



A Comparison of the performance of LFA method with Traditional assessment methods of soil properties in summer rangeland ecosystems, Hezar Jerib, North of Iran

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Abstract

Soil and plant are the main criteria to recognize the function of natural ecosystems, and to evaluate their potentials. Application of new rangeland ecosystems monitoring methods is essential for ecological studies. LFA principles and soil surface assessment parameters are based on ecological conditions of Australia. The aims of this study were calibration of LFA method for a summer rangeland ecosystem and compare two aspects by LFA method and soil parameters in Hezar Jerib rangeland, Mazandaran province, North of Iran. In LFA 11 soil surface parameters are ranked to determine soil surface indices (infiltration, stability and nutrient cycling of soil). To compare LFA method with soil parameters; N, P, K, Organic matter, infiltration and stability were estimated by laboratory methods. Then LFA indices and experimental measurements were comparing by regression. The results indicate that LFA soil surface indices are in moderately verified class ($R: 0.4-0.6$) and strongly verified class ($R>0.6$) respectively. The results also showed that N, P, K, Organic matter, infiltration and stability in both aspects are in strongly verified class. The indexes of landscape stability and nutrient cycle were higher on the northern than southern areas for patches of grass-shrub, and the index of nutrient cycling was higher in south than the north direction for patches of shrubs.

Keywords: LFA; Soil properties; Landscape attributes; Hezar Jerib rangelands

1. Introduction

The most important and basic bio-physical resource of rangeland is the soil (Ata Rezaei et al., 2006). The history of soil science shows that some soil surface functions and soil properties are strongly related to soil productivity and stability (Ata Rezaei et al., 2006). Investigation of the relationships between plant cover, runoff, and sediment transport by Greene et al. (1994) found a significant negative relationship between runoff rate and plant cover. They showed that soil productive potential may be changed without the occurrence of significant actual soil loss (Ata Rezaei et al., 2006). In this situation the vegetation attributes should be evaluated in relation to the criteria for site conservation. Those soil cover situations that meet the criteria for protection of the land would be assigned as site conservation ratings (Ata Rezaei et al., 2006).

In the 1990s some researchers started to identify and use soil properties in range condition assessment and range monitoring (Tongway and Smith, 1989; Ludwig and Tongway, 1993). In 1995 Tongway and Hindley published a manual for assessing soil surface condition of rangelands in Australia. They identified some diagnostic factors of the soil surface based on indicators of surface hydrology. Developing Tongway and Hindley's method of soil condition assessment at the hillslope scale, Ludwig and Tongway (1997) adopted a new framework entitled "Trigger-Transfer- Reserve-Pulse".

This framework enabled the simply observed soil surface indicators to assess the landscape function at the hillslope scale. The framework enables the determination of threshold amounts of available resources. The most important of which are water and nutrient supply. LFA is a monitoring procedure, using simple indicators, to assess how well an ecosystem works as a biogeochemical system. It is intended for repeated measurements to present the data as a time series (trajectory). It can be applied to a wide variety of landscape types and land uses.

It is a synthesis of many years' basic scientific work across a number of disciplines, followed by integration (Tongway, 1997).

Landscape Function Analysis (LFA) is a field-based monitoring procedure, using rapidly assessed, simple visual indicators, to assess how well a landscape works as a biophysical system. It is based on recent, cross-scale, cross disciplinary research and can be applied to a very wide range of landscape and climate types and a variety of land uses. Sometimes it is called "Reading the Landscape".

LFA is comprised of 3 modules:

- A conceptual framework, explaining simply how landscape work as biophysical systems
- A field data collection procedure and data-reduction procedure
- An interpretational framework to facilitate management use of the emergent information

Through analysis of landscape function, some ecologists can judge the landscape's capability based on how it works as a biogeochemical system, ranging from being fully functional to entirely dysfunctional. This respectively characterizes systems as highly conserving to leaky of vital resources, or from completely robust to totally vulnerable (Ludwig and Tongway, 1997; Herrick and Wander, 1998).

The indices derived in the methodology of landscape function analysis (LFA) using soil surface attributes that can generally be used in range capability assessment and especially in rangeland monitoring and management programs are:

1. Stability (resistance to erosion)
2. Infiltration (capacity for rain and run-on water to infiltrate)
3. Nutrient cycling (organic matter decomposition and cycling)
4. Landscape organization index, reflecting the overall resource use of economy of a hillslope.

LFA provides numeric values of the status of soil stability (resistance to erosion), the infiltration of water and the cycling of nutrients, and compares the values with appropriately selected reference sites, representing respectively, the most and the least disturbed examples of the landscape type being evaluated.

Soil surface cover in the LFA approach includes living and dead vegetative material and non-transportable material such as stones and rocks. This is in agreement with the approach taken in the universal soil loss equation (Rosewell, 1997).

In particular, the landscape function analysis (LFA) which was developed by Tongway and Hindley (1995). Originally this method was developed for tropical grasslands in Australia. However, it has been adapted for mine sites (Tongway *et al.* 1997; Setyawan *et al.* 2002). The LFA method provides a simple, repetitive procedure for assessing soil surface conditions. Potential soil fertility is estimated by nutrient cycling index (NCI) under this protocol (Tongway *et al.* 2003).

To prove the validity of LFA method indicators, Tongway and Hindley (2001-2003) conducted the Project named the validity of the LFA soil surface indicators with the help of CSIRO¹ Institute and Queensland and western university. In this project were considered the rate of correspondence LFA method soil surface indicators with Laboratory measurements. The purposes of the study were the compare the effect of different aspects on shrubland community and the rate of correspondence of LFA methods with climatic and ecological conditions of rangeland ecosystem in Hezar Jerib summer rangeland, Mazandaran province.

2. Materials and methods

2.1. Site description

This region is located on 53°54'01"- 53 52' 06" longitudes and 36° 38' 24"- 36° 36' 16" latitude (Fig 1). The maximum and minimum elevations are 1707 meters and 1043 meters above sea level, respectively. The area annual precipitation is 409 mm and the temperature is between -15 °C to 37 °C. The maximum Temperature occurs in May. The climate is semi-arid cold.

2.2. Soil sampling and laboratory analyses

The first step of the project was to select site according to landform attributes (slope, aspect, altitude) and vegetation type. Soil samples for chemical analyses were collected from the top 10 cm of soil, which were collected at 6, 12, 18, 24 and 30m along the 50m transect. The samples were air dried at room temperature, lightly crushed with a pestle in a ceramic mortar and passed through a 2mm sieve. The fine fraction (<2 mm) was weighed and retained for chemical analysis. Organic matter was determined by Walkley-Black method (Nelson and Sommers, 1982). Total nitrogen was measured using the Kjeldahl method (Bremner and Mulvaney, 1982), exchangeable potassium by neutral 1N ammonium acetate extraction (Knudsen *et al.*, 1982). And phosphorus was determined by Bray and Kurtz method (Bray and Kurtz, 1945). In rangeland site soil infiltration was estimated (mm/hr) in each ecological patches and between patch by ring method (Bouwer, 1986). Soil sStability as the main characteristic of soil stability was estimated by Emerson Aggregate Test (1976) (Fig 2).

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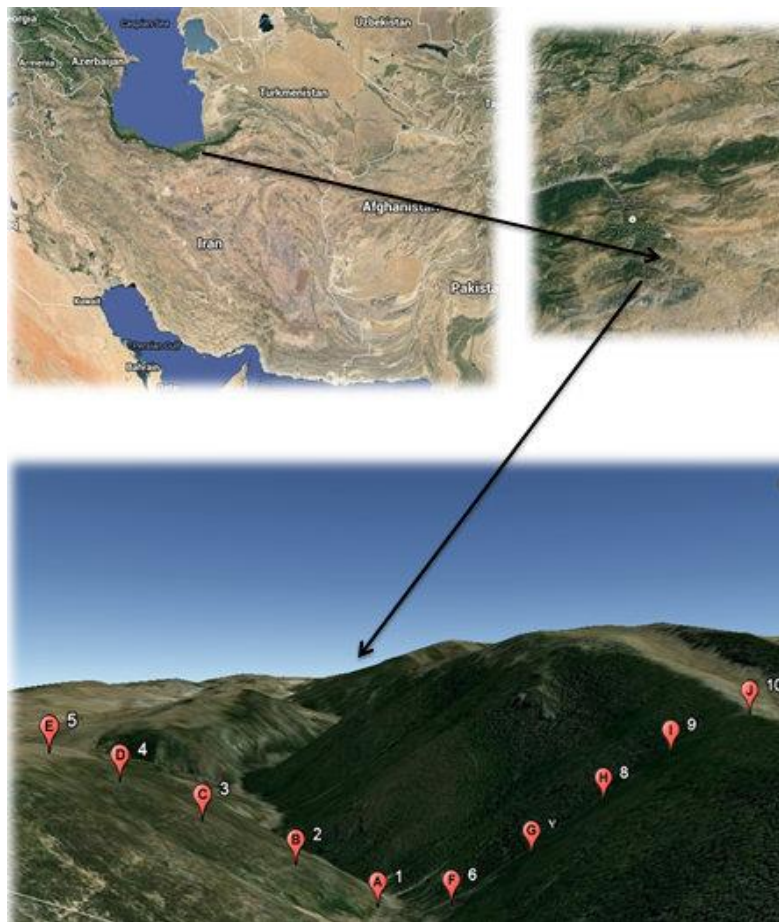


Figure 1, The study area

2.3. LFA data collection and analysis

We considered two areas (northern and southern) and determined 2 kinds of patches in each area, shrub patches and grass-shrub patches (Fig 3). LFA method was used to compare patches in northern and southern areas. Independent T-Test was used to compare the two areas.

The R (regression coefficient) was determined in order to obtain the regression relationship between the parameters from the LFA method and laboratory (Tongway & Hindley, 2003). According to the regression coefficient, more than 0.6 was High accuracy, 0.6-0.4 was moderate accuracy, 0.2-0.4 was low accuracy and <0.2 was without accuracy.



Fig 2, sampling area

2.4. Verification Procedure

The LFA method generates three principal index values that represent respectively, stability, infiltration and nutrient cycling. We tested those indices by regressing them against the field and laboratory measurements. The following criteria were proposed as comprising successful verification.

1. The regression relationship between the LFA index and relevant measured variables should have a high statistical relationship over a wide range of indicator values, with few outliers.
2. The relationship should preferably be linear, implying that the indicator sensitivity to Environmental change was similar throughout the indicator range.

3. Results

On the basis of LFA indices, there isn't significant difference in shrub-grass patches between southern and northern area (table 1). There are significant differences in shrubs patches in northern and southern areas, and stability in north aspect is higher than southern area and infiltration index and nutrient cycle in southern area is higher than northern area. Landscape organization index is higher in northern area.

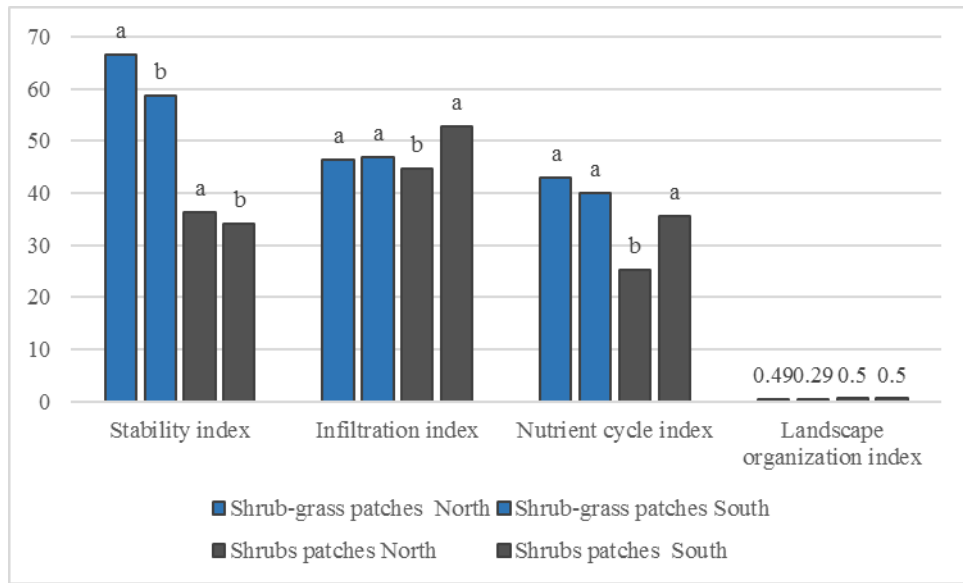


Chart 1. Comparing LFA indices in different area and patches

Similar letters that show there was no significant difference

There isn't significant difference between northern and southern area regarding soil properties. But N, K, P, O.M, stability and infiltration in north aspect is higher than south aspect.

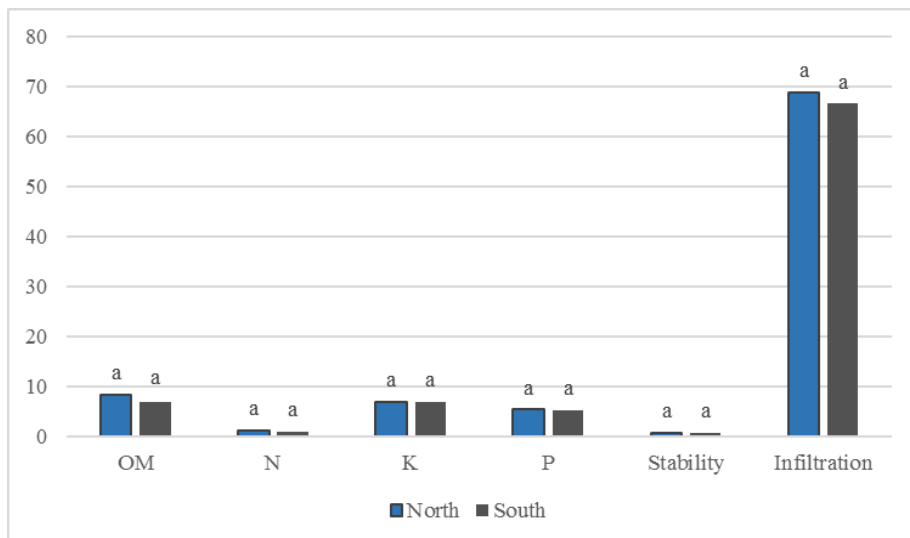


Chart 2. Comparing of soil properties among different aspects

Similar letters that show there was no significant difference among land uses

3.1. Comparing LFA indices and laboratory parameters

Based on the result of the linear regression relationship between LFA infiltration index and soil infiltration measurements in the laboratory, the correspondent rate of LFA infiltration index with laboratory index is 75%. Based on the result of the linear regression relationship between LFA Stability index and soil Stability measurements in the laboratory, the correspondent rate of LFA infiltration index with laboratory index is 45%. The result of the linear regression relationship between LFA nutrient cycle and soil N, P, K and O.M, the correspondent rate of LFA nutrient cycle index with laboratory indexes is 78%, 63%, 60% and 78% respectively (Table 1).

Table 1. Relationship (R) between LFA indexes with measured values in North aspect

soil LFA Index	stability	Infiltration	N	O.M	K	P
Stability	0.45	---	---	---	---	---
Infiltration	---	0.75	---	---	---	---
Nutrient Cycle	---	---	0.78	0.78	0.60	0.63

In Southern area, based on the result of the linear regression relationship between LFA infiltration index and soil infiltration measurements in the laboratory, the correspondent rate of LFA infiltration index with laboratory index is 65%. Based on the result of the linear regression, the relationship between LFA stability index and soil stability measurements in the laboratory, the correspondent rate of LFA infiltration index with laboratory index is 61%. the result of the linear regression relationship between LFA nutrient cycle and soil N, P, K and O.M, the correspondent rate of LFA nutrient cycle index with laboratory indexes is in the order of 75%, 71%, 66% and 66% (Table 2).

Table 2. Relationship (R) between LFA indexes and soil properties in south aspect

Soil LFA Index	stability	infiltration	N	O.M	K	P
Stability	0.61	---	---	---	---	---
Infiltration	---	0.65	---	---	---	---
Cycle of nutrient	---	---	0.75	0.71	0.66	0.66

4. Discussion and Conclusion

LFA can be used to:

- Evaluate the current status of a landscape subject to stress and disturbance
- Use this information to design appropriate restoration procedures, if needed,
- Monitor and report on the response of a landscape to time and or a restoration treatment. The rate of progress overall and or the response of each of 11 different indicators is followed so as to detect a time when the landscape has become self-sustaining as an ecosystem.

Landscape organization index in northern area is higher than southern area because of the large number of shrub-grass patches in northern area. The possibility of establishing ecological pieces in the northern landscape can be caused by more moisture (Lotfi anari et al, 2009).

Also in southern landscape, shrub-grass stability index in comparison to the northern landscape has been significantly different (P<0.05). Because the large area and more pieces shrub-grass In contrast to the southern landscape and eleven factor points in the landscape (North) was also higher and has led to shows the more stability index.

Nutrient cycle index in shrub pieces in South and North landscape is significantly different (p<0.05). It may be due to the large number of shrubs. The shrub will lead to more increase in foliage and thus in this landscape opportunity to decomposition of litter was provided and cause to increasing nutrients cycle index. More shrubs in southern area and grasses in northern area are due to ecological needs. So the most important ecological symbol in southern area is shrubs.

Shrub-grass canopy cover in northern landscape is more than shrubs canopy cover. While shrubs canopy cover in southern landscape is higher than shrubs canopy covers in northern landscape. The effectiveness of shrub-grass vegetative, thereby increasing root volume and also above ground and underground more decomposer is more tangible than other plants in northern area (Tongway and Hindley, 2004). The overall performance of the landscape in the northern and southern area is a function of environmental factors and different life forms. Establishment and spread of grass in Northern landscape and increasing the size of the canopy and shrubs density in southern landscape is a result of different performance of the two areas.

Soil parameters N, P, K, O.M, infiltration and stability in north area are higher than south area because in north area humidity is high and canopy cover and patches area become wide so organic matter and Nitrogen are higher than south aspect. Organic matter affect stability, organic matter cause to adhesion of soil particles and stability increased. When organic matter increases, bulk density decreases and porosity increases and cause infiltration to increase.

4.1. LFA index verification

We use linear regression relationship to determine the accuracy of the soil surface parameters, between field and laboratory measurements with Indicators provided by LFA method that fit the data for this study.

Regression relationship between indicators of stability, permeability and nutrient cycle of LFA and field measurements indicated that the accuracy of the estimated of LFA triple soil surface indicators is located at strongly-class. In other words, the indicators presented in the study area indicate infiltration, stability and nutrient cycle are complete accuracy. Therefore, due to the costly and time-consuming measurements of field and laboratory in management scale, application of this method can be recommended in such situations. But it should be noted that according to the results, the use of indices of the LFA method in similar ecological and climatic conditions are to relative and is justified to compare and evaluate different role of ecological components and the spaces between patches to determine the stability, infiltration and nutrient cycle of a rangeland ecosystem. That is, what kind of space (the space between the patches of ecological or patches), at each level of the soil have a positive or negative effect.

The LFA indicators were shown to have a very high degree of verification with the measured Properties in the surface soil. According to the classification presented in the final report to verify the LFA parameters of the soil surface by Tongway & Hindley, (2003) and regression relationship between LFA indicators of stability, infiltration and nutrient cycling and laboratory data, The accuracy of the estimated of LFA triple parameters of the soil surface in Hezar Jerib summer rangeland ecosystem in northern aspect is located in the moderately class but infiltration and nutrient cycling are located In strongly class. The accuracy of the estimated of LFA triple parameters of the soil surface in Hezar Jerib summer rangeland ecosystem in southern aspect is located in the strongly class in each part of stability, infiltration and nutrient cycling. Setyawan et al, (2011) in their research, Nutrient Cycling Index in Relation to Organic Matter and Soil Respiration of Rehabilitated Mine Sites in Kelian, East Kalimantan, concluded that The nutrient cycling index shows a strong relationship with soil total Organic matter and Nitrogen.

The use of LFA and Offering three levels of soil indices for Hezar Jerib rangeland ecosystem was demonstrated the efficacy of this approach in showing the soil surface characteristics of rangeland ecosystem. Also applying this method is easy and the soil surface assessment is easy and rapid and using this method is easy to (Arzani and Abedi, 2007).

Tongway & Hindly (2000, 2003, 2004) expressed this factors are applicable in a wide range of ecological and climatic conditions, and the results of this study confirm that we can use LFA methods instead of laboratory methods In terms of time, cost and accuracy.

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