Visualization in forest landscape preference research

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Abstract

This paper deals with the needs that landscape preference research has concerning visualization techniques. It compares the benefits and disadvantages of different means of visualization (original and manipulated photographs, virtual landscape simulators). The paper is partly based on experiences gained from landscape preference research, in which different illustration methods have been used both in long-distance and near distance views.

Today digital image editing and virtual landscape simulators offer the most sophisticated means of visualization for landscape preference research. With the aid of these methods it is possible to control the variables that are not in the focus of the study. Landscape simulators are less labour-intensive and offer flexible movement between different viewpoints. Simulators are not restricted to represent limited ares in the manner of photographs; they are also able to link images with forest inventory data and planning systems. However, the illustrations do not correspond to the real world, whereas digital image editing produces images corresponding to the realistic qualities of the original photos.

In the future, virtual landscape simulators will be the easiest and most flexible means of visualization in landscape preference research. However, research purposes also require more realistic illustrations, which sets a need for large photographic databases, as well as integration with different sources of spatial data. The future prospects of research also include the use of virtual reality techniques with multi-stimulus representations of landscapes. More research is needed so that the usability of different visualization media in research purposes can be evaluated and compared.

Keywords: landscape preferences, digital photo editing, landscape simulators

1 Introduction

The quality of landscape is important for people's mental well-being. Its importance can be seen especially in stress recovery and in the formation of restorative effects (Hartig et al. 1991, Ulrich et al. 1991, Kaplan & Peterson 1993, Korpela & Hartig 1996). According to Schroeder (1990), aesthetic enjoyment may actually be the greatest advantage of urban forests. Therefore landscape designers and managers need knowledge about people's perceptions and interpretations of the landscape, as well as about their reactions towards different landscapes. It is important to know both what kind of landscapes generate positive feelings and enhance people's well-being and recreation and also what kinds of stimuli generate negative feelings and views. As the landscape is constantly modified, planning requires knowledge about people's reactions to changes.

Participatory planning is a rather recent development in practical planning situations. Different visualizations of the landscape, produced by alternative planning options, can be shown to different interest groups and/or landowners, which makes it possible for them to decide or at least to participate in decision-making concerning such issues as what kind of landscapes will be created in the area under planning or how much emphasis is put on the landscape when evaluating alternative options. Here the number of participants is rather limited. As all visitors and users of the area under planning cannot be consulted, more general knowledge about landscape preferences is also needed for planning purposes.

Numerous approaches have been used to study people's aesthetic reactions to landscapes. Yet the difficulty of amenity values is that there are no exact methodologies that could be used in their description and prediction. However, in all approaches the visualization of the landscape can be a good instrument: while people are usually good at understanding images, they tend to have difficulties in understanding information presented in other forms.

The quality of the landscape is always determined by human appraisal. The landscape can be evaluated by either experts or the public. Zube et al. (1982) have divided the large variety of landscape perception research into expert, psychopsychical, cognitive, and experiential paradigms. Daniel and Vining (1983) use a similar classification. They have defined the methods of assessing landscape quality as ecological, formal aesthetic, psychopsychical, psychological, and phenomenological models. A modification of these groupings is presented in Table 1. The difference of the approaches lies in their conception of the human being; the way in which the human being is comprehended affects the choice of the medium of visualization too.

In the expert model skilled and trained experts evaluate the landscape according to the principles of art, design, ecology, or management. The experts evaluate either the ecological or formal aesthetic landscape variables.

Table 1. Different approaches to landscape perception research.

Expert evaluations	Opinions of the public
educated experts	**psychophysical** human beings as recipients
principles of art, planning, and ecology	**cognitive** human beings as constructors and interpreters
	phenomenology human beings as active participants

In the psychophysical model the human being functions as a recipient and passive observer of the environment. The visual elements of the landscape are measured, e.g., the amount of logging residue, the diameter of the stands, and the basal area. The respondents are asked to evaluate the quality of the landscape, usually with a single psychological response such as landscape preference, scenic beauty, or scenic quality. The connections between the features measured and the preferences observed are searched by the means of statistical analyses. Many studies do not specify any psychophysical functions but describe the characteristics of preferred and less-preferred landscapes in general terms (Daniel & Vining 1983). In this context preference is defined as a desire to have, to do, or to select one thing rather than an other because the respondent likes it better or because it appears as more convenient for him/her.

The cognitive (or psychological) approach involves a search for human meaning and information associated with landscapes. Cognitive theories emphasize the informational content of the environment and how this information is organized, processed, and interpreted by the viewers (Ruddel et al. 1989). The cognitive model refers to the feelings and perceptions of people: it does not aim at defining the physical features of landscape that would affect evaluations. The aesthetic quality is only one of the several dimensions of human response (Daniel & Vining 1983).

Cognitive research is also often based on the presentation of the object. The respondent may be asked to evaluate the object through such perceptual, cognitive, and affective concepts as mystery, unity, coherence, and complexity. These variables are not separate features in the landscape but they describe the landscape as a whole. The relationship between variables and preferences is examined in order to find out the psychological basis of landscape preferences.

Phenomenological (or experiental) research considers human beings as active participants. It emphasizes the interaction between the human being and his/her environment and (mental) states that both affect each other. The phenomenological approach seeks to understand the total experience of the individual when s/he interacts with the landscape (Herzog 1985). In its way it tries to determine the meaning and significance that the different aspects of a landscape have for a particular person (Daniel & Vining 1983).

In phenomenological research, objects that have been created in the interaction between human beings and the environment are studied. Zube et al. (1982) also classify aesthetic and geographical studies, e.g. studies concerning the sense of place, under this rubric. Personal interviews and verbal questionnaires are often used as methods in phenomenological research. While visualization can be used in phenomenological inquiries, it does not have such an emphasised position here as it does in the approaches mentioned above. Here visualization functions more as a stimulus for the respondent who can then produce his/her own representations, interpretations, feelings, and experiences of nature. Phenomenological research focuses more on the relationship between landscape and a person than on the comparative assessment of different landscapes (Daniel & Vining 1983).

The purpose of this article is to analyze the demands set for visualization in psychophysical and cognitive research. These two approaches can be labelled as landscape preference research proper. Furthermore, the article will also assess the suitability of advanced forest landscape simulation methods developed or used in Finland for the purposes of preference research.

2 Landscape preference research and its requirements for visualization techniques

While also other senses influence the perceiving and experiencing of landscape, the main part of landscape perception occurs through the sense of sight (Jubenville et al. 1987). Thus visualization is the primary method in the description of landscapes; visualizations can also be combined with sounds and smells, for example. Yet visualization and the choice of the medium of visualization is only one aspect among other choices that have to be done in preference research. One key question concerns the choice of settings, as the respondents' judgments are affected by the range and mixture of landscapes presented (Brown & Daniel 1987).

Preferences are usually explained through the physical features of the landscape and variation between respondents tends to receive far less attention. However, the variation between settings does not explain all variation in landscape preferences. There is individual variation in the evaluation of visual landscapes, based on different individual experiences as well as on social and cultural background. There are also other factors that affect assessments and that can be related to the moment of evaluation: the respondent's mood, for example. (Brush 1976, Karhu & Kellomäki 1980, Lyons 1983, Knopf 1987). Despite individual variation we may also be able to find some general principles in landscape perception and preference.

In landscape preference research the respondents are generally non-professional as images evaluators, which sets the visualization a high demand for realism. Although the landscape is experienced as an entity, its details (e.g. special shapes of trees, undervegetation, stones) attract the viewer's attention and create experiences. Therefore the medium of visualization should be able to capture the details too. In addition, landscapes should not be romanticized but the illustrations should correspond to the conditions in nature. In reality, trees are often ill-shaped or injured, and the ground cover may be trampled.

The cognitive approach in particular needs a medium of presentation that is able to capture the whole richness of the environment, as the explaining variables (e.g. complexity and mystery) describe the wholeness of nature. This is in contrast to psychophysical research: in the latter the explaining variables are separate physical features in the environment and it may be more reliable to explain preferences if the number of variables seen in the images is more limited. However, the variables should be illustrated realistically and all explaining variables, as well as their variation, should be seen clearly in the images (Hull and Revell, 1989). Furthermore, because one's impressions of a setting vary because of the location and distance of viewing, it is important that the same object can be seen from different viewpoints.

One aim of preference research may be the clarification of people's reactions to changes in the landscape: these may include forest felling or field afforestation. In order to determine the effect of any particular change, it is important that only one aspect of the landscape changes at a time. A study may also aim at discovering the meaning of variation in different landscapes, i.e., one may ask such questions as in what ways different landscape spaces affect the experience when a person is wandering in the landscape, and what is the optimal variation. Perceptions and a person's relationship with nature are also dependent on the rate of speed, on the means of transport (on foot, by car, by bike, on horseback), and on the activities performed (hunting, sightseeing, camping) (Wagar 1974, Brush 1979, Levine & Langenau 1979, Zube et al. 1982). In order to be able to account for this kind of variation, preference research requires such means of visualization that are able to simulate different ways of moving in landscape.

Although the landscape is always dynamic and changing, in some landscapes movement appears more characteristically than it does in others. Therefore the choice between static and dynamic visualizations should depend on the characteristics of the landscape studied. If every landscape to be compared with other landscapes is motionless and static, static visualization may prove to be adequate. If, however, some of the landscapes include dynamic features such as waterfalls, we need dynamic representations in order to be able to study the differences between static and dynamic landscapes (Hetherington et al. 1993).

The persons' emotional ties connected with their living environment or everyday landscapes are usually strong. While people are, indeed, very sensitive to all changes in the familiar landscape, in non-familiar environments their affective responses are remarkably weaker (Wagar 1974, Brush 1976). Thus the level of realism in the visualization of the landscape is set very high requirements if the relationship between the landscape and a person is long-standing and the person knows the landscape with its details thoroughly. This is the case with local residents and people visiting a particular setting frequently.

3 Forest landscape visualization methods and their suitability for preference research

Such visualization media as models and drawings have been used for hundreds of years. In Finland, photographs have been the most frequently used tool in landscape preference research during the last few decades (e.g. Savolainen & Kellomäki 1981, Pukkala et al. 1988, Hallikainen 1995, Karjalainen 1996). More recently the digital editing of photographs (photomontage) has been used, for example, in the studies of preferences concerning different field afforestation options and that of forest felling alternatives (Tahvanainen et al. 1996, Karjalainen & Komulainen 1998a, 1998b, Tyrväinen et al. 1998). Yet it is only within the past decade that more sophisticated technological innovations, including computerized visual simulations, have been introduced. At present, applications for practical planning purposes are being developed by numerous different institutions, including consultant agencies and universities.

If compared to on-site visits, visualization has several advantages (Table 2). It is not only cheaper but it also offers laboratory conditions where many aspects affecting site evaluation can be avoided (heat, cold, mosquitoes, sun, rain, wind). As all evaluators share the same conditions, it is easier to assess which variables have in the end affected their evaluations. Although many studies have shown that slides and photographs are acceptable substitutes for on-site visits if they include most of the scenic elements of the landscape (Shafer & Richards 1974, Shuttleworth 1980), opposite results have also been obtained (see Hull and Steward 1992). Visualization has also been criticized because it is not able to represent the whole richness of real nature. Photographs, for example, are not only less complex and less multidimensional but they also offer less interaction than real scenes. Furthermore, despite careful attempts to control, there are often noticeable differences between photographs (e. g. shades of light and colour), which makes it difficult to make comparisons.

Digital image editing makes possible the study of the effect of a par-

Table 2. Features of forest landscape visualization methods in preference research.

Application	On-site visits	Photo graphs	Digital image editing	Video	FORSI (Forest simulator)	MONSU (multiple use forest planning)	Smart Forest
Realism	excellent	very good	very good	very good	good	fairly good	fair
Choice of viewpoints	flexible	one	one	flexible	flexible	four viewpoints	flexible
Movement	easy	–	–	easy	fairly easy	fairly easy	fairly easy
Simulation of changes	–	–	labour-intensive	labour-intensive	fairly easy	easy	fairly easy
Use of forest data	–	–	–	–	fairly easy	easy	fairly easy
Tree symbols	–	–	–	–	digitized photo-graphs	vector symbols	geometric objects
Under vegetation illustrated	–	yes	yes	yes	yes	to some extent	no
Other elements	–	yes	yes	yes	yes	to some extent	no

ticular change in landscape and the control over other variables (light, colours, shade and so on) that often vary between photographs. Digital image editing uses computer software in the manipulation of video or photographic images which have been either digitized or originally taken with a digital camera. The images produced are photorealistic. Yet the problem of the method is that images are static and the method cannot be easily automatized; detailed changes in original images are also time-consuming and costly. Furthermore, the pictures produced are, to a certain extent, open to inaccuracy because of the subjective evaluations present in the modification of the original pictures. Since it is difficult to estimate the effect of change in the landscape on the basis of a photograph, without the help of spatial data, the visualizations are mere approximations of the effects of change (Table 2).

Virtual landscape simulators are based on the use of a digital terrain model and some kind of a map and/or forest data, as visualization requires. The main advantage of their use in research is their flexibility; the observer is not limited to any predetermined viewpoints. Moreover, automatized visualization reduces the production costs of illustrations. There are, however, certain limitations in the capabilities of visualization systems. One of the main problems is the quality of the illustrations.

The methods needed in the study of dynamic landscapes include animations and video. While video images are realistic and inexpensive, the simulation of change is labour-intensive. Furthermore, at least at present, animations rely on advanced computing equipment.

An example of the forest landscape simulator is the multiple-use forest management planning system (MONSU) developed at the University of Joensuu (Pukkala 1998). The program is developed for the purposes of teaching and forest planning at the farm level. The illustrations of forest landscapes in the MONSU system are automatized computer drawings based on tree and site parameters included in present forest planning systems. Tree symbols are differently coloured two-dimensional graphic symbols, whose species and size distribution correspond to the local tree populations as described in inventory data. The distinct areas of field, forest, and water are expressed with different ground colours. The program also displays topographical variation and even perspective, which are based on digitized contour lines and a chosen vantage point. The program is also able to illustrate the effects of seasonal change.

The MONSU program is easy to use, inexpensive and it can be run on a PC. Its main advantage is that it is connected with a forest planning system, which means, among other things, that the evaluation of the scenic impacts of alternative forest plans becomes possible. The method also enables a flexible assessment of both close-ups and long-distance scenes with updated forest data. As the program produces illustrations from the main cardinal points, the assessment of landscape from several viewpoints is also possible. In addition, movement in the forest can be simulated by choosing viewpoints along a path and by illustrating the landscape scenes selected.

Although the illustrations include some elements of the undervegetation such as berries and mushrooms, the special features and details of a particular landscape (roads, buildings, shrubs, stones, special shapes of trees and single trees) are absent. Thus MONSU produces more or less standard landscape pictures, which causes that it not really suitable for areas which have for example special scenic values.

Smart Forest is an interactive, three-dimensional visualization system developed by the University of Illinois (Dept of Landscape Architecture) and the USDA Forest Service. The main advantage of the system is that it allows flexible real-time movement in forest landscape. The user may view the ground level, walk between the trees, view large forest areas from user-defined aerial height, and classify stands and trees by highlighting them with different colours (Uusitalo et al. 1997). The simulations of forest operations are realized through a manipulation of tree data.

Its main disadvantages include that the illustrations are based on rather simple three-dimensional tree symbols and that the elements of undervegetation are excluded. Therefore, at the present time the system lacks an ability to address detailed issues of forest management. According to Orland (1994), the high degree of interactivity has resulted in the fact that the tree symbols have been kept rather simple. While the program operates only in an UNIX environment at present, a development project being carried out at the University of Helsinki, Finland, is developing a PC version; they also aim at improving the quality of illustrations by presenting the ground and trees with realistic textures.

FORSI, a commercial landscape simulator that can be used in a PC environment, is intended to fulfil the needs of practical visualization in different forestry organisations. The system has been developed by the Finnish private consultant and development enterprise Plustech Ltd. The functions of the program are based on map information, an elevation model, compartment data of the target area, and visual objects. The advantage of the program lies in its realism and flexibility. The two-dimensional visual objects represent the main elements of a forest landscape (trees, shrubs, undervegetation, logging residue). The objects are generated from digitized photographs. While the program has a rather large tree library, it includes for the time being only the main tree species in Finland. However, other tree species and additional objects (houses, recreational facilities) can be added to the library and included in the pictures manually.

FORSI allows for nearly realtime movement in the landscape, and the choice between different viewpoints is flexible. The simulations of individual forest operations such as clear cuts and thinning can be illustrated by manipulating the compartment data manually. Although the program produces rather realistic images, in particular when describing scenes from a distance, it visualizes standard trees photographed in commercial forests in southern Finland. Because FORSI is a commercial product, its price is significantly higher than that of other visualization tools.

4 Conclusions

Today digital image editing and virtual landscape simulators offer the most sophisticated visualization methods for the needs of landscape preference research. With the help of these methods it is possible to control the variables that are not in the primary interest of the study, e.g. colours and shades. The advantages of landscape simulators include that all pictures can be produced much quicker and that they offer extremely flexible movement between different viewpoints. In addition, simulators are not restricted to represent a limited area in the manner of the photographs. Furthermore, virtual landscape simulators are able to link images both with forest inventory data and with the planning systems of forestry and agriculture. However, their main disadvantage – especially that of those based on vector graphics – is that the images do not correspond to the real world well enough. Indeed, the quality of photographs produced by digital image editing corresponds to the quality of the original photos.

In the 1980s Zube et al. (1987), when comparing the effectiveness of communication in different modes of presentation, found computer-generated line graphics to be the least understood one. More recently Oh (1994) compared perceptual effectiveness or four types of computer simulations (wire frame, surface model, combination of surface model and photographic images, and image capture technique) and came to the conclusion that the image capture technique was the most effective one in portraying reality. However, computer graphics systems, often linked with forest planning programs, have recently been under rapid development.

In some cases the images produced by landscape simulators are already today adequate for the needs of the study of the relationship between separate physical variables and observed preference. While Abello et al. (1986) have stated that it might first be preferable to understand simple environmental representations in which the number of possible explaining variables is low, the case is different when the focus of the research is on cognitive variables describing the landscape as a whole: in this case the demands for visualization are remarkably higher.

Today the quality of the images produced by computer line graphics may be adequate for the use by experts, who can be expected to be able to understand the medium of presentation better than the layman. Furthermore, some studies have suggested that computer graphics may also be an adequate presentation format for public evaluation (Nousiainen & Pukkala 1992, Tyrväinen & Tahvanainen 1998, Nousiainen et al 1998). In the study of Nousiainen and Pukkala (1992), computer graphics and slides proved to be almost equal methods for the ranking of forest trails on the basis of amenity properties. However, they also found out that the recreational value of forest trails cannot be easily evaluated on the basis on computer graphics, presumably because low bushes, dwarf shrubs and obstacles on the ground were omitted from the illustrations.

At present computer graphics seems to be more suitable for illustrating distant sceneries than near-views. In the study of Tyrväinen & Tahvanainen (1998), images illustrating impacts of afforestation produced by the MONSU multiple use forest planning system and panoramic slides were evaluated by land-use experts and landowners. Nousiainen et al. (1998) tested the use of vector graphics in a participatory planning context in North- Carelia, Finland. These studies suggest that computer vector graphics is an adequate medium in the comparison of different large-scale agricultural landscapes and management alternatives for practical planning purposes. In large scale landscapes small landscape elements are not so important and merge easily with the background scenery.

The present forest landscape simulator models have been developed for commercial forests and the illustrations are approximations of real conditions in nature. However, often the areas which are of main interest for researchers are frequently used and visually sensitive areas: urban forests, recreation areas, national parks, and other scenic environments. In such landscapes the illustration of such details as the special shapes of trees and the spatial variation of undervegetation remains also very important. Detailed illustration is also necessary when the respondents are familiar with the environment, as the case is in urban forests. Furthermore, the incorporation of ecological management and nature protection into forest planning sets new requirements for visualizations too. Therefore, for research purposes, original or manipulated photographs are so far the best means of visualization – the case is so in particular when studying close-ups with their special features.

The main requirement for visualization media to be effectively used in landscape preference research is that the images correspond to the visual reality of observers. In addition to realistic images, preference research requires from simulations a flexible use of forest inventory data, real-time movement in the landscape, a flexible change of viewpoints, and interactivity. A good visualization tool illustrates the changes in the environment in a realistic manner both from the near and the distance. While many of these properties exist in current landscape simulators, they should be incorporated in the same program.

It seems that forest simulators will be the best, easiest, and most flexible means of visualization in future preference research. The development of the current simulators should also take into account the needs of research. Landscape preference research requires more realistic illustrations; it also needs a large photographic database (library or tree symbols and other objects) as well as integration with different sources of spatial data. All domestic tree species and regional features of forests (tree shapes and undervegetation) should be included in the database. In addition, three-dimensional tree symbols would greatly improve the quality of images.

At present, the application of landscape simulators is confronted with the problems of access and the price of the data. In Finland, the data collected for forest planning may be difficult to obtain, because it, in principle, belongs to the landowner. In addition, forest inventory data do not have the details and richness required if we are to create realistic images. Therefore, more accurate information should be collected in the context of the forest inventory concerning e.g. forest edges, undervegetation, individual big trees and their shapes, and stones should also be included. However, the inventory usually has restricted resources.

Even at its best the visualization of the landscape cannot fully re-distribute the real landscape experience. The future prospects for landscape research may include a use of virtual reality techniques with multistimulus representations of landscapes. However, more research is needed in order to evaluate and compare the usability of different visualization media for research purposes.

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