D'Andrea, A. F., M. L. N. Silva, N. Curi, and M. M. Ferreira. 2002. Atributos de agregacao indicadores da qualidade do solo em sistemas de manejo na regiao dos cerrados no sul do Estado de Goias. *Revista Brasileira De Ciencia Do Solo* 26, no. 4: 1047-1054.

Portuguese with an English abstract which explains the overall purpose of this article. --Regional scale analysis is attempted; 6 management systems, 5 soil properties, on latosols (oxisols) in Brazil; 1995/6 & 1998/9 sampling from 0-10cm, 10-20cm, & 20-40cm depths.

Dalal, R. C., P. Lawrence, J. Walker, R. J. Shaw, G. Lawrence, D. Yule, J. A. Doughton, A. Bourne, L. Duivenvoorden, S. Chow, D. Moloney, L. Turner, C. King, and A. Dale. 1999. A Framework to monitor sustainability in the grains industry. *Australian Journal of Experimental Agriculture [CSIRO]* 39: 605-620.

Good 'index' information, ranking, etcetera.(jw) A clear delineation of: frameworks, indicators, sustainability, attributes, benchmarking, and monitoring; adequate review & perspective of current literature. This paper includes an awareness of land management, The Montreal Process, and complexities of decision support systems in farming. Sustainability indicators, including for soil resources, are rationalized for selection within an overall parametric framework; with soil pH, electrical conductivity, surface soil organic matter, nutrient availability, microbial biomass, surface cover extent, rooting depth, and surface crust as factors. Ranking & weighting are outlined. Multiple objectives can be accommodated by the decision support system advocated, according to these authors.

Davidson, Donald A. 2000. Soil quality assessment: Recent advances and controversies. *Progress in Environmental Science [Arnold]* 2, no. 4: 342-350.

This discussion paper is an excellent perspective on soil quality assessment in the long-term context of land management and policy frameworks for land use; reviewing and summarizing soil quality research up to 2000. --Takes the soil function approach for the concept of SQ, as defined by Larson & Pierce 1996, and expanded by Karlen et al. (1997:7); --Advocates the position that since soil properties vary by soil function, selection depends upon particular land use requirements and therefore quantitative definition of soil quality is not possible "without reference to a specific objective" (p.344); --gives the Doran & Parkin (1996) minimum-data-set approach for soil quality indicators; --emphasizes need for SQ research to use comparable measures and techniques regarding these indicators in order to identify trends and change; --reports Mausbach & Tugel (1997) i.d. of a reference or "standard" conditions for sets of benchmark soils and acceptable ranges or scoring of functions to provide numerical measure.
<u>Literature reviewed by the author</u>:
--Karlen et al. 1994: --Crop residue management treatments on indicators on an experimental farm near Lancaster, Wisconsin, USA re removing, maintaining, or doubling crop residues for 109 years of no-till, continuous corn production; --developed scoring on indicators for an SQ Index on 0.0 to 1.0 scale; --useful sustainability assessment.
--Karlen et al. 1999: impacts on CRP land in Iowa, Minnesota, North Dakota, and Washington (state).
--Hussain et al. 1999: --computed SQ Indices to assess long-term tillage, dependent on selection of threshold values.
--Mentionns urban (Huinink 1998) and forestry (Burger & Kelting 1999) management studies also.
--Smith et al. 1993: --statistical study re MVIK to integrate a range of soil properties into an SQ Index and to predict probabilities of different land areas to meet a soil quality standard, using threshold values and coded 0 or 1 if below or above, then integrating by indicator variograms and kriging for unsampled locations.
--Oyedele et al. 1996: --Case study for maize; used pH, organic C, CEC, soil depth to plinthite, and exchangeable Al; --used kriging of integrated SQ Index values scored as 0 or 1 from threshold values to predict areas for planting, of great use to farmers/land managers; --result expressed as a map of areas.
--Liebig & Doran 1999: --Eastern Nebraska case study of farmers' perceptions of SQ.
--U.S. National and state initiatives also included, such as Ohio and Iowa with soil health cards, web site initiatives; and web-based tools such as New Zealand's SINDI (soil indicators) for soil assessment.
--Sojka and Upchurch 1999: --critical analyses of SQ concept, and rejection of a SQ Index as an impossibility.
--Harris et al. 1996//Doran & Safley 1997: --Discussion of the "soil health" concept as interchangeable with SQ. Relating to easily observable attributes, or risks, or a dynamic organism soil model, as less rigorous or consistent, Davidson sees soil quality as a valid, more viable concept, less confusing than "soil health". Score card approach allows for farmer observations to be included, but results will inevitably be "inconsistent"; so soil scientists' expert analyses, and standardized sampling must be practised and obtained, in order to identify key attributes/soil properties, to compare, and achieve results for quality land use/management decisions to be possible. All references cited in Davidson's bibliography are useful to any soil quality index literature review.

———. 2002. The Assessment of land resources : Achievements and new challenges. *Australian Georgraphical Studies -- International Review Section* 40, no. 2 (Jul): 109-128.

This paper updates Davidson 2000; is an historical overview that puts recent (1990-2001) soil quality assessments and research into the longer perspective and arena of land resource management [See Abstract[. --Section on "Parametric indices of land quality" (p.118) summarizes the literature by: --Fenton et al. 1971, as an "additive" model or index that rated land components for suitability to grow corn in Iowa soil mapping units; --Fenton et al 12975, which assigned ratings to each soil mapping unit; --the Storie Rating Index (1976) in California, of individual land properties on a scale of 1 to 100 derived into a "multiplicative index"; based on soil profile, texture of surface soil, modifying factors of slope, drainage, alkalinity; modified by Leamy (1974)(in New Zealand, and Lal (1989) in India. --There are comments on various GIS studies worldwide regarding land use assessment. The author accepts the (1996) Larson & Pierce need to consider soil functions in soil quality assessment; and Davidson presents Doran & Parkin's (1996) table of soil properties for minimum data sets, but tempered with the need to consider impossibility of a quantification of soil quality without "reference to a specific objective" (p.124). He also presents the Soil Quality Institute's standards for benchmark soils in the United States, but doubts scoring or defining acceptable ranges, optimal, or target values will be easily possible, due to the inherent variability of soil functions; and also presents New Zealand's Landcare Research web-based SINDI (Soil INDex) assessment tool for consideration. (ch) See p.118 for index method. (jw)

de-Haes, H. U., M. Nip, and F. Klijn. 1991. Towards sustainability: Indicators of environmental quality. In: *In search of indicators of sustainable development.* O. Kuik, and A. Verbruggen, editors. Boston, MA: Kluwer Academic Publishers, Pp.89-105.

A comprehensive method to assess environmental quality is proposed. The method chosen closely resembles the AMOEBA approach developed by J.J.E. ten Brink and S.H. Hosper in 1989. The method is independent of spatial scale considerations and takes into account different land uses. The parameters selected to quantify environmental quality had to meet 4 criteria: relevance, sensitivity, detectability, and appeal. A graphical representation of this quantitative method is presented within a case study of a Dutch ecodistrict.--(review by JW)

Diack, M. and Stott D. E. 2001. Development of a soil quality index for the Chalmers silty clay loam from the midwest USA. In: *Sustaining the global farm—Selected papers from the 10th International Soil conservation Organization Meeting (ISCO99)*D. E. Stott, R. H. Mohtar, and G. C. Steinhardt, 550-555. West Lafayette, IN: International Soil Conservation Organization in cooperation with the USDA and Purdue University.

.Summary Review: Long-term 16-yr field experiment in Indiana Chalmers silty clay loam; 3 tillage systems selected: conventional moldboard plowing, intermediate fall chisel plowing, and no-till system; cropping of: continuous corn, continuous soybean, 2-yr rotation between corn and soybean, and corn-soybean-wheat 3-yr rotation. Soil properties changed; data produced ranges for SQ indicators; model developed to 'score' and thus quantify soil responses to management practices.
Reviewer Comments: --S.Q. Index/model development using formulae & systems design. -- Spring sampling of a static data set (1995 samples) -- replicable -- on Indiana silty clay loam, 16-2-ha field.--Field level; 3 different tillage practices: conventional moldboard plowing of top 15-18cm soil/minimal residue/cover; intermediate chisel plowing with 30% cover, and zero tillage with 90-95% cover. 4 Crop rotation systems were used: corn, soybean, 2-yr corn/soybean, & e-yr corn/soybean/wheat, with sampling done after the corn in the 2-yr & wheat in the 3-yr rotation systems. --Infiltration rate, resistance to penetration, bulk density, aggregate stability, total C, total N, dissolved organic C and particulate organic C and microbial biomass C, flurescein diacetate (indicator for xxx). --Randomized blocks used for field sampling points on 4 cropping systems & 3 tillage types; i.e. 12 crop treatments. --S.Q. model used criteria ranking for high quality & weighting of each soil parameter by ranked criteria; based ranking on ability of soil to resist physical and biochemical degradation, to partition water, regulate absorption/infiltration, & function to sustain plant growth. --Data reduced to a value between 0 & 1; scoring for final infiltration rate, total C, dissolved organic C, microbial biomass C & enzyme activity from "more is better" a perspective; and bulk density, penetration resistance, & sealing index as "less is better" functions; Mean values were then compared per land use practice.

Dick, R. P. 1994. Soil enzyme activities as indicators of soil quality. In: *Defining soil quality for a sustainable environment*; Proceedings of a symposium, Minneapolis, MN, USA, 4-5 November 1992; Pp.107-124. J. W. Doran, D. C. Leman, D. F. Bezdicek, and B. A. Stewart, editors. SSSA.

The importance of soil enzyme activities as a potential biochemical/biological indicator of soil quality is discussed. It is concluded that the measurement of selected soil enzymes has a good potential as soil quality

indicator but also that soil sample pretreatment, assay procedures and units of measurement must be standardized in order to give the most accurate results. However systematic studies across ecosystems and long term soil management sites are also needed to identify the best soil quality enzyme assays and to provide data for calibration and interpretation of these assays as independent **soil quality indexes**. --*Author's abstract; also in CAB Abstracts.*

Dinel, H., and T. Pare. 1998. Agro-environmental indicators of soil quality in Canada // Original Title: Indicateurs agro-environnementaux de la qualité des sols au Canada. *Cahiers Agricultures* 7, no. 3: 195-200.

Indicators of agro-ecological functions were selected and measured with a wide variety of soil textures and cropping practices in Canada. Structural properties and organic matter characteristics were integrated using principal component analysis (PCA) to develop a soil quality index. The quality of organic matter, as assessed by gravimetric ratios between diethyl ether (DEE)/chloroform (CHCl3) extractable lipids or CHCl3/TEL (total extractable lipids), showed that physico-chemical stabilization and biochemical decomposition of soil lipids were affected by soil texture and cropping practices. The best organic matter quality and structural properties were found in forest soils and the poorest in conventional tilled soils, whereas soils under conservation tillage gave intermediate results. Integration of these indicators into a soil quality index effectively reflected anthropogenic disturbances on agricultural land. The index was sensitive to spatial and temporal variation at the field level. --*Authors' abstract.*

Doran, John W., D. C. Coleman, D. F. Bezdicek, and B. A. Stewart, editors. 1994. *Defining soil quality for a sustainable environment*. Madison, WI: Soil Science Society of America. SSSA Special Publication no.35; xxiii, 244pp.

"The papers in these proceedings contribute new perspectives on the definition of soil quality and how it may be measured and quantified." --*R.R. Janke, Rodale Institute Research Center; and R.I. Papendick, USDA-ARS; pp.ix-xi.*

Doran, John W., and Alice J. Jones. 1996. *Methods for assessing soil quality*. Madison, WI: Soil Science Society of America. Special Publication no.49; xxvi, 410 pp.

"Topics covered in the 27 chapters of this publication discuss relations between soil quality and health of plants, animals and humans, farmer-based approaches to assessing soil quality, case studies discerning land use and management impacts on soil quality, development of soil quality indices for sustainability, and techniques for understanding soil quality and its role in the biosphere." --*CAB Abstracts.*

Doran, John W., and T. B. Parkin. 1994. Defining and assessing soil quality. Chapter 1. In*: Defining soil quality for a sustainable environment*; Proceedings of a symposium, Minneapolis, MN, USA, 4-5 November 1992. Doran, John W., Coleman, D. C., Bezdicek, D. F., Stewart, B. A., editors. Soil Science Society of America - Special Publication no.35; Pp.3-22.

Doran and Parkin (1994) set criteria by which basic soil quality indicators should be selected: 1) encompass ecosystem processes and relate to process oriented modeling; 2) integrate soil physical, chemical, and biological properties and processes; 3) be accessible to many users and applicable to field conditions; 4) be sensitive to variations in management and climate; 5) where possible, be components of existing soil data bases. They then proposed seven soil physical characteristics, three chemical characteristics, and five biological characteristics to be included as basic indicators of soil quality. -- *[from Freyenberger et al. Annotated bibliography; SQI Lit.*

The 6 specific soil quality elements included in the index are: food and fibre production; erosivity; groundwater quality; surface water quality; air quality and food quality. Each soil quality element is evaluated with regard to 5 specific soil functions which indicate the capacity of soil to provide a medium for plant growth and biological activity, regulate and partition water flow through the environment and serve as an environmental filter. These specific soil functions are discussed in detail and theoretical examples are given. --*Authors' abstract excerpt, p.3.*

———. 1996. "Quantitative indicators of soil quality: a minimum data set." In: *Methods for assessing soil quality*. J. W. Doran, and A. J. Jones, editors. Madison , WI: Soil Science Society of America.

Classic article; often quoted for the basic defining attributes of 'soil quality'. (ch)

The quantitative assessment of soil quality is of great importance in determining the sustainability of land management systems. Indicators considered necessary for the assessment of soil quality must correlate well with ecosystem processes, integrate soil physical, chemical and biological properties and processes, should be easy to use under field conditions, be sensitive to variations in climate and management, and, if possible, must be components of existing soil databases. --*Authors' Introduction.*

Doran, John W., and M. Safley. 1997. Defining and assessing soil health and sustainable productivity. In: *Biological indicators of soil health; Soil resilience and sustainable land use*: Proceedings of a Symposium held in Budapest, 28 September to 2 October 1992, including the Second Workshop on the Ecological Foundations of Sustainable Agriculture (WEFSA-II). Pp.1-28. C. Pankhurst, B. M. Doube, and V. V. S. R. Gupta, editors. Wallingford; New York: CAB International.

Doran, John W., M. Sarrantonio, and M. A. Liebig . 1996. Soil health and sustainability. *Advances in Agronomy* [San Diego, Calif.: Academic Press] 56: 1-54.

Doran, John W., and Stamatis I. Stamatiadis, editors. 2002. *Agriculture, Ecosystems & Environment*—Special Issue [entitled]: *Soil Health as an Indicator of Sustainable Management;* Summary Findings of an International Workshop, GAIA Environmental Research and Education Center, Kifissia, Greece, 24-25 June 1999 88, no. 2: 107-193. -- *Preface;* Pp.107-110.

> In the preface to a conference re soil health, the authors identified the "need to standardize key soil attributes in a multifunctional and multidimensional sustainability index" with associated arising complications (p.109).

Dumanski, Julian, Samuel Gameda, and Christian Pieri. 1998. *Indicators of land quality and sustainable land management: an Annotated bibliography*. Washington, DC: The World Bank.

> Excellent example of an annotated bibliography; --land use and quality indicators for sustainability; --includes references to titles dealing with soil quality and assessment; --useful model for project to characterize the SQI literature.

Dunjo, G., G. Pardini, and M. Gispert. 2003. Land use change effects on abandoned terraced soils in a Mediterranean catchment, NE Spain. *Catena* 52, no. 1: 23-37.

> A catchment in NE Spain, in semiarid environment, has been progressively abandoned by farmers during the last century. ... Along two altitudinal gradients, we selected 11 random environments representative of the current land uses, in sequence from cultivated to early abandonment. ... Erosion plots were installed in selected environments for soil physico-chemical characterisation, throughout 1-year observation, monitoring nutrient losses, runoff volume and sediment yield data. Analysis of variance (ANOVA) indicates significant differences in the main soil quality parameters such as soil organic matter (SOM), total nitrogen (N), water holding capacity (WHC) and pH, among the selected environments under different land use conditions. Factor analysis of the principal components (PCA) enabled the identification of three soil quality indices: index of soil erosion and nutrient losses (SENL), **index of soil quality and fertility (SQF)** and index of vegetation cover and soil protection (VCP). *--Authors' abstract excerpt*.

DUX, and Umweltbundesamt für mensch und umwelt. 2002. German Environment Index (DUX) // Deutscher Umweltindex (DUX). From URL: http://www.umweltbundesamt.de/dux-e/

> For the first time, the Federal Environmental Agency (UBA) has calculated a characteristic value which reflects developing trends in German environmental protection in a single figure—the German Environment Index, or DUX (*Deutscher Umwelt Index*) for short. The DUX is comprised of various values stemming from the Environment Barometer for Germany on climate, air, soil, water, energy and raw materials. Each environmental field may score a maximum of 1,000 points. If the set environmental political goals were achieved in all fields, the DUX would amount to **6,000 points**.
>
> **How is the DUX calculated?**

The values of the six indicators of the Environment Barometer are fed into the DUX (from the fields of climate, air, soil, water, resources: energy/raw materials). In order to make these very different values comparable, it is not the absolute indicator values that are used, but rather a calculation of each individual indicator's relative achievement of target. This means a calculation of the indicator's stage of development relative to its actual point in the base year (values of the base year) and its theoretical target point (target values in target year). Complete achievement of targets is valued at a maximum of 1,000 points, the base year value at 0. Should development worsen as compared to the base year, the outcome is a negative value. " The Environment Barometer and its six indicators can not include all fields of environmental policy." *--From URL:* http://www.umweltbundesamt.de/dux-e/ ; *Accessed Nov.18, 2003.*