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Landscape and Urban Planning 54 (2001) 267–281

LANDSCAPE AND URBAN PLANNING

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Whither scenic beauty? Visual landscape quality assessment in the 21st century

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Received 29 November 1999; received in revised form 31 August 2000; accepted 15 September 2000

Abstract

The history of landscape quality assessment has featured a contest between expert and perception-based approaches, paralleling a long-standing debate in the philosophy of aesthetics. The expert approach has dominated in environmental management practice and the perception-based approach has dominated in research. Both approaches generally accept that landscape quality derives from an interaction between biophysical features of the landscape and perceptual/judgmental processes of the human viewer. The approaches differ in the conceptualizations of and the relative importance of the landscape and human viewer components. At the close of the 20th century landscape quality assessment practice evolved toward a shaky marriage whereby both expert and perceptual approaches are applied in parallel and then, in some as yet unspecified way, merged in the final environmental management decision making process. The 21st century will feature continued momentum toward ecosystem management where the effects of changing spatial and temporal patterns of landscape features, at multiple scales and resolutions, will be more important than any given set of features at any one place at any one time. Valid representation of the visual implications of complex geo-temporal dynamics central to ecosystem management will present major challenges to landscape quality assessment. Technological developments in geographic information systems, simulation modeling and environmental data visualization will continue to help meet those challenges. At a more fundamental level traditional landscape assessment approaches will be challenged by the deep ecology and green philosophy movements which advocate a strongly bio-centric approach to landscape quality assessment where neither expert design principles nor human perceptions and preferences are deemed relevant. On the opposite side of the landscape–human interaction, social/cultural construction models that construe the landscape as the product of socially instructed human interpretation leave little or no role for biophysical landscape features and processes. A psychophysical approach is advocated to provide a more appropriate balance between biophysical and human perception/judgement components of an operationally delimited landscape quality assessment system.

Keywords: Landscape quality assessment; Landscape aesthetics; Ecosystem management

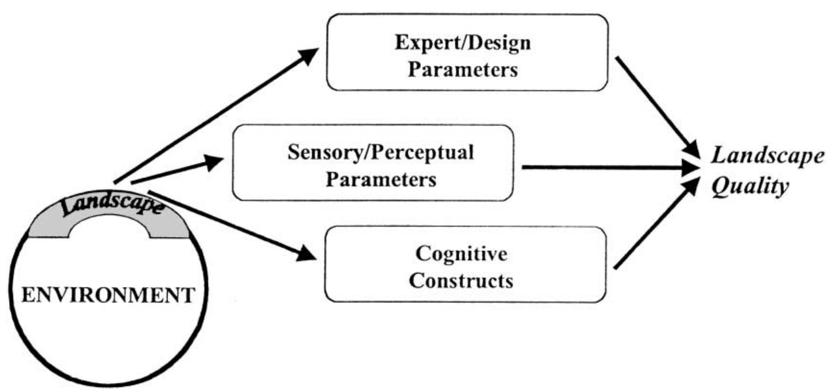
1. Introduction

The purpose of this paper is to briefly review a bit of the history of efforts to systematically assess the quality of "our visual landscape" and to speculate about some aspects of the future of this scientific and practical enterprise. Over the last half-century landscape quality assessment can be seen as a contest between expert/design approaches and public perception-based approaches (e.g. Arthur et al., 1977; Daniel and Vining, 1983; Zube et al., 1982). The former have been principally developed and codified in the context of public land management practice, while the perception-based approaches have been developed and used

0169-2046/01/$20.00 © 2001 Published by Elsevier Science B.V.
PII: S0169-2046(01)00141-4

mostly in applied environmental perception and landscape assessment research. Both approaches share a basic conception of landscape quality in which biophysical features of the environment and human perception/experience are essential interacting components. Landscape quality arises from the relationship between properties of the landscape and the effects of those properties on human viewers.

Expert and perception-based approaches differ in how the relevant features of the landscape are represented, and in the nature and importance of the contribution of the human viewer/experiencer in determining landscape quality levels. The expert approach translates biophysical features of the landscape into formal design parameters (e.g. *form*, *line*, *variety*, *unity*) assumed to be universal indicators of landscape quality derived (implicitly) from classical models of human perception and aesthetic judgement. The perception-based approaches treat biophysical features of the landscape as stimuli that evoke aesthetically relevant psychological responses through relatively direct sensory–perceptual processes and/or through intervening cognitive constructs (e.g. *legibility*, *mystery*, *prospect-refuge*).



Alternative models of the relationship between biophysical features of the landscape and landscape quality.

The shifting focus of environmental management toward *ecosystem management* (e.g. Szaro et al., 1998) has created new challenges for landscape quality assessment, especially by greatly expanding the temporal and geographic scales that must be encompassed on both sides of the landscape–observer interaction. New technological developments, such as high-resolution remote sensing, three-dimensional geographic information systems, and advanced environmental modeling architectures have greatly improved the ability to determine and map changes in ecologically relevant landscape features. More effective and economical computer environmental visualization and "virtual reality" techniques greatly improve the means for visually representing complex landscapes to human viewers (e.g. Bishop and Hull, 1991; Daniel, 1992; Orland, 1993; Sheppard, 1989; Zube et al., 1987). It is as yet unclear, however, exactly what landscape features are most relevant to ecosystem management objectives and how those features should be presented to human viewers to obtain valid indications of perceived landscape quality.

2. Background

Before addressing these and other challenges to landscape quality assessment, it is important first to be clear about the meaning of *landscape*, and about what it means to *assess the quality* of it. A considerable amount of what appears to be controversy among reasonable parties may be traced to differences in what is meant by landscape quality. The discussion below does not aspire to any ultimate resolutions, but seeks to make clear what is meant (and not meant) in this particular paper by *landscape quality assessment*.

2.1. Landscape

The dictionary offers several definitions of *landscape*:

1. a picture/view of natural inland scenery;
2. the landforms of a region in the aggregate;
3. a portion of a territory that the eye can comprehend in a single view.

All of these definitions emphasize a limited area of land *surface*, and the first and third clearly focus on *views/scenes* of the land surface. Such restrictions to the meaning of *landscape* have not necessarily been popular with either landscape practitioners or researchers (e.g. Hartig, 1993; Gobster, 1999; USDA, 1995; Zube, 1984). Instead, there has been a desire to expand the term to encompass virtually every aspect of the environment to the point that it is essentially equivalent to *landscape ecology* (e.g. Linehan and Gross, 1998). By this expanded account *landscape* may include a vast array of biological and ecological processes and conditions which are not landforms (definition 2) and which could not be comprehended in a single view (definitions 1 and 3), or in any view whatsoever. Extending the meaning of landscape to this degree makes it essentially synonymous with *environment* or *ecosystem*, if not hierarchically the more encompassing term. Such an expanded conceptualization of landscape presents a rather daunting task to those who would aspire to assess and/or manage landscape quality.

Without question biological and geological (and technological) processes create the landforms and land cover that define landscape. To the extent that these processes give rise to visible features on the land surface, landscape can indirectly reflect the state/quality of these underlying environmental processes and conditions. Biophysical processes clearly create landscape, but for the purposes of this paper, these processes are not landscape. The discussion that follows will specifically refer to *visual* landscape (though dictionary definitions 1 and 3 make the modifier a bit redundant). This is not to deny the importance of geological and biological (ecological) processes in the broader context of environmental quality assessment and management, nor to ignore the importance of non-visual features of the environment. Rather, the goal is to focus attention in this particular paper on the narrower, but important topic of visual landscape quality.

2.2. Landscape quality assessment

In the context of landscape quality assessment, *quality* has been taken to encompass everything from basic utilitarian wants (food, water, shelter, recreation opportunities, etc.) to spiritual needs (oneness with nature, sense of a higher power) to intrinsic natural values. The human perception component of the interactional landscape-quality construct has been expanded to subsume concepts such as landscape *meaning* and *sense of place* — memories, inferences, and the extraction of symbolic meanings, historical/cultural/social significances, ethical/moral obligations and spiritual values all play a part (e.g. Seamon, 1982; Tuan, 1974). Indeed, by such accounts landscape quality assessment would expand to encompass virtually every aspect of the environment and all human environmental experience, recollection and imagination. In this vein Gobster (1999) has advocated that the conceptualization of landscape quality should be extended beyond *perceptual, immediate, affective/emotional* ... *preference* for *static* ... *visual* landscapes encountered in a *homocentric* ... *passive, object-oriented* context. Instead, landscape quality assessment should be based on a *cognitive, knowledge-based* ... '*refined taste*' ... *appreciation* of a *multi-modal* ... *dynamic* ... *symbolic* ... *unbounded* landscape in the context of a *biocentric, ethical* ... *active, participatory* ... *experiential* ... *dialogue* (from Table 1, p. 57).

Such a view of *landscape quality* differs considerably from that implied in the National Environmental Policy Act that motivated most of the relevant landscape quality research, policy and practice to the end of the 20th century. It might well be argued that the goals of national environmental policy in the 21st century need to be expanded/altered to encompass a new set of biocentric ethical values (e.g. Callicott, 1983, 1985; Rolston, 1984, 1988), or that an expanded view of human–environment relationships (*biocentric, ethical* ... *active, participatory* ... *experiential* ... *dialogues*) is required (Gobster, 1999). But it is misleading in this context to continue to use the term, *landscape quality*, if the meaning is to be so radically changed. It would be far better (and more honest) to acknowledge that a substantially new *environmental* management policy is being advocated, rather than trying to wedge new policies in by so expanding the definitions of the labels associated with the old policies. Certainly, Gobster's (1999) interpretation demands radical changes in assessment procedures as well as fundamental changes in landscape *and* environmental management research, theory and practice (and he suggests several such changes). But would *visual landscape quality assessment* be the appropriate label for this enterprise?

If *quality* in this context is taken to mean *degree of excellence* (as opposed to value-neutral alternatives offered in the dictionary, *characteristics, features or attributes*), then visual landscape quality assessment at a minimum must involve determining which instances of visual landscape are better (more excellent) than others. But better in what regard? Surely determining which landscape is better at providing food, shelter or "sustainable development" for humans would be quite a different task than determining which is better for recreational, spiritual or other purposes. Determining which landscapes represent higher levels of *ecological quality* or *natural/ecological values* (e.g. biodiversity, ecological sustainability) is unquestionably important, but requires still different assessment procedures. Neither the "traditional" expert nor the perception-based methods developed and applied under the earlier "scenic" paradigm/policies would seem appropriate for such assessments, nor were they intended to be.

One approach to determining the intended meaning of *landscape quality* is to inspect procedures that purport to assess landscape quality and then "back into" the meaning by way of operational definitions. That is, one might seek to define landscape quality by the methods most often used to assess it. By this criterion the substantial majority of what have historically purported to be landscape quality assessments (including those purporting to assess "environmental preferences") address what might best be termed *visual aesthetic* quality (though not all have explicitly acknowledged this restriction). Typical assessments, whether expert- or perception-based, rely on inspection and analysis of the visible features of the target land area. Biophysical analyses are rarely directly included, nor are sounds, smells or touches directly assessed (indeed the typical representation in pictures largely precludes such assessments). The quality being assessed is not typically associated with any basic human utilitarian needs (food, water, shelter). Apparent *naturalness* may be a nominal criterion in some expert assessments but the procedures applied are neither botanical nor geological. Operationally the emphasis is on visual design features (e.g. *form, line, color, vividness, harmony, unity*), albeit these may be compared against features that are deemed consistent with the natural (appearing) target landscape (character) type (e.g. USDA, 1995). In perception-based assessments the assessment context and the instructions provided to the human observers who are asked to rate (or rank) landscape quality (*visual quality*, *scenic quality*, *scenic beauty*) or to express preferences among landscape scenes (usually represented by photographs) strongly implies (or explicitly states) that utilitarian values are not at issue. It has frequently been found that perceived landscape quality is strongly correlated with *naturalness* (e.g. Kaplan et al., 1972; Ulrich, 1977; Purcell and Lamb, 1984; Schroeder, 1987; Zube et al., 1974), but this is an empirical outcome based on independent assessments of visual landscape quality and naturalness. Operationally, both expert and perception-based approaches address the *visual aesthetic quality* of the landscape.

2.3. Visual aesthetic quality

The nature of aesthetic quality is a centuries-old area of puzzlement, study and controversy for philosophers, artists/designers and now for environmental managers/policy makers. Lothian (1999) provides a comprehensive review of the philosophical background for landscape aesthetic quality assessment, tracing the history of competing *objective* and *subjective* models. By the objective account the aesthetic quality of a thing is to be found in the properties of the thing. By the subjective account the critical seat of aesthetics is in the mind of the human consumer (the *eye of the beholder*). After several centuries of debate the subjective account seems to have largely won out in modern philosophy.

A reasonable (and popular) resolution of the objective–subjective controversy in the context of landscape aesthetic quality assessment is to acknowledge that quality depends on *both* features of the landscape and the perceptual/experiential processes those features evoke in the human viewer. That is, landscape visual aesthetic quality is a joint product of particular (visible) features of the landscape interacting with relevant psychological (perceptual, cognitive and emotional) processes in the human observer (Brown and Daniel, 1987, 1990; Craik and Zube, 1977; Daniel, 1976, 1977, 1990; Daniel and Boster, 1976; Parsons, 1991; Ulrich, 1983, 1993; Zube, 1974). Exactly what kinds of sensory perceptions, cognitive interpretations and/or emotions/feelings are relevant to aesthetic quality is still a matter of controversy in landscape perception science. But perception-based assessments have in practice generally assumed that whatever landscape (or landscape conditions) produce a combination of perceptions, interpretations and/or feelings that human observers consistently report as being *high aesthetic quality*, are high in visual aesthetic quality.

3. Assessment versus valuation

A distinction must be made between *assessments* of aesthetic quality — the relative aesthetic excellence of one landscape area as compared to others — and *valuations* of aesthetic quality — the worth of given levels of aesthetic quality relative to other values/resources/human desires and needs (e.g. Brown, 1984, 1987; Daniel et al., 1979, 1989; Peterson and Randall, 1984; Peterson et al., 1988). Assessment and valuation are always linked, as the means of defining and assessing any environmental characteristic typically reflects the ultimate use/value expected to be derived. It is not coincidental, for example, that forests have traditionally been assessed in terms of cubic volumes of trunks, rather than any of the many possible alternative measures (e.g. bio-mass, species diversity, foliage surface area). For most traditional resources the distinction between assessment and valuation procedures is generally clear. Assessing the cubic volumes of tree trunks standing in the forest and determining the price of the represented wood and fiber in some market clearly requires different procedures. The assessment–evaluation distinction is often less clear for landscape aesthetic quality, in part because there is no traditional procedure (such as a market) for determining *worth*. While it is reasonable to assume that higher assessed aesthetic quality implies higher value, additional valuation processes are required to determine more precisely the worth of any particular level of visual aesthetic quality relative to other values/resources.

4. Systematic assessment of landscape quality

The visual aesthetic quality of the landscape has been a concern for humans for as long as environmental sites have had to be selected and routes have had to be chosen. It might be argued that the aesthetic quality of the landscape was less a concern when the most basic survival needs were paramount. But even the earliest civilizations exhibited an appreciation of landscape qualities with little direct association to food, water and shelter. Sites capable of meeting basic human needs almost always exceeded the areas that were actually inhabited. The specific sites that were selected may have been determined, at least in part, by the fact that they offered what then were judged to be “pleasing views”. Evolution-based models of human visual aesthetic preferences (e.g. Appleton, 1975, 1984; Balling and Falk, 1982; Kaplan, 1987; Orians and Heerwagon, 1992; Ulrich, 1983, 1993) suggest that contemporary humans would find these same views attractive. Indeed, in many parts of the world good home sites (or resort sites) with beautiful views will often have been discovered and used by the ancients, as well as demanding a substantial premium in the modern real estate market.

The need for formal, systematic assessments of landscape visual aesthetic quality arises in the relatively modern context of environmental management. Responding to the same demands that have driven environmental management in general, landscape quality assessment has increasingly become more technical and more quantitative. It is not sufficient simply to determine which landscape condition is aesthetically better, we must also know how much better. Landscape quality assessments must also meet stringent criteria of precision, reliability and validity if they are to compete favorably with biological, economic and legal concerns of environmental management (Palmer and Hoffman, 2001). It is also increasingly necessary to proceed past assessment to valuation, as environmental management routinely requires explicit tradeoffs between aesthetic quality and other environmental values (e.g. Brown, 1987, 1984; Daniel and Vining, 1983).

4.1. Expert/design approach

The expert/design approach (formal aesthetic approach in Daniel and Vining, 1983) to landscape quality assessment has been dominant in environmental management practice (e.g. USDA, 1974, 1995; USDI, 1980; USDoT, 1981). By this approach a trained expert systematically inspects the landscape and evaluates it with respect to a combination of abstract *design parameters* deemed relevant to landscape aesthetics (e.g. Litton, 1968). The biophysical features of the landscape (mountains, lakes, trees, etc.) are translated into formal features (e.g. *form, line, texture, color*) and relationships among these features (e.g. *variety, unity, vividnesst, harmony*). Then, following prescribed rules and guidelines, areas are ranked from low to high quality (*visual quality* or *scenic class*). In typical applications, the trained expert (e.g. a landscape architect) is also responsible for designing and/or making recommendations about environmental management activities, and for negotiating and defending visual quality (scenic class) objectives in multiple-resource decision contexts.

The expert approach leans heavily toward the objective side of the philosophy of aesthetics, in that the underlying assumption is that landscape quality can be determined by any competent inspection of the relevant features of the landscape (the aesthetic object). The role of the human viewer is acknowledged at one level by the importance of *viewpoints*, locations from which viewers see the landscape in question, and *sensitivity*, based on the number of viewers and the contexts in which the target landscape is viewed (USDA, 1974). More recently (e.g. USDA, 1995) the human viewer's role has been expanded by the addition of a *constituent information* component, and attendant perception-based survey procedures. At a deeper level it might be argued that the formal design parameters on which the assessment of landscape quality is based are derived from classical/historical analyses or theories of human aesthetic perceptions and evaluations (Daniel and Vining, 1983; Lothian, 1999).

Expert landscape quality assessments have been criticized for having inadequate levels of precision, reliability and validity (Daniel and Vining, 1983). Typically only three classes of quality are determined, roughly *high, medium and low*, often with a very substantial proportion of areas classified as *medium* (e.g. USDA, 1974, 1995). As a consequence aesthetic quality will tend to remain unchanged over a substantial range of land management options that produce measurable differences in other resources and concerns. This lack of precision can put aesthetic quality at a considerable disadvantage in tradeoff analyses and multi-resource decision-making processes. Because expert assessments are typically carried out by a single person, the reliability of individual landscape quality judgements is important (Palmer and Hoffman, 2001). Systematic studies of the consistency of individual expert assessments have largely concluded that the resulting landscape aesthetic quality measures may vary as much between different experts assessing the same landscape as between different landscapes. In short, expert assessments of visual landscape aesthetic quality have not proven reliable (e.g. Craik and Feimer, 1979; Feimer et al., 1979, 1981).

Several studies have questioned whether the abstract design parameters on which expert assessments are based are theoretically relevant to either expert or perception-based measures of landscape aesthetic quality (e.g. Arthur, 1977; Craik and Feimer, 1979). These studies have produced mixed results, but no study has confirmed the assumed dependence of visual landscape aesthetic quality on the identified design parameters. It might be asserted that expert assessments, and the classical design parameters on which they are based are more closely related to "true aesthetic values", than are measures based on the perceptions and judgements of samples of the unsophisticated public (the "least common denominator", Carlson, 1977). This argument is least convincing for landscape management on public lands, especially as the public/client has no input into the selection of the expert/designer (Daniel and Boster, 1976). So long as the expert/design approach fails to meet the most basic precision and reliability criteria for assessment systems, determining the validity of the approach will remain problematic.

4.2. Perception-based approach

Perception-based methods clearly derive from the subjective philosophical camp. Typically various survey-research and psychological scaling methods are applied to obtain quantitative measures of perceived landscape aesthetic quality (e.g. Arthur, 1977; Buhyoff and Leuschner, 1978; Daniel et al., 1973, 1977; Daniel and Boster, 1976; Kaplan, 1975; Kaplan et al., 1972; Peterson and Neumann, 1969; Shafer et al., 1969; Shafer and Richards, 1974; Ulrich, 1977; Zube, 1974). Indices of perceived landscape quality are based on overt choices, rankings or ratings of landscapes (usually represented by photographs) provided by samples of (actual or potential) human viewers.

In contrast to the expert approach, perception-based assessments have generally achieved high levels of reliability. Internal reliability of landscape aesthetic quality measures based on small to moderate sized groups of observers/judges (5–30) has consistently been very high (e.g. Brown and Daniel, 1987; Gobster and Chenoweth, 1989; Hetherington et al., 1993; Herzog, 1987; Hull and Buhyoff, 1984; Hull and Stewart, 1992; Palmer, 1997; Ribe, 1994; Schroeder, 1986; Zube et al., 1974). The variation between landscapes is typically several orders of magnitude greater than the variation among observer's judgements of those landscapes; i.e. the landscape variance is greater than the observer-by-landscape interaction (Brown and Daniel, 1990; Palmer and Hoffman, 2001; Tinsley and Weiss, 1975). At the same time, perception-based indices have provided precise interval scale measures that consistently distinguish between landscapes that exhibit only subtle differences in visual characteristics (e.g. Brown and Daniel, 1986; Buhyoff and Leuschner, 1978; Buhyoff et al., 1982; Daniel et al., 1977; Hull and Buhyoff, 1983; Latimer et al., 1981; Parsons and Daniel, 1988; Malm et al., 1981). In short, perception-based assessments have met the generally accepted standards for precision and reliability of measurement systems (e.g. Nunnally, 1978).

Perception-based methods clearly emphasize the human viewer side of the landscape quality interaction, but the essential contribution of the biophysical landscape is also acknowledged. In the psychophysical variant of the perception-based methods (Daniel, 1990) biophysical features of the landscape are systematically related to perceived visual landscape quality (e.g. Brown and Daniel, 1986; Brunson and Shelby, 1992; Buhyoff and Wellman, 1980; Daniel and Boster, 1976; Ribe, 1990; Ruddell et al., 1989; Rudis et al., 1988; Schroeder and Brown, 1983; Schroeder and Daniel, 1980; Shafer et al., 1969). Similar approaches introduce derived perceptual factors (e.g. *visual penetration, focality, complexity*) and/or mediating emotional responses (attention, stress-reduction) into the relationship (e.g. Hartig et al., 1991; Hull, 1992; Parsons et al., 1998; Wohlwill, 1976; Ulrich, 1983; Zube et al., 1974). Other perception-based assessment approaches introduce higher order cognitive constructs (e.g. *coherence, mystery, prospect-refuge*) as factors that mediate (or moderate) the relationship between landscape features and human aesthetic response (e.g. Appleton, 1975; Herzog and Smith, 1988; Kaplan and Kaplan, 1989; Kaplan et al., 1972; Purcell, 1987). Whether emphasizing sensory/perceptual, emotional or cognitive factors, relationships to landscape features have generally been confirmed by direct empirical tests.

Verifying the validity of perception-based landscape aesthetic quality assessments is constrained by the lack of consensus (or an accepted theory) on what landscape aesthetic quality is. The largest number of relevant studies has addressed the more limited question of *representational validity* of photographs used as surrogates for actual landscapes in perceptual assessments. For the most part, when visual aesthetic quality of natural (or near natural) landscapes is assessed, assessments based on color-photographic representations have closely matched assessments based on direct landscape experience (e.g. Daniel and Boster, 1976; Hull and Stewart, 1992; Kellomaki and Savolainen, 1984; Shuttleworth, 1980; Stamps, 1990; Stewart et al., 1984). Representational validity studies have more recently been extended to computer visualizations, where high resolution, high realism visualizations have supported landscape aesthetic quality assessments that correlate highly with photographic representations and, by implication with direct observation of landscapes (e.g. Bishop and Hull, 1991; Bishop and Leahy, 1989; Daniel and Meitner, 2001; Orland, 1993; Vining and Orland, 1989).

A more difficult validity question is whether human observers' perceptual judgements, whether based on viewing photographs, computer images or the actual landscapes, provide valid indications of "true" landscape aesthetic quality. Addressing this question requires resolution of philosophical disputes regarding the meaning of aesthetics, and development of better (agreed-upon) theories of visual landscape aesthetics. In the interim, a conservative approach is to acknowledge these limitations by referring to the results of perception-based assessments as indicating *perceived* visual aesthetic quality.

4.3. Converging operations?

Recently efforts have been made to combine the expert/design and perception-based assessment methods. *The scenery management system* (SMS, USDA, 1995) has explicitly included a role for perceptual assessment techniques. The SMS, like the visual management system (VMS, USDA, 1974) before it, is a comprehensive management system, attempting to cover tasks ranging from inventory, assessment and valuation to designing and implementing the visual aesthetic components of forest plans or individual projects. The SMS continues to rely heavily on the judgement of a trained landscape architect (or appointed others) to perform the primary expert landscape assessments and then to personally represent visual aesthetic interests in an interdisciplinary planning and management context. Thus, success of the expert assessment component still depends very substantially on the skill and judgement of the particular individual conducting the assessment.

A provision new to the SMS is the inclusion of *constituent surveys* to obtain a parallel perception-based assessment of visual landscape quality. In the best of all worlds, the expert and perception-based assessments would agree, lending support to both (affirming conjoint validity) and giving forest managers and other stakeholders increased confidence in the associated management decisions. When the two procedures produce divergent results, however, it is not clear in the SMS how the discrepancy is to be resolved. The joint approach is still quite new, and it is not yet clear how this "marriage" will ultimately work out. The opportunity for direct comparisons between the two approaches, and for systematic efforts to understand and resolve specific inconsistencies can only advance the effectiveness and promote the validity of both approaches. Hopefully it will also improve the landscape quality outcomes of environmental management as well.

5. Aesthetics and ecology

Environmental management has progressed from single-resource, typically focussed on efficient extraction of individual commodities, to multiple-use, including commodities and amenities, to ecosystem management, where the outputs of commodities and amenities are both secondary to maintaining the basic biological/ecological system. While it is clear that maximizing the production of human benefits is not the primary goal of ecosystem management (at least not in the short-term), it is less clear what the goals are. What are the desired ecosystem conditions toward which environmental management should strive? There is no shortage of candidates, including *biodiversity*, *resilience* and *sustainability.* However, it is not yet clear how these factors are to be defined and measured, much less what levels and/or combinations of these complex bio-ecological variables constitute the most desirable conditions. Even more problematic is determining the role (if any) that landscape aesthetic quality might play in ecosystem management.

Underlying the fundamental changes in environmental policy that Gobster (1999) and others advocate, is a green philosophy in which landscape aesthetic quality is defined by natural/ecological values that are argued to be *intrinsic*, independent of human wants and needs (e.g. Callicott, 1983, 1985; Rolston, 1984, 1988). This bio-centric account is not new. Daniel and Vining (1983) identified the "ecological model" as one of five conceptual models underlying the then extant approaches to landscape quality assessment. Leopold's (1969) *uniqueness ratio* was offered as an example from within the expert appraisal approach. In public perception-based landscape quality assessments *naturalness*, indicated either by human-perceptual judgements or by the observed dominance of plants and/or the absence of human artifacts or disturbance, has also been found to be associated with higher levels of judged visual landscape quality (e.g. Kaplan and Kaplan, 1989; Parsons, 1991; Pitt and Zube, 1987; Ulrich, 1983). But the ecological model is not fundamentally interested in human perceptions or preferences. Landscape quality is *defined by* ecological characteristics such as integrity, biodiversity or sustainability (in principle, if not yet operationally), independent of human values, judgements or preferences. Human perception of landscape quality should, it is argued, be consistent with ecological quality. Landscape preferences that are found to be contrary to good ecology (when and if that can be determined) are deemed unethical, immoral or the result of inadequate ecological sophistication (e.g. Carlson, 1977, 1995), and thus are in need of modification.

What is the relationship between ecological quality and visual landscape aesthetic quality? If one allows the conceptual fiat of defining landscape aesthetic quality by naturalness (as the SMS essentially does), then aesthetic quality and ecological quality could be one and the same. If one accepts that aesthetic quality and ecological quality are conceptually separable (perhaps on the basis that procedures/operations for assessing them are substantially different) then determining the relationship between the two is largely an empirical matter. High ecological quality (assuming that some consistent assessment could be made thereof) may or may not be correlated with high visual landscape aesthetic quality, and moreover, the relationship may differ depending upon what ecosystem (or successional stage) is involved. In addition to the essentially biological problem of defining ecological quality, there are some methodological problems obstructing efforts to address the question within the perception-based assessment approach.

5.1. Representing ecosystems

Ecosystem management has posed significant challenges to forest managers, as well as to the underlying biological and forestry science and technology (e.g. Behan, 1990; Kaufmann et al., 1994; Szaro et al., 1998). While not fully defined, *ecosystem* clearly connotes a complex of physical, biological and perhaps social processes that are highly interactive over multiple scales of time and space (e.g. Sexton et al., 1998). Ecosystem management attempts simultaneously to encompass geographic scales that extend from micro-site to landscape to global. Temporal scales that have traditionally been marked by 10-year plans must be substantially extended to encompass much shorter and very much longer intervals. Indeed, if the stated goals of species preservation and ecological sustainability are to be taken seriously, the temporal scale for environmental management becomes infinite, or at least indefinite. Similarly, the geographic scale and resolution of environmental management must be extended. Ecological objectives (e.g. diversity, sustainability) are not definable at any specific point, but require consideration of a changing spatial mosaic of different environmental conditions. Determining relationships between ecological quality and visual aesthetic quality of the landscape, then, must address a dynamic mosaic of conditions that naturally and continually changes in response to ecosystem processes.

These geographic and temporal complexities of ecosystem management pose important challenges to perception-based landscape aesthetic quality assessments. Typical procedures for presenting a particular landscape scene as it appears at a particular point in time are poorly suited to determining relationships with ecological quality. What is needed is a visual aesthetic assessment of geographic and temporal patterns of environmental conditions in comparison to other possible patterns.

5.2. Geo-spatial variations

When the relevant range of spatial variations can be covered within a single view (a *vista*, definition 3 above), single scenes depicting ecologically relevant patterns might provide a sufficient basis to determine aesthetic preferences. Vistas exhibiting different patterns of land cover could be presented to human observers to determine which patterns are associated with higher levels of perceived landscape quality (e.g. Buhyoff et al., 1982; Swaffield and Fairweather, 1996; Thorn et al., 1997). But, many landscapes in which human aesthetic preferences are important do not naturally provide views that would contain even a small part of the range of geographic variations. For example, relatively flat landscapes with dense forest vegetation do not offer vista perspectives.

One representation option for restricted view (*near-view*) landscapes might be to use aerial views that do display the ecologically relevant range of spatial variations. But this would provide a very unnatural view of the landscape. The "real world" experience of relatively flat forested landscapes, for example, would feature restricted views underneath the canopy of trees, penetrating more or less through tree trunks and under-story vegetation. Aerial perspectives would change this experience to an expansive view looking down on the top of the tree canopy, with no view of the trunks or vegetation underneath. A more natural way to experience geographical variations in restricted-view landscapes would be to walk through them, encountering different landscape conditions sequentially as they occur. Computer visualization technology (e.g. Bishop, 1997; Bishop and Hull, 1991; Clay and Gimblett, 1998; Daniel, 1992; House et al., 1998) could readily provide such "walk-throughs". More sophisticated virtual reality techniques could provide the observer with realistic interactive visual experience, including freedom to look about the environment and to proceed into it in any chosen direction (e.g. Rohrmann and Bishop, 2001; Orland, 1993).

It is technically possible to provide "bird's eye views" and interactive walk-throughs as means for representing ecologically relevant geo-spatial variations and patterns in landscapes. It is not clear, however, that such representations would support valid perceptions of landscape aesthetic quality, i.e. perceptions that would be consistent with normal environmental experience. For individual, static landscape scenes representational validity of photographs has traditionally been established by comparing photo-based and on site perceptual assessments. Following a similar approach, the validity of aerial and/or walk-through representations could be determined by comparing perceptual assessments based on virtual and direct experiences of vista landscapes differing in geo-spatial patterns. But representing the ecological quality of landscapes also requires consideration of temporal variations that are not addressed by either aerial or walk-through methods.

5.3. Temporal variations

Representing temporal changes in ecologically relevant landscape patterns presents additional challenges for landscape quality assessments. For landscapes offering vista perspectives, computer-based environmental visualization technologies could provide "time-lapse" presentations of changing patterns of land cover (e.g. Orland, 1993; Swaffield and Fairweather, 1996; Thorn et al., 1997). But, would expressed preferences based on such presentations be valid? The rate of ecological changes in landscape patterns can be very slow-involving intervals that substantially exceed a human lifetime. It is technically possible to visualize and compress these changes and present them in a few minutes. But, would assessments of landscape aesthetic quality based on such presentations be valid or even meaningful? Landscape perception research and relevant psychological theories offer no obvious solutions. Moreover, because of the long time spans often involved, there would not appear to be any direct empirical means for addressing the question by investigating on-site experience.

More complex problems are encountered when trying to represent temporal changes in restricted view landscapes. As for the vista perspectives, visualization technology could combine walk-through and time-lapse techniques to represent changes in land cover patterns over time. But the problem would remain of determining valid ways to represent temporal changes that exceed human lifetimes. In addition, it is not clear whether such changes should be depicted place-by-place as they are encountered within a given "trip" through the landscape, or by separate trips completed at each relevant time/ecological change step. Again landscape perception theories and existing landscape quality assessment research and practice provide little direction for specifying the appropriate procedures, and there is no obvious way to resolve these issues empirically.

Presenting individual static scenes representing conditions at a particular place and point in time is not sufficient for determining relationships between ecological quality and visual landscape aesthetic quality. What is less clear is what the necessary and sufficient representation/presentation procedures should be. The best (perhaps only) approach presently available is to apply several different procedures, such as various versions of on-site, time-lapse, walk-through and/or aerial representations and then compare the outcomes that result from each method. To the extent that different representations of the same ecological conditions yield equivalent assessments of visual landscape aesthetic quality, confidence in the validity of each representation is increased.

5.4. On the horizon: the bio-social chasm

Visual landscape quality assessment will be fundamentally challenged in the 21st century by two opposing forces. On the one hand will be a continuing retreat to a bio-centric environmental management philosophy advocated by some deep ecologists and environmental philosophers. On the other hand, a growing body of environmental policy researchers and practitioners taking the very tenable position that environmental problems are social problems, will extend that premise to conclude that the environment itself is a social invention. The extreme socio-cultural paradigm will insist that the "real environment" is a figment of philosophically naïve imaginations. Bio-centric and socio-cultural approaches will pull the landscape-viewer interaction conception of landscape quality assessment apart.

The bio-centric movement will further depreciate the importance of *human values* in favor of bio-ecological *natural values* that are asserted to be intrinsic. This philosophy will have considerable appeal to environmental managers trained in traditional biological/natural resource fields, and who have been less than comfortable with the intense public involvement/human values conflicts that have dominated the end of the 20th century. Visual landscape aesthetic quality is among the "human dimension" values that have been troublesome for traditional land management, and that can be disenfranchised by a strong bio-centric philosophy. To the extent that visual aesthetic quality is considered at all it must, on ethical/moral grounds, be consistent with ecological values. Expert/design assessments will be welcome, so long as landscape quality assessments support ecological objectives. Human perceptions of aesthetic quality that are consistent with good ecology (assuming that can be defined) will be deemed "right" and accepted. Aesthetic perceptions that are inconsistent with good ecology will be "wrong" and, will need to be corrected by instilling a more appropriate understanding and appreciation of ecology. The role of perception-based assessments will shift from determination of public values/preferences as one of the recognized goals of environmental management, to diagnosis of pathological preferences and prescription of cures.

The socio-cultural paradigm will emphasize cultural determination of environmental values in general, and landscape aesthetic values in particular. Science, whether biophysical or social, will be a system for directing and substantiating a priori cultural truths, with no pretense of objective, value-neutral discovery of consistent relationships among natural phenomena. Physical and biological processes will be unimportant to environmental management and policy, replaced by social consensus and communal decision making exercises. The environment will be viewed as a social construction, and the ultimate goal of management will be to achieve agreement among various constituents/stakeholders about what environment is desired, with little or no concern about what may or may not happen in the non-existent actual environment. Expert assessments of landscape aesthetic quality will be replaced by "facilitation" to lead the social consensus process to correct conclusions. Individual perceptions and preferences will be taken to be indications of cultural background, rather than reactions to any particular features or patterns in the landscape. Disagreements with the prevailing social consensus will be accommodated by conflict resolution and consensus-building efforts, rather than by making changes in non-existent biophysical landscape features.

6. Conclusion

Systematic visual landscape quality assessment was invented and matured in the last half of the 20th century. It has come to play an important role in environmental management and policy and it has become a well-recognized field of scientific research with a substantial literature base. The developmental period has featured contests among opposing paradigms, with the expert/design (formal aesthetic) and the perception-based approaches being the primary contenders. At the turn of the century these two paradigms are beginning to show promise of merging into a more effective approach that better addresses the interdependency of landscape features and human perceptual/judgmental processes in visual landscape aesthetics. A successful merger could better serve environmental managers and insure more effective representation of visual aesthetic quality in management decisions and policies. The shift to more comprehensive ecosystem management presents special challenges to visual landscape quality assessment, but rapid advances in geographic information systems, environmental modeling and environmental visualization technologies have greatly improved the tools available for the task. Efforts to effectively represent the visual aesthetic effects of complex geo-temporal ecological changes will benefit from and contribute to improved theories of landscape aesthetics and human landscape perception and preference.

In the 21st century bio-centric philosophies will question the need for visual quality assessments, advocating that intrinsic ecological values should rein over expert or human perception-based aesthetic values in landscape management. An emerging socio-cultural paradigm would replace any direct assessments of landscape features by experts or by perception-based methods with communal decision making schemes emphasizing negotiation and consensus building. In contrast to these two opposing forces, traditional expert and perception-based assessment approaches could grow together into a more balanced view, reaffirming that landscape aesthetic values result from the interaction between biophysical features of the landscape and associated human perceptual/judgmental processes. As a practical matter, this interactive approach provides two related, but distinct means for managing the aesthetic quality of the landscape-change the objective features of the landscape, or change the subjective judgements of the viewer. Biophysical processes are accepted as appropriate instruments for changing landscape features, and human perceptual judgements are the most important indicators of visual aesthetic quality. Changing public landscape perceptions and preferences in any fundamental way exceeds the mandates of traditional landscape management, and is better addressed in a broader, explicit social-political discourse about environmental values.

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