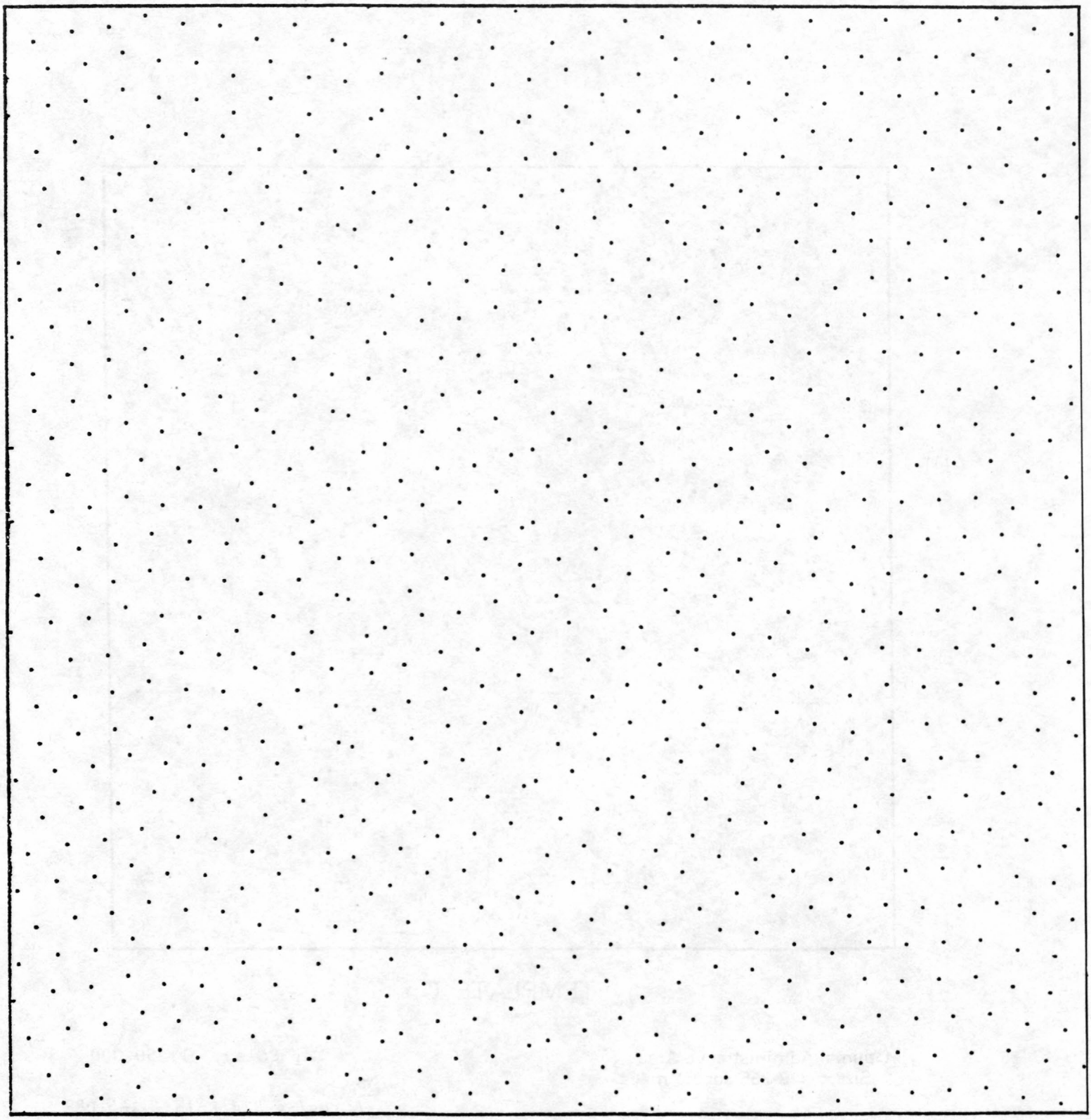


TEMPLATE C

Optimal Administrative Area
Sizes: 128-255 square miles

Map Sales: 1:250,000

Acres/Sample Point: 364.088

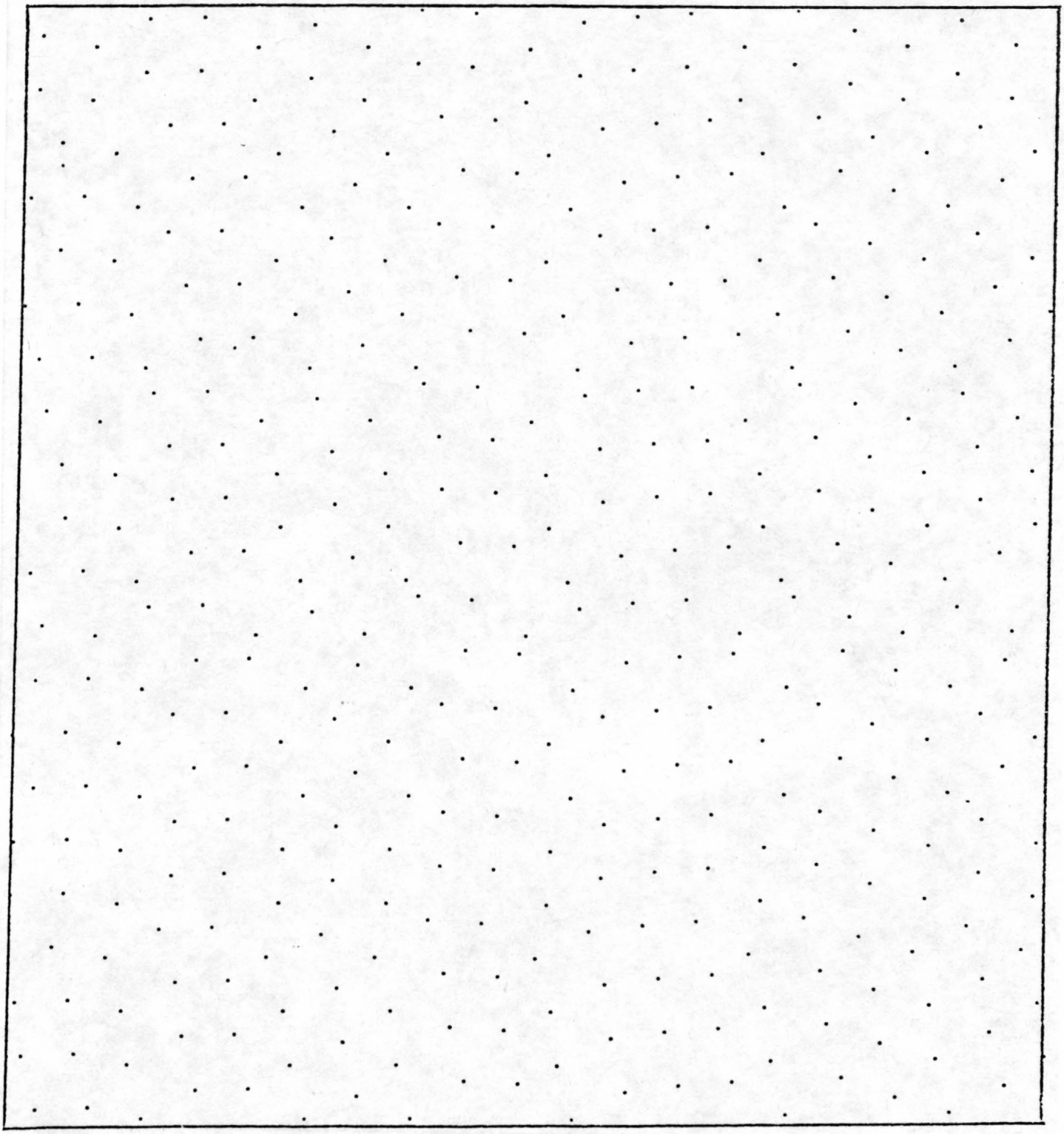


TEMPLATE D

Optimal Administrative Area
Sizes: 256-511 square miles

Map Scale: 1:250,000

Acres/Sample Point: 728.178

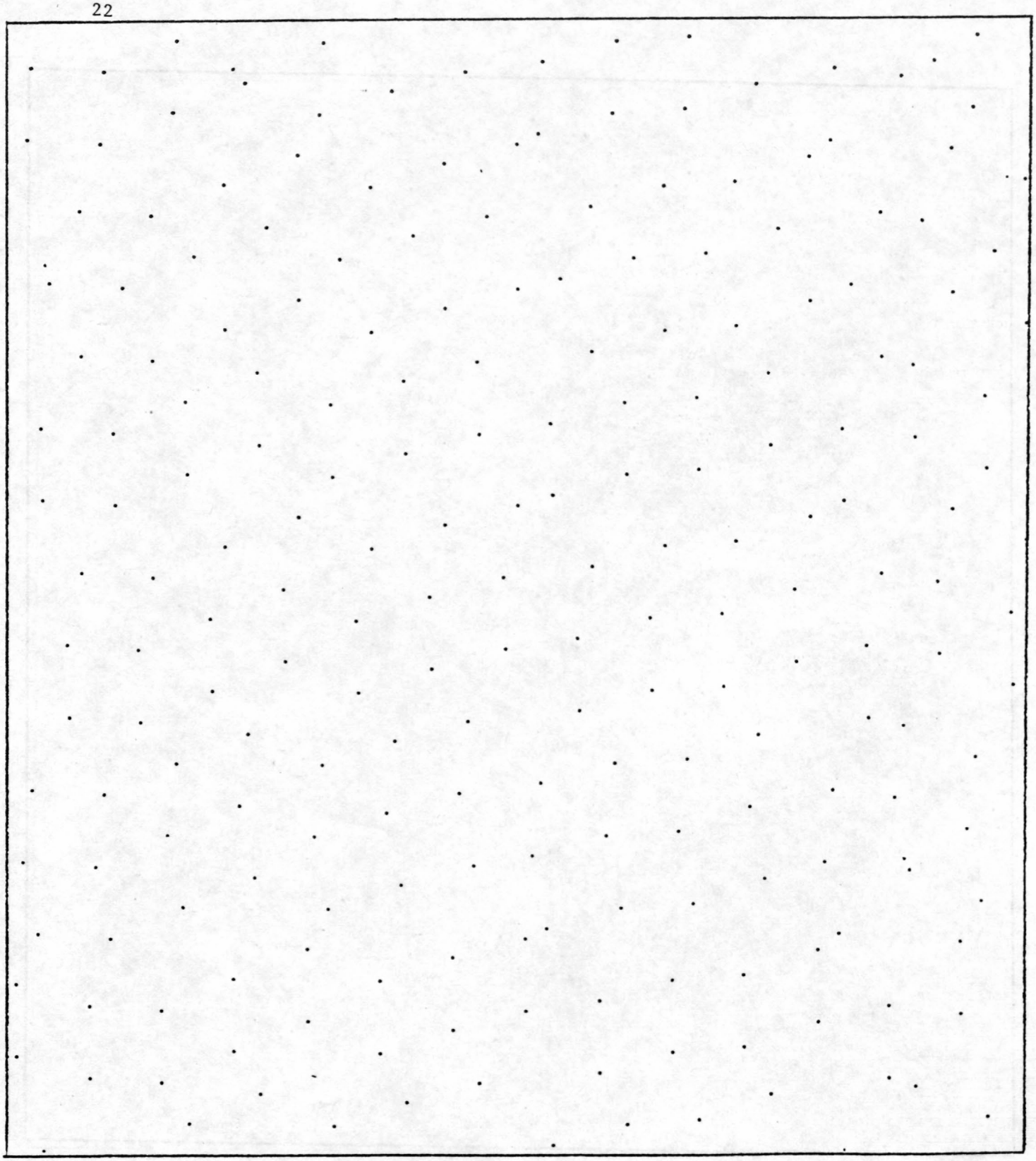


TEMPLATE E

Optimal Administrative Area
Sizes: 512-1,023 square miles

Map Scale: 1:250,000

Acres/Sample Point: 1,456.356

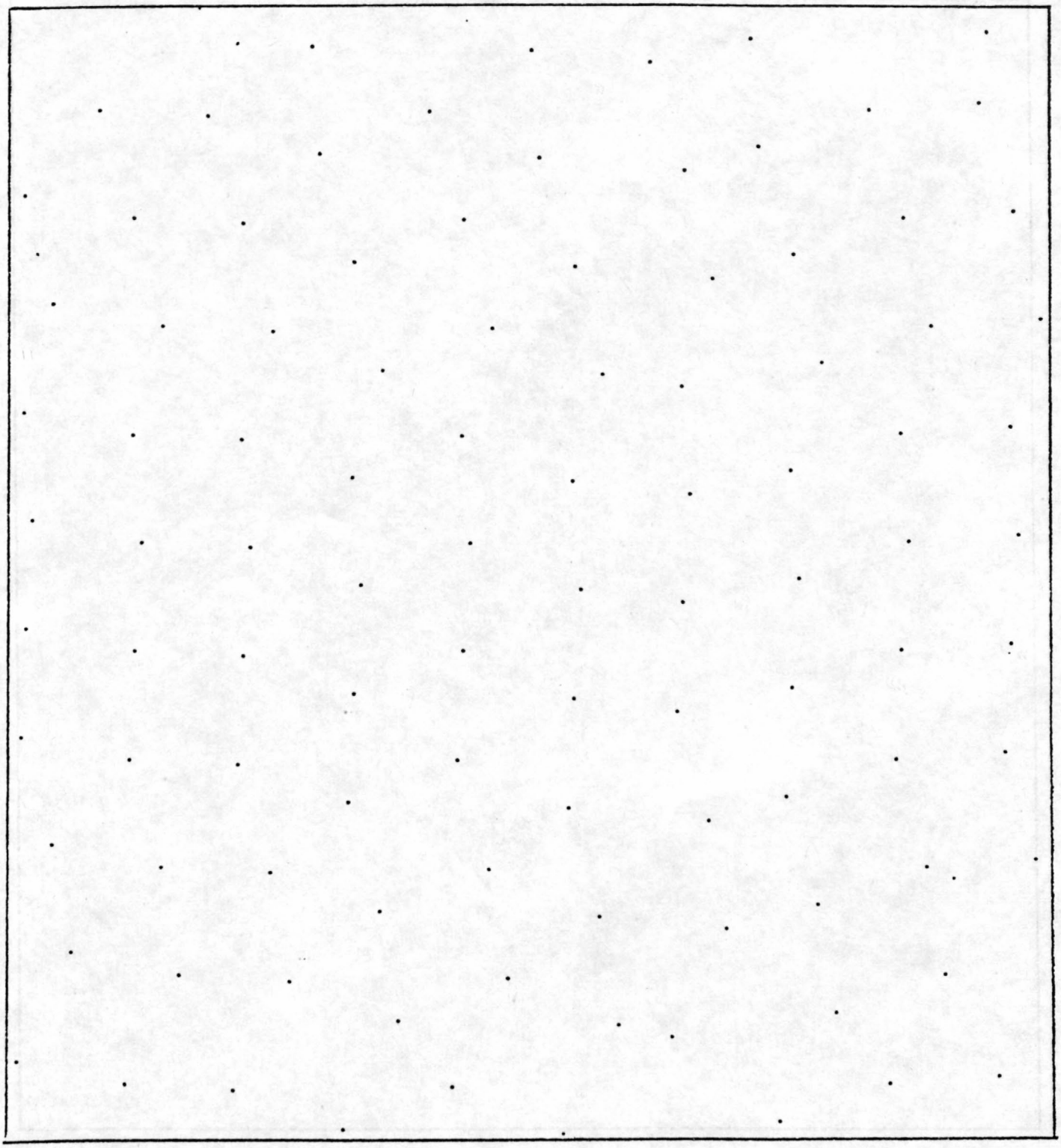


TEMPLATE F

Optimal Administrative Area
Sizes: 1,024-2,047 square miles

Map Scale: 1:250,000

Acres/Sample Point: 2,912.711

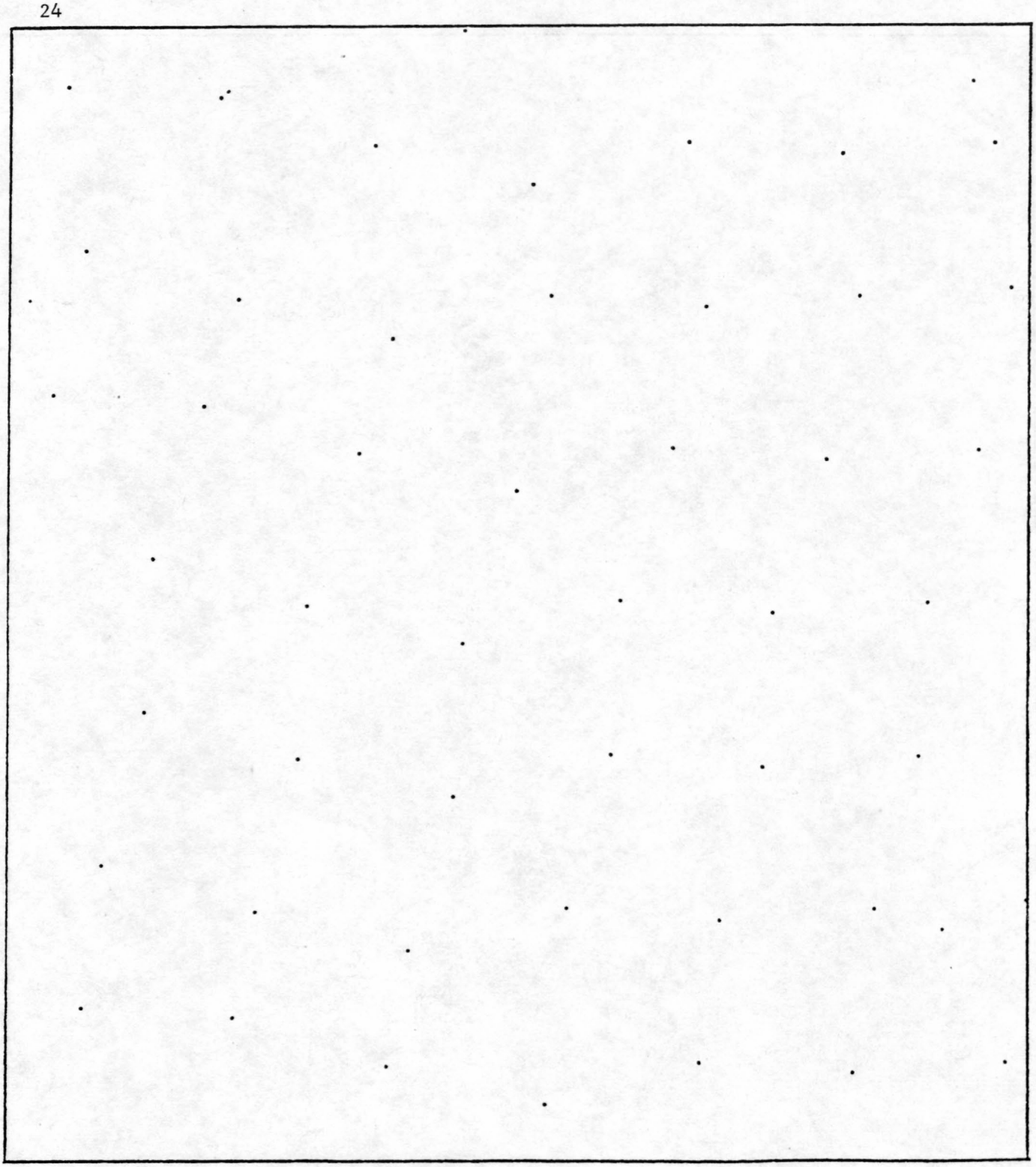


TEMPLATE G

Optimal Administrative Area
Sizes: 2,048–4,095 square miles

Map Scale: 1:250,000

Acres/Sample Point: 5,825.422

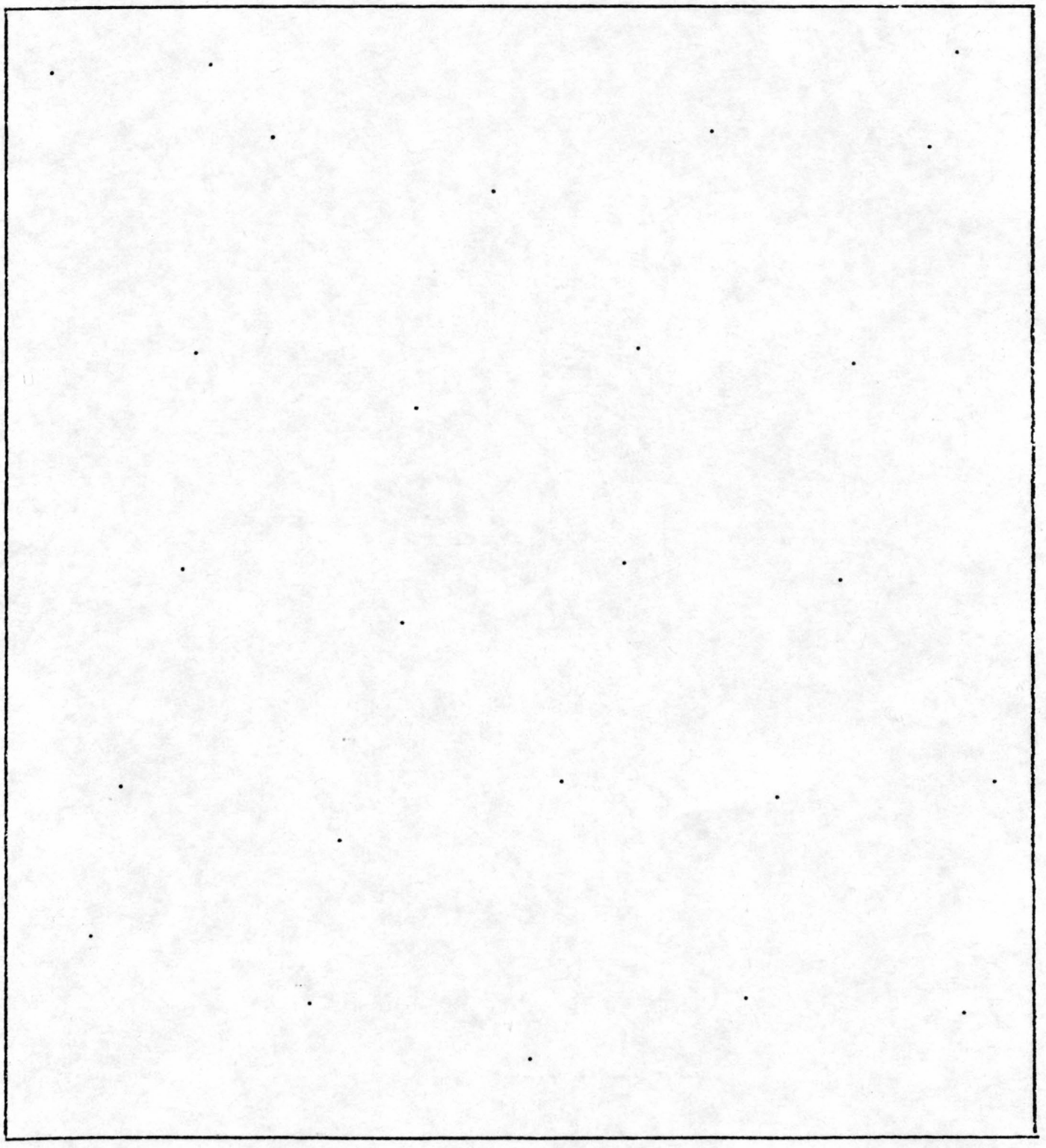


TEMPLATE H

Optimal Administrative Area
Sizes: 4,096-8,191 square miles

Map Scale: 1:250,000

Acres/Sample Point: 11,650.840



TEMPLATE I

Optimal Administrative Area Size: Greater than 8,192 square miles

Map Scale: 1:250,000

Acres/Sample Point: 22,301.689