NEW TECHNOLOGIES FOR THE SIMULATION AND ASSESSMENT OF FOREST LANDSCAPE CHANGE

SHAUN K. KILVERT

Logging Industry Research Organisation,
P.O. Box 147, Rotorua, New Zealand

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ABSTRACT

Public perception of environmental quality is primarily visual, and forest operations, particularly logging, can have a significant negative impact on a visual amenity. In order to visualise landscape change and evaluate reaction to such change, graphic simulations can be produced with a range of technologies. Objective and dynamic, though abstract, models of the landscape can be produced using digital terrain modelling. Photorealistic, though static and subjective, impressions of landscape change can be produced employing digital image-editing software. Image-rendering technologies are available for reducing the abstract appearance of digital terrain models and for increasing the quality of viewer/ image interaction. Spatial analysis and image processing software facilitate quantitative measurement of visual impacts.

Keywords: forestry; logging; computer graphics; visualisation; landscape evaluation.

INTRODUCTION

Within the New Zealand forest industry, there is an increasing concern for the public's perception of forest operations. This is primarily due to new resource management legislation and a desire by the industry to ensure that all aspects of forestry have minimal impacts on both the environment and the community. The Resource Management Act (RMA) 1991 states that the protection of outstanding natural features and landscapes, and the general maintenance and enhancement of visual amenity, are matters of national importance (New Zealand Government 1991). The New Zealand Forest Code of Practice, published in 1990 and revised in 1993, recommends recognising and maintaining scenic values during the planning and undertaking of forest operations (Vaughan *et al.* 1993).

Concern about the visual impact of plantation forest operations in New Zealand is accentuated by the increasing area of forest establishment and logging available for public criticism. The first extensive exotic plantings were predominantly on a volcanic plateau in the central North Island; in this setting operations can be easily screened from the motorist's view or can add interest to an otherwise monotonous journey. However, much of the expansion of the plantation forest estate from the mid-1960s (the first plantings of which are now being logged) has been on hill-slopes, not easily hidden from view. Attention therefore needs to be given to the physical design of landscape change or addressing the public's perception of plantation forestry's visual impacts. Reductions in visual attractiveness as a result of forest operations are of particular concern in frequently seen areas, such as along highways and near cities, or in areas valued for their scenic quality or natural character, such as beside lakes or in high country tussock land (Kilvert & Hartsough 1993; Kilvert 1994, 1995).

Since the 1950s, considerable research has been undertaken in various countries, particularly the United States, on the incorporation of aesthetics into forest management and planning. As a consequence of this research, there are now numerous technologies which can assist with landscape design and evaluation. This paper reviews the range of data visualisation and analysis technologies currently available in New Zealand for landscape evaluation work. The technologies discussed range from digital terrain modelling, developed in the 1970s, through to digital image rendering, still in development.

LANDSCAPE SIMULATION TECHNOLOGIES

Digital Elevation Models

Digital Elevation Models (DEMs), also known as Digital Terrain Models (DTMs), first began to be applied to forest management in the mid-1970s. The technology allows contour lines to be entered into a computer database and a regularly spaced network of spot levels to be extrapolated from these data. Point, line, and area data can then be added (or draped) over this grid to form the base for slope maps, aspect maps, and perspective views. Perspective views produce a view familiar to a lay-person, such as that from a lookout or picnic site, and can also be strung together in an animated sequence, allowing the computer operator or viewer to visualise how the area could look to a motorist driving past.

An early example of digital elevation modelling software was PERSPECTIVE PLOT, developed by the United States Forest Service's Logging Systems Group for use with landscape assessment programs such as SIGHTLINE and SCOPE (viSual management COmputer model for Partially cut timbEr stands). PERSPECTIVE PLOT allowed the form and size of clearcut harvest blocks to be evaluated relative to surrounding landforms. SIGHTLINE calculated the terrain visible from selected viewpoints. SCOPE facilitated the simulation of the visual effect of texture modification in a partially cut stand, and the appearance of such features as skyline corridors and small clearcut removal of diseased trees (Nickerson 1980).

A program developed in the early 1980s, called PLANS (Preliminary Logging Analysis System), was modified for New Zealand in 1990. PLANZ includes digital terrain modelling programs called VISUAL and SLOPE, which can be used to create perspective views of an area and classify terrain according to slope, aspect, and elevation. Other features, such as roads and harvest boundaries, can be draped over the terrain model, facilitating visualisation of the landscape and providing ground data for analysis of hauler profiles (Clement 1990).

DEMs can now be generated from a wide range of computer programs, such as Terrasoft, Arc/Info, SAGE, and IDRISI, using digitised elevation data. The landscape simulations produced are beneficial in that they provide objective perspective views displaying the mathematically correct size and scale of proposed landscape change (Moore & Bennison 1993). DEMs tend to carry more weight than landscape sketches (traditionally used to portray landscape design plans) in planning forums (Dunningham & Thompson 1989).

However, the point-elevation grid produced is not sufficient for producing realistic imagery. A schematic wireframe outline of the terrain is usually the final image (Moore & Bennison 1993).

Digital Image Editing

While DEMs are an effective tool for visualising terrain and assessing the visibility of proposed forest management activities, their abstract appearance does not make them conducive for use in public relations or landscape evaluation research. The model lacks natural landscape features and requires explanation and interpretation.

Traditionally, the main tools for showing the public what a landscape is going to look like, and to assess what the public think about design proposals, have been the landscape sketch and photomontage. Landscape sketches generally involve the drawing of the existing landscape and the proposed landscape using pencil, pen, or paint. Photomontages involve the manual alteration of photographs of the existing landscape (Moore & Bennison 1993).

Advances in computer technologies in the past decade, particularly with regard to data storage, colour, and printing, now allow photographs to be easily modified using computers. A photograph or video frame can be captured using a scanner or video digitiser board, then changed by adding, deleting, moving, or modifying elements in the digital image (Moore & Bennison 1993). The altered image can then be printed using a laser printer, dye-sublimation printer, or film recorder.

Digital image editing is currently being used in a number of landscape preference studies relating to plantation forestry in New Zealand. One such study, being undertaken by the Logging Industry Research Organisation, relates to public perception of inter-rotation landscape change in pine forests. In order to show people a hillside with various amounts and types of logging, as well as various amounts and types of regrowth, photographs were scanned on to Kodak PhotoCD and then modified using Aldus PhotoStyler software. The altered photographs were then printed using a dye-sublimation printer. When rated by 400 New Zealand residents and 40 overseas tourists, few respondents realised that the photographs were simulations.

Digitally manipulated photographs are an excellent tool for assessing public reaction to landscape change or for public consultation and education. One problem is that the images must be identified as artistic impressions. While DEMs can be used to verify that the size and scale of the changes made are accurate (Antenucci *et al.* 1991), a degree of artistic licence is still involved in modifying the images. Consequently, it is difficult to fully defend digital photomontages of proposed landscape change in a court of law.

Digital Image Rendering

The desire for accurate and objective simulations with a high degree of photorealism and user/image interaction is helping to drive the development of new Virtual Reality (VR) technologies. At the low end of the spectrum, these technologies simply involve rendering (or painting) a DEM to make it look more realistic. At the high end of the spectrum, these technologies allow Total Sensory Immersion (TSI)—providing the illusion of being projected into the rendered landscape. With some TSI hardware, the viewer can even hear, feel, and smell the surroundings.

Image rendering involves the use of algorithms to paint and add texture to the surface of a DEM. Often this involves smoothing the surface of the DEM so that it loses its abstract, grid-like appearance, then adding texture, colour, shading, and natural landscape features. Entirely synthetic natural landscapes can be produced, complete with different species of trees, clouds, waterbodies, shadows, and reflections (Reid 1993).

A number of VR technologies are now being investigated in New Zealand for use in landscape management. One such technology is VistaPro, a natural landscape simulation program initially developed for the video games industry. VistaPro works by rendering a DEM from the background to the foreground using a 2D painting process. As it avoids the complex calculations involved in determining what objects are closer to the camera (objects in the background are simply obscured by foreground objects), VistaPro can quickly render a scene on a 486 IBM-compatible PC. In addition, VistaPro uses fractal geometry on all surfaces that it paints, so that as the viewer gets closer to a natural feature or the surface of the DEM, the level of detail depicted increases (Raulings 1994). The quality of the rendering produced by VistaPro depends on the number of polygons used to smooth the surface of the DEM; between 2048 and 130 000 can be used (Reid 1993). The computer operator also has control over variables such as sun direction and azimuth, camera, and target view positions, field of view, colour of surfaces, species and size of trees, the placement of lakes and rivers, use of clouds and stars, and so on. The final graphic can be saved as a PCX, Targa 24, or BMP 24 file (Raulings 1994).

The images produced by image rendering programs such as VistaPro can be animated, morphed, and viewed in 3D (using 3D glasses). Images can be strung together in an animated sequence, allowing the operator to view the forest landscape from more than one point in space or time (Raulings 1994). An animated sequence can be produced to show what the forest landscape could look like to a motorist driving past. A morphed sequence can be produced to show how a forest landscape could change over a number of years or decades if various landscape design strategies were followed.

Digital image rendering offers the opportunity to produce objective and dynamic data visualisation in the form of images which can be easily understood by the general public. At this stage, however, the graphics and image analysis capabilities of this Virtual Reality software are still being adapted for the New Zealand forest industry. The main problems, still to be overcome, relate to the fixed cell size of the DEM (Raulings 1994), the need to produce appropriate graphics for depicting *Pinus radiata* D.Don, and the integration of this technology with landscape perception models and planning software such as PLANZ.

Digital Image Processing and Geographic Information Systems

An advantage of digital image editing and rendering is that the pictures produced are stored as raster images. The pictures are made up of a grid of pixels, with each pixel having associated data stored in numerical form. This data can be analysed using digital image processing software, facilitating measurement of colour, texture, length, and area. Ratings of visual quality for photographs can therefore be directly compared to visible features in the images, such as area of visible cleared ground and colour of soil and vegetation, in order to develop quantitative explanatory models of natural landscape preference; this technique was used in a study by Orland (1991). Such a capability makes digital image editing and rendering technologies conducive to integration with raster-based Geographic Information Systems (GIS) for the measurement and prediction of visual impacts.

Two methodologies are available for analysing landscape constraints using GIS. The first involves the analysis of regional or district data through map overlay. Management constraints, such as the proximity of a forested area to a main highway, the viewshed from each point on the highway, the average number of people travelling the highway, and the scenic quality of the surrounding area, can be evaluated. This identifies the ability of the landscape to absorb change (called Visual Absorption Capability) and/or sets limits on the amount of acceptable landscape change in different parts of the forest (called Landscape Priority Zones) (Mawson 1990; Itami & Raulings 1994).

The second methodology involves the measurement and prediction of visual impacts based on natural landscape preference models and the spatial analysis of computer-generated landscape simulations. Assessments of the extent to which different landscape features contribute to ratings of scenic quality have been researched since the 1960s (Ribe 1989). The potential exists to integrate these empirical models with GIS and decision support systems to assist forest management decisions in sensitive operations, such as near cities and along scenic highways.

CONCLUSIONS

DEMs or DTMs are effective models for objective and dynamic visualisation forest management data. However, the traditional grid-like appearance of these models makes them too schematic for effective use in public consultation and perception research. Recent advances in computer technologies (particularly in data storage, colour, and printing) offer two new techniques for simulating forest landscape change. Digital image editing software facilitates the creation of photorealistic, though subjective, simulations. Image rendering technologies aim to reduce the abstract appearance of DEMs.

Of the two methodologies available for using GIS, the map overlay procedure to ascertain areas of high visibility and low visual absorption capability is particularly useful for setting regional or district landscape management guidelines. The method using image analysis and models of natural landscape preference has a role for measuring and predicting visual impacts for specific operations. The potential application of these methodologies in New Zealand is currently being investigated.

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