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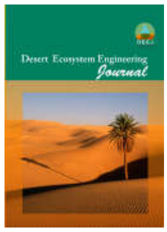

Comparison of soil and vegetation indicators between protected and unprotected areas using LFA method

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Abstract

Rangelands include patches with different ecological functions. To determine a rangeland ecosystem function, the relations between plant and soil indices are important. The aim of this research was to evaluate and compare of plant and soil indices in the protected and unprotected areas in semi-arid rangelands of Iran by Landscape Function Analysis (LFA) method. This method is an appropriate way to preventive desertification programs in semiarid sites. Landscape function indices include soil stability, infiltration and nutrition cycle. At the first step width and numbers of ecological plots, bare soil as interpatch, and 11 parameters of soil surface were recorded. The results showed that landscape function indices were better in the protected site than the other one. In this site, bush types increased soil surface stability more than other types. The maximum infiltration and nutrient cycle indices were in grass species. Mean comparison of landscape function indices was performed by t-test and results showed a significant difference between indices in two studied sites ($P<0.01$) which determine the positive effect of restoration in a protected area on rangeland functional features improvement.

Keywords: Infiltration, LFA, nutrition cycle, rangeland, stability.

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1. Introduction

The most important and basic bio-physical resource of rangeland is the soil. The history of soil science shows that some soil surface functions and soil properties are strongly related to soil productivity and stability (Rezaei et al., 2005). The concept of a functional landscape arises from the idea that resources (soil, water, and nutrients) can be gained or lost in a system. Resources may be lost to the system by runoff, and other areas may absorb or gain more resources. Landscapes can be "fully functional" or "totally dysfunctional". A highly functional landscape is one where resources are conserved within the landscape. In contrast, a dysfunctional landscape tends to lose resource (Randall, 2004).

Patches are parts of ecosystems in which resources accumulate, and interpatches are transmission resources sites. Patches differ from each other by type, composition, and function. They include individual plant stand, set of plant stands, cliff or any barrier which can keep resources (Whitford, 2002).

There was a significant negative relationship between final runoff rate and plant cover (Duran Zuazo et al., 2006). It is probable that the plants increase infiltration and decrease runoff by funneling water down their stems and providing macropores at the base of the plant through which water can rapidly enter the soil.

Arid landscapes function as strongly coupled ecological–hydrological systems, including horizontal and vertical flows and interactions across fine to coarse scales. One particularly important interaction is how, during rainstorms, patches of vegetation serve as surface obstructions that slow and trap runoff, sediments, and nutrients from open interpatch areas (Ludwig et al., 2005).

In semiarid landscapes, these surface obstructions can include logs, rocks, and ant and termite mounds, but more typically are distinct patches of vegetation with sufficient stem and biomass densities to trap water- and windborne sediments and litter (Tongway & Ludwig 1997b). These vegetation patches can vary from small clumps of grasses (e.g., 0.5-2 m^2) to large groves of mulga (*Acacia aneura*) trees (e.g., 100-1000 m^2), such as those observed in central Australia (Dunkerley, 2002).

Pyke et al. (2002) detailed the development and evolution of the technique and introduce a modified ecological reference worksheet that documents the expected presence and amount of each indicator on the ecological site. They identified 3 attributes of ecosystem status that can be evaluated using multiple indicators: Soil or Site Stability, Hydrologic Function, Integrity of the Biotic Community.

"LFA" (Landscape Function Analysis) is a monitoring procedure developed by the CSIRO. It provides a rapid, reliable, and easily applied the (or a) method for assessing and monitoring landscape restoration or rehabilitation projects. LFA examines the way physical and biological resources are acquired, used, cycled and lost from a landscape. For example, water is a landscape resource that can be stored in the landscape, providing for maximum benefits, or may run off and become lost from the system, often taking soil and other resources with it. The manner in which each type of landscape resource is utilized within local catchments influences the individual characteristics or ‘function’ of the site. These characteristics can be easily measured to provide indicators of different aspects of the functioning of the overall system (Tongway, 2007). The Landscape Functional Analysis (LFA) presents a method to assess rangeland health based on structural vegetation and soil indicators (Lopez et al., 2013).

Rostagno (1989) evaluated infiltration and sediment production of eroded and uneroded shrub interspace soils in a severely grazed, arid range site in northeastern Patagonia. In Iran, this method has been used and examined in rangeland ecosystems (Mahmoud et al., 2014).

In Lorestan province rangelands are very important, so evaluation of vegetation status and their function in planning to better management of rangelands have a key role. Based on this importance, in this paper, we selected one of the indicator rangelands of western Iran and by LFA method, ecological functions of protected and unprotected area were examined.

2. Materials and Methods

2.1. Study area

Study area is located in the southern Lorestan rangelands (between longitude: E 47°39'37"-47°42'56" and latitude: N 33°03'06"-33°06'33"). The Goribalmak climate is semi-arid. Site elevations range from 695 m to 917 m above mean sea level and soil texture is clay. Sampling was conducted on two sites as protected and unprotected area.

2.2. Vegetation

In the study area, four major plant community types (shrub, bush grass, grass, and bush) were identified.

Historically the Goribalmak has been exploited as rangeland which mainly is grazed by sheep and some goats in an extensive grazing system.

2.3. LFA data collection

The LFA (Landscape Function Analysis) method (Tongway & Hindley, 1995, 2004) was employed to the investigation of studied ecosystem function. By this method, three major indices were determined from soil surface characteristic. These indices are including:

-Soil stability index: This index is indicator of soil resistance to erosion agents.

-Infiltration index: This index estimates precipitation water penetration capacity of the soil.

-Nutrient cycling index (NCI): This index determines nutrient cycle potential or landscape fertility.

Three-50m transects line laid across the slope direction (direction of sedimentary material movement) in a key area of both protected and unprotected sites. Then all patches were identified by types of vegetation (bush, grass, and shrub or composed types as bush-grass).

Along each transect length and width of patches, and length of interpatch soil were recorded and 5 replicates from each vegetation type were determined randomly, 11 indices of soil surface evaluation were recorded according to LFA method (Tongway & Hindley, 2004). Soil surface indices and class numbers of each one are presented in table 1. Relationship between field indicators and LFA indices are summarized in figure 1.

2.4. Statistical analysis

All data of LFA were analyzed according to the LFA method. The differences between ecological sites and soil properties of both sites were quantified using t-test. This procedure was performed on the Windows-based SPSS 20th edition software.

Table (1): Soil surface evaluation indices and related class numbers of them (Tongway and Hindley, 2004)

	Soil surface evaluation indices	classes numbers
1	Soil cover	1-5
2	Basal cover of perennial grass and tree/shrub canopy cover	1-4
3	litter cover	1-10
4	cryptogam cover	1-4
5	crust brokenness	1-4
6	erosion type and severity	1-4
7	deposited material	1-4
8	Surface roughness	1-5
9	Soil surface resistance to disturbance	1-5
10	slake test	1-4
11	soil texture	1-4

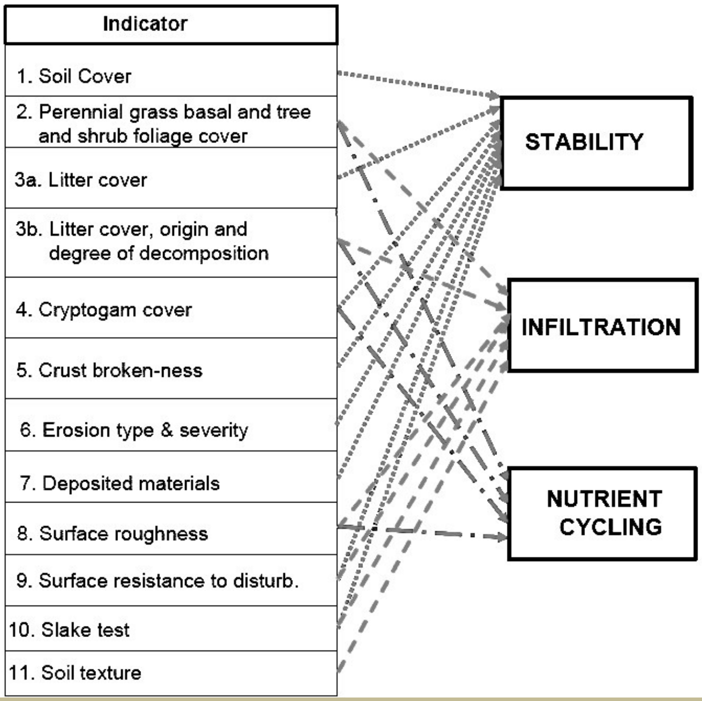

Figure (1): Relationship between field indicators and LFA indices (Tongway and Hindley, 2004)

3. Results

3.1. Soil surface indices:

In both sites, these indices (Soil stability index, Infiltration index, and Nutrient cycling index) were evaluated. Results of LFA method are displayed in figure 2. Figures showed that in protected area vegetation cover of soil surface was more abundant and bare soil was little. Two studied sites were significantly different in three indices.

3.2. Functional indices

According to soil surface factors of each site, functional indices were measured. The t-test results and the mean value of indices are shown in Table 2. According to table 2 there is a significant difference between three functional indices (P<0.01).

Table 2. Comparison of mean value of indices in two studied sites according to t-test

Functional indices	Protected Area		Unprotected Area		Sig.
	Mean	Std. Deviation	Mean	Std. Deviation	
Stability	58.300	0.721	37.900	0.854	0.000 **
Infiltration	31.300	0.600	24.200	1.311	0.001 **
Nutrients	25.100	0.173	12.800	0.529	0.000 **

** Significant difference according to t-Test at p≤ 0.01

3.3. Soil surface indices determination

In the area, five ecologic types were identified: Bush, grass, shrub-grass, shrub, and interpatch zone or bare soil.

Stability: According to LFA method results, the bush type was more effective (68.8%) than other types in a protected site, in the other site grass was more effective (52.1%) instability index.

Infiltration: The maximum infiltration was in the grass by average infiltration of 38.7% and 30.5% in protected (ungrazed) and unprotected (grazed) site respectively.

Nutrient cycle: The soil surface of grass had the highest or a higher percentage of the nutrient cycle in both protected and unprotected sites (31.4% and 26.2% respectively).

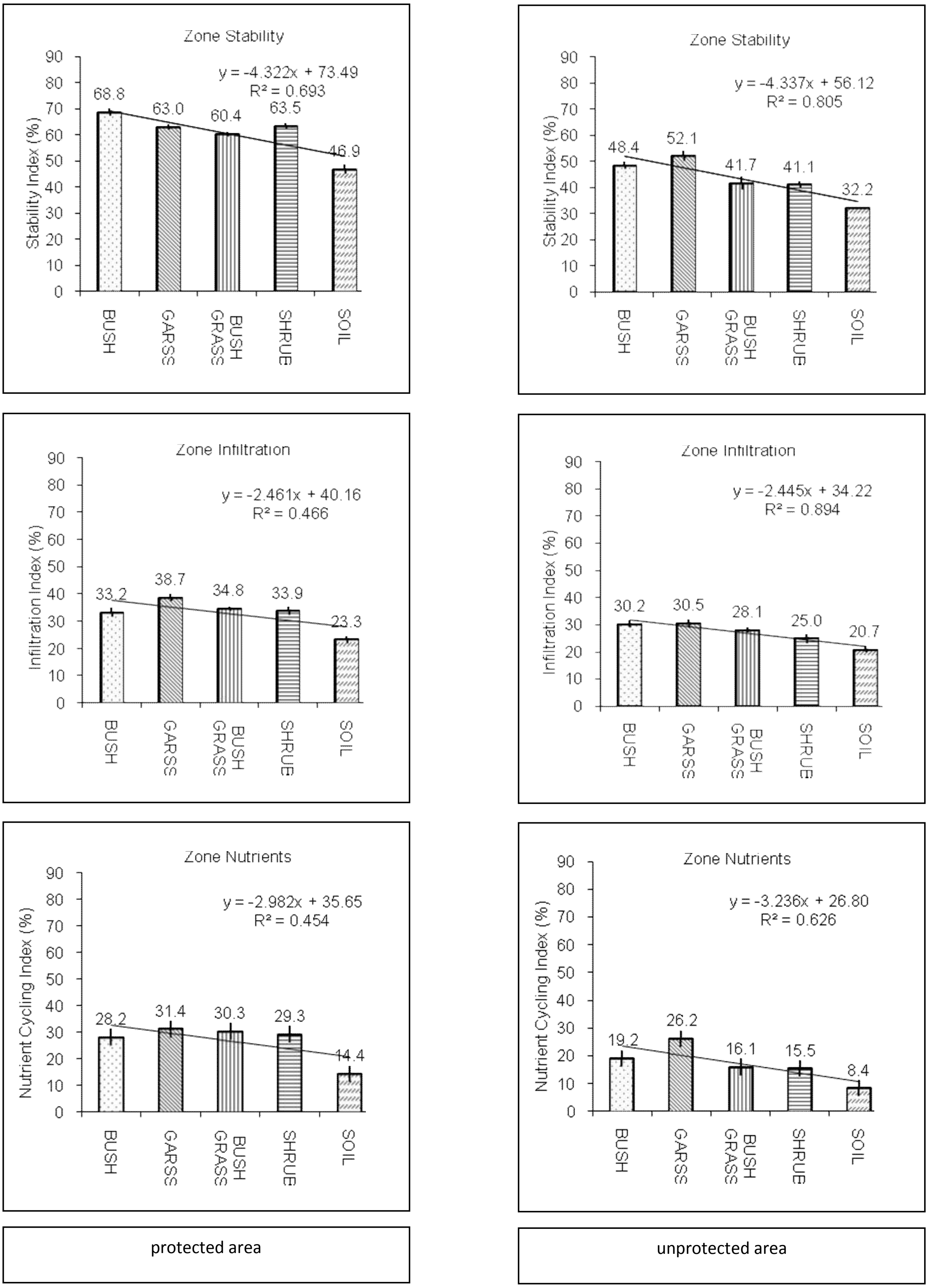

Figure (2): Results of LFA. Three indices value in both sites

4. Discussion

There were clear differences in the stability values for different types of landscape structures. In general, protected area exhibits high value of stability than the unprotected area. Variation in stability across vegetated-bare patch boundaries tended to be lower in the unprotected area than in the intact area. These patterns are consistent with the notion that soils in plots associated with fragmented grassland tend to have reduced function (Tongway & Ludwig, 1997a).

Variation of stability within different types of a landscape is because of point values for what we classified as "vegetated" and "bare" strata. Although sometimes a simple classification of patches into "bare interspace" and "plant" would not have been sufficient to understand variation in soil function (Bestelmeyer et al., 2006).

The results of Ghodsi et al. (2011) in Golestan National Park showed that shrub forms more increase soil surface stability than other forms. Permeability showed no significant differences among the other growth forms. The soil surface of wheatgrasses had a higher percentage of nutrient cycle, but the difference with others was not significant (Ghodsi et al., 2011).

The high stability values associated with vegetated patches are consistent with theories of arid landscape function (Tongway & Ludwig 1997b).

Nutrient cycle index was more in bush grass than other types of protected landscape. This is probably due to morphologic features. Degradation rate and infiltration of organic matter into soil are more in grass species. The mixture of bush and grass species trepan to more shoots per area, so can increases litter degradation rate.

Mayor and Bautista (2012) evaluated the LFA infiltration and stability indices against quantitative measurements of water and sediment flow at multiple scales in Mediterranean semiarid landscapes. The bare-soil infiltration index predicted bare-soil infiltration rate and hillslope runoff better than common simple indicators of soil functioning such as soil organic carbon, stone cover, crusted bare-soil cover, bulk-density, and plant cover, and exhibited a similarly high indicatory potential that a variety of plant spatial-pattern indicators.

In our study bare soil (interpatch) infiltration and stability were relatively admissible in the unprotected site. Litter coverage and humus on soil surface justify this phenomenon. Thurow et al. (1988) showed that total organic cover is the most important factor determining the infiltration rate. Differences between the nutrient cycle are in agreement with Tongway and Ludwig (1990).

The LFA methodology has an enormous potential to assist land managers and policymakers in the establishment of cost-effective desertification monitoring and restoration programs in arid environments (Maestre & Puche, 2009).

Due to the high stability of soil in bush grass, these species can be used for breeding operation in same rangelands.

Conclusion

The relationships between plant and soil indices in rangelands represent ecosystem function. By comparison of the protected and unprotected area in arid rangelands of Iran, landscape function was evaluated. Landscape Function Analysis (LFA) method examines the way physical and biological resources are acquired, used, cycled and lost from a landscape. Three important indices in this method were stability, infiltration and nutrition cycle. Results showed that between two sites there are significant differences in above indices. The protected area has well functional features improvement. Amendment operation in same rangelands can be managed by grass types which showed high stability of the soil.

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