

James J. Kay¹

A. PERSONAL DATA

I POST-SECONDARY EDUCATION

Jan. 1978-May 1984

University of Waterloo (Waterloo, Ontario)

Ph.D. in Systems Design Engineering from the Faculty of Engineering.

Dissertation: *Self-Organization in Living Systems*

Sept. 1975-Dec. 1977

University of Waterloo (Waterloo, Ontario)

Master of Applied Science in Systems Design from the Faculty of Engineering.

Engineering Project: *An Investigation into Engineering Design Principles for a Conserver Society*

Sept. 1972-May 1975

McGill University (Montreal, Quebec)

Bachelor of Science with First Class Honours in Physics.

Sept. 1970-May 1972

Vanier CEGEP (Ville St. Laurent, Quebec)

Diploma in Collegial Studies in Pure and Applied Sciences.

II AWARDS

Visiting Professor, Danish Academy of Science, Copenhagen, May-August 1996.

NSERC post-doctoral fellowship

III EMPLOYMENT

Department of Environment and Resource Studies, Faculty of Environmental Studies

July 1993- present Associate Professor

July 1984 - July 1993 Assistant Professor

July 1983 - July 1984 Lecturer

September 1982 - April 1983 Sessional Lecturer

Fall 1978,79 80 Course Instructor

Systems Design Engineering

July 1993- present Associate Professor (Cross Appointment)

July 1984 - July 1993 Assistant Professor (Cross Appointment)

July 1983 - July 1984 Lecturer (Cross Appointment)

Fall 1981 Course Instructor, General Engineering

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School of Planning
July 1997- present

Associate Professor (Cross Appointment)

Management Sciences
July 1999- present

Associate Professor (Cross Appointment)

Department of Geography
September 2000- present

Associate Professor (Cross Appointment)

School of Rural Planning and Development, University of Guelph
Nov 2001- present

Associate Graduate Faculty

B. RESEARCH AND SCHOLARSHIP

I ACADEMIC AND PROFESSIONAL INTERESTS

My research for the last twenty five years has been about the development of the ecosystem approach as a way of understanding and managing our role in the biosphere. My research activities span the full spectrum from the theoretical and epistemological basis for an ecosystem approach, to the formulation of ecosystem based environmental policy, the development of ecosystem monitoring programs, to on the ground planning both in the context of urban, industrial, and natural ecosystems and the greening of institutions.

My research work began with my Ph.D. which focused on the thermodynamics of the self-organization of living systems using the ideas of complex systems theory, particularly non-equilibrium thermodynamics. The purpose of my research is:

1. to understand the development process of complex systems
2. to use this understanding to develop a theory of ecosystem dynamics (both human -socio-economic and natural-biophysical)
3. to develop a method for evaluating and measuring ecosystem integrity
4. to develop a theory and practice of ecosystem management and planning.

This work incorporates elements of information theory, systems theory, hierarchy theory, thermodynamics, catastrophe theory and ecology imbedded in the epistemological framework of post-normal science.

The Development of Complex Systems (Self-organization theory and Thermodynamics):

What is the appropriate thermodynamic description of self-organizing systems?

We (with R. Fraser, Mechanical Engineering, UW) are examining different exergy analysis techniques in order to ascertain their utility in describing self-organization. In particular we are looking at simple self-organizing systems (e.g. Bénard cells) and very simple biological systems (single cell systems).

A theory of the thermodynamics of self-organization.

In collaboration with E. Schneider, we have developed a theory which suggests that self-organization is a phenomenological manifestation of the propensity to survive while increasing exergy use, thus furthering the universal proclivity for equilibrium, the destruction of all gradients. We have discussed the implications of this theory for describing and measuring the development of biological systems, particularly ecosystems. This research was the subject of the cover story in *New Scientist*, 5 October, 2002

What are the empirically observed thermodynamic changes in self-organizing systems?

We have examined this for simple systems such as Bénard Cells. With J. Luvall (NASA), we are working to analyse the energy budgets of ecosystems using thermal remote sensing equipment from aircraft. In particular we use surface temperature as a surrogate for exergy use. C. Swanton (University of Guelph) in association with us, has measured surface temperature in crops and in old fields (regenerating agricultural lands) over the course of two summers. T.F.H. Allen and John Norman (University of Wisconsin, Madison) has performed a series of microcosm experiments on plant communities. In all these case studies surface temperature decreases (exergy use increases) as ecological organization increases. These empirical tests suggests that surface temperature is a robust measure of ecosystem development which holds promise as an indicator for use in remotely sensed evaluation of ecosystem integrity. We presented our work as a plenary panel at *Advances in Energy Studies: exploring supplies, constraints and strategies*, Porto Venere, Italy, 23-27 May, 2000

How does the flow structures in ecosystems change with self-organization?:

This work focuses on developing measures which describe the flow of resources in ecosystems. The measures are based on economic input/output analysis, trophic analysis, cycle analysis, and information theory. Much of this work has been done in conjunction with R. E. Ulanowicz (Chesapeake Biological Laboratory, University of Maryland).

Ecosystem Management for Integrity:

The concept of "ecosystem integrity" is the current attempt to characterize the well being of ecosystems. I am working closely with D. Waltner-Toews, G. Francis & H. Regier, on the evolution of the notion of stress-response and ecosystem health as put forward by Regier & Rapport. We have developed an ecosystem approach for evaluating ecological integrity and for the development of management strategies that promote ecological integrity. We are currently working on several case studies.

Most notable of these is the Huron Natural Area project which is an exercise in the rehabilitation of a remnant piece of landscape into a natural area. In collaboration with V. Rynnimeri and T. Seebohm, of the UW school of Architecture, we have recently completed a Master Plan for the natural area.

The practice of Post-Normal Science: an Ecosystem Approach

What are the guiding principles for studying complex systems?

In collaboration with the so-called *Dirk Gently* gang; G. Francis, H. Regier, S. Funtowicz, J. Ravetz, G. Gallopin, M. Giampietro, D. Waltner-Toews, M. O'Connor and T.F.H. Allen, we are developing a set of guiding questions for the study of complex systems and a methodology for doing this. In particular this focuses on the issues of uncertainty and surprise in nested self-organizing systems. The problematique is of decision making in the face of complexity and high risk, of charting a sustainable course in uncertain waters.

Developing the practice of post-normal science: an ecosystem approach.

Through a number of case studies we are developing an ecosystem approach for sustainability as an example of a post-normal science. In particular we have been developing:

- an ecosystem approach to natural areas (with N-M Lister, V. Rynnimeri, and T. Seebohm)
- a methodology for designing monitoring programs which is rooted in an ecosystem approach (with M. Boyle and B. Pond)
- an ecosystem approach to health (with D. Waltner-Toews, T. Murray et al)
- an ecosystem approach to sustainable land use planing and ecological economics. (with G. Francis, S. Slocombe, C. Sunde, D. Bavington, D. McCarthy, B. Dempster.)

We have presented this work at a number of meetings, most recently as a full day symposium as part of the *World Congress of the Systems Sciences*, July 16-19, 2000, Toronto. This work is the subject of a review article in *Frontiers in Ecology and the Environment*, 2003; Vol.1 entitled: *Perspective changes everything: managing ecosystems from the inside out.*

Greening the Campus

Turning the University of Waterloo campus into a showcase, environmentally appropriate institution is the goal of the Greening the Campus initiative. Students, faculty, and staff together are investigating ways in which to improve the university as an ecosystem. Since 1990, over one hundred student reports have been done. Many of these reports have resulted in changes in university practice. A recent evaluation (1999) of resource use on campus suggests that these initiatives have decreased consumption by thirty (for water) to sixty per cent (for energy) depending on the resource stream. In 1995, a formal university committee with representation from each faculty was created along with a WWW site showcasing student work. I was the founding chair of this initiative from 1990-1995.

Other Interests:

- Socio-political and technical problems of implementing a Conserver Society and Sustainable Development;

- Industrial Ecology, (my masters thesis in engineering was on this topic);
- Developing a Hydrogen Economy.
- The problems involved in designing technology so that it will serve humans and enrich their lives rather than the traditional approach of designing technology to which humans must adapt themselves;
- The philosophical issues involved in systems theory, and their communication to students;
- The teaching of problem solving and design, particularly creativity, to students.
- The use of the WWW as a teaching tool.

II PUBLICATIONS

a) *Journal Articles*

Waltner-Toews D., Kay J. J., Neudoerffer C., Gitau T., 2003. "Perspective changes everything: managing ecosystems from the inside out", *Frontiers in Ecology and the Environment*, Vol.1, pp.

Waltner-Toews D., Kay, J., 2002. "An Ecosystem Approach to Health", *LEISA*, 18:1, March 2002

Kay, J., Regier, H., Boyle, M. and Francis, G. 1999. "An Ecosystem Approach for Sustainability: Addressing the Challenge of Complexity" *Futures* Vol 31, #7, Sept. 1999, pp.721-742

Regier, H.A., Kay, J.J., 1996 "An Heuristic Model of Transformations of the Aquatic Ecosystems of the Great Lakes-St. Lawrence River Basin", *Journal of Aquatic Ecosystem Health*, Vol. 5: pp3-21

Curi, W.F., Unny, T.E., Kay, J.J., 1995. "A Stochastic Physical System Approach to Modelling River Water Quality" *Stochastic Hydrology and Hydraulics*, Vol.9 , #2, pp117-

Schneider, E.D, Kay, J.J., 1994 "Complexity and Thermodynamics: Towards a New Ecology", *Futures* 24 (6) pp.626-647, August 1994

Kay, J, Schneider, E.D,. 1994, "Embracing Complexity, The Challenge of the Ecosystem Approach", *Alternatives* Vol. 20 No.3 pp.32- 38

Schneider, E.D, Kay, J.J., 1994, "Life as a Manifestation of the Second Law of Thermodynamics", *Mathematical and Computer Modelling*, Vol. 19, No. 6-8, pp.25-48.

Tobias, T., Kay, J.J., 1994, "The Bush Harvest in the Northern Village of Pinehouse" *Arctic* Vol. 47, No. 3. pp.207-221.

Kay, J.J., 1991. "A Non-equilibrium Thermodynamic Framework for Discussing Ecosystem Integrity", *Environmental Management*, Vol. 15, No.4, pp.483-495.

Ulanowicz, R.E., Kay, J.J., 1991. "A Package for Analysis of Ecosystem Flow Networks.", *Environmental Software* Vol. 6 No. 3, pp.131-142.

b) *Chapters in Books:*

Kay, J., Boyle, M., 2003. "A hierarchical conceptual model for discussing the relationships between natural ecosystems and societal systems" for Drake, J.A., C.R. Zimmermann, S. Gavrillets, and T. Fukami (eds), *Complexity Emerging: a paradigm for ecological thought*. Columbia University Press.

Waltner-Toews D., Kay, J., Murray, T., 2002. "Adaptive Methodology for Ecosystem Sustainability and Health (AMESH): An Introduction". In Gerald Midgley & Alejandro E. Ochoa-Arias (Eds.) *Community Operational Research: Systems Thinking For Community Development*, Plenun Press.

Fraser, R., Kay, J.J., 2002. "Exergy Analysis of Eco-Systems: Establishing a Role for the Thermal Remote Sensing" in D. Quattrochi and J. Luvall (eds) *Thermal Remote sensing in Land Surface Processes* Taylor & Francis Publishers.

Murray, T., Kay, J., Waltner-Toews D., Raez-Luna, E.; 2002. "Linking Human and Ecosystem Health on the Amazon Frontier: An Adaptive Ecosystem Approach", in Aguirre, A. A., R. S. Ostfeld, C. A. House, G. M. Tabor and M. C. Pearl (eds.). *Conservation Medicine: Ecological Health in Practice*. Oxford University Press, New York. (Chapter 23, in press)

Kay, J.J., 2002, "On Complexity Theory, Exergy and Industrial Ecology: Some Implications for Construction Ecology" in Kibert, C., Sendzimir, J., Guy, B. (eds), *Construction Ecology: Nature as the Basis for Green Buildings*, Spon Press, pp.72-107.

Regier, H.A., Kay, J.J., 2001. "Phase Shifts Or Flip-Flops In Complex Systems", in Munn, R., editor in chief. Vol. 5, *Encyclopedia of global environmental change*. London: Wiley; 2001; pp. 422-429.

Boyle, M., Kay, J.J., Pond, B., 2001. "Monitoring in Support of Policy: an Adaptive Ecosystem Approach", in Munn, R., editor in chief. Vol. 4, *Encyclopedia of global environmental change*. London: Wiley; 2001; pp.116-137.

Kay, J., Regier, H., 2000. "Uncertainty, Complexity, And Ecological Integrity: Insights from an Ecosystem Approach", in P. Crabbé, A. Holland, L. Ryszkowski and L. Westra (eds), *Implementing Ecological Integrity: Restoring Regional and Global Environmental and Human Health*, Kluwer, NATO Science Series, Environmental Security, pp. 121-156.

Kay, J. 2000. "Ecosystems as Self-organizing Holarchic Open Systems: Narratives and the Second Law of Thermodynamics" in Sven Erik Jørgensen, Felix Müller (eds), *Handbook of Ecosystem Theories and Management*, CRC Press - Lewis Publishers. pp.135-160

Lister, N., Kay, J.J., 1999, "Celebrating Diversity: Adaptive Planning and Biodiversity Conservation", in S. Bocking (ed), *Biodiversity in Canada: An Introduction to Environmental Studies*, Broadview Press. pp.189-218.

Kay, J., Regier, H., 1999. "An Ecosystem Approach to Erie's Ecology" in M. Munawar, T.Edsall, I.F. Munawar, (eds), *The State of Lake Erie (SOLE) - Past, Present and Future. A tribute to Drs. Joe Leach & Henry Regier*, Backhuys Academic Publishers, Netherlands, pp.511-533

Regier, H., Shimizu, R., Kay, J.J., Ulanowicz, R.E., 1997. "Government Organizations and Rehabilitation of the Great Lakes Basin" Chapter 15 in A. Brooks and S. VanDeveer (eds.), *Saving the Seas: Values, Scientists, and International Governance*, Maryland Sea Grant College pp. 359-380

Kay, J, Schneider, E.D., 1995, "Embracing Complexity, The Challenge of the Ecosystem Approach", in *Perspectives on Ecological Integrity*, L. Westra, J. Lemons (eds) Kluwer, Dodrecht, pp. 49-59. (Republication, originally Alternatives Vol. 20 No.3 pp.32- 38)

Schneider, E.D, Kay, J.J., 1995, "Order from Disorder: The Thermodynamics of Complexity in Biology", in Michael P. Murphy, Luke A.J. O'Neill (ed), *What is Life: The Next Fifty Years. Reflections on the Future of Biology*, Cambridge University Press, pp. 161-172

Regier, H.A., Lister, N.M., J.J. Kay, 1994, "Cumulative effects of cultural stresses on ecosystems: a Niagara escarpment case study", in R.E. Munn (ed) *Keeping Ahead: The Inclusion of Long Term Futures in Environmental Impact Assessment.*, Environmental Monograph # 11, Institute for Environmental Studies, University of Toronto and the Canadian Electrical Association (CEA 9129 G-31).

Kay, J.J., 1993, "On the Nature of Ecological Integrity: Some Closing Comments" in S. Woodley, J. Kay, G. Francis (Eds.), 1993. *Ecological Integrity and the Management of Ecosystems*, St. Lucie Press, Delray, Florida. pp.201-212.

Kay, J.J., L. Graham, R.E., Ulanowicz. 1989. "A Detailed Guide to Network Analysis" in *Network Analysis in Marine Ecology: Methods and Applications*, F. Wulff, J. Field, K. Mann (Eds.), pp.15-61, Springer-Verlag.

Field, J.G., Wulff, F.V., Allen, P.M., Fasham, M.J.R., Flos, J., Frontier, S., Kay, J.J., Silvert, W., and Trainor, L. 1985. "Ecosystem Theory in Relation to Unexploited Marine Ecosystems" in *Ecosystem Theory for Biological Oceanography*, Ulanowicz, R.E., Platt, T. (Eds.), Canadian Bull. Fish. Aquatic Science, Vol. 213.

c) *Books:*

Woodley, S., J. Kay, G. Francis (Eds.), 1993. *Ecological Integrity and the Management of Ecosystems*, St. Lucie Press, Delray, Florida, 217 pages.

d) *Published Conference papers:*

Mánuel-Navarrete, D., D. Dolderman, and J.J. Kay, 2002. "A historical overview of the ecological integrity concept". In J.Porter and G.Nelson (eds.) *Ecological Integrity and Protected Areas*, 113-123. Proceedings of the Parks Research Forum of Ontario 2001. North York, Ontario.

Foster, J., Kay, J., Roe, P., 2001. "Teaching Complexity and Systems Thinking to Engineers", 4th UICEE Annual Conference on Engineering Education, Bangkok, Thailand, 7-10 February 2001, UNESCO International Centre for Engineering Education, in press

Waltner-Toews, D., Murray, T., Kay, J., Gitau, T., Ruez-Luna, E., McDermot, J., 2000, "One Assumption, Two Observations, Some Guiding Questions and a Process for the Investigation and Practice of Agroecosystem Health, in Jabbar, M.A., Peden, D.G., Saleem, M., Li Pub, H. (eds), *Agro-ecosystems, natural resources management and human health related research in East Africa: Proceedings of an IDRC-ILRI international workshop held at ILRI, Addis Ababa, Ethiopia, 11-15 May, 1998*. Published by International Livestock Research Institute, Nairobi. pp.7-14

Kay, J, 2001. "Ecosystems, Science and Sustainability", in Ulgiati, S., Brown, M.T., Giampietro, M., Herendeen, R., Mayumi, K., (eds) *Proceedings of the international workshop: Advances in Energy Studies: exploring supplies, constraints and strategies*, Porto Venere, Italy, 23-27 May, 2000 pp. 319-328.

Kay, J., Allen, T., Fraser, R., Luvall, J., Ulanowicz, R., 2000. "Can we use energy based indicators to characterize and measure the status of ecosystems, human, disturbed and natural?" in Ulgiati, S., Brown, M.T., Giampietro, M., Herendeen, R., Mayumi, K., (eds) *Proceedings of the international workshop: Advances in Energy Studies: exploring supplies, constraints and strategies*, Porto Venere, Italy, 23-27 May, 2000 pp. 121-133.

Kay, J.J., 1999, "New Applications of the Ecosystem Approach" in R. E. Munn, (Ed.), *Emerging Environmental Issues in Ontario*, Report of a May 14, 1999 Workshop, Environmental Monograph No. 15, Institute for Environmental Studies , University of Toronto, Sec 3.11, pp.35-37

Kay, J.J., Foster, J., 1999, "About Teaching Systems Thinking" in Savage, G., Roe, P. (eds), *Proceedings of the HKK conference*, 14-16 June, 1999, University of Waterloo, Ontario, pp.165-172

Martell, R., Kay, J., 1998 "Prospects for an Ecosystem Approach to Monitoring at Long Point", in Carty, S., Murzin, R., Powell, S., Ramsay, D., (eds.) *Leading Edge '97: The Edge and the Point, Proceedings* October 16-18, 1997, Burlington Ontario. pp. 122-126.

Pond, B., Boyle, M., Kay, J., 1998 "State Of The Landscape Reporting: A Framework for Indicators of Land Use Policy Performance", in Carty, S., Murzin, R., Powell, S., Ramsay, D., (eds.) *Leading Edge '97: The Edge and the Point, Proceedings* October 16-18, 1997, Burlington Ontario. pp. 207-213

Kay, J. 1997, "The Ecosystem Approach: Ecosystems as Complex Systems", in Murray, T., Gallopin, G., (eds) *Proceedings of the First International workshop of the CIAT-Guelph Project "Integrated Conceptual Framework for Tropical Agroecosystem Research Based on Complex Systems Theories"*, Centro Internacional de Agricultura Tropical, Cali, Colombia, 26-28 May, 1997. pp. 69-98

Gallopin, G., Kay, J., Waltner-Toews, D., Ráez-Luna, E., Murray, T., 1997, "Agroecosystem Development in Ucayali, Peruvian Amazon. A Catastrophe Theory Representation ", in Murray, T., Gallopin, G., (eds) *Proceedings of the First International workshop of the CIAT-Guelph Project "Integrated Conceptual Framework for Tropical Agroecosystem Research Based on Complex Systems Theories"*, Centro Internacional de Agricultura Tropical, Cali, Colombia, 26-28 May, 1997. pp. 129-141.

Schneider, E.D, Kay, J.J., 1993, "Exergy Degradation, Thermodynamics, and the Development of Ecosystems" in Tsatsaronis G., Szargut, J., Kolenda, Z., Ziebig, A.,(eds) *Energy, Systems, and Ecology, Volume 1*, Proceedings of ENSEC' 93, July 5-9 Cracow, Poland, pp.33-42.

Curi, W.F., Unny, T.E., Kay, J.J., 1993. "A Stochastic Physical System Approach to Modelling River Water Quality" in *Proceedings of the Conference on Stochastic and Statistical Methods in Hydrology and Environmental Engineering*, Waterloo, Ontario

Kay, J.J., Schneider, E.D., 1992. "Thermodynamics and Measures of Ecosystem Integrity" in *Ecological Indicators*, Volume 1, D.H. McKenzie, D.E. Hyatt, V.J. Mc Donald (eds.), *Proceedings of the International Symposium on Ecological Indicators*, Fort Lauderdale, Florida, Elsevier, pp.159-182.

Kay, J.J., 1990. "A Non-equilibrium Thermodynamic Framework for Discussing Ecosystem Integrity" in *An Ecosystem Approach to the Integrity of the Great Lakes in Turbulent Times*, Edwards, C.J., Regier, H.A. (eds), Great Lakes Fish. Comm. Spec. Pub. 90-4, pp. 209-238

Kay, J.J., 1989. "A Thermodynamic Perspective of the Self-Organization of Living Systems" in *Proceedings of the 33rd Annual Meeting of the International Society for the Systems Sciences*, Edinburgh, Scotland, P.W.J. Ledington (ed), Vol.3, pp. 24-30

Schneider, E. D., Kay, J.J., 1989. "Nature Abhors a Gradient" in *Proceedings of the 33rd Annual Meeting of the International Society for the Systems Sciences*, Edinburgh, Scotland, P.W.J. Ledington (ed), Vol.3, pp.19-23

Kay, J.J., 1988. "The Administrative Requirements for Data-Base Co-ordination and Co-operation", in *Proceedings of the Conference and Workshop on Data Bases and Heritage Areas*, P. Eagles (ed) Heritage Resource Center, UW, pp. 68-70.

Kay, J.J., Jernigan, M.E., 1980. "Soil Type Classification for Land Use Planning", *Proceedings of the Conference on Cybernetics and Society* (Institute of Electrical and Electronic Engineers - Systems, Man, Cybernetics Section - Annual Conference), Boston, Mass., U.S.A. pp. 52-57

e) Other Papers

Hoekstra, T., Allen, T.F.H., Kay, J.J., Tainter, J.A., 1998. "Criteria and Indicators for Ecological and Social System Sustainability; with system management objectives" in Woodley, S., Alward, G. Gutierrez, L. Hoekstra, T., et al. "North American Test of Criteria and Indicators of Sustainable Forestry" Center for International Research, 1998, pp.142-149.

Boyle, M., Kay, J.J., Pond, B. 1996. "State Of The Landscape Reporting: The Development of Indicators for the Provincial Policy Statement Under the Land Use Planning and Protection Act" prepared for the Ontario Ministry of Natural Resources, 81 pages.

Boyle, M., Kay, J.J., 1996. "State of the Landscape Reporting: A Background Literature Review and Database on Monitoring and Indicators" prepared for the Ontario Ministry of Natural Resources, 101 pages.

Akbari, M.H., Murphy, S.D., Kay, J.J., Swanton, C.J., 1996. "Energy Based Indicators of Ecosystem Health", Agroecosystem Health Project, Discussion Paper #37, University of Guelph, 15 pages.

Royal Society of Canada, Global Climate Change Program, Long-term Ecological Research and Monitoring Panel, 1995, *Looking Ahead: Long-term Ecological Research and Monitoring in Canada*, Technical Report no 95-1, (J. Kay wrote Chap 2 and contributed sections to other chapters)

Kay, J.J., 1994, "The Ecosystem Approach, Ecosystems as Complex Systems and State of the Environment Reporting", prepared for North American Commission for Environmental Cooperation, *State of the North American Ecosystem meeting*, Montreal, Canada. 8-10 December, 1994, 42 pages.

Kay, J.J., 1994, "The Ecosystem Approach: Ecosystems as Complex Systems" and "The Ecosystem Approach Applied to the Huron Natural Area", prepared for Environment Canada, State of the Environment Reporting, Ottawa, Canada. 19 pages and 12 pages

Kay, J.J., 1991. "The Concept of "Ecological Integrity", Alternative Theories of Ecology, and Implications for Decision-Support Indicators". in: Canadian Environmental Advisory Council *Economic, Ecological, and Decision Theories: Indicators of Ecologically Sustainable Development*. pp. 22-58 Commissioned background paper prepared for Canadian Environmental Advisory Council workshop on *Indicators for Ecologically Sustainable Development*, 25-26 July 1990, Ottawa, Canada.

Simpson, M., Kay, J.J., 1989 "Availability, Exergy, the Second Law and all that....." 10 pages (privately circulated).

Kay, J.J., 1988. "Playing 'What If' Games with Mother Nature", in *Alternatives*. Vol. 15, #4, pp. 68-70.

Kay, J.J., 1988. "Framework of Concepts for Dealing with Integrity" Background paper for The International Joint Commission & Great Lakes Fishery Commission *Workshop on Ecosystem Integrity in the Context of Surprise*, June 14-16, 1988 Burlington, Ontario.

Kay, J.J., 1987. "Self-Organization and the Thermodynamics of Living Systems: A Paradigm". Working Paper Series, Department of Environment and Resource Studies, University of Waterloo. 46 pages

Kay, J.J., 1987. "An Annotated Bibliography of Exergy/Availability". 2 pages (privately circulated)

Kay, J.J., 1986. "Network Thermodynamics and Ecology", A Commissioned Background Paper for SCOR WG73.

Ulanowicz, R.E., Kay, J.J., 1986. "NETWRK3: A Package of Computer Algorithms to Analyze Ecological Flow Networks. Pascal Implementation for the IBM-PC." Center for Environmental and Estuarine Studies, Chesapeake Biological Laboratory, University of Maryland. UMCEES Ref. No. 82-7c CBL.

III COMPUTER SOFTWARE

Ulanowicz, R.E., Kay, J.J. 1989. "NETWRK 4", Software for measuring Ecological Flow: Pascal Implementation on the Macintosh, presented at the Annual General Meeting of the International Society for Ecological Modelling (North America), University of Toronto, 8, 9 August, 1989.

Kay, J.J. 1986. "Structures", Software to measure organization of Ecosystem Structure, presented at the Scientific Committee for Oceanic Research (UNESCO) Working Group 73 Symposium: *Ecosystem Flow Analysis*, Santa Cruz, California, December 1986

Ulanowicz, R.E., Kay, J.J., 1986. "NETWRK 3", Software for measuring Ecological Flow: Pascal Implementation on the IBM-PC, presented at the Scientific Committee for Oceanic Research (UNESCO) Working Group 73 Symposium: *Ecosystem Flow Analysis*, Santa Cruz, California, December 1986

IV PRESENTATIONS²

Keynote Addresses

Kay, J*., 2000. "Biocomplexity: Complex systems theory and ecosystem approaches" keynote address to the *National Science Foundation Advisory Committee on Environmental Research and Education*, Washington, D. C., 11 October, 2000.

Kay, J*., 2000. "Understanding complexity in biological systems" Keynote address to the *4th International Conference on integrating GIS and environmental modeling*, Banff center for conferences, 6 September, 2000.

Kay, J*., 2000. "Complex systems theory applied to ecosystem management" Keynote address at *Modelling complex systems conference*, Montreal, 1 August, 2000.

²An * after a name indicates who presented the address at the conference.

Kay*, J., 1999. "An Ecosystem Approach to Sustainability of Ecological Economic Systems", presented at the bi-annual conference of the *Canadian Society for Ecological Economics*, Regina, Sask., August 28, 1999.

Kay, J.J.*, 1995 "An Ecosystem Approach based framework for Environmental Monitoring in Ontario", keynote presentation to workshop on *Planning Reform Effectiveness Indicators*, Ministry of Natural Resources, Maple, Ontario, 19 December, 1995.

Kay, J.J.*₁, 1995, "Perspectives on Sustainability: The Ecosystem Approach", Keynote speaker, workshop on *Measuring Sustainable Development*, Env. Cdn., Niagara-on-the-Lake, 15-17 Nov. 1995

Kay*, J., 1993, "Thermodynamics, Ecology, Economics and Complex Systems", Keynote and Opening Address to a joint session of the *First Annual Meeting of the Canadian Chapter of the International Society for Ecological Economics* and the *Third Annual Meeting on Environmental and Natural Resource Economics* University of Ottawa, 1 October, 1993.

Kay, J.J.*, 1993. "Sophisticated Modesty", opening keynote address to the Annual General Meeting of the *Ontario Parks Association*, Kitchener, Ontario, July 22, 1993.

Kay, J.J.*, Schneider, E.D, 1992. "A Thermodynamic Perspective of Ecosystem Development", keynote address presented to the *CUSIS IV: Management and Uses of the Great Lakes Ecosystem Approach*, at Wingspread, Racine, WI, 7-9 June, 1992.

Kay, J.J., 1989. "Availability, Exergy, the Second Law and all that.....(and living systems)", Keynote Speaker to the *Symposium on Dynamics and Information in Self-Organizing Systems*, University of California, Fullerton, California, 17-18 March 1989.

Invited presentations

Kay*, J., 2001. "A systems theoretic framework for community-based resolution of ecological health issues: AMESH" presented at the *43rd annual meeting of the Organizational Research Society* of the United Kingdom, Bath, England, 5 September, 2001.

Kay*, J., 2001. "What is Industrial Ecology about? Some musings from Complex Systems Theory", presented at the bi-annual conference of the *Canadian Society for Ecological Economics*, Montréal, Québec, 24 August, 2001.

Special Roundtable: The Ecological Nature of Economics: A Conversation with Author Jane Jacobs, World Congress of the Systems Sciences, (Panelists Jane Jacobs, J. Kay, R. Anderson, S. Goerner) Annual meeting of the *International Society for the Systems Sciences*, Toronto, July 21, 2000

Kay, J*., 2000. "Exergy, the Second Law and Self-Organization: Some Observations", presented to *Thermodynamics and Systems Theory SIG (Institute for the Study of Complex Systems)*, *Thermoeconomics: Beyond the Second Law*, World Congress of the Systems Sciences, Annual meeting of the International Society for the Systems Sciences, Toronto, 20 July, 2000

Kay, J*., 2000. "An Introduction to the Ecosystem Approach", presented at the symposium *The Ecosystem Approach SIG (Network for Ecosystem Health and Sustainability) Panel I. General Introduction – Post-Normal Science & The Ecosystem Approach: Theory and Challenges*, World Congress of the Systems Sciences, annual meeting of the International Society for the Systems Sciences, Toronto, 20 July, 2000

Kay, J*, 2000, "The extended second law of thermodynamics", presented at the course on *Ecosystem theory-application in environmental management of aquatic systems*, at The Royal Danish School of Pharmacy, Copenhagen, Denmark, 1 June, 2000.

Kay, J*, 2000, "Use of satellite images to assess ecosystem health", presented at the course on *Ecosystem theory-application in environmental management of aquatic systems*, at The Royal Danish School of Pharmacy, Copenhagen, Denmark, 2 June, 2000.

Kay, J*, 2000. "Science, sustainability and irreducible uncertainty" presentation at *Advances in Energy Studies: exploring supplies, constraints and strategies*, Porto Venere, Italy, 25 May, 2000.

Kay, J*, 2000. "Can we use energy based indicators to characterize and measure the status of ecosystems, human, disturbed and natural?: An Introduction" presentation at *Advances in Energy Studies: exploring supplies, constraints and strategies*, Porto Venere, Italy, 25 May, 2000.

Murray, T., Waltner-Toews, D*., Kay, J*., 1999 "Health, Biodiversity and Natural Resource Use in the Western Amazon Lowlands: An Integrated Ecosystem Approach", presented at *Ecosystem Approaches to Health: Theory and Case Studies*, Sixth Canadian Conference on International Health, Palais des Congrès, Hull, Québec, 16 November, 1999.

Waltner-Toews, D*., Kay, J.*, 1999. "An Ecosystem Approach to Health: What is it and who needs it?", presented at the symposium *Ecosystem Disruption and Human Health*, Sixth Canadian Conference on International Health, Palais des Congrès, Hull, Québec, 15 November, 1999,

Kay*, J. Regier, H., Boyle, M., Francis, G. 1999. "An Ecosystem Approach for Sustainability: Addressing the Challenge of Complexity", presented at *NATO Science Advanced Research Workshop Implementing Ecological Integrity: Restoring Regional and Global Environmental and Human Health*, József Fodor National Public Health Centre, Budapest, June 28, 1999.

Kay*, J.J., Foster, J., 1999, "About Teaching Systems Thinking" presented at the *H. K. Kesavan* conference, University of Waterloo, 16 June, 1999,

Regier*, H., Kay. J., 1999. "One Heuristic Model for Aquatic Ecosystems to Include Streams, Wetlands and Lakes?", presented at *Ecosystem Health Symposium*. Annual meeting of the International Association for Great Lakes Research (IAGLR), Cleveland, OH., 25 May, 1999

Kay. J., Regier*, H., 1999. "Developing indicators for monitoring: An ecosystem approach", presented at *Ecosystem Health Symposium*. Annual meeting of the International Association for Great Lakes Research (IAGLR), Cleveland, OH., 25 May, 1999

Kay*, J.J. 1999. "The Challenge Of Designing For Sustainability" presented at *Rinker Eminent Scholar Workshop on Construction Ecology and Metabolism: The Material Cycles*; University of Florida, Gainesville, 6 May, 1999.

Murray, Tamsyn P., Kay, James J., Waltner-Toews*, David, Raez-Luna, Ernesto. 1999. "Adaptive Methodology for Ecosystem Sustainability and Health (AMESH):An Introduction." Presented to *Conservation Medicine Conference*, White Oak Conservation Center, Fla., April 29-May 2, 1999.

Kay, J*, 1999, "A Conceptual Framework for Discussing Ecological-Economic Systems", presented at the World Bank *Workshop on Natural Capital: Values in Two Perspectives*, Institute for Environmental Studies, University of Toronto, 23 April, 1999.

Kay, J*, 1999, "A Framework for an Ecosystem Approach for Urban Issues", presented at the Environment Canada *Workshop on Air Issues and Urban Environment*, Institute for Environmental Studies, University of Toronto, 22 March, 1999.

Kay, J*, 1999, "Considerations for Ecosystem Monitoring in Urban Woodlots", *50th Annual Conference* of the Ontario Chapter of the International Society for Arboriculture, Kitchener, Ont. 25 February, 1999.

David Waltner-Toews*, Otieno G.O, Gitau T, Suda C, Kangethe E.K, Gathuma JM, Tamsyn Murray, James Kay, Ernesto Raez-Luna, John McDermott, Mwangi J.M, Kariuki R.N. "Agroecosystem health: integrating systems theories, participation and sustainable practice", presented at *Rural Livelihoods, Empowerment and the Environment, going beyond the Farm Boundary*, Association for Farming Systems Research-Extension's 15th Symposium, Pretoria, South Africa, 29 November - 4 December 1998.

Regier, H*. Kay, J*, 1998, "Ecosystemic Phase Shifts" presented at *Next Generation Indicators workshop, State of the Lakes Ecosystem Conference*, Buffalo, N.Y., 23 October, 1998

Kay, J*, 1998, "The Challenge of Next Generation Indicators" presented at *Next Generation Indicators workshop, State of the Lakes Ecosystem Conference*, Buffalo, N.Y., 23 October, 1998

Kay, J*, 1998, "The Ecosystem Approach and ecosystems as complex systems" presented at *The Ecosystem Approach: The Next Generation*, sponsored by Network for Ecosystem Sustainability and Health, University of Waterloo, 9 October 1998

Kay, J*, 1998. "Thermodynamics and Network Analysis of Ecosystems" presentation at *Advances in Energy Studies: Energy flows in Ecology and Economy*, Porto Venere, Italy, 29 May, 1998.

Kay, J*, 1998. "Exergy, what is it?", presentation at *Energetic and Thermodynamic Foundations of Ecological Systems*, Santa Fe Institute, Santa Fe, New Mexico, 13 May, 1998

Kay, J*, 1998. "The second law and the thermodynamics of ecological systems", presentation at *Energetic and Thermodynamic Foundations of Ecological Systems*, Santa Fe Institute, Santa Fe, New Mexico, 11 May, 1998

Kay, J. J.*, 1997. "Recent Conceptual and Empirical Developments with self-organizing complex cultural/natural systems, in ecosystemic and bioregional Basin contexts", invited presentation to the symposium: *Towards a Laurentian Basin Bioregional Agreement, Code or Canon*, (40th Conference on Great Lakes Research, IAGLR), Buffalo, N.Y., 5 June, 1997

Kay, J.J.*, 1977, "Complex Systems Thinking and Tropical Ecosystem Management" invited presentation at the *First International workshop of the CIAT-Guelph Project "Development and Applications of an Integrated Conceptual Framework for Tropical Agroecosystems Based on Complex Systems Thinking"*, Centro Internacional de Agricultura Tropical, Cali, Colombia, 27 May, 1997.

Kay, J.J.*, 1997, "Post-Normal Science and Ecosystem Health" invited presentation at the *Second Roundtable Discussion on Ecosystem Health*, University of Guelph, Guelph, Ontario, 6 May, 1997

Kay, J.J.*, 1996. "The ecosystem approach to co-operative decision making; Post-Normal Science applied". *Ecosystem Approach in economics, health and environmental management: a post-normal science*. At the IV Biennial Meeting of the International Society for Ecological Economics, Boston, 4-7 August, 1996.

Kay, J.J.*, 1996. "A Post Normal Science Approach to Environmental Stewardship: The Huron Strasburg Natural Park Environmental Area Case Study" , Invited keynote presentation at the *Second Workshop of the SCOPE Project on Integrated, Adaptive Ecological Economic Modelling and Assessment*, SCOPE ICSU, Boston University, Boston, 2 August, 1996.

Kay, J.J.*, 1996. "State of the Landscape Reporting -- The Development of Indicators for Land Use Planning and Protection", Invited presentation at the *Second Workshop of the SCOPE Project on Integrated, Adaptive Ecological Economic Modelling and Assessment*, SCOPE ICSU, Boston University, Boston, 31 July, 1996.

Kay, J.J.* 1995, "The New Science- A general introduction", Invited presentation at the *Workshop on the Ecosystem Approach and its Applications to Agriculture and Governance*, University of Guelph, 21-22 February, 1995

Francis, G*., Kay, J.J.* 1995, "Implications for Institutional Arrangements", Invited presentation at the *Workshop on the Ecosystem Approach and its Applications to Agriculture and Governance*, University of Guelph, 21-22 February, 1995

Kay, J.J.*, 1994, "Monitoring, Assessing and Reporting Upon Change: Implications for Planning and Management", invited commentary at the *Symposium on the Heritage Estate in Canada and Ontario*, 8 November, 1994, Heritage Resource Center, University of Waterloo.

Kay, J.J.*, 1994, "The challenge of the second law for ecological economics", invited presentation to the *III International Congress of Ecological Economics*, 27 October, 1994, San José, Costa Rica

Kay, J.J.*, Schneider, E.D, 1994, "Thermodynamics, energy degradation, and the development of ecosystems. Part 1 and 2" presented to the symposium: *A Thermodynamic Perspective of Ecosystem Development* at INTECOL VI International Congress of Ecology, Manchester, England, August, 24, 1994

Kay, J.J.*, Schneider, E.D*, 1994, a) "Introduction to complex systems thinking" b) "Ecosystems as Self-Organizing Systems" c) "Towards a definition of Ecosystem Integrity" invited presentations to the *Workshop on Complex Systems Theory and Ecosystem Health* at the Symposium : *Ecosystem Health and Medicine: New Approaches to Environmental Management* 23 June, 1994, Ottawa, Ontario.

Regier, H., Kay, J. J.*, "A 1990's version of the Ecosystem Approach to Great Lakes Phenomena", invited presentation to the symposium: *Applying the Ecosystem Health Concept as a Management Tool*, (37th Conference on Great Lakes Research, IAGLR) University of Windsor, Windsor, Ontario, 9 June, 1994

Kay, J. J.*, Lister, N-M., Regier, H., "Self-Organizing Processes in the Great Lakes Ecosystems", invited presentation to the symposium: *Applying the Ecosystem Health Concept as a Management Tool*, (37th Conference on Great Lakes Research, IAGLR) University of Windsor, Windsor, Ontario, 9 June, 1994

Kay*, J., 1994, "The Challenge of the Ecosystem Approach" invited presentation to the *International Symposium on Issues in Science, Sociology, and the Urban Environment*, University of Windsor, Windsor, Ontario, 25 March, 1994.

Kay*, J., 1994, "Ecology and the New Science of Complex Systems", invited presentation to a *Workshop on the Ecosystem Approach*, sponsored by Environment Canada, State of the Environment Reporting, University of Waterloo, 18 March, 1994

Kay*, J., 1993, "Thermodynamics, Information Theory, Ecology, and Complex Systems", guest speaker, *Colloquia on Mankind in Non-Linear Systems*, University of Toronto, 9 December, 1993

Kay*, J., 1993, "Emergent Complexity and Ecosystem Integrity", invited presentation to the session *Ethics of Integrity and the Ecosystem Approach* at the *Second International Conference on the Environmental Management of Enclosed Coastal Seas*, Baltimore, 11 November, 1993.

Luvall, J.*, Kay, J., Schneider, E. 1993, "Thermal remote sensing in landscape ecology: a powerful tool in the characterization of landscapes on a functional basis" invited paper presented to the workshop on *Thermal Remote Sensing of the Energy and Water Balance over Vegetation in Conjunction with other Sensors*, 20 September, 1993, L'Agelonde, France.

Schneider, E.D*, Kay, J.J., 1993. "The State of Ecosystem Theory", Invited Presentation to the Chautauqua Institution, 3 August, 1993.

Luvall, J.*, Kay, J., Schneider, E.. 1993, "Thermodynamics and Ecological Integrity from Remote Sensing, examining evapotranspiration" invited paper presented to the *Aspen Global Change Institute Summer Science Session*, July 23, 1993, Aspen Colorado .

Ulanowicz, R.E., Kay, J.J*., 1993. "NETWORK, the Analysis of Mass and Energy Flows in Ecosystems", invited presentation to *Symposium on the use of Computer Graphics and Animation to Visualize Scientific Results*, (Annual Meeting of the Canadian Federation of Biological Societies), Windsor, Ontario, June 17, 1993

Westra, L.*, Kay, J.J., 1993, "The Value of Integrity Reexamined", invited paper presented to *7th Annual Meeting of the Society for Conservation Biology*, Arizona State University, Tempe, Az. June 11, 1993

Kay, J.J.*, Ulanowicz, R.E., Schneider, E.D, 1993. "A Nonequilibrium Thermodynamic Framework for Modelling Ecosystems", invited paper presented to *Symposium on Trophic Transfer and Production Dynamics of Lake Michigan and Ontario*, (36th Conference on Great Lakes Research, IAGLR) , Green Bay, Wisc., June 6, 1993

Kay, J., 1993. "Self-Organizing Systems Approaches to Ecological Integrity", invited presentation to *Royal Society of Canada, Long Term Ecosystem Research and Monitoring Panel*. 18 May, 1993, Toronto, Ontario.

Kay, J.J.*, 1993, "Implications of Current Theories of Ecosystem Dynamics for the Conservation of Biodiversity" invited paper presented to the workshop *Conserving Biodiversity within the Canadian Great Lakes Basin*, Heritage Resource Center, University of Waterloo, 11 March, 1993

Kay, J.J.*, Schneider, E.D, 1993, a) "The Thermodynamics of Self-Organizing and Evolving Systems" b)"Structural and Functional Measures of Ecosystem Integrity" c) "Integrity and Thermodynamics: An Ethical Issue", Invited presentations to *The Evolutionary Ecology of Open Systems: A Workshop* University of Toronto, 18-19 February, 1993.

Kay, J.J.*, Schneider, E.D, 1993, "Why thermodynamics suggests that ecological integrity is an ethical issue", invited presentation in the session: *The Scientific Foundations of Environmental Ethics* at the *Annual Meeting of the American Association for the Advancement of Science*, February 15, 1993, Boston, Ma.

Kay, J.J.*, Schneider, E.D, 1992. "A Thermodynamic Perspective of Ecosystem Development", invited presentation to the *Symposium on Energy, Entropy, Ecology and Evolution*, (Annual Meeting of the Canadian Federation of Biological Societies) Victoria, B.C., 18-20 June, 1992.

Ulanowicz, R.E., Kay, J.J.*, 1992. "The Propensities of Evolving Systems", invited paper presented to the *Symposium on Energy, Entropy, Ecology and Evolution*, (Annual Meeting of the Canadian Federation of Biological Societies) Victoria, B.C., 18-20 June, 1992.

Kay, J.J.*, Schneider, E.D., 1992. "A Thermodynamic Perspective of Ecosystem Integrity", invited presentation to *Environmental Ethics and Values* (35th Conference on Great Lakes Research, IAGLR) 31 May- 4 June, 1992, University of Waterloo, Waterloo, Ontario.

Kay, J.J., Schneider, E.D*, 1992. "Life as a Manifestation of the Second Law of Thermodynamics" invited presentation to *Thermodynamics and Scale in Evolving Biological Systems*, the 4th International Ames Group Meeting, 14-16 May 1992, Brigham Young University, Provo, Utah

Kay, J.J., 1991. "Structural and Functional Measures of Ecosystem Integrity", invited presentation to *Theoretical Ecology: Progress and Prospects*, 29 April-1 May, 1991, Gaithersburg, Md.

Schneider, E.D*, Kay, J.J.*, 1991. "A Thermodynamic Perspective of Ecosystem Development", invited presentation to *Theoretical Ecology: Progress and Prospects*, 29 April-1 May, 1991, Gaithersburg, Md.

Schneider, E.D*, Kay, J.J., 1991. "The Thermodynamics of Self-Organizing (Evolving) Systems and Ecosystem Development", invited presentation to IEEE Regional Meeting on *Modelling Complex Biological Systems*, Williamsburg, Va. 8-11 April 1991

Kay, J., 1991. "Self-Organizing Systems Approaches to Ecological Integrity", invited paper presented to *Ecological Integrity and the Management of Ecosystems*. 2-4 April 1991, University of Waterloo, Waterloo, Ontario.

Kay, J.J., Schneider, E.D*, 1990. "System Measures of Ecosystem Integrity", invited paper presented to the *International Symposium on Ecological Indicators*, Fort Lauderdale, Florida, 16-19 October 1990.

Curi, W.*, Kay, J.J., Unny, T., 1990. "Network Thermodynamics as Applied to Stochastic Modelling of Aquatic Ecosystems", invited presentation to the *Symposium on Network Thermodynamics and Other Methods of Analysis of Complex Biological Systems* (8th International Congress of Cybernetics and Systems), 11-15 June 1990, New York.

Kay, J.J., 1989. "A Thermodynamic Perspective on the Self-Organization of Living Systems", invited presentation to the *Symposium on Emergence and Evolution*, (33rd Annual Meeting of the International Society for the Systems Sciences) Edinburgh, Scotland, 3-7 July 1989.

Schneider, E. D.*, Kay, J.J., 1989. "Nature Abhors a Gradient"; invited presentation to the *Symposium on Emergence and Evolution*, (33rd Annual Meeting of the International Society for the Systems Sciences,) Edinburgh, Scotland, 3-7 July 1989.

Kay, J.J., 1986. "Measures of Ecosystem Self-Organization", presented to the Scientific Committee for Oceanic Research (UNESCO) Working Group 73 Symposium: *Ecosystem Flow Analysis*, Santa Cruz, December 1986.

Kay, J.J., 1980. "An Overview of Energy and Ecology", presented to the *First Global Conference on the Future*, Toronto, Ontario.

Presentations in lecture series

Kay, J*., 2001."Ecosystems as Complex Systems: Implications for Environmental Policy" presented as part of the Policy Research Directorate, *Distinguished Speakers Program*, Environment Canada, Hull, Québec, 28 September, 2001.

Kay, J*., 2001."Complex systems theory and the ecosystem approach", presented as part of the *Séminaires en Écologie Forestière* at Département de Géographie de l'Université de Montréal, 20 April, 2001.

Kay, J*, 1998. "Examples of the Elements of Complex Systems Thinking", Seminar for the *Program of Research in Interdisciplinary Systems Management*, University of Ottawa , 17 November, 1998.

Kay, J*, 1998. "Examples of Systems Identification", Seminar for the *Program of Research in Interdisciplinary Systems Management*, University of Ottawa , February 16, 1998.

Kay, J*, 1997. "The relationship between natural and societal ecosystems: A thermodynamic perspective" presented as part of the seminar series *Thermodynamics and Environment*, Institute for Research on Environment and Economy, University of Ottawa , November 13, 1997.

Kay, J.J.*, 1997, "Life as a Manifestation of the Second Law of Thermodynamics", presentation in the *Department of Botany Colloquium series*, University of Wisconsin, Madison, 2 October, 1997

Kay, J.J.*, 1996 "On Greening..." A series of lectures (12 hours) given as part of the *Environment, Health and Welfare Summer School* Cultural University 96, Royal Danish School of Pharmacy, Copenhagen, DK, 22, 23, 24 July 1996.

Kay, J.J.*, 1996 "A thermodynamic perspective on ecosystem response to stress", *Great Lakes Research Consortium Seminar Series*, University of Ottawa, Ottawa, 15 February, 1996.

Kay, J.J.*, 1994, "Embracing Complexity, The Challenge of the Ecosystem Approach to Environmental Protection and Management", invited lecture in the *Ecology and Environment Series*, S.U.N.Y.Syracuse College of Environmental Science and Forestry and The Great Lakes Research Consortium, Syracuse, N.Y., 26 September, 1994

Kay, J.J.*, Schneider, E.D, 1994. "Ecology and the New Science of Complex Systems", invited presentation to *Wildlife Research Section Seminar Series*, Ministry of Natural Resources, ICI House, Toronto, Ontario, 3 May, 1994.

Kay*, J., Schneider, E.D, 1994, "Complex Systems Theory, Thermodynamics and Ecosystems", guest speaker, *School of Fisheries and Wildlife Seminar series*, University Of Minnesota, St. Paul, 20 January, 1994 .

Kay, J.J.*, Schneider, E.D, 1993. "A Non-equilibrium Thermodynamic Framework for Discussing Ecosystem Integrity", invited presentation to *Wildlife Research Section Seminar Series*, Ministry of Natural Resources, Maple, Ontario, 20 April, 1993.

Presentations at learned meetings

David Waltner-Toews, D., Neudoerffer , C., Kay, J., Joshi, D., Sherpa, L., Lama, M., 2002. "An ecosystem approach to health in Kathmandu" presented in the session *Biodiversity and Community Approaches to Conservation* at the bi-annual meeting of the *International Society for Ecosystem Health* Washington, D.C., 9 June, 2002

David Waltner-Toews, D., Kay, J., Murray, T., 2002. "Ultimate Patients: an ecosystem approach to health" presented in the session *Bioethics for a Small Planet: Moral Philosophy, Global Context, Practical Response* at the bi-annual meeting of the *International Society for Ecosystem Health* Washington, D.C., 10 June, 2002

Manuel-Navarrete, D*., Dolderman, D., Kay, J.J*.. 2002, "Managing for Ecological Integrity", presented in the session: *Moving Beyond Managerial Ecology: Change, Contestation, Critique and Counterproposals*, at the annual general meeting of the *Environmental Studies Association of Canada*, Toronto, May 28-30, 2002.

Bunch, M.J.*, Kay, J.J., 2002. "Uncertainty in Normal and Post-Normal Science: Implications for Management of Socioecological Systems" presented in the session *Systems and Frameworks in Environmental Management I* at the *Association of American Geographers, Annual General Meeting*, Los Angeles, USA, 20 March 2002.

Kay, J.*, 2001, "The second law of thermodynamics and ecosystem self-organization: Exergy and surface temperature", presented at the *annual meeting of the Ecological Society of America*, Madison, WI., 6 August, 2001.

Foster, J*., Kay, J. 2000. "About Teaching Systems Thinking", presented to *Designing Educational Systems SIG*, World Congress of the Systems Sciences, Annual meeting of the International Society for the Systems Sciences, Toronto, 22 July , 2000

Rynnimeri, V*., Kay, J*, 2000, "The Huron Natural Area: an example of an adaptive ecosystem approach to master planning", presented at *The Fourth International Conference of Science and the Management of Protected Areas*, University of Waterloo, May 18, 2000.

Lister, N-M E.; Kay, J., 1999, "Celebrating Diversity: Adaptive Planning For Biodiversity Conservation in the Huron Natural Area" presented at *Tenth International Conference of the Society for Human Ecology*, Montreal, May, 29, 1999 and at *ECOGIFTS 2000 Conference: A Millennium Perspective on Conservation in Canada*, Canadian Council on Ecological Areas, Ottawa, October 1999.

Martell, R*., Kay, J., 1997 "Prospects for an Ecosystem Approach to Monitoring at Long Point", presentation at *Leading Edge '97: The Edge and the Point*, October 17, 1997, Burlington Ontario.

Pond, B*., Boyle, M., Kay, J., 1997 "State Of The Landscape Reporting: A Framework for Indicators of Land Use Policy Performance", presentation at *Leading Edge '97: The Edge and the Point*, October 17, 1997, Burlington Ontario.

Luvall, J.*, Kay, J., Schneider, E.. 1992, "Thermal remote sensing in landscape ecology: a powerful tool in the characterization of landscapes on a functional basis" paper presented to the *Annual meeting of the Ecological Society of America*, 11-13 August 1992, Honolulu, Hawaii.

Schneider, E.*, Kay, J., Luvall, J*., 1992, "Thermal remote sensing as a tool for categorizing landscapes in terms of their ecological development" paper presented to the *Seventh Annual U.S. Landscape Ecology Symposium*, 8-11 April 1992, Oregon State University.

Luvall, J.*, Holbo, R.*, Kay, J., Schneider, E.*. 1992, "Thermal remote sensing in landscape ecology: a powerful tool in the characterization of landscapes on a functional basis" paper presented to the *Seventh Annual U.S. Landscape Ecology Symposium*, 8-11 April 1992, Oregon State University.

Kay, J.J., "Structural and Functional Measures of Ecosystem Integrity", presented at *Lake Ontario Trophic Transfer working group Symposium*, Canadian Center for Inland Waters, 23 January 1992, Burlington, Ontario.

Kay, J.J.*, Schneider, E. D.*, 1990. "The Thermodynamics of Self-Organizing (Evolving) Systems and Ecosystem Development" presented to the *Fourth International Congress of Systematic and Evolutionary Biology*, Washington, D.C., 3-7 July, 1990.

Guest lectures

Kay, J*, 2001, "Complex Systems Thinking: What is it? What is its relevance to environmental issues?", presented at the McGill School for the Environment, Montreal, 21 November, 2001

Kay, J*, 2001, "Biocomplexity: What is it?" presented at the Medical School of Virginia, Virginia Commonwealth University, Richmond. Virginia, 1 May, 2001.

Kay, J*, Luvall, J.*, 2000. "Thermal Indicators of Ecosystem Status", A video conference presentation by Science Development and Transfer Branch, Ontario Ministry of Natural Resources, Friday March 31, 2000

Kay, J*, 1999, "An Ecosystem Approach to Sustainable Livelihoods", presented to the Sustainable Livelihoods working group, UNDP, at the United Nations, NY, NY, February 22, 1999

Kay, J. J.*, 1997. "The Ecosystem Approach", Full day seminar presented at Environment Canada, AES, Downsview, 24 June, 1997.

Kay, J.J.*, Schneider, E.D, 1993. "Thermodynamics and Measures of Ecosystem Development and Integrity", Guest Lecture to: *Postgraduate course on Ecosystem Theory*, sponsored by the European Economic Community and the Danish Government, at The Royal Danish School of Pharmacy, Copenhagen, Denmark, 19 August, 1993.

Schneider, E.D*, Kay, J.J., 1993. "Thermodynamics and Ecosystem Development", Guest Lecture to: *Postgraduate course on Ecosystem Theory*, sponsored by the European Economic Community and the Danish Government, at The Royal Danish School of Pharmacy, Copenhagen, Denmark, 19 August, 1993.

Kay, J.J., 1992. "A vision of the City of Kitchener in 2016", presented to *Developing a Vision for the city of Kitchener in 2016*, 29 June 1992, Kitchener, Ontario.

Schneider, E. D., Kay, J.J., "The Thermodynamics of Self-Organizing (Evolving) Systems and Ecosystem Development" presented at :

- a) Brown University, Dept. of Earth Science and Biology, 13 November, 1990
- b) University of Rhode Island, Graduate School of Oceanography, 14 November, 1990
- c) Woods Hole Oceanographic Institute, Biological Sciences Department, 15 November, 1990
- d) University of Wisconsin, Madison, Department of Botany, 12 November 1991.
- e) Smithsonian, Washington, D.C., 10 February, 1992
- f) University of Montana, Boise, 25 February, 1992.
- g) Oak Ridge National Laboratory, Ecosystem Group, Oak Ridge, Tenn, 29 May 1992
- h) Workshop on theory in ecology, Albuquerque, N.M., 24 August, 1992.
- i) Santa Fe Institute, Santa Fe, N.M., 25 August, 1992.
- j) University Of Toronto, 13 October, 1992 (by J. Kay).
- k) University Of Toronto, 22 February, 1994 (by J. Kay).
- l) McGill University, School of Planning, 14 November, 1994
- m) Ministry of the Environment and Energy, Ontario. Toronto 13 December, 1994 (by J. Kay).
- n) Boston University, Center for Energy and Environmental Studies, 23 January, 1995. (by J. Kay)

C. TEACHING ACTIVITIES

I COURSES TAUGHT³

SD 762	Complex Systems Theory II
ERS 669	Project work in environmental studies
ERS 218	Introduction to Sustainable Environmental and Resource Systems
ERS 305/605	Ecosystem Perspectives and Analyses
SD 761/ERS 675S	Introduction to Systems Thinking
ME 772	Urbanization: Can We Design With Nature?
ERS 285	Greening The Campus
ERS 385	Technologies and Lifestyles for a Conserver Society

³ SD: Systems Design, ERS: Environment & Resource Studies, ME: Mechanical engineering. Courses numbered 5XX and higher are graduate courses.

II GRADUATE STUDENTS

Supervision:

Ph.D.: N. Lister (Planning, current)
 B. Dempster (Planning, current)
 D. Navarrete (Geog, current)
 D. McCarthy (Planning, current)
 W.Curi: Analysis of a Large Scale Stochastic Environmental System.
 (Systems Design, 1992)

Masters: G. Vaidyanathan (current)
 E. Tucs (current)
 R. Martell :The participatory design of an ecosystem approach to monitoring in support of sense-making: What's the Point? (1999)
 K. Oxley, Education in Support of the Ecosystem Approach at the Huron Natural Area. (1998)
 M. Boyle: An Adaptive Ecosystem Approach to Monitoring (1998)
 B. Dempster: A Self-Organizing Systems Perspective on Planning For Sustainability (Planning, 1998)
 M. Akbari: Energy-Based Indicators of Ecosystem Health (Crop Sciences, University of Guelph, co-supervised with C. Swanton, 1994)
 M. Lagimodiere: Evapotranspiration of Macrophytes in a Freshwater Marsh (1994)
 J. Collis: Energy Flow in Mangrove Ecosystem. (Planning, 1993)
 T. Tobias: Bush Harvest Economy in Northern Saskatchewan: A Case Study. (School of Urban and Regional Planning, 1988).

Committee Member:

Ph.D.:

D. Connell: University of Guelph, Rural Studies (current)
 D. Bavington: Wilfred Laurier Univeristy: Geography (current)
 H. Venema: Systems Design (current)
 D. Armitage: (Re)Constructing Conservation Practice (Geography 2001)
 J. Levy: Multi-Criteria Decision Analysis for Managing Environmental Systems Under Uncertainty (Systems Design 2001)
 M. Bunch: An adaptive ecosystem approach to the rehabilitation and management of the Cooum River in Chennai, India. (Geography, 2000)
 R. DeAbreu: Albedo of Sea Ice (Geography, 1996)
 Way Leong: Bénard Cells in uninsulated containers (Mechanical Engineering, 1996)
 S. Woodley: A Database Framework for Measuring Ecological Integrity in National Parks (Geography, 1993)
 S. Slocombe: Holism and Uncertainty in Environmental Planning: Kluane, Wrangells, St.Elias Regions (School of Urban and Regional Planning, 1990)

Masters:

- J. Foster Understanding and Improving Undergraduate Engineering Education (Systems Design, 2001)
 F. Siddiq: A Systematic Comparison of Federal Water Management Policies of Canada, The United States, and Germany (Systems Design, 2000)
 A. Hatfield: Risks, Systems, and Uncertainty (Systems Design, 1998)
 D. Gardner: Evaluating the Potential for Improved Energy Efficiency with Applications to SERF. (Systems Design, 1987)

(N.B. Environment & Resource Studies did not have a Graduate Program before 1991)

III SENIOR HONOURS ESSAYS

- 2001 D. Pozega: Complexity and Engineering Design (SD)
 2000 D. Croft: Connecting design with the Environment. (SD)
 1999 A. Crober: The Ecosystem Approach To Ecosystem Management (Geog)
 J. Wu: Construction ecology standards
 M. Lo and K. Garvis: The Truth About Environmental Labels
 1997 C. Roenspiess: Using the WWW as a teaching tool in ERS.
 J. Flanagan: Purple Loosestrife in the Huron Natural Area: Can its Spread be Contained?
 1995 R. Metcalfe: Huron Natural Area: Wetlands monitoring
 R. Green: Huron Natural Area: Aquatic monitoring
 S. Diggon: Huron Natural Area: history and WWW home page
 C. Burgess: Huron Natural Area: monitoring network
 C. Johnson: Huron Natural Area: history
 I. Thomson: Huron Natural Area: hydrology monitoring
 C. Smith: Recycling in the library
 1994 M. Torreyter: The Elimination of Disposable Cups at the University of Waterloo
 1993 L. Deane: WATgreen study on alternative turf grass maintenance strategies
 S. Hetherington: Cullet use in Container Glass Manufacturing
 M. Conrad, B. McHattie: Ecosystem Integrity in Huron Park.
 1992 B. Milligan: A Critique of the Environmental Assessment Process for Sanitary Landfills
 D. Biggs: Educating Owners of Old Homes about Conserving Energy.
 J. Solomon: A hypercard stack of Forestry Companies in Canada.
 E. Rigler: Watgreen: Reusable Dispensers for Food Services
 M. English: The Use of Cattails for Water Filtration of Mine Tailing Ponds.
 M-K. Whitten: Three Mile Island Re-visited.
 1991 G. Peterson: Evolving Machine Systems (SD)
 1988 K. Ludwig: Ontario Hydro Route Selection Process: An Evaluation of the Computer-Aided Component
 T. Bedard: Environmental Hypersensitivity
 J. Murdoch: Watgreen: Composting Organic Waste on Campus. (SD)

- 1987 M. Harrison: Tamagimi Logging Conflict
 G. Kauffman: A Handbook for Effective Advocacy
 T. Grignon: Designing a Self-Contained Ecosystem
- 1986 M. Walker: PISCAN Software to Analyze Fish Populations from Fish Catch Records
- 1985 D. McCracken: Eco-neighbourhood (Geog)
- 1983 J. Ho: WATPLAN: the Database (SD)
 S. O'Connor: WATPLAN: The Interface (SD)

D. SERVICE

I UNIVERSITY

- Greening the Campus (WATGREEN) Committee (FES rep.) (1996-2001)
- Chairman of the Greening the Campus (WATGREEN) Committee (1990-1995)
- UW Interdisciplinary Ph.D. committee (1995)
- Walter Bean/ Canada Trust Visiting Professor: Arranged the 2000-2001 visiting professorship of Dr. N. Singh (UNDP, director of sustainable livelihoods programme) and with R. Fraser, arranged the 1999-2000 visiting professorship of Dr. J. Luvall (NASA)
- President's Committee on Turf Management. (1992-1994)
- Senate sub-committee on Research (FES rep, 1992)
- University of Toronto, University of Waterloo, Co-operative on Information Technology Steering Committee Faculty (rep, 1984-1988)

Faculty and Departmental service:

- Faculty Student Appeals Committee (Chair) (1997-2001)
- Faculty Computer and Communications Operations Committee (1984, 85, 87, 88(chair), 90, 91, 92, 97, 98, 99)
- Faculty Promotion and Tenure committee. (1995, 97, 98)
- Dean's Nomination Committee (1990-1991).
- Chair Selection Committee (1998-99)
- Graduate Admissions Officer (1997-2001)
- Graduate Programme Review Committee (1997-98)
- Undergraduate Programme Review Committee (1999)
- Admissions Committee (1992-1993)
- Scholarship Committee (1988, 1990-1995) (Chair, 91-95)
- Performance Review Committee (1989, 1991, 1999)
- Co-op rep (Jan.-Sept. 1990, 2000)
- Ecology Minor Committee (1995)
- Environmental and Urban Design Committee (1995)
- Environmental Engineering planning committee. (1990)

II COMMUNITY SERVICE

National Science Foundation (United States): Advisory committee for environmental research and education (2000-2003)

Chair of the NSF AC-ERE task group: *strategic planning for environmental research and education, 2001-2002*

Network for Ecosystem Sustainability and Health: Vice President (1997-current)

International Society for Ecosystem Health Board of Directors (1997- 1999)

Journal of Aquatic Ecosystem Health editorial board (1994-1995)

Huron Strasburg Natural Park Environmental Area Master Planning Committee (1997-2001)

Huron Strasburg Natural Park Environmental Area Technical Advisory Committee (1997-2001)

Huron Strasburg Natural Park Environmental Area Steering Committee (1994-1995)

Environment Committee, City of Kitchener.

1991-1995, 1997-2000 Citizen appointee to the committee

Bicycle planning committee, City of Kitchener.

1997-98 Citizen appointee to the committee

Hydrogen Economy planning committee, City of Kitchener.

1999-2001 Citizen appointee to the committee

Waterloo Region Green Communities Initiative,.

1995 City of Kitchener representative

E. PROFESSIONAL ACTIVITIES

I CONSULTING:

Huron Strasburg Natural Park Environmental Area

Preparation of the master plan and monitoring programme (part of team) (1997-2001)

Commissioner of the Environment for Canada

Applications of the Ecosystem Approach (1999-2000)

International Development Research Council

Developing an ecosystem approach to health (1999)

Inventory and Monitoring Institute (US Government Agency)

Monitoring for sustainability in US Forests (1997)

Ontario Ministry of Natural Resources

An ecosystem indicator framework for Ontario (1995-96)

North American Commission for Environmental Co-operation

A commentary on State of the Environment reporting (1995)

Ontario Ministry of Environment and Energy

Advised a meeting of the ADMs/DM on complex systems thinking and its implications for the ecosystem approach(1994)

International Joint Commission

Advised on using the ecosystem approach to develop the Lake Erie model (1994)

Environment Canada, State of the Environment Reporting

Advised on the use of an *ecosystem approach* for State of the Environment Reporting (1994)

An ecosystem research program in Settled Landscapes of Southern Ontario; Ontario Ministry of Natural Resources

Advised on a framework for designing the research program including running a one day workshop on the Soft Systems Methodology and Visioning and the design of a workshop on Perspectives on Settled Landscapes of Southern Ontario (1993-94) Advised on a proposal for provincial aggregates research strategy, 1994

Seaton Planning Project, Ontario Ministry of Housing

Advised on the use of an Ecosystem Approach for planning (1993)

IJC/CCIW/LOTT

Advised on the use of network flow analysis and the development of measures of ecosystem integrity. (1992,1994)

Science Council/Ontario Agricultural College

Advised them on developing an approach to ecological health. (1991)

Canadian Environmental Advisory Council:

Advised the Council on the state of ecosystem research in Canada. This included development of and participation in workshops and the critique of resulting documents. (1990)

Canadian Parks Service:

Assisted in the development of a workshop on Ecosystem Integrity and a database framework for park monitoring. (1990-1991)

II PANELS/SYMPOSIUM ORGANIZATION/WORKSHOPS*Panels and Working Groups:*

Reading in Systems Thinking, Sage Publications, *International Advisory Group*, 2002

Local Unit Criteria and Indicator Development Project (for sustainable ecosystem management) of the USDA Forestry Service Inventory and Monitoring Institute, *Science Review Panel*, 2001.

Collaborative Mercury Research Network - COMERN, *Science Review Panel*, 2001.

State of the Lakes Ecosystem Conferences "SOCIO-ECONOMICS/LAND USE Core Group", group member 1997-1998 for SOLEC 98, 21-23 October, 1998, Buffalo, NY.

CIAT-Guelph Project "Development and Applications of an Integrated Conceptual Framework for Tropical Agroecosystems Based on Complex Systems Thinking", 1996-2000 *Scientific Advisor*.

"Enhancing the role of the Great Lakes Coastal Wetlands for Water Quality Improvement and Wildlife Protection", Ohio State University Wetlands Project, *Advisory committee 1995-96*

Agroecosystem Health Research Project (Tri-Council Ecofund), University of Guelph, *Advisory Panel*, 1994-1996

Royal Society of Canada, Global Climate Change Program, *Long-term Ecological Research and Monitoring Panel*, 1992 - 1995.

Royal Swedish Academy of Sciences, Beijer Institute, *Working Group on Complex Ecological Economic Systems Modelling*. 1992-1993.

Ministry of the Environment, *Environment-Economy Linkages and Sustainable Development in Ontario*. Advisory Group. (1990-91)

Symposium Organization:

Panel Session Organizer: "Environmental integrity and health of adaptive dissipative systems" at *Advances in Energy Studies: Reconsidering the importance of energy*, Porto Venere, Italy, 24-28 September 2002

International Organizing Committee, International workshop on *Advances in Energy Studies: Reconsidering the importance of energy*, Porto Venere, Italy, 24-28 September 2002

Organizer: Workshop on *Complex Systems Theory and Sustainable Livelihoods*: the University of Waterloo, 10, 11 April, 2001 (Included academics, NGOs and three international speakers from the EU and UNDP).

Symposium Organizer (with David Waltner-Toews, Nina-Marie Lister): *The Ecosystem Approach SIG (Network for Ecosystem Health and Sustainability) Panel 1. General Introduction – Post-Normal Science & The Ecosystem Approach: Theory and Challenges, and Panel 2, Applications: Sustainable Development in Practice*, World Congress of the Systems Sciences, Annual meeting of the International Society for the Systems Sciences, Toronto, July 20, 2000

International Organizing Committee, International workshop on *Advances in Energy Studies: exploring supplies, constraints and strategies*, Porto Venere, Italy, 23-27 May, 2000

Panel Session Organizer: "Can we use energy based indicators to characterize and measure the status of ecosystems, human, disturbed and natural?" at *Advances in Energy Studies: exploring supplies, constraints and strategies*, Porto Venere, Italy, 25 May, 2000

Symposium Organizer (with David Waltner-Toews), Ecosystem Approaches to Health, two day seminar presented at *International Development Research Council*, Ottawa, 13,14 September, 1999

Symposium Organizer (with David Waltner-Toews), *The Ecosystem Approach: The Next Generation*, sponsored by Network for Ecosystem Sustainability and Health, University of Waterloo, 9 October 1998

Session chair, *Main Methodological issues in energy accounting and energy policy*. At the international workshop on *Advances in Energy Studies: Energy flows in Ecology and Economy*, Porto Venere, Italy, 26-30 May, 1998.

International Organizing Committee, International workshop on *Advances in Energy Studies: Energy flows in Ecology and Economy*, Porto Venere, Italy, 26-30 May, 1998.

Eco-Summit 96, Copenhagen Session chair: (but NOT session organizer)

- Forest Ecosystem Health, 19 August, 1996
- Aquatic Ecosystem Health I, 20 August, 1996
- Aquatic Ecosystem Health II, 20 August, 1996
- Ecosystem Theory II, 22 August, 1996.

Convener of Three Sessions on: *Ecosystem Approach in economics, health and environmental management: a post-normal science*. At the IV Biennial Meeting of the International Society for Ecological Economics, Boston, 4-7 August, 1996.

International Organizing Committee (six members), IV Biennial Meeting of the International Society for Ecological Economics, Boston, 4-7 August 1996.

Scientific Steering Committee, Ecological Summit 96, Copenhagen, 19-23 August 1996

with M. Giampietro et al.: Workshop II on *Complex systems: Policies and Decision-Making* Boston University, Boston, 4 August, 1996

with M. Giampietro et al.: International Workshop on *Complex systems: Policies and Decision-Making* Cortina d'Ampezzo, Italy, 27-29 May, 1996

Co-Chair with D. Waltner-Toews of: *The New Science: a workshop on the Ecosystem Approach and its Implications to Agriculture and Governance*, University of Guelph, 21-23 February, 1995.

Co-Chair with Schneider, E. D., Luvall, J. Symposium: *A Thermodynamic Perspective of Ecosystem Development* INTECOL VI International Congress of Ecology, Manchester, England, August, 24, 1994

Co-Chair with K. Minns, M. Munawar, G. Sprules of the *International Workshop on the Modelling of Large Lakes: Lake Ontario and Lake Erie Food Web Examples*, Canada Centre for Inland Waters, Burlington, Ontario, June 24, 1994.

Chair of *Workshop on Ecological Science and Sustainability* at the Institute for Environment and Economy, University of Ottawa, Ottawa, Ontario, 21 June, 1994.

Symposium Planning Committee: *Ecosystem Health and Medicine: New Approaches to Environmental Management* 19-22 June, 1994, Ottawa, Ontario.

Chair of *Workshop on Complex Systems Theory and Ecosystem Health* at the Symposium : *Ecosystem Health and Medicine: New Approaches to Environmental Management* 23 June, 1994, Ottawa, Ontario.

Conference Co-Chair: *Ecological Integrity and the Management of Ecosystems*. 2-4 April 1991, University of Waterloo, Waterloo, Ontario.

Co-Chair with Schneider, E. D., "A Thermodynamic Perspective of Evolution" a session at the *Fourth International Congress of Systematic and Evolutionary Biology*, Washington, D.C., 7 July, 1990.

Chairman of the Working Session on "The Administrative Requirements for Data-Base Co-ordination and Co-operation" at the *Conference and Workshop on Data Bases and Heritage Areas*. February 12-13, 1987, University of Waterloo.

Workshop Convenor at the Scientific Committee for Oceanic Research (UNESCO) Working Group 73 Symposium: *Ecosystem Flow Analysis*, Santa Cruz, California, December 1986.

Invited participation in workshops:

IDRC/UNEP Working Group on *Ecosystem Disruption and Human Health*, Sixth at Canadian Conference on International Health, Palais des Congrès, Hull, Québec, 17 November, 1999.

NATO Science Advanced Research Workshop Implementing Ecological Integrity: Restoring Regional and Global Environmental and Human Health, József Fodor National Public Health Centre, Budapest, June 28-1 July, 1999.

Emerging Environmental Issues in Ontario Workshop, Institute for Environmental Studies, (Ontario Ministry of the Environment) University of Toronto, May 14, 1999.

Rinker Eminent Scholar Workshop on Construction Ecology and Metabolism: The Material Cycles; University of Florida, Gainesville, 6-8 May, 1999.

World Bank Workshop on Natural Capital: Values in Two Perspectives, Institute for Environmental Studies, University of Toronto, 23 April, 1999.

Workshop on Air Issues and Urban Environments, (Environment Canada), Institute for Environmental Studies, University of Toronto, 22 March, 1999.

Scoping meeting on future of Canada/IIASA relations, Carleton University, Ottawa, 18 November, 1998.

Advances in Energy Studies: Energy flows in Ecology and Economy, Porto Venere, Italy, 26-30 May, 1998.

Energetic and Thermodynamic Foundations of Ecological Systems, Santa Fe Institute, Santa Fe, New Mexico, 11-13 May, 1998

First International workshop of the CIAT-Guelph Project "Development and Applications of an Integrated Conceptual Framework for Tropical Agroecosystems Based on Complex Systems Thinking", Centro Internacional de Agricultura Tropical, Cali, Colombia, 26-28 May, 1997.

panelist at the *Second Roundtable Discussion on Ecosystem Health*, University of Guelph, Guelph, Ontario, 6 May, 1997

Workshop on Ecosystem Integrity. IUCN Biodiversity Meeting. Montreal, 18, 19 October 1996.

Second Workshop of the SCOPE Project on Integrated, Adaptive Ecological Economic Modelling and Assessment, SCOPE ICSU, Boston University, Boston, 31 July-4 August, 1996.

The Spontaneous Order of Life; In Search of Self-Organization in Physical Biological and Cognitive Systems. The First Copenhagen International Interdisciplinary School in the Biological Sciences, The Niels Bohr Institute, Copenhagen, 26-41 August, 1996.

Agroecosystem Health project, workshop: *Sharing Accomplishments and Knowledge*, University of Guelph, 28 November, 1995,

Workshop on Measuring Sustainable Development, Env. Cdn., Niagara-on-the-Lake, 15-17 Nov. 1995

Workshop on the Ecosystem Approach and its Applications to Agriculture and Governance, University of Guelph, 21-22 February, 1995

Workshop on the Modeling of Large Lakes: Lake Ontario and Lake Erie Food Web Examples II, Canada Centre for Inland Waters, Burlington, Ontario, 30,31 January 1995.

Island Institute, *Workshop on a model of Grand Banks Fisheries*, Portland Me., 21, 22 January, 1995. (one of four invited outside experts)

Agroecosystem Health Research Project, *Midterm Workshop*, University of Guelph, October 13, 14, 1994

Ecosystem Integrity and Public Policy Focus Group at the *Second International Conference on the Environmental Management of Enclosed Coastal Seas*, Baltimore, 11 November, 1993

Conference on the Complex Ecological Economic Systems Dynamics II, The Beijer International Institute of Ecological Economics, Stockholm, 9-11 September, 1993

Postgraduate course on Ecosystem Theory, Guest Instructor, sponsored by the European Economic Community and the Danish Government, at The Royal Danish School of Pharmacy, Copenhagen, Denmark, 16-20 August, 1993.

Workshop on Ecosystem Theory, sponsored by the European Economic Community and the Danish Government, Isle of Møn, Denmark, 21-27 August, 1993.

Ecosystem Integrity Focus Group University of Guelph 28, 29 June 1993, Guelph, Ont.

The Four Box Workshop, sponsored by The Beijer International Institute of Ecological Economics, at the A.R. Marshall Laboratory, University of Florida, Gainesville, 14-17 April, 1993.

Ecosystem Integrity Focus Group (Annual Conference of the Society of Entomologists) 9 December, 1992, Baltimore, Md..

The International Joint Commission; Great Lakes Science Advisory Board *Workshop on Ecosystem Health*, Ann Arbor, Mich., 14-15 Sept., 1992.

Conference on the Complex Ecological Economic Systems Dynamics, The Beijer International Institute of Ecological Economics, Stockholm, 27-29 July, 1992

Workshop on Energy, Entropy, Ecology and Evolution, (Annual Meeting of the Canadian Federation of Biological Societies) Victoria, B.C., 18-20 June, 1992.

CUSIS IV: Management and Uses of the Great Lakes Ecosystem Approach, at Wingspread, Racine, WI, 7-9 June, 1992.

City of Kitchener Planning Dept.: *Developing a Vision for the city of Kitchener in 2016*, 29 June 1992, Kitchener, Ontario.

Ecosystem Integrity Focus Group (35th Conference on Great Lakes Research, IAGLR) 2 June, 1992, University of Waterloo, Waterloo, Ontario.

Thermodynamics and Scale in Evolving Biological Systems, the 4th International Ames Group Meeting, 14-16 May 1992, Brigham Young University, Provo, Utah

Lake Ontario Trophic Transfer working group Symposium, Canadian Center for Inland Waters, 23 January 1992, Burlington, Ontario.

IUCN Commission on Environmental Strategy and Planning: *Workshop Tools of Sustainability*, 7,8 October, 1991, Waterloo, Ontario.

A workshop on Ecosystem Health and a proposed Environmental Problem Clinic, University of Guelph, 15 July, 1991, Guelph, Ontario.

The International Joint Commission: *Roundtable on Ecosystem Framework Development*, 29-31 July, 1991, Racine, Wisconsin.

U.S. Department of Energy: *Theoretical Ecology: Progress and Prospects*, 29 April-1 May, 1991, Gaithersburg, Md.

Council of Great Lakes Research Managers *Ecosystem Model Workshop*, 4-6 December, 1990, Milwaukee, Wisconsin.

Canadian Environmental Advisory Council *Workshop on Institutional Options to Apply Ecosystemic Research in Policy*, 22 August, 1990, Ottawa, Canada.

Canadian Environmental Advisory Council *Workshop on Indicators for Ecologically Sustainable Development Economics*, 25-26 July 1990, Ottawa, Canada.

The International Joint Commission & Great Lakes Fishery Commission *Workshop on Ecosystem Integrity in the Context of Surprise*, June 14-16 1988 Burlington, Ontario.

The Scientific Committee for Oceanic Research (UNESCO) Working Group 73 Symposium: *Ecosystem Theory in Relation to Biological Oceanography*, Quebec, March 1984.