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DEGRADATION OF SEMI-ARID PASTURES IN KYRGYZSTAN AND POTENTIAL PATHWAYS FOR IMPROVEMENT

A Case Study of Talduu-Bulak Aiyl Aymak Pasture in Bazar-Korgon District

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ABSTRACT

Rangeland condition is often associated with its productivity, which is based on its economic value. This is how it has gone for many years in Kyrgyzstan, as well. However, such an assessment of rangeland condition has not been justified in terms of biodiversity conservation and structural stability of the ecosystem. In this regard, in recent years there has been a large number of approaches developed on the study of plant communities, which help to efficiently identify the pathways of change in an ecosystem to improve the management of natural resources. In this project, I used a functional group analysis approach to investigate the effect of grazing on species diversity of plant communities according to their morphological and phenological characteristics. The list of analysed plants contained a total 59 species. These species were recorded in 2013 in pastures near the village in Talduu Bulak AA (Kyrgyzstan).

The results of the analysis showed that the vegetation of the study area was dominated by sagebrush and ephemeral species. Most of the 46 species (78%) are palatable, while 13 are considered unpalatable. The dominant life forms are perennials (44 species), three species are biennials and 12 annuals (including seven annual grasses and five legumes). The analysis of height and flowering period, life cycle and seed production, and seed viability in the soil indicated that short-height and short lived annual grasses were tolerant to grazing compared to tall plants.

The different pathways of semi-arid pasture responses to grazing were conceptualized and have been compared with conditions of the study area. According to the conceptual model, a low level of grazing pressure in semi-arid pastures in Kyrgyzstan can be associated with palatable perennial grasses and legumes, compared to high grazing with ephemeroids and ephemerals. Furthermore, extremely high pressure can lead to a succession of unpalatable herbs and woody thorny species.

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ABBREVIATIONS

AA – Ayil Aymak (local self-government in Kyrgyzstan)
ECE/CEP –Economic Commission for Europe Committee on Environmental Policy
SAEPF - State Agency for Environmental Protection and Forestry
USSR - Union of Soviet Socialist Republics
FAO - Food and Agriculture Organization of the United Nations
NAS – National Academy of Sciences
NSC - National Statistical Committee of the Kyrgyz Republic
KyrgyzGiproZem – Kyrgyz State Project Institute for Land Management.
PF – Public Foundation
CAMP – Central Asian Mountain Program
PUA – Pasture Users Association

1. INTRODUCTION

Kyrgyzstan is a republic in Central Asia. The entire area of the country covers 198,500 km^2. The country is mountainous and lies entirely above 500 m above sea level. About 43% of the territory of Kyrgyzstan is at altitudes higher than 2,500 m, and only about 15% below 1,500 meters (Sidorenko 1972).

The main natural resource are the mountain pastures, which cover 40% of the country and account for 85% of agricultural land (SAEPF [State Agency on Environment Protection and Forestry] 2012). Pastures in the Kyrgyz Republic are divided by the distance from settlement into near-village (winter use), intensive (spring and autumn use) and distant (summer use) pastures. Spring-autumn pastures occupy 32%, summer pastures 45% and winter 23% of the total area of pasture land (SAEPF 2007).

The productivity of natural pasture lands of Kyrgyzstan is not high (Shihotov et al. 1981). Therefore, to avoid a degradation of pastures, it is necessary to follow strict rotation periods and optimize the frequency of pasture use. The "nomadic" system of pasture use which was widely practiced by Kyrgyz people in the pre-Soviet period was a very good rotational system (World Bank 2007). It facilitated sustainable pasture use by the seasonal movement of livestock between the valley floors and the high mountain pastures (Van Gelder 2003). The main features of this system were lack of individual rights to grazing lands and a highly decentralized system of adjudication of rights to grazing pastures. Based on these principles, it can be regarded as a system of social acceptability and environmental sustainability (World Bank 2007). But the nomadic pattern of pasture management was lost during the Soviet period.

A major reason for the abandonment of the nomadic system was the collective intensive animal husbandry established on an industrial scale. This system was limited by the lack of involvement of traditional pasture users in pasture management, which reduced knowledge of sustainable pasture utilization (Van Gelder 2003). Repeated efforts were made during the Soviet period to adapt arrangements of a transhumance system of livestock to the collective farming system (World Bank 2007). But obviously, the large herd size limited livestock mobility for rotational grazing within the season as well. In addition, the number of livestock doubled or even tripled during the Soviet period (1916 to 1990). For example, cattle stocks increased 2.03 times and sheep and goats by 2.99 times (Central Statistical Office of USSR 1930, 1982; State Statistics Committee of the USSR 1991). Thus, Kulov (2007) noticed that during the USSR era overstocking sustained over decades and due to largely increased grazing pressure, caused severe land degradation.

To enhance productivity of degraded and unproductive grazing areas, a number of superficial or radical measures were implemented (Kurinskih 1992). From 1991 to 1996, the number of livestock declined sharply due to disintegration of the Soviet Union. This precipitated the corresponding collapse of the rural economy (Kulov 2007). But in the last two decades from 1997- 2015, recovery of livestock numbers has been very fast with sheep and goats together increasing by 59.6% and cattle by 76.1% (FAO 2016; NSC (National Statistical Committee) of the Kyrgyz Republic 2016). Near village pastures became the most degraded among the three types of pastures, reflecting their closeness to the settlement. Although nearby pastures were mainly designed for spring and autumn grazing (Kitaeva 2016), many smallholders now keep their herds there in all seasons, thereby increasing grazing pressure (SAEPF 2006; Mirzabaev et al. 2016). The main reason for staying on

the nearby pastures is to be close to the market. Distant pastures have limited communication with the market due to a number of difficulties such as distance, poor roads and lack of bridges. Due to the degradation of nearby pastures, the income of rural families is suffering.

The declining outputs from livestock (especially milk, which women directly depend on) arising from poor pasture conditions and with women having limited mobility and therefore access to long distance pastures, have become issues of concern in the community, and the need to improve pasture condition is being discussed in the community meetings.

In the period 1991-2009, pasture management was a three-tier system of rangeland management. In this system, nearby pastures were managed by the municipalities, intensive pastures by the district, and distant pastures by regional administrations (Ministry of Agriculture and Water Resources of the Kyrgyz Republic 2000; UN 2009; Bussler 2010; Mirzabaev et al. 2016). This division of administrative responsibility made it difficult to ensure the sustainable use of pastures (World Bank 2007; Mirzabaev et al. 2016).

Currently, the State has transferred the right of pasture management to the municipal authorities. This new approach is justified by the fact that pasture management plans developed top to bottom, were in most cases far from reality. With this new approach, the best plans can be developed based on the knowledge of experienced local residents. Since 2009, local governments have delegated their right to management and control of pasture grazing to local Pasture User Associations (PUA). Now PUA is responsible for the development of pasture management and use plans, in line with existing national regulations (Bussler 2010).

PUA is a recent institution, established only in 2009. The officials of the PUA are not qualified in pasture management by education. Therefore, there is need for expert knowledge on the floristics and ecology of pasture communities and on the impact of different grazing regimes. It is also very important to establish criteria to evaluate pasture condition, for example by identifying plants which are indicators of pasture degradation. All this is a necessary basis for sound and sustainable pasture management.

The purpose of this project was to study the relationship between plants dynamics in relation to livestock grazing in the semi-arid vegetation type of the near village pastures. Based on the overall goal, the specific objectives were set, as follows:

- Describe the use and grazing history of the AA pastures and their botanical composition.
- Discuss the impact of grazing on semi-arid pastures and on pasture degradation
- Develop approaches for the ecological description and evaluation of AA pastures
- Outline the basis for further work on developing methods for pasture evaluation in Kyrgyzstan and recommendations for improved pasture management.

1.1 The Kyrgyzstan AA pastures: species composition, ecology and characteristics

1.1.1 The natural vegetation of the region

Up to 1984, the vegetation of Central Asia had been described by many reputable scientists but only in very general terms (Halmuhamedova 1984). In 1984, Halmuhamedova described the history of the vegetation of Fergana in Central Asia through pollen analysis. She concluded that the formation of vegetation in the Central Asian mountains was greatly influenced by the Pleistocene glaciation, which was characterized by high humidity and a severe climate that was wetter and colder than at present. This conclusion was supported by a paleontological study that demonstrated the existence of oak trees (*Quercus* sp) in Quaternary sediments in the Dzhilanchak river valley (Chatkal ridges north-east part of the Fergana valley). Currently in Central Asia, oak does not grow naturally. Previously, Nalivkina (1908) as cited by Halmuhamedova (1984) had suggested that the post-glacial climate became more arid and the Central Asian steppes were replaced by dry semi-deserts.

The western slope of the Fergana ridge has features of a subtropical climate type. Some geobotanists classified the vegetation of these areas as semi-desert (desert steppe), with the dominance of ephemerals and ephemeroids or semi-savanna short grass. Historically, semi-deserts are formed from old steppes 25-30 million years ago (Avdeev 2012). However, the climate regime and the rhythmic fluctuations of environment in the south of Central Asia, have nothing in common with those in the tropical savannas (Gvozdetskiy & Mihaylov 1970). Ephemerals and ephemeroids are "vegetation" that often come after the disappearance of forest flora. Even as part of savannah and desert ecosystems, trees and bushes are favourable ecological niches and maintain a forest character. These characteristics of flora are much more similar to the forest rather than to the steppe or desert conditions (Safarov 2013).

1.1.2 The study area and its climate

The study area selected is Talduu-Bulak AA which is located in the Bazar-Korgon district of the Jalalabad region (southern part of Kyrgyzstan within the Fergana Valley) (Fig. 1). This area was selected because the necessary data were available.

According to local experts on land management, the total area of pasture land is 9,277 ha, of which 5,631 ha are spring and autumn pastures and 3,667 ha are summer (distant) pastures. Also in the AA there are 1,202 ha of hay land. This therefore makes the total area of grazing land in Talduu-Bulak to be approximately 11,184 ha (K. Nurseitov, May 2013, local land manager - Talduu-Bulak AA).

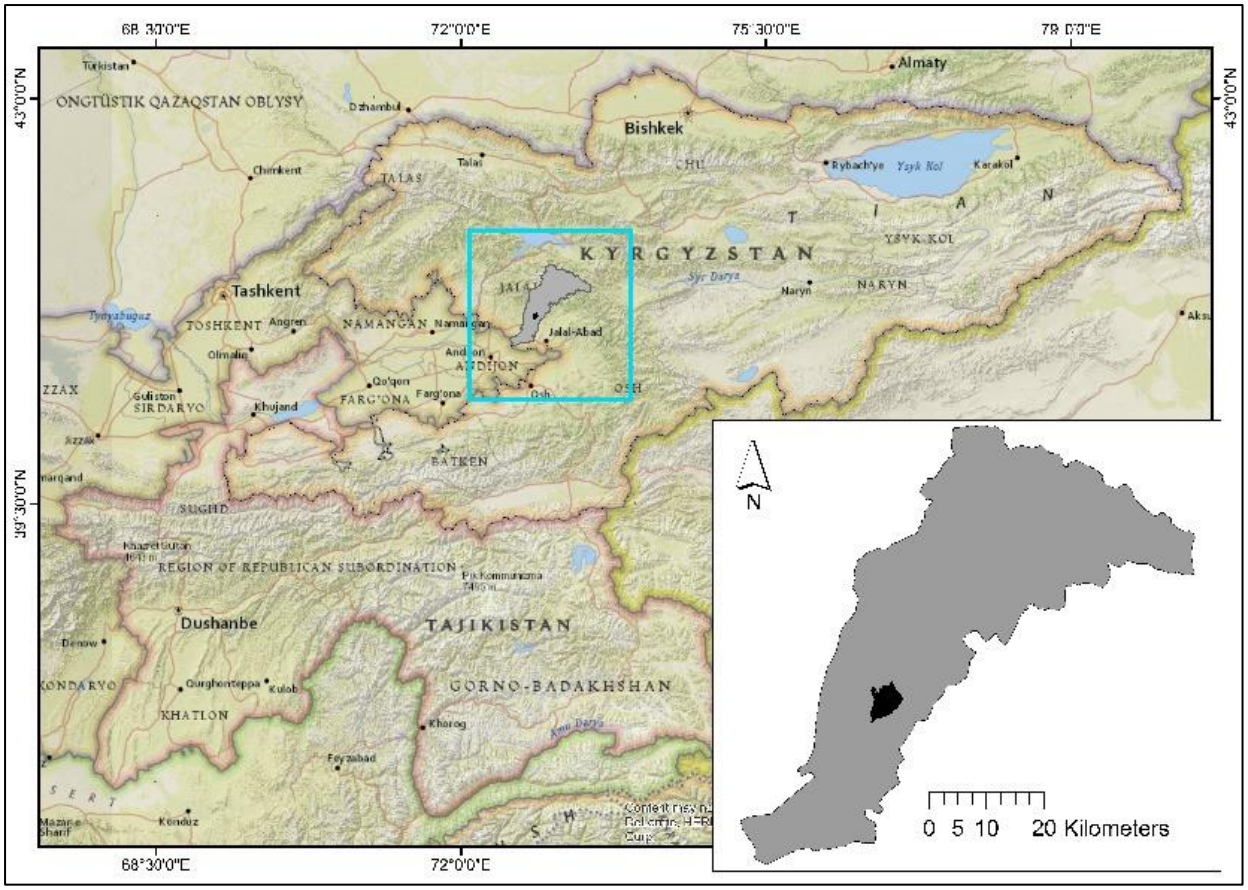

Figure 1. Location of Bazar-Korgon district and Talduu Bulak AA on the map of the Kyrgyz Republic. The territory of the district is shown by grey colour within the blue frame, and black marks show the study area in Talduu Bulak AA in Bazar Korgon district. *(Source: National Geographic base maps and archive of PF CAMP Alatoo).*

In terms of climate, Bazar-Korgon district lies within the warmest region of Kyrgyzstan. Except for the south-west, this climatic zone is surrounded by mountain ranges. In the north-west and north is the Chatkal ridge and its spurs; in the south are the Alai and Turkestan ranges, and the Fergana Range spans the whole area from west to east up to the north-east. These physical features have greatly influenced the climate of this area and this too has a direct impact on the growth of vegetation in the pastures. The effects of cold air currents moving from the north are weak. The climate of the Fergana region is characterized by three main features: it is continental, dry, and has a strong vertical climatic zonation (PF CAMP [Public Foundation Central Asian Mountain Programme] 2014).

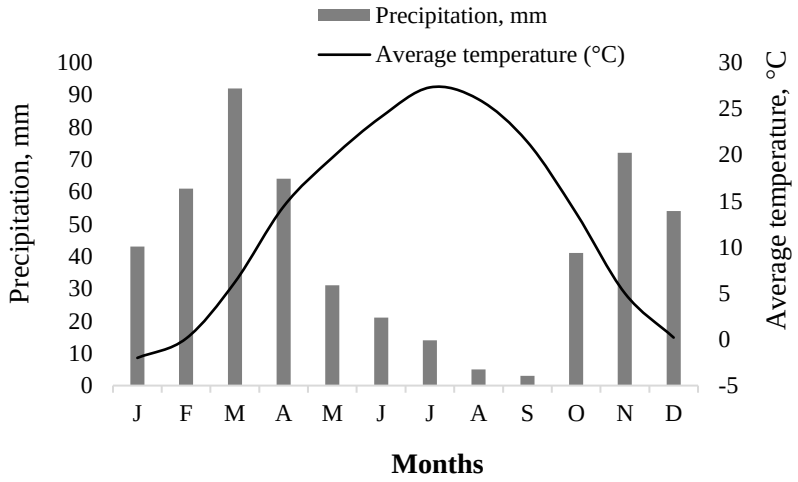

Figure 2. Climate diagram for average monthly precipitation and temperature from Ak Terek meteorological station (1,748 m a.s.l.) based on data recorded from 1983 to 2007 (Borchardt et al. 2011).

2. MATERIALS AND METHODS

2.1 Species composition in the AA pastures

The data used were obtained from two studies conducted by KyrgyzGiproZem in 1983 and CAMP Alatoo in 2013 in the same area in Talduu-Bulak AA (Kyrgyzstan). In 1983 experts from the KyrgyzGiproZem Institute conducted a geo-botanical expedition to the natural pastures of Talduu-Bulak AA. The data available from this survey include vegetation type, dominant species, foliage cover and productivity.

In 2013, specialists from PF CAMP Alatoo conducted a field survey in the same area of the Talduu-Bulak AA. This study was conducted two times in June and September, using field methods developed by the specialist staff. Following the sampling design, 7 plots were allocated (10 m x 10 m), as shown in Figure 3. Within each plot, 5 subplots of 1x1 meter were selected. Within these 5 subplots, firstly, all vascular species were recorded and total above ground cover of the 1x1 subplot estimated, as well as identification of the palatability of each species.

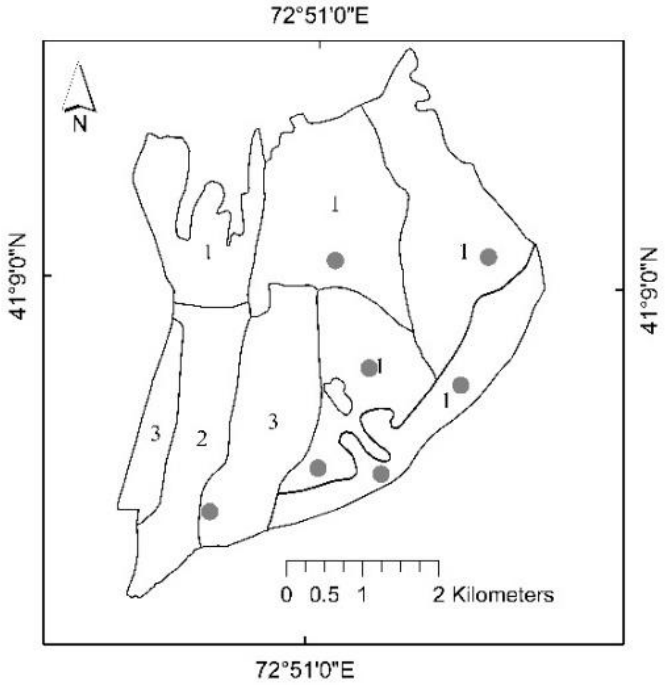

Figure 3. Distribution of monitoring plots in the study area and the dominant vegetation types of nearby pastures in Talduu Bulak AA in Kyrgyzstan. 1, ephemeral sagebrush; 2, ephemeral mug-wort; 3, cheat grass and forb. The grey circles are monitoring plots where the 59 species were recorded.

The vegetation cover in the study area is represented by semi-arid (desert) vegetation, characterized by widespread xerophytic plant species. Botanically, the village pastures are classified as desert and semi-desert grasslands and characterized by low productivity which does not exceed 0.2-0.4 t/ha/yr. (Shihotov et al. 1981). According to the botanical classification, monitoring plots were separated into three vegetation sub-types, as shown in Table 1.

The list of dominant species in three vegetation formations contained 11 species (Table 1). Only four *(Poa bulbosa, Hordeum bulbosum and two Artemisia taxa – A. tenuisecta, A. glandulifera)* are perennial. The rest are annuals with short life cycles. In addition to the 11 dominant species, another 48 species were recorded during the survey in 2013.

Table 1. Vegetation types, vegetation formation and dominant species in surveyed plots in nearby pastures Talduu-Bulak AA in Kyrgyzstan

Index	Vegetation type	Vegetation formation	Dominant species
1.	Semi-desert	Sagebrush-ephemeral with dominancy of *A. tenuisecta*	*Artemisia tenuisecta, Aegilops cylindrical, Bromus danthoniae, B. oxyodon, Phleum paniculatum*
2.	Semi-desert	Sagebrush-ephemeral with dominancy of *A. glandulifera*	*Artemisia glandulifera, Aegilops cylindrica, B. oxyodon, Taeniatherum crinitum*
3.	Semi-desert	Cheat grass and forb	*B. oxyodon, Hordeum bulbosum, H. leporinum, Aegilops cylindrical, Phleum pratense, Poa bulbosa, Taeniatherum crinitum*

Deserts with sagebrush vegetation types in the Fergana valley are mainly confined to low foothills at an altitude of 600 to 1000-1600 m above sea level; they are represented by formations of *Artemisia*. These desert pastures are dominated by ephemeral and ephemeroids. Ephemerals (short-lived annuals) and ephemeroids (short-lived perennials) plants have a great pastoral value and are important for grazing in the early spring, autumn and winter seasons. The complete list of species, sorted by family, are presented in Table 2.

Table 2. List of plant families with number of species recoded in the nearby semi-desert pastures of Talduu-Bulak AA in Kyrgyzstan

#	Family	Number of species	#	Family	Number of species
1.	*Alliaceae*	1	9.	*Gentianaceae*	1
2.	*Amaranthaceae*	1	10.	*Geraniaceae Juss.*	1
3.	*Asphodelaceae*	1	11.	*Lamiaceae*	3
4.	*Asteraceae*	12	12.	*Plantaginaceae*	1
5.	*Brassicaceae*	1	13.	*Poaceae*	22
6.	*Capparaceae*	1	14.	*Polygonaceae*	1
7.	*Convolvulaceae*	1	15.	*Ranunculaceae*	2
8.	*Fabaceae*	8	16.	*Rosaceae*	2
				Total	**59**

The 59 species from the study area are shown in Figure 4 according to their life form (annual, biennial and perennial) and growth form (grass, herb and shrub). Amongst the listed species, 22 are grasses, 35 herbs and two are semi-shrubs. From the 59 available species, 46 of them are palatable and the remaining 13 are not. Information on palatability for the rest of the species is given in Appendix 1.

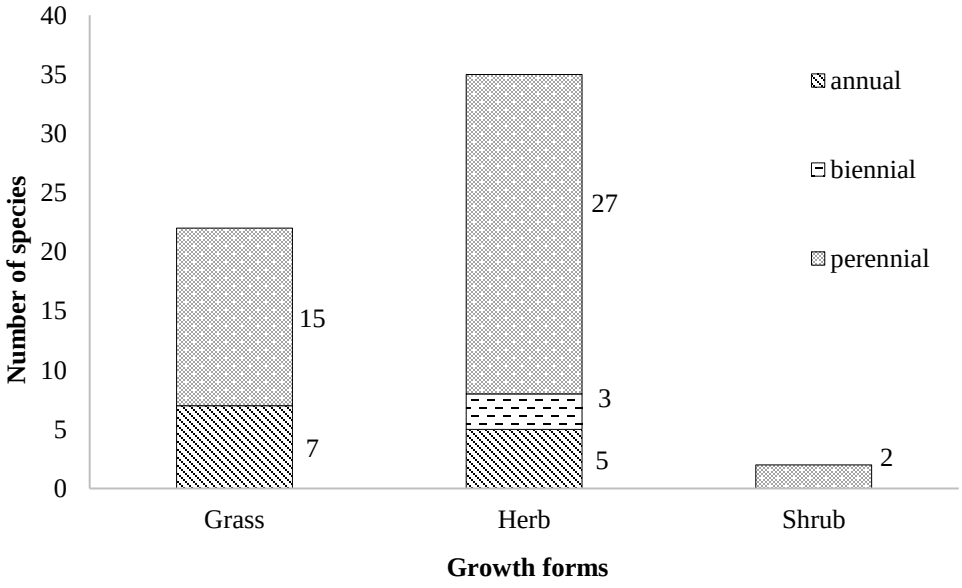

Figure 4. Growth forms (grass, herb and shrub) of recorded species in the nearby pastures of Talduu Bulak AA in Kyrgyzstan. Nomenclature of these species was listed during the monitoring of nearby pastures of Talduu Bulak AA in Kyrgyzstan in 1983 and 2013.

As shown in Figure 4, seven grass species and three herb species are annuals. The list of these annuals is given in Table 3 below. Following the characteristic features of annual ephemeral grass species in pastures within desert and semi-desert pastures, seven species have been selected in order to study proper control strategies in relation to grazing so as to maintain them.

Table 3. List of annual species recorded in 1983 and 2013 in Talduu-Bulak AA (Kyrgyzstan) nearby semi-arid pastures

Annual grasses	**Annual herbs**
Aegilops cylindrica	*Ceratocarpus arenarius*
Bromus danthoniae	*Capsella bursa-pastoris*
Bromus oxyodon	*Trigonella arcuata*
Bromus squarrosus	*Medicago lupulina*
Hordeum leporinum	*Medicago minima*
Phleum paniculatum	
Taeniatherum crinitum	

2.2 Pasture degradation: the effects of overgrazing on the plant community

Intensive grazing can change vegetation cover within 4-5 years (Shihotov et al. 1981; Kitaeva 2016). As a result of overgrazing and cessation of rotation in pasture use, plant growth potential has been strongly inhibited (Shihotov 1981). The most valuable legume and cereal-type grasses have been lost. Overgrazing has had a positive impact on unpalatable plants which have then increased in cover and thereby had a negative impact on the productivity and species composition of the near village pastures (Ministry of Agriculture and Water Resources of the Kyrgyz Republic 2000).

Several studies have dealt with the relationship between livestock grazing management or mismanagement on the palatability ratio (palatable aboveground biomass vs total above-ground biomass) in a pasture. Grazing alters the competitive hierarchy of species and can cause shifts within the plant community from palatable to less palatable species (Arnalds & Archer 2000). Havstad et al. (2000) noticed that degradation in desert pastures is often accompanied by encroachment of long-lived woody shrubs which will replace the desirable perennial herbaceous species.

At present in Kyrgyzstan, there is no detailed study on classification of pasture flora and analysis of their ecological traits in order to develop relevant indicators of conditions for each pasture unit. This is important to estimate changes in species richness and composition and fluctuations in biomass and hence illustrate the succession pathway in the ecosystems. Functional group analysis of the plant communities may reflect the impact and the intensity of disturbances and to predict them in order to sustainable ecosystem management. But, unfortunately, published information on the ecology and classification of the Tien Shan pasture plant is scarce (Borchardt et al. 2011).

It has often been assumed that changes in steady states and crossing of thresholds is related to woody plant dominance and/or soil degradation (Svejar & Sheley 2001). The shift to annual dominance may also be viewed as a threshold shift, but the mechanism is unclear yet. It was argued that in semiarid grasslands, climate warming may be expected to shift the composition of plants

towards short-lived species. And according to the SAEPF (2006), it has been observed that overgrazing on the near village pastures promoted development of unpalatable rough-stemmed plants. Other authors also noticed that the abundance of annuals indicated strong overgrazing in a pasture area (Duysenbekov et al. 2014; Fedorova & Muchkaeva 2015). These are all warning indicators of different levels of pasture degradation. Based on these indicators I have constructed a conceptual model (Fig. 5) reflecting different degrees of semi-arid pasture degradation in Kyrgyzstan. Although this model is not actually possible to develop using data from 59 species alone, this model has been formulated based on the literature about the semi-arid pastures and succession trends with regards to degradation. In this regard, further research must be carried out to cover a wider range of information about the vegetation of the semi-arid pastures of Kyrgyzstan. Also, the analysis of annual plants must take into account their susceptibility to fluctuations, depending on the annual precipitation. Therefore, we consider it necessary to have data for at least three years.

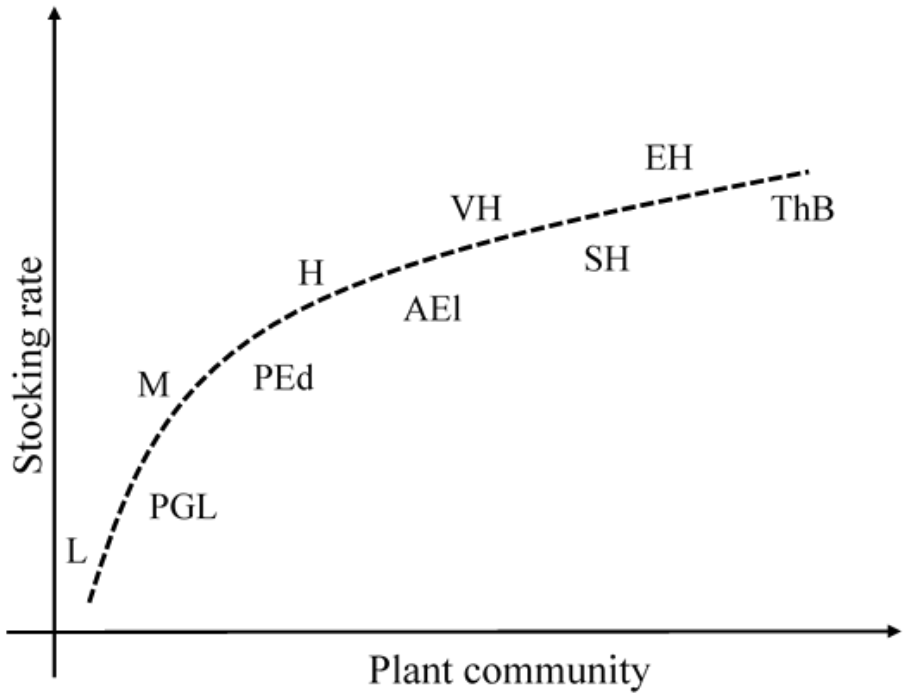

Figure 5. Conceptual model of the succession of the semi-arid pasture vegetation and conditions. Attributes under the line, from desirable species to thorny bushes, refer to the different pasture plant communities and refer to plant community condition (PGL, palatable perennial grasses and legumes; Ped, palatable ephemeroids; AEl, annual ephemerals; SH, stemmy herbs; ThB, thorny bushes). Attributes above the line show different levels of grazing pressure exerted on the plant community (L, low; M, medium; H, high; VH, very high; EH, extremely high grazing pressure).

2.3 The concept of thresholds

The study of changes in plant communities arouses a great interest among scientists. Eventually, the main objective of these studies is improvement of human activities for the sake of sustainable use of natural resources. The prospect for abrupt changes in the environment is a signal to managers because it indicates that a system can be more susceptible than it seems (Suding & Hobbs

2009). There are a number of study approaches for environmental changes and threshold theory is one of them. A concrete explanation for the threshold model was given in the following paper "Threshold concepts and their use in range management and restoration: The good, the bad, and the insidious" by Bestelmeyer (2006):

> *"The threshold concept has become a major theme in ecology and natural resources management. Ecological thresholds are used to describe the non-linear and persistent reorganization of ecosystem properties (i.e., states) in response to gradual or discrete changes in environmental patterns and drivers. Crossing thresholds leads to loss or recovery of ecosystem functions and bio-diversity. The significance of thresholds for management has made them a key emphasis in restoration ecology, landscape ecology and rangeland ecology. The concept has been used to discuss natural resource issues within the U.S. Senate. In the United States, ideas about thresholds are beginning to influence public land management policies and to determine federal assistance provided to private landowners"* (Bestelmeyer 2006, p. 325).

However, the threshold model cannot be applied uniformly to different ecosystems since ecosystems differ in their responses to disturbances. Therefore, dynamics of changes and thresholds are nonlinear. This makes application of the threshold model complicated (Groffman et al. 2006; Suding & Hobbs 2009).

In Kyrgyzstan, the threshold model has not been used at all. Even the state and transition model which is more practical has not been used though it is considered easier in application with experts in a certain system (Spooner & Allcock 2006). Nevertheless, as evidenced in the literature, sources determine thresholds in ecosystems, and different states with their transition pathways are more or less covered by the life forms analysis of plants. However, this is a limited explanation for thresholds and states transition pathways since it is only focused on plant species traits. Life form analysis in scientific articles written in Russian more or less fit the concept of functional group analysis. Nevertheless, functional group analysis is broader than life form analysis that mainly follows bio-morphological structure classification by Raunkiaer from 1934 and Serebryakov from 1962 (Aipeisova 2009).

2.4 The shift towards short-lived species as an indication of pasture degradation

Archer & Stokes (2000) and Sassi et al. (2009) have reported that short-lived grasses are more tolerant to defoliation than taller grasses. The short-lived species that are less palatable, are mostly annuals, and they often thrive after significant disturbances in response to environmental stress. This has been one mechanism of evolution of species in desert ecosystems. Annual species often become dominant after severe drought, thereby ensuring their high abundance within a plant community (Espigares & Peco 1993). Because annuals, in contrast to perennials, have short periods of active growth and long periods of seed dormancy, they will remain dormant during a drought until they get enough moisture during a rainfall (Sassi et al. 2009). This was seen Mongolia in 2007, when annuals dominated after steppe pastures experienced severe drought, and these continued being dominant for several years (Kinugasa et al. 2016).

According to Ionov (2003), a shift in plant community on the semi-arid pastures toward ephemerals and ephemeroids (annuals and perennials with a short life cycle), which usually occurs

in springtime is due to climate change. This is mainly expressed in a decrease in annual precipitation and an increase in air temperature since the productivity of desert pastures is strongly coupled with precipitation (Maliha et al. 1999). Abundant existence of ephemeral vegetation in the desert areas of the Turkestan mountains (which includes the study area as well) has been noticed by several scientists (Gvozdetskiy & Mihaylov 1970; Stotzky 1991; Avdeev 2012).

Duysenbekov (2014) and Fedorova et al. (2015) noted that replacement of perennial plant species by palatable annuals, which have a lower forage value, reflects a dangerous degree of pasture degradation. Underlying this statement is the assumption that the economic value of annual species is very low in comparison to perennial species. In contrast, several authors looking at issues from ecological perspectives have said that annual plants are an important component of desert rangeland vegetation in terms of biodiversity and even in forage value (Institute of Botany under NAS of USSR 1934; Kyrgyz Branch of NAS [National Academy of Sciences] of USSR 1950; Taganov 1965; Maliha et al. 1999). Annual grasses are palatable, even though they are not highly desirable, they support livestock grazing. Furthermore, the annual species fix nutrients in the soil and provide conclusive conditions for perennial species and better competitors with other weed species (Brooks & Esque 2000). Also, the existence of annual species indicates the suitability of that place for cropland development (Taganov 1965).

In the list of recorded species from the study area of Talduu Bulak, there are four ephemeral brome grasses (*Bromopsis inermis, B. danthoniae, B. oxyodon and B. squarrosus*) and three barleys (*Hordeum bulbosum, H. jubatum and H. leporinum*). All these are short ephemeral grasses which are typical of semi-desert areas (Avdeev 2012). This implies that all these annual ephemeral species are native in Kyrgyzstan semi-arid pastures, although all brome grasses have a tendency to become weedy (Avdeev 2012). But being weedy means that annual ephemeral species can withstand competition from undesirable species. Moreover, annual species can facilitate establishment of desirable species by creating safe sites for germination and seedling survival (Taganov 1965). Early successional species may cause changes in soil properties that would facilitate later succession or more desirable species (Lacey & Sheley 1996). Having knowledge about management and proper treatment of these species means that the succession processes can be shifted to desirable directions.

3. RESULTS AND DISCUSSION

3.1 Approaches to the ecological description of AA pastures and their conditions

Approaches used in this study were developed based on methods of analysis of structural and functional traits of plant communities, which was in a way an analysis of ecological characteristics. The use of plant morphological and phenological information data sheets from the available literature was the first step in the approach, to compile a list of the recorded 59 species in Talduu Bulak AA. The ecological traits of the species considered in this project were then analysed. Information was collected from the Flora of Kyrgyzstan and the Flora of the USSR, published in the USSR era from 1930s to 1960s. The data sheet consisted of information about species such as height, blooming period, life and growth forms, palatability, and also further information for annual grass species was collected, providing data on the amount of seeds, seed

germination and soil-seed bank, information about whether ephemeral or non-ephemeral, whether spring or winter annuals, their weedy features, and forage value.

3.2 The main species, their ecology, role and usefulness in the pastures

3.2.1 Main species groups: grasses, legumes

Complete lists of species, sorted by family, are presented in Table 2. The family Poaceae includes the greatest number of species (22) (37.3%). Grasses and legumes are the most valuable forage species. Legume species in terms of nutrient content and palatability rate better than the grasses. But an increased amount of nutrients, especially proteins, is accompanied by the presence of toxic substances (Medvedev & Smetannikova 1981). Therefore, some legumes are harmful to cattle, especially when they are consumed damp. Cattle can be affected and get ruminal tympany / bloat (McIntosh 1937) and in the list of legume species included, three species of *Medicago* and two species of *Trifolium,* for example, contribute to this. Therefore, grass species as pasture forage are highly preferable to legumes.

The results show a relatively high diversity of plant species, and this means that these pastures have potential to be a seed source. These pastures, despite being considered degraded in terms of cover and productivity, in terms of forage plants actually have high diversity. The diversity of the community shows to what degree the ecosystem has the capacity to heal itself (Elmqvist et al. 2003). On the other hand, the composition includes a lot of weeds. Many of these plants (*Onopordum acanthium, Cirsium arvense, Alhagi pseudalhagi, Sonchus oleraceus, Capsella bursa-pastoris,* etc.) are not palatable species. Therefore, there is a need for anti-weed activities against these plants on the part of the pasture committees on site. Furthermore, these species need to be studied in more depth in Kyrgyzstan in order to be able to indicate whether and how much their presence is a sign of overgrazing.

3.1.1 Introducing the functional groups concept, its meaning and uses

Plant life forms reflect their adaptability to environmental conditions and are units of ecological classification by groups of plants with similar adaptive structures (functional groups). The study of the plant community and its constituent floristic complexes cannot be completed without an analysis of functional groups, since it is important to address both theoretical and practical issues. Functional group analysis of plant communities has been derived in different ways, depending on given objectives (McIntyre & Lavorel 2001). But the main aim behind of all these studies is identification of groups responding in similar ways to given specific factors (Steneck & Dethier 1994).
Currently, the conditions of pasture resources in Kyrgyzstan are being estimated according to their productivity and by other economic criteria. But productivity cannot be used as an estimate of biological diversity. In a review of the national Kyrgyzstan literature, information on the value of annual grasses was limited to their economic importance as forage for livestock. Therefore, the basic data were found in foreign literature and functional analysis was done on the basis of the methods used by McIntyre and Lavorel (2001), which they developed for subtropical pastures in Australia and work done in Saudi Arabia by Al-Rowayly (2015).

3.1.2 Classification of the species by morphological and phenological traits

In this study, all recorded plant species have been classified by life forms, height and other morphological and phenological characteristics (Table 4). In addition, we have added to the classification reproductive traits and distinguished between ephemeral and ephemeroid life cycles. The features of ephemeral plants were described in the introduction.

Table 4. Classification of the recorded 59 species in 1983 and 2013 in Talduu-Bulak AA (Kyrgyzstan) according their morphological and phenological traits. Traits reviewed in the literature and analysed into the three functional groups: grasses, herbs and shrub.

Trait	**Number of species with attribute**								
	Grass			**Herb**			**Shrub**		
PLANT MORPHOLOGICAL TRAITS	(cm)			(cm)			(cm)		
Table height (cm)									
Short	(<35)	8		(<25)	5		(<40)	1	
Medium	(40-55)	8		(30-55)	8		(40-65)	1	
Tall	(>65)	6		(>60)	14		(>70)		
	An.	Per.		An.	Bien.	Per.	Per.		
Length of life-cycle									
Short (≤2 month)	2	6				7	1		
Normal (≥3 month)	3	6		2	1	7	1		
Long (≥4 month)	2	3		3	2	13			
PLANT PHENOLOGICAL TRAIT									
End of blooming (month)									
Spring (March-May)	2								
Summer (June-July)	3	6		5		4			
Autumn (August)	2	8				5			
Late autumn (September-November)		1			3	18	2		
PLANT REPRODUCTION TRAIT									
Regeneration pattern									
Seed	7	15		5	3	27	2		
Bulbous		2			-	1	2		
PALATABILITY									
Palatable	7	15		4	2	16	2		
Unpalatable				1	1	11			

An., annual; Bien., biennial; Per., perennial.

Of the species, 46 (77.96%) are palatable while 13 are considered unpalatable. The dominant life forms are perennials - 45 species.

Grasses, whether perennial or annual, are all palatable. Although annual grasses are less palatable compared to perennials, appropriate use of annual grasses during the early stage of development can ensure efficient grazing. Detailed information on the palatability and the appropriate time of use are given in Table 5.

Table 5. Description of seven native weedy annual grass species in nearby village semi-arid pastures in Talduu Bulak AA in Kyrgyzstan.

Species	Site adaptation	Palatability and forage value	Reference
Aegilops cylindrical	Foothills, terrains in sandy weedy areas	Well eaten by adult and young cattle and horses in spring. Palatability drops rapidly as plants flower and mature because they become tough to graze. Also, its awns become sharp with maturity, thus avoided by livestock. However, it can be effectively grazed when young.	[2; 3]
Bromus danthoniae	On dry stony slopes	Well eaten at a young age, the palatability decreases dramatically after spikelets develop. In June, the spikelets fall off and plant no longer grazed. The best time to graze it is the end of eating (the beginning of flowering) as its food value is lost.	[2; 3]
Bromus oxyodon	Valleys and foothills where agriculture is practised	In spring and summer, satisfactory, eaten by all types of livestock. Shoots of brome grass in autumn provide green fodder. In spring, it is edible before seed head formation; during first mowing period it is the main grass in old Lucerne (*Medicago sativa*) fields. It may be recommended for introduction in culture as early spring pasture forage.	[2; 3]
Bromus squarrosus	Low valleys and foothills, arid zones, overgrazed pastures, fields, waste places, and road verges, waste ground	Cattle on an autumn pasture willingly eat it. Does not have economical value since it grows sparsely. During prolonged good weather with rainfall, these "winter brome grasses" grow up to 15 cm and can be mowed for winter forage. Considering the scarcity of autumn feed, ephemeral bromes should be sown on these pastures in order to have autumn feed. In the autumn after the rain, brome shoots appear on the foothills and valleys and are as dense as if sown.	[2; 3]
Hordeum leporinum	Agriculture areas, valleys and foothills, fallows	Autumn shoots provide forage with seedlings of ephemeral brome grasses. In the spring before heading, green mass of barley is readilyeaten; after flowering, stalks grow coarse and palatability declines. It has large number of awns and by flowering and getting dry it becomes tough for animal feed, though well eaten in early vegetative stage. It should be grazed severely at early stages in order to control seed production.	[2; 3]
Phleum paniculatum	Valleys and foothills, sunny slopes, stony places, abandoned crop fields, dry meadows	Willingly eaten by horses; cattle like it less - considered bad pasture plant of less value. During autumn and winter, it is well eaten by sheep and camels. Growth begins in early spring and becomes dry in summer. During early spring, it has an average amount of protein but later in the summer, the protein content drops sharply. Worthwhile for testing in the cultural pastures of the desert zone.	[2; 3]
Taeniatherum crinitum	In the valleys and slopes in the agriculture. areas, stony foothill zones.	Livestock will eat when it is in the vegetative stage and significant reductions in plant populations are possible within 2 years of heavy grazing at high stock density. Livestock use of the plant declines rapidly as the plant matures. Weed, the rigid spine causes damage to the animal mouths while eating it as hay (if the plant is harvested later for hay). Autumn shoots play a significant role in the creation of autumn green fodder on the foothills and valleys alongside brome grass shoots Livestock can be effective grazers it if they are allowed to graze on it as soon as enough plant material is available to sustain grazing and heavy utilization levels can be achieved.	[1; 2; 3]

[1] Davison (2013); [2] Institute of Botany under NAS of USSR (1934); [3] Kyrgyz Branch of NAS of USSR (1950).

Weedy species are tolerant to disturbances. It is justified by their weediness. The main 12 characteristics which make plants weedy and become dominant in a system are listed by Baker (1974). Among these characteristics, rapid growth through vegetative phase to flowering and high seed output are listed. A look at the annual grasses from the study area in Table 6 shows that all of them are high seed producers.

Besides weediness which makes them high seed producers, annuals in general have larger seed outputs than perennials. This statement was confirmed by Primack (1979), that *Plantago spp* produce larger amounts of seed than the perennial forms. He also reviewed Pitelka's paper from 1977 who had found that annuals of *Lupinus spp* also has larger seed output compared to the perennial counterparts.

Table 6. Seed characteristics of annual grass species in nearby pasture of Talduu Bulak AA, Kyrgyzstan

Species	Seed production	Seed longevity in soil	Germination rate	References
Aegilops cylindrica	3000 seeds or more per plant	3-5 years	72-86%	[1; 13; 4]
Bromus danthoniae *Bromus oxyodon* *Bromus squarrosus*	700-1200 seeds per plant	4 years	88,27%	[6; 2]
Hordeum leporinum	720 seeds per plant	Seed longevity in the soil is expected to be at least a couple of years	97%	[7; 5; 12]
Phleum paniculatum	400 - 1,000 seeds per plant	2 years*	84%	[10; 9; 8]
Taeniatherum crinitum	1,400 to 60,000 seeds m-2	≥2 years with very few seeds surviving for three years or more	100%	[3; 11]

[1] Anderson et al. (2002); [2] Atkinson (2013); [3] Coebel et al. (1988); [4] DiTomaso & Kyser (2013a); [5] DiTomaso & Kyser (2013b); [6] Fenesi et al. (2011); [7] Fleet & Gill (2012); [8] Fransen & Chaney (2002) * Seed longeviry in soil has been given for *Phleum pratence;* [9] Julve (2016); [10] Koul (1971); [11] Kyser et al. (2014); [12] Popay & Sanders (1975); [13] Quinn et al. (2006).

It is evident from Table 6, that all seven annual grass species produce large amounts of seeds. Additionally, the seed germination rate for each species is remarkably high, from 72% up to 100%. Among these species *Taeniatherum crinitum* has a very high germination rate which makes it very aggressive (DiTomaso et al. 2008). Pastures that face degradation due to overgrazing or other types of disturbances are highly susceptible to *Taeniatherum crinitum* encroachment (Kyser et al. 2014).

As already mentioned, annuals exert a great reproductive effort compared to perennials. Primack (1979) also stated that all early spring annuals (called winter annuals in the Russian literature) can contrast with middle or late spring flowering annuals in terms of seed production. Early spring annuals produce larger amounts of seeds. As shown in Table 7, all seven annual grasses are winter species. The statement of Primack (1979) regarding higher productivity of winter annuals was validated by Prohorov (1993). He attributed this to their germination during autumn rainfall and

development within early spring when soil moisture is good enough (Prohorov 1993). This also applies for ephemeral species, which are represented in the list of annual grasses by two species *Hordeum leporinum* and *Phleum paniculatum.* The wider description of ephemerals has been given in the paper below:

> *"Ephemeral plants (or short-lived plants) are a group of plant species which are able to complete their life cycle quickly and successfully at the end of spring or the beginning of summer by using the available melting snow and rain water, and then get through the harsh environment in the form of seeds; they exhibit lots of special characteristics, such as fast growth and development, high efficiency of photosynthesis, strong capability of reproduction and seed setting, etc."* (Lan & Zhang 2008 p. 1478).

Table 7. Blooming time of seven annual grasses recorded in 2013 in Talduu Bulak AA, Kyrgyzstan

Species	Season of development	Blooming period	References
Aegilops cylindrica	Winter	May	[1]
Bromus danthoniae	Winter	March-May	[1]
Bromus oxyodon	Winter	April-June	[1]
Bromus squarrosus	Winter	June-July	[1]
Hordeum leporinum	Ephemeral winter	June-July	[1]
Phleum paniculatum	Ephemeral winter	May-June	[1]
Taeniatherum crinitum	Winter	April-July	[1]

[1] Kyrgyz Branch of NAS of USSR (1950).

Information about blooming period for others of the recorded 52 species is available in the data set in Appendix 1.

3.1.3 Annual species: good or bad?

Most of the annual grasses are important forage species in semi-desert pasture conditions (Maliha et al. 1999). For Kyrgyz semi-desert pastures, the Kyrgyz Branch of the NAS (National Academy of Sciences) of USSR (1950) recommended that maintenance of annual brome species should be offered for the sake of forage in the autumn. But some annual grasses such as *Bromus tectorum* and *Taeniatherum crinitum* have been recognized as a symptom of pasture degradation because of their low forage quality. These annual grasses may become dominant and replace other valuable species (Stonecipher 2015). As in Table 3, the list of annuals includes seven species of grasses and three of herbs. Among seven annual species recorded from the study area, *Taeniatherum crinitum* is also present. The information on palatability and forage value for these seven annual grass species is presented in Table 5. The palatability rank of the seven annuals is lower compared to perennials due to their awns, which make them almost unpalatable by becoming sharp and tough. The sharp awns of annuals damage the mouths of animals. Therefore, annual grasses are not desirable as forage. However, winter annuals are important ecologically as they provide vegetative cover that prevents soil erosion during winter and early spring when no other cover exists. They

also provide fresh vegetation for livestock (Kyrgyz Branch of NAS of USSR 1950). Therefore, information about the growing season of annuals is given as well.

The environmental and economic characteristics of annual grasses are important aspects of the evaluation of their forage value. Because they are palatable at an early stage, recommendation for their use as a pasture grass was made for the relevant period. The basic characteristics of annual cereals are summarized as follows:

- Negative features of annual grass species

  a) Annuals have a tendency to become weedy and produce large amounts of seeds, which makes them weedy and undesirable (Table 7).

  b) Annuals are less palatable in comparison to perennials; have awns which become very sharp and tough after forming spikelets. Therefore, after earing, the annual grasses are almost not palatable (Table 5).

- Positive features of annual grass species

  a) Annual grasses fix nutrients in the soil and provide conditions for perennial species and better competitors against other weed species.

  b) Annuals are palatable in early growth stages in spring and late autumn. Therefore, they are valuable forage in pasture units in the autumn (Table 5).

On the basis of the above positive and negative characteristics of annuals, it is in each case possible to develop recommendations for pasture committees. For example, in order to restore the severely degraded grazing areas, annuals must be maintained. While in good condition, perennials have a good potential to take over annuals.

However, according to Svejar and Sheley (2001) there are cases when brome grasses replaced native perennials even though there had been no historic grazing. Tausch et al. (1994) suggested that there is a gradient of environmental potential, with annuals being very competitive in an arid area and perennials more competitive in more humid area (Tausch et al. 1993). This opens a new area for study of the behaviour of the brome grasses within the hydrological properties of the study area.

3.3 Developing ecological indicators of pasture conditions and recommendations for improvement and management of pastures: a preliminary proposal

The “trait” concept allows us to understand the expression of different functions in plants. It helps us to comparatively study species ecology (the same as functional ecology) (Garnier & Navas 2012). The results of the comparative analysis have been presented in the previous section and discussion is continued below.

3.3.1 Height of the species

The statement from Pavlu et al. (2003) about short plants showing a greater stability and tolerance to grazing pressure as compared to tall plants has been considered in this analysis. The most striking result was obtained by the example of grasses; among 22 cereals, seven were annuals with short heights. During the analysis of plant heights, all annual grasses except *Bromus oxyodon* were in the class of short plants. I classified the 59 plant species on the basis of being short, medium or tall. This once more confirms that the short annuals in degraded semi-desert pastures are more stable then tall plants (Osem et al. 2002). Perennial grasses, however, always have a natural competitive advantage over annual grasses because the preceding root growth lets them maintain contact with obtainable soil moisture. This argument supports the "inhibition" model proposed by Connell and Slatyer in 1977 on secondary succession. According to this model, the perennials which exist in a place already have advantages to resist invasion by competitors. The first occupants pre-empt space and continue to exclude or inhibit later colonists until the former die or are damaged (Borman et al. 1991).

3.3.2 Blooming time and life cycle of annual grasses

All perennials (both grasses and herbs) bloom from late July to late autumn (late October), as shown in Table 4. While most annuals' blooming time will not reach August and they complete their life cycle in June and July, two species - *Aegilops cylindrica* and *Bromus danthoniae* finish their life cycle within May. This is due to the climatic regimes of the region (see Fig. 1) since the peak of the hot days and a low level of precipitation fall between the end of July to the end of September – thus annuals complete their growth before this dry period. The growth and reproduction of spring ephemeral plants appears to represent a specific adaptation to the short period of high resources availability (i.e. light, water and nutrients). This occurs just after snow melt and canopy opening. Then light reaches the understory in temperate deciduous forests, and at such a time, competition is low (McKenna & Houle 2000). Under such circumstances, annuals may also be affected by climate change even though they are indicators of degradation due to their resistance to grazing (Duysenbekov et al. 2014). However, their characteristics as weeds give them a competitive advantage over other species (Tausch et al. 1993; Brooks & Esque 2000).

For most of the time, annual plant seeds are in dormancy (Carta et al. 2013). However, many annual brome grasses give good growth during autumn rains, which makes them suitable for pasture grazing in the autumn (Institute of Botany under NAS of USSR 1934; Kyrgyz Branch of NAS (National Academy of Sciences) of USSR 1950).

Also of interest for this project was the analysis of the length of the plants' life cycles. It was observed that plants with short life cycles have a competitive advantage in conditions of pasture degradation and climate change (Archer & Stokes 2000; Ionov 2003). The foothill-desert zones are traditionally represented with short life cycle grass species, which grow in spring and autumn; these are mainly annual ephemeroids and ephemerals. The abundance of these plants in different seasons of the year depends on the moisture of the growing period.

The results in Table 4 (from the list of 59 plants) show that 12 plants are annuals (20.3% of the total). Among these 12 species, seven are grasses and five are herbs. The life cycle of most annual grasses (five of the seven) is completed within 2 - 3 months. Only two of the annual grasses (*Taeniatherum crinitum* and *Phleum paniculatum*) have a life cycle with a length of about 4 - 5 months. The annual grassland is fundamentally functional during the late autumn, winter and early spring and non-functional during the summer (Baldocchi et al. 2004).

The list of annual species also contains three ephemeral species, namely- *Hordeum leporinum, Phleum paniculatum* and *Trigonella arcuata;* and there are also two perennial species (*Poa bulbosa* and *Hordeum bulbosum),* which are ephemeroids. All listed annual grasses have awned spikelets that following maturation decrease the palatability and prevent grazing. Therefore, they should be used at the early growth stage which ends after the first half of June. After that, their spikelets become tough and damage the mouths of animals (Kyrgyz Branch of the NAS [National Academy of Sciences] of the USSR 1950). This shows that pastures with ephemeral plant communities should mainly be utlilized for grazing in the spring. However, as has been stated earlier, these pastures do not regrow after one grazing regime during the year and therefore, to maintain stability on these pastures, they should be used moderately in late spring and late autumn or early winter when annuals are in an active vegetative stage.

Ephemeral vegetation types mainly occupy plains, arid low mountains, and arid lowlands, which are the main autumn and winter pastures of Kyrgyzstan. These pastures have a small regrowth potential after one cycle of grazing. However, these pastures are allowed for double use as a control measure because of their weediness. Therefore, ephemeral ephemeroid plant communities in semi-desert pastures should be used in an optimal time frame (early stages of growth and start of the earing period).

3.3.3 Regeneration / seeding characteristics of annual grasses

Plant propagation can be by seeds, clones or through bulbs (George et al. 2008). Annuals grow from seed each year (Sadhu 2005), while most perennials reproduce by seeds and clones. Among the perennial species, there are also three that propagate through bulbs (*Poa bulbosa, Hordeum bulbosum* and *Allium oreoprasum*). Annual plants often produce a large number of seeds. As shown in Table 7; the lowest seeding rate is 400 seeds per plant while the highest goes up to 60,000 seeds per plant. High seed production is accompanied by a high germination rate (72-100%). These two indicators contribute to the vitality and tendency to weediness in annuals. Hence, they become dominant (Ionov 2003). However, in annuals, seed viability in the soil does not exceed 5 years. This may be a disadvantage after dry summers due to possible failure to germinate and seed during arid summers. It is because of this that annuals cannot sustain/withstand long harsh climatic conditions compared to perennials (Ruppert et al. 2015). In this regard, perennial species have a better climatic adaptability and yield a better forage value compared to annuals. Thus, the presence of annual grasses is more indicative of overuse than climate change in the region. This hypothesis should be tested by considering a wider dataset for different species in a detailed study of plant communities.

3.3.4 Palatability/ forage value of annual grasses

In assessing the state of pasture resources, attention is first drawn to palatability of plant communities that grow on a section of grassland (Sukachev et al. 1952). Diversity tends to decline in highly productive environments due to competitive exclusion by favoured species that become abundant under such conditions (Osem et al. 2002). To determine the economic value of each species as forage, we have been guided mainly by the Flora of the Kyrgyz Republic. The results show that there were 22 grasses among the total of 59 species. All grasses (without any exception) are palatable, whether annual or perennial. This is a good indicator of availability of forage for livestock. But due to limited information about the density of each species within the total plant cover, it is difficult to come up with a true estimation of how much forage is available for livestock.

One important factor regarding the palatability of annual grass species which is important to note is their awns, which reduce their palatability after the seed have emerged (Tozer et al. 2007). Therefore, the feeding value of annual grasses is much inferior to perennials. As an example, *Taeniatherum crinitum* (common name medusahead) has a long sharp awn which decreases its palatability to livestock. The high silica content of medusahead makes it less desirable as forage to livestock and can reduce grazing capacity on rangelands. As medusahead grows it accumulates silica, which makes it unpalatable to livestock except when the plant is in the immature growth stage. Due to a large amount of silica, the dead plants decompose more slowly than other annual grasses and form a dense thatch on the soil (Zimmerman et al. 2002; Davison 2013).

4. CONCLUSIONS

In this project, the morphological and phenological characteristics of 59 species have been analysed. Plants with short life cycles (annual ephemerals) and of short height (annual grasses) are more tolerant to grazing pressure, which is in line with the findings of other authors. Based on this, we can state that annuals are an indication of pasture degradation following overuse of pastures. However, according to other authors, these plants are indicators of climate change, disappearing forests, and they are an integral part of the semi-desert pastures.

Despite the several arguments fronted by different authors linking annuals as indicators of climate change, forest disappearance, pasture overuse and being an integral part of the semi-desert pastures, it is difficult to attribute any of these particular factors to contributing the greatest or the smallest share to the development of ephemeral annual species under the study area's condition. To answer this question, long-term studies are necessary to fulfil in the picture of these ecosystems, and finally accomplish the building of predictive models for the management of pasture resources. It should also be considered necessary to experiment at multiple sites with and without grazing pressure for the sake of comparison during several years so that the result can be used to analyse the dynamics of changes in the composition of two matched fields.

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APPENDICES

APPENDIX I. Flowering and fruiting time (month I-XII) of the different plant species

#	Species	FG	PB	GF	Height, cm	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	References
1	*Allium oreoprasum*	h	P	per.	15-50													[2]
2	*Ceratocarpus arenarius*	h	P	an.	5-30													[2]
3	*Eremurus fuscus*	h	U	per.	70-100													[7]
4	*Achillea millefolium*	h	P	per.	40-100													[9]
5	*Arctium tomentosum*	h	P	bien.	60-100													[9]
6	*Artemisia ferganensis*	h	P	per.	60-100													[9]
7	*Artemisia glanduligera*	h	U	per.	40-75													[9]
8	*Artemisia tenuisecta*	sh	P	per.	35-60													[9]
9	*Artemisia tianschanica*	sh	P	per.	25-40													[9]
10	*Artemisia absinthium*	h	P	per.	40-150													[9]
11	*Cirsium arvense*	h	U	per.	100–120													[9]
12	*Inula helenium*	h	U	per.	60-150													[9]
13	*Onopordum acanthium*	h	U	bien.	100-200													[9]
14	*Sonchus oleraceus*	h	P	bien.	40-150													[9]
15	*Taraxacum officinale*	h	P	per.	10-20													[9]
16	*Capsella bursa-pastoris*	h	U	an.	5-60													[4]
17	*Capparis spinosa*	sh	U	per.	50-80													[4]
18	*Convolvulus arvensis*	h	P	per.	40-100													[6]
19	*Alhagi pseudalhagi*	sh	P	per.	50-111													[6]
20	*Medicago lupulina*	h	P	an.	10-65													[5]
21	*Medicago minima*	h	P	an.	10-40													[5]
22	*Medicago sativa*	h	P	per.	60-140													[5]
23	*Trifolium pratense*	h	P	per.	15-18													[5]
24	*Trifolium repens*	h	P	per.	10-40													[5]
25	*Trigonella arcuata*	h	P	an.	5-40													[5]
26	*Vicia tenuifolia*	h	P	per.	50-100													[5]
27	*Gentiana olivieri*	h	U	per.	10-30													[6]
28	*Geranium collinum*	h	P	per.	18-70													[5]

29	*Mentha arvensis*	h	U	per.	15-60		[7]
30	*Origanum vulgare*	h	U	per.	20-60		[7]
31	*Phlomis oreophila*	h	U	per.	30-80		[7]
32	*Plantago major*	h	P	per.	1-10		[8]
33	*Aegilops cylindrica*	g	P	an.	20-50		[1]
34	*Alopecurus pratensis*	g	P	per.	20-100		[1]
35	*Helictotrichon pratense*	g	P	per.	30-100		[1]
36	*Bothriochloa ischaemum*	g	P	per.	30-50		[1]
37	*Bromopsis inermis*	g	P	per.	80-120		[1]
38	*Bromus danthoniae*	g	P	an.	15-40		[1]
39	*Bromus oxyodon*	g	P	an.	30-90		[1]
40	*Bromus squarrosus*	g	P	an.	15		[1]
41	*Hordeum jubatum*	g	P	per.	30–60		[1]
42	*Cynodon dactylon*	g	P	per.	10–40		[1]
43	*Agropyrum trichophorum*	g	P	per.	60-100		[1]
44	*Agropyron repens*	g	P	per.	80-120		[1]
45	*Festuca tianschanica*	g	P	per.	10-70		[1]
46	*Hordeum bulbosum*	g	P	per.	60-150		[1]
47	*Hordeum leporinum*	g	P	an.	15-40		[1]
48	*Phleum paniculatum*	g	P	an.	3–45		[1]
49	*Phleum pratense*	g	P	per.	40–120		[1]
50	*Poa bulbosa*	g	P	per.	15–55		[1]
51	*Stipa pennata*	g	P	per.	30-100		[1]
52	*Stipa capillata*	g	P	per.	90		[1]
53	*Taeniatherum crinitum*	g	P	an.	15-40		[1]
54	*Rumex acetosa*	h	P	per.	40-100		[3]
55	*Aconitum excelsum*	h	U	per.	51-100		[4]
56	*Ranunculus asiaticus*	h	P	per.	30		[4]
57	*Alchemilla vulgaris*	h	U	per.	30-40		[5]
58	*Poa pratensis*	g	P	per.	30-90		[1]
59	*Potentilla asiatica*	h	P	per.	15-60		[5]

[1] Kyrgyz Branch of NAS of USSR (1950); [2] Kyrgyz Branch of NAS of USSR (1951); [3] Kyrgyz Branch of NAS of USSR (1953); [4] NAS of Kyrgyz USR (1955); [5] NAS of Kyrgyz USR (1957); [6] NAS of Kyrgyz USR (1959); [7] NAS of Kyrgyz USR (1960); [8] NAS of Kyrgyz USR (1962); [9] NAS of Kyrgyz USR (1965).

APPENDIX II. Common and local names of the plant species

№	Family	Species	Name in English	Name in Russian	Name in Kyrgyz
1	*Alliaceae*	*Allium oreoprasum*	Wild onion	Лук горный	Тоо пиязы
2	*Amaranthaceae*	*Ceratocarpus arenarius*		Рогач песчаный	Эбелек
3	*Asphodelaceae*	*Eremurus fuscus*	Foxtail lilies or desert candles	Эремурус загорелый	Чырыш, Кулунчак
4	*Asteraceae*	*Achillea millefolium*	Yarrow	Тысячелистник обыкновенный	Каз таңдай
5	*Asteraceae*	*Arctium tomentosum*	Burdock	Лопух паутинистый	Уй кулак, коко тикен
6	*Asteraceae*	*Artemisia ferganensis*	Fergana wormwood	Полынь ферганская	Ферган шыбагы
7	*Asteraceae*	*Artemisia vulgaris*	Mug wort	Полынь железистая	
8	*Asteraceae*	*Artemisia tenuisecta*	Sagebrush	Полынь тонкорассечённая	Шыбак
9	*Asteraceae*	*Artemisia tianschanica*	Sagebrush	Полынь Тянь-Шанская	Тянь-Шань шыбагы
10	*Asteraceae*	*Artemisia absinthium*	Afsanthin	Полынь горькая	Эрмен
11	*Asteraceae*	*Cirsium arvense*	Creeping thistle	Бодяк полевой	
12	*Asteraceae*	*Inula helenium*	Elecampane	Девясил высокий	Карындыз
13	*Asteraceae*	*Onopordum acanthium*	Scotch Thistle	Татарник колючий	Кемирчек
14	*Asteraceae*	*Sonchus oleraceus*	Smooth sow thistle	Осот огородный	Сүт тикен
15	*Asteraceae*	*Taraxacum officinale*	Dandelion	Одуванчик лекарственный	Какым
16	*Brassicaceae*	*Capsella bursa-pastoris*	Shepherd's purse	Пастушья сумка обыкновенная	
17	*Capparaceae*	*Capparis spinosa*	Caper Bush	Каперцы травянистые	
18	*Convolvulaceae*	*Convolvulus arvensis*	Field bindweed	Вьюнок полевой	Чырмоок
19	*Fabaceae*	*Alhagi pseudalhagi*	Camel thorn	Верблюжья колючка обыкновенная	Төө тикен
20	*Fabaceae*	*Medicago lupulina*	Median-grass	Люцерна хмелевидная	Сары беде
21	*Fabaceae*	*Medicago minima*	Small alfalfa	Люцерна маленькая	Жапан беде
22	*Fabaceae*	*Medicago sativa*	Alfalfa	Люцерна посевная	Кара беде
23	*Fabaceae*	*Trifolium pratense*	Red clover	Клевер луговой	Кызыл
24	*Fabaceae*	*Trifolium repens*	White Clover	Клевер ползучий	Ак гүлдүү уй беде
25	*Fabaceae*	*Trigonella arcuata*		Пажитник дугообразный	Чытыр
26	*Fabaceae*	*Vicia tenuifolia*	Fine-leaved Vetch	Вика тонколистная	Ичке жалбыractуу жер буурчагы
27	*Gentianaceae*	*Gentiana olivieri*		Горечавка Оливье	Көк базин
28	*Geraniaceae*	*Geranium collinum*	Hill Geranium	Герань холмовая	Казтаман
29	*Lamiaceae*	*Mentha arvensis*	Field Mint	Мята полевая	Жалбыз

30	*Lamiaceae*	*Origanum vulgare*	Oregano	Душица обыкновенная	
31	*Lamiaceae*	*Phlomis oreophila*		Зопник горный	Шимүүр
32	*Plantaginaceae*	*Plantago major*	Plantain	Подорожник большой	Чоң бака жалбырак
33	*Poaceae*	*Aegilops cylindrica*	Jointed Goatgrass	Эгилопс цилиндрический	
34	*Poaceae*	*Alopecurus pratensis*	Meadow foxtail	Лисохвост луговой	Түлкү куйрук
35	*Poaceae*	*Helictotrichon pratense*	Meadow oat-grass	Овсец луговой	
36	*Poaceae*	*Bothriochloa ischaemum*	Plains blue-stem	Бородач кровоостанавливающий	Кызыл от, кылкансыз түбү бош
37	*Poaceae*	*Bromopsis inermis*	Hungarian brome	Костер безостый	Кызыл от
38	*Poaceae*	*Bromus danthoniae*	Drooping brome	Костёр Дантонии	
39	*Poaceae*	*Bromus oxyodon*	Brome grasses	Костер острозубый	
40	*Poaceae*	*Bromus squarrosus*	Rough brome, corn brome	Костер растопыренный	
41	*Poaceae*	*Hordeum jubatum*	Squirrel-tail	Ячмень гривистый	
42	*Poaceae*	*Cynodon dactylon*	Bermuda Grass	Свинорой пальчатый	Ажырык
43	*Poaceae*	*Agropyron trichophorum*	Stiff hair wheatgrass	Пырей волосоносный	Ак чөп, Наргыя чөп
44	*Poaceae*	*Agropyron repens*	Couch Grass	Пырей ползучий	Буудайык
45	*Poaceae*	*Festuca tianschanica*	Fescue	Овсяница тяньшанская	Тяньшан бетегеси
46	*Poaceae*	*Hordeum bulbosum*	Bulbous barley grass	Ячмень луковичный	Жоодар
47	*Poaceae*	*Hordeum leporinum*	Mouse barley	Ячмень заячий	Коён арпа
48	*Poaceae*	*Phleum paniculatum*	British timothy	Тимофеевка метельчатая	Аксокто, кара-кыяк
49	*Poaceae*	*Phleum pratense*	Timothy	Тимофеевка луговая	Аксокто
50	*Poaceae*	*Poa bulbosa*	Bulbous Bluegrass	Мятлик луковичный	Түймөкчөлүү жылган
51	*Poaceae*	*Stipa pennata*	Feather Grass	Ковыль перистый	
52	*Poaceae*	*Stipa capillata*	Needle Grass	Ковыль волосатик	Кылкан чөп
53	*Poaceae*	*Taeniatherum crinitum*	Medusa head	Лентоостник длинноволосый	Жаман арпа
54	*Polygonaceae*	*Rumex acetosa*	Sorrel	Щавель кислый	Козу кулак
55	*Ranunculaceae*	*Aconitum excelsum*	Northern Wolfsbane	Борец обыкновенный	
56	*Ranunculaceae*	*Ranunculus asiaticus*	Persian buttercup	Лютик азиатский	
57	*Rosaceae*	*Alchemilla vulgaris*	Lion's foot	Манжетка обыкновенная	Тогуз төбөл
58	*Rosaceae*	*Poa pratensis*	Kentucky Blue Grass	Мятлик луговой	Жылган
59	*Rosaceae*	*Potentilla asiatica*	Cinquefoil	Лапчатка азиатская	Казтаман

APPENDIX III. Geo-botanical map of the pastureland nearby Talduu-Bulak AA