Extension Note

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Computer-based visualization of forest management: A primer for resource managers, communities, and educators

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Abstract

Landscape visualizations are pictures of real places seen in perspective that show visible or non-visible features or recognizable landscapes in the future, the present, or the past. This paper is intended to provide an introduction to landscape visualization technology for rural communities, planning professionals, and educators who are interested in, but are generally unfamiliar with, the use of visualization in environmental planning and management. In non-technical terms, we describe what landscape visualization is and how visualization datasets are assembled. We also provide examples of how landscape visualizations can be used in resource management, predictive ecosystem modelling and community consultation.

KEYWORDS: *landscape, visualization, simulation, primer.*

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Introduction

British Columbia's mountainous landscape forms an important backdrop for many communities and tourist destinations. In these areas, managing the forest to meet Visual Quality Objectives (VQOs) has consequently become imperative. To visualize the effects of different forest management scenarios, forest managers increasingly depend on computer-based landscape visualization tools, a number of which were developed specifically for this purpose. While many of these tools were applied to mainstream concerns relating to the aesthetic impacts of forest management on Crown lands, the use of photo-realistic visualization is expanding into the areas of predictive ecological modelling and community consultation. These visualizations present complex and cryptic forms of landscape data in a format that technical experts, decision makers, and public stakeholders alike can comprehend and discuss.

As landscape visualization becomes more common in forest management, questions abound relating to the range of visualization formats available, how the technology works, and how it can be applied to landscape planning and design. In this paper, we attempt to address these questions. This primer provides a practical introduction for professional land managers, consultants, academics, and community organizations who wish to understand how landscape visualization may assist in their essential resource planning and land management activities. It also serves as a reference guide for others who may use or encounter visualizations in the context of forest management.

Landscape Visualization: A Primer

Landscape Visualization Defined

Broadly defined, "visualizations" are pictures of objects, conditions, processes, or places that help the viewer understand and interpret the subject matter by revealing its appearance or visually displaying certain significant characteristics. The landscape visualizations we refer to in this paper are pictures of real places seen from a particular perspective (Figure 1). These pictures can be manipulated in countless ways to show important features from different perspectives or future landscape conditions based on land management decisions. When combined with other non-visible forms of information, such as property boundaries, soil types, or wildlife habitat values (Figure 1), landscape visualizations enable the depiction of alternative forest management actions and their potential consequences in a format that is understandable to a broad spectrum of stakeholders (e.g., planning experts, non-expert members of the public, and key decision makers).

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Many of the landscape visualization techniques described here and elsewhere (see, for example, Sheppard *et al.* 2004) have been available in some form for 20–30 years. Recent advances in computing technology and its application to resource management have made visualization more common in certain professional contexts (e.g., landscape architecture and regional planning) and jurisdictions such as the United States and Great Britain, where its use as a landscape design and decision-making tool is more routine than in Canada. Nevertheless, the rise in personal computing and the growing sophistication of special effects and interactive modes of entertainment are helping to create a new generation that takes computerized visual media for granted. The use of visualization in public communications, resource planning, and forestry decision making is attempting to cater to these rising expectations.

Over the last 25 years, universities and researchers have conducted various studies into the value and effectiveness of landscape visualization in land planning and resource management (Wood 1972; Daniel and Boster 1976; Appleyard 1977; Sheppard 1982; Kroh and Gimblett 1992; Perkins 1992; Pitt and Nassauer 1992; Oh 1994; Bergen *et al.* 1995; Lewis 2000; Tress and Tress 2003). In general, both the research literature and practical experience indicate that landscape visualizations can significantly improve the public's access to information and understanding of projects. Furthermore, visualizations can convey more powerfully than cartographic formats the personal, cultural, and emotional qualities that the public associates with their landscape, and can help to predict community reactions to proposed projects. However, we still know very little about the ways in which visualizations influence people's perceptions and responses to environmental decisions in practice.

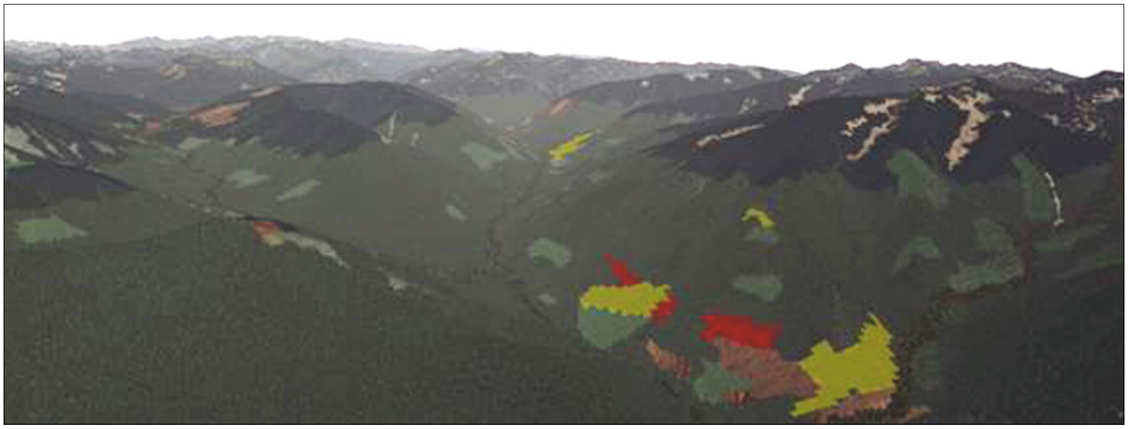


FIGURE 1. Landscape visualizations are commonly used to portray the landscape and proposed changes in a manner that is familiar and understandable to stakeholders and decision makers. When combined with non-visible landscape features and values, the non-expert user's capacity for making informed and intelligent decisions is greatly enhanced. This figure provides an aerial view of management and land-use zones draped onto a digital terrain model and forest cover data from a portion of the Peace River District, B.C. Visualization credit: Jon Salter, Collaborative for Advanced Landscape Planning, University of British Columbia, Vancouver, B.C.

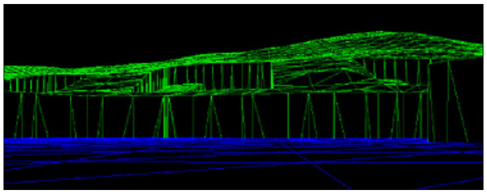
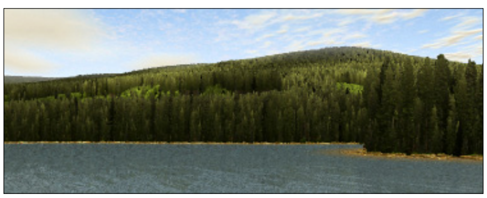
Several different types of landscape visualization are available for use in planning and resource management (e.g., see McGaughey [1998], Orland and Uusitalo [2001], and Sheppard *et al.* [2004] for additional reviews of simulation types and their uses in forest management). Wireframe, photomontage, and surface models (Table 1) are different types of visualization that demonstrate a range of realism, from the somewhat simple and abstract to the highly realistic. Choosing an appropriate type can be very important in determining how visualization is used in forest management applications.

How Landscape Visualization Works

In their current form, most landscape visualization applications are workstation-based computer programs that create and display full-colour perspective images of landscapes ranging in size from a forest harvest unit to the multiple watershed level (i.e., 10–8000 ha). Landscape modelling packages can display ground models, terrain represented by a digital terrain model (DTM), forest stands, and generic line information representing roads, harvest unit boundaries, and so on. The more sophisticated applications can manipulate tree stands to simulate various operational or landscape planning alternatives. World Construction Set® (WCS) and its most recent variant, Visual Nature Studio™ (VNS), are the landscape or surface modelling applications currently preferred by the British Columbia Ministry of Forests (MOF) and several landscape planning consultants throughout the province (for more information about these applications see: ***www.3dnature.com***). These applications vary mostly in terms of the speed with which they can import and process digital elevation data. Their current status as the preferred modelling software by government and industry is predicated on the ability to generate accurate and realistic simulations which, in turn, draw on the following capabilities.

- Accurate ground surfaces can be constructed from digital topographic data sets available from the B.C. Ministry of Sustainable Resource Management's Terrain Resource Information Mapping (TRIM) series.
- Forest stand data can be imported from MOF digital forest cover inventories; visible stand characteristics (e.g., species composition, stand height, and stand density) can be incorporated into the visual model, but only after performing a number of basic query operations in a Geographic Information System (GIS).
- Tree libraries, which are customized to local biogeoclimatic zone characteristics, can be built from photographs of local overstorey and understorey vegetation to replicate foliage characteristics of composition, colour, and texture.
- Ephemeral conditions (e.g., sunlight intensity; ambient light; and atmospheric blur, fog, and cloud cover) can be calibrated with site photographs to enhance the realism of the final output.
- Disturbance conditions (e.g., harvest cutblocks, fire patches, and plantings) can be imported as polygon boundaries from a GIS.

TABLE 1. The range of visualization types commonly used by environmental planners and resource managers. Visualization credit: John Lewis, Collaborative for Advanced Landscape Planning, University of British Columbia, Vancouver, B.C.

Visualization type	Technique description	Software required	Advantages/disadvantages
 WIREFRAME	Geographic Information System (GIS) or Computer-aided Design (CAD) software mathematically interpolates a continuous lattice from contour vertices or spot elevation data.	AutoCAD®, MicroStation®, or any GIS software (e.g., ArcView®, ArcInfo®, or ArcGIS®)	*Advantages*: Easy to produce for anyone with a moderate to high level of training in GIS and (or) CAD. *Disadvantages*: Very low realism; difficult to translate into a clear mental image of how the landscape will be affected by the alterations.
 PHOTOMONTAGE	Simulated disturbances are manually "painted" onto a site photo using standard photo-retouching software. The "artists" will often drape a wireframe image (see above) to aid in siting and sizing the proposed disturbance.	AutoCAD or MicroStation and Adobe Photoshop®	*Advantages*: High realism; high degree of credibility and believability by the public and decision makers. *Disadvantages*: Questionable accuracy; relies extensively on artistic judgement of the simulation preparer.
 SURFACE MODEL	See discussion, "How Landscape Visualization Works."	World Construction Set and any GIS software	*Advantages*: High photo-realism and accuracy; assuming good base data, very credible and defensible. *Disadvantages*: Time consuming to produce; requires a high level of training and experience.

Preparing good visualizations is achieved not only by selecting the appropriate software and having a trained person press the right buttons. The process includes several stages, and each of these is influenced by numerous factors, including data quality and availability, project requirements, the preparer's level of training and experience, influences of the project proponent, and early assumptions regarding post-harvest and development conditions. Various decisions and assumptions are made, deliberately and often inadvertently, during the preparation process. Figure 2 provides a flowchart that outlines the generic process of preparing visualizations and points to the importance of defining the purpose and scope of the visualizations at the outset of the project process. For example, what information are the visualizations intended to provide, and what questions or issues are they intended to address? Of course, the process that is represented here is deceptively simple and omits much of the effort and tedium that is inherent in working with geographic data, particularly when repeated iterations of the visualization project need to be prepared to correct data errors, modify assumptions, accommodate adjustments to the underlying silvicultural prescription, or deal with problems that are introduced by the all-too human simulation preparer.

Applications of Landscape Visualization in Forest Management

Despite the complexity and effort required to produce defensible simulations (see Sheppard *et al.* [2004] for a more detailed review of simulation procedures and standards), planners and resource managers who represent government, industry, and resource consulting practice have recently begun applying landscape visualization to the task of environmental planning and management (B.C. Ministry of Forests 2001). The B.C. Ministry of Forests, for example, requires visualizations of visually sensitive areas where the compliance of proposed harvesting plans with established VQOs must be demonstrated as part of a visual impact assessment. Several small companies now provide WCS and similar

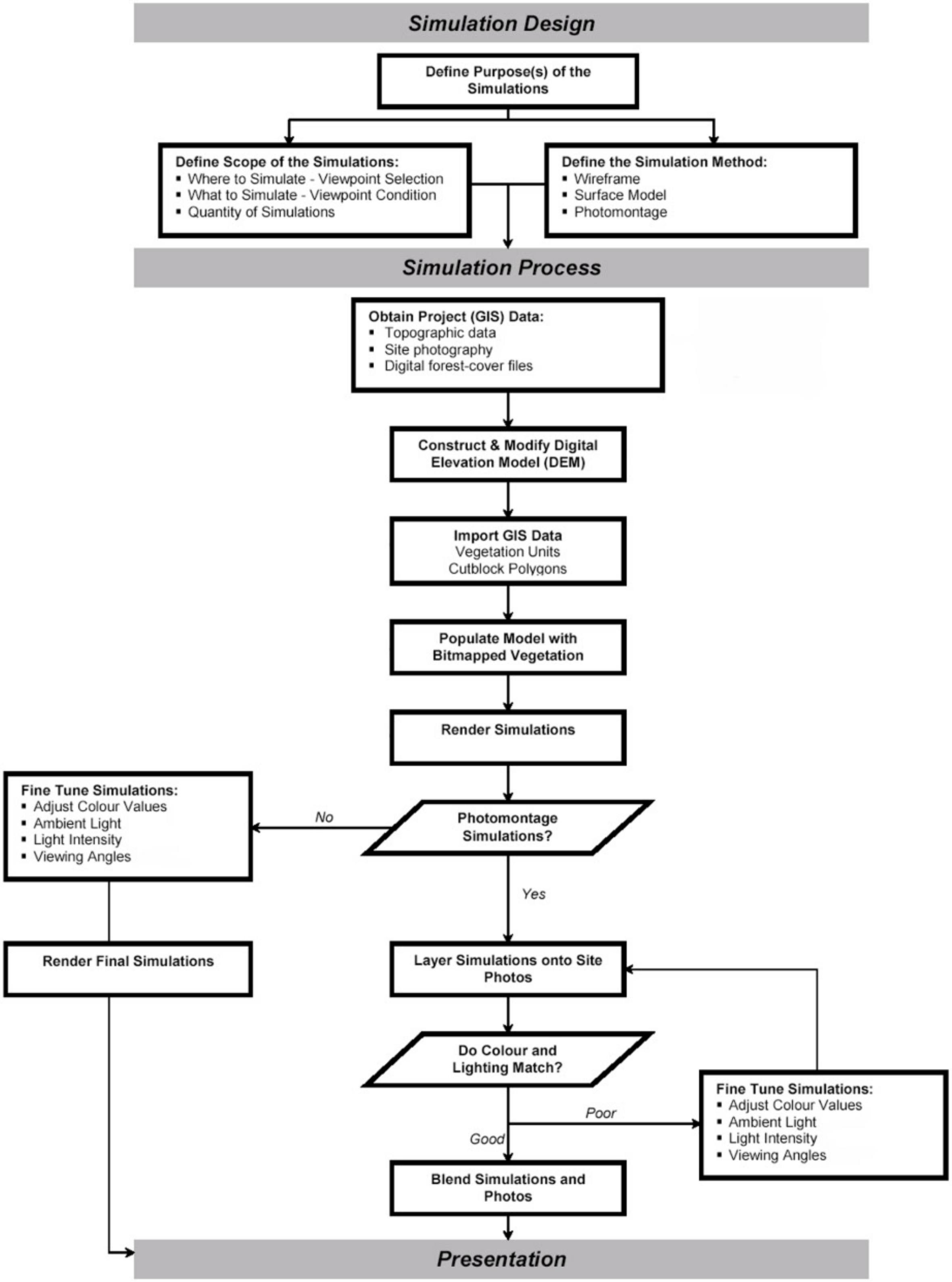


FIGURE 2. Flowchart outlining the generic visualization process.

visualization products (e.g., VNS) and services to forestry companies and government agencies for this purpose. Visualization is also used as a general communication tool to explain proposed plans to decision makers, the public, or concerned stakeholders. Organizations, such as the McGregor Model Forest (***www.mcgregor.bc.ca/***) and the University of British Columbia's Collaborative for Advanced Landscape Planning (CALP; ***www.calp.forestry.ubc.ca***), have used computer animation and enhanced three-dimensional visualizations of forest landscapes to explain plans and relate different types of resource information to recognizable scenes in perspective.

Visualizing the Future

Most of the visualization techniques described here produce realistic, data-driven images that, depending on the quality of the data used, should accurately represent changes related to forest management in the landscape or stand. In recent years, various researchers (Buckley *et al.* 1998; Sheppard 2000; Ervin 2001; Orland and Uusitalo 2001; Orland *et al.* 2001) have taken visualization one step further by allowing the preparer to show possible future conditions or reconstructions of past historical conditions. Ervin (1992) explored the use of computer simulation technology to produce landscape images of future land management alternatives, enabling planners to carry out a series of simple "what if?" exercises. For example, a community could ask, "What if we used partial cutting as opposed to clearcutting on this hillside?" and see visualizations comparing the effects of these two silvicultural systems. Just as with photographs, some visualization applications can show early morning or sunset conditions, summer or winter conditions, or even long-term changes. In forestry, for example, it is often important to show the regeneration of harvested or disturbed areas over the length of a forest rotation (Figure 3); however, such uses are still quite rare because, in the absence of sophisticated models of ecological and silvicultural conditions, predicting landscape conditions over the long term is difficult.

Stephen Sheppard and several of his CALP graduate students have taken visualization further along the path towards ecologically rigorous and photo-realistic simulation of future conditions. Their work on the Arrow Innovative Forest Practices Agreement (IFPA) incorporates growth and yield software (FORECAST; ***www.forestry.ubc.ca/forestmodels/mod/forecast/forecast.htm***), timber supply software (Atlas; ***www.forestry.ubc.ca/atlas-simfor/atlas/about.html***), and habitat supply software (SIMFOR; ***www.forestry.ubc.ca/simfor/***). The modelling package uses visualization software (i.e., WCS) to create photo-realistic models that, projected through time, show how different harvesting plans will develop and change across the landscape. Ultimately, this visualization output was used to investigate community perceptions of alternative forest management scenarios in the Slocan Valley of British Columbia and surrounding areas (for results of this work, see: ***www.calp.forestry.ubc.ca/projects_Arrow.htm***). The integration of visualization with other stand- and landscape-level modelling software is one of the few available options that illustrate how harvested areas change over time. This software package requires significant technical support to produce the dynamic images and is currently not commercially available.

Community Consultation

Forestry planners and resource managers from government, industry, and the conventional consulting industry have applied land-based computer technologies such as GIS to resource inventory and management. These technologies are also occasionally used for public consultation in the provincial Forest Development Plan (FDP) process, which reviews and approves logging operations. In these contexts, plan information is translated into map data and text, which is then presented as wall posters at open houses or meetings, or as planning reports or information on the Internet. However, people often find it difficult to understand text and maps used in the FDP process. The inadequacy of cartographic presentation formats in conventional public processes has been clearly articulated through research (Duerden and Keller 1992; Crerar *et al.* 1999; Lewis 2000; Lewis and Sheppard, in review) and by organizations such as the British Columbia Forest Practices Board:

> *While the public is usually provided an adequate opportunity to review and comment on FDPs … the presentation of plan material may not always be appropriate for the intended audience … [who] often lack the technical knowledge and resources to provide informed comments on FDPs (B.C. Forest Practices Board 2000).*

The ability to understand resource maps and mentally reconstruct the landscape from two-dimensional cartographic symbols is taken for granted by those who

FIGURE 3. Time series visualizations of strip-selection harvesting on Little Gavin Lake at the University of British Columbia's Alex Fraser Research Forest: (a) existing condition, (b) first entry (year 1), (c) third entry (year 40), and (d) final entry (year 80). Visualization credit: John Lewis, Collaborative for Advanced Landscape Planning, University of British Columbia, Vancouver, B.C.

frequently use conventional planimetric maps. In reality, relatively few people can look at a map and visualize the landscape that it represents. Pictures ultimately say a great deal more than an abstract, often confusing, assortment of points, lines, and polygons (Figure 4). The research conducted by CALP members underscores the need for more accurate and realistic visual representations of land use plans to enhance understanding by local communities. Such representations would also:

- explain complex projects, mapped information, and technical issues to local community representatives who may not be familiar with reading maps and interpreting other technical information;
- provide a check on information supplied by others (e.g., government agencies or forest companies), which would serve to highlight any concerns or errors that might otherwise go undetected with map or report information; and
- provide a simple means to verify actual performance by comparing the implementation of projects on the ground with the visualization of predicted conditions.

Implications

Inevitably, integrated GIS and landscape visualization technologies will become accessible to most forest management planning and community organizations (e.g., First Nations bands and tribal councils) within the next 5–10 years as the cost and technical complexity of the software decreases. Advances in technology will also enhance the display and use of visualization output in more sophisticated ways. For example, animated visualizations will fly or drive viewers through the landscape and viewers will be able to change the viewing direction at will, as with QuickTime™ Virtual Reality applications; visualizations projected onto panoramic screens will provide an immersive visual experience making viewers feel as if they are at the actual site; and

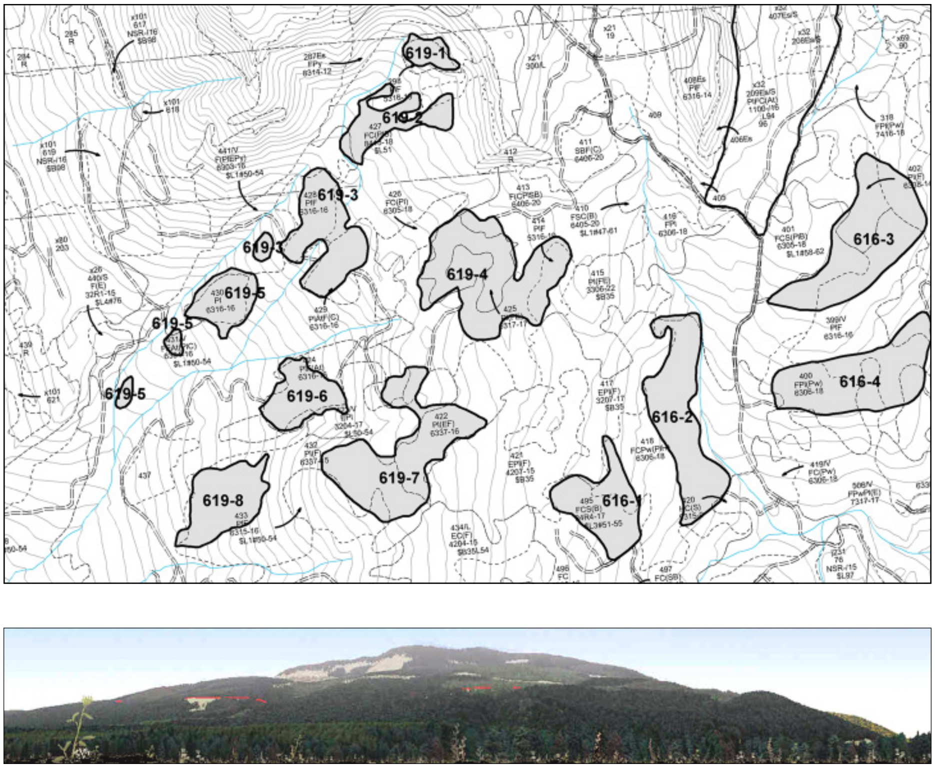


FIGURE 4. Reproduction of Forest Development Plan data in cartographic and visualization formats. The difficulties that public stakeholders encountered in their efforts to interpret the map information related to the map's graphic complexity, as well as trying to mentally visualize the temporal sequence of the proposed harvest plan on the southeast slope of Mount Ida near Salmon Arm, B.C. Their capacity to interpret and comment on the plan information was greatly enhanced by converting the Geographic Information System-based plan data into the photo-realistic visualization shown at the bottom. Visualization map credit: John Lewis, Collaborative for Advanced Landscape Planning, University of British Columbia, Vancouver, B.C.

increasingly, image content will be queried or manipulated by viewers using a computer mouse or laser pointer.

Despite the widespread and growing application of visual simulation techniques in some sectors of environmental planning and research, few standards exist to guide the use of landscape visualizations. These tools must be applied in appropriate ways by users who are mindful both of their inherent benefits and their potential limitations and disadvantages. If important issues cannot be visually displayed with ease, or if supportive data are not available, then landscape visualization will be of little benefit. Worse yet, either intentionally or unwittingly, this technology may be used a biased manner, which could mislead the public or decision makers about the potential impacts of a management proposal.

Landscape visualization tools must be applied in appropriate ways by users who are mindful both of their inherent benefits and their potential limitations and disadvantages.

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