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Research Paper

# Using 3D visualization methods in landscape planning: An evaluation of options and practical issues

Andrew Lovett[a,*], Katy Appleton[a], Barty Warren-Kretzschmar[b], Christina Von Haaren[c]

[a] School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK
[b] Department of Landscape Architecture and Environmental Planning, Utah State University, 4005 Old Main Hill, Logan, UT 84322-4005, USA
[c] Department of Environmental Planning, Leibniz University Hannover, Herrenhäuser Str. 2, Hannover D 30419, Germany

## HIGHLIGHTS

- Landscape visualization methods should be tailored to planning process stage.
- Intended purpose, audience and resources should influence content and presentation.
- Stakeholder involvement in visualization design can improve communication efficacy.
- Robust, empirical research is needed to better compare visualization options.
- Visualization methods require structured evaluation in real planning contexts.

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## ABSTRACT

Technical advances in landscape visualization have tended to, and still do, outstrip the understanding of how best to use them in practical planning contexts. This paper draws upon recent literature and experience gained during a number of projects to address three key questions regarding the most effective use of 3D landscape visualizations for communication purposes. In essence these are "when?" (to use them), "what?" (to include) and "how?" (to display them). Three main visualization options (rendered still images, animations and real-time models) are compared and particular constraints and strengths are discussed. In addition, an evaluation is made of the ability of the information presented in landscape visualizations to meet criteria of credibility, salience and legitimacy when communicating with stakeholders. Closing guidance is given on the use of visualizations in landscape planning and suggestions regarding future research needs are made. These focus on the need for applications of 3D visualization techniques to be more systematically evaluated, ideally as part of landscape planning exercises where the benefits of particular approaches for different purposes and audiences are examined across all stages of the decision-making process.



## 1. Introduction

Visual communication, in one form or another, has a long history in environmental management, particularly in landscape architecture and planning (Zube, Simcox, & Law, 1987). Moreover, as the field of landscape planning has grown to cover a wider range of issues, and members of the public have become more involved, both the opportunity and need for visualization have increased. Starting in the 1970s, and particularly since the 1990s, the use of digital techniques for landscape representation has increased dramatically, with visualizations of greater realism and more interactive viewing capabilities, alongside substantial reductions in the costs involved (Bishop & Lange, 2005; Lovett, Appleton, & Jones, 2009). Nevertheless, despite the many options for landscape visualization now available to the planner, there remain a substantial research agenda in terms of both technical and practical application issues (Lange, 2011). With respect to the latter, it is striking that the comment made by Orland, Budthimedhee, and Uusitalo (2001, p. 147) over a decade ago about the trend for technical advances to outstrip the knowledge base of how to best use them in planning contexts, still finds echo in more recent papers. For instance, Pettit, Raymond, Bryan, and Lewis (2011, p. 232) note "little has

* Corresponding author. Tel.: +44 1603 593126; fax: +44 1603 591327.
*E-mail addresses:* a.lovett@uea.ac.uk (A. Lovett), k.appleton@uea.ac.uk (K. Appleton), warren@usu.edu (B. Warren-Kretzschmar), haaren@umwelt.uni-hannover.de (C. Von Haaren).

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been done in formally evaluating the strengths and weaknesses of landscape visualizations in communicating modeled landscape futures to multiple end users". This paper seeks to contribute to the literature on such practical implementation issues by drawing on experience gained during a number of recent studies to present guidance on what types of visualizations should be used during a landscape planning process and how they can be best displayed and employed.

Landscape visualization techniques take a variety of forms. Traditionally they included models, drawings and paintings. Since the 1960s photographs and photomontages have been widely used (e.g. Sheppard, 1989; Al-Kodmany, 1999) and from the 1990s the improved capabilities to link CAD, GIS and landscape visualization software have substantially enhanced the possibilities for digital representation. At the present time a common approach is to compile information for a study area in a CAD or GIS database and then generate three main types of 3D outputs. These can be summarized as rendered still images (or scrolling panoramas) from defined viewpoints, animated sequences (showing fly-throughs along specified paths or changes over time) and real-time models (or virtual worlds) where the user has the ability to freely navigate a landscape (Appleton, Lovett, Sünnenberg, & Dockerty, 2002). In the past decade the availability of free virtual globe software has opened up additional opportunities for real-time display, particularly given the scope for customization and incorporation of 3D buildings or vegetation (Schroth et al., 2011a; Harwood, Lovett, & Turner, 2012; Google Earth, 2013).

From the many studies that have used visualizations in the context of planning decisions it is clear that one of their key benefits is that they provide a "common language" to which all parties can relate (Kwartler, 2005). In addition, visualizations can be of value for the responses they stimulate. For example, Meitner et al. (2005, p. 203) note "It seems that simply creating a picture of a proposed management alternative causes people to question and think about these proposals in ways that they might not typically do otherwise". This can be attributed to the power of visualizations to encapsulate issues, helping to "bring home" choices and providing a focus for debate regarding alternative courses of action (Sheppard, 2006). In more conceptual terms, visualizations represent a mechanism to support the "boundary management" functions (i.e. communication, translation and mediation between actors) identified by Cash et al. (2003) as crucial for the creation of knowledge systems underpinning sustainable development.

A pragmatic answer to the question "why use landscape visualizations?" is therefore that they help facilitate the exchange of information and opinions between the wide variety of parties that can be involved in discussions on a planning issue. However, this communication needs to be multi-directional to build up a mutual understanding of possible problems or solutions, and it is essential to recognize that simply creating visualizations (of whatever sophistication) does not necessarily achieve this goal (Steinitz, 2012). The design and display of visualizations often needs to vary according to context, particularly the stage in the planning process (Williams, Ford, Bishop, Loiterton, & Hickey, 2007; Wissen Hayek, 2011). For instance, a broad "visioning" exercise concerned with plan creation might usefully employ a more abstract approach than an application in development control where site-specific detail is important (Kwartler & Longo, 2008).

Elaborating on the basic role of communication, other "boundary spanning" functions that landscape visualizations can perform include facilitating engagement (raising interest in an issue), developing shared understandings (social learning), collaboration (reaching agreement on a course of action), mediation (e.g. resolving conflicts regarding criteria for decision making) and education (e.g. encouraging lifestyle changes that would support climate change mitigation and adaptation initiatives, Nicholson-Cole, 2005). For a visualization to be effective in any of these roles it needs to possess certain characteristics. Sheppard (1989, p. 51) defines good visual simulations as "pictures or images that meet the following fundamental objectives: (1) they are understood by people, (2) they are convincing to people, and (3) they are unbiased". Similar views are expressed by Cash et al. (2003, p. 8086) in the broader context of environmental assessments when they suggest that "information is likely to be effective in influencing the evolution of social responses to public issues to the extent that the information is perceived by relevant stakeholders to be not only credible, but also salient and legitimate". In their terminology credibility relates to the scientific adequacy of the underpinning evidence, salience concerns relevance to the needs of stakeholders and legitimacy stems from the perception that the production of information has been unbiased and fair in its treatment of opposing views. Cash et al. (2003) also emphasise that these criteria may be coupled so that efforts to improve one can impair another (e.g. Clark, Mitchell, Cash, and Alcock (2002) note that increasing the legitimacy of a participatory process by making it accessible to a wide range of actors may require compromises in information content such that scientific credibility is reduced) and an appropriate balance needs to be sought. In the particular context of landscape visualizations it is also important to consider how these criteria relate to both the overarching context (i.e. the setting for visualization creation and use) as well as the end products viewed or evaluated by different participants.

For visualization products a further key criterion is that of validity which concerns the extent to which reactions or decisions based on visualizations are similar to those that would be obtained with views of the real-life landscape represented (Zube et al., 1987). However, there is much debate in the research literature as to how validity can be assessed and the extent to which it is achieved by different techniques (e.g. Daniel & Meitner, 2001; Lange, 2001; Wergles & Muhar, 2009), not least when possible futures are being simulated for which no current comparison is possible (Sheppard, 2012). In addition, it is essential to recognize that any 3D landscape visualization, as with a 2D map, is inevitably an abstraction of reality (Wood & Fels, 2008) and that consequently any decisions made regarding content or presentation should reflect fitness for purpose with regard to the roles and objectives mentioned above.

During the past five years we have been involved in a number of studies that have utilised the full range of 3D visualization techniques outlined in previous paragraphs. The contexts of these applications have included multi-functional rural development (e.g. van Berkel, Carvalho-Ribeiro, Verburg, & Lovett, 2011), public attitudes to energy crops (e.g. Dockerty, Appleton, & Lovett, 2012) and community-scale landscape planning (e.g. Warren-Kretzschmar, 2011). This paper does not intend to discuss the detailed findings of these projects, but it does draw upon the wider experience gained, coupled with other publications from the research literature, to address what we see as important practical questions regarding the use of landscape visualizations. Any participatory planning process needs to address a set of definitional questions (i.e. what are the issues? how should change occur or stakeholders be engaged? e.g. see Schroth, 2010; Steinitz, 2012) which, in turn, shape the setting in which visualizations may be developed. Key issues in this latter respect are "when?" (to use them), "what?" (to include) and "how?" (to display them). Fig. 1 links these questions in terms of a framework of issues to consider when developing and using visualizations. Aspects of the setting will influence matters of content and presentation, but these latter two can also interact with each other (e.g. decisions regarding the desired level of realism may impact on display options) to shape the types of visualizations produced. During a project it is also possible that there can be feedback effects so that, for example, initial visualizations alter audience opinions and lead to changes in

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