Identifying grazing-driven plant indicators of rangeland degradation in semi arid zones of Uzbekistan

Toshpulot F Rajabov [A], *Bakhtiyor K Mardonov* [A] *and Mahmud A Muminov* [A]

[A] Samarkand State University, Laboratory of Environmental Problems, University Boulevard 15, Samarkand, Uzbekistan

Contact email: rtoshpulat@yahoo.com

Abstract. The development of practical indicators of vegetation degradation is an important element in predicting and assessing rangeland health due to disturbances such as livestock grazing. Once established, phytoindicators provide a simple and visual operative way to diagnose active and possibly undesirable vegetation changes. This paper aimed to identify rapid, yet realistic and easily communicated plant indicators of rangeland degradation caused by intense grazing. The grazing gradient approach is applied to study plant traits affected by increased levels of grazing pressure. Qualitative and quantitative changes in key species of the plant community alongside successive changes of vegetation attributes along an apparent grazing gradient were used as potential indicators for detection of rangeland degradation. The presence of different environmental (edaphic properties) and management (grazing regime) conditions in two study sites allowed selection of fine scale plant indicators. Effective use of *rapid assessment* plant indicators in rangeland monitoring provides a baseline for improved rangeland management practices to prevent further degradation processes.

Keywords: Rangeland condition, overgrazing, grazing intensity, monitoring, Karnabchul, *Artemisia* spp.

Introduction

Rangelands of arid and semi arid ecosystems in Uzbekistan are under ever-increasing pressure from human activities. More than 60% of rangeland areas of the country have already been affected by different levels of degradation (Ashurmetov *et al*. 1997). The native state of vegetation communities and their pristine composition is drastically altered by intense livestock grazing. Of all disturbance types, overgrazing of livestock is the most serious, accounting for 44% of the total degradation, followed by uprooting and cutting of vital shrubs for fuel wood (25%) (Yusupov 2003). Currently such degradation trends are active across vast rangeland areas of the country, but the exact ecological condition of rangeland vegetation is unknown. As a result of intense use of natural resources, the need to evaluate current state of vegetation and to manage rangeland ecosystems becomes increasingly critical. Traditional geobotanical methods are complicated, time consuming and expensive to apply in monitoring and assessment of the degradation processes affecting large rangeland territories.

Rapid assessment methods, and in particular the so-called biophysical indicators which are an integral part of these methods, are increasingly used in predicting and assessing the rangeland health of different ecoregions. Various frameworks for developing indicators of environmental state are proposed and their implementation steps are explicitly described (*e.g.* Cairns *et al*. 1993, Pyke *et al*. 2002). Biophysical indicators of rangeland condition are considered to be quantative, rapid, repeatable, easily communicated and susceptible to sensitivity analysis which all should be related to ecosystem function (Herrick *et al*. 1996). Developed indicators are recognized to be cost effective and to best support management goals and actions. All these flexible features of rapid assessment techniques suggest the need to extend the broad utility of indicators in effective management of natural resources, in particular on rangeland vegetation.

The development and use of plant indicators as "snapshot" assessment techniques are poorly understood in the rangelands of Uzbekistan. In this paper we present the results of studies identifying the grazing-driven vegetation patterns to be used in the development of potential plant indicators of rangeland degradation in the case of Karnabchul rangelands. We expect that the phytoindicative approach to vegetation studies will result in an efficient way to detect patterns of rangeland degradation, such that the method can be extended and implemented as an operational monitoring method in semi desert rangelands of Uzbekistan.

Method

Study areas

The study area was located in the Karnabchul semi desert which is representative of typical Central Asian *Artemisia* spp. dominated arid rangelands and occupies about 0.5 Million ha in the West of Uzbekistan (Gaevskaya 1971). Predominantly winter precipitation with high intra and inter-annual variability, and dry summer make the climate of Karnabchul a Mediterranean variant with extremely cold

Table 1. Distribution of grazing-driven native weeds in rangelands with different soil type.

Species name	Life form	Palatability	Village site - gypsum soils	Well site – sierozem soils
Acanthophyllum pungens (Bge.) Boiss.	perennial	unpalatable	+	+
Anisantha danthoniae Trin.	annual	medium to poor		+
Boissiera squarrosa (Soland.) Nevski.	annual	poor	+	+
Capsella bursa-pastoris (L.) Medic.	annual	poor		+
Ceratocephalus falcatus (L.) Pers.	annual	poisonous	+	+
Cousinia resinosa Juz.	biennial	poor	+	
Descurainia sophia (L.) Webb ex Prantl.	annual	poor		+
Hordeum leporinum Link.	annual	poor		+
Hypecoum parviflorum Kar. et Kir.	annual	unpalatable	+	
Iris songarica Schrenk.	perennial	poor	+	
Koelpinia linearis Pall.	annual	medium	+	+
Papaver pavoninum Schrenk.	annual	unpalatable		+
Peganum harmala L.	perennial	poisonous	+	+
Roemeria hybrida Boiss.	annual	unpalatable	+	
Strigosella grandiflora (Bunge) Botsch.	annual	medium		+
Vulpia ciliata (Danth.) Link.	annual	poor		+
Ziziphora tenuior L.	annual	poor	+	+

winter (Gintzburger *et al*. 2003). The mean temperature of the coldest (January) and warmest (July) months are 1.61°C and 30.9°C respectively. Precipitation occurs mostly during the cold season as rain and often snow. Annual average rainfall is 183 mm with high yearly fluctuations from 112 mm to 257 mm. Soils are light sierozem and grey-brown with a low organic matter content (<1.0%) and basic nutrient elements (Shamsutdinov 1975). The dominant vegetation type is of perennial and annual *Artemisia* spp. species and desirable ephemeral and ephemeroid plants. The rangelands are characterized by low annual production varying from 0.15 to 0.36 t DM/ha (Gintzburger *et al*. 2003).

Sampling design

Field surveys were conducted at two sites in Karnabchul: around the Tim village (39°40'N; 65°46'E, 460 m a.s.l.) and at a watering well (39°38'N; 65°31'E, 334 m a.s.l.), located to the south and south-west of the Karnab-Zirabulak mountain ranges. Each site was divided into subplots along a grazing gradient at a distance of 300 m, 500 m, 1000 m and 1400 m from the Tim village and 1000 m, 2000 m and 3000 m from the well. An important distinctive feature of sites is the presence of differing soil conditions and grazing patterns.

Rangelands around the village site have gypsum grey-brown soils with extended grazing regime, while rangelands around the well are located on light sierozem soils with a radial symmetry of grazing pressure. Plant community data were repeatedly collected during four successive seasons from 2005 to 2008. Traditional geobotanical methods were used to determine plant biomass and plant cover projection using 2 m x 50 m transects, randomly distributed with 3 replications. Changes of species composition, density, mortality rate, biomass, and plant cover projection of key plant species were monitored to detect grazing-driven indicators of rangeland degradation. Data from spring season were chosen as benchmarks for further analysis since at this time vegetation structure is represented by its full species composition.

Results

The pristine condition of both investigated sites is represented by homogeneous vegetation with a dominant single semi shrub (*Artemisia diffusa*) plant community associated with ephemeroids and palatable annuals (*Carex pachystylis, Poa bulbosa, Alyssum desertorum, Trigonella noeana, Veronica compylopoda*, and *Holosteum umbellatum*).

Different grazing regimes at both sites caused considerable changes of vegetation composition. In total, 10 species are considered as native weeds with low palatability (during growth period) at the village site, whereas this number consisted of 13 species around the watering well. *Cousinia resinosa* and *Iris songarica* were found as intermediate weeds in the village site, while *Peganum harmala*, an unpalatable and toxic plant, was abundant in a close proximity (1000 m) to the watering well. The majority (76%) of present pastoral weeds at both sites belonged to annual grass species (Table 1). *Hordeum leporinum, Capsella bursa-pastoris, Vulpia ciliata, Ceratocephalus falcatus,* and *Descurainia sophia* were most common weeds in areas with high stocking rates. The ratio of grassy weeds in species composition of annuals was higher at the well site (11 species out of 23) than the village site (6 species out of 17). Despite a relatively high species diversity of annuals, the grass layer of both sites was dominated by ephemeroids (*Carex pachystylis* and *Poa bulbosa)*. Patches of ephemeroids became gradually denser and more abundant when moving closer to the village and the well.

The density of *Artemisia diffusa* and *Iris songarica* appear to decrease along the grazing gradient on the village site (Fig. 1a, b). In contrast, increasing density of *Artemisia diffusa* was noted as a function of distance away from the watering well, but was not present in the first gradient (1000 m) of the well due to severe overgrazing and trampling. The density of *Peganum harmala* was the highest (10492 ± 840 plants/ha) in close vicinity to the watering well and significantly declined (325±121 plants/ha) as a result of decreased grazing pressure further away from the watering well (Fig. 1c, d). Observation of

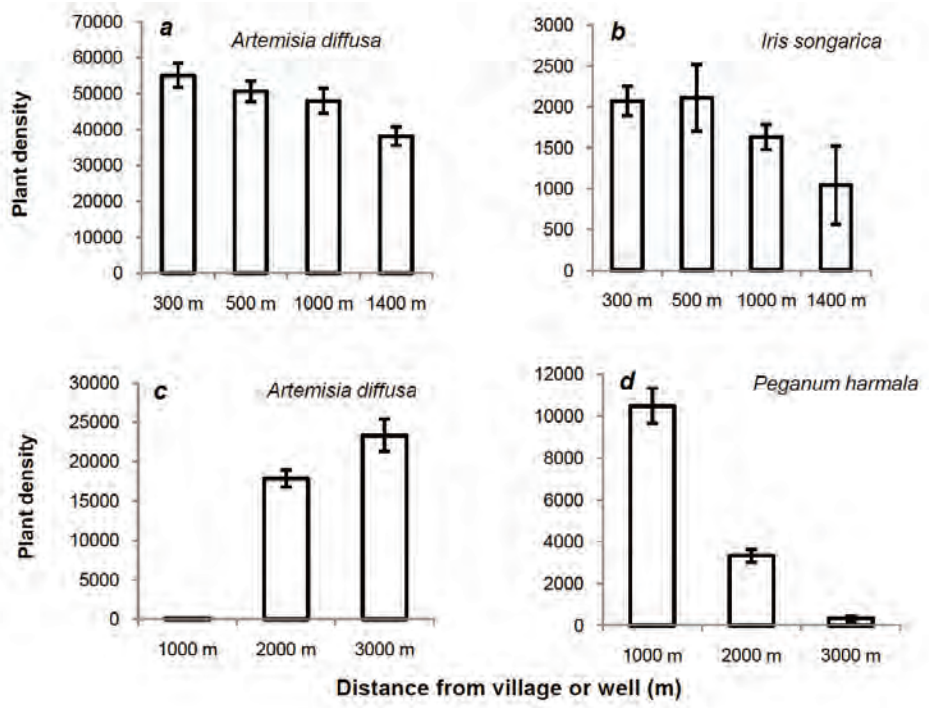

Figure 1. Density (plants/ha) of key plants in the condition of grey-brown gypsum soils on the village site (*a*, *b*) and sierozem soils on the well site (*c*, *d*). Note different y-axes on the graphs for each species. Vertical bars represent ±SE.

the mortality rate of *Artemisia diffusa* did not demonstrate a clear directional trend along the gradients, but showed strongly differing values between the village and well sites. The average number of dead individuals of *Artemisia diffusa* at the well site were significantly and considerably higher (4395 ± 195 plants/ha) than at the village site (1287 ± 194 plants/ha).

Changes of biomass and plant cover projection values of key species at both sites were directly related to plant density and to grazing intensity. Due to the scattered distribution of livestock grazing at the village site, no significant linear trends of biomass of *Artemisia diffusa* could be identified, but the general trend was a biomass drop from 228 kg DM/ha to 194 kg DM/ha along the grazing gradient. An identical reduction of biomass occurred for *Cousinia resinosa* and *Iris songarica* with a small contribution to total biomass (5 kg DM/ha and 76 kg DM/ha respectively on average). At the well site, the *Peganum harmala* biomass was the highest (600 kg DM/ha) at 1000 m from the well along where there was a high plant density, while biomass significantly decreased (to 30 kg DM/ha) at 3000 m due to a low plant density. In contrast, due to the severe overgrazing of *Artemisia diffusa* close to the well, its biomass was higher (109 kg/ha) at 3000 m from the watering well.

Discussion

The pristine structure of an *Artemisia diffusa* dominated community was dramatically altered by heavy grazing and was particularly visible on areas with a high livestock concentration around the village and the well. The initial indication of such alterations is reflected in the strong colonization by ephemeroids on the rangelands of both study sites. The relatively favourable condition of sierozem soils (sandy loam with light texture) with a combination of radial grazing pressure resulted in a wider spread of *Carex pachystylis* and *Poa bulbosa* at the well site than at the gravelly-gypsum soils of the village site. Likewise, pastoral annual weeds (*e.g. Hordeum leporinum, Vulpia ciliata*) expanded considerably on sierozem soils, and under heavy grazing close to the well.

We assume that the high density of *Artemisia diffusa* (55033 ± 5108 plants/ha) at the village site occurred under long-term increased grazing impacts and thus it can be taken as one of the indicators of transitional vegetation changes on gypsum soils caused by heavy grazing. Further to this, the appearance of poorly palatable *Cousinia resinosa* and *Iris songarica* in species composition, and their increasing density close to the village, indicate further unwanted rangelands alterations. These herbaceous plants were more abundant close to the village due to higher grazing pressure than at distant areas (Figure 1b). In comparison to the village site, a density increase in *Artemisia diffusa* was not observed at the well site, but the occurrence of high mortality can be considered as a site-specific feature of vegetation changes caused by grazing and trampling. We speculate that a wider expansion of ephemeroids in sierozem soils resulted in high rate of mortality of *Artemisia diffusa*. This process is explained by intense growth of a strong mat rooting system of *Carex pachystylis*, which captures most of soil moisture to the detriment of the root system of *Artemisia* spp. constrained by a compacted gypsum layer at 40-45 cm in the soil profile (Mavlyanov 1972; Maylun 1976). Radial attenuation of grazing pressure away from the watering point resulted in an increase of *Peganum harmala*. *P. harmala*, when green is not grazed by livestock due to its toxicity, strong characteristic smell and high content of alkaloid in green leaves and seeds (Gintzburger *et al.* 2003). The appearance of *Peganum harmala* clearly signals

potential severe and irreversible changes in vegetation structure and rangeland degradation.

Biomass and plant cover projection values of key species did not generate reliable trends caused by the long term effects of livestock grazing. Current vegetation variables of palatable species such as *Artemisia diffusa* are subject to short term and direct impacts of livestock grazing (browsing intensity) and thus can be considered as secondary indicators of grazing effects on changes in vegetation. The dynamics of unpalatable species are mostly dependent upon plant density and livestock trampling and can be considered as the driving factors shaping the biomass and cover values of these unpalatable species.

Conclusion

Grazing-driven rangeland alterations appear more severe at the well site than at the village site. Due to the various edaphic factors and grazing regime, the *Artemisia* spp. vegetation community generated different grazing-driven indicators. The proportion of weeds in species composition, plant density and mortality rate of *Artemisia diffusa* are promising long-term indicators of rangeland degradation in Karnabchul semi desert. Plant cover projection and plant biomass are short-term indicators of vegetation alteration. The indicators developed must be combined and used together to obtain a reliable diagnosis of the rangeland vegetation status under livestock grazing. These plant indicators could be used in assessing the functional integrity of a site and may allow sustainable management of *Artemisia* spp. dominated semi desert rangelands.

Acknowledgement

We thank Dr. Gustave Gintzburger for constructive remarks and suggestions that greatly improved the paper.

References

Ashurmetov OA, Rakhimova T, Hasanov OH, Shomurodov HF (1998) Recommendations on improvement of desert rangelands of Uzbekistan. *Journal of Desert Development* **1**, 87-90.

Cairns J, McCormick PV, Niederlehner BR (1993) A proposed framework for developing indicators of ecosystem health. *Hydrobiologia* **263**, 1-44.

Gaevskaya LS (1971) 'Karakul sheep breeding rangelands of Central Asia'. (Fan Publishing: Tashkent)

Gintzburger G, Toderich KN, Mardonov BK, Mahmudov MM (2003) 'Rangelands of the arid and semi arid zones in Uzbekistan.' (CIRAD/ICARDA Publishing: Montpellier)

Herrick JE, Whitford WW, Soyza AG, Van Zee J (1996) Soil and vegetation indicators for assessment of rangeland ecological condition. In: North American Workshop on Monitoring of Ecological Assessment of Terrestrial and Aquatic Ecosystems. CA Barvo (ed.) USDA Forest Service, Ft. Collins, CO Gen. Tech. Rpt. RM-GTR-284.

Mavlyanov S (1972) Ecological-phytocoenological characteristic of ephemeroidal-sagebrush Karnabchul rangelands in relation to fodder production. PhD thesis, Samarkand, Uzbekistan.

Maylun ZA (1976) Xerophyte semi shrub vegetation – Xerohemithamnisca. In `Vegetation cover of Uzbekistan and the ways of its rational utilization`. (Eds KZ Zakirov *et al.)* Vol. III, pp. 72-138. (Fan Publishing: Tashkent)

Pyke DA, Herrick JE, Shaver P, Pellant M (2002) Rangeland health attributes and indicators for qualitative assessment. *Journal of Range Management* **55**, 584-597

Shamsutdinov ZSh (1975) `Establishment of perennial pastures in arid zones of Central Asia. (Fan Publishing: Tashkent)

Yusupov SU (2003) Interaction between livestock and the desert environment in Uzbekistan.Proceedings of NATO Advanced Research Workshop Desertification Problems in Central Asia and its Regional Strategic Development. 11-14 June 2003, Samarkand, Uzbekistan. pp. 93–96