Integrating Eucalypt Forest Inventory and GIS in Western Australia

Practical Paper

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Abstract

*A method for integrating forest inventory data with geographic information systems to provide flexible and responsive information for forest management is described. The method has been applied successfully to a recent resource-level inventory of jarrah (*Eucalyptus marginata*) in Western Australia.*

Introduction

Flexible and responsive inventory systems are required to provide information that meets the changing demands of forest management. Such flexibility can be achieved by integrating inventory systems with a geographic information system (GIS). This approach was taken by the Department of Conservation and Land Management (CALM) to meet the requirements of a recent resource-level inventory of jarrah (*Eucalyptus marginata*) forest in Western Australia.

The inventory was required to meet the following objectives:

- Provide sufficient samples to achieve a sampling error of ±25 percent (95 percent probability) for management units of 10,000 ha,
- Sample 1.4 million ha of forest at this intensity within three years, and
- Be able to provide estimates of timber volume for any large patch of forest land with sufficient samples, however defined.

The first two objectives dictated a rapid and efficient sampling technique, which was achieved using double sampling. The first-phase sample was obtained using 1:1,000-scale aerial photographs, and ten percent of the samples were re-measured on the ground in the second phase.

The third objective was met by integrating the inventory data with a GIS.

This paper contains an outline of the sampling technique used in the inventory followed by a description of the integration of sample data with a GIS.

Sampling

Large-scale aerial photographs (1:1,000 scale) were acquired with a fixed-base photographic system consisting of twin 70-mm cameras attached to each end of a 7.5-m boom on a helicopter (Biggs *et al.*, 1989; Biggs and Spencer, 1990). This system produced stereopairs by simultaneously exposing film in two cameras and enabled photo scale to be calculated from the ratio of photo-base over actual air-base (Lyons, 1967; Spencer, 1979; Spencer and Hall, 1988). A grid spacing of 1000 m between flight-lines and 500 m along flight-lines produced a photo-sample for every 50 ha of forest. Photographic estimates of volume were derived from measurements of total tree height and interpretation of tree species (Biggs, 1991).

Ground samples were measured on ten percent of all photo-samples. Wood qualities, both defects and attributes, were recorded in the ground plots and then related to specified log products to facilitate adjustments due to changes in product specifications over time (Strelein and Boardman, 1992).

GPS Navigation and Plot Positioning

It was critical to determine accurately the position of every sample point, both to allow the ground samples to be located and to permit the inventory data to be integrated with the GIS. This was achieved using Global Positioning System (GPS) navigation during photography. A GPS receiver, coupled with a lap-top computer, was used to navigate along pre-determined flight-lines and to record the location of each stereopair of sampling photographs.

These locations were plotted onto 1:25,000-scale map sheets showing the position of every sample point. The ground crews could then use these maps to locate their ground samples (Biggs *et al.*, 1989). Most importantly, the plot position data allowed the integration of the inventory information with the GIS.

Integration with GIS.

The Department of Conservation and Land Management used three separate geographic information systems, all linked through the same cluster of computers. The Intergraph system was used for map input, editing, storage, and presentation; ARC/INFO was used for spatial analysis (buffer generation and some overlaying); and FMIS (an in-house raster GIS) was used for extensive overlaying of multiple map themes.

Because all data collected from the photo and ground samples were associated with geographical locations, the inventory data could be integrated with these geographic information systems (Figure 1). This was achieved in the following manner:

- The locations of all sample points were stored as a "point" coverage in the ARC/INFO geographic information system.
- The inventory data associated with these locations were stored in Oracle database tables linked to their positions by common plot identifiers.
- A "polygon" coverage was created within ARC/INFO, defining the area of forest for which a volume statement was required.

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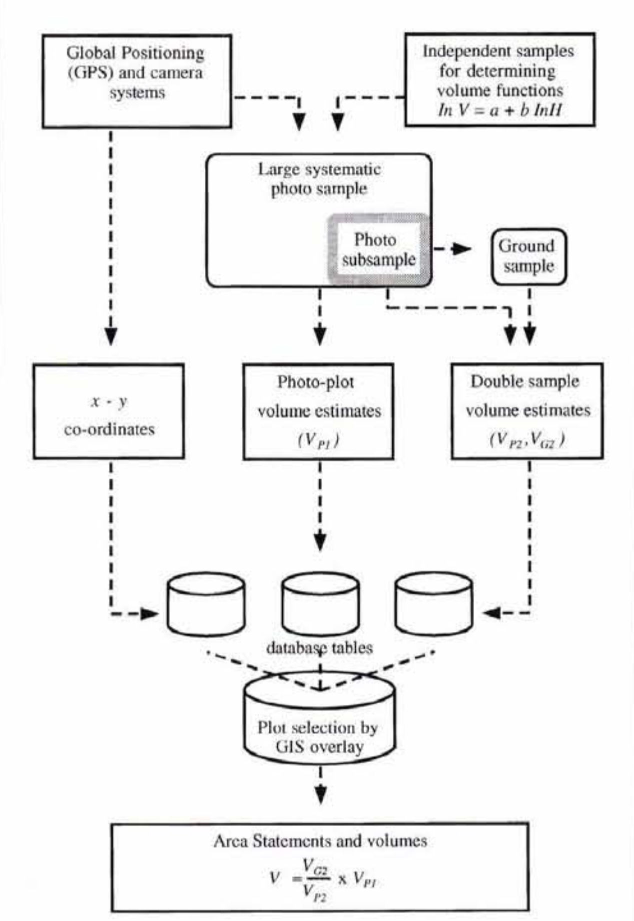

Figure 1. Flow chart showing the relationship between components of the inventory.

This area was termed a "window" and could be created by overlay of map themes within FMIS or ARC/INFO.

- The window coverage was intersected with the point coverage of sample plot locations, and those plots that fell within the window were selected from the database.
- The data from the selected points were passed on to the relevant statistical programs to derive estimates of timber volumes and their confidence intervals.

For example, a particular window might be defined as all State Forest; excluding conservation reserves and pine plantations; excluding road, river, and stream reserves; and only within 25 km of a timber mill. The area of State Forest, without conservation reserves or pine plantations, could be defined within FMIS and transferred to ARC/INFO. ARC/INFO could then be used to define the road, river, and stream reserves as buffers of particular widths and to define the 25-km zone from the timber mill. The resultant polygon coverage could then be intersected with the point locations to select the relevant sample points (Figures 2 and 3).

If the forest managers wanted to test other options, these could be simulated by changing the window coverage. For example, the distance from the mill could be increased to 30 km to determine the extra resource available, the size of the river and stream reserves could be changed, or the areas of proposed new conservation reserves could be removed from the window. A revised resource estimate could then be derived for the new window by reselecting the sample points.

The results from the analysis could then be presented in tables or could be passed back to the GIS and presented graphically. Graphical presentation of timber volumes in both two-dimensional and three-dimensional displays proved extremely useful for showing trends in volume density over an area, highlighting the areas of extreme volume. This approach could also be used to show the distribution of particular species or other parameters in the forest.

Conclusions

The methods described in this paper demonstrate how forest inventory data can be integrated with geographic information systems to provide useful and flexible information for forest management. GIS overlay techniques make it possible to examine the effects on timber supplies of different management options such as the width of stream reserves, haul distances, and new conservation reserves. The inventory results can be displayed through the GIS to show graphically the distribution of volume across the forest.

Acknowledgments

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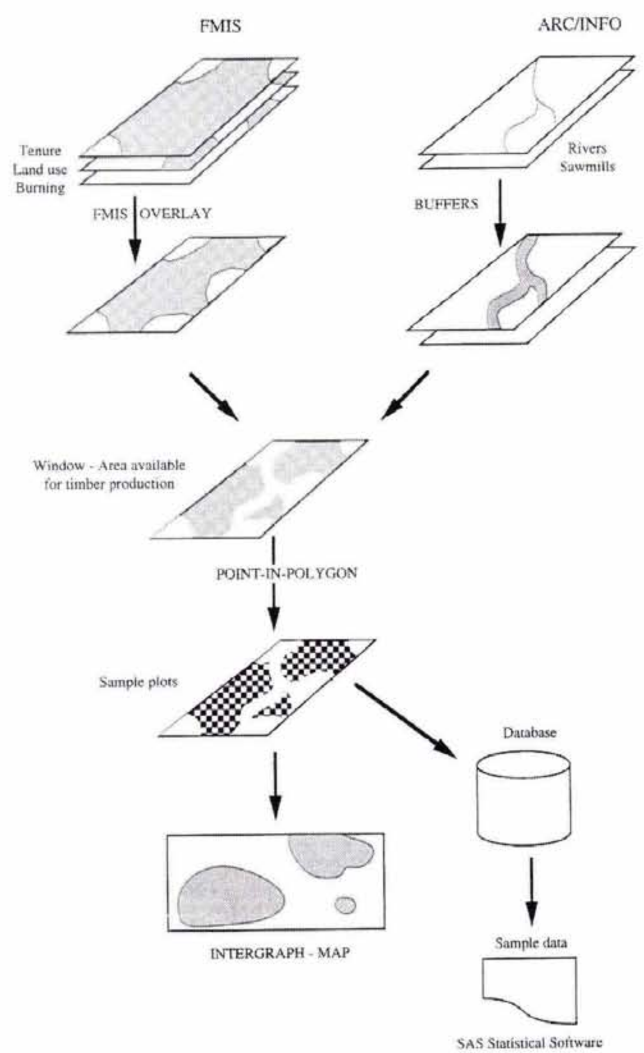

Figure 2. Example of the overlay procedure used to define an inventory zone or window.

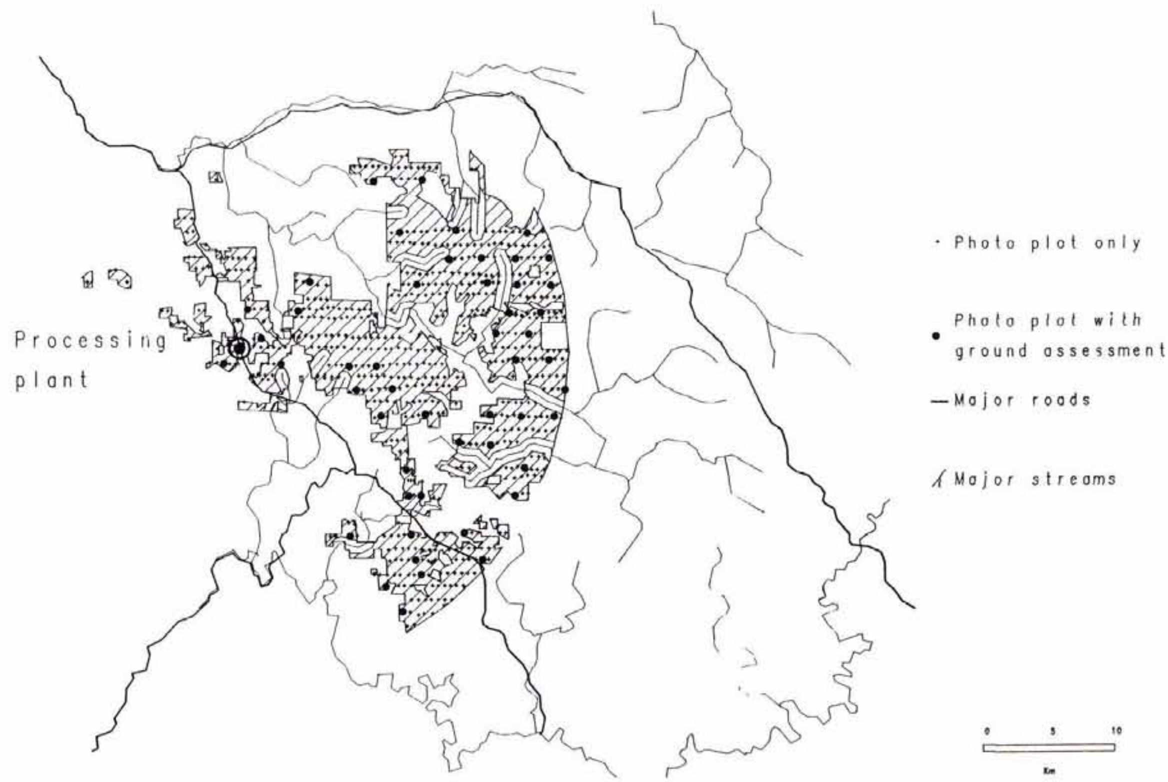

Figure 3. Example of a "window" area resulting from the overlay process. It depicts a photo-location plot from the ARC/INFO geographic information system (GIS) based on positional data from the Global Positioning System (GPS) as recorded by the on-board computer. It shows only those photos that fall within a 25-km radius of a hypothetical timber mill. + = photo plot, ● = photoplot with ground measurement.

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