Weed Mapping Workshop

Proceedings of a workshop held at Keith Turnbull Research Institute, Franston, Victoria on Monday 28 February 2000. Organized by the Weed Science Society of Victoria Inc.

GIS – traps, maps and databases

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Introduction

Digital Geographical Information Systems (GIS) have been common-place for more than a decade now, but many people are still not quite sure what they are. Further, although many organizations are GIS-ready, Geographical Information Systems are often under-utilized because they're mainly used for digital mapping rather than spatial analysis. One reason for this is that many people focus on software functionality rather than database quality. GIS can be a dangerous tool in inexperienced hands because some users do not understand the nature of spatial data. This short paper is devoted to defining what a GIS is, describing some mapping pitfalls that an inexperienced GIS user can fall into, and demonstrating that new usage opportunities arise when digital mapping is formatted to be a spatial database.

What is a Geographical Information System?

A geographical information system (gis) is a computer-assisted system for the acquisition, storage, analysis and display of geographic data… central to the system… is a spatial database describing the shape and position of the earth surface features, and an attribute database describing the characteristics or qualities of these features (Eastman 1992).

Perhaps the single most powerful aspect of a GIS is the ability to relate things to each other 'implicitly' by where they are, rather than some 'explicit' relationship such as customer number. Within a GIS, any maps in identical coordinate systems (and by default the attributes of the mapped items) can be related to each other. A GIS consists of the following five components:

i. **Corporate environment.** A GIS includes the corporate environment within which it operates. For some people this relates to the GIS software that their organization supplies, and for others it relates to the types of analysis that their job description allows them to undertake. The corporate environment also influences which datasets will be made available for use.

ii. **Data input.** Map and attribute data must be *input* so that the GIS has a database to operate on. Map data can be collected using photogrammetry, survey and Global Positioning System (GPS) techniques, or digitized from existing mapping using a digitizing tablet or a scanner.[A] There are three types of map data:
   - Points – a tree, power pole…
   - Lines – a fence, road…
   - Polygons – a paddock, sports oval…

   Attribute data is quite simply, information about a map. It could be input from a keyboard or imported from some other source such as an Excel spreadsheet.

iii. **Database.** The *database* is undoubtedly the single most important component of a GIS. In most cases, other than being able to view a digital map, the spatial database itself is quite invisible to the user. In contrast, users have much control over the attribute database. The GIS links the spatial and attribute databases together so that a mapped object can have a description. For example, a point might be described as a eucalypt tree planted in October 1963.

iv. **GIS software.** The GIS software allows operations such as map overlay (a map of trees overlayed onto a map of soils), statistics (average height of eucalypt trees on clay soils), spatial search (find all eucalypts that are on publicly owned land), to be undertaken.

v. **Data output.** The final step is *output*, and this can be to a computer screen, printer, disk, or as an input into other GIS routines.

Traps with maps

GIS has come a long way since Ian McHarg gathered a series of mapping themes at a common scale, and related them to each other to create a land suitability map for siting a section of freeway (McHarg 1969). The major problem that McHarg encountered in the 1960s, that of finding appropriate mapping at a common scale, is still with us today.

Like McHarg, present day GIS practitioners often need to relate their own map data to off-the-shelf datasets. These are often inherited in the form of map themes aggregated to areas such as parishes, local government areas, suburbs, parks... Although such aggregations will not always relate well to your present study, they are base data that can be value-added. Inexperienced GIS users can fall into a number of traps when value adding, most of which relate to a failure to understand the data being worked with (Monmonier 1991). The major traps relate to scale, photographic distortion and data pedigree.

Scale

The cartographers skill of making the look of a map relate to the amount of information within the map (e.g. by the use of thick lines or scale of publication) is lost on digital data. Because digital mapping is aesthetically pleasing, an inexperienced user can wrongly assume the data is accurate, and wrongly adopt poor quality mapping into their analyses. Maps become scaleless in a GIS and often people combine maps that have different levels of detail. Whether this is appropriate or not depends on whether the subject of the thematic map occurs at that particular scale. For example, it would be inappropriate to use large interval contours to model terrain in areas of very low relief.

Photographic distortion

An air photo backdrop is an invaluable GIS layer. It can assist with interpretation, and can also be used as a source to on-screen digitize using a mouse. Most of Victoria is regularly photographed under State Government contract so in most cases both archival and recent photographs can be purchased off the shelf.

However, using unprocessed air photography is fraught with danger because although air photos are accurate at their centre, they are inaccurate at their edges. The extent of this inaccuracy often depends on flying conditions at the moment the photo was taken. For example, a gust of wind could push the plane off course and distort the angle the photo is taken on.

If the photo is not already digital, you will need to scan the photo so that you can relate it to your mapping and make it

Footnote

[A] A map is placed onto a digitizing tablet, and its outline is 'traced' into the computer with the aid of a digitizing puck (much like a computer mouse). Maps can also be scanned into the system using a scanner large enough to take full size maps.

useful in the GIS. The three ways to make an air photo GIS compatible are known as registration (geo-correction), rectification and ortho photo rectification. Which you choose will depend on the level of accuracy you require, the size of your project and your budget. Most GISs have the capability to display photo backdrops, but functionality to correct air photography differs between GISs.

Registration is the least accurate of the three processes and most often involves using the mouse to find ground control points that are common to both a digital map or surveyed data, and a photograph. Due to the distortion present in air photographs, registration is unsuitable for air photography. If you must use a registered photo, wherever possible, analysis should only be undertaken on very small areas. This technique is most legitimately used on satellite imagery because these are gathered from such a high altitude (around 700 kilometres) that distortion is minimal.

Rectification is the next most accurate method for correcting air photos and the product you would purchase would be a 'rectified' photo. The technique for doing this is almost identical to photo registration except that once ground control points are identified, a computer algorithm 'resamples' the photograph by picking up each photo pixel and placing it in a geographically correct position. Rectification is best suited to areas with low relief and least suited to low level air photography in areas of high relief.

Ortho-photo rectification is the most accurate method for correcting air photos, and the product you would purchase will be referred to as either an ortho-photo or a survey-accurate air photo. Ortho-photo rectification is similar to rectification except that in addition, information from the camera calibration report (such as focal length and lens model) is required, and the photo is digitally draped over a digital terrain model in order that terrain distortions (peaks of mountains versus feet of valleys) can be corrected. Assuming good ground control and a reasonable quality digital terrain model, the accuracy of an ortho-photo is most limited by the resolution the photo was scanned at.

Pedigree of source data

Whenever using digital mapping, particularly for site level decision making, it is important to understand the history of the dataset. In Victoria, the usage of GIS is shaped by the legacy of government involvement in the production of both infra-structural and environmental base mapping. Historically the state has determined which mapping themes would be collected, at what scales, and what data would be archived with them. Further, in the analogue to digital conversion process, government determined which map themes would be digitized, which would not, and in what priority. When using off-the-shelf datasets, you need to be aware that these may have been collected for different reasons than your present study, at collection scales that are too broad to be relevant, or may be out of date.

For some archival studies, mapping will have been a central component, while for others it will have been auxiliary. You should also consider the study methodology and the skill of the study author. These may not be obvious from the explanatory notes in the front of the study, and it can be worth making the effort to speak to the study author to gain an understanding of these issues.

The stable-base maps used in the map printing process are not prone to atmospheric distortion or deterioration, and maps digitized from these are likely to be more accurate than maps digitized from paper copies. Paper maps also vary in quality, the very worst maps to digitize from are enlarged photocopies.

Although you should always try to understand the datasets you are using, this does not mean that you should discard datasets if they don't stand up to strict criteria. As a rule-of-thumb, it is quite wrong to use highly generalized mapping to make decisions that affect small areas.

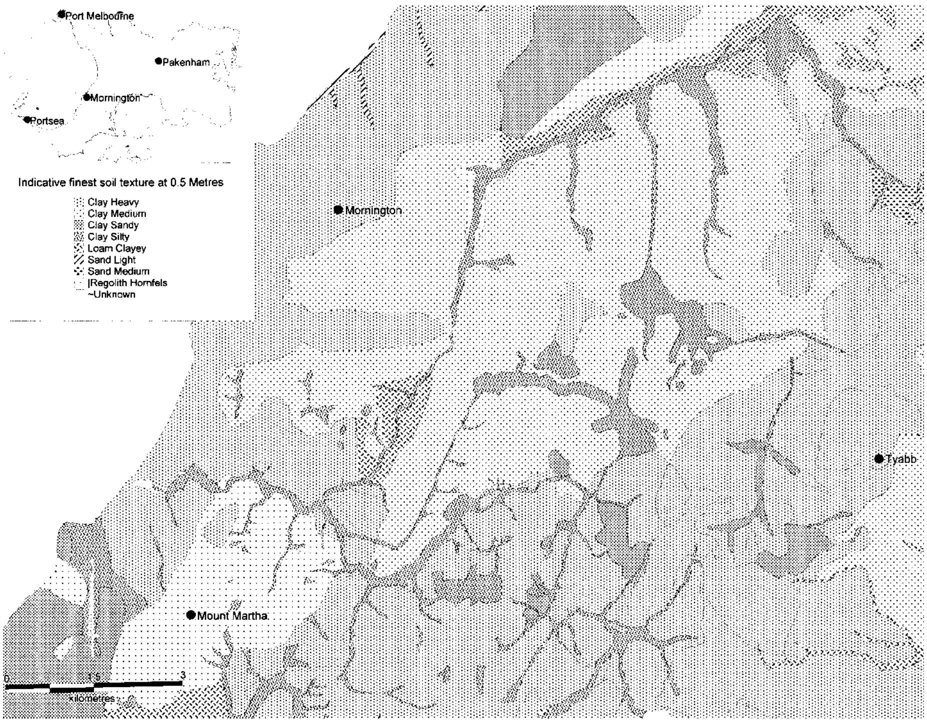

Figure 1. Map of soil texture for part of Melbourne's Mornington Peninsula at a half metre depth, produced by querying a spatial database. The database provided the foundation upon which to write software with functionality to map soil texture at any chosen depth. This map therefore is dynamic, and will change depending on both which menu options are chosen, and what depth is entered by the user. The original small-scale paper mapping (Grant 1972, 1973, Grant and Ferguson 1978) had sufficiently detailed descriptions for it to be reinterpreted at large scale (Jenkin 1974).

Maps as spatial databases

There is a vast difference between using a map as a map, and using a map as a spatial database. A map is something that is usually used in relatively small areas because it is most often physically impossible to consider the entire map at once. For example, imagine you have a road map with roadside vegetation on it, and you are travelling to an area on the other side of the city. You will be interested in major routes as you cross the city, and local streets as you approach your destination. When you reach your destination, a 'eucalypt' tree has been incorrectly mapped and you find it a little further along the road (spatial error). Later on you come across another eucalypt that is labelled on the map as a 'euc' (difference in nomenclature). You can compensate for this because you are undertaking ground truthing in real-time, but because computers cannot easily compensate in the same way as people can, this map is not a spatial database.

In contrast, a spatial database has two pre-requisites, the first of these being a requirement for spatial integrity (is the tree where the map says it should be), and the second, a requirement for attribute consistency (are eucalypts identified the same way throughout the database). A spatial database that satisfies these two pre-requisites can be used for modelling. The soil map depicted in Figure 1 could only be created once compatibly scaled mapping was combined with a consistent naming convention and study methodology.

Conclusion

A GIS can be defined to include data input and output functionality, software, and a database which is influenced by the corporate environment within which it operates. Although many reviews of GIS focus on technical functionality, the reality is that in most cases such functionality is meaningless in the absence of a quality dataset. In many circumstances, datasets will be available off the shelf, but to use these effectively, you really need to feel confident with the data's scale and pedigree. In some cases you will need to add your own data, an ideal source for which is air photography in the form of a GIS backdrop. Air photography has its own accuracy related problems, most of which can be overcome.

The highest quality databases are those where mapped components have an accuracy that is appropriate for the use the database is being put to, and the attributes of those components have a consistent nomenclature so that comparisons can be made across the dataset. Such a database can be queried in the most meaningful and flexible ways. Clearly then, it is the database that makes GIS such a beast to tame.

References

Eastman, R., (1992). IDRISI Student Manual, p. 10. (Clark University, Massachusetts, USA).

Grant, K. (1972). Terrain Classification for Engineering Purposes of the Melbourne Area, Victoria. Division of Applied Geomechanics Technical Paper No. 11. (CSIRO, Melbourne).

Grant, K. (1973). Terrain Classification for Engineering Purposes of the Queenscliff Area, Victoria. Division of Applied Geomechanics Technical Paper No. 12. (CSIRO, Melbourne).

Grant, K. and Ferguson, T.G. (1978). Terrain Classification for Engineering Purposes of the Warragul Area, Victoria. Division of Applied Geomechanics Technical Paper No. 21. (CSIRO, Melbourne).

Jenkin, J.J. (1974). The Geology of the Mornington Peninsula and Westernport. Geological Survey Report 1974/3.

McHarg, I.L. (1969). 'Design With Nature'. (The Falcon Press, Philadelphia, USA).

Monmonier, M. (1991). 'How to Lie with Maps'. (University of Chicago Press, Chicago).

Priority weed mapping in Melton Shire

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In 1997, Melton Shire Council was successful in receiving grant funding for a GIS Weed Mapping Officer. The primary role of this person was to map the extent of Melton's five priority weeds.

Priority Weeds

- African boxthorn – *Lycium feroissimum*
- Artichoke thistle – *Cynara cardunculus*
- Paterson's curse – *Echium plantagineum*
- Prairie ground cherry – *Physalis viscosa*
- Serrated tussock – *Nassella trichotoma*

A third year of funding has just been received and in addition to priority weed mapping, there will be more complex GIS operations, identifying heavily weed infested riparian zones and mapping Chilean needle grass.

Mapping system

GPS Unit

- (Global Positioning System) determines position of user by co-ordinates e.g. latitude and longitude.

Stylistic 1000 / Pen Computer

- Pen based computer directly linked to the GPS unit.
- 'Weedmap' was the program used for the first two years of mapping.
- New program is 'Field Notes', which is more GIS focused. Each table can have fields the user sets up.

Differential / RDS 3000

- Overcomes selective availability of the satellites from the US Defence Department.
- Corrections are calculated by the JJJ Station at Mt. Dandenong, Victoria and sent to the RDS.
- With a differential, accuracy is increased from 1–3 m. Without a differential, accuracy can be between 10–70 m.

Aims

i. Compare all three years of weed mapping for:

- Weed movement or spatial change across the whole Shire.
- The movement of heavily infested areas or 'Hotspots'.
- New outbreaks of the weeds previously unmapped.

ii. Reasons for spread.

- Birds – common in distributing boxthorn (as seen along fence lines).
- Water – severe gorse and boxthorn weed infestations along creeks.
- Wind – importance of wind breaks to stop seed distribution.
- Non conformance with the EEP (explain later).

Methodology

Can only be attempted when the GPS is fully functional depending on satellite availability.

i. Data collection can be done in two ways:

a. On foot carrying equipment. This was the more common method involving walking around an infestation such as serrated tussock or standing close to a boxthorn.

b. By estimating the extent of an infestation from the car and manually drawing in the area symbol (termed polygon).

ii. Weed infestations are recorded in Fieldnotes as either a symbol point (as for a single boxthorn) or area polygon (as for serrated tussock).

iii. Each time a point or polygon (weed) has been entered, a form is filled out. For example I have a table called 'Weeds' and when I enter data, a pop down form comes up automatically and I have to chose from each category before I enter the next object, e.g.:

- Weed type – select from list
- Intensity – i. 1–10%, ii. 11–50%, iii. 51–100%
- Environs – riparian, open plains, fence line, roadside

iv. This data will then get exported to MAPINFO as a mid / mif. I'll then do a query and separate all the different weed types and create individual maps.

Limitations

Mapping and evaluating a feature such as a weed infestation and its rating is a subjective exercise. Two people have been involved with weed mapping for this project and therefore differences in opinion may have occurred.

Originally, weeds were categorized into eight levels of intensity by the first Mapping Officer. I changed it to three categories: i. 1–10%, ii. 11–50%, iii. 51–100% because I found eight categories too