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The effects of landscape attributes and plant community on soil physical properties in rangelands

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Abstract

This study addressed the effect of landscape attributes on the spatial distribution of soil physical properties in an alpine rangeland in a semi-arid area of Iran. Soil physical properties are recognized for their important role in supporting plant growth. To identify the effects of landscape attributes on soil physical properties the present study collected and analysed information from air photos, satellite images, field survey, and the laboratory using statistical analyses. Land stratification allowed the study area to be subdivided into Land Unit Tracts (LUT), according to specified criteria including landform attributes (slope, aspect, and altitude) and vegetation type. A factorial model on the basis of a completely randomised design was used to analyse the data collected from 234 LUT. The interrelationships between soil physical properties and landscape attributes were investigated and interpreted based on statistical analysis and expert knowledge. Slope significantly ($P<0.05$) affected most properties of the 0–10 cm topsoil including grade of pedality and slake test. Also, many soil properties that reflect parent material and likely to be related to soil moisture status including coarse fragment ratio, soil profile effective thickness, first layer effective thickness, water retention capacity, and depth to water table were significantly related to slope gradient. These soil properties noticeably affect range productivity.

Keywords: Soil physical properties; Landscape attributes; Vegetation type; Rangelands

1. Introduction

Soil physical properties and in turn plant growth are significantly controlled by variation in landscape attributes including slope, aspect, and elevation which influence the distribution of energy, plant nutrients, and vegetation by affecting:

(1) Organic activity such as exposure of soil, flora and fauna to direct sunlight, and mixing of mineral soil and organic matters by animals,
(2) Exposure of soil to wind and to precipitation including snowfall and snow drifts,

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(3) Conditions for natural positive and negative runoff and erosion, and accumulation, and
(4) Conditions for natural drainage including depth to water table (Buol et al., 1989).

Almost all soil properties exhibit variability as a result of dynamic interactions between natural environmental factors (i.e., climate, parent material, vegetation, and topography; Jenny, 1941). Significant differences in soil chemical and physical properties in a small area on uniform geology are known to be related to landscape position (Jenny, 1941; Ruhe, 1956). Due to this relationship geomorphic information has long been routinely used in soil mapping as a stratifying factor (Pachepsky et al., 2001). Contrary to many soil chemical properties that are of a dynamic nature, soil physical properties range from quite constant to quite dynamic. For instance, soil texture and soil depth, which are results of soil formation factors, are expected to be constant during a short or medium time period. However, soil surface layer thickness, bulk density, and soil structure are quite dynamic, as they are sensitive to both the soil formation factors and to some extent are dependent on land management factors (e.g., erosion, exploitation, conservation). In this research the dynamic nature of soil physical properties (soil water and nutrient storage and some stability indicators) were hypothesized to be directly affected by landscape attributes in addition to the indirect influences of landscape attributes via providing different microclimates that support the growth of plant species with different characteristics (e.g., growth form and density) in the absence of management factors. In other words, we examined how soil physical properties are controlled by environmental factors in an alpine semi-arid rangeland in Iran.

2. Study system and data generation

2.1. Site description

Experimental data was collected from three vegetation types within the Lar aquifer, between 35°4′36″ and 35°48′40″N and 51°32′ and 52°4′E 78 km north of Tehran, Iran. The climate is semi-arid with mean monthly temperatures ranging from −6.5 °C in January to 18.4 °C in July (Iranian Meteorological Organization, 2001). The annual mean precipitation is 496 mm, most of which falls during winter and spring seasons (November–May). The Lar area was selected for its relatively well-managed rangelands, compared with other similar alpine rangelands of Iran. Many of the soils in the study area are quite shallow and steeply sloping. Based on US soil taxonomy classification (USDA-NRCS, 1998), the study area is classified into different great groups of Lithic and Typic Xerorthents, Typic Haploxerepts, Haploxeralfs, and Fluvaquents. Elevation ranges between 2500 m in the lower part (Lar Dam) and 3950 m in the upper part. This range in altitude shows that the general landscape of the study area is mostly steeply mountainous terrain dissected by valleys (Figs. 1 and 2).

To carry out this research, three major plant community types[1] (herb, shrub-grass, and grass) consisting of 15 different vegetation types[2] were identified; three of which: *Bromus tomentellus–Astragalus adscendens* (sub-area 1); *B. tomentellus–Onobrychis cornuta* (sub-area 2); and *Agropyron repense–Chaerophyllum macrospermum–Ferula galbaniflua* (sub-area 3) were chosen to conduct this research. The vegetation type of *B. tomentellus–A. adscendens* in sub-area 1 with an area of 1100 ha is the second major type of *cushion plant-grass* plant community. Predominant species in this vegetation type are *B. tomentellus* (Russian brome), *A. adscendens*, *Agropyron intermedium* (Intermedium wheatgrass), *Agropyron cristatum*, *Onobrychis cornula* (Onobrychis), *Tymus kotschyanus*, *Achilla melifolium*. The sub-area 2 is covered by the vegetation type of *B. tomentellus–O. cornuta.* This vegetation type is the first major vegetation type of *cushion plant-grass* and covers 1450 ha of the study area. This vegetation type dominantly comprises the following species: *B. tomentellus* (Russian brome), *O. cornuta* (Onobrychis), *T. kotschyanus*, *A. intermedium* (Intermediate wheatgrass), *A. adscendens*, *Astragalus* spp., *A.*

[1] Plant community type is defined as "An aggregation of all communities with similar structure and floristic composition. A unit of vegetation within a classification with no particular succession status implied".

[2] Vegetation types "A kind of existing plant community with distinguishable characteristics described in terms of present vegetation that dominates the aspect or physiognomy of the area".