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Bridging the sustainability gap with landscape visualisation in community visioning hubs

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Abstract

There is a substantial gap between awareness and action on sustainability issues. This paper addresses the potential of landscape visualisation, integrated with other participatory modelling tools and disseminated through the mechanism of community visioning hubs, in advancing peoples' awareness of sustainability issues such as climate change, and possibly affecting behaviour and policy. The ability of visual communications to accelerate social learning has long been recognised. Realistic landscape visualisations offer special advantages in bringing home to people the possible consequences of unsustainable behaviour or climate change mitigation strategies; they can be compelling, in part through engaging the emotions on local and personal issues. The rationale for such hopes is reviewed in the context of a proposed theoretical framework on the effects of landscape visualisation on perceptions and behaviour; implications are also reviewed for the persuasive use of visualisations following principles of disclosure, drama, and defensibility. Methods of developing landscape visualisations to express salient future sustainability scenarios are explored, together with ways to incorporate them into public dialogue, community planning, and decision-making. The concept of neutral, community visioning hubs, providing the public with access to advanced interactive, immersive visualisation capabilities in a Decision Theatre setting, is developed.

Keywords: Visualisation; climate change; visual communications; carbon consciousness; behavioural response; community planning; sustainability; public perceptions; decision support.

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1 Introduction: The need for increased public awareness, individual action, and policy response on sustainability

Evidence of the misuse of resources and high-consumption lifestyles, and resulting impacts on society and the environment, are discussed at length elsewhere in other publications, for example in the area of climate change impacts and adaptation imperatives (e.g., Fawcett et al., 2002; Adger, 2003). Many authors have addressed the substantial gap between the possession of environmental knowledge or behavioural intent and actual pro-environmental behaviour (e.g., Kollmuss & Agyeman, 2002; Trumbo & O'Keefe, 2004).

The principal question therefore becomes: what are the most effective ways to stimulate sustainable behaviours in society before crises occur? (Tickell, 2002). In a previous paper (Sheppard, 2005*a*), the author explored the hypothesis that certain kinds of visual communication (i.e., landscape visualisations) which show future landscapes and which engage the emotions, may substantially improve the awareness-building process on issues of climate change; furthermore, they may help motivate behavioural change at the individual to societal levels. This paper summarises the theoretical context for this assertion, and examines how such visualisation systems, combined with other modelling and planning tools, could be made available to a wider public through a system of visioning hubs within an enhanced planning infrastructure.

The next section (Section 2) provides a brief overview of the rationale and guiding principles for the role of landscape visualisation in promoting awareness and pro-environmental behaviour. Climate change examples will be used to illustrate this potential to address sustainability gaps. Section 3 examines how such visualisations could be produced to address awareness and action on climate change, and identifies preferred means to make such visioning systems accessible to planners and the public via community visioning hubs. Section 4 concludes with research priorities.

2 The rationale for using landscape visualisation to influence awareness, attitudes, and behaviour around sustainability

This section examines the potential benefits of using landscape visualisation on sustainability issues, briefly reviews the theoretical basis for and early evidence of impacts on awareness and behaviour, and summarises proposed guiding principles for the use of visualisation in this context.

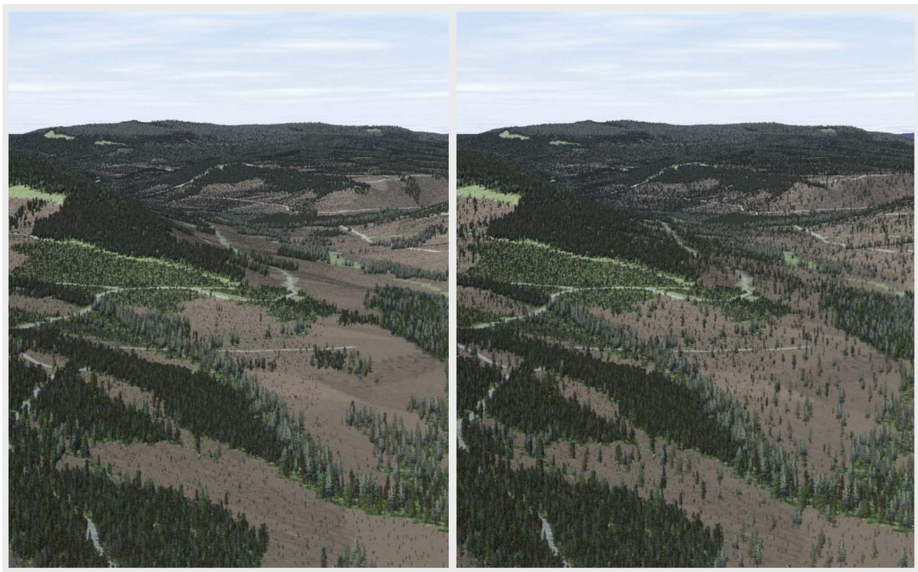


Figure 1: Visualisations of landscapes can now be modelled and realistically rendered rapidly from any viewpoint and under many different conditions, such as this depiction of forest management alternatives after 38 years of plan implementation. CREDIT: Collaborative for Advanced Landscape Planning (CALP), UBC.

2.1 Potential benefits of landscape visualisation in increasing environmental awareness and influencing behaviour.

The ability of visual imagery to communicate messages quickly and powerfully has long been recognized and utilized in fields of human activity. The cognitive advantages of visual information over written or verbal information have been widely documented (e.g., Tufte, 1983). Cognitive information processing associated with rational analytical thinking occurs in different parts of the brain from emotional processes associated with affective responses and innate, instant reflexes such as fear or happiness (LeDouk, 2000). Visual imagery can also be a powerful tool to reach this emotional side (Slovic et al., 2002), as witnessed in the more dramatic imagery from the news media.

Among the various forms of visual imagery available, landscape visualisation may have some unique characteristics which could be beneficial in bringing consequences of environmental change home to people in a compelling manner. Landscape visualisation attempts to represent actual places and on-the-ground conditions in three-dimensional (3D) perspective views (Figure 1), with varying degrees of realism (Sheppard & Salter, 2004). These specific forms of visualisation or virtual reality are now typically computer-generated in three or four dimensions, and can convey detailed information on the expected future appearance of environments under certain assumed conditions. This amounts to a unique form of visual communication, conveying information in the dominant form to which the human species is genetically adapted (i.e., visual landscapes) but capable of showing future worlds as they would be seen by the human eye if the viewer were actually there. To date, landscape visualisations have been used primarily in urban or natural resource planning and design (Porter, 1979; Bosselmann, 1998). Recent breakthroughs in real-time photo-realistic landscape visualisation, based on interactive 3D modelling of terrain, buildings, and vegetation, provide unprecedented possibilities for dynamic viewing of future environments over space and time (Figure 1) (Danahy, 2001). In recent years, this expanded technology has begun to be applied to multiple-objective community or resource planning, whereby alternative future landscapes are projected to aid visioning, analysis, public input, and decision-making (Tress & Tress, 2003; Steinitz et al., 2003; Sheppard & Meitner, 2005). In the remainder of this chapter, the term 'visualisation' refers to landscape visualisation, unless otherwise noted.

In the context of sustainability awareness-building and environmental decision-making, potential benefits of landscape visualisation include:

- The combination of the predictive capabilities of modelling and GIS with the intuitive and experientially rich media of photography and realistic representation, providing 'windows into the future' with potentially meaningful socio-cultural associations for lay-people;

- The ability to localize the information by detailed depiction of recognizable and familiar sites as they would be seen by local residents or users, in contrast to a detached plan, aerial view, or an expert's conceptualization.

- The ability to present alternative futures side-by-side and pose 'what-if' questions (Ervin, 1998; Steinitz et al., 2003);

- Transparency and flexibility: digital visualisation techniques can be augmented or modified to highlight or simplify almost any aspect of the 4D modelling being conducted, such as underlying meta-data or different levels of realism selected by the user (Sheppard, 2005*b*);

- Attractiveness to lay-people, due to the novelty of the medium and its dynamism and interactivity.

2.2 Theoretical basis and early evidence for the impact of visualisation on awareness, attitudes, and behaviour around sustainability.

This section addresses issues of whether, why, and how landscape visualisations can be expected to impact awareness, perceptions, behaviour and policy on sustainability. It briefly reviews theoretical concepts and available evidence on people's response to landscape visualisation in planning and public perception contexts. There has been little work to date on integrative theories supported by empirical studies to explain or assess the impact of visualisation on the full

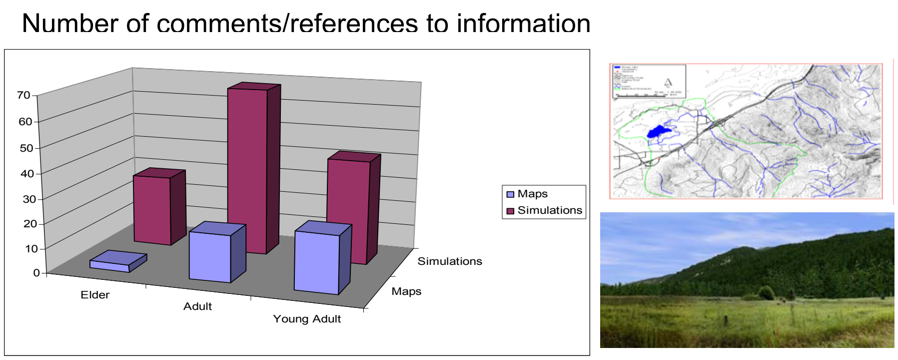


Figure 2: The impact of imagery: substantially increased dialogue was obtained with members of a First Nation community on resource management issues when using realistic landscape visualisations, compared with using simple GIS maps. CREDIT: John Lewis, CALP, UBC. Courtesy of Cheam Band, B.C. Reprinted from Sheppard (2005*a*).

range of responses to sustainability issues (Sheppard, 2005*a*). In particular, few actual climate change visualisations have yet been produced to scientific standards, and to the author's knowledge, no studies have yet been published which formally collected responses to such visualisations. Consequently, we must rely on other precedents and applicable theory.

A considerable proportion of the empirical research that has been carried out to evaluate visualisations in general usage focuses on the users' or participants' assessment of their utility. There is already considerable evidence of the apparent communications effectiveness and usability of landscape visualisation in planning and decision support (e.g., Bengtsson et al., 1997; Al-Kodmany, 2000; Appleton & Lovett, 2003; Sheppard & Meitner, 2005), including the ability to engage lay-people (MacEachren, 2001; Lewis & Sheppard, 2006) (Figure 2). Realistic, immersive, and/or interactive systems have demonstrated high levels of engagement with users (e.g., Winn, 1997; Salter, 2005), and some early research findings suggest credibility with diverse publics can be high (Sheppard et al., 2004). However, self-report evidence from users or viewers of visualisations on its own does not reliably demonstrate whether people are actually learning appropriately from visualisations or engaging emotionally with them (Lewis & Sheppard, 2006).

Human responses to environmental or visual stimuli such as landscape visualisations can be broadly categorized as cognitive (related to knowledge and understanding), affective (related to feelings, perceptions, and emotions such as like/dislike, anxiety, or fear), and behavioural (related to changes in behaviour of the viewer) (Zube et al., 1982). There has been some research on the effectiveness of visualisation in cognition, e.g., with 'digital workshops' in a planning context (Campell & Salter, 2004). Research by Winn (1997), Furness III et al. (1998) and Salter (2005) suggests that interactive 3D visualisation displays may provide qualitatively and quantitatively superior forms of teaching and learning relative to other media in fields such as environmental change and forest planning. There has also been some research on the nature of affective responses (e.g., Bishop & Rohrmann, 2003). Daniel & Meitner (2001) describe several studies which show that visualisations can stimulate positive or negative emotional reactions in observers, but few studies have measured the degree of emotional intensity aroused.

Nicholson-Cole (2005) documented the influence of popular visual media on people's mental imagery of climate change, and found that respondents were most emotionally affected by national, local, and personal imagery rather than international imagery, in part because it was easier to relate to and more salient. This is consistent views expressed by the IPCC (2001) and others: "there is a better prospect for mobilizing stakeholder interest and concern if climate change impact can be demonstrated 'on the ground', in familiar locations, and upon landmarks and businesses, etc.," (Shackley & Deanwood, 2002, p. 381.)

Very few studies have been carried out on the behavioural impacts of landscape visualisation, either during the exposure to the visualisation material or afterwards in the short and long term. Research is underway at the Collaborative for Advanced Landscape Planning (CALP) to track behaviour in collaborative immersive settings during planning charettes (Campell & Salter, 2004). Orland (1992, p. 259) has speculated that visualisations may be used "in a more persuasive mode to motivate people to do something about the impact being represented." Supporting evidence with other media includes: McKenzie-Mohr & Smith (1999), reporting that using social marketing to change behaviour depends on visual and other communications that are vivid, personal, and concrete; Slovic et al. (2002, p. 398), stating that "many theorists have given affect a direct and primary role in motivating behaviour," and suggesting that vivid and sensational narratives associated with feelings rather than with cognition have more influence on risk behaviours; and Kollmuss & Agyeman (2002), describing the increased effectiveness of fear, sadness, or pain in triggering pro-environmental behaviours. Nicholson-Cole (2005, p. 267.) found that her participants felt they would be more motivated to take some action on climate change "if they could understand what it would mean for them, what they could do, and be regularly reminded of that by the media, government efforts, and other everyday sources of information." Lowe et al. (2006) have evaluated attitudes and behaviour of people who watched the film "The Day after Tomorrow" which contained extensive visualisations of supposed climate change effects, and found both attitude change and some limited changes in behavioural intent, especially immediately after the viewing.

There is also the important issue of how the use of visualisation could influence policy, either directly through presentations to key decision-makers and policy-makers, or indirectly through public opinion and collective individual actions. While there is little scientific information on such policy responses to visualisation, there is some evidence from visualisation practice that use of computer visualisations has led to significant policy changes in planning strategies and approvals (Sheppard, 2005*a*). Cohen (1997) used GIS and remote sensing imagery with other information in communicating climate change scenarios to stakeholders in northwest Canada, who reported that the scenarios made a difference in their visions of the future and potential interventions in policy debates.

Drawing these threads together, we should expect that landscape visualisations may condense complex information, convey strong, salient messages quickly and memorably, arouse emotional feelings, make experiences more meaningful, and motivate at least the intent of personal action on sustainability issues such as climate change (Nicholson-Cole, 2005; Sheppard, 2005*a*). It is argued that visualisations may help to accelerate social learning and behavioural change in particular by bringing sustainability home to people in their back yard: for example, "making climate change personal". A key challenge for visualisation is therefore to make future implications of environmental, policy and behavioural choices relevant and tangible to people at the local level now. It is understood that in reality a combination of techniques and influences will be required to effect societal change on sustainability issues; this chapter attempts to articulate the additional or value-added contributions of visualisation within larger planning systems, and is not meant to imply that visualisations alone can achieve societal transformation.

Kollmuss & Agyeman (2002) and Lorenzoni & Langford (2001) describe various forms of barrier or gaps between perceptions/intentions and actions conducive to climate change mitigation, These gaps include gaps in cognition and awareness (ignorance), gaps between knowledge and intent to act, and gaps between intent and real action. Based on a synthesis and simplification of the available evidence and theoretical arguments discussed above, Sheppard (2005*a*) presents a conceptual diagram in the form of a spectrum (Figure 3) of possible responses to visual information on climate change. This spectrum (shown on the right side of the diagram in Figure 3) represents different states of awareness or perceptions of climate change, ranging from a low state of awareness to action; the hypothesis is that gaps between different levels of awareness, attitude, and action may be bridged by a progression from cognitive processing of information, through emotional responses, ultimately to behavioural responses, perhaps stimulated by different kinds of imagery (see below). The spectrum is not meant to imply that chronologically any individual will move through the range of responses in this specific order; it is presented here as a simple way of structuring the types of response we may look for as the result of applying different types of visualisations of climate change (see below) as tools for learning and engagement/motivation. It is recognised that there are many other models of pro-environmental behaviour which may not be reflected in this simplified framework.

In the context of promoting pro-sustainability attitudes and action, ethical questions loom large. Various authors (e.g., Luymes, 2001; Orland & Uusitalo, 2001; Sheppard, 1989, 2001) express concerns about the high credibility and low transparency of realistic immersive forms of virtual reality, which foster assumptions of authority and scientific neutrality that are not necessarily deserved. There is the risk of biased responses from unintentional imbalances

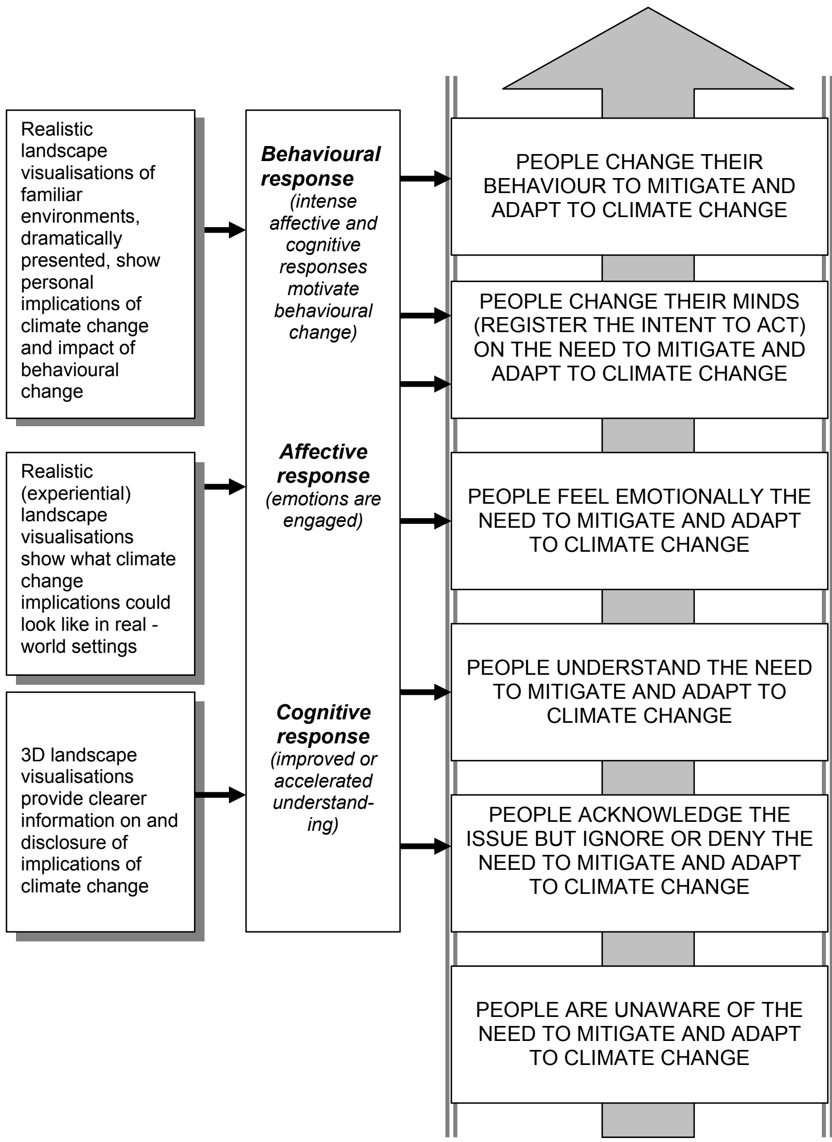


Figure 3: Theoretical effects of different types of landscape visualisations in stimulating a spectrum of perceptual and behavioural responses to climate change. Reprinted from Sheppard (2005*c*), with permission from Elsevier.

or deliberate attempts to mislead or exaggerate (McQuillan, 1998). Sheppard (2005*a*) has listed various other risks in such use of visualisations, including:

- Lack of credibility (Sheppard, 1989) of the visualisation imagery or the underlying modelling/assumptions where these cannot be explained or appear to be in error.
- The risk of overkill through over-stimulation or information overload (Orford et al., 1999; McKenzie-Mohr & Smith, 1999).
- The risk of confusion: visualisation of climate change scenarios with their attendant massive uncertainty and complexity could simply confuse people with the number of policy assumptions, contingencies, associated risks, and consequent choices to be considered.
- The risk of upsetting people and triggering emotional reactions such as fear or unease which may be counter-productive to fostering engagement and action (Furness III et al., 1998; Nicholson-Cole, 2005).
- The risk of trivialising or downplaying real sustainability problems with visualisations that are visually too subtle or depict positive imagery that may result, for example, from some climate change scenarios in certain areas at certain times (Sheppard, 2005*a*).

Arguments for the deliberate use of visualisation to influence the public or impact government policy emphasize the need to forestall an actual sustainability crisis and simply disclose the truth: Luymes (2001) has advocated the use of powerful visualisation tools to shape public values on sustainable forestry practices, for example. There is also an argument that scientifically-produced visualisations are needed to counter the misinformation propagated by entertainment media such as the recent film "The Day After Tomorrow", while utilizing a similar medium and technique. More generally, Michaelis (2003) has argued for a government strategy to change public behaviour on greenhouse gas emissions through a process of leadership, dialogue, and facilitation: there would appear to be a strong role for visualisation in helping project "visions for a sustainable way of living" (Michaelis, 2003, p. S143.).

2.3 Guiding principles and criteria in visualising sustainability issues.

Based on the theoretical framework described by Sheppard (2005*a*), in order to bridge the various kinds of perceptual or behavioural gaps on climate change, different forms of visualisation may be required, as suggested on the left side of Figure 3. Cognitively effective landscape visualisation might focus on disclosure of possible future effects, through augmenting reality to make the invisible visible, collapsing long time horizons into short periods, and jumping in scale quickly (Winn, 1997; Furness III et al., 1998). Clarity of message is important

Present Day

S1 – 2050

S4 - 2050

Figure 4: Generic landscape visualisations of existing conditions and future climate change mitigation scenarios, showing ærial views and semi-realistic rendering. CREDIT: Credit: Images from "Visualizing renewable Energy in the Landscape of 2050": Copyright of The Countryside Agency. Images by ethos-uk.com. *S4 scenario uses energy projections from the Royal Commission for Environmental Pollution.

Figure 5: Landscape visualisations comparing existing conditions and a hypothetical low-carbon future in southern England. CREDIT: Cecilia Achiam, CALP UBC. Reprinted from Sheppard (2005*c*), with permission from Elsevier.

in promoting cognition (Sheppard, 1989) (Figure 4), but there is debate whether realism helps or hinders cognition (e.g., Furness III et al., 1998).

In order to reach the emotional side of viewers, the following additional attributes of visualisation would appear to be important:

- Realism, in the sense of photorealistic or 'lifelike' imagery in re-creating experiential qualities (Appleyard, 1977) and making abstract concepts 'concrete' (McKenzie-Mohr & Smith, 1999)(Figure 5);

- Depicting personally relevant environments, such as local and recognizable neighbourhoods (Nicholson-Cole, 2005) or iconic, well-known landscape symbols to which people can relate (Sheppard, 2005*a*). The environmental psychology literature has demonstrated that familiar landscapes tend to be associated with stronger and more positive affective responses (e.g., Kaplan & Herbert, 1988). People seem most affected by personal implications of climate change (McKenzie-Mohr & Smith, 1999; Nicholson-Cole, 2005).

- Immediacy: near-term conditions (Lorenzoni & Langford, 2001) or possibly longer-term conditions made to seem more near-term by speeding up time, combined with meaningful locales which the viewer can relate to tangible future considerations such as their grand-children's environment.

- Containing images of people, animals, or other symbols with strong affective content (Nicholson-Cole, 2005).

Furness III et al. (1998, p. 28) argues that "Using simulations so that students may see the future consequences of their actions or of their inactions can help them become more responsible citizens. Doing so within a compelling virtual environment will likely heighten their motivation to act responsibly." In theory, behaviour change therefore may require the emotional and rational attributes of visualisation described above, but intensified to be vivid and memorable (McKenzie-Mohr & Smith, 1999). Winn (1997) and Furness III et al. (1998), among others, argue that compelling visualisations can be obtained through a range of dramatic effects:

- Immersion in a virtual environment: large images and panoramic 'wrap-around' displays (Figure 6) can increase the sense of presence (Furness III et al., 1998), engagement (Appleyard, 1977), and intensity of experience (Sheppard et al., 2001);

- Dynamic or animated imagery that increases enthusiasm and engagement (e.g., Dykes, 2000) and/or provides freedom of virtual movement for the viewer (Orland & Uusitalo, 2001);

- Interactivity with the displayed data in real-time, to increase engagement (Morris & Ogan, 1996, cited by Orland & Uusitalo (2001)).

Figure 6: An immersive visualisation environment which can present life-size panoramic imagery on large wrap-around screens, sometimes to dramatic effect. CREDIT: CALP, UBC.

The type of content in the climate change message appears important if behaviour is to be influenced. McKenzie-Mohr & Smith (1999) argue that messages which emphasize environmental losses due to inaction are consistently more persuasive than those which simply emphasize benefits of action; nevertheless, such threats should be combined with positive implications of action to overcome the barrier of helplessness (Kollmuss & Agyeman, 2002), and to relate individual action to cumulative societal behaviour and resulting benefits or impacts.

In order to minimize the kinds of risk identified earlier, and to maintain and demonstrate a credible and ethical stance, defensible methodologies are needed for preparing visualisations. If there is no overall scientific or logical underpinning to the visualisations, they are unlikely to change peoples' minds, particularly given the high levels of uncertainty associated with climate change. The development and presentation of visualisations by a trusted source (Sheppard & Meitner, 2005; Nicholson-Cole, 2005) would appear to be an important aspect of defensibility. Allowing the doubtful or sceptical user to interactively and freely navigate and interrogate the visualisation imagery and underlying databases, and to choose their own viewing conditions or view sequence, may help in assuring defensibility (Furness III et al., 1998; Sheppard & Salter, 2004). Another strategy for building in defensibility would be to ensure effective stakeholder participation in the development of socioeconomic scenarios (Robinson, 2003), in the application of decision-rules for visualising the scenarios, and even in the process of generating the visualisations (Sheppard & Salter, 2004). While such actions are relatively seldom done today, they could be crucial in the emotional context of climate change and public persuasion.

In summary, therefore, there is strong evidence of the cognitive effectiveness of visualising global change, a strong likelihood of the ability to engender emotional responses, and the possibility that the use of landscape visualisation could affect behaviour with regard to climate change. Success would appear to require: 1) Disclosure: a window into the future which is personally meaningful and tangible, making the global both local and personal, putting scientific information into understandable forms and contexts, and showing possible negative and positive outcomes; 2) Drama: a vivid and compelling presentation with emotional content, landscape realism, and intensity of engagement in the display media; and 3) Defensibility: a systematic and credible process that enables transparency and trust in the presenters and underlying information. However the effectiveness of visualisation would be dependent on many factors including the intended purpose of the exercise (i.e., nature of response sought), socio-cultural and environmental context, the contribution of other forms of information, and the type of audience.

3 Delivering landscape visualisation to the community

What we may label as the '3Ds' of visualising issues such as climate change—disclosure, drama, and defensibility—need to be delivered through a set of practical procedures and standards, perhaps adapted from existing models for visualisation codes of ethics (Sheppard, 2001, 2005*b*), in order to reflect an increased emphasis on awareness building and behavioural impact. Implementation would require both a systematic process for integrating visualisation into modelling and other sustainability education and decision-support tools, and a way to make the resulting visioning system accessible to the public and other potential users.

3.1 A process for sustainability visioning with landscape visualisation.

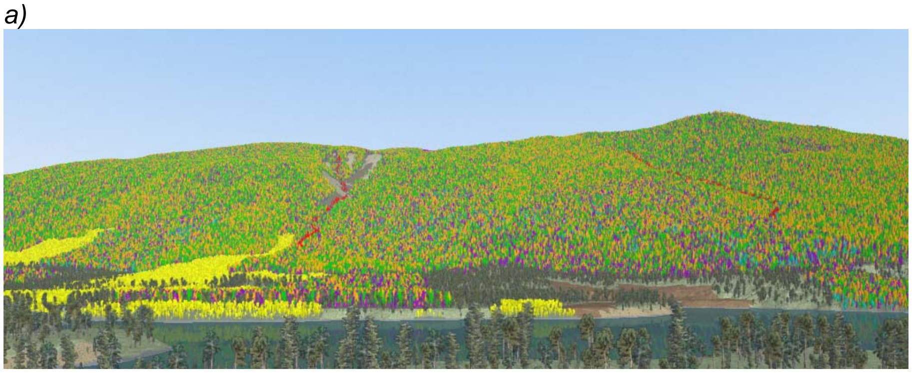
Here we consider how our present knowledge and theory on visualisation can be applied in a process for generating visualisations of future community scenarios that can increase awareness and perhaps motivate action on sustainability, focusing on climate change. The issue here is how defensibly to achieve disclosure of possible future implications, with the emphasis on dramatic content: essentially, how to spatialise, localise, personalise, and visualise the phenomenon of climate change.

The characteristics of climate and climate change render them difficult to visualise in some ways. Carbon dioxide, and even the carbon source itself is effectively invisible. Tickell (2002) has described the problems of communicating change which occurs over long time periods and of acceptance of uncomfortable and uncertain future consequences with or without action. Winn (1997) and Nicholson-Cole (2005) have described the complexity and abstraction of climate change (as typically presented in a scientific context) as a challenge to communicate. It is also difficult to relate global or national figures on climate change to local scales and spatial variability (Furness III et al., 1998), and for individuals to relate their actions (good or bad) to the larger state of climate change (Nicholson-Cole, 2005).

Other implementation problems in visualising aspects of climate change, and possible approaches to them, include:

- representing uncertainty, e.g., through presentation devices (Dockerty et al., 2005) or through multiple alternative visualisations per given scenario as sensitivity tests.
- down-scaling from broad global, regional, or even local climate change scenarios (see below).
- representing critical non-visible data (within as well as outside the visualisation medium) to mediate and augment the visible aspects of climate change, though there remains the question of whether a blend of abstraction and realism, as shown in Figure 7 or with other forms of augmented

a)



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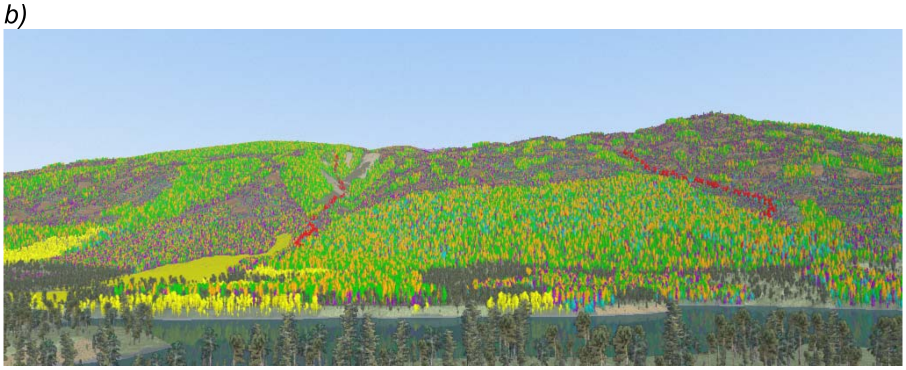

Figure 7: Non-visible data (in this case colour-coded tree species changing over time on a BC mountainside) can be displayed with landscape visualisations to express important trends or environmental changes due to policy implementation or climate change. CREDIT: Jon Salter, CALP, UBC. Reprinted from Sheppard (2005*c*), with permission from Elsevier.

a)

b)

Figure 8: Images such as these showing the visual impact of the loss of mature trees in a neighbourhood setting could be used to depict dramatically the effects of climate change on quality of life. CREDIT: Kathy Beaton, Canadian Forest Service, New Brunswick.

reality, can still deliver intense affective responses as well as cognition (Salter, 2005).

- choosing permissible types of drama, including dramatic content such as loss of mature trees or buildings (Figure 8), dramatic viewing conditions such as animated drive-throughs and unusual lighting, or dramatic display formats (see below)

The technical process of creating visualisations of landscapes with climate change requires the following steps and supporting infrastructure:

- Data acquisition for the study area in GIS format (standard geomatics 2D and 3D data, e.g., land use/cover, property mapping, topography, water features, etc.)

- Calibrating and running various models to help generate scenarios: e.g., climate change modelling, land use change modelling, ecosystem shift modelling (Berry et al., 2002); and to evaluate their impacts (e.g., visual impact modelling, economic or population modelling, etc.)

- Selection and development of scenarios, representing a range of plausible conditions over salient areas and time frames at salient locations (Sheppard, 2005*a*)

- Down-scaling or "telescoping" of model outputs to spatialize the scenarios at a regional scale, either through modelling refinements or qualitative processes informed by local and scientific experts (Cohen, 1997).

- Development of visualisation decision rules: the process of creating visualisations is never fully data-driven (Sheppard, 2001), since multiple decisions have to be made for example on viewpoints, lighting, season, site-specific interpretations to localise even down-scaled modelling (e.g., which trees die back), what human elements should be used to personalise the imagery, etc.

- Creation of visualisation and associated imagery using selected software such as Community Viz which links visual imagery interactively with non-visible data (Campell & Salter, 2004), Visual Nature Studio (e.g., Dockerty et al., 2005; Sheppard & Meitner, 2005), or other programmes.

- Preparation of other media to supplement the visualisation, e.g., tables, time-lapse maps, etc. (Sheppard & Meitner, 2005; Salter, 2005).

- Display of initial visualisations to permit review by users or project team members and revision if necessary, before use in decision-making.

The selection of appropriate global, regional, and local scenarios to visualise is a key decision. While the IPCC (Nakicenovic & Swart, 2000) and various levels of national and regional governments have developed generic alternative

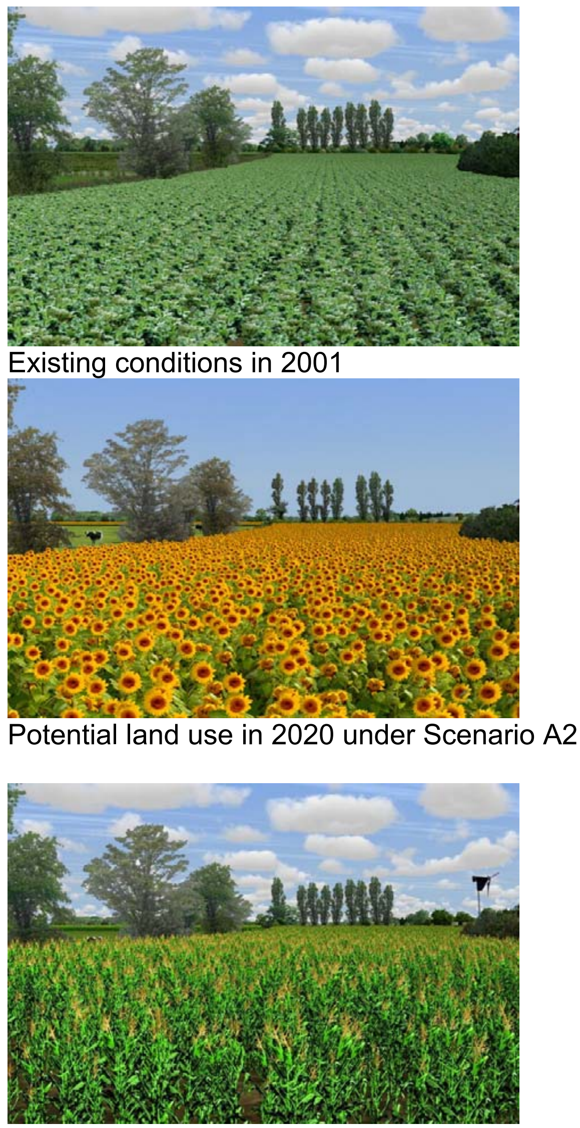

Figure 9: Examples of imagery showing existing rural landscape conditions and photo-realistic visualisations of the same landscapes affected by different climate change scenarios. CREDIT: Katy Appleton, University of East Anglia. Reproduced from Dockerty et al. (2005), courtesy of Computers, Environment & Urban Systems and Environmental Science & Policy/ Elsevier.

scenarios for future climate change and adaptation (e.g., UKCIP—Climate Impacts Programme, 2000), systematic mechanisms for down-scaling these to local landscapes are needed. However, these require multi-dimensional global or regional policy assumptions, complex socioeconomic scenarios, and multi-attribute modelling systems, which can be very abstract and remote for local communities (Shackley & Deanwood, 2003). Dockerty et al. (2005) describe one of the first studies to visualise scientifically predicted effects of climate change, in a rural landscape in Norfolk (Figure 9). Here, local scenarios visualised were developed from the four basic socioeconomic scenarios described by Nakicenovic & Swart (2000), by applying an agricultural land use model and locally-specific decision-rules and assumptions.

Mechanisms for developing and analyzing defensible visualisation scenarios which can be derived independently from the global scenarios (through a 'bottom-up' approach) may also be necessary. These could address specific local environmental or cultural issues which would be more meaningful to local planners and communities, and relate more to specific vulnerabilities than to much larger scale scenarios. The problem would lie in still making these visual scenarios scientifically grounded and credible. One possibility is for projection of documented local trends, e.g., drought, forest die-back, rising oil prices. Alternatively, there might be relevant scenarios which resonate with other initiatives or policy alternatives on climate change; for example, it would be informative to identify what Canadian communities might look like if everyone met the federal government's One Tonne Challenge to reduce personal greenhouse gas (GHG) emissions, or if 'Fossil-Fuel-Free Zones' were established. Careful studies of readily grasped conceptual scenarios, such as a radical increase in oil prices or rapid reduction in fossil-fuel supply (through for example a moratorium on all new fossil fuel production fields), might yield important information on the possible impacts on the economy, environment, and quality of life. Trade-offs could be examined to explore, for example, whether it is possible in western communities to maintain 80% of quality of life with 20% of current fossil fuel usage.

Downscaled scenarios to date have tended to focus on impacts, on mitigation measures, or on adaptation possibilities (Shackley & Deanwood, 2003). Integrated local scenarios may need to combine climate change assumptions on direct impacts (e.g., sea-level rise), adaptation (e.g., dyke-construction), and mitigation of CO_2 emissions (e.g., offshore wind energy development), to provide a more realistic range of salient conditions. One of the biggest challenges will be in articulating for the public the difference over time in aggressive mitigation actions versus less radical (and more likely) scenarios of compromise and delay. Scenarios will still need to combine both local policy assumptions with global assumptions: what if everyone does what we do to mitigate climate change, versus if only we do it and the rest continue largely as before? Disappointing results here could jeopardise climate change mitigation actions at the grass-roots level.

3.2 Disseminating visualisations

How should appropriate and localised visualisations be made widely accessible to communities, under conditions of controlled drama and defensibility? What would be the most effective mechanisms for disseminating visualisations to the public and policy makers? What infrastructure would be required?

Table 1 provides an initial classification of alternative dissemination mechanisms and media outlets, relative to principles and criteria identified in Subsection 2.3 for potentially effective visualisation, with a focus on the public setting for experiencing such visualisations. In addition to relevant aspects of disclosure, drama, and defensibility, issues of accessibility of visualisation to the public and impact on community-level decisions (as a vehicle for action on sustainability) are considered in Table 1. For example, visual imagery and sometimes landscape visualisations are already used in TV documentaries and Hollywood movies. Both these media can provide compelling visual imagery on sustainability issues, but suffer from serious limitations in conveying personal or local implications of climate change for most viewers. Fictional films may connect to individuals through personal identification with screen characters, but lack scientific credibility (Lowe et al., 2006). TV documentaries and even local news programmes lack much interactivity or personal control over information, and generally have weak linkages to planning processes and environmental outcomes.

By contrast, local and community-level planning fora, in democratic countries at least, provide a mechanism for almost universal access to the public as local tax-payers and affected residents, with an existing infrastructure that specifically organises some level of participation, addresses technical issues, and delivers the primary process for local decision-making. Planners are the people most qualified to address sustainability and climate change issues, and in many cases are already doing so. However, as Table 1 suggests, conventional planning fora are often woefully inadequate in conveying the future environment they deal with, typically lacking the facilities, expertise, and procedures to display compelling visualisation imagery and supporting quantitative modelling; partly because of the low level of drama and the formality of the procedures, conventional planning sessions are often not well attended by most community members. The author argues that more sophisticated community-based visioning hubs for delivering visualisation, with supporting models, data, Virtual Reality display techniques, public response capture systems, etc., could overcome some of the limitations of the local facilities, and attract greater community engagement. Such Decision Theatres could provide a neutral, interactive space for deliberation, supplemented by other media such as local TV, the internet, and even a return to news shorts in cinema previews. They could also extend their reach to more remote or rural communities through the use of mobile immersive visualisation equipment, particularly as this equipment becomes more portable and streamlined in operation. The facilities could be used for public education, ‘edutainment’, and awareness building; for long term strategic planning with scenarios as described in this chapter; and for shorter term traditional planning

Table 1: Potential effectiveness of various dissemination mechanisms for visualisation of sustainability and climate change issues. Effectiveness is rated as Low, Moderate, or High, respectively; Main advantages shown in shaded boxes; Serious limitations shown in italic bold text

	VISUALISATION PRINCIPLES						ACCESSIBILITY AND IMPACT		
	DISCLOSURE & SALIENCE		DRAMA		DEFENSIBILITY				
MEDIA	Local	Personal	Compelling visual imagery	Interest/excitement level and ease of comprehension	Scientific methods	Trusted source/ neutral ground	Capacity to display all visualisation aspects	Ability to reach the public	Link to community decision-making/action/ policy
Radio documentary/news	Mod	L-M	***None***	Mod	Mod	High	***None***	High	***Low***
Newspaper	High	Mod	Mod	M-H	Mod	Mod	***Low***	High	L-M
Television documentary/news	L-M	***Low***	M-H	M-H	Mod	High	Mod	High	***Low***
Movies: documentary	***Low***	***Low***	High	M-H	Mod	Mod	High	High	***Low***
Movies: fiction	***Low***	L-H	High	High	***None***	***Low***	High	High	***None***
Internet	M-H	Mod	M-H	M-H	M-H	M-H	M-H	High	L-M
Informal community dialogue	High	High	***None***	M-H	***None***	***Low***	***Low***	Mod	L-M
Conventional council planning session	High	M-H	***Low***	***Low***	M-H	M-H	L-M	L-M	High
Community-based visioning hub	High	M-H	High	M-H	High	High	High	M-H	High

applications on individual project approvals, to help defray costs.

Other policy issues include the question of who would plan, implement, and manage the process of delivering visualisations to the public and policy makers. Practical implementation would require not only a significant investment in hardware, software, and data, but also the adoption of ethical standards or codes and a considerable increase in planning staff skills if these were the chosen providers. The repeated use of such facilities is both necessary to maintain such an advanced capabilities (Sheppard et al., 2004) and to justify the amortised costs over several years. The concept of regional or community-based visioning hubs might allow various local governments or communities to share advanced facilities and data on a repeated basis, and at the same time provide a neutral common-ground where any community or stakeholder group could apply to use the facilities, regardless of financial support (Sheppard et al., 2004). Precedents exist in regional GIS hubs for some First Nations in Canada; certain technically advanced visualisation groups in larger North American cities; and academic labs such as the Centre for Spatial Analysis (CASA) and University of East Anglia' in the UK, and the Canadian Collaborative for Advanced Landscape Planning (CALP). NGOs and other sustainability-focused outreach organisations such as the UK Climate Impacts Programme (UKCIP) seldom have the resources to maintain such advanced facilities, and, like the academic hubs, may not be closely connected to routine local community applications.

Who should set the decision rules and multiple other factors driving the preparation of landscape visualisations on sustainability issues? Multi-disciplinary experts and stakeholders could be used in collaborative workshops to provide best professional and local opinion on decision rules. Planners would need to be careful in deciding how persuasive to be with visualisations, particularly where particular stakeholder groups or development/corporate interests may wish to exploit the messages contained in the visualisations. There might also be considerable local pressure to focus on adaptation to climate change, rather than contribute to a much broader, less tangible global or national mitigation effort. On the plus side, such innovations could revolutionise how planning is done, and lead to better, more informed decisions.

Practical needs would include the following elements for background support and multi-media display:

- Permanent staff highly trained in both computing methods and perceptual implications of visual information and communications.
- Databases, models and established indicators of key community dimensions.
- Visualisation equipment (hardware, software, licenses, etc.).
- Standard procedures and formats to avoid bias: different methods may be needed to address objectives for awareness building versus climate change adaptation or project approval.

- A large, flexible deliberative space, for workshops or large theatre-style activities.
- Large immersive screens (see Figure 6) or other dramatic display devices capable of accommodating multiple imagery or panoramic angles-of-view at life-size scale (i.e., the same angle-of-view as in the real world (Sheppard, 1989).
- Visualisation-data linkages with user-friendly interfaces and real-time response rates for 'on-the-fly' rendering and viewing of 'what-if' scenarios.
- Public or decision-maker response measurement, e.g., voting systems, allowing automated data capture and almost real-time analysis and feedback to participants.

Such a system is being planned as part of the Centre for Interactive Research on Sustainability (CIRS) in Vancouver. Although located in the heart of the City of Vancouver, it is intended to provide to the community a window on the region, shifting scales from the local downtown precinct to the outlying watersheds, and tangibly demonstrating the linkages between the urban community and its ecological hinterland.

4 Discussion and conclusions

The notion of community visioning hubs using visualisations integrated with many other information and analysis tools, will require considerable leadership and risk-taking if it is to attract the necessary funding and inform and motivate sustainable actions or policies. The theory behind the impact of visualisation in motivating sustainable action remains largely untested scientifically, although the normative arguments for a more informed citizenry and better decision-making processes would alone justify such experiments.

4.1 Implications for research

Future research priorities to support the theoretical framework described here and in Sheppard (2005*a*) include controlled lab-testing with representative subject groups on perceptions of alternative sustainability futures, as mediated by landscape visualisation (in combination with other tools); this should help to identify some of the underlying triggers for cognitive/attitudinal/behavioral change on sustainability policy and life-styles, as well as risks and benefits of particular visualisation approaches. In particular, research is needed on defining, and measuring the effects of, salience: what are the behavioural implications of visualising local versus non-local subject matter, or generic versus iconic landscapes? Also, what are the effects of collapsing time: representing long future time periods in short, concentrated presentations?

Specific research questions on effective processes for visualising sustainability scenarios include:

- How to model the local effects on the landscape of socio-economic scenarios for climate change and sustainability, addressing the effect of different decision rules on participants' perceptions.

- Whether such tools contribute to accelerating social learning and changing the behaviours of users or policy makers (e.g., lasting effects).

- What the ethical dilemmas and consequences are of using realistic landscape visualisation that on the one hand can engender dramatic emotional responses in users on some issues but, on the other hand, may fail to express serious environmental degradation that happens not to be visible.

- Testing the effectiveness of different methods of disseminating and displaying dramatic visualisation-based tools to a large sector of the population, documenting the pros and cons of immersion, animation, and interactivity.

- Monitoring of real-world projects or processes of long-term planning (see Robinson, 2003) where visualisation are used. Often visualisations are prepared but the effects on awareness or decisions are not recorded or evaluated.

Visualisation research of the type described above could be built into ongoing studies focused more on people's reactions to possible climate change or sustainable development strategies, e.g., alternative technologies for house construction and energy sources (Fawcett et al., 2002). While the primary purpose in such studies is to use landscape visualisations as surrogates for real world conditions in determining preferences or acceptability, such experiments could provide a valuable additional stream of research results on the performance of visualisation as the instrument.

4.2 Conclusions

There is an alarming gap between awareness and action on sustainability and climate change. Emerging techniques of landscape visualisation may help to develop more engaging, informative, and defensible tools for communicating sustainability concepts and choices, fostering social learning, and possibly influencing popular attitudes and behaviour on climate change. There is evidence of the effectiveness of visualisation as a planning tool, its ability to enhance cognition, and its effect on affective responses, but very little research has taken place on behavioural impacts. However, experience in practice suggests that landscape visualisations can sometimes have substantial effects on policy, and there is evidence with other media of behavioural effects through engaging emotional responses. If new immersive and interactive visualisation systems are to be used to promote sustainability and action on climate change, ethical procedures need to be developed. Visualisation tools are potentially too powerful either to be ignored or used without careful consideration of the '3 Ds' (disclosure, drama, and defensibility) of visualising sustainability issues such as climate change.

The hypothetical mechanism to help bridge the gap between awareness and action on sustainability, suggested in this chapter, is to bring the impacts of unsustainability and climate change home to people in their back yard, dramatically: 'making climate change personal' through realistic views of their familiar landscape under possible future scenarios. The process to create and visualise integrated future visions of local communities under climate change is highly complex and few precedents exist. If implemented, such processes as sketched out here would require technically advanced regional or community-based visioning hubs to support interactive dialogue and decision-making on sustainability issues, potentially engaging a wide cross-section of the population in many neighbourhoods. Relative to other dissemination media channels, this could be a highly effective mechanism for awareness building and impacting local decisions; at the very least, it would inform many more people in compelling and tangible ways about the risks or climate change and continuing inaction on sustainability. Experimentation with visioning hubs, such as the CIRS Decision Theatre in Vancouver, may also substantially alter how participatory planning is done, and help embed climate change mitigation and adaptation in everyday community planning.

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