Haberern, J. 1992. Viewpoint: A Soil health index. Journal of Soil and Water Conservation 47: 6.

Editorial/opinion paper, announcing the intent of the Rodale Institute to develop a "Soil Health Index".

Halvorson, Jonathan J., Jeffrey L. Smith, and R. I. Papendick. 1995. Integration of multiple soil parameters to evaluate soil quality : a field example. Biology and Fertility of Soils 21: 207-14.

Development of a method to assess and monitor soil quality is critical to soil resource management and policy formation. To be useful, a method for assessing soil quality must be able to integrate many different kinds of data, allow evaluation of soil quality based on alternative uses or definitions and estimate soil quality for unsampled locations. In the present study we used one such method, based on non-parametric geostatistics. We evaluated soil quality from the integration of six soil variables measured at 220 locations in an agricultural field in ||southeastern Washington State. We converted the continuous data values for each soil variable at each location to a binary variable indicator transform based on thresholds. We then combined indicator transformed data for individual soil variables into a single integrative indicator of soil quality termed a multiple variable indicator transform (MVIT). We observed that soil chemical variables, pools of soil resources, populations of microorganisms, and soil enzymes covaried spatially across the landscape. These ensembles of soil variables were not randomly distributed, but rather were systematically patterned. Soil equality maps calculated by kriging showed that the joint probabilities of meeting specific MVIT selection were influenced by the critical threshold values used to transform each individual soil quality variable and the MVIT selection criteria. If MVIT criteria adequately reflect soil quality then the kriging can produce maps of the probability of a soil being of good or poor quality. *--Authors' abstract, p.207*

———. 1997. Issues of scale for evaluating soil quality. *Journal of Soil and Water Conservation* 52, no. 1 (Jan-Feb): 26-30.

Issues of scale relating to the concept of soil quality are discussed, including the interrelationships between soil quality data and subsequent interpretations that are affected by spatial and temporal soil variability. Soil quality data needs to be collected from sampling units that are of a size, shape, and orientation and at times that result in an efficient trade off between the gain of useful information and the cost of sampling. The data must also be collected so that the resultant **soil quality index** is useful and valid at the temporal and spatial scales of real world applications.

Harms, Deborah S. and Seybold, C. A. 2001. Use of Microsoft Access to compute near surface Morphology Index for soil quality evaluation. In: I*nternational Soil Conservation Organization Abstracts 1999*; Abstract A-0387, p.42.

A soil quality index based mainly on soil structure and rupture resistance is presented in a separate paper by Grossman et al. Computerization would facilitate applicaiton of the index for soil quality evaluation. The calculations are not complex, but they are numerous. By creating a series of relational databases the index can be quickly obtained. The data and the calculations can be stored and calculated in Microsoft Access.

Harris, R. F., and D. F. Bezdicek. 1994. Descriptive aspects of soil quality/health. Chapter 2. In: Defining soil quality for a sustainable environment; Pp.23-26. J. W. Doran, D. C. Coleman, D. F Bezdicek, and B. A. Stewart, editors. Soil Science Society of America.

Harris, R. F., D. L. Karlen, and D. J. Mulla. 1996. A Conceptual framework for assessment and management of soil quality and soil health. In: Methods for assessing soil quality; Pp.61-82. John W. Doran, and Alice J. Jones, editors. Madison, WI: Soil Science Society of America.

Hatcher, J. F. 2002. Soil health index in remediation of contaminated sites; Approach and application. Annali Dell'Istituto Superiore Di Sanita 38, no. 2: 111-113.

The **soil health index** is an approach for assessing the ecological potential of a soil. The index is based on a physical, chemical, and biological characterization and rating of soil conditions. The approach is flexible, permits comparisons amongst soils with widely different properties and contaminant levels, and it can be adapted to site specific conditions. The rationale and development of the index are documented in this report along with sample handling, assessment methods, and quality assurance practices. Standardized reporting formats have also been developed for compiling and presenting the findings. An interpretive guide is included for the reporting formats and how to apply the results to site specific conditions. --Author's Abstract

[HydroQual Laboratories Ltd., 3, 6125 12 street SE, Calgary, Alberta, T2H 2K1, Canada]

Haynes, R. J. 2000. Labile organic matter as an indicator of organic matter quality in arable and pastoral soils in New Zealand. Soil Biology and Biochemistry [Oxford : Elsevier Science Ltd.] 32, no. 2 (Feb): 211-219.

The effects on soil condition of increasing periods under intensive cultivation for vegetable production on a Typic Haplohumult were compared with those of pastoral management using soil biological, physical and chemical indices of soil quality. The majority of the soils studied had reasonably high pH, exchangeable cation and extractable P levels reflecting the high fertilizer rates applied to dairy pasture and more particularly vegetable producing soils. Soil organic C (C(org)) content under long term pasture (>60 years) was in the range of 55 g C kg 1 to 65 g C kg 1. With increasing periods under vegetable production Soil organic matter (SOM) declined until a new equilibrium level was attained at about 15 20 g C kg 1 after 60 80 years. The loss of Soil organic matter (SOM) resulted in a linear decline in microbial biomass C (C(mic)) and basal respiratory rate. *--Author's Abstract.*

Haynes, R. J., and R. Tregurtha. 1999. Effects of increasing periods under intensive arable vegetable production on biological, chemical and physical indices of soil quality. Biology and Fertility of Soils [Berlin, Germany: Springer Verlag] 28, no.3 (Jan): 259-266.

He, Z. L., X. E. Yang, V. C. Baligar, and D. V. Calvert. 2003. Microbiological and biochemical indexing systems for assessing quality of acid soils. Advances in Agronomy 78: 89-138. Donald L. Sparks, editor. New York, NY: Academic Press.

Complete review of SQI literature, & application parameters for acidic soils in international perspective; sometimes interchanges 'index' with 'indicator'--as in pH--but, provides overall formula for inclusion of numerous variables and indicators to calculate a relative SQI and to normalize data; discusses recent history of SQ Index development, uses ARC/INFO & FOXBASE software for SQI information systems analysis; considers benchmark, critical/threshold values, limitations, and suggests ways of using soil attributes to reflect change in soil quality, processes, and to consider soil functions. Includes 9 pages of references.

Hellkamp, A. S., S. R. Shafer, C. L. Campbell, J. M. Bay, D. A. Fiscus, G. R. Hess, B. F. McQuaid, M. J. Munster, G. L. Olson, S. L. Peck, K. N. Easterling, K. Sidik, and M. B. Tooley. 1998. Assessment of the condition of agricultural lands in five mid-Atlantic states. Environmental Monitoring and Assessment [Dordrecht: Kluwer Academic Publishers] -- Special Issue: Monitoring Ecological Condition at Regional Scales 51, no.1/2 (Jun): 317-324.

"Condition assessment" of agricultural lands in 5 states; Regional in scale; from 122 field sites selected using recommended USDA-NASS probability sampling; but, has study design flaws (ch). --Used 1994 crop yield as a productivity index, compared as a ratio to 1980-1989 actual yield data. --8 soil properties measured: % clay, CEC, total C, base saturation, pH, Na absorption ratio, total N, total C, & microbial biomass (as measured by respiration & C). -- Also determined crop rotation plans & pesticide use as management practices; samples from long-term continuous cropping on all lands. -- S.Q. index was a sum of all soil properties, each ranked low (1), moderate (2), or high (3) quality to derive a mean value; No relative ranking or weighting of soil factors was used; Found "moderate" S.Q. overall. --Microbial biomass not correlated to pesticide use in this study. --Single-season time frame; static; no adjustments re topography or soil type.

Herrick, J. E., J. R. Brown, A. J. Tugel, P. L. Saver, and K. M. Havstad. 2002. Application of soil quality to monitoring and management: Paradigms from rangeland ecology. Agronomy Journal 94, no. 1 (Jan/Feb): 3-11.

Recent interest in soil quality and rangeland health, and the large areas set aside under the USDA Conservation Reserve Program, have contributed to a gradual convergence of assessment, monitoring, and management approaches in croplands and rangelands. The objective of this paper is to describe a basis for integrating soils and soil quality into rangeland monitoring, and through monitoring, into management. Previous attempts to integrate soil indicators into rangeland monitoring programs have often failed due to a lack of understanding of how to apply those indicators to ecosystem function and management. We discuss four guidelines that we have used to select and interpret soil and soil quality indicators in rangelands and illustrate them using a recently developed rangeland monitoring system. The guidelines include (i) identifying a suite of indicators that are consistently correlated with the functional status of one or more critical ecosystem processes, including those related to soil stability, soil water infiltration, and teh capacity of the ecosystem to recover following disturbance; (ii) basing indicator selection on inherent soil and site characteristics and on site- or project-specific resource concerns, such as erosion or species invasion; (iii) using spatial variability in developing and interpreting indicators to make them more representative of ecological processes; and (iv) interpreting indicators in the context of an understanding of dynamic, nonlinear ecological processes defined by thresholds. The approach defined by these guidelines may serve as a paradigm for applying the soil quality concept in other ecosystems, including forests and ecosystems managed for annual and perennial crop production. --*Authors' abstract, p.3.*

Herrick, J. E., and M. M. Wander. 1998. Relationships between soil organic carbon and soil quality in cropped and rangeland soils: the importance of distribution, composition and soil biological activity. Chapter In: *Advances in Soil Science: Soil processes and the Carbon cycle;* Pp.405-425. R. Lal, J. Kimble, R. Follett, and B. A. Stewart, editors. Boca Raton, FL: CRC Press.

Herrick, J. E., W. W. Whitford, A. G. de Soyza, and J. Van-Zee. 1995. Soil and vegetation indicators for assessment of rangeland ecological condition. In: *North American Workshop on monitoring for ecological assessment of terrestrial and aquatic ecosystems // Taller Norteamericano sobre monitoreao para; la evaluacion ecologica de ecosistemas terrestres y acuaticos.* C. A. Bravo, editor. Pp.157-166. Fort Collins, CO: USDA Forest Service.

Indices of ecological condition for desert rangelands are examined; methods for selection of quantitative indicators are demonstrated in this case study.

Hopmans, Jan W., Dennis E. Rolston, and Mike J. Singer. 2003. "Soil quality assessment in irrigated agriculture: Influence of soil and water management on physical properties." [Research project] Hydrologic Science Graduate Group, University of California-Davis. -From URL: http:// lawr.ucdavis.edu/hsgg/Hopmans.htm

We propose to use the existing LTRAS (Long-Term Research on Agricultural Systems) Project to define one or more soil quality indices which relate the soil physical characteristics to soil water and air quality. ... it is proposed to return to the LTRAS plots in the last year of the Kearney mission and to repeat the soil physical measurements to infer temporal changes as caused by the different treatments. The objectives are (1) to assess the potential of soil physical characterization to define soil quality indices for the monitoring of the soil's environmental quality, (2) to study their differences and temporal changes as caused by soil and water management. Successful completion will provide farmers, scientists, extension specialists and policy makers with criteria and guidelines in the evaluation of soil and water management practices to protect soil, air and water resources from irreversible degradation. --- *MSN online abstract.*

Huddleston, J. H. 1984. Development and use of soil productivity ratings in the United States. Geoderma 32: 297-317.

This paper introduces the Storie Index, a multiplicative index that considers crop yield data in order to develop ratings for soil productivity. It is important in historical perspective for soil scientists developing an SQ Index.

Hussain, Imtiaz, Kenneth R. Olson, Michelle W. Wanter, and Douglas L. Karlen. 1998. Adaptation of soil quality indices and application to three tillage systems in southern Ilinois. *Soil & Tillage Research* 50, no.3/4 (May): 237-249. [Amsterdam, The Netherlands : Elsevier Science B.V.] // TEKTRAN [Electronic/Web Page] at URL: http://www.nal.usda.gov/ttic/tektran/data/000009/21/0000092194.html

This is a good review of soil quality indexing. In Southern Illinois, on experimental plots, soil was sampled in 1995 & 1996 after spring planting, to 15cm depth. Lab analyses on porosity, bulk density, aggregate stability, surface cover, crop yield are included. The researchers used SAS software to run analysis of variance and least squares means for selected variables; --for 3 tillage systems, and to test sensitivity of SQ Indexing and weighting factors re scoring of variable values. The authors present a good review of the soil quality literature, with excellent use of current SQI knowledge. Attributes studied were: Organic C, Bray P, exchangeable K, soil pH, water storage porosity, air porosity, crop residue, aggregate stability weighted (with a clear presentation of weighting factors; and replicable from field data), on 3 indices to assess 8-year tillage effects on silt-loam. Results are presented in table form (pp.241-242). No-till, chisel plow, moldboard plow management practices are compared.