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Workshop in Landscape Change: Final Report

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WORKSHOP IN LANDSCAPE CHANGE

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Introduction

One of the most persistent tensions in science is that between basic and applied research; between research that is driven essentially by curiosity, and research that is driven by recognized societal need. But although this distinction is useful with respect to many disciplines, including mathematics, it still does not encompass the full range of academic pursuits, because many disciplines are concerned not so much with acquiring new knowledge, whether the process of acquisition is driven by curiosity or recognized need, but by the process of putting knowledge into practice. Landscape architecture is an example of these disciplines whose primary contribution lies in *implementation* through professional practice, and the mobilization of knowledge in policy, decision, and action, more than in *investigation*.

The goal of the National Science Foundation, and similar agencies in other countries, is to support both basic and applied forms of investigation; but within NSF there are no programs of direct support for the implementation disciplines of landscape architecture or planning. Yet the process of implementation is clearly of critical importance in science. Research into methods of conservation, for example, will have much greater value if it can be integrated with a process of implementation; and conversely, the disciplines that deal with implementation have a critical role in driving both basic and applied research agendas, towards improved and more readily implemented methods and concepts.

This report describes a workshop held in January, 2001 in Santa Barbara, California. The workshop focused on landscape architecture, and brought together participants from both sides of this tension between the investigative and implementation disciplines, to explore its dimensions and to map directions for the future. Its central theme was *landscape change*, an area of concern to both investigators and practitioners. Landscape change offers a timely and compelling opportunity to explore the relationships between scientific investigation, the development of policy, and the practice of intervention and design. Landscape change is high on the public agenda, in issues of urban sprawl, environmental sustainability, and quality of community life. Landscape architecture and urban planning have long been recognized as academic disciplines, based on the systematic study of practice and the education of new generations of practitioners, and have a complex and evolving relationship to disciplines that are dominated by basic research rather than by a focus on normative implementation.

The specific goals of the workshop were:

- to promote the building of a collaborative research community between landscape architecture and related investigative disciplines;
- to develop a joint research agenda that would be informed by the needs of implementation; and

- to facilitate the exchange of ideas across the boundaries of the assembled disciplines.

Funding to support a workshop of approximately 45 participants was obtained from the Geography and Regional Science program of the National Science Foundation (Award BCS 0079979), and from Environmental Systems Research Institute (ESRI), Redlands, CA.

The workshop was held from January 25 to January 27, 2001, and followed a format for meetings of specialists pioneered by the National Center for Geographic Information and Analysis (NCGIA) beginning in 1988. The model formula was defined in the original NCGIA proposal, and has evolved since then based on experience and feedback. 19 specialist meetings were held under the original NCGIA cooperative agreement (SES 8810917), and a further 10 under the Varenius cooperative agreement (SBR 9600465). The role of each meeting in community building and agenda setting is documented in the meeting reports, and summarized in the NCGIA Annual Reports, all of which are available on the NCGIA Web site or in hard copy from NCGIA.

In 1967 the late Ian McHarg initiated an earlier dialog between landscape architecture and the environmental sciences, by obtaining funding from the Ford Foundation to recruit a faculty of natural scientists into the Department of Landscape Architecture at the University of Pennsylvania to "integrate their perceptions into a holistic discipline applied to the solution of contemporary problems" (McHarg, 1996, p. 192). The notion that one can practice landscape architecture by integrating the views of soil scientists, hydrologists, ecologists, climatologists, *etc.*, echoes the multi-layered view of geography that McHarg did much to popularize with his *Design with Nature* (McHarg, 1969), and has been important in the building of many environmental programs.

Much has changed since 1967. First, the multi-layered model that McHarg experimented with using transparent overlays has evolved into the technology of geographic information systems (GIS; see Foresman, 1998, for a history of the development of GIS, and see Longley *et al.*, 1999, 2001, for comprehensive reviews of GIS), a collection of tools that support the handling and manipulation of vast amounts of digital geographic data. Landscape architects are now routinely trained in the use of GIS. Moreover, models and methods of analysis developed by researchers in related disciplines are now readily executed within GIS environments, providing a more effective connection between basic research and practice. For example, it is now easy for a landscape architect investigating the impacts of a project on groundwater to make use of an array of sophisticated groundwater modeling tools, all embedded in commonly available GIS packages.

Second, new disciplines and subdisciplines have emerged to conduct research in areas that are essential to the design process. They include environmental perception, landscape assessment, the human dimensions of global change, land use analysis, and land conversion modeling.

Third, the growth of information technologies has drawn attention to information as a commodity that is essential to the design process. Decision making is now seen as an enterprise involving many stakeholders, in which information plays a vital role. There is interest in developing GIS and spatial decision support systems that serve the needs of all participants in the decision process (see, for example, the work on Public Participation GIS under the Varenius project, Craig *et al.*, 1999); and the Federal Geographic Data Committee's six Community Demonstration Projects are aimed at demonstrating the value of geographic information in planning at the community level.

These trends have shifted the research base significantly. Whereas in 1967 it was the environmental sciences that were seen by McHarg as the primary producers of research to support enlightened landscape architecture, by 1999 the relevant producers are as likely to be geographic information scientists, social psychologists, behavioral geographers, or decision theorists. The same basic need remains, however—to develop a dialog between basic researchers and design professionals, in the interests of cross-fertilization of ideas, development of collaborations, and negotiation of a research agenda that is both useful to design professionals and interesting and stimulating to basic researchers.

Because the base of investigative research has broadened substantially since 1967, the workshop was organized around four parallel themes: information technologies, to recognize the importance of GIS and spatial decision support systems; decision making, to explore research progress in the concepts and theories that address human decision making; landscape perception and assessment, to reflect current interest in these aspects of design; and the environmental and social sciences. The following general questions provided an overarching framework for the discussions:

- What basic research issues are raised by the call for "smart growth", “sustainable communities", and "livable communities"? What do these terms imply about the need for knowledge in the relevant social and environmental sciences, the decision sciences, the information sciences, and landscape perception, and what gaps exist in our current knowledge?
- What are the roles of industry, government agencies, professional societies, and foundations in promoting, funding, and conducting research in landscape change? What mechanisms might foster greater collaboration with the academic sector?
- What are the best structures for conducting multidisciplinary research in this aarea, and for integrating multidisciplinary perspectives? Do adequate structures already exist, or is there need for new ones?
- What specific research needs to be undertaken under each of the four themes?
- What research issues should have highest priority?
- What previous efforts among the design disciplines have attempted to establish research agendas (*e.g.*, Palmer *et al.*, 1984), and are they in need of updating?
- What do we know about integrating basic research and scientific knowledge accumulation with prescriptive intervention and normative design? What do we know both in general terms, and specific to landscape change?

- What benefits would be gained from designating a set of communities as long-term research sites, comparable to the Long Term Ecological Research sites sponsored by NSF, and now extended to include urban and marine ecology?
- What changes should be made in the curricula of the design disciplines, notably landscape architecture, to reflect recent advances in the four themes of the workshop? What is the state of pre-college education in this area?

Organization of the report

Although this report is largely self-contained, much additional information is available at related Web sites. The workshop site (see http://www.ncgia.edu under Meetings) includes a full list of participants and contact information, and the short position papers written by each participant in advance of the workshop. Also available at this site are the Powerpoint presentations made by the workshop's keynote speakers, and the workshop program.

The next section of the report describes the specialist meeting process. This is followed by four sections giving short summaries of the four keynote presentations and subsequent plenary discussion on each of the four themes, and by summaries of each of the workshop's breakout sessions. The final section provides a short summary of the workshop's conclusions and ideas for follow-on actions. Appendix A provides the list of participants, and Appendix B presents an aggregated synthesis of the 80 research agenda suggestions provided by the participants during the workshop.

The specialist meeting process

The workshop was chaired jointly by Michael Goodchild, a geographer at the University of California, Santa Barbara, and Chair of the Executive Committee of NCGIA; and Fritz Steiner, a landscape architect at Arizona State University and shortly to move to an endowed chair at the University of Texas at Austin.

The workshop was organized by a steering committee consisting of the co-chairs and the following individuals drawn from the disciplines represented at the meeting:

Susan Crow, Product Specialist with ESRI and faculty affiliate to the Community and Regional Development Division of the Institute of Government at the University of Georgia;

Jack Dangermond, President of ESRI with Masters degrees in Urban Planning and Landscape Architecture from the University of Minnesota and Harvard University respectively;

Stephen Ervin, Lecturer in Landscape Architecture and Assistant Dean for Information Technology at the Harvard Graduate School of Design;

Tom Evans, Assistant Professor of Geography at Indiana University and Research Associate at the Center for the Study of Institutions, Population and Environmental Change, with research interests in modeling population–environment relationships, demography, GIS, and satellite remote sensing;

Susan Everett, Executive Director of the Landscape Architecture Foundation and a Fellow of the American Society of Landscape Architects;

Doug Johnston, Director of the Geographic Modeling Systems Laboratory, University of Illinois at Urbana-Champaign;

Mary Kihl, Associate Dean and Director of the Herberger Center in the College of Architecture and Environmental Design, Arizona State University;

Marguerite Madden, Associate Director of Environmental Science at the Center for Remote Sensing and Mapping Science, Department of Geography, University of Georgia, with research interests in geographic information systems, remote sensing, and landscape ecology;

Laura Musacchio, Assistant Professor in the School of Planning and Landscape Architecture and Center for Environmental Studies at Arizona State University; her research focuses on landscape change in urban watersheds and riparian systems;

Joan Nassauer, Professor of Landscape Architecture in the School of Natural Resources and Environment, University of Michigan; she conducts research in landscape perception, landscape ecology, and watershed management;

Forster Ndubisi, Professor of Landscape Architecture at Washington State University and President of the Council of Educators in Landscape Architecture;

James Palmer, Associate Professor of Landscape Architecture at the SUNY College of Environmental Science and Forestry, Syracuse, NY; his resesrch interests lie in public landscape perceptions, professional landscape assessments, and GIS models of these perceptions;

James Sipes, landscape architect with Jones & Jones, Seattle, with extensive experience in academic positions and computing editor of *Landscape Architecture*; and

Melinda Sippel, Development Coordinator of the Landscape Architecture Foundation, American Society of Landscape Architects.

Participants were selected by a two-stage process. First, announcements were distributed calling for participation, and requesting the submission of a short resumé and a personal position statement regarding the objectives of the workshop. The announcements appeared in newsletters and email lists of the communities most likely to be interested in the workshop. A total of 67 applications were received by the deadline. Second, the steering committee selected individuals who they believed would best contribute to the objectives of the workshop. The final list of 48 participants included the 14 steering committee members and two co-chairs, the four keynote speakers, 8 participants who responded to the open call, and 26 invitees selected by the steering committee. Efforts were made to achieve an appropriate balance of disciplines and regions of the U.S. The steering committee was especially conscious of the need to include traditionally under-represented groups (the final list of 48 included 19 women and one African-American).

Following NCGIA practice, the workshop was organized as a series of four sections, one focused on each of the four themes. Following a general introduction of the participants and a review of the objectives by the co-chairs early in the morning of Thursday January 25, the first section focused on information technology, followed by sections on decision-making, landscape perception and assessment, and environmental and social sciences. Each section included a keynote presentation, a response by a landscape architect, plenary discussion, breakout discussions in four groups, and a plenary summary. The workshop ended with a closing plenary discussion of conclusions and future plans.

The next four sections summarize the workshop discussions on each of the four themes.

Information technology

Geographic information technologies have had enormous impact on the process of decision making over the past two decades. One of their attractions is the creation of an audit trail—without a clear record of how a decision was made, it is easy to accuse the process of being arbitrary and capricious. Another attraction lies in the ease with which digital information can be communicated and shared with many stakeholders, through the Web or simple map-making software. Of course there are many counter-arguments (see, for example, Pickles, 1995), but the popularity of GIS among regulatory agencies is indisputable.

By formalizing geographic data in a database and by capturing aspects of the decision process in an audit trail, GIS allows us to begin to address questions of the role of information in decision making:

- What levels of spatial, thematic, and temporal detail are needed to inform effective design?
- How can the benefits of data be estimated and compared to the costs of data acquisition?
- How do the limited representations possible in today's GIS, and in digital systems generally, impact the decision process and the ability of individuals and groups to express their views?
- How can alternative methods of data acquisition, sketching, and other design tools be incorporated into GIS?
- What changes are needed in today's GIS to facilitate public participation in decision making?

The opening keynote presentation was made by Jack Dangermond, President of ESRI. Jack noted the enormous progress that has been made in GIS in the past 30 years, and the steady growth in vision, from a processor performing tasks at the behest of a single user, to an enterprise-wide model for organizing the information needs of a corporation or agency, and most recently to a society-wide model based on the Web. ESRI’s range of products has grown with the vision, so that today it includes software designed for many distinct niche applications. The new ArcGIS technology includes the potential for greatly increased use of the Web as a source of data and of data processing and analysis services; and the potential for highly customized representations using Unified Modeling

Language. The new tools exploit industry-wide standards for data and software interoperability.

Jack argued that our world is a living system, composed of dynamic, interconnected, and interdependent parts. Humans are part of this living system, and co-evolve with its landscapes. Globalization is impacting the system by creating stronger linkages over longer and longer distances. But at the same time our global society is evolving to become more specialized, and to see the world only in its pieces. Our information systems are similarly focused, fragmented, and unconnected. Thus our task should be to put the pieces of the world together again, by visualizing, connecting, and relating its component parts.

Jack introduced a new metaphor for GIS in the context of the workshop, and the participants seemed to appreciate its value. The human body has a highly evolved central nervous system, which is spatially organized, in the sense that it can detect both the magnitude and the location of pain. The Earth has no comparable, spatially organized system for detecting stress, and humans concerned about the planet's environmental health must therefore construct one. Jack asked the group to explore the concept of a central nervous system based in information technology. A global GIS could provide a new way to integrate and share data; an open, multi-user, multi-participant system capable of measuring change, performing spatial analysis and geographic accounting, modeling, decision support, and managing.

With current GIS technology it is possible for users to achieve great sophistication in the sharing of data, through technologies such as ESRI's Geography Network
, or the Federal Geographic Data Committee's National Geospatial Data Clearinghouse. But while these technologies are powerful approaches to sharing data, landscape architects and planners may be more interested in the sharing of *designs*, and the use of collaborative Web-based design tools.

Jack ended by asking what it will take to move this vision forward. He argued that widespread adoption will require improved spatial data, new procedures and methods, a substantially larger cadre of GIS professionals, organizational support, and a generation of technology that is easy to use. The rate of advance of technology is accelerating, and will continue to accelerate in the near future. But at the same time the worlds of geographic design, GIS, and geographic science are becoming more synergistic, held together by the glue of technology. Focusing the growing power of these technologies and human resources on the problems of landscape change and global environmental health will require a mix of cross-disciplinary education, collaborative projects, publications and data, and the kind of prominence that can be achieved by a National Research Council study or a national research center.

In his discussion of Jack's presentation, Steve Ervin asked the group to consider a number of questions in the subsequent breakout discussions:

- What is a technology for design, and how is it different from GIS?
- What technological tool do you not have, that you would like to have in 2–5

years?

- Is technology good, bad, neutral, or limiting in its impacts?
- How is representation important in the practice of landscape architecture, and what limitations do current GIS representations impose?
- Object orientation is a powerful new paradigm for GIS design, but are there aspects of object orientation and landscapes that are inherently antithetical?
- What should be the half life of information technologies in landscape architecture?

In addition to the points raised by the keynote speaker and discussant, each of the four breakout groups was asked to consider the set of six opening questions above. The following points emerged from the discussion:

- In practice, the data available for analysis and design are determined by a complex set of past events and practices, and are rarely ideal. Methods are needed for selecting the best among the practical alternatives, or what one might call *best available data* (BAD). Since many data sets will have been created by others, rather than for the specific needs of the project, it is important to have access to methods for checking validity.
- These issues are especially important in those parts of the world where data are comparatively scarce, notably in developing countries.
- There is a need for a *data dictionary* that can provide guidance to designers seeking to apply GIS.
- The data used in a design project frequently affect other decisions made by individuals and groups. It follows that data should never be selected in isolation, but rather in the broadest possible context.
- Because GIS data are subject to uncertainty that is often substantial, there is a need for confidence limits on designs, predictions, and models. Knowledge of uncertainty must be communicated effectively to the users of GIS products, to counter the tendency to regard all computer results as exact. Approaches to uncertainty need to be fine-tuned to reflect differences across the country.
- In recent years there has been substantial progress on the incorporation of concepts of fuzziness and vagueness into GIS, as a means of dealing with uncertainty. There is a need to investigate such concepts in the context of design.
- Design is inherently a hierarchical process, in which details are aggregated within larger schemes. Small, detailed changes can propagate to have large, aggregate consequences. Information technology and data must be similarly hierarchical, able to produce results quickly at multiple scales, and able to analyze impacts of changes at one scale on changes at another scale.
- Information technologies have value in their ability to engage attention (the “gee whiz” factor), but it is dangerous to allow this to mask the inherent importance of

the decisions at stake.

- Current methods for visualizing and mapping the results of analysis and design often go beyond the *visual literacy* of individuals, or their ability to understand data in spatial context. There is a need for new, more intuitive methods that may be radically different from the ones that have been inherited from traditional cartography.
- There is a need to understand better the role of information technology at various stages in the decision-making process. At what stages is its potential greatest?
- GIS has a critical role to play in the physical and cultural recovery of a community after a catastrophe.
- GIS is rarely sufficient in itself for design and problem solving. Instead, it is more often necessary to integrate GIS with other forms of information technology, into collaborative planning environments for decision support.
- Information technology could aid the design process if it were capable of incorporating sketches, and linking them to models; and if it provided access to precedents, past history, and simulations. Such technology would be particularly useful in the field, on-site. Currently available GIS has few of these capabilities.
- GIS and design promote distinct views of data. The emphasis in GIS is on measurement, representation, and modeling, while the emphasis in design is on conceptualization, problem solving, and uncertainty. There is a need to find effective and workable links between these two views.
- GIS encourages an emphasis on the properties of a site, while design requires an understanding of the relationships between a site and its wider context.
- Design is intentional, goal-oriented, and active, but landscape change is not guided as design is guided. Better information can help to avoid the unintended consequences of design.
- Information technology makes it possible to examine and compare many alternative designs, including the “no change” option.
- Although GIS is often used to analyze data at a single point in time, or data that are static through time, effective decision making inevitably requires information about what is changing, and why it is changing. Detection and evaluation of change are of critical importance.
- In addition to asking about data as input to design, it is important to ask about design’s impact on the landscape, and the levels of detail needed to capture and represent its effects. How does effective design create levels of spatial and temporal detail that need to be incorporated in GIS?
- Technology is increasingly driving landscape change, as design technology becomes more and more accessible to individuals and community groups.
- There is a need to analyze failed planning projects, to gain a better understanding

of their economic costs and adverse effects on ecosystems.

Decision making

The decision sciences focus on formal models of the decision making process, and their accumulated knowledge is clearly of importance in the design aspects of landscape change. Workshop participants were asked to consider the following questions with respect to decision making:

- What is the state of knowledge with respect to decision making by communities, and what has been the pattern of success and failure among the design disciplines in applying this knowledge to landscape change?
- What can be done to increase awareness of this knowledge among the design disciplines, specifically landscape architecture and regional planning?
- What gaps exist in our current knowledge that must be filled to improve the practice of landscape architecture and regional planning?

The opening keynote presentation was given by Ron Eastman, Professor of Geography at Clark University, and originator of the Idrisi GIS, a tool that is perhaps the most sophisticated among currently available GIS in its support for spatial decisions and implementation of decision science methods.

GIS is understood in various ways by its users, but there is little doubt that its ultimate purpose is decision support. Many types of decisions can be addressed, including decisions over the allocation of scarce resources; the evaluation of evidence; and decisions regarding policy. In his presentation, Ron first reviewed the implementation of decision science research in GIS, and then explored the ways in which decision analysis procedures can be used to elucidate processes of landscape change. In landscape change, the real decision makers are the individuals and corporations who buy, sell, and modify the use of land. If the behavior of these decision makers can be understood, then policies can be formulated to influence behavior in ways that are consistent with public aspirations.

Decision science is an interdisciplinary field that has grown from a set of concerns that are common to a number of disciplines, including operations research, cognitive and computational science, psychology, geography, and business management. The need to address the distinct concerns of many stakeholders has led to the development of the methods of multicriteria decision-making (MCDM). Multicriteria decisions are defined by the need to bring several distinct lines of evidence or conditional requirements to bear on outcomes, and the primary focus of research in this area has been on the aggregation of these multiple lines of evidence into a single composite statement. Ron showed several compelling examples of the application of MCDM techniques to spatial decision support, drawing on case studies from around the world. He showed how it is possible to incorporate uncertainty into such methods, in the form of uncertainties associated with the underlying data and also with the criteria and constraints, and how it is possible to make effective decisions under such conditions.

GIS and decision science have many important roles to play in the analysis of landscape change. They can support public participation in the analysis and design process, enabling the active review of issues and outcomes via the Internet. They can provide the necessary design tools for MCDM, and the tools for simulation of the consequences of uncertainty. They can also be used to simulate the behavior of actors, and to observe the implications of policy options. The presentation included a case study that integrated all of these roles in a study of landscape change.

Ron concluded with the comment that landscape change is the corporate manifestation of the decision-making behavior of many individuals and organizations; and that decision support tools in GIS offer considerable scope for the modeling of that behavior, and for gauging the effects of policy interventions.

In her discussion of Ron's presentation, Joan Nassauer reviewed some of the broader implications of GIS, and information technologies in general. The kinds of information needed to create models of the behavior of individuals and corporations inevitably raise issues of privacy, and the technologies required to collect such data raise issues of surveillance (Pickles, 1995). Access to data raises issues of intellectual property and ownership as well as confidentiality, and the growing data industry is increasingly strident in protecting its own commercial interests. There are also ethical issues surrounding the use of GIS and decision-support tools, including the need to ensure accuracy.

The following points emerged from the breakout sessions that followed:

- The methods summarized in Ron's presentation are important parts of the decision-making process, but we must look further afield for complete models, to such fields as financial management, political science, and communications. In the absence of comprehensive models, most of us currently learn through case studies rather than through theory and generalization, in part because of a general lack of the latter.
- This lack of appropriate theory about the community decision-making process and landscape change needs to be addressed. It should encompass scales and complexity of decision making, and should provide a framework for decision-making tools.
- A national center could provide the critical mass needed to develop such theory, to identify and elaborate fundamental research questions, to assemble and disseminate case studies and tools, and to provide assistance to the design professions.
- Success or failure in spatial decision support may relate less to techniques than to the nature of the group of stakeholders. Motivation, level of community attachment, and belief in success are all critical but unmeasurable. We have anecdotal information on some of these issues, but systematic research is needed on the kinds of analysis and presentation techniques that produce success in the decision support process. We can also learn much from past histories of success

and failure.

- The distinction between success and failure may depend on who is measuring—success to one agency may be failure to another. For example, government regulatory agencies seek to optimize against their own criteria, while the private sector seeks to maximize the value of investment.
- Dissemination of information is critical in building awareness of decision science among the design professions. There is a need for examples of best practice, and for documented case studies of success and failure. Case studies can be disseminated through organizations and their conferences, including URISA (Urban and Regional Information Systems Association and LIAA (Land Information Access Association, and through community design workshops. There is a lack of resources to support greater awareness—a lack of foundation textbooks, for example. Greater interdisciplinary collaboration is the key to improved resources, as researchers in the decision sciences come to appreciate the need for design-science applications. Internships are another way of fostering greater interdisciplinary collaboration and awareness.
- There is a need to examine the basic principles of education in the design disciplines. Too often the emphasis is on how to get a better job, rather than on reflection and thought, and on teaching technology rather than practice. Decision science is not often taught in the design disciplines, but is much more widely used in business and medicine.
- GIS should be used to document the process of change and possible futures, by recording both geographic change and critical decision events. This will require substantial effort to develop the necessary methods of representation. The term *geo-accounting* seems appropriate to describe a process of monitoring and assessing change.
- GIS could also be used to monitor the design process, in a continuous data collection activity. Such data would be invaluable as the basis for research into the design process.
- Although much use of design tools is prescriptive, there is a need for hypothesis-based research into mental maps, environmental behavior, experimental and normative landscape creation, and landscape information assessment.
- There is a need for a better understanding of the drivers of landscape change. It would be useful to create a typology of regional variation in the roles of public agencies in dictating landscape change, and in regulating the private sector. At what level or scale is the greatest power invested in government to influence landscape change?
- Conversion of land to other uses creates landscape change, and may result in the generation of wealth. Research is needed to identify the economic and non-economic drivers of landscape change through landuse conversion within

communities.

Landscape perception and assessment

Landscape perception is recognized as a significant subfield in several disciplines, and as an important dimension of design. Participants were asked to consider the following questions in addressing this topic:

- What is the state of theory regarding human behavior in response to landscape change, and the role of landscape in perception and attitude formation? Do certain groups of people develop different attachments to landscape that affect their way of life?
- What economic effects are attributable to landscape change?
- What do we consider when deciding whether a landscape is "healthy", "livable", or "sustainable"?
- What is the stability of human landscape perceptions (*e.g.*, Palmer, 1997)? How do changes in the environment affect our perceptions? Do we acclimate or adapt to such changes, or do they change our quality of life?
- Are there ways that landscape assessments are used by one cultural group to control another cultural group? To what extent are landscape assessments objective science or cultural interpretations?
- How can landscape assessments be used to help prepare for possibly catastrophic events, such as global climate change? What are possible scenarios in response to global climate change, and how do they affect various populations?

The opening keynote presentation on landscape perception and assessment was provided by Jim Palmer. Landscape perception is one branch of landscape assessment, which investigates how well the landscape fulfills specified criteria; in the case of landscape perception the criteria typically deal with scenic beauty and preference, as judged by the general public or some subset of the public. However there are also professional methods for assessing the landscape, which may evaluate economic benefits, functional services, or resource quality.

Maslow’s Hierarchy of Needs (Maslow, 1954) provides a useful heuristic for understanding the importance of landscape perception research. At the highest levels of the hierarchy are human needs for self-actualization and beauty; at the most basic levels the individual must meet physiological needs for food, water, and safety; while in the middle, social needs concern our relationships with others. It seems that landscape addresses needs at the highest (the need for aesthetic value) and lowest levels (there is some indication that people prefer landscapes that appear to support basic needs, and evidence of links between landscape aesthetics and health), but little research is available about the role of landscape perception in the middle levels.

A simple model of landscape perception involves three components: the person, the land, and the view of the land created by natural lighting and other factors. Landscape perception researchers have developed methods for investigating all three components, but individual researchers have tended to favor one of the three at the expense of the others. But for the purposes of this workshop, a key element is the degree to which the model is affected by changes in time, because landscape change can be augmented by changes in people and in views.

Jim ended his presentation with some suggestions for research topics:

- *Identify the role played by landscape perceptions through Maslow's Hierarchy of Needs*. Landscape perceptions contribute to the full scope of the hierarchy, not only to aesthetics. At the most basic levels are indications that green scenic landscapes contribute to physiological recovery from operations. At the social levels, landscape designers work to make settings that facilitate social interaction, but we know little about how to measure success. At the highest levels, Maslow's hierarchy helps us to understand that scenic value is more than amenity or luxury, and that there is a need for people to create and protect beautiful surroundings.
- *Determine whether particular landscape qualities are necessary for healthy humans, and whether this is determined by culture or nature*. We need to know more about these relationships, and whether they hold for all cultures.
- *Investigate the value of sense of place, and sense of self-in-place*. Sense of place is an attribute of places, whereas sense of self-in-place is an attribute of people. We need to develop sound methods to discover sense of place and sense of self-in-place, as well as honest ways to analyze and interpret this information.
- *Broaden the types of landscapes and people studied*. Past research has focused on temperate rural to wild landscapes in the summer, and the perceptions of white, college-educated middle-class people.
- *Study how people's perceptions change as landscape changes*. We know very little about the adaptation of people's perceptions to landscape change, but such knowledge will be increasingly valuable in an era of accelerating global change.
- *Improve the tools of measurement and analysis, and create more meaningful simulations and scenarios*. We need to understand how virtual reality is perceived and understood relative to the real world. There are clearly enhanced opportunities for manipulation as well as clarification in these new technologies, so professional standards are needed.
- *Study how people classify landscapes, and discriminate among them*. How do people classify landscapes, and for what purposes? What are the primary dimensions that identify these classes, and can they be managed to improve our enjoyment of the landscape?

Jim Sipes provided a discussion of Jim Palmer's keynote presentation. He began by recalling early experiences with landscape simulation at Evans and

Sutherland, as new technologies were employed to create increasingly realistic views of designs. He quoted William James: “Whilst part of what we perceive comes through our senses from the object before us, another part always comes out of our own mind.” Research in perception, which deals with what we see, what we think, what we feel, how we react, and why we react, is increasingly making the transition from academia to public and private practice. If perception is unavoidably selective (we can’t see all there is to see, and we can’t show all there is to show), how should we convey designs to others, what media are most effective, and how does perception influence choice among media? Jim used a series of examples to show the range of possibilities.

Recently, advances in the technologies of visualization and simulation, many of them originating in the entertainment industry, have reopened the possibility of realism. Jim showed how this possibility is unreachable, and how design is often better served by avoiding certain aspects of realism; while it is essential that one be conscious of the associated danger of manipulation.

The following additional points were made in the breakout sessions that followed:

- There is a need for long-term study of the relationship between landscape change and landscape perception. How do perceptions induce or modify change, and how do changes affect perception?
- Stability is a key property of human perceptions. We need to know more about the appropriate scales of stability, in both space and time. For example, the perceptions of Newfoundland seals and wolves in Montana vary spatially, and the scales of variation are also variable.
- There is interesting potential in a linkage between Maslow’s hierarchy and the initiation of intervention. Safety, a lowest-level need, often trumps all other needs.
- Different groups appear to develop different attachments to the landscape. It would be interesting to investigate a matrix which organized perceptions by age, gender, ethnicity, income, education, or length of residency.
- We know that visual quality is connected to tourism, such that if visual quality declines, the attraction of the landscape for tourism suffers. But we know much less about how such changes affect the local, permanent population’s perception of their place.
- We know little about the roles of each of the senses in landscape perception, and most research has focused only on the visual sense.
- Change must be perceived before people react, but we know little about the critical thresholds of change that produce perception and action.

Environmental and social science

In the McHarg model of 1967, landscape architecture integrated reductionist knowledge in the environmental sciences into holistic design. But the social and environmental sciences have advanced dramatically since 1967, so now may be the time to undertake a reappraisal, and to ask how the McHarg model should be modified and adapted to fit contemporary knowledge. Specifically, the following questions seem particularly relevant at this time:

- What new areas of science have emerged in the past 30 years that are essential to the practice of landscape design?
- How effectively has the McHarg model been implemented over the past 30 years? What problems have been discovered in its implementation that can be addressed by new initiatives?
- Is the multilayer model capable of addressing questions of the complexity demanded by current conceptualizations? For example, do we know enough about the pathways by which biological and chemical agents generated by urban growth move, disperse, concentrate, etc? Are existing paradigms sufficient to address these questions?

The opening keynote presentation was given by Helen Couclelis. She began her comments with the question of whether landscape change is currently out of control: sprawl is the consequence of innumerable human actions, rather than a reflection of any community's collective desires. Against this backdrop there is a need for better science, and better representations of reality for scientists and designers to manipulate and analyze. But our science is dominated by studies of physical and natural processes, and the human dimensions are often missing, or if present, not effectively integrated. On the design side, there is often a lack of representation of all of the stakeholders in a decision. Change is also difficult to detect, measure, and handle in our information technology.

Landscape is an exceedingly complex concept, with many associated perspectives, some of which were captured in Jim Palmer's use of the Maslow hierarchy. Views of landscape are static, dynamic, historical, and anticipatory. Landscape can be addressed as form, but also as process. It has social, biological, and physical dimensions, each of which invoke aesthetic, cultural, and even religious connotations. Against this complexity, the weaknesses inherent in McHarg's layer model are obvious. Representational layers are valuable for inventory and review, but the simple concept of adding or multiplying cannot do justice to the complexity of landscape. Many aspects of landscape change defy representation in a simple raster or vector layer— functions, purposes, processes, evolution, transformations, goals, values, perceptions, customs, practices, and institutional frameworks, to name a few.

Instead, we should address landscapes as wholes made up of interconnected parts, and serving a variety of natural and social functions. Landscapes are in constant flux, evolving under a wide variety of natural and social processes. They embody many human values and serve many purposes. Design must be seen as an imperfect process for addressing tensions: positive *versus* normative, descriptive *versus* prescriptive, analytic *versus* synthetic, and objective *versus* subjective.

How can we extend or adapt the overlay model to address these problems? Helen suggested an approach based on regarding landscapes as objects of discourse (Moravcsik, 1975). An object of discourse has four levels of meaning: formal, constitutive, agentive, and telic. Helen suggested that this could provide the basis for a new ontology of landscape, to replace the layer ontology that has served well for the past 30 years but is now too limited. She proposed a seven-level scheme of objects with spatial and temporal properties that incorporated all of the four levels of meaning.

Joanne Westphal suggested that much could be learned by drawing parallels with the landscape of the human genome. Genomics involves three-dimensional mapping and visualization, and raises ethical questions that have interesting parallels to those about landscape. The genome also responds to environmental stressors, reflecting the human's adaptive ability to respond to change.

Participants made the following points in the breakout sessions that followed:

- Among the scientific developments of the past 30 years, the following topics seem particularly apposite for landscape change research: fuzzy sets, object-oriented design, the science of complex systems and emergent behavior, agent-based modeling, spatial statistics, social network analysis, landscape ecology, hierarchy theory, and remote sensing.
- Information science and information technology have both had dramatic effects on the practice of science, by providing better tools, by vastly increasing the ability of scientists to share and collaborate, and by promoting a fundamentally new perspective on the roles of data and representation in science.
- Despite the previous point, there are still substantial impediments to communication, because of differences in language between cultures and disciplines, and because many methods of visualization of spatial data are not readily understood.
- The infrastructure for sharing data is now well developed, through such tools as metadata standards. There is a growing need to extend this infrastructure to the sharing of methods and software components, including support for automated search for methods meeting specified needs.
- Much progress has been made in developing views that are less anthropocentric, and more landscape-centric. Conservation planning is an excellent instance.
- Much of the value of science in design stems from the need to predict future impacts and relationships, since science must characterize those parts of the landscape system that are not under the designer's direct control.
- Landscape design is an inexact field and must be approached as inherently approximate, using appropriate methods such as heuristics, and successive approximation through iteration.
- Landscape design must draw from domains of knowledge that recognize complexity, including complexity theory (chaos, fractals), general systems theory, artificial intelligence, *etc*.
- In addition to the problems with layers identified above, it is difficult to reconfigure them to address horizontal flows and change through time, and to

represent multiple perspectives. In addition, layers can be misleading, in the sense that the information gathered in layers is too often assumed to be exactly the information relevant to a problem—all of the layer contents are important, and no other information is important.

- The McHarg model has been applied effectively with respect to operational and management tasks, but does not work so well with respect to strategic tasks. It is used most effectively at landscape scales, and less effectively at finer scales.
- There are gaps in our current research in the areas of scaling (scaling up ecological, physical, and fiscal models), non-monetary value systems, and narrative approaches (such as those popular in ethnography).

Concluding section

The closing plenary provided an opportunity to develop a final consensus among the participants, and to identify appropriate next steps. The following two sections identify first the points on which there was general agreement among the participants, and second the steps that should be taken to continue the momentum of the workshop.

Consensus points

- The workshop amply confirmed its original premise, that investigators and practitioners concerned with landscape change have much to gain from interaction. Investigators can gain a greater appreciation for the problems that must be solved in implementing effective policy, and practitioners can benefit from the scientific knowledge that has been accumulated in relevant areas.
- Fields such as the study of landscape change that fall between established disciplines, and depend on paradigms that are amalgams of those of their neighbors, require extraordinary efforts to ensure healthy progress. The processes of peer review and professional evaluation that dominate all aspects of academic life make it very risky for young scholars who try to succeed in such interstitial areas. Experience in other areas such as geographic information science demonstrates that investments that establish critical mass, such as national centers, can have the necessary scale of impact, because they are able to build extensive networks and research agendas, to support substantial outreach and education efforts, and to operate without being beholden to the norms of any one discipline. The participants agreed that such a strategy would be appropriate in the case of landscape change, and that a national center for landscape change would be a wise societal investment.
- The research topics identified in the keynote presentations and breakout sessions, and contributed individually by participants, constitute a substantial and unique agenda, that borders on the domains of many disciplines but is not central to any of them; yet it includes topics whose pursuit is vitally important as society tries to grapple with the effects humanity is having on its home planet.

Follow-on activities

Participants agreed that a summary report of the workshop would be prepared, circulated for comment, and published, primarily as a record of the workshop, and as a means of disseminating its results to a wider audience, including those who were not able to attend because of space limitations. Other publishing activities might emerge from the report, including versions adapted to particular needs and audiences. Participants were anxious that the workshop Web site be maintained indefinitely.

To pursue the notion of a national center, an appropriate next step would be to explore funding possibilities with foundations, and with NSF. A lunchtime presentation at NSF that summarized the key findings of the workshop would be a suitable approach. Participants also shared various plans for additional presentations at conferences, and other ways of drawing attention to the workshop, including postings in newsletters and on Web sites.

The National Research Council has approved a study, to be conducted by its Committee on Geography, on *place-based planning*, that shares many of the objectives of this workshop.

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APPENDIX B: RESEARCHABLE QUESTIONS CONTRIBUTED BY INDIVIDUAL PARTICIPANTS

During the workshop, each participant was asked to contribute a list of potentially researchable topics in the general area of landscape change, and bearing in mind the four themes of the workshop. 75 suggestions were received. This section provides a synthesis of the contributions, organized under the four themes, and ending with more general and policy-related topics.

Information technology

1. How can current technological tools be improved to address user needs, for landscape architects as they weigh a variety of impacts when considering alternatives, and for local governments and community groups considering the merits of alternative proposals?
2. What emerging analytical, modeling, and visualization approaches and tools should be incorporated into practical land-use planning decision-support tools? Would an NCEAS-like analysis and assessment activity be useful in facilitating the identification of emerging approaches and tools that are ready to be further developed and applied? (NCEAS is the National Center for Ecological Analysis and Synthesis, located in Santa Barbara).
3. How can decision-support tools aid or guide priority setting with respect to habitat restoration? How can historical imagery (e.g., Landsat) and other information be used to set restoration priorities and goals? How can this information be used to answer the question "What do we restore to?"?
4. Define a new ontology for landscape architecture; define a new data model for GIS by extending the overlay model into the constitutive, agentive, and telic dimensions of landscape objects; and develop a model of strategic landscape planning that is integrated with these.
5. Develop a methodology and representation standard for integrating cultural and social perceptions into a GIS layer.
6. Develop a data model that integrates socio-economic and environmental data for measurement, analysis, and design of land-use change.
7. It's clear that representations of landscape and landscape change will have to encode multiple levels of detail, to support foreground, midground, and background visualization and perception on the one hand, and to enable ecological analysis across trophic levels. What data structures and operators support efficient and robust level-of-detail representation and computation for visualization and modeling?
8. Landscapes are characterized by "forests and fields" consisting of aggregations of multiple individual objects (trees, leaves of grass). It is infeasible to model every blade of grass or every tree, and the salient characteristics of fields and forests are different from the sum of their constituent parts. How can these multiple "field" objects be represented computationally, perhaps extending the techniques of

object-oriented modeling and programming, so that landscape models can be correctly built upon them?

9. Designers and planners traditionally use multiple representations, including maps, diagrams, sketches, and photographs, in the course of designing and communicating landscape change. What are the salient differences between these representations, in terms of the visual inferences they support on the part of the viewer? What potential exists for automatically converting between them (e.g., extracting a diagram from a map, or constructing a photograph from a sketch)?
10. What rules of combination, generation, and placement, and what libraries of symbols, images, and textures ae required to generate a 3D model or image from a typical map (such as a USGS topographic quadrangle) such that the model or image so produced is useful for various visualization or analytic tasks? Realism is only one sub-question of the more general questions of utility of representations.
11. Develop a GIS methodology to enable the integration of data, multi-scale and multi-temporal analysis, modeling and representing spatial complexity, and simulating scenarios for better understanding of landscape change, and for developing and evaluating the best design.
12. How effectively do existing data products (maps, 3D images) communicate about landscape change and its individual elements, and how can they better represent the elements and processes involved?
13. Develop creative techniques and theory for seamless translation of scale and level and type of information within a GIS.
14. What landscape changes are poorly represented within the current state of technology (e.g., GIS, CAD, visualization)? What technologies or adaptations of existing technologies might address these limitations?
15. How can the consequences of landscape change be better represented for decision-makers and the public?
16. How can design be integrated with GIScience for multi-scale and multi-temporal analysis and modeling, for better understanding of landscape change?
17. How can we better represent uncertainty and abstraction of data in models? Can tools be developed to help planners, policy makers, and citizens to understand better this uncertainty (through creation of probabilities for particular outcomes, etc.)? This could be tied to a manual translating decision science for planners' use.

Decision making

18. What economic variables and measures can be integrated with biological and physical landscape characteristics to inform conservation and land-use decision-making? In other words, how can we build social and economic considerations into land-use planning activities? Specifically, what measures should be incorporated and what value would they add to the decision-making process?
19. Which community-based decision-making processes for place making are most effective, and why, to what degree, and under what conditions (size, scale, social, economic, and political context)? What is the appropriate role of technology (e.g., GIS) in facilitating community decision processes?

20. What decision methods, information technologies, and data are needed to facilitate multijurisdictional communication and cooperation, particularly to represent cumulative impacts and trade-offs, for local decision-making within a regional context?
21. How are specific decisions and outcomes affected by the introduction of information technologies and data in various decision processes? How do technology and data facilitate environmental decision-making?
22. How can we best integrate landscape change knowledge and technology into public and private landscape-change decision-making processes?
23. Solutions to multi-objective decision problems are dominated by procedures that maximize the sum of suitabilities. While this is an efficient technique, it is not necessarily the most acceptable to stakeholders (e.g., one subgroup might be severely disadvantaged). We need more research and development in this area.
24. When do you introduce information and technology into the decision-making process, especially in the case of public processes? This research would include considerations of visualization and scientific literacy, the influence of media type, and the differing perspectives of those involved in making the decisions.
25. What are the outcomes of formal decision-making processes in land-use and landscape change planning? Can these be documented through case studies?
26. Are there ways of including citizen input on planning decisions via the Internet that overcome the problem of averaging the results (*i.e.*, thinking as though a unitary public exists)? Can techniques be developed to recognize patterns of responses that would allow creation of various biased plan alternatives?

Landscape perception and assessment

27. How well do landscape description and categorization by experts and professionals match up with the public's understanding of land types and landforms?
28. What are the implications of early childhood and adolescent's experiences with the natural environment for the development of values, attitudes, and behaviors towards the Earth?
29. Theories and knowledge of the health and well-being implications of landscape change are woefully inadequate. Other than economic models, we know very little about acute or chronic impacts on human physical or psychological well-being when we alter local, immediate landscapes. Basic psychological processes (e.g., stress, motivation) as well as physical condition (e.g., cardiovascular, neuroendocrinological) are influenced by changes in the physical environment. What and how does alteration of our immediate natural environment contribute to such processes? Note that these impacts could be direct as well as moderated effects, in concert with other factors influencing health and well-being.
30. What are human perceptions and values towards areas with and without large carnivores? Do humans consider an area more or less wild? What are the psychological values of wildness? Do people notice the difference in species assemblages? Is the loss of large carnivores and the associated decrease in ecological integrity a type of landscape change?

31. What degree of decline in ecological services (e.g., crop pollination, water and air purification, seafood production) constitutes landscape change? How is the answer affected by the different stakeholders considered (i.e., what does the general public consider change, versus a fisheries biologist)?
32. How effective are landscape perception studies in capturing ecological processes (pathways for the flow of materials, nutrients, and energy) across the landscape mosaic since some pathways are not readily visible in the landscape?
33. What are the benefits of developing a unified theory of landscape perception that synthesizes the three key paradigms (person, view, and land)? What has impeded such a synthesis?
34. Explore the phenomenon of iconography linked to landscape and place. What are the elements that draw people not from a place to value the symbolism of an icon of a certain landscape (e.g., salmon in the Pacific Northwest, wolves)?
35. Construct and test a set of typical definitions and perceptions of landscape among different groups, particularly as a function of landscape scale.
36. How do different groups of people view landscape change?

Environmental and social science

37. What magnitudes, and what types of landscape change are caused by the removal or introduction of a region's large carnivores (i.e., does the loss of large carnivores cause an explosion of medium carnivore populations, and the decimation of their prey)?
38. What degree of ecological degradation causes a noticeable decline in ecosystem services? Specifically, does the ecological degradation caused by large-carnivore loss lead to decline in ecosystem services (and thus decline in the quality of human life)?
39. What measures or characteristics of biodiversity should be incorporated into land-use modeling and planning exercises? How should these measures or characteristics be depicted, and how should they be related to or integrated with other considerations in land-use planning (corridor habitat continuity and fragmentation, species location and status, stressors, etc.)?
40. Conduct a case study of representation, communication, and perception of landscape change through cartography, 3D, animation, sketches, and other graphical and digital forms. This should be formulated through an interdisciplinary collaboration of planners, landscape architects, GIScientists, and visualization specialists.
41. Research the representation and use of social, economic, legal, political, historical, and cultural drivers in models of landscape change.
42. Expand the concepts of complexity theory, systems theory, and fuzzy sets to work towards a more rigorous assessment of nature and culture.
43. Examine methods and approaches for integrating holistic, qualitative, dynamic measures of cultural meaning or representation of place within a spatial-analytic model, including aspects that are not easily geocoded.
44. Examine how major landscape trends (*e.g.*, globalization, urbanization) are affecting bio-cultural communities as systems, including ecological literacy, food

security, and environmental justice. Use this knowledge toward more integrated conservation design for functioning, dynamic, complex natural-cultural systems.

45. A critical stage in the development of models of landscape change is validation. However, we do not have adequate methods for model validation that can suggest where weaknesses lie spatially, temporally, or culturally.
46. We need efficient routines for the analysis of past land-cover maps to uncover the spatial trends in landscape change. Trend surface analysis has no ability to uncover trends that may be associated with the presence of other land covers and features (e.g., forest loss relative to roads). Such procedures should be able to uncover the spatial pattern and the numeric characteristics of distance relationships.
47. We need a procedure for the ingest and aggregation of individual preferences that can recognize the emergence of different preference profiles, and separate them rather than aggregating them into a single group.
48. What are transferrable approaches for quantifying confidence in plausible, spatially explicit alternative futures?
49. What are the circumstances most appropriate for expert-driven versus citizen-driven techniques for creating spatially explicit alternative futures?
50. Are there gradients of terrestrial and aquatic biodiversity response to land development intensities (e.g., various residential densities from low to high)? If so, do they vary by bioregions, and what are the major factors controlling this variation?
51. What would be the key characteristics of a nationally applicable approach for geographically prioritizing lands and waters for ecological restoration, and how would such an approach need to adapt to local peculiarities?
52. How do cross-scale dynamics between different social agents affect the process of land-cover change?
53. What feedbacks exist in the dynamic relationship between landscape design, landscape perception, and landscape outcomes? How do past landscape changes and design decisions affect how communities and individuals consider proposed landscape changes?
54. To what extent are individuals important in the process of landscape change? Is it appropriate to think of communities as single entities in regards to quality of life?

General and policy

55. What are the ecological (structure, function, change) benefits and costs of neo-traditional forms of design intervention (smart growth) and how do they compare to the social costs and benefits?
56. Discussion of decision-making has focused on data mapping and representation, but the human systems in the decision-making process deserve equal attention. The discipline of organization development offers a research base for matching interventions to purpose, and to the various levels and units within a social system. There is an opportunity for research and inquiry into the application of intervention processes to decisions about landscape. For example, what are the processes and criteria by which stakeholders and decision-makers are determined?

Are there issues of human scales or levels within systems that are, or should be applied to these systems? Are some interventions better suited than others for certain types of decisions, for certain types of groups? How are the decisions made by stakeholders translated into specific designs? What accountability measures are in place?

57. Construct a rigorous, replicable model for creating baselines to measure landscape change (may need several models for different situations).
58. Identify opportunities to do follow-up work on the success or failure (or mix thereof) of policy intended to effect or affect landscape change. Using case studies, identify the components of successful policy as well as less successful policy, and how we might be more rigorous in the post-occupancy assessment of policy, and work towards an adaptive management approach to landscape change legislation.
59. What is the intellectual foundation from which landscape change is derived? What are the major topical areas of landscape change, and what other disciplines can contribute to research? Is GIS the most important tool for measuring and detecting landscape change?
60. Extend landscape change models to allow design intervention in the landscape during the model execution, to investigate impacts of changes as part of scenarios, and projections made by models.
61. What are the infrastructure requirements and how do we build community capacity to make more-informed environmental decisions (including assessing and understanding landscape change and cumulative impacts)?
62. Do incentive-based public policies affect landscape pattern, structure, function, and change? In particular, how do individuals adopt and implement these policies, and maintain landscapes?
63. Develop a quantifiable and scientific theory of landscape change (e.g., what are the underlying natural, economic, geographic, ecological, and political processes?).
64. Develop a methodology to describe and detect landscape change. At what point can we say it is change, can we detect it, and can we identify trends?
65. Develop a definition of best design and a methodology to achieve it. The purpose of developing theory and methods for describing and capturing change is to have an ability to reduce vulnerability, increase sustainability, increase economic growth and social well-being, and to have an ability to predict and respond to change. How do we measure the health of the landscape, sustainability, and other characteristics?
66. What is the current condition of the landscape? What baseline data exist? What can and should be collected? What can be done to institutionalize the collection, production, and dissemination of data and information about the landscape?
67. Conduct the field work to characterize a significant area (*e.g.*, Massachusetts or Vermont). The methods might be similar to the Countryside Commissions in England. The field data are gathered and recorded for each sq km. Data include special attributes (*e.g.*, covered bridges), ratings (*e.g.*, spaciousness), sketches and photographs, and narratives from residents. Character areas would be formed

from adjacent cells of similar quality. These data would be incorporated into the state GIS and used in normal planning processes (*e.g.*, Act 250 review in Vermont). Models to predict these character areas from existing physical data in GIS would be developed. These models would be used to evaluate landscape change retrospectively and prospectively.

68. Compare Dennis, Massachusetts residents' perceptions of their landscape in 1973 and 2003 (also some data are available for 1984 and 1994). These perceptions include scenic quality, landscape classes, and other attributes at permanent viewing sites. Develop GIS models to extend the perception of particular views to describe the whole landscape. These models could be applied retrospectively, using land-cover and topographic data from 1950, 1970, 1980, 1990 etc. How do these changes together influence the sense of place and sense of self-in-place of these residents? What are the salient characteristics of this landscape, and what physical landscape dimensions best describe and predict them? Particular attention would be paid to characteristics that can be managed (*e.g.*, tree cover). How much can these dimensions change before there is a perceived qualitative change (*i.e.*, sensitivity)?
69. Evaluate the reliability and validity of methods used to measure visible landscape change, and develop improved methods. Currently planners and designers use various ways to simulate and measure perceptions of visible landscape change. These evaluations are required by laws and regulations from the local (*e.g.*, zoning laws) to federal (*e.g.*, NEPA) levels. They have developed over thirty years of practice, but have not been subjected to rigorous review. A similar assessment needs to be conducted of professional approaches.
70. Collect narratives from a diverse sample of residents about their sense of self-in-place. Classify (*e.g.*, cluster) these descriptions to identify groups that share similar landscape experiences. Evaluate the extent that these senses of self-in-place are supported by physical landscape attributes (and can be moved to similar places) or personal experiences (that cannot be moved). How do these perceptions relate to Maslow's hierarchy?
71. Develop a set of information categories to inform citizens about their communities and regions prior to engaging in a planning process. Develop and test delivery methods for the educational package. Integrate Internet polling with live forums to involve more stakeholders. Develop critera for that integration.
72. Recruit and train mediation consultants in planning issues and strategies. Develop criteria to be used by communities as they request the services of the mediators (a list of steps the communities should follow in order to qualify for assistance). Publish reports of the successes and failures of the mediators.
73. Develop incentives and strategies for communities to incorporate critical or sensitive lands identified at the regional level into their community planning maps and ordinances. Monitor the effects of implemented techniques over time, and publish the results. Make interim observations available on the Internet.
74. Establish a committee of academics and practitioners to participate in ongoing forums to share research results and set new research agendas.

75. Where are the key data gaps in monitoring landscape change? Are these gaps a function of spatial scale, temporal scale, spatial extent (local to global), temporal extent, or substantive area (soils, vegetation, ecology, quality-of-life indicators, etc.)? How can existing institutional structures be leveraged to address these data gaps?