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Computers and Electronics in Agriculture 49 (2005) 1–5
Computers and electronics in agriculture
www.elsevier.com/locate/compag

Editorial

Decision-support systems for forest management

The basic concept of sustainable development, formulated in the Brundtland report and applied to forest management by the Montreal Process, has focused attention on the need for formal decision processes (Brundtland, 1987). The application of decision theory is essential because meeting the needs of the present without compromising the ability of future generations to meet their own needs is anything but a simple problem. The basic decision process involves, (1) setting goals, (2) measuring current conditions, (3) constructing alternative courses of action, (4) predicting the consequences of applying each alternative course of action, (5) analyzing the results, and (6) either looping back to an earlier point or making a decision (Mintzberg et al., 1976). The problem is that "actions today affect the availability of not only other present actions but of future actions as well. And the reason why this global procedure is only followed piecemeal, if at all, lies in the boundedness of human rationality: the inability of human beings (with or without computers) to follow it" (Simon, 2003; emphasis added). There are no more promising or important targets for forest management research than understanding how we can solve sustainable forest management problems effectively and learning how to continually improve our decision-making processes and our decision-support capabilities (Rauscher, 1996, 1999).

The first special issue of Computers and Electronics in Agriculture on Decision-support systems (DSSs), entitled "The Application of Scientific Knowledge to Decision-Making in Managing Forest Ecosystems", was published in June 2000 (Rauscher et al., 2000). This, the second special issue on DSSs is entitled "Decision-Support Systems for Forest Management" and presents contributions from a trans-disciplinary Conference on decision support in multiple-purpose forestry, held at the University of Natural Resources and Applied Life Sciences in Vienna, April 23–25, 2003. A major objective of the Conference was to review the "state of the art" in the field of decision support in forest management, bringing together experiences gained in the United States and Canada with the longer tradition of forestry and current approaches to DSSs for forest management in Europe. Participants from 28 countries presented the current state of knowledge in 70 oral presentations, including 6 keynotes, and 51 posters. Selected contributions from the Conference have been compiled in this special issue of *Computers and Electronics in Agriculture* and a companion issue of *Forest Ecology and Management*.

0168-1699/$ – see front matter. Published by Elsevier B.V.
doi:10.1016/j.compag.2005.02.001

The keynote paper, "Integrated decision support for sustainable forest management in the United States: fact or fiction?" by Reynolds, provides a status report from a US perspective. He concludes that the task posed to the decision-support community, to deliver effective, integrated decision support for forest management, was much too large and complex to be achieved in a single development cycle. It has required an adaptive approach to system design. While substantial opportunities remain for continued development to support plan implementation and forest ecosystem monitoring, significant progress has been made in the last few years in providing support for evaluation and planning. Several contributions demonstrate the progress made in expanding the capabilities of "full service" DSSs, meaning those systems that aim to provide support for all the steps of the decision process outlined above. Twery et al. report on the expanded functional capabilities of the NED DSS in a paper entitled "NED-2: A Decision-Support System for Integrated Forest Ecosystem Management". Nute et al. discuss the software tactics used to make implementation and updating of the NED system efficient and effective in a paper entitled "Adding New Agents and Models to the NED-2 Forest Management System". Crookston and Dixon provide an update on the venerable and widely used growth and yield model system called "The Forest Vegetation Simulator: a review of its structure, content, and applications". This extremely well designed and maintained growth and yield model has been used for over 20 years. During that time, its capabilities have been expanded continuously and it has evolved from its beginnings as a simple growth and yield simulator to a very flexible DSS in its own right.

Some new decision-support systems were introduced at this conference. Lexer et. al. describe the development and application of the DSS DSD Version 1.1 (Decision Support Dobrova) for the design, analysis and evaluation of silvicultural treatment alternatives for Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* (L.) Karst.) stands in southern Austria. The tool is particularly designed to support the forest resource management consultation process by forest authorities with forest landowners. Salminen et al. introduce MOTTI, a stand-level decision-support tool for assessing the effects of alternative forest management practices on growth and yield and on the profitability of forest management. It is capable of predicting growth responses to silvicultural practices. The MOTTI project demonstrates that it is practical to reuse old applications as subcomponents and expand a simple growth simulator to a multiple-use decision-support application. Andersson et al. presented a new DSS called "The Forest Time Machine: a multi-purpose forestry projection model system." The system includes modules for tree growth, regeneration, mortality and wood decay, forestry operations, economics, nutrient balances, and various indicators for biodiversity. A model for estimating the probability of wind-throw is planned. The primary purpose of the forest time machine is to evaluate and compare different strategic management regimes in a long time perspective and from a multi-objective viewpoint. Ellis et al. describes "The Southeastern Agroforestry Decision Support System (SEADSS)". SEADSS is a web-based application being used to assist landowners and extension agents in the Southeast United States with evaluating potential sites and suitable tree and shrub species for agroforestry planning. SEADSS offers on-line access to county-level spatial information such as topography, hydrology, soils, and land use, which are essential in evaluating potential agroforestry sites and matching these sites to suitable species. Gilliam et al. introduce the AFFOREST DSS. The main goal of AFFOREST is development of a spatial DSS capable of providing advice for policy and planning decisions pertaining to the afforestation of agricultural land. The system addresses questions on where, how and how long to afforest by considering changes in total carbon sequestration (i.e., carbon sequestration in the soil and in biomass), nitrate leaching, and groundwater recharge.

"Full service" DSSs are composed of sub-models, or components, that provide many different specific functions to support the entire decision process. Several papers presented at this conference addressed new research and development to make these functional sub-models more useful. Martin-Fernandez and Garcia-Abril present a paper entitled "Optimisation of Spatial Allocation of Forestry Activities within a Forest Stand." Their paper describes the methodology for finding the optimal assignation of forestry activities at the tree level. The optimisation method employed is simulated annealing, which converges to the alternative with the largest probability of being the best one. The objective was to optimise ecological, economic and recreational functions resulting in a decision of whether or not to cut a particular tree in a stand. Chertov et al. write about "Geovizualization of Forest Simulation Modelling Results: A Case Study for "Russky Les" Forest." They describe a prototype system for data analysis and decision-making at the level of the forest enterprise on the basis of the forest ecosystem model EFIMOD-PRO and CommonGIS system for geovisualization and exploratory spatial data analysis. Using this system, four silvicultural regimes are simulated and evaluated. Similarly, Meitner et. al. also focus on exploring effective visualization techniques. Cost effective computer visualization techniques have made it increasingly feasible to visually represent environmental conditions that are otherwise only represented by abstract statistics. Currently, members of the Collaborative for Advanced Landscape Planning (CALP) at the University of British Columbia are investigating the effectiveness of various environmental/data visualization methods as applied to land management decision-making processes. Forest managers can use high-speed, low-resolution analytic visualizations to interactively explore the visual characteristics of forests and forest health changes at stand and landscape scales.

Effective DSSs cannot be constructed without first understanding essential theoretical aspects of decision science. The final paper in this special issue presents a theoretical exploration into participatory decision making. Thomson describes a knowledge management and reporting system for participatory processes in general, and for community forestry in particular. Deliberations on the prototype and related human processes led to development of a new philosophy of system design: adaptive knowledge management. This new approach is currently being used in development of new software tools for use in participatory multi-stakeholder processes. Three major components of participatory decision-making, namely knowledge, communication and reporting, are reviewed. A prototype knowledge management system based on these components is developed in the context of community forestry.

In conclusion, design concepts for, and implementations of, DSSs have been evolving rapidly in recent years. European approaches on decision support focus primarily on the forest stand or forest enterprise level with heavy emphasis on timber management support. Due to the heterogenity of European ecosystems, the landscape level is not as frequently a focus of DSSs so far. The concept of forest sustainability has a long tradition in Europe and current practice of forest management is confronted with an ongoing shift of paradigm from sustained yield and constant forest cover towards sustainability of an increasing diversity of values, goods and benefits obtained. The decision-support tools presented at the conference try to help forest managers in this complex environment direct a stronger focus on a sustainable forest management. Researchers and forest managers in the United States and Canada have had a longer tradition in the development and application of DSSs. We find that current North American approaches focus more heavily on non-timber forest products such as clean water, wildlife and aesthetics than their European counterparts. In summary, existing DSSs are maturing and expanding in capabilities and are being used more frequently in actual management practice. On the other hand, DSSs have not yet been widely adopted as standard tools of forest management in most areas of the world. We sense, however, that we may be soon approaching a point in time when existing DSSs have matured enough that decision-makers in forest management will routinely turn to them for help in their complex decision-making environment.

As a consequence of this conference and to further promote the exchange of ideas, approaches, and information regarding the decision support for multiple-purpose forestry, a Community of Practice (COP) was initiated and can be joined at http://dss.boku.ac.at. Abstracts of all papers and posters presented at the IUFRO conference can be found there.

Acknowledgements

We are grateful to our companion conference organizers M.J. Lexer and R.T. Brooks who guest edit a related Special Issue of *Forest Ecology and Management*. The hard work is always compensated by the camaraderie between the editors and authors and the enjoyment that comes from a good final product.

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