UNIT 48: DESIGNING PRODUCTS FOR PRINTING

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Context

Printed geographic products can take one of several forms. Among these are tables, charts, surfaces, and maps. Each of these formats has unique characteristics for displaying spatial information, and specific requirements for doing so effectively.

The printed map is one of the most widely used tools for the presentation of geographic information. The proper design insures that a map will effectively communicate the results of a geographic analysis or description. Poor design will cause the map to become - at best - an ineffective tool for the transfer of information, and - at worst - a source of misinformation.

The elements of proper map design can be roughly broken into two groups - 1) the features, symbols, and text to be printed on the map (and their relative placement) and 2) the process of choosing the data to be placed on the map given the information to be conveyed and the audience for which it is intended. Issues of cartographic tradition, common knowledge of symbols, and the limits of artistic license must be taken into consideration when a cartographer chooses the elements that will comprise a given map. The proper design for other types of geographic information (charts, graphs, etc.) can be considered as a sub-set of proper map design, and will be discussed as such.

While no single map can be considered "typical" of more than a small subset of maps, the following Example Application will demonstrate the process of selecting the proper map elements. Moreover, it will illustrate a method of arranging the map elements in such a way as to effectively communicate the intended information through the medium of a printed product.

Example Application

Consider the following scenario:

It is believed that the incidence of a particularly rare form of cancer is believed to be abnormally high in the Atlanta Metropolitan region. It is known that this type of cancer can often be attributed to exposure to a specific toxic material, particularly through the consumption of contaminated drinking water. Residents are concerned and are pressuring their elected officials to investigate the problem and determine whether or not additional cases can be prevented.

The citizens and their representatives must present data regarding the relative and absolute locations of the cases and their surrounding areas to the Center for Disease Control (CDC) in Washington D.C. Based on your cartographic experience, you have been given the task of presenting this information in the form of both a table and a map. Lives literally depend on your ability to effectively communicate this spatial data.

You must produce 100 copies of the table. It should be black and white text, with 95 copies on 8.5" by 11" paper, 4 copies on 8.5" by 11" transparencies for use on an overhead projector, and one copy on E-size paper (36" by 48") for wall display. You must also produce 100 copies of the map. The number of copies and paper sizes are the same as for the table, with the exception that all maps should be in color.

The following steps show a possible method of presenting the necessary information:

1. ***Create a list of the available information:***

   You know that you have the following resources:

   - **Several digital coverages of the Atlanta region in Arc/View format:**
     - **Census tracts (polygons);**
     - **Bodies of Water (lines representing rivers and shorelines);**
     - **Incidents of the Cancer (points at coordinates of victims homes).**
   - **Demographic data showing number of toxin producing manufacturing sites by Census Tract.**

1. ***Create a table listing the census tracts within which incidents of the cancer have been reported and include all appropriate auxiliary information:***

   Include the following information:

   - **The census tract number or another identifier;**
   - **The area of the census tract;**
   - **The population of the census tract;**
   - **The number of households in the census tract;**
   - **The number of firms involved in the use or production of the toxin within that census tract;**

   Use a word processor or other software to format the information into a readable table.

   Your output may look something like the table below. Be sure to include a

title and cite any data sources used in the creation of the table.

Census Tracts Containing Incidents of Cancer
(and associated demographic data)

Source:

U.S. Bureau of the Census.

CENSUS TRACTS CONTAINING INCIDENTS OF CANCER (AND ASSOCIATED DEMOGRAPHIC DATA)				
021304	3.029	8093	3800	6
050705	28.867	7475	2471	8
110500	54.895	10449	3701	10
110200	63.410	2493	904	11
050704	21.651	8256	2647	12
110400	13.414	4739	1782	10
110600	60.831	6319	2221	24
060100	37.950	7409	2521	7
110800	50.213	4334	1529	26
100100	47.556	6451	2236	27
023407	24.295	11979	4502	9
100200	92.717	5829	2044	28
040402	15.876	10161	3375	7
060401	21.050	8010	2617	10
100300	13.446	5239	2086	30
070102	13.757	7273	2462	11
100900	36.140	6122	2175	12
060402	24.221	12050	3886	13

1. ***Print the required copies of the table:***

   The 95 copies to be printed on 8.5" by 11" paper and 4 overheads can be easily created by printing multiple copies through any ordinary laser printer or (depending on the quality demanded) by printing a single copy and photocopying duplicates. The single copy on E-size (36" by 48") paper must be created by setting the paper size in the word processor or software package in which the table was created. The size of the table itself and the text within it will need to be adjusted accordingly. In order to accommodate such a large paper size you may need to install a driver for a large-format output device. If you do not have such a device at your disposal you will need to contract out the printing (or plotting) of this table at this size.

2. ***Create a map of the region demonstrating the spatial relationship between toxin producing firms, bodies of water, and cancer incidence.***

   Use the following

themes:

- **Census tracts shaded by number of firms using or producing the suspect toxin;**
- **Points marking the locations of cancer victims homes;**
- **Bodies of water.**

Use all required map elements to make the theme information useful.

070201	**19.907**	**5229**	**1829**	**14**
070103	**26.531**	**13839**	**4966**	**14**
070202	**21.145**	**2204**	**774**	**15**
040604	**5.150**	**9331**	**3664**	**2**
100800	**49.186**	**3230**	**1136**	**23**
070203	**35.639**	**3136**	**1084**	**13**
070302	**29.637**	**9936**	**3473**	**12**
040606	**9.656**	**1473**	**273**	**20**
070402	**34.237**	**2030**	**710**	**21**
150100	**88.644**	**4233**	**1565**	**22**
150200	**38.256**	**6702**	**2302**	**23**

 Figure 1

A typical output from ArcView using the aforementioned themes may look something like the following map:

On this map, the map features themselves are as large as the paper size will allow, the text is descriptive of the data layers, and all required map elements are included.

The users of this map are free to draw conclusions based on the absolute and relative locations of the incidents of cancer, the bodies of water, and the toxin producing firms.

The 8.5 X 11 maps can be printed in color on a standard color ink jet or laser printer. After resizing the features and text, the larger map must be printed on an E-size printer or plotter.

Learning Outcomes

The following list describes the expected skills which students should master for each level of

training, i.e. Awareness/Competency/Mastery.

Awareness:

An awareness of the procedures for producing geographic products for printing demands a knowledge of several formats for output such as tables, charts or graphs, and maps. The limitations and advantages of each format should be clear. Basic rules for output should be well understood. In particular, the student should be aware of the required and suggested map elements, and the ways in which they are used.

Competency:

The student should be capable of 1) selecting the appropriate map type for the data to be presented, 2) arranging the map elements to effectively convey the results of a geographic analysis, and 3) printing the map on a range of media and at a number of different scales.

Mastery:

The student will use their knowledge of map elements, map types, and proper cartographic conventions to guide their map design decision making. Tradeoffs between style and efficiency are chosen in the best interest of the maps audience. The number of maps to be printed, the use of color and pattern, and the accuracy of the spatial data must be considered in the design process.

Preparatory Units

Recommended:

- Unit 1 - Acquiring existing digital data
- Unit 7 - Assessing data; using and interpreting metadata
- Unit 9 - Converting digital spatial data between formats, systems and software
- Unit 10 - Projecting data
- Unit 15 - Labeling

Complementary:

- Unit 19 - Creating tabular data; Planning a tabular database
- Unit 22 - Merging tabular data with spatial data
- Unit 23 - Creating maps with CAD
- Unit 39 - Performing statistical analyses
- Unit 42 - Using map algebra

Awareness

Required Map Elements:

- ***Title:*** A map, like any other document, must be introduced to the reader through the use of a brief, descriptive title. The title should be written in a larger font than any other supporting map text or annotation. It may be in bold type for greater emphasis. The title need not be placed at the top of the map, especially if doing so would detract from the importance of the map features themselves. It is often useful to include the location of the map elements in the title. Never use abbreviations or unspecified acronyms in the title.
- ***Scale:*** Many GIS applications are considered to be scaleless due to the ability to rapidly and interactively change scale on screen, reducing or enlarging features as appropriate (Clarke 1997). This is **NOT** true for printed maps. In order to be usable, the map must state the scale at which its features are drawn. The map scale shows the relationship between distances on the map and distances in the real world. There are several ways to represent the scale of a map including:

 Figure 2

1. a **scale bar** that marks off world distances, usually with several intervals to show the map lengths of units of earth distance. This is most useful for maps to be used in the field, such as road maps where distance calculations must be made quickly;
2. a **representative fraction** or ratio. Virtually all maps can benefit from the presence of a representative fraction. A representative fraction is a statement of the number of units of real world distance corresponding to a single unit of map distance. Representative fractions apply to all linear units of measurement and therefore should not include unit notation. Units should never be mixed on a representative fraction;
3. a **verbal statement** of the representative fraction. This is an expression of the map scale given to facilitate understanding of the real world distances portrayed on the map. This form of scale commonly uses mixed units of measurement, such as:

    - 1 inch = 40 feet
    - 1 inch = 1 mile
    - 1/4 inch = 1 foot

1. an **area scale** which states that 1 unit of area on the map is proportional to a stated number of the same square units on the earth. This type of scale must only be used when an equal-area projection has been applied to the map. As with a linear representative fraction, an area scale is unitless.

Your choice of a scale or scales for your map output is dependent on the uses to which the map will be applied. The map scale is essential for a comprehensive understanding of the map and is therefore an absolutely essential map element.

- ***Legend:***The map legend or key is the element that explains the meaning of the point, line, and area symbols used to represent features on the map. Every symbol that appears on the map MUST appear in the legend, and it must appear exactly as it does in the body of the map.
- ***Location:*** With few exceptions, it is imperative to include some description of the location of the features on the map. The fact that the cartographer easily recognizes the features portrayed, does not guarantee that this area will be familiar to the map users. The location of the map features may be given in one or more of several ways:
  - In the Title of the map (e.g. "United States Interstate Network")
  - Through the use of graticules (longitude and latitude lines or some other reference to a well accepted coordinate system)
  - Through the use of an "Inset Map" which shows the larger surrounding region usually at a smaller scale. This larger region must be easily recognizable by virtually all potential map users.
- ***Sources:***Every map is a collection of information. All sources of map information must be referenced just as all sources for any research paper must be cited. The omission of source references from a map is a clear form of plagiarism. The source should be as complete as a reference in a research paper. That is, it should include the date, title, author, publisher, and any other known and pertinent information. Moreover, two general sets of map items must be referenced:
  - the features on the map (linework, markers, etc.)
  - the data associated with the map features (attributes).
- ***Projection:***With the exception of a globe, all printed output of geographic data is projected onto a surface with different characteristics than the Earth itself. Most commonly, map output is projected onto a flat surface - a plane. This can be done in many ways and is guaranteed to distort the data. While the subject of projecting data is covered thoroughly in Unit 10, it is sufficient here to state that a statement of the projections is mandatory on virtually all maps. This statement should include:
  - the name of the projection;
  - any parameters specific to the projection (central meridian, zone, lines of tangency, etc.)
  - the datum and spheroid specific to the projection.

  In the case of a map which covers a very small area (a very large scale map) over which the curvature of the earth can be considered insignificant, the map projection may be omitted from the map. This is the case when mapping building footprints, whose foundations are on a portion of the Earth which has been artificially graded to make it locally flat.

 Figure 3

- ***Orientation:***The orientation of the map is provided by one or more directional cues. Most commonly, this take the form of a north arrow. This may be supplanted or supplemented by labeled graticules of latitude and longitude, or any other device which allows the map reader to determine direction. Because there are numerous styles of north arrows, the cartographer must choose one that is appropriate for the map. In a map designed to convey a specific set of information, it is generally accepted that a non-intrusive north arrow be chosen. A map which is intended to serve as a work of art as well as a means of conveying information may require a more ornate compass rose. Several north arrow styles, ranging from the simple to the ornate are shown.

Suggested Map Elements

- ***Prepared By:*** It is good cartographic practice to include the name of the cartographer on the map. Just as you would not submit a paper or report without acknowledging authorship, you should not create a map without identifying yourself. The are, however, exceptions to this rule. If the map is created on behalf of your employer, the employers name may be more appropriate. If the map is one in a series, it may be inappropriate to include the cartographers name on each map (just as you would not sign your name to every product you worked on in a factory). The presence of the cartographers name on the map is clearly function of the intended map use.
- ***Prepared For:*** In the case where a map is being produced for a third party (a client, a professor, etc.) it is appropriate to include the name of that party on the map. This not only identifies the intended user, but suggests to other potential users that the map was created for a specific purpose, and other uses of the map should not deviate substantially from this intended use.
- ***Date:***In a situation similar to the requirements for source references, the date must be provided for two elements of the map:
  - the date of the creation of the features and attributes displayed on the map
  - the date of the creation of the map itself.

Competency

In order to possess skill in map-making more is required than a simple awareness of the elements which comprise a complete map. A competent cartographer must be capable of selecting the appropriate map type for the data to be presented and printing the map on a range of media and at a number of different scales.

Map Types: Since there are many ways to display information on a map, the cartographer has

a responsibility to choose the method most suitable for a particular set of geographic data. Some of the more common general types of maps and their characteristics are:

- *Reference Maps* - (or general purpose maps) are collections of point, line, or polygon features. These are generally designed to convey information about the absolute location of objects on the surface of the earth, and are used for navigation and as a reference for feature location. Road maps fall into this category as do most boundary maps which show political features (states, cities, counties, etc.), and topographic maps which show the delineation of physical features on the landscape.
- *Dot Maps* - use dots to show the distribution and density of some phenomenon over an area. Often each dot will represent some number of entities. For example, each dot may represent 100 people in a given county, or a dot may stand for 10 bushels per acre of some crop grown in a state. The dots are commonly assigned simply to one polygonal feature and should not be considered as point locations of the phenomenon.
- *Picture Symbol Maps* - are similar to dot maps, in that they locate a phenomenon of the surface of the Earth. However, the symbol is representative of the phenomenon being described rather than a generic dot. Examples are pictures of busses to locate bus stations or stops, pictures of male or female silhouettes to show the locations of rest-rooms, or pictures of baseballs to located cities with minor league baseball teams.
- *Graduated Symbol Maps* - are dot or other symbol maps with variation in symbol dimension based on the value of the feature at a particular location. Generally, the larger the symbol the larger the value at that location.
- *Network Maps* - display an integrated system of linear features. The intersections are well defined and the potential routes along the network system are often identified. Maps of transportation systems (trains, subways, bus routes, etc.) and other means of delivery are network maps.

  Flow maps - are similar to graduated symbol maps in that they depict varying quantities of some phenomenon. In the case of a flow map, however, the quantity is depicted through the use of a linear feature of varying thickness. The thicker the line, the larger the quantity of the material flowing from the start of the linear feature to the end. Examples, include maps which show the flow of oil from producing countries to consuming countries, maps which depict the flow of troop movements over a continent, or maps which show the flow of migrants.

- *Choropleth Maps* - display values of data in polygonal areas through the use of color. There are many variations of choropleth maps including:
  - *classed choropleth* - data are classed and areas are shaded or colored differently according to their class value
  - *unclassed choropleth* - differences in data values are shown using a continuous variation in tone or color rather than the steps that result from classes
  - *area qualitative map* - a color is assigned to a value, but the range of colors does not imply an association or ranking among different values.
- *Stepped Statistical Surface Maps* - are representations of polygons as volumes with the height of the volume corresponding to the value associated with the polygon.
- *Isoline Maps* - utilize the intervals between lines joining points of equal value to represent areas of varying value. These intervals may be shaded, colored, or identified

with a text value. If the color scheme is used to illustrate variation in data values the isoline map is known as a Hypsometric Map. Examples include maps of temperature or other climate factors, contour maps, and maps displaying travel times from a given point.

There are also a number of ways of displaying 3-dimensional geographic data (gridded fishnet, realistic perspective, simulated hill shading) and these require an even greater amount of care in their use. For example, the scale of a map shown in 3-dimensions is very different at the foreground of the image than it is at the background. You may want to consider 3-dimensional displays of geographic data as "graphics" rather than "maps" and plan your printed product accordingly.

Production Cartography: When the map type has been chosen, the cartographer must use their knowledge of the required map elements to output a printed product. Production Cartography requires that the following steps be completed:

- *Compilation* - the process of assembling the diverse elements of the map that will be included in the final product. This includes the source data for the map features, any thematic data to be associated with the features, and the construction of the required map elements (scale, title, legend, etc.).
- *Layout* - the collection of objects from the compilation process must be arranged on a layout. This can be physically or with the assistance of a mapping software package. Based on an initial layout, additions, deletions, or other edits can be made to the elements of the map.
- *Map Production* - the actual process of outputting a map on one of many possible devices. The output may go to a computer screen, a pen plotter, a hydrostatic plotter, an ink jet device, or one of many possible hardware products. The map may even be stored in its finished form in a computer file waiting to be reproduced in some other medium at an appropriate time.
- *Map Reproduction* - The number of copies of the map must be considered in order to choose the appropriate medium, output device, and method for map reproduction. Map reproduction methods designed for a small number of copies are not necessarily the correct choice for a map which much be reproduced many thousands of times. The cartographer must assess the extent of the maps audience in order to choose the most cost efficient map reproduction method.

Mastery

When a cartographer is aware of the elements that are required to make an acceptable map, and is competent to choose the proper map type given the data to be presented, the process of designing maps can be mastered. Map design requires

1. an understanding of the use of color and pattern in mapping applications
2. a familiarity with cartographic tradition in the use of symbols
3. the development of a style of mapping which is efficient

Color and Pattern: Choropleth maps use color to differentiate between values associated with map features. However, the colors employed must be carefully considered. Opposing colors should only be used for distinguishing between opposing data values on the same map. Examples include values below and above a given temperature, values for profit and loss, or two-party election results. In other cases variation in shade or tone for a single color is appropriate. The use of pattern is similarly constrained. Use pattern sparingly as it can be confusing to a map reader. Refrain from combining pattern symbols - use color and pattern or some other visual variable instead.

Traditional Cartographic Use of Symbols: With few exceptions, it is advisable to follow cartographic convention when mapping, that is, color water blue, forest green, contours brown, etc. These conventions have been accepted by the very large majority of map readers over their lifetimes. By straying from these traditional methods of symbolization you are risking that people will misinterpret your map.

Mapping Style: Lastly, the cartographer must implement the awareness of map elements and the ability to competently design and produce maps which show the mastery of color, pattern and traditional use of cartographic symbols. By doing so the cartographer will develop an individual style. This style will likely grow and mature over time as the cartographer experiments with variations on the mapping themes. This style will incorporate the cartographers knowledge with artistic skill to produce exceptional maps.

Follow-up Units

- Unit 50 - Operating plotter/printer software
- Unit 51 - Preparing Digital Presentations
- Unit 52 - Project management
- Unit 53 - Communicating about and distributing GIS products

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Resources

[Outdated links have been removed.]

The following is a short list of world wide web addresses for sites that engage in mapping activities or cartographic education. This is a very limited list, many more sites exist.

LLU Contouring and Mapping Tutorial

Maps and Cartography Resources Page

Cartographic Communication

References

Clarke, K.C. 1997. Getting Started with Geographic Information Systems. Prentice Hall: New Jersey.

DeMers, M.N. 1991. Fundamentals of Geographic Information Systems. John Wiley & Sons, Inc.: New York.

Robinson, A.H., R.D. Sale, J.L. Morrison, and P.C. Muehrcke. 1984. Elements of Cartography. John Wiley & Sons: New York.

Wood, D. 1992. The Power of Maps. The Guilford Press: New York.

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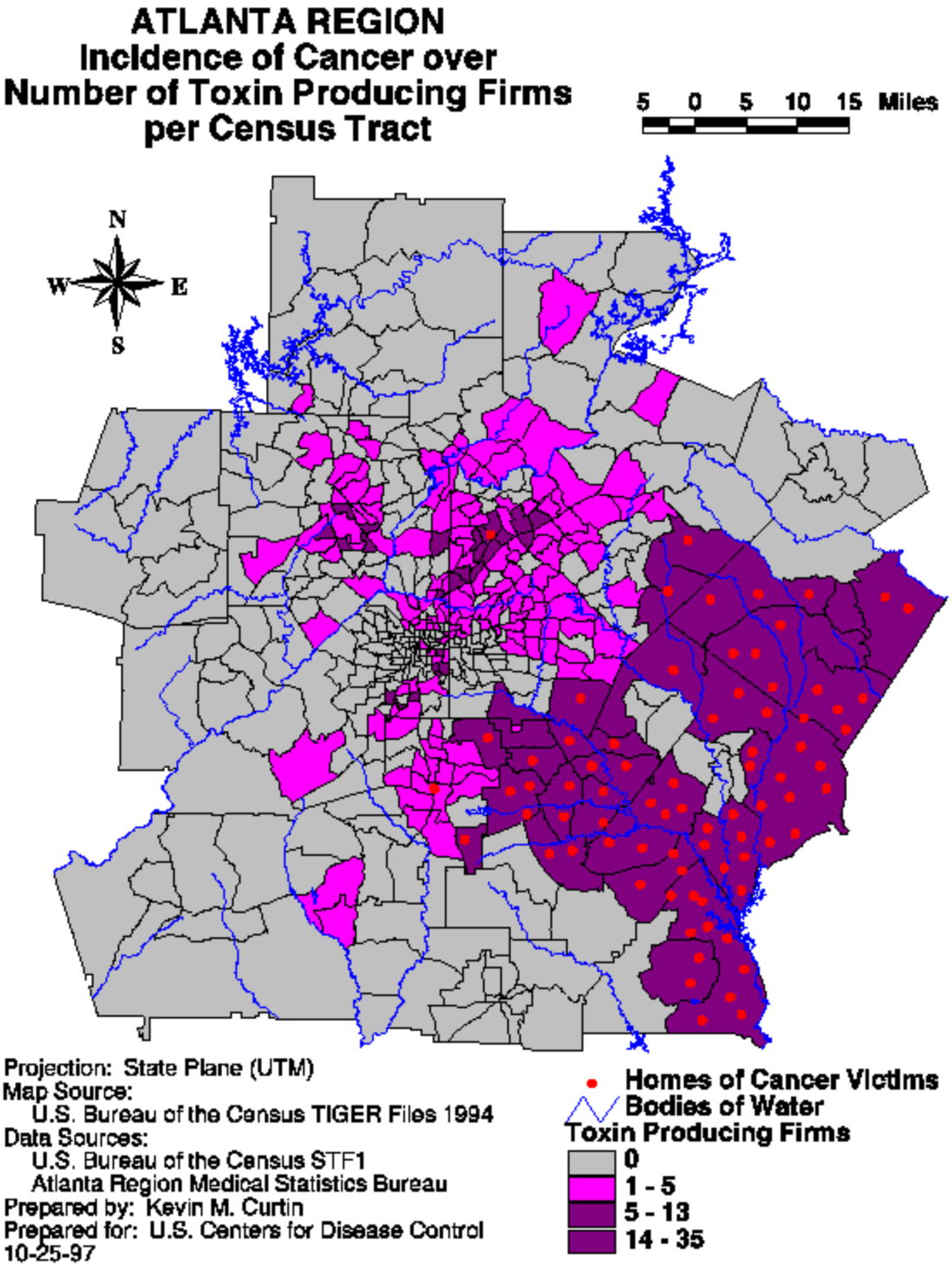
ATLANTA REGION
Incidence of Cancer over
Number of Toxin Producing Firms
per Census Tract
5 0 5 10 15 Miles
N
W
E
S
Projection: State Plane (UTM)
Map Source:
U.S. Bureau of the Census TIGER Files 1994
Data Sources:
U.S. Bureau of the Census STF1
Atlanta Region Medical Statistics Bureau
Prepared by: Kevin M. Curtin
Prepared for: U.S. Centers for Disease Control
10-25-97
Homes of Cancer Victims
Bodies of Water
Toxin Producing Firms
0
1 - 5
5 - 13
14 - 35

Figure 1

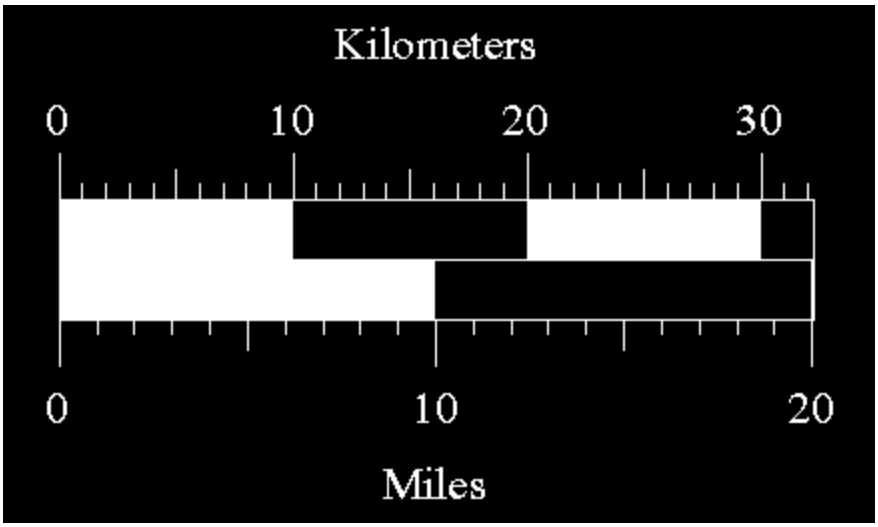

Figure 2

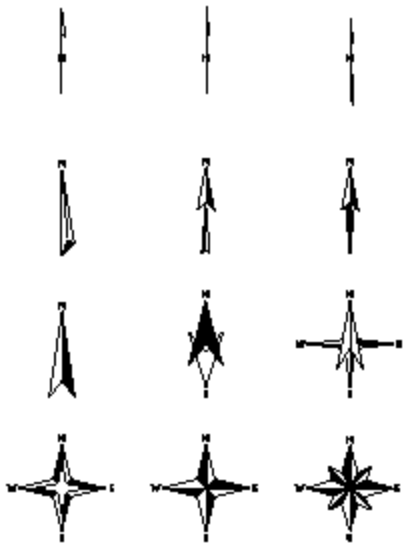

Figure 3