The importance of SDI in the context of sustainable development of Romanian forestry

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Abstract: *Spatial Data Infrastructures aim at making spatial data and thus content available for the benefit of the economy and of the society.*
The SDI is a set of measurements, standards, specifications and services within the framework of establishing e-government aimed at enabling effective gathering, managing, transfer and usage of georeferenced spatial data.
SDI encompasses the establishment of the following: a metadata system, spatial data sets, spatial data services and networking services and technology. Also it includes: agreements concerning spatial data transfer, access and usage, coordination and monitoring mechanisms, processes and procedures.

Keywords: *SDI (Spatial Data Infrastructure) , sustainable development, forest cadastre.*

1. SDI for Sustainable Development

Sustainable development is the balance of meeting humankind's present needs while protecting the environment to ensure the fulfillment of future generations' needs. The growing human population and its demands on the earth's resources generate a need for sustainable practices.

Implementing these practices often requires collaboration between different organizations. SDI allows GIS users across the globe to share ideas on how to meet their resource needs, plan efficient land use, and protect the environment to guarantee the survival of future generations.

1.1. Forest Sustainability and Planning

"No one can predict the future—how people will live, or what exactly they will need—but it is possible to foresee the likely effects of some of today's decisions and to make choices that honor the interests of present and future generations" (President's Council on Sustainable Development 1996)

Sustainability is a complex idea involving environmental, social, and economic factors.

Forest sustainability considers the following:

- ❖ How to retain and use forests to meet human needs.
- ❖ How to preserve the health of forest ecosystems in perpetuity.
- ❖ How to make ethical choices that preserve options for future generations.

The role of the National forestry agencies (NFA) in sustainable forest management is defined as follows:

- ➢ Use the seven internationally recognized criteria of sustainability to organize and communicate information on forest resource conditions and uses.

- Support inventory, monitoring, and assessment to provide a comprehensive picture of forest conditions, management, and resource uses.
- Coordinate conservation, management, and protection programs and partnerships.
- Provide education and communication opportunities for professionals and the public.

The concepts of forest sustainability, sustainable forestry, and sustainable development embrace people's expectations that the Nation's forests, indeed *all* natural resources, should be used wisely to meet today's needs and be available to meet the needs of future generations. Sustainability embraces the desire to preserve the health of forest ecosystems in perpetuity and to meet human social, physical, and economic needs.

Definitions of forest sustainability generally incorporate three components: (1) a process based on the integration of environmental, economic, and social principles; (2) satisfaction of present environmental, economic, and social needs; and (3) maintenance of forest resources to assure that the needs of future generations are not compromised.

Assessments of Montréal Process Criteria, which often are the means for evaluating the sustainability of forest management, increasingly require the analysis of spatial data in the forms of maps and digital data.

The first priorities of NFA to compile and distribute spatial data, not to create tools to facilitate the analysis and interpretation of the data. Unfortunately, natural resources decision makers and analysts need such tools, and they need them now.

Relevant tools are currently available in two forms, geographic information systems (GIS) and spatial decision support systems (DSS). GIS, while providing broad arrays of functionality, require a relatively high level of expertise which decision makers and analysts usually do not have. Spatial DSS, while not requiring exceptional GIS skills, usually are limited in geographic scope and/or are targeted to specific themes. A user-friendly software system that provides basic GIS functionality without requiring extensive GIS expertise would be particularly useful at this time. Such a system would provide spatial analysis tools to support both decision making and assessments of the effects of decisions that have already been made.

2. Spatial Decision Support Systems

Spatial DSS are computer programs that typically consist of four components: (1) a database of spatial information relevant to the decision; (2) an analytical engine to process the data; (3) output capabilities in the forms of tables, graphs, and maps that depict results in ways useful to decision makers; and (4) a graphical user interface. Spatial DSS have considerable overlap with GIS; in fact, one application of a GIS may be considered to be a spatial DSS. Functionally, however, the roles of spatial DSS are as information systems that provide selected GIS functions to decision makers and analysts who generally do not have the expertise to use a GIS, nor the time and resources to assemble and manage the requisite spatial data. Thus, many of the distinctions between GIS and spatial DSS are derived from differences in their intended users rather than their functions. Finally, spatial DSS create efficiencies by assembling data only once and then providing the database and selected system functionality to a decision maker or analyst.

The geographic context of many natural resource management decisions includes regions with diverse climates, topographies, land uses and covers, resource conditions, human population densities, and economic conditions. Spatial DSS accommodate this multi-faceted decision context, provide the capability to evaluate scenarios derived from multiple and competing objectives, reveal the consequences of decision alternatives under consideration, and provide a means of assessing the effect of decisions following their implementation.

Spatial DSS have been developed for a variety of environmental and natural resources applications. Mowrer (1992) and Power et al. (1995) provide excellent overviews and discussions of DSS for a variety of applications including, but not limited to, forest management planning, scheduling management treatments, scheduling and transportation planning for forest harvest, landscape disturbance, wildfire, watershed analyses, and forest insect and disease risks.
Forestry-related DSS tend to be defined by a small number of application themes of which forest protection and forest treatment are most common.

The Landscape Management System (LMS; McCarter et al., 1998) is a joint effort among the University of Washington, Yale University, and the USDA Forest Service. LMS assists in the development of forest management concepts and tools to accommodate social values including commodities, wildlife habitat, fire safety, employment, and carbon sequestration. The system integrates forest inventory data and growth models with visualization and analysis tools for evaluating stand- and landscape-level forest management alternatives. The common features of these forest treatment systems are similar to the common features of the forest protection systems: they are regional in scope; they focus on specific applications; and they rely heavily on models, simulations, or analyses tailored to the applications.

3. The Spatial Resource Support System

The integration and analysis of data layers portraying spatial information is becoming crucial to decision making and post-decision assessments in the natural resources field. Inevitably, these analyses require selections of data layers and parameters for integrating the layers, and each selection may lead to a different implementation which, in turn, may lead to different outcomes. Thus, a DSS that emphasizes spatial analyses and permits multiple approaches to integrating data layers and comparisons of the effects of the different approaches would contribute objectively to decision making and be of substantial benefit to decision makers and analysts who are not GIS experts.

The Spatial Resource Support System (SpaRSS) has been designed to demonstrate how basic GIS functionality can be used to inform decision making and post-decision assessments.

3.1 Objective and Specifications

SpaRSS is a GIS-based system that incorporates a suite of digital data layers; provides intuitive, accessible, user-friendly tools for analyzing spatial data; but does not require high-level spatial or GIS skills. SpaRSS permits decision makers to design alternatives using real data and then
display the results in tabular and graphical formats. The system displays nuances of decision alternatives, permits refinements prior to implementation of a decision, and accommodates post-decision assessments. SpaRSS provides decision making and analytical support in three areas:
(1) assembly of relevant, digital data layers obtained from external sources or created internally; (2) analyses based on the integration of spatial data; and (3) comparison of results of different methods for integrating spatial data and different decision alternatives.
To achieve these objectives, SpaRSS has been designed with specific features:
1. A user-friendly, graphical user interface;
2. Database with a core set of useful layers;
3. Options for approaches for integrating data layers;
4. Options for selection of parameters for a given integration approach;

5. Options for summarizing and portraying results;
6. User help documentation.

Many of SpaRSS's features are more similar to those of environmental DSS than to those of forestry-related systems. In particular, SpaRSS relies more heavily on created or acquired data layers than on internal models or prediction systems, although prediction systems may easily be incorporated.

However, SpaRSS has two features not known to be represented in existing spatial DSS. First, nearly all the existing systems are limited in scope; either they are limited geographically to localized areas of pest risk, corridors of burgeoning urban development, or single-river basins, or they are limited thematically to specific pests, species, or environmental issues. SpaRSS has been designed to be national in scope and appropriate for data of any theme, although the accompanying database focuses on forestry-related problems. Second, the range of scenarios featured by existing systems derives nearly exclusively from using the same integration methods or the same models.

SpaRSS permits scenarios derived in these same ways but also permits scenarios to be derived from different approaches to integrating the data. SpaRSS should be viewed as national in scope, generic with respect to thematic data, and flexible with respect to approaches for analyzing data.

3.2. Database

The SpaRSS database includes digital data layers including, but not limited to, the following:

1. Census: For example, population centers, distance to population centers, census block data, housing densities, and projected housing densities;
2. Socio-economic: For example, measures of persistent poverty, mill locations, and wild land-urban interfaces, land ownership, and land use;
3. Abiotic: For example, drought and fire risk indices, locations of historic forest wildfires, and digital elevation models;
4. Biotic: For example, land cover, natural fire history regime, fire condition class, fuel loadings, and treatment opportunities.

Before incorporation into the system, all data layers were converted to a common grid system with common and fixed projection and spatial resolution of 1 km^2. This spatial resolution is appropriate for large area analyses but would not be appropriate for analyses at the scale of forest stands, for example. Data layers with finer spatial resolution could be used, but the tradeoff for large area analyses would be increased processing time, a potentially limiting factor for Web-based systems.

3.3. Functionality

SpaRSS provides tools for accomplishing three categories of GIS tasks: portraying data layers, integrating data layers, and providing estimates in tabular form. Portrayals may be for categories or aggregations of categories of data layer variables, or they may be for only those grid cells for which the values of data layers satisfy selected threshold criteria. Portrayals of continuous variables are also by categories, although a large number of small width categories provides the sense of a continuous mapping.

Integrating data layers may be accomplished either by a portrayal of one data layer overlaid on another data layer or by combining the values of two or more data layers on a grid cell by grid cell basis. Combining values is accomplished using one of three approaches.

The first approach, designated *intersection*, selects grid points for which values of all layers to be integrated simultaneously satisfy threshold criteria.

The *intersection* approach is extremely restrictive. Although values for all except one layer may satisfy their threshold criteria by large margins, if the value for a single layer fails to satisfy its threshold criterion, even by an infinitesimal amount, the grid point is not selected.

The second approach, designated *addition*, selects grid points on the basis of whether the sum of values for all layers to be integrated satisfies a threshold criterion. Whereas the *intersection* approach is very restrictive, the *addition* approach is very permissive, because for any grid point the value for one layer may dominate the sum and satisfy the threshold criterion, regardless of the values for the other layers.

The third approach, designated *multiplication*, selects grid points on the basis of whether the product of values for all layers to be integrated satisfies a threshold criterion. The *multiplication* approach tends to produce results midway between the *intersection* and *addition* approaches, although in the absence of large numbers of values at the extremes of the distributions of values for the layers, the differences between the *addition* and *multiplication* approaches may be slight.

With all three approaches, individual data layers may be weighted to reflect the importance the decisionmaker wishes to attach to layers to be integrated.

Weighting data layers is particularly useful when objective standards for thresholds do not exist or when decisionmakers wish to incorporate explicit indications of relative importance. Finally, debates about whether the perceived importance of data layers matches outcomes may be informed through the use of thresholds and weights.

Once layers, weights, and threshold values have been selected and the data layers have been integrated, decision makers usually desire a meaningful summarization of the results. In some instances, a map depicting the geographic areas satisfying a threshold criterion may be the only summarization necessary. Frequently, however, a quantification of the results is desired.

For example, the number of acres represented by the grid points of a data layer with values satisfying a threshold criterion may be desired. Also, suppose that several layers are to be integrated as a means of determining areas at risk of forest wildfire. The proportions of observed wildfires located inside and outside the area resulting from a particular selection of data layers, threshold values, and weights may be used to guide the selection process, thus providing a means of groundtruthing decisions. SpaRSS provides the capability of quantifying and tabulating results for selected areas such as National Forest Regions, congressional districts, and states.

4. Conclusions and proposals

Sustainable development indicators are pieces of information that summarise or typify characteristics of complex systems and are designed to make perceptible trends which are not otherwise immediately apparent (Hammond et al., 1995). Sustainability is, of course, a very complex concept. It includes environmental, social, economic and institutional dimensions, as well as numerous actors, interests, and groups .

Spatial information in the forms of maps and digital data layers and GIS tools for analyzing them are of substantial value for decision making and post-decision assessments in the natural resources.

Using basic GIS techniques to integrate maps and data layers assists both decision making and post-decision assessments by facilitating comparisons of alternatives, by leading to more objective and defensible decisions, and by portraying the effects and results of decisions. Unfortunately, decision makers and analysts frequently do not possess or do not have access to the GIS expertise necessary to integrate, analyze, and interpret relevant data layers. Spatial DSS, of which SpaRSS is only one example, may be designed to provide accessible, user-friendly, functional GIS tools to assist decision making post-decision assessments in the natural resources.

The greatest utility for spatial DSS will be if they are made accessible via online applications. Such development is underway for SpaRSS.

5. References

1. *Corbett, J.D., J.W. White, and S.N. Collis. 2002. Spatial decision support systems and environmental modeling: An application approach. In: Geographic information systems and environmental modelling. Clarke, K.C., B.E. Parks, and M.P. Crane (Eds.). Prentice Hall. Upper Saddle River, NJ. 306 p.*
2. *Masser I., 2007. Building European Spatial Data Infrastructures. ESRI Press.USA. 91 p*
3. *Mowrer, H.T. 1992. Decision support systems for ecosystem management: An evaluation of existing systems. Gen. Tech. Rep. RM-GTR-296. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 145 p*
4. *Perera, A.H., D.J.B. Baldwin, F. Schneckenburger. 1997, LEAP II: A landscape ecological analysis package for land use planners and managers. Ontario Ministry of Natural Resources, Forest Research Report No. 146.*
5. *Star, S.L. and K. Ruhleder, 1996, Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces, in: Information Systems Research, 7 (1), pp. 111-134.*