Decision Support Systems for Sustainable Development

A Resource Book of Methods and Applications

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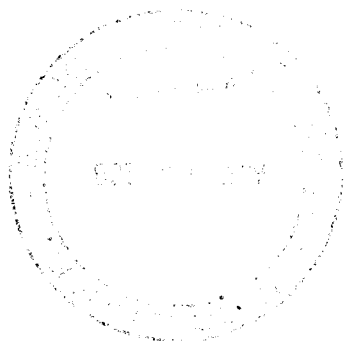# DECISION SUPPORT SYSTEMS FOR SUSTAINABLE DEVELOPMENT

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For
Margaret Kersten,
Anna Mikolajuk and
Brenda Yeh
with thanks for
their inspiration
and encouragement.
Thank you!

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1. Introduction

The concept of computer-based decision support was born in the early 1970s and is generally attributed to two articles. The first, written by Little (1970), introduced the notion of decision calculus as a "model-based set of procedures for processing data and judgements to assist a manager in his decision making." The second article, written by Scot Morton (1971), introduced support systems for managerial decision making.

The objective of this chapter is to provide references to various implementations of DSSs that were published in the 1990s. In the following nine sections we mention a number of DSS applications to environmental decision making and assessment, water resource management, agriculture, forestry, manufacturing, medicine, business and organizational support, and infrastructure. The list of references is not exhaustive but it demonstrates both scope and interest in practical research in the decision support systems field. It gives MIS managers, developers and decision makers a rich source of information about the specific domains where different DSS technologies have been used in both developing and developed countries.

1.1 General books and articles

Since the late 1980s DSS has been widely studied and taught in business, engineering, information systems and other university courses. A number of books providing a comprehensive introduction to the DSS area has been published. Recently published books include those by Dhar and Stein (1997), Holsapple and Whinston (1996), Marakas (1999), Mallach (1994), Sauter (1997), Sprague and Watson (1997), Turban and Aronson (1998).

DSSs have been applied in a variety of problems. A good survey of the application literature can be found in Eom, Lee et al. (1998), Santhanam and Elam (1998) and

Liang and Hung (1997). Surveys of negotiation and group decision support systems have also been conducted (Aiken *et al.*, 1993; Vogel and Nunamaker, 1990).

1.2 Web resources

Numerous World Wide Web (Web) sites provide DSS related resources. Several Web sites (Arnott, 1999; Demarest, 1999; Kersten, 1999; Power, 1999; Power and Quek, 1999) provide general information related to the design, development, evaluation, and implementation of DSSs. A list of DSS software publishers can be found in these sites and also in the *Data Warehousing Information Center* which is available on the Web (LGI, 1999). Quek (1999) maintains a site which contains a listing of Decision Support Systems Courses conducted by many institutions and universities across the world.

Demonstration or scaled down versions of DSSs can be downloaded from the Web. Many software publishers place demonstration versions of their products on the Web. DSSs for specific domains and types of problems can be obtained directly from the Web. For example, there are DSSs developed for agricultural purposes (Agriculture Canada, 1999; FARAD, 1999). Several water resources management DSSs can be downloaded from the Internet (CDSS, 1999; IIASA, 1999; Silvert, 1999). The Environmental Programs group of the North Carolina Supercomputing Center (NCSC, 1999) has developed an environmental DSS Web site that provides definitions and software available for downloading.

2. Environmental decision making

Environmental DSSs have been developed to assess the impact of utilization of natural resources and to evaluate the impact of agricultural and industrial activities on the environment. Guariso and Werthner (1989) discuss environmental decision support systems and provide architecture for such systems. Several applications of multiple criteria decision making in environmental management can be found in Paruccini (1994). References to many systems (including environmental DSSs and GISs) which were developed to solve environmental problems in Argentina, Chile, Columbia, Egypt and Poland are available on the Web site ERDAS (1999). Sandia National Laboratories (1999) developed an environmental DSS that performs risk assessment, based on potential risk to human health and the environment and on the cost of alternatives. Shaw et al (1998) describes several DSSs used for natural resource management in Australia.

Zhu et al (1998) discuss a knowledge-based spatial decision support system for effective environmental management. Gough and Ward (1996) provide a DSS framework that was applied for the management of Lake Ellesmere in New Zealand. Hipel et al (1998) developed GMCR used, among others, to model and analyze international environmental management disputes involving governments in both Canada and the U.S. The cross-disciplinary nature of environmental DSSs explains why relevant materials can be found in journals such as *Computers in Industry*, *IEEE Transactions on*

Systems, Man and Cybernetics, Journal of Environmental Management and *Journal of Water Resources Planning and Management.*

Hokkanen and Salminen (1994) explore the use of an integrated DSS that assist decision makers to identify optimal schemes for treatment, storage, transport and solid waste disposal. Several DSSs which use multiobjective methods and GIS technology have been developed for this purpose (see Hokkanen and Salminen, 1994; Pinter, Fels et al, 1995; Walker and Johnson, 1996; Swetnam, Mountford et al., 1998; Subramaniam and Kerpedjiev, 1998).

Paigee et al (1998) developed a DSS to assist risk managers to evaluate landfill cover designs for mixed waste disposal sites at Los Alamos. Moon et al. (1998) discuss LANDS (Land Analysis and Decision Support) System, which manages and integrates the data and models required to meet a broad spectrum of land management and planning needs.

The USDA-ARS in Tucson, Arizona has developed DSS to select land conservation management system in Mexico; its implementation revealed problems which are common to many applications of decision support technology in developing countries (Hernandez et al., 1998). Issues of environmental planning are also discussed by Barnikow *et al.* (1992) and Kainuma *et al.* (1990).

Several DSSs for the evaluation of land management practices and their effects can be found in Yakowitz et al. (1992, 1993, 1998a, 1998b) and Robotham (1998). DSSs for land management in developing countries are discussed by Mira Da Silva et al. (1998); Matthew and Peasley (1998); Jones et al. (1998) and Zhang et al. (1998).

3. Environmental impact assessment

An important topic within the scope of EDSS is environmental impact assessment. Several authors have described systems that can be used for this specific purpose (Barnikow et al., 1992; Kainuma et al., 1990; Kampke et al., 1993; Winsemius and Hahn, 1992; Wadsworth and Brown, 1995; Yakowitz et al, 1998). Muth and Lee (1986) present a model that can be used to assess the impact of natural resource exploitation. Ecozone II, a decision support system (DSS) was designed to facilitate EIA's in the sectors of agriculture, agro-industries and aquaculture in less developed countries (Howells, 1998).

GISs are often linked with forecasting models for environmental prediction (Hokkanen and Salminen, 1994; Specht and Owls, 1995). Chiueh et al. (1997) present the benefits of applying spatial decision support systems to assess soil contamination problems.

4. Water resource management

Water resource management is another facet of environmental decision making where DSSs have been applied. Water quality management decision support has been discussed by Berkemer et al. (1993), Camara et al. (1990), Lovejoy et al. (1997), and Xiang (1993). DSSs to support water reservoir decision analysis have been developed by Grobler and Rossouw (1991), and Simonovic (1992). Further, tools to support

water delivery maintenance and planning have been presented by Pingry et al. (1991), Sutherland and Lambourne (1991), Thrall and Elshaw-Thrall (1990). DSSs for planning irrigation systems have been developed by Bandyopadhyay and Datta (1990); Tyagi et al. (1993) and Wilmes et al. (1990).

DSSs for strategic planning of water resources in Jordan have been developed by Alshemmeri (1997) and, in the Middle Nile Delta, by Abdel-Dayem et al. (1998). Riverside Technology (1999) designs, develops, and implements water resources management systems that are used in the Yellow River and Huai River in China, and the Nile River in Egypt.

A relatively simple ground water DSS was developed to assist in identifying salt water vulnerable areas and in developing management policies to prevent salt water intrusion in central Kansas (Sophocleous and Ma, 1998). DSS is also used for conjunctive management of surface water and ground water under prior appropriation; (Fredericks, Labadie et al., 1998; Sophocleous, Koelliker et al., 1999).

The system called WATERSHEDSS (WATER, Soil, and Hydro-Environmental DSS) was designed to help watershed managers and land treatment personnel to identify their water quality problems, and to select appropriate management practices. (Osmond, Gannon et al., 1997). Anderssen, Mooney et al. (1996) present a model of hydrodynamic behavior of water resources to construct wetlands in order to meet environmental regulations.

5. Agriculture

DSSs focusing on the overall improvement of agricultural production have been described by Goodrich (1998); Jacucci (1996), Gonzalez-Andujar et al. (1993), Power (1993) and Wagner and Kuhlmann (1991). Gameda and Dumanski (1998) developed Soilcrop system, which provides biophysical and socioeconomic criteria for determining the sustainability of cropping practices in different agroregions.

The comprehensive resource planning system (CROPS) is a multiobjective scheduling system that uses heuristics and constraint satisfaction to find acceptable farm-level plans in Virginia (Stone et al., 1998). DSSs have also been developed for management of agricultural operations and production control (Sorensen, 1998; Vickner and Hoag, 1998). These systems are playing an important role in agricultural management in developing countries such as Egypt, Indonesia and Mexico.

Shtienberg et al. (1990) and Yost and Li (1998) discuss several systems in the area of the disease identification and the specification of treatments.

Knowledge-based computerized DSSs have been designed to solve complex problems in soil acidity, phosphorus deficiency and nitrogen deficiency (Yost and Li, 1998; Kovacs et al., 1998). Jones et al (1998) developed a DSS to identify cropping and tillage options for profit maximization for a wide range of soil erosion control levels.

A DSS that aids decision making in agricultural and water resource management in the Eastern Nile Delta of Egypt was developed by Abu-Zeid (1998). Datta (1995) designed an integrated DSS for generating alternative water allocation and agricultural production scenarios for a semi-arid region. A geographical DSS was developed for the Ministry of Agriculture in Dominican Republic (Grabski and Mendez, 1998).

Amien (1998) developed an expert system that assesses the suitability of specific soil and climate conditions for supporting proper agricultural systems, and the selection of crops in Indonesia.

6. Forestry

Several DSSs have been used to assist decision making in forestry and natural resources (Marathe *et al.*, 1991; Payandeh and Basham, 1993). Covington et al. (1988) developed a DSS called TEAMS that can be used as "a tactical planning system to aid forest managers in developing site specific treatment schedules". Reforestation problems have been addressed by Johnston et al. (1993). Ecosystem management, with the aid of DSS, has been proposed as a solution to many problems facing forestry today (Rauscher, 1999; Twery et al., 1998; Dewhurst et al., 1995). Financial matters related to forest management have been considered by Meyer (1992) and Payandeh and Basham (1993). The identification and treatment of diseases and pests have been analyzed by Power (1988).

Manley and Threadgill (1991) developed a DSS that imbeds a linear programming model to evaluate New Zealand's forests. Aggarwal et al. (1992) discuss methods of providing decision support for planning appropriate lumber harvests. Wood (1998) discusses the case of the Menminee Tribe's reservation timberlands. Forest managers determined that one third of the tribal forest could be converted to more productive and valuable tree species. Working together with Northern Arizona University they developed a DSS to devise a schedule for implementing the conversion Wood (1998). Wybo (1998) introduces a DSS dedicated to forest fire prevention and fighting.

Naesset (1997) discusses the use of GISs to search for sensitive areas that should be devoted to careful timber management practices. Tecle et al (1998) developed a multi-objective and/or multi-person decision support system for analyzing multi-resource forest management problems.

Forest resource managers in two U.S. Forest Service Ranger Districts use INFORMS-R8, a DSS to support common district planning activities (Williams and Holtfrerich, 1998). Ross and Hannam (1998) discuss three DSSs (TEAS, LOGSPERT9, HABASYS) used to manage legal, ecological, and social information required to make decisions about the conservation of forests on Protected Land in Australia.

7. Manufacturing

Deciding on appropriate investment in industrial/manufacturing ventures can be difficult. Park et al. (1990) and Rios (1993) provide some instances of the use of this technology. The analysis and planning of the manufacturing processes, including planning of materials requirements and manufacturing resources, can be assisted with specialized DSSs such as those suggested by Ozdamar, Bozyel et al. (1998), Migliarese and Paolucci (1993), Srihari and Cala (1992) and Suresh (1990).

Production related DSSs have been discussed by Agarwal and Tanniru (1992), Garza et al. (1992), Kleijnen (1993), Martin et al. (1993) and Migliarese and Paolucci

(1993). Numerically controlled machine tools are successfully used in manufacturing. For example, IDSSFlex is a DSS to analyze and evaluate flexible manufacturing systems (FMS) design alternatives (Borenstein, 1998).

8. Medicine

DSSs to support hospital services planning have been developed by many researchers (Beech and Fitzsimons, 1990; Sharkey et al., 1993; Kadas, 1995; Stodolak and Carr, 1992), likely in response to the importance and cost of these services. However, this is not the only type of medical decision making that has been supported using a DSS. Health-care systems are discussed by Datta and Bandyopadhyay (1993) and Doukidis and Forster (1990).

According to Hagland (1998) the number of physicians who use clinical information systems, including decision support tools at the point of care is constantly increasing. DSS applications allow the collection and manipulation of financial and clinical data on a variety of levels, including patient, procedure and physicians (DeLuca and Cagan, 1996). Keegan (1995) notes that the U.S. healthcare decision-support market is growing faster than the market for all other healthcare software.

Morgan (1996) illustrates the use of an intelligent DSS to solve information overload problems faced by health authorities. Leibovici (1997) developed a problem-orientated DSS to improve empirical antibiotic treatment. The development of proper nutritional balance for diets has been considered by Bandyopadhyay and Datta (1990), and Zwietering et al. (1992).

Tropical disease diagnosis has been investigated by Doukidis and Forster (1990). Mishra and Dandapat (1993) propose a system for EMG diagnosis. Further, patient simulation, using a negotiation metaphor, has been investigated by Kersten et al. (1993) and Kersten and Szpakowicz (1993). DSSs related to pharmaceutics was developed by Green and Krieger (1992) and Islei et al. (1991).

9. Business and organizational support

There are numerous examples of DSS applications in support of common organizational decision making activities. They include administration (Edwards, 1992; Johnson, 1996; Mohanty and Deshmukh, 1997); assessment of risk in international investments (Tessmer et al., 1993); corporate crises management (Mak, Mallard et al, 1999), banking network planning (Coats, 1990); credit decisions (Coffman and Brooks, 1992; Levary and Renfro, 1991; Fuglseth and Gronhaug, 1997); portfolio management (Kira et al., 1990); investment strategies (Huynh and Lassez, 1990); marketing (Arinze and Banerjee, 1992; Coffman and Brooks, 1992; Green and Krieger, 1992; Mak H-Y. and T. Buim 1996; Sisodia, 1992; Bruggen, Ahn and Ezawa, 1997; Smidts et al., 1998; Ghose and Nazareth, 1994); capital budgeting (Moribayashi and Wu, 1990); operations management (Proudlove, Vadera et al., 1998); scheduling (Ecker, Gupta et al., 1997; Djukanovic, Babic et al., 1996); strategic management (Martinsons and Davison, 1999); business reengineering (Barua and Whinston, 1998). Further, DSSs have been shown to improve the decision maker's

capabilities by improving the visualization of the pertinent financial data (Lawton, 1993).

10. Infrastructure

Support for decision making related to trains and railroads has been discussed by Hoffman (1993), Hanif, S. and Arief, S (1998), Tanzi and Guiol (1998) and Missikoff (1998). Bielli (1992) developed a DSS for urban traffic management. A DSS for a district in the Commonwealth of Virginia was developed through the application of System Dynamics concepts (Garza, Drew et al., 1998). A sea navigation DSS has been presented by Grabowski and Sanborn (1992).

Several DSSs for truck routing and maintenance have been suggested by Bradley (1993), Lysgaard (1992), Ott (1992) and Shannon and Minch (1992). A DSS designed for use with construction projects has been described by Crosslin (1991). Project management DSSs include those described by Arinze and Partovi (1992), Courtney and Paradice (1993), Hastak, Halpin et al. (1996), Liberatore and Stylianou (1993), Archer and Ghasemzadeh, (1998) and Stewart (1991).

References

Abdel-Dayem, S., S. Abedel-Gawad and K. Abu-Zeid (1998). "Water Management Scenario Simulation for Decision Support in Multiobjective Planning", in S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 629-639.

Abu-Zeid, K.M. (1998). "A Multicriteria Decision Support System for Evaluating Cropping Pattern Strategies in Egypt", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 105-120.

Adamopoulos, G. (1994). "Production Management in the Textile-Industry Using the YFADI Decision Support System", *Computer & Chemical Engineering*, 18, 577-583.

Aggarwal, A. K., R. R. Vemuganti and W. Fetner (1992). "A Model-based Decision Support System for Scheduling Lumber Drying Operations", *Production and Operations Management*, 1(3), 320-328.

Agarwal, R. and M. Tanniru (1992). "A Structured Methodology for Developing Production Systems" *Decision Support Systems*, 8(6), 483-499.

Agriculture Canada (Apr 1999). "Demonstration DSS/ES for Manure Management", http://ozone.crle.uoguelph.ca/manure/default.htm.

Ahn, J. and K. Ezawa (1997). "Decision-Support For Real-Time Telemarketing Operations Through Bayesian Network Learning", *Decision Support Systems*, 21(1), 17-27.

Aiken, M., J. Krosp and J. Johnson (1993). "A Survey of Group Decision Support System Use", *SIGOIS Bulletin*, 14(1), 43-46.

Alshemmeri, T. (1997). "Computer-Aided Decision-Support System For Water Strategic-Planning In Jordan", *European Journal Of Operational Research*, 102(3), 455-472

Amien, I. (1998). "An Agroecological Approach to Sustainable Agriculture", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 465-480.

Anderssen, B., J. Monney, et al. (1996). "Decision Support for the Design of Constructed Wetlands", *Applied Mathematical Modelling*, 20(1), 93-100.

Archer, N. and F. Ghasemzadeh (1998). "A Decision-Support System For Project Portfolio Selection", *International Journal Of Technology Management,* 16(1-3), 105-114.

Arinze, B. and S. Banerjee (1992). "A Framework for Effective Data Collection, Usage and Maintenance of DSS", *Information & Management,* 22(5), 257-268.

Arnott, D. (Apr 1999). "The Monash Decision Support Systems Laboratory", *Monash University,* http://www.sims.monash.edu.au/dsslab/.

Badri, M. A. (1999). "A simulation model for multi-product inventory control management", *Simulation,* 72(1), 20-32.

Baird, I. A., P. C. Catling, et al. (1994). "Fire Planning for Wildlife Management - A Decision Support System for NADGEE-NATURE-RESERVE, Australia", *International Journal of Wildland Fire,* 4(2), 107-121.

Ballou, D. P. and G. K. Tayi (1996). "A Decision Aid for the Selection and Scheduling of Software Maintence Project", *IEEE Transactions on Systems , Man, and Cybernetics,* 26(2), 203-221.

Bandyopadhyay, R. and S. Datta (1990). "Applications of OR in Developing Economies. Some Indian Experiences", *European Journal of Operational Research,* 49(2), 188-199.

Barnikow, A.-M., U. Behrendt, et al. (1992). "DICTUM: Decision Support System for Analysis and Synthesis of Large-scale Industrial Systems", *Computers in Industry,* 18(2), 135-153.

Barua, A. and A. Whinston (1998). "Decision-Support For Managing Organizational Design Dynamics", *Decision Support Systems,* 22(1), 45-58.

Beech, R. and B. A. Fitzsimons (1990). "Application of a Decision Support System for Planning Services within Hospitals", *Journal of the Operational Research Society,* 41(12), 1089-1094.

Behan, R. W. (1994). "Multiresource Management and Planning with EZ-Impact", *Journal of Forestry,* 92(2), 32-36.

Berkemer, R., M. Makowski and D. Watkins (1993). "A Prototype of a Decision Support System for River Basin Water Quality Management in Central and Eastern Europe", Research Report, IIASA, Laxenburg, Austria.

Berner, E. S., G. D. Webster, et al. (1994). "Performance of 4 Computer-based Diagnostic Systems", *New England Journal of Medicine,* 330(25), 1792-1796.

Beulens, A. J. M. and J. A. van Nunen (1988). "The Use of Expert System Technology in DSS" Decision Support Systems 4(4), 421-431.

Bielli, M. (1992). "A DSS Approach to Urban Traffic Management", *European Journal of Operational Research,* 61(1, 2), 106-113.

Bonczek, H., C. W. Holsapple and A. Whinston (1980). "Evolving Roles of Models in Decision Support Systems", *Decision Sciences,* 11(2), 337-356.

Borenstein, D. (1998). "IDSSFlex: an intelligence DSS for the design and evaluation of flexible manufacturing systems", *Journal of the Operational Research Society,* 48(11), 734-744.

Bradley, P. (1993). "The Quiet Revolution in Trucking Services", *Purchasing,* 114(3), 36-38

Bruggen, G. H. v., A. Smidts, et al. (1998). "Improving Decision Making by Means of a Marketing Decision Support System", *Management Science,* 44(5), 645-658.

Camara, A. S., M. Cardoso da Silva, et al. (1990). "Decision Support System for Estuarine Water-quality Management", *Journal of Water Resources Planning and Management,* 116(3), 417-432.

Caporaletti, L. E. and S. E. Dorsey (1994). "A Decision-Support System for In-Sample Simultaneous Equation Systems Forecasting using Artificial Neural Systems", *Decision Support Systems,* 11(5), 481-495.

CDSS (Apr 1999)."Colorado's Decision Support Systems", http://crdss.state.co.us/.

Chiueh, P. -T., S. -L. Lo, et al. (1997). "Prototype SDSS for Using Probability Analysis in Soil Contamination", *Journal of Environmental Engineering,* 123(5), 514-519.

Coffman, J. Y. and R. Brooks (1992). "Interactive Decision Systems for Improved Profitability", *Credit World,* 80(3), 30-33.

Covington, W. W., D. B. Wood, et al. (1988). "TEAMS: A Decision Support System for Multi-resource Management", *Journal of Forestry*, 86(8), 25-33.

Coats, P. K. (1990). "Combining an Expert System with Simulation to Enhance Planning for Banking Networks", *Simulation*, 54(6), 253-264.

Courtney, J. F. and D. B. Paradice (1993). "Studies in Managerial Problem Formulation Systems", *Decision Support Systems*, 9(4), 413-423.

Crosslin, R. L. (1991). "Decision-support Methodology for Planning and Evaluating Public-private Partnerships", *Journal of Urban Planning and Development*, 117(1), 15-31.

Datta, S. (1995). "A Decision Support System for Micro-Watershed Management in India", *Journal of Operational Research Society*, 46(5), 592-603.

Datta, S. and R. Bandyopadhyay (1993). "An Application of OR in Micro-level Planning in India", *Computers and Operations Research*, 20(2), 121-132.

DeLuca, J.M. and R.E. Cagan (1996). *The CEO's Guide to Health Care Information Systems*, American Hospital Publishing.

Demarest, M. (Apr 1999). "Technology And Policy In Decision Support Systems", DP Applications Inc, http://www.dpapplications.com/library/tpdss.html.

Dewhurst, S.M., W.W. Covington, et al. (1995). "Developing a model for Adaptive Ecosystem Management: Goshawk Management on Arizona's Kaibab Plateau", *Journal of Forestry*, 93(12), 35-43.

Dhar V. and R. Stein (1997). *Intelligent Decision Support Methods. The science of Knowledge Work*, Upper Saddle River, NJ: Prentice Hall.

Djukanovic, M., B. Babic, et al. (1996). "Fuzzy Linear Programming Based Optimal Fuel Scheduling Incorporating Blending/Transloading Facilities", *IEEE Transactions on Power Systems*, 11(2), 1017-1023.

Doukidis, G. I. and D. Forster (1990). "Potential for Computer-aided Diagnosis of Tropical Diseases in Developing Countries. An Expert System Case Study", *European Journal of Operational Research*, 49(2), 271- 278.

Edwards, J. S. (1992). "Expert Systems in Management and Administration - Are They Really Different from Decision Support Systems?", *European Journal of Operational Research*, 61(1, 2), 114-121.

Eom, S. B., S. M. Lee, et al. (1998). "A survey of decision support system applications (1988-1994)", *Journal of the Operational Research Society*, 49(2), 109-120.

ERDAS (Apr 1999). "ERDAS, Inc. – Before You Buy", http://www.erdas.com/before/casestudies/index.html.

FARAD (Apr 1999)."Food Animal Residue Avoidance Databank", http://www.farad.org/.

Finlay, P. and C. Martin (1988). "The State of Decision Support Systems: A Review", *Omega*, 17(6), 525-531.

Fredericks, J. W., J. W. Labadie, et al. (1998). "Decision Support Systems for Conjunctive Stream-Aquifer Management", *Journal of Water Resources Planning and Management*, 124(2), 69-78.

Fuglseth, A. M. and K. Gronhaug (1997). "IT-enable Redesign of Complex and Dynamic Business Processes: the Case of Bank Credit Evaluation", *Omega*, 25(1), 93-106.

Gameda, S. and J. Dumanski (1998). "Soilcrop - A Prototype Decision Support System for Soil Degradation - Crop Productivity Relationship", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 349-362.

Garza, O. F., A. J. Golub, et al. (1992). "Load Cubing at R J. Reynolds", *Production and Operations Management*, 1(2), 151-158.

Garza, J. M. d. l., D. R. Drew, et al. (1998). "Stimulating Highway Infrastructure Managment Policies", *Journal of Management in Engineering*, 14(5), 64-72.

Ghose, S. and D. L. Nazareth (1994). "Selecting Appropriate Support for Marketing Decisions", *Omega*, 22(5), 443-456.

Gonzalez-Andujar, J. L., J. L. Garcia-de Ceca and A. Fereres (1993). "Cereal Aphids Expert System (CAES): Identification and decision making", *Computers and Electronics in Agriculture*, 8(4), 293-300.

Goodrich P.R. (1998), "Smart Pitchfork", in: S.A. El-Swaify and D.S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 189-195.

Gough, J. D. and J. C. Ward (1996). "Environmental Decision-Making and Lake Management", *Journal of Environmental Management,* 48(1), 1-15.

Grabowski, M. and S. Sanborn (1992). "Knowledge Representation and Reasoning in a Real-time Operational Control System: The Shipboard Piloting Expert System (SPES)", Decision Sciences, 23(6), 1277-1296.

Grabski, S. V. and D. Mendez (1998). "Implementation of a knowledge-based agricultural geographic decision-support system in the Dominican Republic: a case study", *Information Technology & People,* 11(3), 174-193.

Green, P. E. and A. M. Krieger (1992). "An Application of a Product Positioning Model to Pharmaceutical Products", *Marketing Science*, 11(2), 117-132.

Grobler, D. C. and J. N. Rossouw (1991). "Applications of a decision support system to develop phosphorus control strategies for South African reservoirs", in *Water Quality Modeling*, 273-396

Guariso, G. and H. Werthner (1989). *Environmental Decision Support Systems*. New York, Halsted Press.

Hagland, M. (1998). "IT and Point-of-care Decision Support", *Health Management,* 19, 10-15.

Hanif, S. and Arief, S (1998). "A Tactical Decision Support System for Empty Railcar Management", *Transportation Science*, 32(4), 306-329

Hastak, M., D. W. Halpin, et al. (1996). "COMPASS-New Paradigm for Project Cost Control Strategy and Planning", *Journal of Construction Engineering and Management,* 122(3), 254-264.

Hernandez, M., P. Heilman, et al. (1998). "Use of a DSS for Evaluating Land Management System Effects on Tepetate Lands in Central Mexico", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 571-583.

Heylighen, F. (1992), "A Cognitive-systemic Reconstruction of Maslow's Theory of Self-actualization", *Behavioral Science*, 37, 39-58.

Hill, P.H. *et al.*, (1982), *Making Decisions. A Multidisciplinary Introduction*, Reading, MA: Addison-Wesley.

Hipel, K.W., D.M. Kilgour, et al. (1998). "Using the Decision Support System GMCR for Resolving Conflict in Resource Management", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 23-47.

Hoffman, T. (1993). "Union Pacific rail says, 'I know I can'", *Computerworld*, 27: 91- 93.

Hokkanen, J. and P. Salminen (1994). "The Choice of a Solid Waste Management System by Using the ELECTRE III decision-aid method", in: M. Paruccini (Ed.), *Applying Multiple Criteria Aid for Decisions to Environmental Management*, Kluwer Academic Publishers, 111-154.

Holsapple, C. W. and A. B. Whinston (1996). *Decision Support Systems. A Knowledge-based Perspective*, New York: West.

Howells, O. (1998). "Ecozone-II - A Decision-Support System For Aiding Environmental-Impact Assessments In Agriculture And Rural-Development Projects In Developing-Countries", *Computers And Electronics In Agriculture,*20(2), 145-164.

Huff, S. L., S. Rivard, A. Grindlay and I. P. Suttie (1984). "An Empirical Study of Decision Support Systems", *INFOR*, 21(1), 21-39.

Huynh, T. and C. Lassez (1990). "Expert Decision Support System for Option-based Investment Strategies", *Computers and Mathematics with Applications*, 20(9-10), 1-14.

IIASA (Apr 1999). "IIASA - WATER RESOURCES PROJECT - DESERT MODEL", http://www.iiasa.ac.at/Research/WAT/docs/desert.html.

Islei, G., G. Lockett and M. Stratford (1990). "Resource Management and Strategic Decision Making in Industrial R&D Departments. Decision Support Using Judgmental Modelling in the Chemical Industry", *Engineering Costs and Production Economics*, 20(2), 219- 229.

Jacucci, G. (1996). "Developing Transportable Agricultural Decision-Support Systems: An Example", *Computers and Electronics in Agriculture,* 14(4), 301-315.

Johnson, M. L. (1996). "GIS in Business: Issues to Consider in Curriculum Decision-Making", *Journal of Geography,* 95(3), 98-106.

Johnston, M., Y. Wand and M. Curran (1993). "An Expert System to Support Site Preparation Decisions Related to Reforestation" *INFOR*, 31(3), 221-243.

Jones. A.J., R. Selley and L.N. Mielke (1998). "Multi-Objective Decision Support Strategies for Cropping Steep Land", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 93-103.

Kadas, R. (1995). "Healthcare Data Analysis Systems", *Health Management Technology*, 16(7), 12-14.

Kainuma, M., Y. Nakamori and T. Morita (1990). "Integrated Decision Support System for Environmental Planning", *IEEE Transactions on Systems, Man and Cybernetics*, 20(4), 777-790.

Kampke, T. (1988). "About Assessing and Evaluating Uncertain Inferences Within the Theory of Evidence", *Decision Support Systems*, 4(4), 433-439.

Keegan, A. (1995). "Decision-support Systems Aiding New Care Delivery", *Health Management Technology,* 16(7), 50-55.

Keen, P. G. W. and M. S. Scott-Morton (1989). Decision Support Systems: An Organizational Perspective. Reading, MA, Addison-Wesley.

Keeney, R.L. (1992). *Value-focussed Thinking. A Path to Creative Decision Making*, Cambridge, MA: Harvard University Press.

Kersten, G.E. (Apr 1999). "IS Resource Page", *Carleton University,* http://www.business.carleton.ca/~gregory/teaching/is_materials/.

Kersten, G.E., (1997). "Support for Group Decisions and Negotiations. An Overview", in J. Climaco (ed.), *Multicriteria Analysis*, Heilderberg: Springer Verlag, 332-346.

Kersten, G.E., S. MacDonald, et al. (1993). "Knowledge-based Simulation for Medical Education", *Modelling and Simulation: Proceedings of IASTED International Conference*, M.H. Hamza (Ed.), Anaheim, CA: IASTED, 630-633.

Kersten, G.E. and S. Szpakowicz (1995). "Forming Decision Making Skills with a Patient Simulator", *Control and Cybernetics*, 24(3), 301-326.

Kira, D. S., M. I. Kusy, et al. (1990). "A Specific Decision Support System to Develop an Optimal Project Portfolio Mix under Uncertainty", *IEEE Transactions on Engineering Management*, 37(3), 213-221.

Kleijnen, J. P. C. (1993). "Simulation and Optimization in Production Planning: A Case Study", *Decision Support Systems*, 9(3),: 269-280.

Kovacs, G.J., J.T. Ritchie and T. Nemeth (1998). "CERES Models in Multiple Objective Decision-Making Process", in: S.A. El-Swaify and D.S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 281-289.

Lawton, G. (1993). "Transforming Numbers into Graphics Yields Insight from Images", *Bank Management*, 69, A16-A18.

Leibovici, L., V. Gitelman, et al. (1997). "Improving Empirical Antibiotic-Treatment - Prospective, Nonintervention Testing Of A Decision-Support System", *Journal Of Internal Medicine,* 242(5), 395-400.

Levary, R. R. and M. D. Renfro (1991). "Application of Assembly Line Balancing Techniques to Installment Lending Operations of Commercial Banks", *Computers and Industrial Engineering,* 20(1), 104-109.

LGI (Apr 1999), "The Data Warehousing Information Center – Decision Analysis Tools", http://pwp.starnetinc.com/larryg/decision.html.

Liang, T.-P. and S.-Y. Hung (1997). "DSS and EIS applications in Taiwan", *Information Technology & People,* 10(4), 303-315.

Liberatore, M. J. and A. C. Stylianou (1993). "The Development Manager's Advisory Systems: A Knowledge-Based DSS Tool for Project Assessment", *Decision Sciences,* 24(5), 953-976.

Little, J. D. C. (1970), "Models and Managers: The Concept of a Decision Calculus", *Management Science,* 16(8), 35-43.

Lovejoy, Stephen B., J.G. Lee, et al. (1997). "Research Needs for Water Quality Management in the 21st Century: A Spatial Decision Support System", *Journal of Soil and Water Conservation,* 52(1), 18-22.

Lysgaard, J. (1992). "Dynamic Transportation Networks in Vehicle Routing and Scheduling", *Interfaces,* 22(3), 45-55.

Mak, H-Y, A. P. Mallard, T. Bui and R. Au, "Crisis Management Support Systems using Workflow", May 1999, *Decision Support Systems* (in print).

Mak H-Y. and T. Bui, "Modeling Experts Consensual Judgments for New Product Entry Timing", *IEEE Transactions on Systems, Man and Cybernetics,* 1996, 26(5), 659-667.

Mallach, E. G. (1994). *Understanding Decision Support Systems and Expert Systems,* Burr Ridge, IL: Irwin.

Manley, B. R. and J. A. Threadgill (1991). "LP Used for Valuation and Planning of New Zealand Plantation Forests", *Interfaces,* 21(6), 66-79.

Martin, C. H., D. C. Dent and J. C. Eckhart (1993). "Integrated Production, Distribution, and Inventory Planning at Libbey-Owens-Ford", *Interfaces,* 23(3), 68-78.

Marakas G. M. (1999). *Decision Support Systems in the 21st Centure,* Upper Saddle River, NJ: Prentice Hall.

Marathe, A., V. Ghate, P. Abhyankar and V. D. Vartak (1991). "Computer Aided Decision Making in Social Forestry", *Indian Forester,* 117(5), 403-410.

Martinsons, M. and R. Davison (1999). "The Balanced Scorecard: A Foundation For The Strategic Management Of Information Systems", *Decision Support Systems,* 25(1), 71-88.

Matthew, P.L. and B.A. Peasley (1998). "A Case Study in the Use of an Expert System as a Multiobjective Decision Support System (MODSS) – Boobera Lagoon Environmental Management Plan", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management,* Lewis Publishers, 655-666.

Meyer, J. E. (1992). "SCADA for Financial Planning and Management", *Management Quarterly,* 33(1), 20-30.

McNurlin, B. C. and Sprague, R. H., Jr. (1993). Information Systems Management in Practice. Engelwood Cliffs, NJ, Prentice Hall.

Migliarese, P. and E. Paolucci (1993). "A System for Group Production Planning in Manufacturing", *Interfaces,* 23(3), 29-40.

Mintzberg, H., D. Raisingham and A. Theoret (1976). "The Structure of 'Unstructured' Decision Processes", *Administrative Science Quarterly,* 21, 246-275.

Mira Da Silva, L., J. Park, and P.A. Pinto (1998). "Decision Support Systems for Irrigated Zones: An Integrated Approach to Land Use Planning and Management in Southern Europe", in: S.A. El-Swaify and D.S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management,* Lewis Publishers, 599-614.

Mishra, R. B. and S. Dandapat (1993). "A Knowledge-based Interpretation System for EMG Abnormalities", *Int. Journal of Clinical Monitoring and Computing*, 10(2), 131-142.

Missikoff, M. (1998). "An Object-Oriented Approach To An Information and Decision-Support System For Railway Traffic Control", *Engineering Applications Of Artificial Intelligence*, 11(1), 25-40.

Mohanty, R. and S. Deshmukh (1997). "Evolution Of A Decision-Support System For Human-Resource Planning In A Petroleum Company", *International Journal Of Production Economics*, 51(3), 251-261.

Moon, D.E., S.C. Jeck, et al. (1998). "Elements of a Decision Support System: Information, Model, and User Management", in: S.A. El-Swaify and D.S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 323-334.

Morgan, R. F. (1996). "An Intelligent Decision Support System for a Health Authority: Solving Information Overload", *Journal of the Operational Research Society*, 47(4), 570-582.

Moribayashi, M. and C. Y. Wu (1990). "Decision support system for capital budgeting and allocation", *Computers and Industrial Engineering*, 19(1-4), 524-528

Muth, R. M. and R. G. Lee (1986). Social Impact Assessment in Natural Resource Decision Making: Toward a Structural Paradigm, in H. A. Becker and A. L. Porter (Eds.), *Methods and Experiences in Impact Assessment*, Dordrecht, Reidel. 168-183.

Naesset, E. (1997). "Geographical Information-Systems In Long-Termforest Management And Planning With Special Reference To Preservation Of Biological Diversity - A Review", *Forest Ecology And Management*,93(1-2), 121-136.

Osmond, D. L., R. W. Gannon, et al. (1997). "WATERSHEDSS: A Decision Support System for Watershed-scale Nonpoint Source Water Quality Problems", *Journal of the American Water Resources Association*, 33(2), 327-342.

Ott, J. (1992). "Federal Express Develops C3I-Based Information System", *Aviation Week and Space Technology*, 137, 57-60.

Ozdamar, L., M. Bozyel, et al. (1998). "A Hierarchical Decision-Support System For Production Planning (With Case-Study)", *European Journal Of Operational Research*, 104(3), 403-422.

Paige, G.B., J.J. Stone, et al. (1998). "Overview of a Decision Support System for the Evaluation of Landfill Cover Designs", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 153-165.

Paruccini, M. (1994). *Applying Multiple Criteria Aid for Decision to Environmental Management*, Dordrchet: Kluwer.

Park, Y. H., E. Park and C. A. Ntuen (1990). "Investment Decisions. An Integrated Economic and Strategic Approach", *Computers and Industrial Engineering* 19(1-4), 534-538.

Payandeh, B. and D. Basham (1993). "'FIDME-PC': Forestry Investment Decisions Made Easy on Personal Computers", *International Journal of Modelling and Simulation*, 13(2), 72-6.

Pingry, D. E., T. L. Shaftel and K. E. Boles (1991). "Role for Decision Support Systems in Water-delivery Design", *Journal of Water Resources Planning and Management*, 117(6), 629-644.

Pinter, J., M. L. D. Fels, et al. (1995). "An Intelligent Decision Support System for Assisting Industrial Wastewater Management", *Annals of Operations Research*, 58(1), 455-477.

Power, D. and F. Quek (Apr 1999)."ISWorld Decision Support Systems Research Page", http://power.cba.uni.edu/isworld/dss.html.

Power, D. J. (Apr 1999)."Decision Support Systems (DSS) Resources - Home Page", http://dss.cba.uni.edu/DSShome.html.

Power, J. M. (1988). "Decision Support Systems for the Forest Insect and Disease Survey and for Pest management", *Forestry Chronicle*, 64, 132-135

Power, J. M. (1993). "Object-oriented Design of Decision Support Systems in Natural Resource Management", *Computers and Electronics in Agriculture*, 8(4), 301-24.

Proudlove, N.C., S. Vadera, et al. (1998). "Intelligent Management Systems in Operations: a Review", *Journal of the Operational Research Society*, 49(7), 682-699.

Quek, F. (Apr 1999). "Decision Support Systems Courses", http://is.lse.ac.uk/iswnet/dss/courses.htm

Rao, H. R., V. S. Jacob, F. Lin, D. Robey and G. P. Huber (1992). "Hemispheric Specialization, Cognitive Differences, and Their Implications for the Design of Decision Support Systems Responses" *MIS Quarterly*, 16(2), 145-154.

Rauscher, H. M. (1999). "Ecosystem Management Decision Support for Federal Forests in the United States: A Review", *Forest Ecology And Management*, 114(2-3), 173-197.

Rios, J. P. (1993). "Investment in New Production Capacity Under Uncertain Market Conditions", Industrial Engineering 25(6), 31-40.

Riverside Technology (Apr 1999). "Decision Support Software Systems for Water Resource Management", http://www.riverside.com/dss/dssshow/next/index.html.

Robotham, M.P. (1998). "AGFADOPT: A Decision Support System for Agroforestry Project Planning and Implementation", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 167-176.

Ross, S. and I. Hannam (1998), "Multiple Objective Decision Support Systems Used in Management of Temperate Forest Ecosystems in Southeast Australia", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 667-684.

Sandia National Laboratories (1999). "Environmental Decision Support & Resource Coalition", http://www.nwer/sandia.gov/coalition/.

Sankaran, J. K. and R. R. Ubgade (1994). "Routing Tankers for Dairy Milk Pickup", *Interfaces*, 24(5).

Santhanam, R. and J. Elam (1998). "A survey of knowledge-based systems research in decision sciences (1980-1995)", *Journal of the Operational Research Society*, 49(5), 445-457.

Sauter, V. (1997). *Decision Support Systems*, New York: Wiley.

Scot Morton, M. S. (1971). "Management Decision Systems. Computer-based Support for Decision Making", Division of Research, Harvard University, Cambridge, MA.

Shannon, P. W. and R. P. Minch (1992). "A Decision Support System for Motor Vehicle Taxation Evaluation", *Interfaces*, 22(2), 52-64.

Sharkey, P. D., M. J. DeHaemer, et al. (1993). "Assessing the Severity of Patients' Illnesses to Better Manage Health Care Resources", *Interfaces*, 23(4), 12-20.

Shaw, R., J. Doherty, et al. (1998). "The Use of Multiobjective Decision Making for Resolution of Resource Use and Envirnomental Management Conflicts at a Catchment Scale", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 697-716.

Shtienberg, D., A. Dinoor and A. Marani (1990). "Wheat Disease Control Advisory, a Decision Support System for Management of Foliar Diseases of Wheat in Israel", *Canadian Journal of Plant Pathology*, 12, 195-203.

Silvert, W. (Apr 1999)."Decision Support Systems for Aquaculture Regulation", http://www.maritimes.dfo.ca/science/mesd/he/staff/silvert/dss/dss.html

Simonovic, S. P. (1992). "Reservoir Systems Analysis: Closing Gap between Theory and Practice", *Journal of Water Resources Planning and Management*, 118(3), 262-280.

Sisodia, R. S. (1992). "Marketing Information and Decision Support Systems for Services", *Journal of Services Marketing*, 6(1), 51-64.

Sobanjo, J. O., G. Stukhart, et al. (1995). "Evaluation of Projects for Rehabilitation of Highway Bridges", *Journal of Structural Engineering*, 120(1), 81-99.

Sophocleous, M. and T. Ma (1998). "A Decision Support Model to Assess Vulnerability to Salt Water Intrusion in the Great Bend Prairie Aquifer of Kansas", *Ground Water*, 36(3), 476-483.

Sophocleous, M. A., J. K. Koelliker, et al. (1999). "Integrated numerical modeling for basin-wide water management: The case of the Rattlesnake Creek basin south-central Kansas", *Journal Of Hydrology*, 214(1-4), 179-196.

Sorensen, C. G. (1998). "A decision support system for planning field operations", *Computers in Agriculture*, 446-454.

Specht, J. and Owls (1995). "Loggers Share Forest Wealth", *GIS World*, 8(10), 36-38.

Sprague, R. H., Jr. and E. D. Carlson (1982). Building Effective Decision Support Systems. Engelwood Cliffs, NJ, Prentice Hall.

Sprague, R. H. and H. J. Watson (1997). *Decision Support for Management*. Upper Saddle River, NJ: Prentice Hall.

Srihari, K. and M. Cala (1992). "Knowledge Based Decision Support for PCB Assembly Using SMT", *Computers and Industrial Engineering*, 23(1-4), 405-408.

Swetnam, R., J. Mountford, et al. (1998). "Spatial Relationships Between Site Hydrology And The Occurrence Of Grassland Of Conservation Importance - A Risk Assessment With GIS", *Journal Of Environmental Management*, 54(3), 189-203.

Stewart, T. J. (1991). "Multi-criteria Decision Support System for R&D Project Selection", *Journal of the Operational Research Society*, 42(1), 17-26.

Stodolak, F. and J. Carr (1992). "Systems Must Be Compatible with Quality Efforts", *Healthcare Financial Management*, 46(6), 72-77.

Stone, N.D., D. Faulkner, et al. (1998). "CROPS: A Constraint-Satisfaction System for Whole-Farm Planning", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 527-537.

Subramaniam, C. and S. Kerpedjiev (1998). "Dissemination of Weather Information to Emergency Managers: A Decision Support Tool", *IEEE Transactions on Engineering Management*, 45(2), 106-114.

Suresh, N. C. (1990). "Towards an Integrated Evaluation of Flexible Automation Investments", *International Journal of Production Research*, 28(9), 1657-1672.

Sutherland, F. R. and J. J. Lambourne (1991). "Development of a Decision Support Mapping Utility for Water Resources Planning" *Water*, 17(4), 281-288.

Tanzi, T. and R. Guiol (1998). "A System For Motorway Management Based On Risk Rate Estimation", *Safety Science*, 30(1-2), 9-23.

Tecle, A., B. Shrestha, et al. (1998). "A Multi-objective Decision-Support System For Multi-resource Forest Management", *Group Decision And Negotiation*, 7(1), 23-40.

Tessmer, A. C., M. J. Shaw and J. A. Gentry (1993). "Inductive Learning for International Financial Analysis: A Layered Approach", *Journal of Management Information Systems*, 9(4), 17-36.

Thrall, G. I. and S. M. Elshaw-Thrall (1990). "Computer Assisted Decision Strategy for Evaluating New satellite Hub Sites for a Local Utility Provider", *Computers, Environment and Urban Systems*, 14(1), 37-48.

Turban, E. and Aronson, J.E. (1998). *Decision Support Systems and Intelligent Systems*. Upper Saddle River, NJ: Prentice-Hall, Fifth Edition.

Twery, M.J., S.L. Stout and D.L. Loftis (1998). "Using Desired Future Conditions to Integrate Multiple Resource Prescriptions: The Northeast Decision Model", ", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 197-203.

Tyagi, N. K., K. C. Tyagi and N. N. Pillai (1993). "Decision Support for Irrigation System Improvement in Saline Environment", *Agricultural Water Management*, 23, 285-301.

Vickner, S.S. and D.L. Hoag (1998). "Advances in Ration Formulation for Beef Cattle Through Multiple Objective Decision Support Systems", in: S.A. El-Swaify and D.S. Yakowitz (Ed.),

Multiple Objective Decision Making for Land, Water, and Environmental Management, Lewis Publishers, 291-298.

Vogel, D. R. and J. F. Nunamaker Jr. (1990). "Group Decision Support System Impact: Multi-Methodological Exploration", *Information & Management*, 18(1), 15-28.

Wadsworth, R. and M. Brown (1995). "A Spatial Decision-Support System to Allow the Investigation of the Impact of Emissions from Major Point Sources Under Different Operating Policies", *Water Air And Soil Pollution*, 85(4), 2649-2654.

Walker, D. and A. Johnson (1996). "NRM Tools - A Flexible Decision-Support Environment For Integrated Catchment Management", *Environmental Software*, 11(1-3), 19-24.

Wagner, P. and F. Kuhlmann (1991). "Concept and Implementation of an Integrated Decision Support System (IDSS) for Capital-intensive Farming", *Agricultural Economics*, 5, 287-310.

Williams, S. B. and D. R. Holtfrerich (1998). "A Knowledge-Based Reasoning Toolkit for Forest Resource Management", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 251-268.

Wilmes, G. J., D. L. Martin and R. J. Supalla (1990). "Decision Support Systems for Improved Irrigation Management", *Visions of Future*, American Society of Agricultural Engineers, 594-600.

Winsemius, P. and W. Hahn (1992). "Environmental Option Assessment", *Columbia Journal of World Business*, 27(3, 4), 248-266.

Wood, D. B. and S. M. Dewhurst (1998). "A Decision Support System for the Menominee Legacy Forest", *Journal of Forestry*, 96(11), 28-32.

Wybo, J.L. (1998). "FMIS: A Decision Support System for Forest Fire Prevention and Fighting", *IEEE Transactions on Engineering Management*, 45(2), 127-131.

Xiang, W. N. (1993). "A GIS method for Riparian Water Quality Buffer Generation" *International Journal of Geographical Information Systems*, 7(1), 57-70.

Yakowitz , D.S., B. Imam and L.J. Lane (1998a). "Effects of Optional Averaging Schemes on the Ranking of Alternatives by the Multiple Objective Component of a U.S. Department of Agriculture Decision Support System", in: S.A. El-Swaify and D.S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 217-232.

Yakowitz , D.S., J.J. Stone et al. (1998b). "Evaluation of a Prototype Decision Support System for Rangelands in the Southwest United States", in: S.A. El-Swaify and D.S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 363-378.

Yakowitz , D.S., J.J. Stone et al. (1992). "Evaluating Land Management Effects on Water Quality Using Multi-Objective Analysis within a Decision Support System", *American Water Resources Association 1st International Conference on Ground Water Ecology*, April, Tampa, Fl, 365-373.

Yakowitz , D.S., J.J. Stone et al. (1993). "Evaluating Land Management Practices with a Decision Support System: An Application to the MSEA Site Near Treynor, Iowa", *Soil and Water Conservation Society Conference on Agriculture Research to Protect Water Quality*, Minneapolis, MN, Feb, 404-406.

Yost, R. and J.Z.C. Li (1998). "Developing an Integrated Nutrient Management Decision Aid", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 177-185.

Zhang, X., Chen, S., et al. (1998). " Season No-Tillage Ridge Cropping System: A Multiple Objective Tillage System for Hilly Land Management in South China", in: S. A. El-Swaify and D. S. Yakowitz (Ed.), *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 685-696.

Zhu, X., R.G. Healey, et al. (1998). "A Knowledge-Based Systems Approach to Design of Spatial Decision Support Systems for Environmental Management", *Environmental Management,* 22(1), 35-48.

Zwietering, M. H., T. Wijtzes and J. C. De Wit (1992). "A Decision Support System for Prediction of the Microbial Spoilage in Foods", *Journal of Food Protection*, 55, 973-979.