Soil Quality Assessment in Rangelands Using a Minimum Data Set

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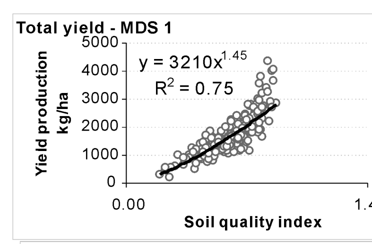
Introduction Soil quality is assessed in terms of the ability of soil to perform those soil functions that are necessary to meet the goals of the particular land use (Karlen et al., 2001). For rangelands, these goals include plant growth and community composition to support grazing animals. Our main objectives for this research were: 1) Demonstrating a technique for scoring predictive indicators of soil quality proposed by Rezaei (2003) for two data sets (Table1); and 2) Designing predictive models for the relationships between soil properties and plant growth characteristics. With regard to key indicators, total nitrogen, exchangeable potassium, and nutrient cycling index imply nutrient availability for plant growth; topsoil and effective soil depth denote both water availability and nutrient resources; water retention capacity indicates available water, grade of structure, and the slake test (aggregate stability) shows soil resistance to erosion.

Methodology Samples were taken from a total of 234 transects within stratified land units in Alborz Mountain, Iran. For soil chemical analyses samples were collected from (0-10cm) and for soil physical characteristics a pit was dug to 150 cm (or less if bedrock was encountered) at the mid point of each transect. We used the current year production of above ground biomass as an indicator of the productivity of the soil-landscape system.

An integrated soil quality assessment procedure was derived from methods developed by Mausbach & Seybold (1998), and Andrews *et al*.,(2002). The method for scoring the components of the data sets and construction of the Soil Quality Index (SQI) for native rangelands aimed to detect the criterions that maximize production and environmental performance. Observed indicator values were transformed to unitless 0 to 1 values, with 1 given for the maximum potential and the optimum performance of the associated soil function(s) for a particular indicator. Principal Components Analysis (PCA) was performed for each data set. The PCA decomposition properties, indicator loading factors and the % of variability explained by each eigenvector (λ), were combined and used as weighting factors for the scored indicators.

Results and discussion The first three principal components (PCs), were retained as having latent roots > 10% for Data Set 1. In order to approximate the proportion of each variable, x_i, the individual percent variance explained by each PC was first divided by the cumulative variance for the first three retained PCs to provide weighing factors for each PC ($\mathbf{f}_i$) for the components of the data sets 1 & 2. Next, the size of the elements (λ_{1i}, λ_{2i}, λ_{3i}, λ_{4i}, ...) was multiplied by the corresponding weighing factor ($\mathbf{f}_i$). Finally, the corresponding products for each variable were added together to produce the additive approximate contribution for each variable (vector of variables). The soil quality index for Land Units was calculated for rangelands using Equation 1: $SQI = \sum \rho_i \times S_i$ (1) Where ρ_i is a weighing factor for each indicator that is derived from a PCA for the ascribed indicators and S_i is the score for each indicator based on bivariate relationships between soil properties and plant growth characteristics.

The percentage of variance explained by the regression of SQIs with plant yield produced R^2 values of 0.75 and 0.77 for total yield (TY) for Data sets 1 & 2, respectively (Figure 1). The results of this research imply that for soil quality assessment and monitoring purposes, the use of inherent properties such as effective profile depth and water retention capacity together with dynamic indicators such as nutrient cycling index and slake test gives a better understanding of the system. The small but consistently higher correlations between yield and SQI using Data set 2 indicators rather than Data set 1, suggests that Data set 2 may be more suitable for rangeland assessment in this semi-arid system. This priority for Data set 2 was driven by the nutrient cycling index.



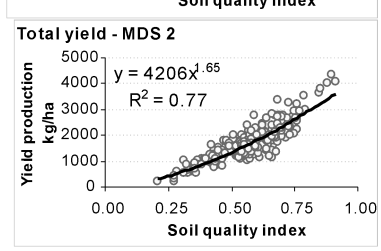


Figure 1 *Relationships between assigned soil quality indices and measured values of total yield for MDSs 1 & 2.*

Table 1 *Proposed minimum data sets for calculating Soil Quality Index (SQI).*

Soil functions	Minimum Data Set 1	Minimum Data Set 2
Fertility	Total nitrogen% (N%)	Exchangeable potassium (K)
		Nutrient cycling index (from LFA)
Water retention	First layer thickness (FLT)	Water retention capacity at wilting point (WP)
capacity	Soil profile effective thickness (PET)	Soil profile effective thickness (PET)
Stability	Grade of pedality (GP)	Slake test (ST)