Place-Based Decision Support Systems: A Bridge Between Democracy and Sustainability

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The Context

The management of places — whether National Parks and Forests, cities and towns, or small communities and watersheds — is becoming more complicated and more contentious. There is an increase in concern with both the aesthetic and functional aspects of our environments, more people are living in or utilizing any one place, and the demand to participate in decisions is growing. We want our places to retain those features that we value (many of them environmental), while improving in other, mostly social and economic ways. At the same time, access to the scientific data, information, expertise, and analytical tools that should help us plan for sustainable development has grown enormously. Yet, there is still considerable frustration in the search for science-based, participatory decision making. Two reasons for this frustration are the different perspectives of science and decision-making (whether by elected leaders or stakeholders), and the quantity of information available. It is suggested that the emerging technology of place-based decision support systems has the potential to help with both.

The Program of Action: Technical Performance and Value Decisions

People want *scientific solutions* for the problems of where to store nuclear waste, how to manage watersheds, or improve ocean fisheries. However, as is evident from the debates that attend each of these issues, science cannot provide solutions that satisfy all stakeholders. At best, science can objectively analyze the problem, develop and analyze alternative solutions, and anticipate and forecast consequences. The ability of science to provide solutions becomes more limited as issues become more complex, (the management of Chesapeake Bay), uncertainty more extreme (global climate forecasts), or goals more poorly defined (habitat restoration). But whether science provides extensive assistance or limited insight, its contribution is in understanding how alternatives will "score" on various measures of performance, not in the importance of these measures to society. Science provides a basis for a technical comparison of alternatives, and is the result of logical analyses; society's selection of a specific alternative reflects the *values* of elected leaders or stakeholders, and is the result of a political process.

The difference in these two perspectives is crucial, and is illustrated graphically for a hypothetical issue in Figure 1, using concepts from economics. In the first panel, a series of alternative solutions are placed on the graph in a position reflecting their environmental (the y axis) and economic (the x axis) performance. Each is evaluated and developed using science, scientists, engineers, analysts and other sources of objective information. The farther an alternative is from the origin, the better its performance. In some cases, we can conclude that one alternative is better than another because it performs better on both measures. For example, the alternative enclosed in a square is better environmentally and economically than the one enclosed in a circle. In other cases, (e.g. the two enclosed in triangles), there is no clear "winner." Each alternative is preferable on one measure but worse on the other. If we weed out all alternatives that are clearly inferior to others, and keep only those that are not, we can develop the "efficient frontier" shown in the second panel.

The third panel adds a representation of the values of decision-makers and stakeholders using a "preference function." It shows the different mixes of environmental and economic performance that would yield the same level of satisfaction, without regard to their feasibility. Higher levels of satisfaction would be shown by preference functions further from the origin, and lower levels by functions closer to the origin (dotted lines). A theoretically best solution would be one that is on the efficient frontier (that is, it is technically among the best we can devise using good science), and on the higher preference function (that is it gives decision-makers the highest level of satisfaction possible). This would occur where the preference function and the efficient frontier are tangent to each other. But the point of Figure 1 is not the search for a best solution: rather it is the distinction between the search for alternatives that are technically good, and the application of society's values to those alternatives. Science can and should help in the former; the latter is a social process.[1]

Information and Problem Overload

A second major source of frustration is the wealth of data, information, and expertise available, and the complexity of place-based management problems. Information is available on elevation, soils, water, roads, economic conditions and development plans, utilities, vegetation, climate, wildlife and wildlife habitat, home ownership, commuting patterns, retail sales and growth, schools, and mineral resources. Increasingly, there are also models that relate elevation and climate to flooding, development to habitat, home ownership and employment to energy consumption, and so on. Each of the types of information can be important to technically good alternatives, and can provide important insights into the consequences of decisions. But the number of sources and the volume of information can easily be overwhelming. Our ability to generate, archive, and serve data has grown rapidly; our ability to integrate it in ways useful to understanding and managing places lags behind.

At the same time, there is increasing awareness of the potential secondary consequences of decisions, from the impacts of building waste facilities on nearby property values, to the impacts of Midwestern agricultural practices on hypoxia in the Gulf of Mexico, to the impacts of urban development on air quality and wildlife. The characteristics of decisions about places are changing from single objective, single decision maker, with limited scope to multi-objective, multiple decision makers, with potential impacts in other places and after many years. Place-based decisions are becoming more complex, both technically and politically.

The Experiences: Place-Based Decision Support Systems

Decision support systems (DSS) are combinations of data, hardware, software, and models, along with tools to analyze, visualize, and communicate results. They have been developed for a range of purposes, typically limited in scope to a single type of problem or a narrow part of an organization (diagnosis of automobile problems, income tax calculations and reporting, facility management, etc.). In the last decade, scientists and software developers in the government, universities, and the private sector have begun adding these capabilities to geographic information systems, providing a new avenue to deliver scientific information and analysis to managers of public lands or communities. These new capabilities, in combination with a new emphasis on involving citizens in the decision making process, are resulting in both the creation of, and the demand for place-based decision support systems (PBDSS).[2]

Figure 2 presents a generalized framework for PBDSS. It can be used to express several points that have emerged from both formal and informal groups collaborating in the development of PBDSS: 1) The architecture of PBDSS's should be open, modular, and extensible. Modules should be interoperable, and users should be able to add, replace, or upgrade specific capabilities without affecting others. 2) Analytical models, databases, GIS, scientific capabilities and other tools are not substitutes for the decision process. They support it. PBDSS should be a bridge between the two. 3) A PBDSS should include tools to help elicit and assess stakeholder goals and values, and incorporate them in the decision process. Other guidelines and recommendations have been developed (Case et al.; Lessard 1999), but these three are sufficient to suggest that a PBDSS can be a mechanism to:

- Deliver and manage the explosion of data, information, and knowledge. This includes not only traditional, and often inaccessible, technical reports and journal articles, but also new forms (e.g. dynamic models that relate water quality to land use, transportation, and agriculture, or habitat to urban sprawl);
- Help decision makers and other stakeholders better understand problems, alternatives, and consequences — both intended and unintended; and
- Express and reflect the values of stakeholders in the development decisions.

There are other, related benefits as well, including a better understanding of the relationship between local and regional concerns, an improved ability to track outcomes and practice adaptive management; and better returns on investments in science, data collection, and geographic information systems.

Next Steps

The evolution of PBDSS is providing an important mechanism to combine science and democratic principles in the management of geographically defined places. Certainly, not all science can be packaged and delivered through such systems, and their existence does not guarantee more participation in decision-making. But the combination of data, models, tools and other components can result in better decisions, with more citizen involvement, in more places, at lower costs. There are currently a variety of PBDSS activities underway, addressing cities, small watersheds, large tracts of Federal lands, or large river systems. There are also efforts aimed at creating guidelines and standards for software developers, helping users learn about the range of capabilities currently available, or addressing the way science components can be developed. It seems likely that these efforts will help enable science-based participatory decision-making.

Endnotes

1. This is not to say that science has nothing to contribute to social or political processes. For example, social science can provide assistance in understanding, measuring, and expressing values. But it is still social values, rather than physical, chemical, or other objective qualities that determine the outcome.
2. For information on current activities regarding PBDSS contact the Federal Geographic Data Committee (http://www.fgdc.gov), the Open Geographic Information Systems Consortium (http://www.opengis.org), or the Aurora Partnership (http://www.aurorapartnership.org).

References

Case, Michael P. et al. 2001. *Decision Support Capabilities for Future Technology Requirements*. US Army Corps of Engineers, Engineer Research and Development Center.

Lessard, G. and T. Gunther. 1999. *Report on the Decision Support Workshop*. OFR 99-351 US Geological Survey.

Figure 1a. *Societal Choices.*

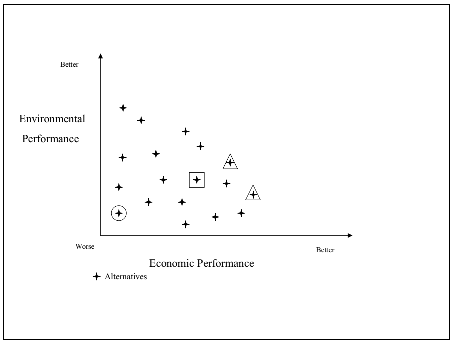

Figure 1b. *Societal Choice and the Efficient Frontier.*

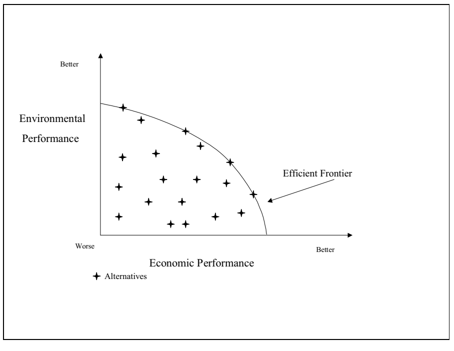

Figure 1c. *Societal Choices and Societal Values.*

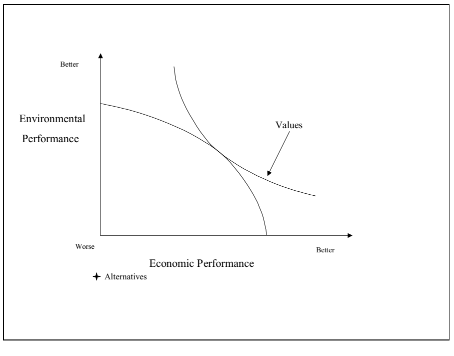

Figure 2. *A Framework for Place-Based Decision Support Systems.*