MAPPING BASICS

This section provides general guidelines for creating maps and displaying geographic analyses in reports, presentations, and displays. The section begins with a discussion of some basic mapping conventions in terms of color, symbolism, lines, and typography. Then, after reviewing map elements (e.g. legend, scales, and titles), guidelines are provided regarding the differences between and issues associated with various media (i.e. printed map versus a Power Point presentation). These tips are exemplified in a couple of images that demonstrate suggested layout and design. A list of resources containing additional information about these issues concludes this section.

Mapping Conventions:

Colors can have emotional connotations to the viewers, so they need to be chosen carefully. For example, using too much red on a map of crime may raise the public's fear of crime in an area. Selecting the appropriate colors for your map is related in part to aesthetics and part to cartographic standards. The general rule is that simple is better. Overloading the audience with a wide range of color will only obscure important patterns. When possible select different hues of the same color or select primary colors (or those closely associated). Principal or dominant features should have more eye-catching colors and background features should almost blend away (use grays and neutral colors).

Cartographic Principles. Centuries of map-making have lead to the establishment of general color conventions. Since most people are familiar with these representations, reversing the color symbology would render your map unintelligible and misleading. Use the following color selections for different zoning or land-use

- ❑ green to represent agricultural areas, forest or vegetation. Saturation is related to "density" of vegetation. For example, light green for fields and dark green for heavy forests.
- ❑ brown for land surface symbols and yellow or tan to represent dry or sparsely vegetated areas.
- ❑ shades of gray for urban areas. Again, darker shades should be associated with dense commercial development and light gray for industrial.
- ❑ water is represented with blue with the darker more saturated colors reserved for deep water.
- ❑ residential property should be colored beige or cyan with more saturated colors reserved for dense, multi-family housing (i.e. apartment complexes).
- ❑ elevation should range light yellow in low lying areas to orange/brown for mountain ranges.
- ❑ contours are usually neutral gray, green or brown depending on the background color.

❑ parcels should be the same color (darker hue) than the background lot they are situated on.

❑ streets should be gray or black (sometimes red) depending on background color (if any). Major roadways, such as highways and interstates can be thicker, double lined or a different color. Labeling these features should also conform to cartographic standards. As with width and color, different highways and street types have special labeling conventions. When in doubt see a local street map or the Thomas Guide.

❑ Text (labels) can be black or at times match the color of the type of data (i.e. blue names for water)

Road Line Colors		**Labels**
Highway	————————	15 91
Artery	————————	
Side Street	————————	

Magnitude and Quantity

❑ Color progressions are used to show differences in magnitude (qualitative differences), with lighter colors indicating "less" and darker or more saturated colors indicating "more".

❑ For crime mapping, densities are usually shown with a graduated color scheme (one color ranging from light to dark) using warm colors (i.e. red, orange, yellow) to illustrate hot spots. The human eye can only detect 3 to 7 shades depending on printer resolution. While many different colors can be detected, too many can be confusing. Use the fewest number of colors possible. Try keeping the general rule of one color per variable.

❑ A bi-polar progression should be used when displaying data that ranges from negative to positive, bad to good, or below to above average. A common bi-polar progression color scheme is blue to white to red. The values below the mid-point (negatives, bad or below average) are shown in blue with the values farthest from the mid-point shown in the darkest blue and those closest shown in light blue. The values above the mid-point (positives, good or above average) are shown in re with the values farthest from the mid-point shown in the darkest red and those closest shown in light red.

Background

❑ Lighter colors should be used in the background with more vibrant or darker colors used for the main features of the map in order to create good figure-ground contrast. Figure-ground contrast allows important data to stand out from the rest

of the map by appearing to "float" over the background. This draws the reader's eye to the most important feature of the map.

Symbols/Markers
- ❑ When applicable, use field specific markers. Markers for crime mapping can be found in ArcGIS using the "create markers" feature.
- ❑ An understandable, visual hierarchy needs to be established. Different types of markers (circle s vs. triangles) should be used to show differences in kind (qualitative differences). The same markers in different sizes should be used for differences in magnitude (quantitative differences).
- ❑ When using numerous lines, lighter colors/shades of gray should be used to reduce confusion. A visual hierarchy should be created when appropriate. For example, thick double lines should be used to represent highways whereas thinner single lines should represent streets.

Typography
Selecting the appropriate font and position for text is also subject to general rules of thumb. Again, if you are in doubt consult a world atlas (i.e. Rand McNally), the Thomas Guide, or a street map.
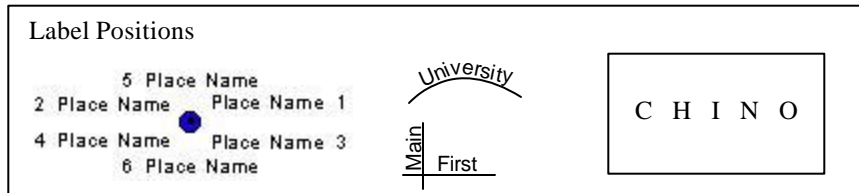
General
- ❑ The text on maps is almost always black because colors may be difficult to read. White text may be used on a dark background. Usually only 2 to 3 font families (i.e. Arial, Times New Roman, etc.) are used in a large mapping project. The best rule is to keep it simple and not use numerous font types.
- ❑ There are two basic typestyles, serif and sans serif. Serif fonts have decorative accents on the characters. Examples of serif font types are **Times New Roman** and **Garamond**. Serif fonts are less tiring to read and are easier to read in large blocks of text. Sans serif fonts have clean, simple characters. Examples of sans serif fonts are **Arial** and **Helvetica**. Sans serif fonts are easier to read than serif fonts for individual words that are a small point size, especially below 8-point font. In order to maintain consistency, **use Arial unless you have a reason to stray to another font.**
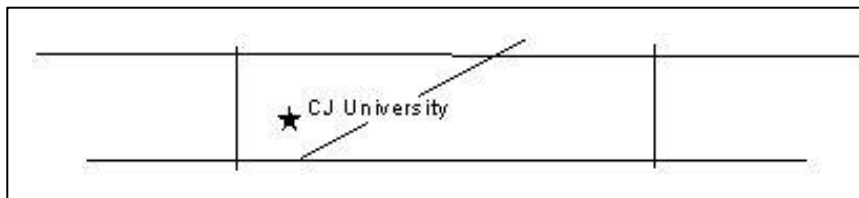
Labels
- ❑ Labels should be placed so it is clear what feature is being labeled.
- ❑ Labels should be on land or water, not on both.

- When labeling a place (a point), the preferred position for the label is above and to the right of the feature. The order of preference for position place labels is shown below.
- Line features should be labeled parallel to the feature. Labels should be placed above the line. If the feature is curved the label should follow the curve.
- Polygon features should be labeled within the boundaries when ever possible. Letters should be spaced out to extend across the area but not too far apart so that they cannot be read as part of the label.

Label Positions

5 Place Name
2 Place Name   Place Name 1
4 Place Name   Place Name 3
6 Place Name

University

Main   First

C H I N O

- Water features are usually labeled in italics.
- When a label crosses a geographic feature a "knockout" should be used so the label is readable (see example). A "knockout" is a graphic that separates the feature and the text and should be the same color/shade as the background.

★ CJ University

- Curved and angled labels should be used sparingly. Curved lines should be smooth, gentle and constant for the entire word.
- Lettering should never be upside down.
- The use of all capital letters should be limited because it is more difficult to read.
- When a map has a lot of text labels, different shades of gray can be used to help clean up the map. The most important features should be labeled in black while less important labels can be shown in gray.

Map Elements:

Maps should be clear and easy for the viewer to understand. It is important to know the audience in order to assess their ability to understand. The map is the most important feature in the layout and should be sized accordingly. Maps like other figures (and tables) require a number of basic features in order to for the audience to be able to understand the messages you are trying to convey. In many situations, one layout is equivalent to a short report with references, citations, footnotes, and text.

Legend. Legends should clearly and concisely explain the symbolization used on the map. Every symbol used on the map does not need to be included. Symbols that would

be easily understood by the map audience, such as streets and highways, should be omitted. It is important that the key elements or themes of the map are prominent in the legend. The labels in the legend should be meaningful and not contain cryptic file names (e.g. street.shp). You must change these "data labels" into something that will be understood by the reader (and make sure you remove the .shp). Place the legend on the bottom left or right hand side of the map whenever possible. If the page layout has a number of images with the same symbology, place one legend in a central or easily visible location.

Scale. A scale of some sort should almost always be included in the final layout of a map. Various types of scales can be used including a graphic scale bar, a measure (1 inch to a mile), or a ratio (1:24,000). When using a graphic scale bar there should be no divisions to the left of zero, meaning the scale bar should start at zero. Scales should be small and should not overshadow any major elements of the layout. This means they should be a couple of centimeters in length at the longest. If using a ratio, the font size must be smaller than any other writing in your legend.

Directional Indicators. North arrows are the most common directional indicator. It is important to remember to adjust the north arrow as necessary to point north, which may not be at the top of the map. Some north arrow styles may be misleading depending on the projection being used, so it is important to choose the style of the north arrow carefully and not just for aesthetic reasons. Select the most simplistic version that fits the style of your presentation. (Hint, only use the "4 star" compass if you have a historic map!). If the true direction of north cannot be determined a north arrow should not be included. Directional indicators should be small and should not overshadow any major elements of the layout. Try to place the arrow in a corner (lower left, lower right or upper right). Do not place the arrow in the upper left hand corner. The best place for the arrow is close to the legend.

Title. Titles should be concise but informative. If the basic information of when, where, and what the map is trying to show is too unruly, place this information in a narrative and use a simple phrase that best describes the central purpose of the image. The title should be placed on top of the image, or within the top left hand corner if it does not block out any important features.

Text/ Interpretation. Often there is a limited amount of space on the map to include all of the essential information for the map audience. Only text that provides the reader with information should be included. Always include an explanatory body of text that explains what the map is showing, what data were used, what analysis was performed,

and why it is significant to the reader. Additional information about data sources and analytic limitations should be included in a block of text.

The font style used for the marginal information in the layout (title, legend, scale, etc.) should be in the same font but may be different sizes (e.g. Arial or Times New Roman). Bold text should be used sparingly, usually only for the title. It is important that the text add to the layout without distracting from the map itself.

Source Information/ Metadata. Information on where the data came from and the time period for which it was collected must always be included somewhere in the image. All layers of data must be properly referenced. Include geocoding rate and sample size for event data (e.g. crime) and details of the analytic procedures used to create data (e.g. Kernel Density with a .25 m radius). Information on what projection the map is in should be included if applicable to inform the audience of potential distortions. This text is equivalent to the methodology and reference sections of a written document. This means you must include all the information necessary so your audience knows where the data are from and can assess the validity of your data and limitations of your analysis.

Somewhere in the bottom right hand corner, you must include information about who created the map, date of completion, and revisions status (and date of creation). There should also be a legal disclaimer, Project name (or funding source), and the Center's name (or CPAL depending on the politics of the project). Make sure your inset is very small in relation to the main image and that is not placed in a position that makes it appear to be a central focus of the page layout. The upper right or lower left hand corners are good places if you can manage it.

Insets. Insets can be very useful in helping the map audience locate where they are looking at in the world. For example, an inset can be used to show where a city is located within a county or a state. Insets can also help with the problem of scale. Sometimes to show the proper amount of data without being misleading a map must be at a relatively large scale (zoomed in), however this can limit what can be seen of the surrounding geography and may make it difficult for the reader to reference what is shown in the map to the larger area. By using an inset the reader can get an idea of where the map is within the larger region while the data analysis is shown at the proper scale.

Neatlines. Neatlines are graphic boxes drawn around certain objects to help them standout and give a layout a more finished look. However, the use of too many neatlines in a layout can cause it to look too boxy and cluttered. The primary image must always have a neatline.

Summary: Elements of a Good Graphic or Table

1. Informative title and Notes: who, where, when, what… all source/ methods information needed to satisfy the "If it fell out of your book, could a stranger understand it" rule"
2. Number of Categories

    -   Tables: No more than 10 rows/columns – collapse categories, make sure they are meaningful
    -   Graphics: Pie (<6), Bar (<15), Line and Histogram (no limit).
3. Readable and consistent font size
4. Use space

    -   Tables: spacing is even and numbers line up.
    -   Graphics: no dead space
5. Number issues: Percent (Frequency or N) and 2-3 decimal places
6. Zero issue: never leave a blank space use 0.0+ if the value is smaller than the number of decimal points permissible.

Graphics Summary

Level of Measurement	Best Figure Style to Use
Discrete	Pie (<5-8 categories)
(Nominal & Ordinal)	Bar Chart (bars do not touch)
Continuous	Histogram, Line or Area
(Interval & Ratio)	(bars must touch)

-   Do not use 3-D or include background color
-   Pie: do not pull slices apart
-   Bar/Hist.: add major axis lines
-   Fewer colors better – use grey scale w/ yellow, red, or blue highlight
-   All elements of Tables needed… if fall out rule applies

Interpreting Figures and Tables Summary

Refer to graphic or table by number. Insert it into text when possible.

- Figures and tables number consecutively as two groups of things (figures include graphs, images, maps)
- Draw readers' attention to key findings:
    - Extreme scores
    - Unexpected findings
    - Consistent findings
    - Ask yourself … What does this mean for your study site?
- Translate by explaining without using variable names (use variable names in brackets & italics)
- Do not repeat everything in the table.

General Mapping Tips:

Cartographic Design Considerations

- Keep it simple. Do not use too many colors and symbols just because they are available.
- Establish a visual hierarchy for lines, symbols, and colors to make the map easily understandable to the reader.
- Always check the legibility of symbols, colors and text with the type of media the map will be in before using it for the entire map or map series.

Map Composition

Map layouts should be balanced and readable. Elements should be placed so that the design is pleasing to the eye and so that flow of the map follows conventional standards. For Western cultures, the standard is to read left to right and top to bottom therefore a map should reflect this with the title at the top and minor elements near the bottom. When creating a series of maps a similar style of organization for the layouts should be used. In other words, the map elements should be similarly place in each layout. This allows readers to quickly understand the series of maps.

Univariate and Bivariate Models

The following templates and examples should be consulted for ideas on how to arrange your maps. Use the template that best reflects the nature of your analysis.

Map Templates 1a, 1b and 1c (the first three that follow) are used when you have one or two images to present that are fairly straight forward and do not require a context. Map
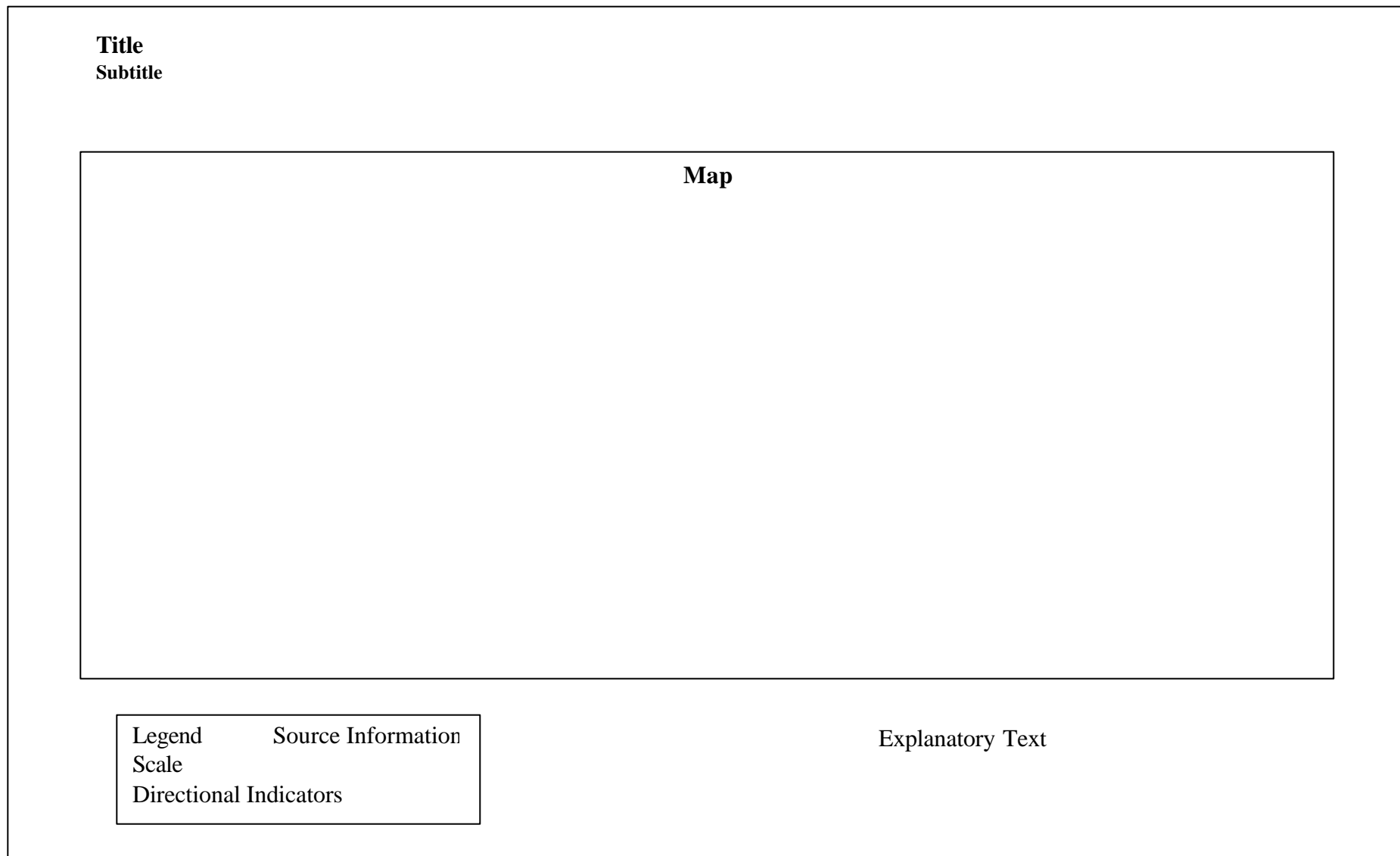
Template 1a is used for single areas whereas the other two are used when comparing one area over time or showing two different analyses for the same area.
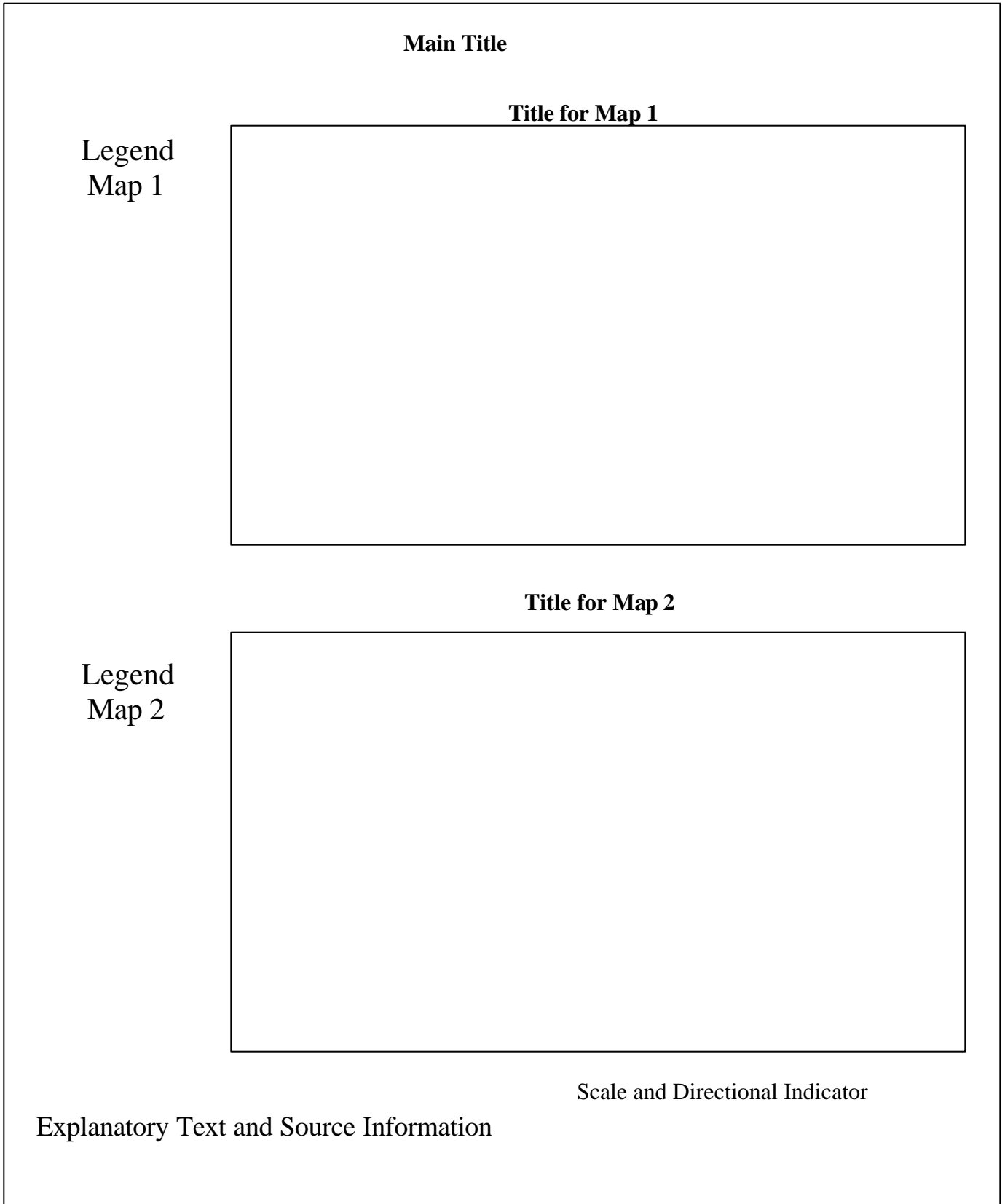
Map Templates 2a, 2b, 2c, and 2d provide examples of how to layout a map that requires an inset to give the reader context for the site being examined (depicted) in the main image.
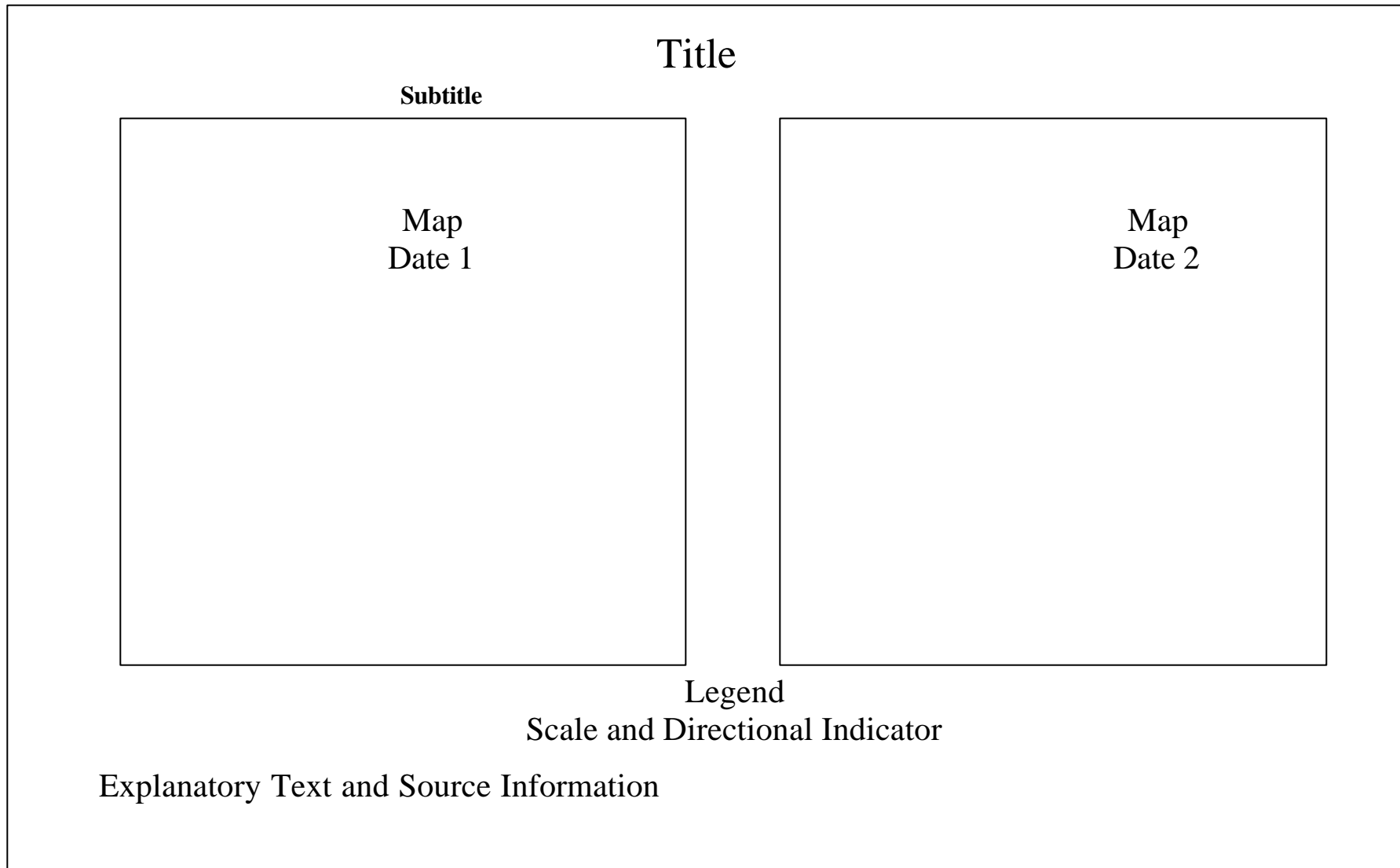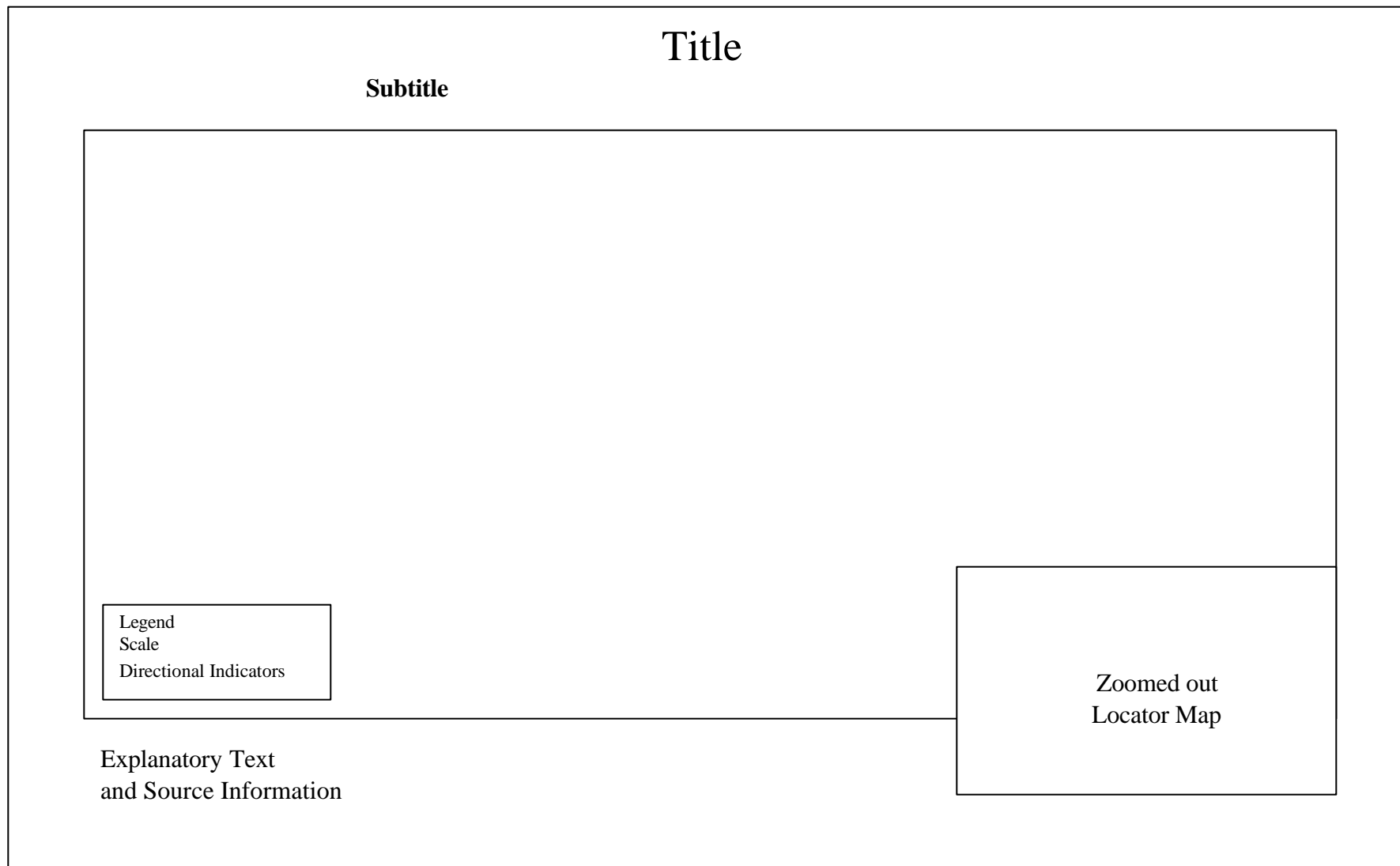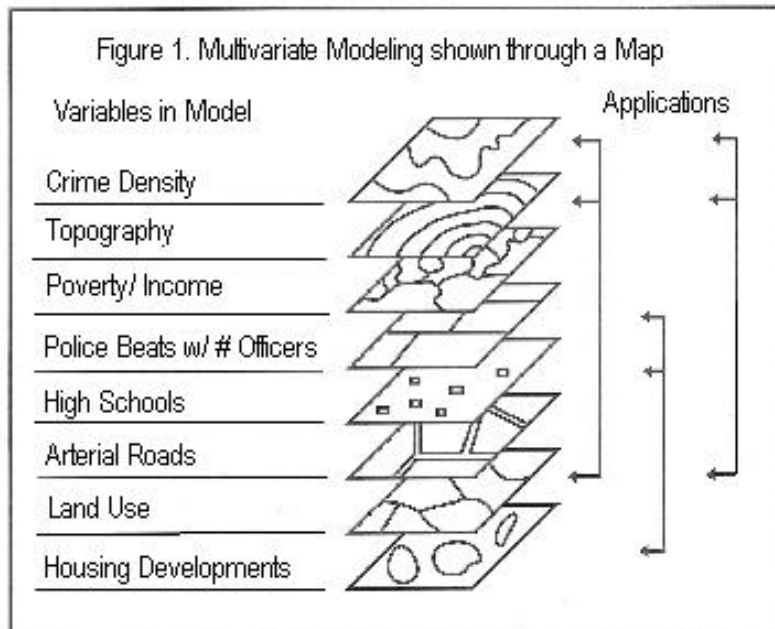
EXAMPLE 1(a)

Title
Subtitle

Map

Legend	Source Information
Scale	
Directional Indicators	

Explanatory Text

CENTER FOR CRIMINAL JUSTICE RESEARCH
California State University, San Bernardino
September 2004

EXAMPLE 1(b)

Main Title

Title for Map 1

Legend
Map 1

Title for Map 2

Legend
Map 2

Scale and Directional Indicator

Explanatory Text and Source Information

CENTER FOR CRIMINAL JUSTICE RESEARCH
California State University, San Bernardino
September 2004

EXAMPLE 1c

Title

Subtitle

Map
Date 1

Map
Date 2

Legend
Scale and Directional Indicator

Explanatory Text and Source Information

EXAMPLE 2

Title

Subtitle

Legend
Scale
Directional Indicators

Zoomed out
Locator Map

Explanatory Text
and Source Information

CENTER FOR CRIMINAL JUSTICE RESEARCH
California State University, San Bernardino
September 2004

Multivariate Models

Multivariate models require the illustration of the final layer but also some explanation of the data that were combined to create that layer. This necessitates a more complex layout and a greater amount of detail in a single page. The reason for the complexity is that you are integrated both the variables (and their distribution) and the changing polygon shape.

Figure 5 presents a conceptual illustration of a number of variables that may be integrated into a model of crime density. The model may involve multiple analytic techniques to account for various interaction effects between different variables. If this information is not presented in the final map, it may be lost and this will lead to a biased or inaccurate interpretation of the final image.

Example 3(a), (b), and the 6 images that follow present excellent layouts that you can follow when developing figures for multivariate models. The images are drawn from maps profiled at the Annual ESRI user's conference. The annual volume of award winning maps is an excellent source for ideas on map layout and design.

Figure 5. Multivariate modeling shown through a Map

Figure 1. Multivariate Modeling shown through a Map

Variables in Model — Applications

Crime Density
Topography
Poverty/ Income
Police Beats w/ # Officers
High Schools
Arterial Roads
Land Use
Housing Developments

Source: Adapted from Davis, 1996:324.

The other issue affecting multivariate modeling is how to illustrate the different polygon shapes that may affect the size and shape of areas illustrated in the final map. Overlaying different layers that have data aggregated to different shapes will lead to changes in the final layer of polygons. Figure 6 illustrates how polygons are bisected if two variables are placed on top of each other. Imagine the changes that occur with 15 variables.
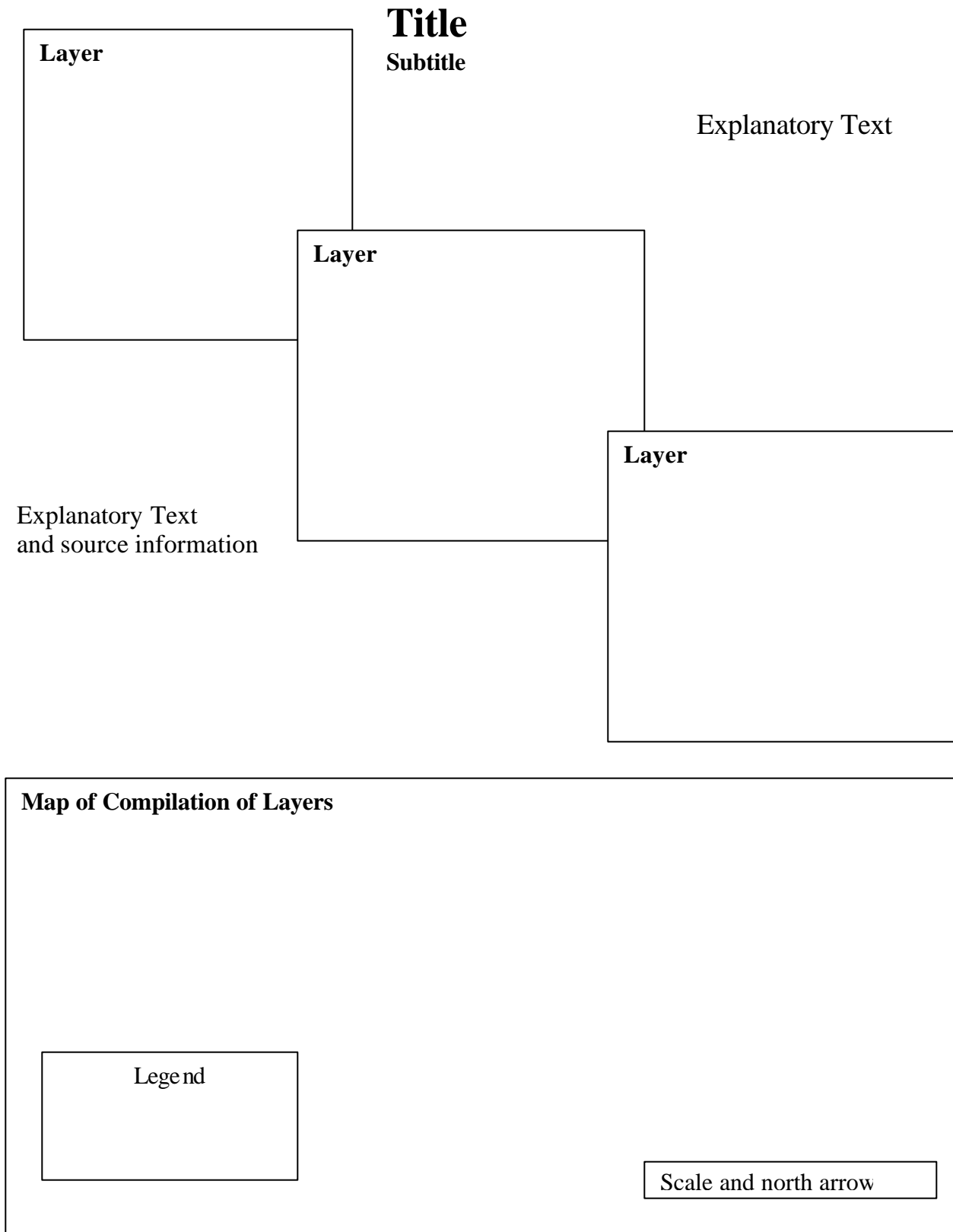
Figure 6. Overlaying Data
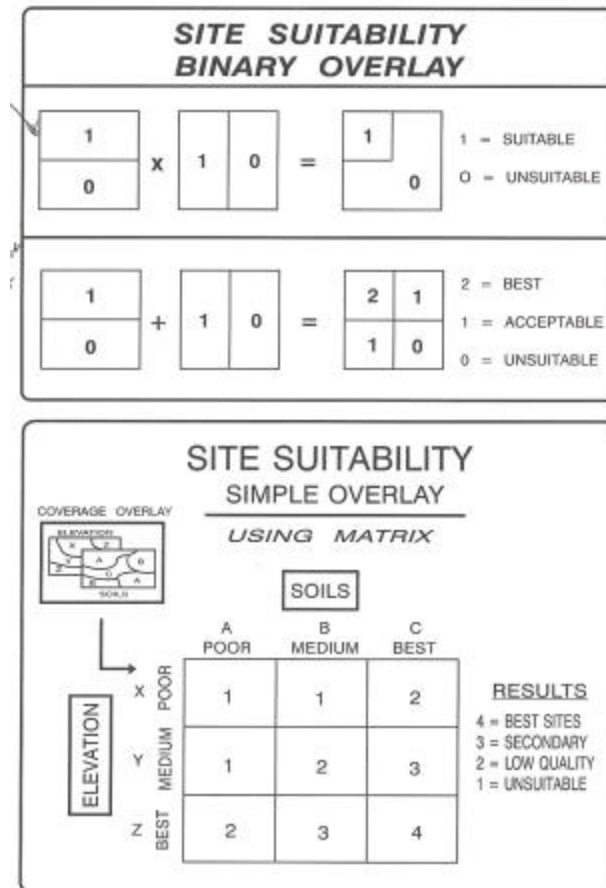
Source: Davis, 1996:304.

Map Templates 3a and 3b present two ways you can layout a multivariate geographic model. The first would be used if you only had a few variables (small images) that were being integrated into the final image (large image). The second example, Map Template 3b can be used when there are a larger number of variables in the model. Other examples of how to layout multivariate models can be found in the Power Point slides that are located at the conclusion of this section of the research manual.
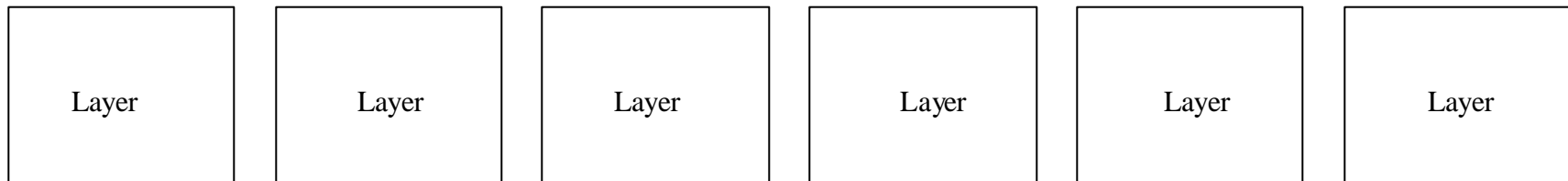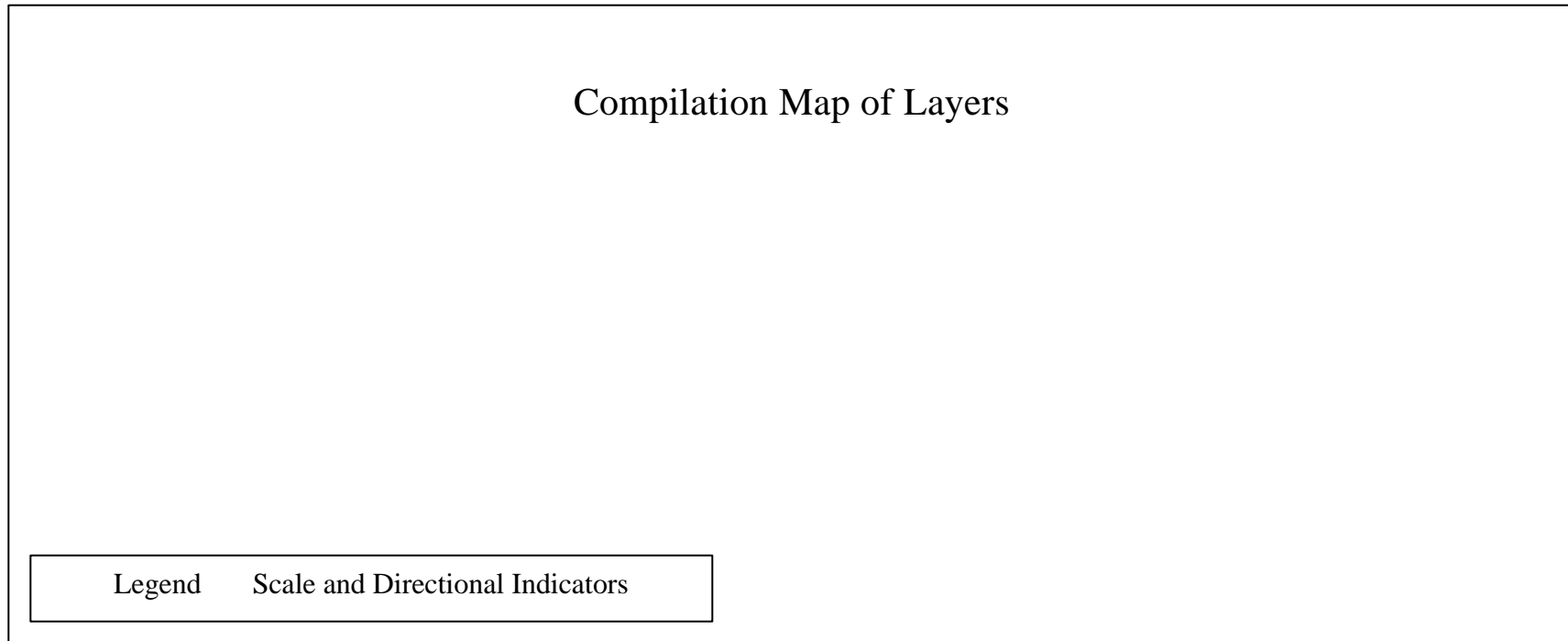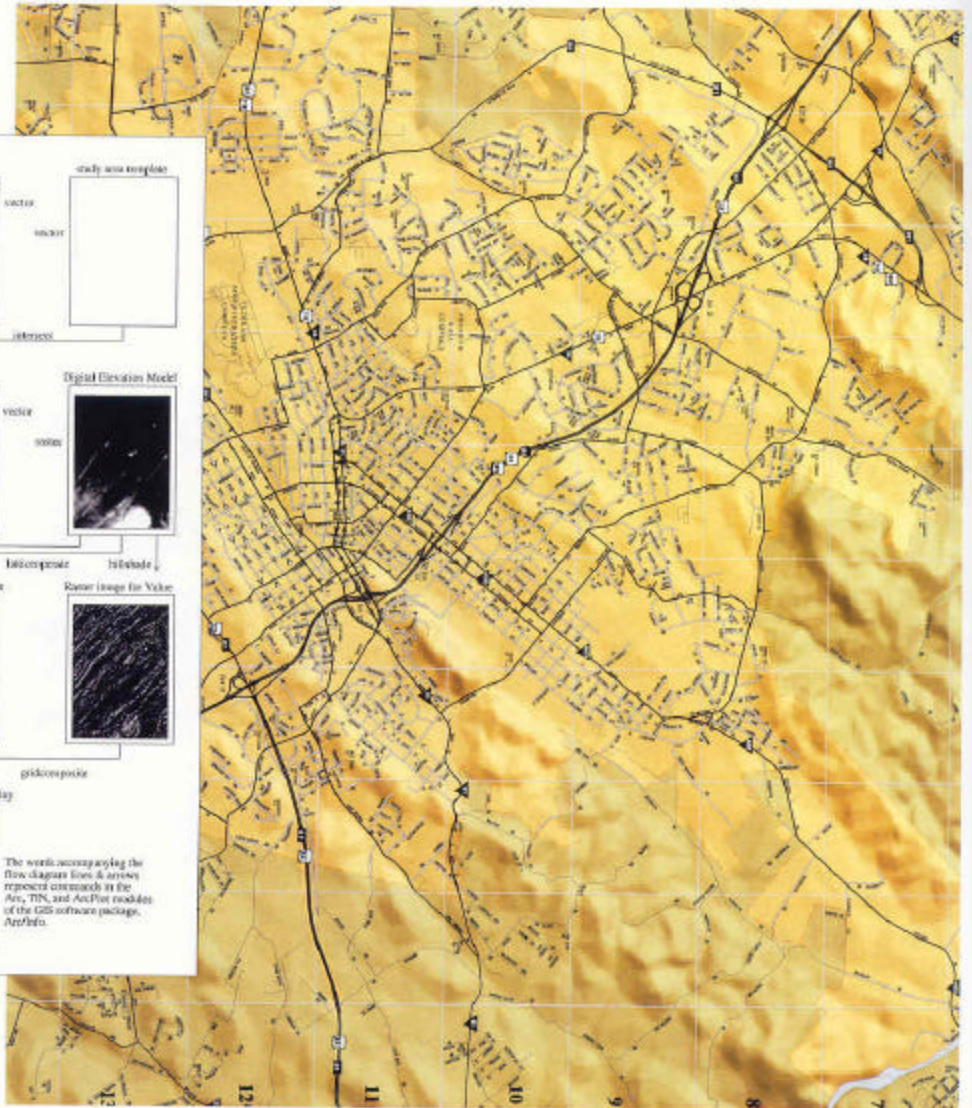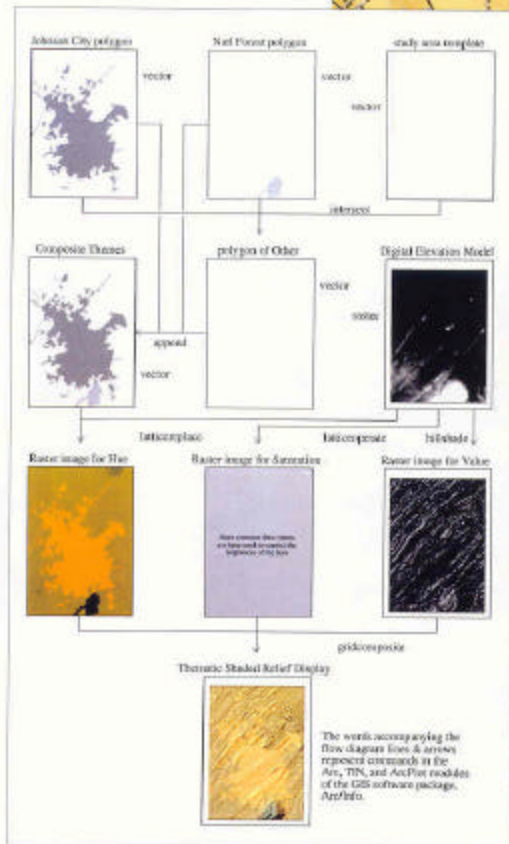
EXAMPLE 3a

Title
Subtitle

Explanatory Text

Layer

Layer

Layer

Explanatory Text
and source information

Map of Compilation of Layers

Legend

Scale and north arrow

CENTER FOR CRIMINAL JUSTICE RESEARCH
California State University, San Bernardino
September 2004

EXAMPLE 3b

Title
Subtitle

Compilation Map of Layers

| Legend | Scale and Directional Indicators |

| Layer | Layer | Layer | Layer | Layer | Layer |

Explanatory Text and Source Information

CENTER FOR CRIMINAL JUSTICE RESEARCH

California State University, San Bernardino
September 2004

LAYER EXPLANATION

CENTER FOR CRIMINAL JUSTICE RESEARCH
California State University, San Bernardino
September 2004

Possible Environmental Impacts of the Breakdown of the Oil Products Pipeline in Section KRYRY-HAJEK

T-Mapy, Hradec Kralove, Czech Republic

By Miloslav Sindlar, Jan Kamenicky, and Lubomir Kriz

Contact:
Jan Kamenicky
tmapy@tmapy.cz

Software:
ARC/INFO Version 7.2.1 and ARC GRID
Hardware:
Sun UltraSPARC 5
Plotter:
Hewlett-Packard DesignJet 650C
Data Source(s):
Environmental institutions, private companies, and environmental studies
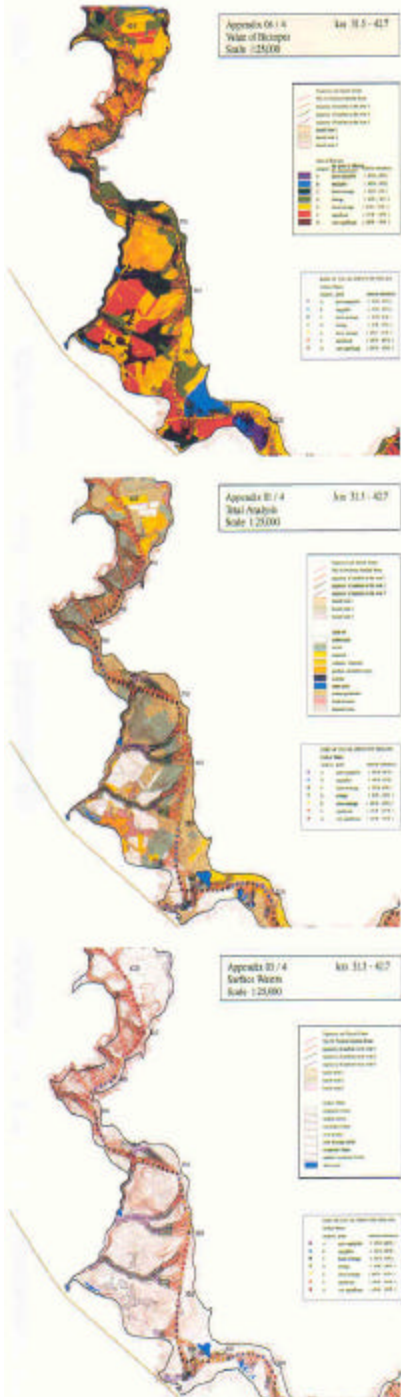
This map describes possible environmental impacts of the breakdown of the oil products pipeline in section KRYRY-HAJEK (pilot project).

Ecological and environmental specialists captured source data in the terrain. Captured information was drawn to maps, and the collected information was digitized from those maps. Digital data was analyzed with the analytical tools of ARC/INFO. The potential trajectories were produced with the ARC GRID module from a digital elevation model and resistance of environment data against medium movement (land use, streams). Important information was joined with pipeline trajectory at 100-meter intervals.
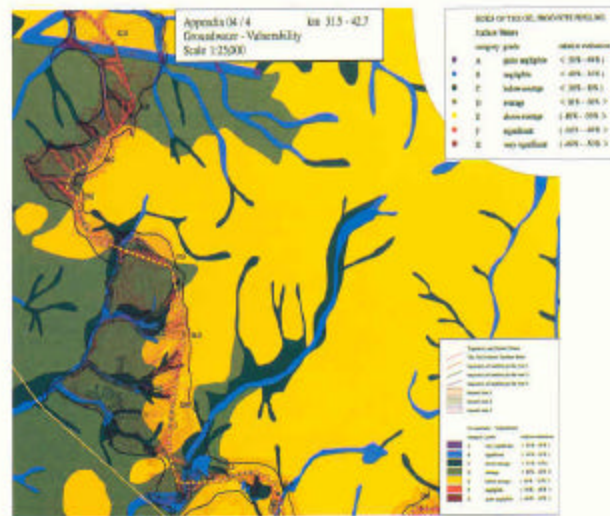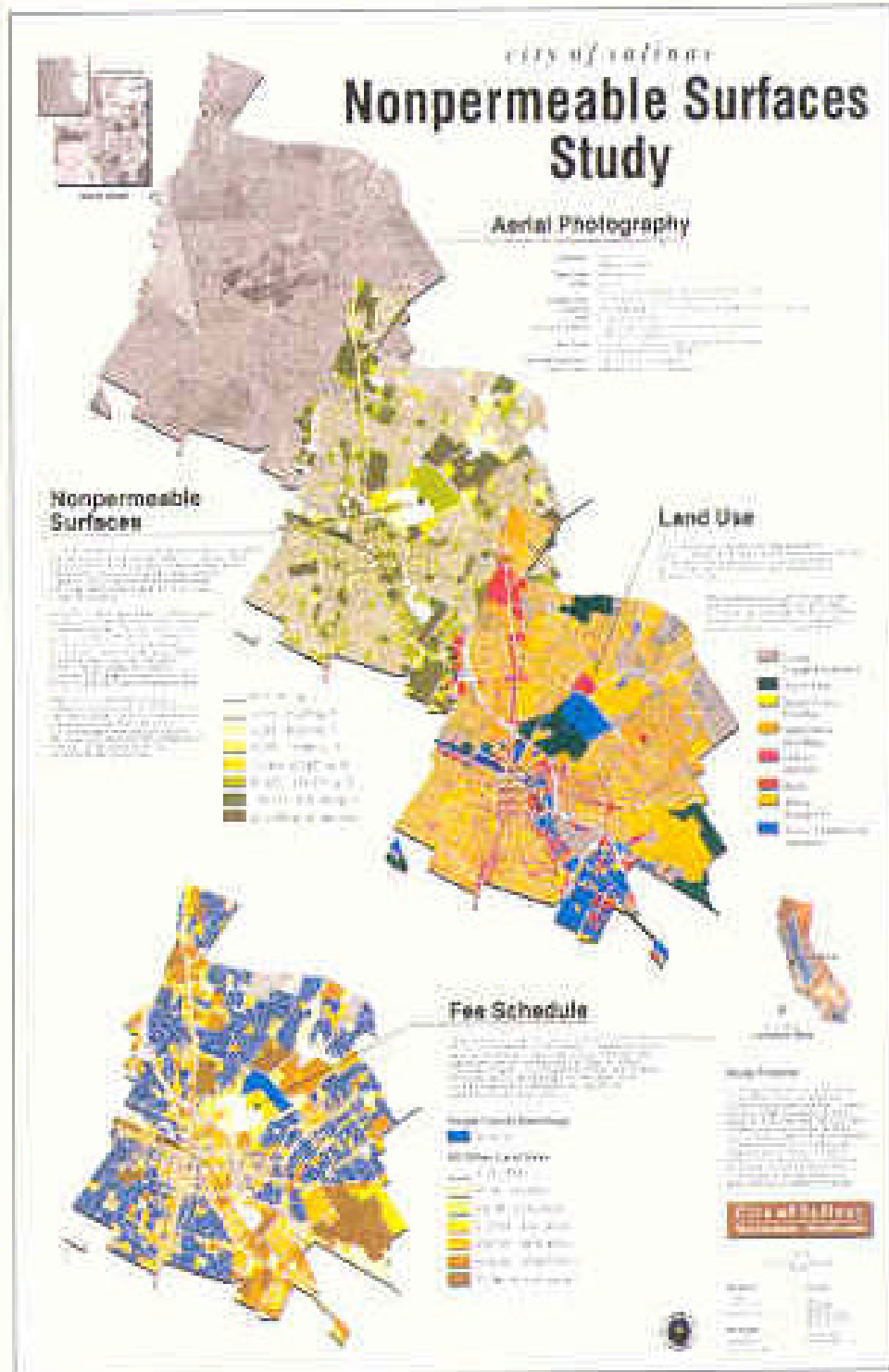
The final output is a result of multi-criteria analyses in LABE software. In the event of an accident, users can see the possible environmental risks at any point along the pipeline.

Source: ESRI Map Book Vol. 14, p. 37

Source: ESRI Map Book Vol. 14, p. 63

INSET

Source: ESRI Map Book Vol. 14, p. 35

ORIENTATION

The Sound Transit project, approved by voters from a three-county area, will develop commuter rail, light rail, and additional freeway high occupancy vehicle (HOV) lanes to reduce traffic congestion in central Puget Sound.

The Tacoma Dome Area Land Use map provides necessary background and neighborhood information in the light rail/commuter rail development area.
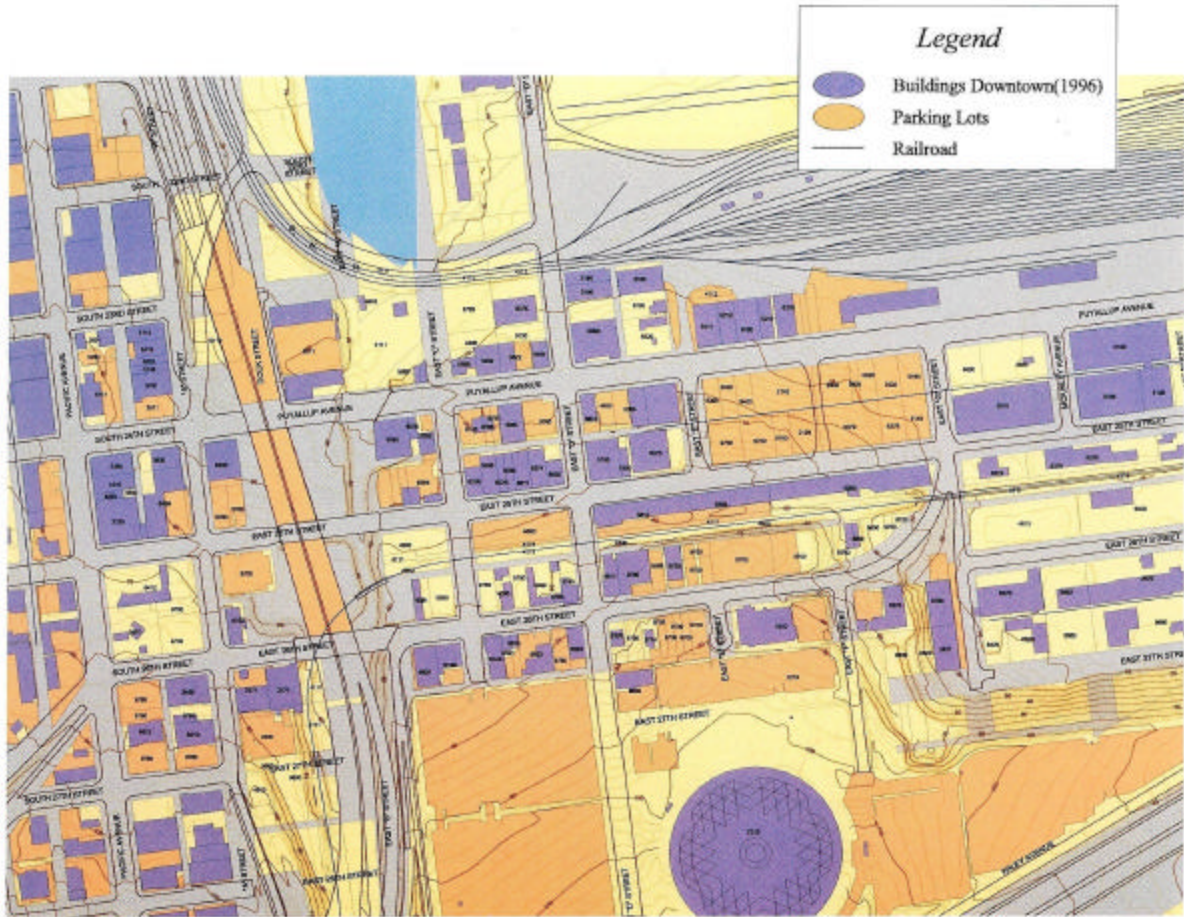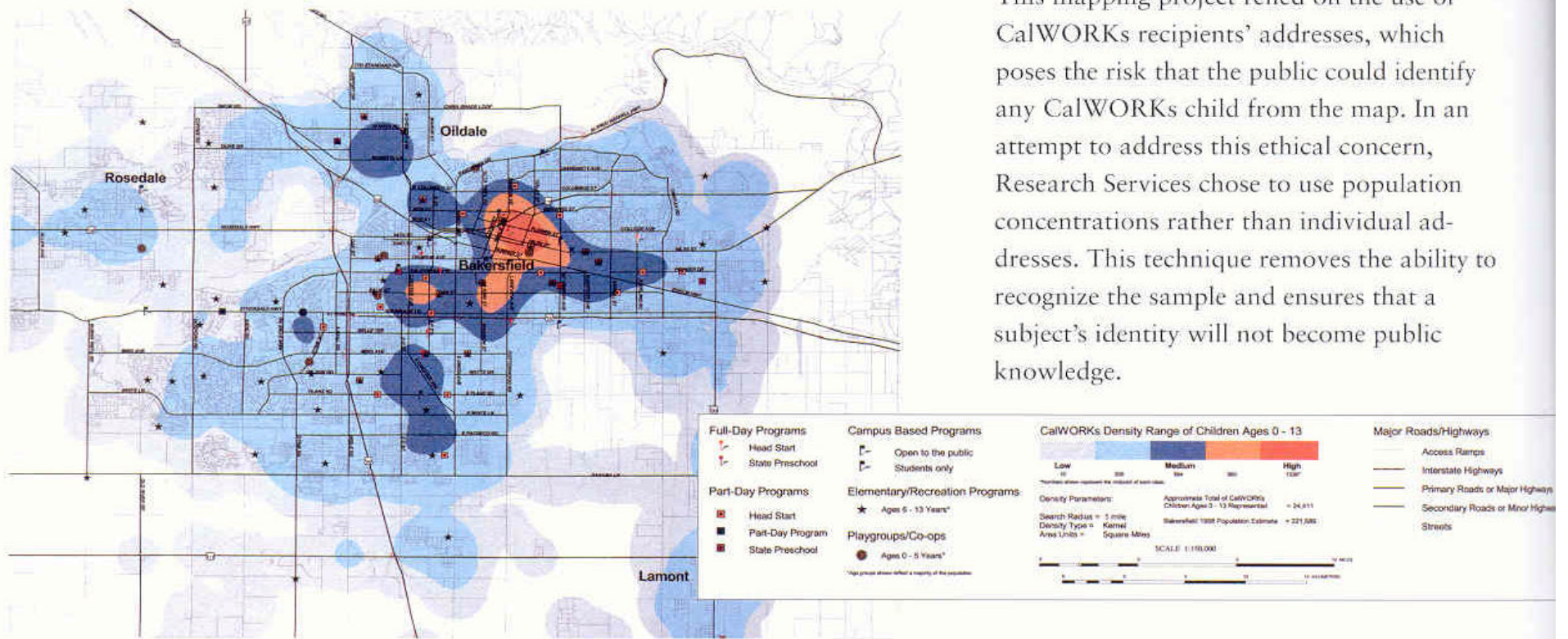
Source: ESRI Map Book Vol. 14, p. 70

ORIENTATION with INSET

...of 5,792 children. These numbers can be very misleading when ZIP codes are the only method used. The estimated area of 93305 is seven square miles while the viewable area of 93307 is approximately 80 square miles. This

Due to the social stigma surrounding welfare and poverty, any welfare reform research must take into account the issue of anonymity and safeguard against invasion of privacy. This mapping project relied on the use of CalWORKs recipients' addresses, which poses the risk that the public could identify any CalWORKs child from the map. In an attempt to address this ethical concern, Research Services chose to use population concentrations rather than individual addresses. This technique removes the ability to recognize the sample and ensures that a subject's identity will not become public knowledge.

Source: ESRI Map Book Vol. 14, p. 66

Geographic Resources:

DATA

    www.fgdc.gov/clearinghouse - Federal Geographic Data Committee – collection of
            250+
spatial data servers. Can search for various types of data including GIS data or
            imagery.
    www.geographynetwork.com - includes various forms of data for the world.
    www.gis.ca.gov - California Spatial Information Library – includes shapefiles, ortho
            photos (DOQs), elevation maps (DRGs).
    www.gis.ca.gov/catalog - The California Environmental Catalog - an online directory
            for reporting and discovery of information resources for California.
    www.sdc.ucsb.edu - University of California, Santa Barbara – includes various forms
            imagery.
    www.usgs.gov - U.S. Geological Survey – includes some shapefiles and imagery.
    www.esri.com - ESRI – includes some downloadable shapefiles and census data.
    www.census.gov - US Census Bureau – includes census data and downloadable Tiger
            files.
    www.firstgov.gov - US government's official site – includes various data and
            statistics.

ARCVIEW/ARCGIS

    ESRI. 1997. *Getting to Know ArcView GIS: the geographic information system (GIS)
        for everyone*. Redlands: Environmental Systems Research Institute, Inc.
    Ormsby, Tim, and Jonell Alvi. 1999. *Extending ArcView GIS: Teach yourself to use
        ArcView GIS extensions.* Redlands: Environmental Systems Research
        Institute, Inc.
    Ormsby, Tim, et al. 2001. *Getting to Know ArcGIS desktop.* Redlands:
        Environmental Systems Research Institute, Inc.

CARTOGRAPHY

    Davis, Bruce. 1996. *GIS A Visual Approach.* Sante Fe: Onward Press.
    Dent, Borden D. 1999. *Cartography: Thematic Map Design.* 5th ed. Boston: WCB
        McGraw-Hill.
    Madej, Ed. 2001. *Cartographic Design using ArcView GIS.* Sante Fe: Onward Press.
    Robinson, Arthur H. 1995. *Elements of Cartography.* 6th ed. New York: John Wiley
        & Sons, Inc.

CRIME MAPPING

    Harries, Keith. 1999. *Mapping Crime: Principle and Practice.* Washington, DC:
        National Institute for Justice.