Practical Paper

Overplotting Digital Geographic Data Onto Existing Maps

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ABSTRACT: Traditionally, when a hard copy of GIS data was needed, the copy was plotted employing an electronic plotter with a blank medium. This action required the storage and reproduction of all pertinent data. However, it is possible to plot GIS data directly onto existing maps, thereby eliminating the need to store and reproduce data currently available on existing paper maps. Overplotting allows a more detailed map to be produced in much less time than traditional plots made on blank media. This paper describes a procedure for overplotting and compares overplotting to traditional plotting.

INTRODUCTION

TRADITIONALLY WHEN A HARD COPY OUTPUT of digital cartographic data was needed, the data were plotted by a pen plotter or an electrostatic plotter onto blank media such as paper, vellum, or film. All the data to be included on a plotted map had to be included on a computer system. As the amount of data to be plotted increased, computer data storage requirements, plot file sizes, and plotting times increased proportionally.

Often, it is advantageous simply to add digital cartographic or geographic information system (GIS) data to an existing map instead of plotting onto blank media. The ability to overplot existing maps reduces the amount of data that must be stored in a GIS, allows smaller plot files, and decreases plotting times. It also produces a product with a map base familiar to most users.

METHODS

Several procedures have been identified and have been used in overplotting existing maps using a pen plotter and a special computer program. Here, overplotting is presented and compared with traditional plotting by evaluating the same GIS data using both methods.

To implement this approach, several steps were used to overplot a map:

- The registration points were chosen.
- The plot file was built.
- The map to be overplotted was loaded into the plotter.
- The overplotting program then executed the following functions:
  - The registration points were extracted from the plot file.
  - The map was registered in the plotter.
  - Each X-Y coordinate was read from the plot file, adjusted, and sent to the plotter.

The first step in overplotting a map was to choose registration points. Registration points are coordinate pairs used to register the location of the existing map onto the plotter, similar to the way a map is registered to a digitizing tablet before it can be digitized. The registration points had to be points that could be identified on the existing map and put into the plot file. If too few points were used, the data would not be properly adjusted to the map. If too many were used, an inordinate amount of time would have been needed to register the map in the plotter.

The plot file was built containing the data to be overplotted in addition to the registration points. The registration points were extractable from the plot file.

The map was loaded into a pen plotter in the same manner as any blank sheet media. The map could have been oriented in any direction.

The computer program that performed overplotting was the key to the overplotting process. A typical plotter driver program reads the pen commands stored in the plot file and sends the pen commands to the plotter (Hewlett-Packard, 1983). The overplotting program read the pen commands from the plot file, adjusted the pen commands to fit the map in the plotter, and then sent the commands to the plotter. The overplotting program opened the plot file and extracted the registration points from it. The same points were obtained from their map locations in the plotter. The overplotting program prompted the operator to input a registration point. The operator positioned the plotter's pen holder over the specified registration point. This was helped by using a digitizing sight or reticle. A digitizing sight fits into the pen holder and provides a slightly magnified view of the media directly underneath the sight. The operator moved the pen holder by manipulating directional buttons on the plotter's control panel. When the operator had positioned the pen holder directly over the registration point, an appropriate button on the plotter's control panel was pressed. The plotter then sent the pen holder's *X-Y* coordinates to the computer. The operator repeated the plotter registration process until all the registration points were entered.

The overplotting program then had two sets of registration points: one set from the plot file, and one set from the plotter.

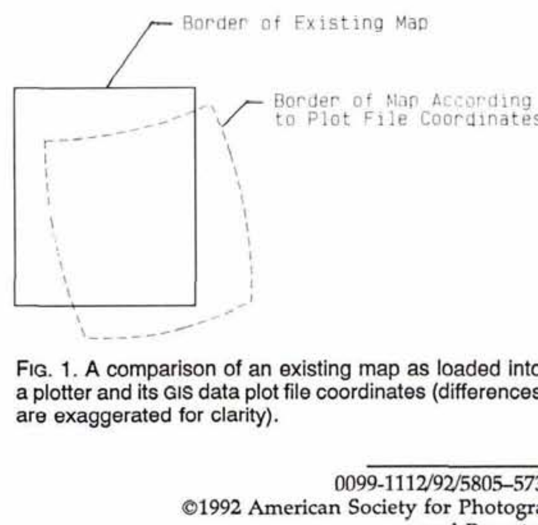

FIG. 1. A comparison of an existing map as loaded into a plotter and its GIS data plot file coordinates (differences are exaggerated for clarity).

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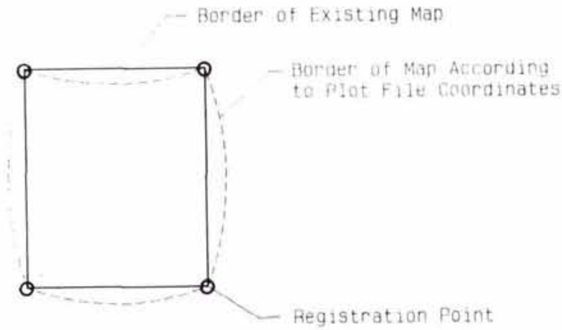


FIG. 2. A comparison of an existing map and its plot file coordinates adjusted to match at four registration points at different projections (differences are exaggerated for clarity).

Given these two sets of points, the overplotting program determined how to adjust the pen movement commands so that the data would be overplotted in the correct position on the map. For highest accuracy, a comprehensive rubbersheeting algorithm was used to adjust the plot file coordinates.

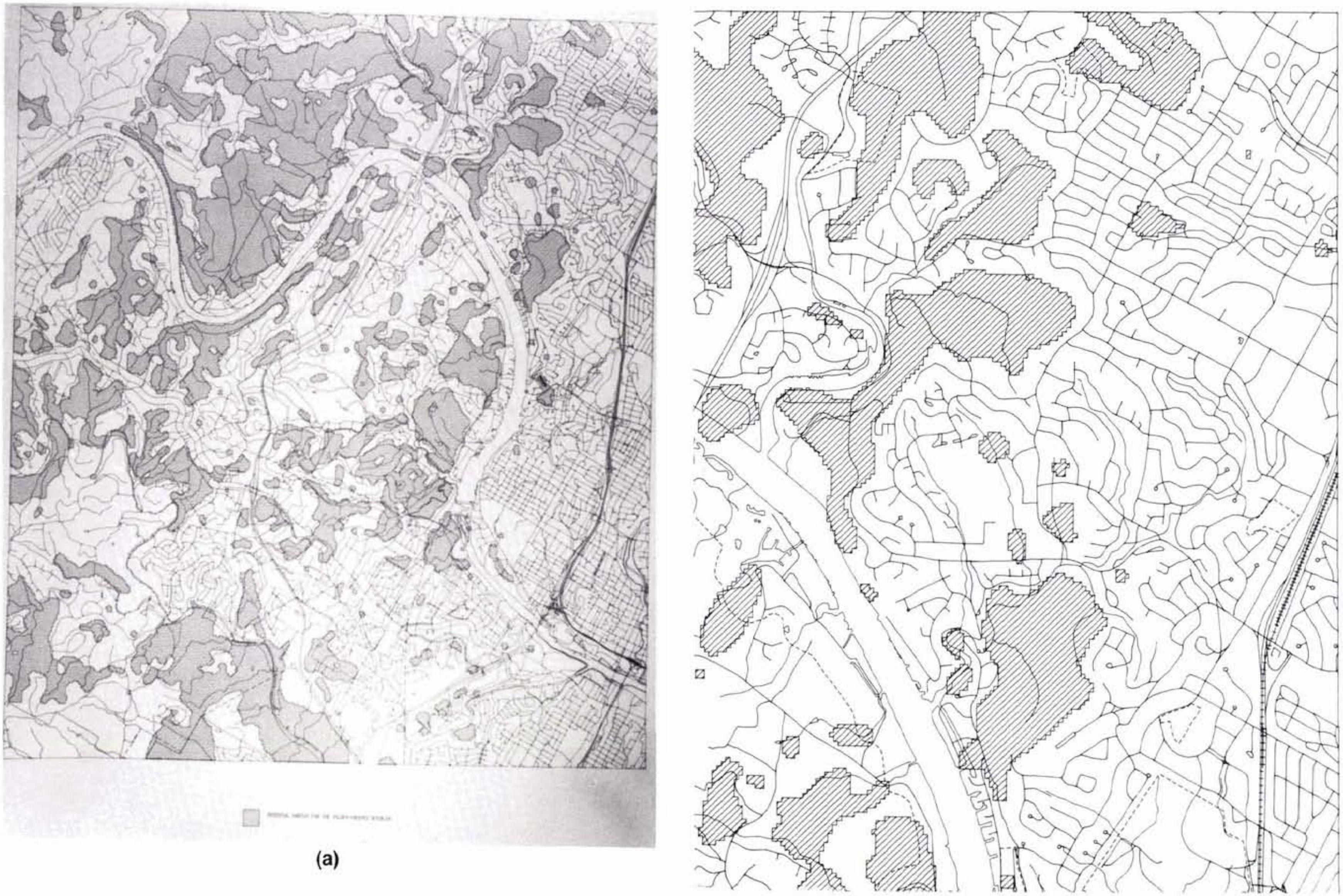
Figure 1 illustrates the need for adjustment of the plot file data. Each coordinate had to be adjusted to compensate for factors that affect plotting accuracy, such as map "warpage," map rotation, media thickness, and inconsistent data. Each X-Y coordinate pair from the plot file was read, adjusted, and sent to the plotter with non-coordinate commands such as pen up, pen down, and/or pen select.

Special consideration had to be given to documentation, projection, and annotation. Documentation was added to the overplotted map to explain the overplotted data to anyone who used the map. A title, legend, and notes explaining the overplotted data complemented the process. The overplotted documentation could be built into the plot file and placed near the existing map title for clarity.

The digital data were in the same projection as the existing map. Overplotting data in one projection onto a map of a different projection could produce unsatisfactory results, even though all points were properly adjusted according to the registration points (Figure 2).

Some GIS software produce plot files that contain "smart"

FIG. 3. The subject data: Potential habitat of an endangered species of bird, the golden-cheeked warbler.



(a)

(b)

FIG. 4. (a) The subject data with topographic data presented using traditional plot: Golden-cheeked warbler potential habitat plotted with topographic data from U.S. Geological Survey Digital Line Graph data layers for the Austin West, Texas 7.5-minute (1:24,000-scale) quadrangle map. (b) Detail of Figure 4a.

FIG. 5. The Austin West, Texas U.S. Geological Survey 7.5-minute (1:24,000-scale) quadrangle map.

text. "Smart" text provides the position, text size, angle, and the characters to be plotted. When overplotting, the text size and angle must be adjusted to provide accurate text size and position on the map.

A COMPARISON

As a comparison, GIS data were presented in hardcopy form by two methods: Traditional plotting on blank media and overplotting on an existing map. As many variables as possible were held consistent for both methods to facilitate comparisons. For example, both methods used Arc/Info from ESRI running on a Hewlett-Packard 9000 Series 345 workstation computer. Both used the same GIS subject data to be output. The subject data had been derived from 30-m resolution Landsat Thematic Mapper data and defined plant associations that characterize potential habitat of the golden-cheeked warbler, an endangered species of bird (Shaw *et al.*, 1989). The subject data were digitally stored as an Arc/Info polygon coverage in a UTM projection (Figure 3). For both methods the GIS data were presented using a Hewlett-Packard DraftPro pen plotter. Disposable drafting pens were used at 20 cm/s.

METHOD 1: TRADITIONAL PLOT

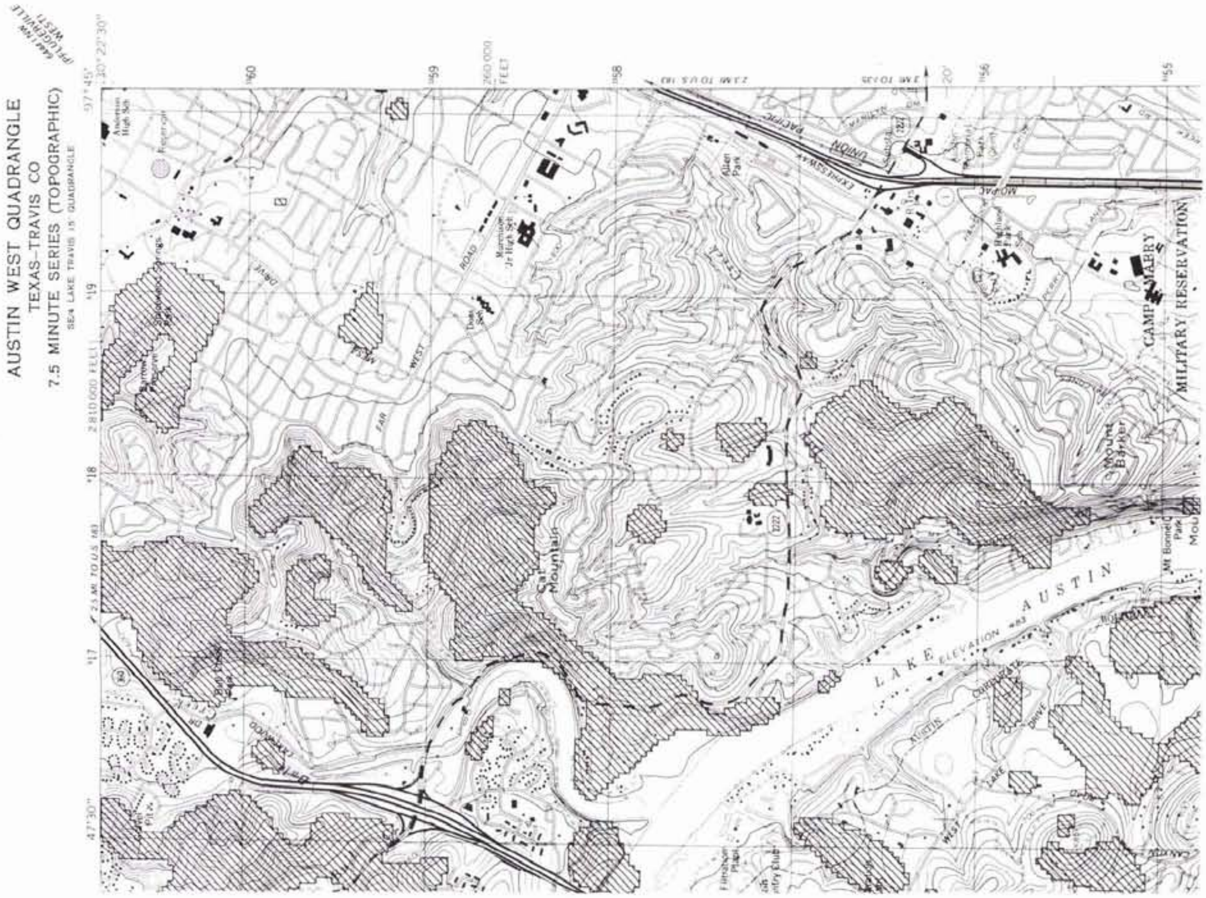
To produce output showing the GIS habitat data in relation to other cartographic features, USGS Digital Line Graphs digitized from 1:24,000-scale topographic quadrangle maps were used. Files containing data for hydrography, boundaries, roads, railroads, and pipelines for the Austin West, Texas quadrangle were read from tape and converted to Arc/Info format. These data layers plus the GIS habitat data occupied approximately 2,606 kilobytes (kb) of computer disk space.

These data layers were then built into a plot file at 1:24,000 scale that occupied approximately 995 kb of disk space. This plot file was sent to the plotter using architectural D-size (610 mm by 914 mm) plotter bond paper. The plot was completed after 114 minutes of uninterrupted plotter operation with no other tasks running on the computer (Figures 4a and 4b).

METHOD 2: OVERPLOT

The subject data were transformed to the same projection as the quadrangle map (Lambert conformal conic projection). The four corners of the quadrangle were chosen as registration points

(a)



(b)

FIG. 6. (a) The subject data with topographic data presented on an overplot: Golden-cheeked warbler potential habitat overplotted onto the Austin West, Texas U.S. Geological Survey 7.5-minute (1:24,000-scale) quadrangle map. (b) Detail of Figure 6a. Note that more map features, such as topography and annotation which were not included in the U.S. Geological Survey Digital Line Graphs, are available on the overplotted map.

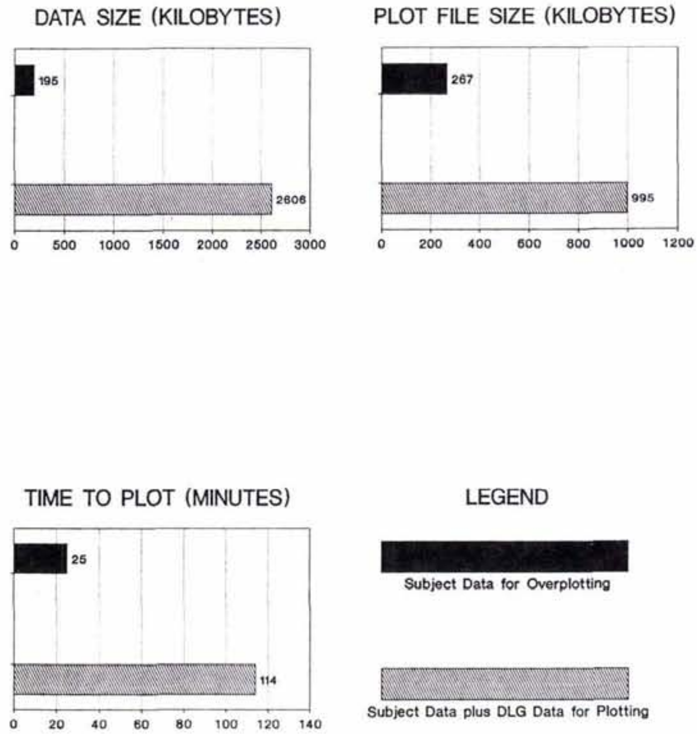


FIG. 7. Comparison of data storage requirements and plotting times for overplotting and traditional plotting of the subject data.

because their coordinates were easily determined from the map and they were readily identifiable (Figure 5). An Arc/Info coverage of the border of the quadrangle was generated using the geographic coordinates. The border coverage was then transformed to the same projection as the habitat data and the existing quadrangle map. The border and the GIS habitat data occupied approximately 195 kb of computer disk space.

The plot file was built so as to contain the quadrangle border and the habitat data at 1:24,000 scale. This plot file occupied approximately 267 kb of disk space. The quadrangle map to be overplotted was loaded into the plotter. The overplotting program was then executed. The registration process was completed by an operator in less than one minute, and the plot was completed in 25 minutes of uninterrupted plotter operation with no other tasks running on the computer (Figures 6a and 6b).

DISCUSSION AND CONCLUSIONS

The capability to overplot existing maps gives the advantages of potentially more expedient hard copy output of digital geographic data and possibly more efficient use of computer storage resources (Figure 7). Overplotting may not always be possible as it requires an appropriate computer system, a suitable pen plotter, and a special overplotting program. Also, some users may not wish all the map detail found on a standard USGS quadrangle to be present in their product. Should one wish to take advantage of this approach, an experienced programmer can develop a similar program, including the adjustment algorithms, in two to four weeks.

Overplotting can also be used on aerial photographs, remotely sensed data, previously made plots, or other suitable material if registration points can be established. If overplotting directly onto a photograph is not feasible, an accurate overlay can be produced by transferring the registration points to translucent media and then overplotting the media. The media can then be attached to the photo-graph. If one wishes to add data to an existing plot, it can be overplotted as opposed to duplicating the entire plot. Overplotting a very detailed plot is usually much faster than starting from scratch, especially when only a small amount of data needs to be added.

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REFERENCES

Hewlett-Packard Company, 1984. *Hewlett-Packard 7580B, 7585B, and 7586B Drafting Plotters Interfacing and Programming Manual*, San Diego, California.

Shaw, D.M., B.A. Hunter, S.F. Atkinson and K.J. Smith, 1989. *Remote Sensing and GIS for the Austin Regional Habitat Conservancy Plan*. Institute for Applied Sciences, Center for Remote Sensing, University of North Texas, Denton, Texas.

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