Assessment of the land condition in the Kyrgyz Republic with respect to grazing and a possible development of a quoting system on the local governmental level

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Author(s): Azamat Isakov, CAMP Alatoo Public Foundation, Kyrgyz Republic,
azamat_isakov@mail.ru
Dr. Johann Thorsson, Soil Conservation Service of Iceland, johann.thorsson@land.is

Isakov Azamat, Dr. Johann Thorsson
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Animal husbandry is the most important livelihood strategy for a large proportion of the rural population in Kyrgyz Republic. The pastures they depend on are common property, which encourages an increase of the livestock number throughout the country, leading to an excess of the carrying capacity, and consequently, to degradation. The condition of the Kyrgyz pastures was estimated using different methodologies, and the results vary. The aim of this study is to research current international l literature on land management in order to understand what is currently acknowledged as good practice. By using available data on land use, land condition, and vegetation in Kyrgyz Republic, the study aims to assess the land condition of Kyrgyz pastures and suggests appropriate approaches for tackling land degradation. A State and Transition Model (STM) of Jergetal A/O was constructed based on the available data. The model indicates that the upland pasture areas comply with the equilibrium paradigm, where stocking rate plays a key role in the transition from one state to another. The regulation of the stocking rate will be decisive for the prevention of pasture degradation, whereas, in the lower zone of pastures, dynamics comply with the non-equilibrium paradigm, where the stocking rate does not have a significant influence on pasture degradation. In this zone, abiotic factors have a bigger impact on the pastures. Hence, it seems feasible to apply STM as a tool in individual vegetation zones. A quota system based on carrying capacity of pasture does also seem feasible to control common land use. Income generated by such a system could also provide funding for the establishment and improvement of grazing land infrastructure.

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1. INTRODUCTION

Since the collapse of the Soviet Union in 1991, land use in the Kyrgyz Republic remained uncontrolled until 2009. This changed in 2009 when a new legislation on pasture use and management was enforced. Now the local governments on the aiyl okrug[1] (A/O) level are responsible for land management. Local land users are now responsible for managing the land in a sustainable way through formal committees. Communal pastures cover half of the total Kyrgyz agricultural area (Undeland 2005).

The purpose of this new legislation is to improve the pastures' condition, which is a challenging task. About 64% of the Kyrgyz population, or 3.5 million people, live in rural areas and depend on farming as their main source of income (Bussler 2010). It is hence critical that the land they depend on for agricultural production, especially livestock breeding, does not continue to degrade.

However, there are obvious obstacles on the way. Land use during the period from 1991 – 2009 is a classical example of the so-called "tragedy of the commons", as described by Hardin (1968). Everyone during that time tried to maximize their production on the common lands, but neglecting the land maintenance at the same time. This becomes evident when looking at livestock numbers from 1997 – 2011. During these 14 years the number of livestock units[2] (LU) rose from 9.5 million LU to 13.8 million LU, an increase of 45.3% (Atadjanov et al. 2012).

Another obvious problem is the fact that only 7% of the total land area is arable land. Consequently, the main income of rural residents of Kyrgyz Republic is generated from animal husbandry, which creates an enormous pressure on the pasture land use.

Because much of the income depends on livestock production, all restrictions on land use will affect the farmers in a very direct way and not many are prepared for such changes. Moreover, they do not realize the problem within current land management practices and of land degradation, and are thus not easy to convince to take action against it. It may well be that it requires repeated severe land degradation episodes over the coming decades for the pasture users to get together to seek ways to control the access to the pastures, and agree upon a set of rules to limit exploitation, as predict Feeny et al. (1990). However, the question is if we can wait for that to happen?

Current livestock numbers exceed the estimated land carrying capacity by 1.5-2 times according to Atadjanov et al. (2012). Thus, land degradation is a real threat today. According to the Kyrgyz State Project Institute of Land Management (Kyrgyzgyprozem) 29% of all pastures show signs of or are severely degraded (Penkina 2004) and 25% of all pastures are deteriorating (Khusamov et al. 2009).

Enforcing restrictions on land use is a complicated and sensitive issue. Such intervention must be based on best available knowledge and cooperation with the affected communities, which must at the same time understand what the objectives are and how the imposed restriction measures will help them to manage their pastures in a sustainable way in the future.

To apply restrictions we need a rationale, which can be achieved through an adequate assessment of the pastures by measuring the resistance and resilience of the pastures.

1.1. Aim of the work

The aim of the work is to:

1. Use available data on current and past land use, land condition and vegetation to assess land suitability for traditional Kyrgyz animal husbandry,
2. Research current international literature on common land management practices in order to understand what is currently acknowledged as good practice and which management approaches should rather be avoided,
3. Use points 1 and 2 to propose a way to achieve a sustainable management scheme, including considerations on why it may - or may not - be successful (risk assessment).

[1] The Kyrgyz Republic is subdivided into Oblasts, which are further subdivided into Rayons, and on the municipal level, aiyl okrugs.

[2] A standard livestock unit (LU) in the Kyrgyz Republic comprises one cattle. One cattle is equal to 5 sheep.

2. BACKGROUND

Applied ecology disciplines, such as range management, are organized around models that describe how they affect ecosystem functions. A model is a system of concepts, generalizations, or assumptions relevant for the interaction between the management and the ecosystem. The model guides which data are to be collected, and how that information is to be compiled to serve management decisions. Two main schools have dominated management approaches for the last decades. Those are the «climax school» based on the «range succession model» (Dyksterhuis 1949) and the «dynamic equilibrium school» derived from Westoby et al. (1989) and often presented as State and Transition models.

2.1. The range succession model

The range succession model became widely accepted within the range management profession around the middle of the 20th century (Westoby et al. 1989). Its application was associated with concerns on sustainability of the pastures.

The range succession model is constructed around the interaction between herbivores and their resources and based on the assumption that every environment has a certain carrying capacity, which is determined by biophysical characteristics such as mean annual rainfall, soil type and other biophysical characteristics of the area, which determine the potential production (Bell 1982; Fritz & Duncan 1994). The model predicts that the condition of pastures follows a linear pathway and can therefore be manipulated predictably with a stocking rate (Foran et al. 1978; Trollope 1990). Low grazing pressure or absence of grazing allows vegetation to get to climax stage, and heavy grazing returns it to initial stage. Thus, such reaction of vegetation to grazing pressure is linear, reversible and predictable (Vetter 2003). Pastures can therefore be maintained in optimal conditions (subclimax or climax) if the stocking rate is managed properly.

However, on the contrary, continuous intensive grazing often leads to vegetation changes such as the replacement of palatable grasses with less palatable plant species, replacement of perennial grasses by annuals, bush encroachment, lower standing biomass and reduced basic vegetation cover (Coppock 1993; Ash et al. 1995; Fynn & O’Connor 2000). These changes are sometimes irreversible, hence contradicting the model assumptions (Vetter 2003).

At the same time as range managers were realizing that the range succession model did not reflect the herbaceous-herbivore interaction adequately. There was an increasing general recognition among ecologists that equilibrium dynamics included a far more complex interaction between ecosystem components than previously thought and were therefore impossible to predict in many ecological systems (Wiens 1984; DeAngelis & Waterhouse 1987).

2.2. The State and Transition models (STM)

This discrepancy was addressed by Ellis and Swift (1988) and Westoby et al. (1989) by applying non-equilibrium concepts to rangeland systems. They suggested an alternative approach based on state and transitions, emphasizing non-linear responses of ecosystems under grazing or other varying disturbances. The model also acknowledges the existence of thresholds between different states of pastures (Friedel 1991). The state and transition model (STM) observes that several alternative stable states exist, and that changes between states require certain sets of conditions. Changes from some states to previous states requires major management inputs. Natural grazing systems, where rate of disturbances is higher than the potential herbivore population response, are unlikely to degrade because the populations are unlikely to reach the necessary critical sizes (Ellis & Swift 1988).

It should be noted that the range succession model and the STM are not necessarily incompatible. The range succession model can be seen as focusing on a single state or a limited spatial scale when compared to the STM (Ellis et al. 1993; Stafford Smith 1996; Bestelmeyer et al. 2004), and many of the ecosystems include elements of both models (Fernandez-Gimenez & Allen-Diaz 1999). Evidence from arid environments (e.g. Ellis & Swift 1988) suggests that these particular ecosystems comprising elements of both models are well described by the non-equilibrium paradigm and may thus be seen as a state within STM that encompasses a larger spatial and temporal scale. An arid pasture area can be more resilient in regard to animal husbandry: vegetation cover, composition and productivity are influenced more by rainfall, while grazing has smaller influence on those ecosystems.

2.3. Controversy surrounding the two models

There is an ongoing debate on the various predictions of the two models regarding the degradation of arid and semi-arid pastures. In some cases, the STM have been supported with such passion that the relevance of the stocking rate has been completely rejected (Dikeni et al. 1996) Other scholars believe that STM are not applicable in areas not experiencing predominantly non-equilibrium dynamics (Fernandez-Gimenez & Allen-Diaz 1999; Illius & O'Connor 1999; Cowling 2000).

Some authors (e.g. Cowling 2000) have portrayed the non-equilibrium paradigm as irresponsible in its views on the degradation of pastures and its recommendations on opportunistic strategies. Proponents of the non-equilibrium paradigm, on the other hand, criticize the equilibrium view, because of its general assumptions, such as that climate is constant and because of inflexible management strategies (Vetter 2004).

The assumption that biomass production is largely determined by rainfall and is unaffected by animal population density, leads to the conclusion that stocking rates are not the critical factors in land degradation, because severe mortality during droughts would keep livestock densities well below the system's carrying capacity (Ellis & Swift 1988). This leads to the assumption that grazing has limited effect on long-term forage production. However, this assumption may not be true for all arid ecosystems. If animals grazing in arid pastures are fed during periods when natural forage is insufficient, their numbers are no longer being controlled top-down by e.g. climate. Their effect on the pastures may therefore increase dramatically, as is the case in Kyrgyz Republic.

2.4. Pasture management models in Kyrgyz Republic

Based on the discussion above, it is interesting to compare the two paradigms of pasture management in Kyrgyz Republic. Animal husbandry started in Kyrgyz Republic about 8,000 years ago by domesticating cattle, yaks, sheep, goats and horses (Blench & Sommer 1999). Nomad societies were organized based on kin and tribal groups. Since much of the pastures could only be used in a short period each season for grazing, due to low rainfall and weather extremes (Rischkowsky & Pilling 2007), livestock was moved within the region to make use of seasonal changes in natural vegetation from summer to winter. Pastures were common property, their use was regulated by tribal councils through a decentralized decision-making process. This method of regulation appeared to be successful, since land degradation due to grazing was not a problem (Schillhorn-van-Veen et al. 2003). Tribes used to alter their management routines every year so that the same area was grazed only every third to fifth year (Undeland 2005). This pattern of land management might bear some resemblances to what is the underlying concept of STMs, but was based on the nomad experience gathered through the generations.

This scenario changed in 1930's. Under the modernization theory adapted by the new Soviet regime, rural people were forced to settle down and hand over their livestock to the local authorities. The animals were then distributed to the kolkhozes and sovkhozes[3]. The idea was to increase production and people's welfare. Nomads were especially targeted by this new policy (Kreutzmann 2013). With the beginning of the sedentarization in Kyrgyz Republic, radical changes followed. All livestock and land became the property of cooperatives and was managed by them or the state. Nomads were forced to settle and work on the large kolkhozes and sovkhozes. Decisions on pasture use and management were made by state agencies, they organized the herd rotations and land use, including the use of remote areas. The main objective was to maximise livestock production and that was achieved by moving the herds from the lowland winter pastures to lowland valleys in early spring, then to higher pastures in late spring finally to summer pastures in the highlands in June to July. The herds were then brought back to the lowland winter pastures in autumn (Undeland 2005).

Pasture management plans were developed by the government based on the carrying capacity of pastures. The carrying capacity was estimated for 80 different vegetation types and became the main management tool to avoid land degradation. However, serious pasture degradation occurred in the late 1980s, albeit starting earlier. From 1960 to 1990, the average productivity of the summer pastures declined from 640 kg/ha to 410 kg/ha (36%) and the spring and autumn average pasture yield went from 470 kg/ha to 270 kg/ha (43%). The productivity of winter pastures declined even more dramatically or from an average of 300 kg/ha to less than 100 kg/ha (67%), thereof were 50,000 km^2 affected by encroachment of woody and unpalatable species, making over 5,400 km^2 of pasturelands useless for grazing (Fitzherbert 2005).

3 The term kolkhoz describes a form of collective farming in the former Soviet Union. Kolkhoz members received shares in the farm's production and profits according to the number of days they worked. Along with kolkhozes there were also state-owned sovkhozes.

Today it is a commonly accepted assumption that pastures in Kyrgyz Republic are in a degraded state. According to Khusamov et al. (2009), about 25% of pastures are deteriorating and the Kyrgyz State Kyrgyzgyprozem estimates that about 29% of the total pastures are degraded. Various projects have been implemented by the government to change this development, but they have often been based on questionable ideas or understanding of the grazing ecosystems.

However, new field studies assessing the causes, effects, characteristics, and implications of grazing and pasture degradation in Central Asian mountains question the previous assumptions of simple causal relationships between overgrazing and land degradation (Bimüller et al. 2010). This situation underlines the importance of empirical studies on the impact of grazing on pasture conditions, what main factors are affecting pasture capacity and condition.

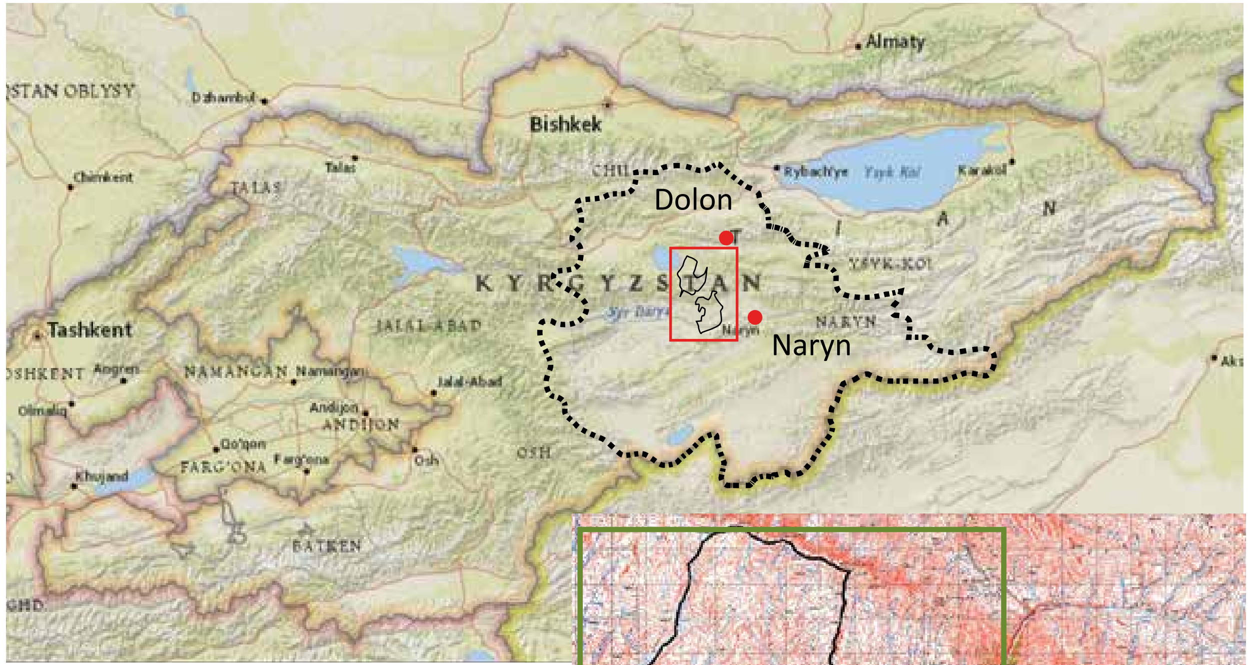
3. MATERIAL AND METHODS

3.1. Study area

The selected study area was the Jergetal A/O in Naryn district (Fig. 1). About 70% of the population is engaged in animal husbandry, mainly using mountain pastures. More than 29% of the pastures of the Kyrgyz Republic, and about 15% of the total livestock is found within this region. The area is well suited for grazing animal husbandry, both because of the topography and the climate (Atadjanov et al. 2012).

Jergetal A/O's pastures amount to about 42,000 ha (Bussler 2010). They range between 2,000 to 3,100 m.a.s.l. and extend to over a 50 km area. Additionally, there are pastures of State Forest Fund (SFF). SFF's pastures can be leased for the grazing by livestock owners. There is, however, some ambiguity over which land belongs to the SFF and it is consequently not clear how much pastureland is available to the herders (Atadjanov et al. 2012). Most herders utilize pastures near the villages intensively all year round and only large heard owners do relocate their livestock to the remote summer pastures. This change in land use from the traditional obligatory relocation of livestock depending on season has resulted in underuse of many remote pastures.

Arable land is scarce in Jergetal A/O. The total arable land is estimated at 1,650 ha, whereof about 1,000 ha are irrigated. During Soviet times, all arable land was irrigated and cultivated. However, the irrigation systems have not been maintained and which has made cultivation difficult since the collapse of the Soviet Union. The main cultivated fodder crops are legumes (especially sainfoin, *Onobrychis viciifolia*), barley and grass. The total population of Jergetal A/O amounts to about 6,000, the households number is 1,164 and total LU number is 12,300 (Bussler 2010).



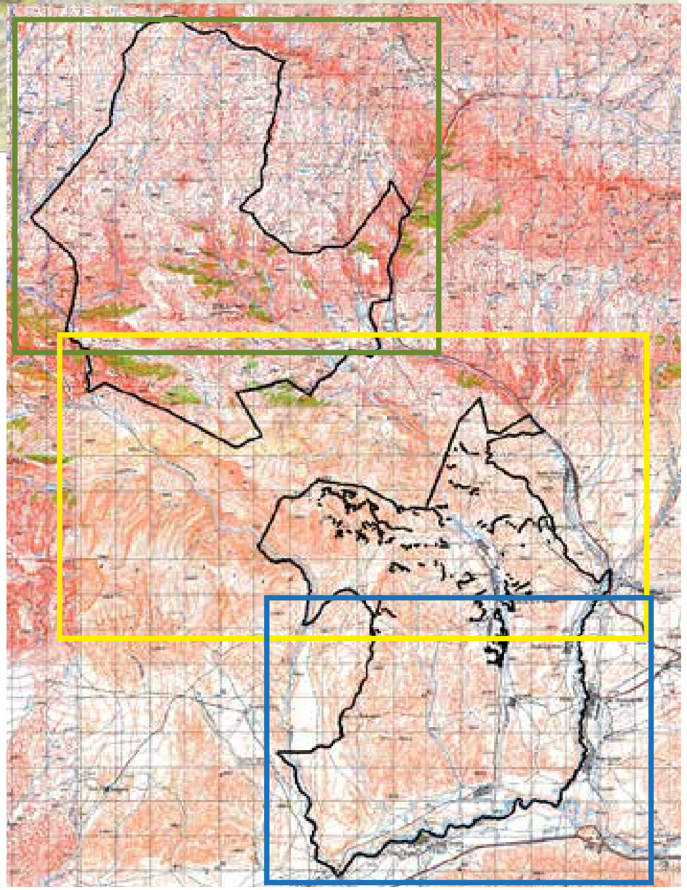


Fig. 1. *Top: Location of Jergetal A/O pastures in Kyrgyz Republic (source: National Geographic Basemaps). The borders of the Naryn district are shown by a dotted line. Red points mark the location of the Naryn and Dolon weather stations. Right: Map of Jergetal A/O showing summer pastures (green frame), spring and autumn pastures (yellow frame), winter pastures (blue frame) and border of Jergetal A/O pastures (black lines) Source: Kyrgyz Institute of Geography.*

Naryn region's climate is continental, with cold dry winters and warm, wet summers. Mean annual temperatures and precipitation are 3.8 °C and 298 mm respectively. Corresponding numbers for Dolon are -1.67°C and 390 mm in the 3,000 m.a.s.l. Coefficients of variation for precipitation range from 66% on the 2,200 m to 55% on the 3,000 m.a.s.l. (Fig. 2).

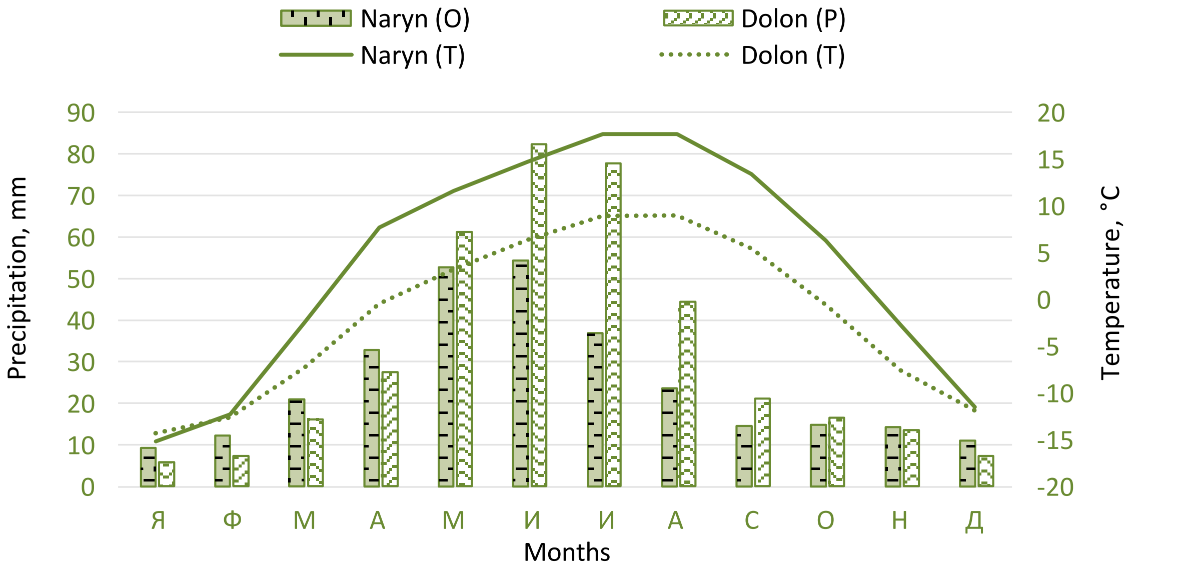


Fig. 2. *Mean monthly precipitation (P) and temperature (T) for two different pasture areas of Jergetal A/O for 1985-2006. Naryn is at 2,200 m.a.s.l. and Dolon at 3,000 m.a.s.l. (Source: Kyrgyz Institute of Meteorology).*

3.2. Data sources

The CAMP Alatoo Public Foundation has conducted several projects since 2008, focusing on sustainable pasture management issues. As a part of that effort, a large amount of information has been accumulated and compiled for various parts of the Kyrgyz Republic. This includes digitization and rectification of geobotanical maps from 1986-1988. The resulting database includes information from 4,248 sites on 70 different vegetation types, including their biomass and vegetation cover. Vegetation types were defined by Kyrgyzgyprozem during the 1986 inventory and adopted by CAMP Alatoo Public Foundation in 2009. The database now covers more than 40,000 hectares. These data have been used to assess land conditions and for building STM for Jergetal A/O (CAMP Alatoo Public Foundation 2012).

For awareness raising of pasture users CAMP Alatoo Public Foundation has since 2010 conducted series of seminars on «Sustainable Pasture Management» in all regions of the country. A total of about 30 workshops involving more than 600 farmers and other stakeholders have been conducted. Seminar topics include the assessment of pasture conditions, estimation of livestock numbers and their dynamics and possible solutions to the degradation of pastures. This has given an opportunity to discuss with the participants on land use and management issues. Some of these data is used and presented in section 4.3.2.

3.3. State and Transition modelling

A State and Transition Model (STM) was constructed for selected key vegetation types as originally defined by the Kyrgyzgyprozem geobotanical maps. The STM structure was based on Briske et al. (2008). STMs are conceptual frameworks constructed around land conditions (states) and their possible change (transitions) under a given set of conditions (e.g. disturbances). They recognize the presence of ecosystem thresholds and multiple pathways (Stringham et al. 2003).

3.4. Calculation of current and potential capacity of pasture

Current capacity of pasture is defined by the following formula (Isakov 1975):

$$CC_{cur} = \frac{(Y_i*P_i+Y_{i+1}*P_{i+1}+...+Y_n+P_n)*S*0.7}{7.5*D}, \qquad (1)$$

where:

CC_{cur} – current carrying capacity

P – percentage of represented state within the pasture unit (Appendix 2)

Y – palatable yield of states within the pasture units

S – area of pasture unit

D – number of pasture use days

0.7 – coefficient of pasture use (based on Kyrgyzgiprozem recommendation)

7.5 – required amount of dry matter for one LU per day, kg.

The formula can also be used to calculate potential carrying capacity of pastures by replacing *palatable yield of states with desirable state's palatable yield* as estimated in the field.

3.5. Calculation of grazing pressure

The grazing pressure (GP) is defined as the ratio of the number of livestock (R) on pasture carrying capacity (2):

$$GP = \frac{R}{CC_{cur}}, \qquad (2)$$

where values equal to 1 represents optimal grazing pressure but, values less than 1indicates low grazing pressure, and values above 1 indicates heavy grazing pressure. See also Fig. 7.

3.6. Statistical analysis

Data derived from the CAMP Alatoo Public Foundation database on total biomass, palatable biomass and vegetation cover were analysed for statistical differences using Kruskal-Wallis and Mann-Whitney non-parametric tests to identify significances of variability's between states of STM. These nonparametric tests were selected because of the non-normality of the data.

4. RESULTS AND DISCUSSION

About 70 types of vegetation are found in Jergetal A/O according to the CAMP Alatoo Public Foundation database. Those include desert and semi-desert vegetation types as well as steppe, meadow steppe and meadow vegetation types. Type 62 is shrubs and type 63 is *Picea tianschanica* forests. Thus, this system appears to be feature of the classical range succession model, but in the STM framework, it represents just one state. However, the spatial distribution of these types varies, caused by varying climatic, geographic and soil conditions (Fig. 3.).

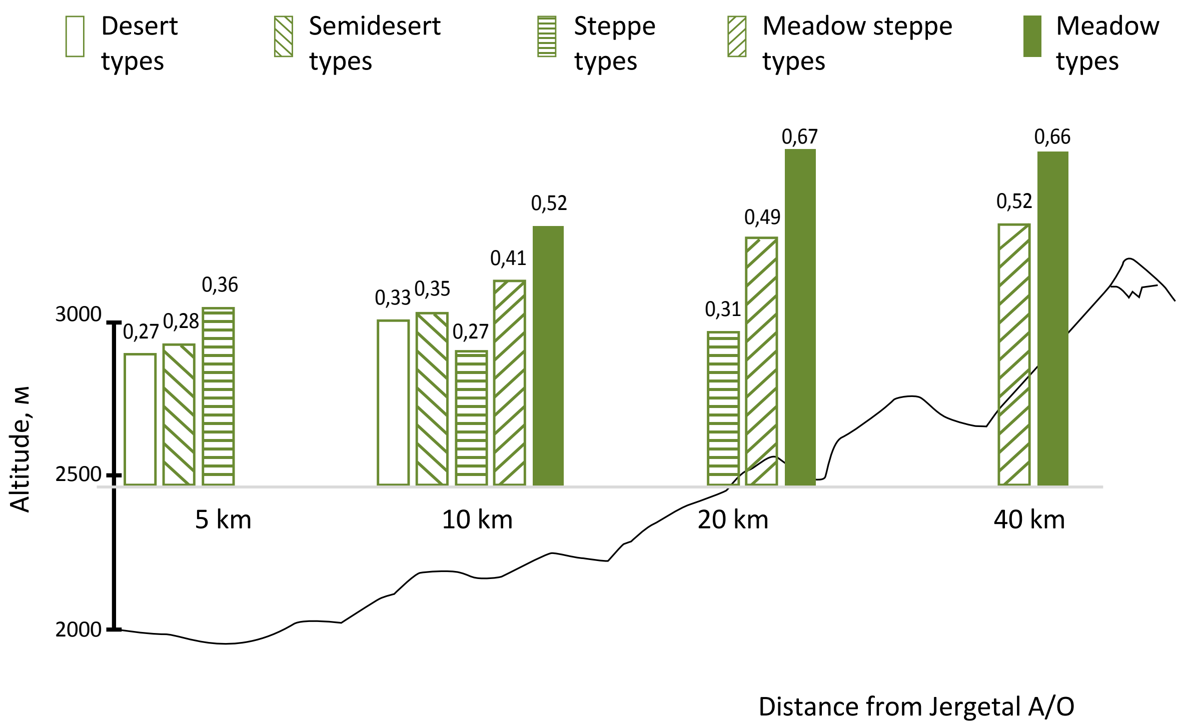


Fig 3. *The horizontal and vertical distribution of Jergetal A/O pasture types from the village and their biomass in t/ha. At a distance, about 5 km from the village, within the altitudes 2,000-2,600 m.a.s.l. there are desert, semi-desert and steppe types of pasture. On 10 km from the village appears small shreds of meadow steppe and meadow types of pastures. At the distance of 20 km from the village desert and semi-desert pastures disappear while steppe types disappear on the 40 km. From the 40 km within an altitudes 2500-3000 m.a.s.l., remains only meadow steppe and meadow pasture types.*

Figure 3 indicates that altitude influences the formation of vegetation types. This means e.g. that a transition from semi-desert pastures to the meadow steppe under current climatic conditions is unlikely, but might be possible by intervention such as constructing an irrigation system in the semi-desert. Such projects are currently unlikely to be implemented, which is reflected in the proposed STM (Fig. 4). The transition from one state to another is first and foremost assumed to occur driven by natural changes such as in climate. The STM is presented on Fig. 4, Fig. 5 and Tables 1 and 2.

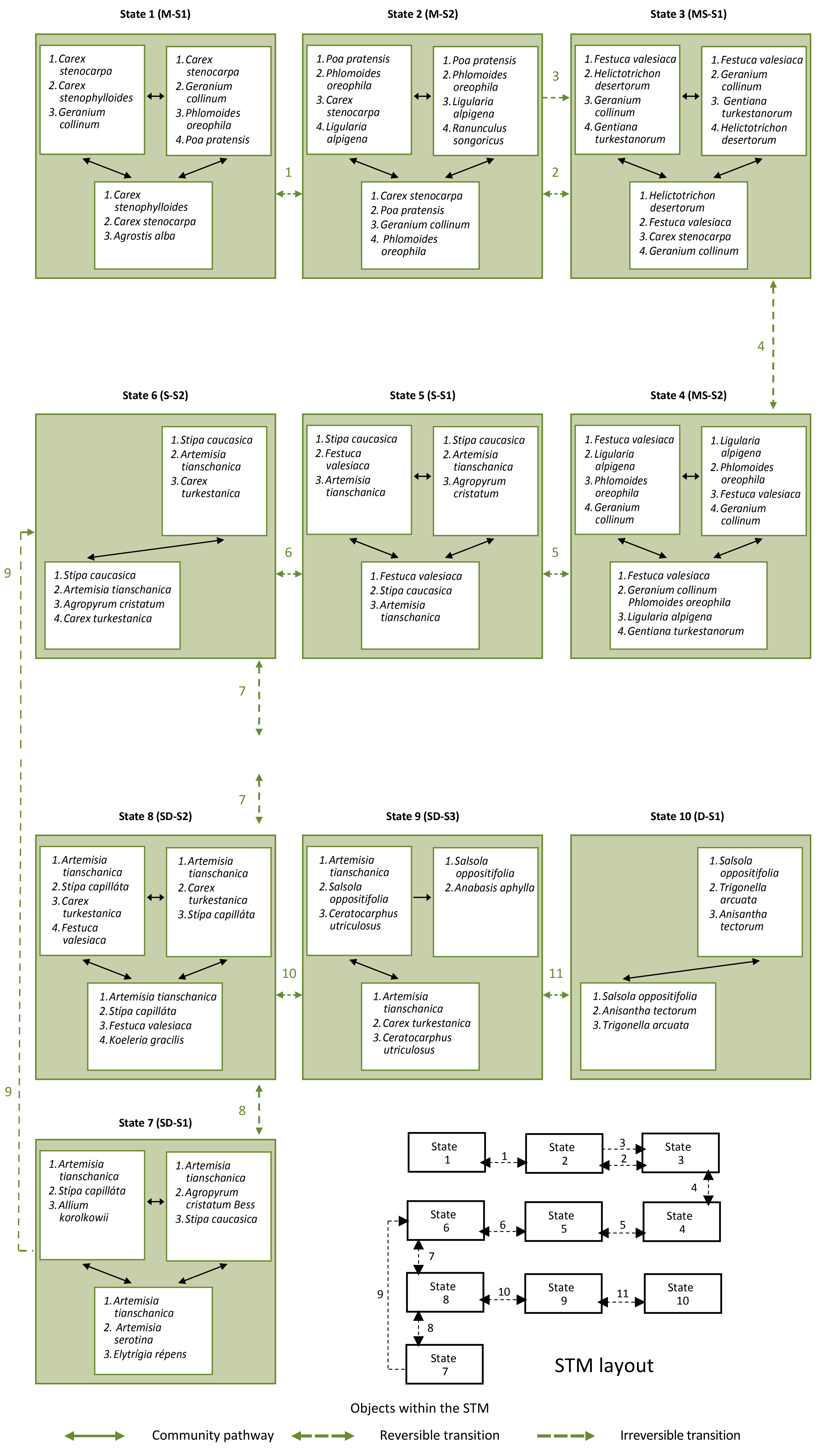


Fig. 4. *A conceptual State and Transition Model (STM) of pastures and vegetation changes of Jergetal A/O. See Tables 1 and 2 for clarification on state names and transitions (species are listed and numbered according to their dominance).*

Table 1. *List of states in the proposed STM model (Fig. 4).*

State 1 (M-S1: Meadow type - state 1). This state contains meadow pastures located in the upper mountain zone. The pasture communities are dominated by graminoids - *Carex stenophylloides*, *C. stenocarpa* and *Poa pratensis.*

State 2 (M-S2: Meadow- type - state 2). This state is the latter of the two meadow types. It is characterized by the appearance of hardy species, such as *Ligularia alpigena*, but the state is first and foremost dominated by *P. pratensis*.

State 3 (MS-S1: Meadow-Steppe type - state 1). The MS type is dominated by Poacea, especially *Festuca valesiaca*. This state occupies large areas and is one of the most productive pasture types. Beside *F. valesiaca*, *Helictotrichon desertorum* and miscellaneous herbs such as *Geranium collinum* are common.

State 4 (MS-S2: Meadow-Steppe type - state 2). The second MS state. It is characterised by the decreasing dominance of *F. valesiaca* and appearance of unpalatable and grazing tolerant species, such as *Ligularia alpigena*.

State 5 (S-S1: Steppe type - state 1). This state is characterized by dominance of *Stipa caucasia* and *F. valesiaca*, both typical for steppe and meadow steppe pastures of the Kyrgyz Republic. The fescue is a valuable pasture species. The dominance of *S. caucasica* indicates low grazing pressure in the spring, because *S. caucasica* is very palatable in spring but looses palatability in summer, and autumn.

State 6 (S-S2: Steppe type - state 2). This is the second steppe state. It is characterized by dominance of *S. caucasica* as in the first steppe state, but is distinguished from it by increased appearance of *Agropyrum cristatumand* later *C. turkestanica*. The *C. turkestanica* and Artemisia *tianschanica* are considered indicators for pasture degradation.

State 7 (SD-S1: Semi-Desert type - state 1). State 7 represents the most productive vegetation state within the semi-desert vegetation type. They dominated by perennial vegetation and presented by *Artemisia tianschanica* and *Artemisia serotina*. The herbacious layer is dominated by *S. capillata*, *S. caucasica* and *Elytrigia repens*. These species have high nutritive value in early spring.

State 8 (SD-S2: Semi-Desert type - state 2). This state is dominated by *Artemisia tianschanica* but lacks *Agropyrum cristatum* when compared to state 6. However, *F. valesiaca* is present in this state. It is both palatable and grazing tolerant. This state may also contain *C. turkestanica, its appearance is considered an indicator of* pasture degradation.

State 9 (SD-S3: Semi-Desert type - state 3). *Artemisia tianschanica* is still common but is being replaced by *Salsola oppositifolia*, which is not feasible as grazing plant and considered an indicator for soil degradation.

State 10 (D-S1: Desert type - state 1). This state is characterised by desert type vegetation, *Salsola oppositifolia*, *Anisantha tectorum* and *Trigonella arcuata*. In the second seral stage, the abundance of *T. arcutata* increases.

A detailed description of pasture types presented in Appendix 1.

Table 2. *List of transitions in the proposed STM model (Fig. 4).*

Transition 1 (T1). Meadow pastures are the most productive. These pastures are located far from a village and the period of use relatively short (60-90 days). This is a reason why meadow pastures almost do not feature bare soil. There is another type of degradation – domination of hard and unpalatable plants. It is reversible by regulating the stocking rate.

Transition 2 (T2). The transition from state 2 to state 3 is possible in the high mountains in the remote pastures, where at an altitude of 3000 m the difference in thermal and water conditions in the various expositions of the slope is not significant. The average temperature in the growing season is 6.6º C and about 300 mm of rainfall during the growing season. In these circumstances, a mutual transition at the optimal regime of grazing transition is possible.

Transition 3 (T3). An irreversible transition from meadow types to meadow steppe types of pasture (from state 2 to 3) may happen in the middle zone (2,500-2,800 m.a.s.l.), where the soil and climatic conditions are somewhat different from the upper zone. In these circumstances, state 3 and 4 are concentrated at the southern, south-eastern and south-western slope exposure. The reverse transition from state 3 to 2 is unlikely. Transition is possible only under the influence of climate change.

Transition 4 (T4). Transition 4 depends on overgrazing as well as on undergrazing. Both cases are cause of appearing unpalatable and hard plant species such as *Ligularia alpigena* and *Phlomoides oreophila*. Pastures may recover through adapted stocking rate on the pasture.

Transition 5 (T5). The transition 5 from meadow-steppe to steppe pasture types, such as the transition from state 4 to 5, is possible. In this case, the drought plays a key role. In addition, the stocking rate on pastures is also important. Under high stocking rate, the transition will appear first on slopes with higher insolation (south oriented slopes).

Transition 6 (T6). Mismanagement is the main cause of transition from state 5 to state 6. Recovery is possible through regulation of the stocking rate and intermitting the grazing for several years. The recovery can be further supported by seeding and fertilization

Transition 7 (T7). This transition occurs between state 6 to state 8 (from steppe to semi-desert types of pastures). The transition occurs under the influence of a high stocking rate in combination with less precipitation (from 180 to 220 mm) and high temperature (13-15 ºC) in the lower region of 2,000 to 2,500 m.a.s.l. The transition from state 6 to state 7 is unlikely, because state 7 is a derivative of the state 8 and is formed due to transition 8.

Transition 8 (T8). Low stocking rate on pastures in state 8 and favourable hydrological conditions (irrigation, the availability of water sources nearby, etc.) influence the emergence of state 7. Overgrazing during the prevailing hydrological conditions will lead to soil degradation (salinization, soil erosion, etc.). Exclusion of irrigation combined with overgrazing lead to the reverse transition to state 8

Transition 9 (T9). Exclusion of the irrigation in state 7 and compliance of the optimal stocking rate will lead to an one-way transition from state 7 to state 6. Adjusted grazing will contribute to the emergence and dominance of cereal grasses.

Transition 10 (T10). Continuous overgrazing which is happening around the villages, results in pasture degradation and desertification. It leads to the appearance of unpalatable and hard plants. A reverse process requires restoration work like the seeding of desirable plant species and long-term intermitting of grazing for 5-10 years, which is very difficult to apply currently.

Transition 11 (T11). Under the influence of a continued overgrazing up to the altitude of 2,300-2,400 m.a.s.l. state 9 passes into the desert pastures type of state 10. A relatively small amount of precipitation (200 mm) and high temperature during the growing season (15 º C) reinforces this transition. In state 10 the annual plants start to dominate.

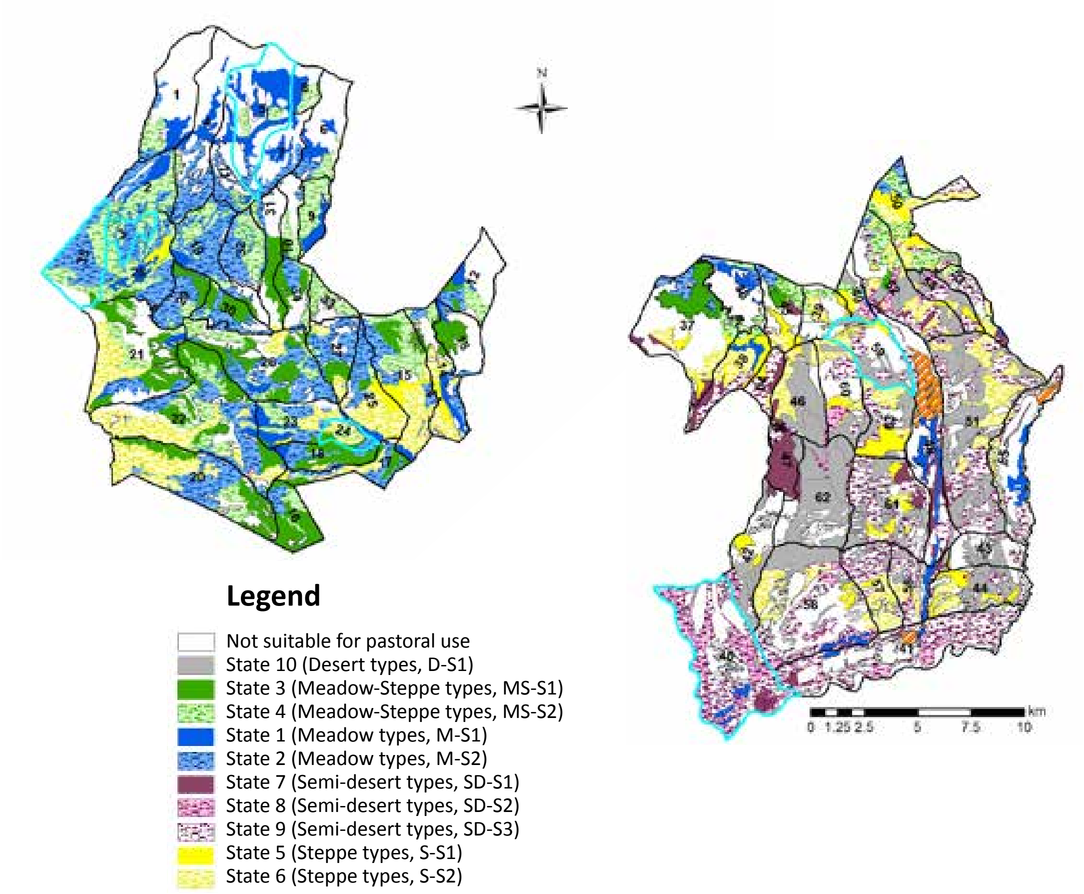


Fig. 5. *States distribution within the Jergetal aiyl okrug's pastures based on the CAMP Alatoo Public Foundation database. Black lines show borders of pasture units, figures indicate number of pasture units. Blue lines indicate pasture unites which are used as an example in Table 5.*

Consequently, 10 states which differ from each other in a number of parameters within Jergetal A/O can be registered. The comparison of states within similar pasture vegetation types shows that there are significant differences between states 1 and 2 when total palatable biomass is compared (P<0.001) but that significance does not hold for vegetation cover (Table 3). Thus, it can be assumed that transition 1 leads mostly to species change but to a lesser degree to a change of biomass. Vegetation cover in state 3 is still high and almost same as in state 1 (Fig. 6) but significantly less in state 4. but again, that does not show for biomass (P<0.07; Table 3).

Total biomass significantly decreased in state 4 comparably with state 3, due to general decreasing of vegetation cover, which in turn is most likely an effect of overgrazing.

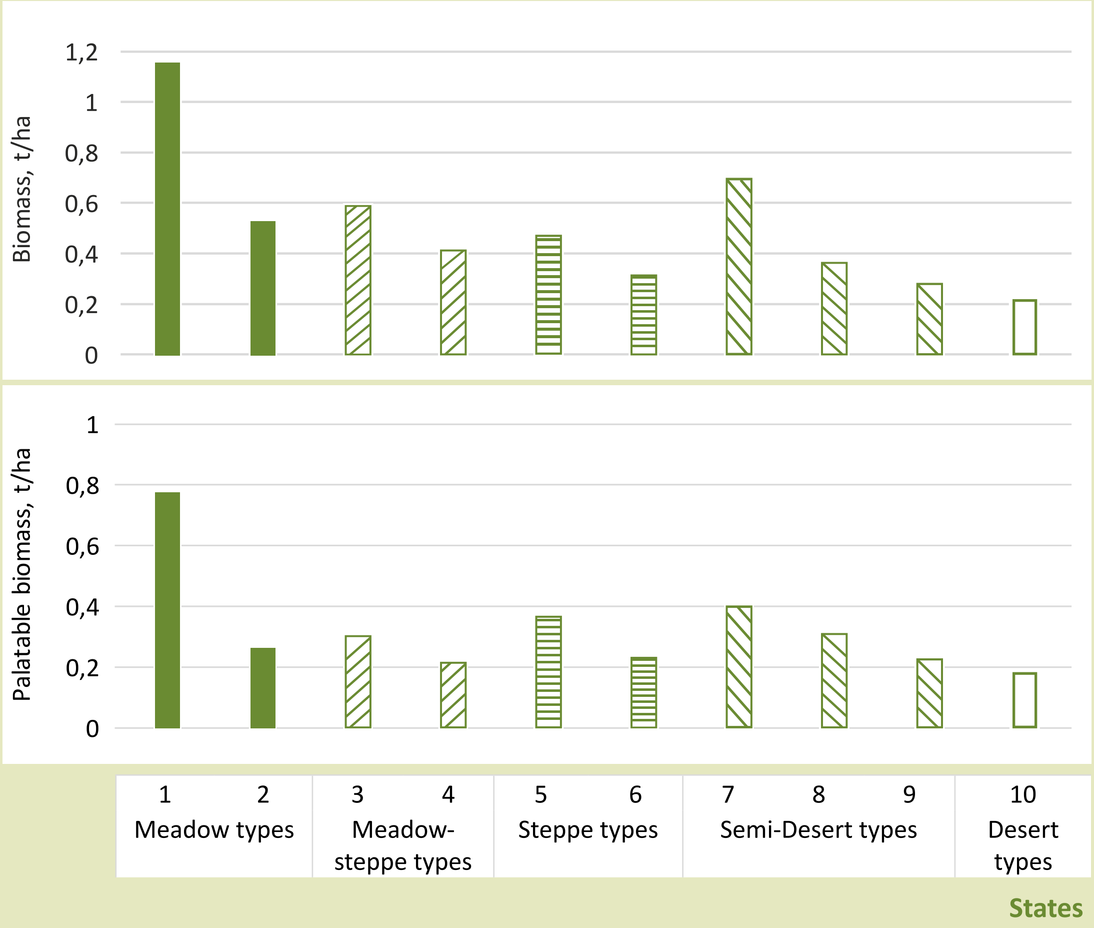
Table 3. *Summary of Mann-Whitney tests significances of variability of states within the meadow, meadow-steppe and steppe types of pastures. Significance level is at p <0.05.*

Effect	State	P	Effect	State	P
Total biomass	State 1 – State 2	0.001	Palatable biomass, %	State 1 – State 2	0.001
	State 3 – State 4	0.001		State 3 – State 4	0.07
	State 5 – State 6	0.001		State 5 – State 6	0.38
Palatable biomass, t/ha	State 1 – State 2	0.001	Vegetation cover	State 1 – State 2	0.57
	State 3 – State 4	0.001		State 3 – State 4	0.002
	State 5 – State 6	0.001		State 5 – State 6	0.39

State 6 is derived from state 5 and characterized by decreasing total biomass from 0.47 t/ha down to 0.31 t/ha (Fig. 6). Vegetation cover and percentage of palatable biomass are not statistically different (P>0.39; Table 3). This could be because species like *Agropyrum cristatum* is highly palatable in its early stage represented in state 6. Later its fiber contend increases and the palatability is reduced correspondingly. The Kruskal-Wallis tests were used to test states within the semi-desert pastures. The results indicated that there is significant variability between three states of the semi-desert vegetation types with respect to all parameters. The results are presented in Table.

Table 4. *Summary of Kruskal-Wallis tests of states within the semi-desert pastures.*

Effect	DF	H	P
Total biomass	3	110.3	0.001
Palatable biomass, t/ha	3	91.53	0.001
Palatable biomass, %	3	22.95	0.001
Vegetation cover	3	13.59	0.004



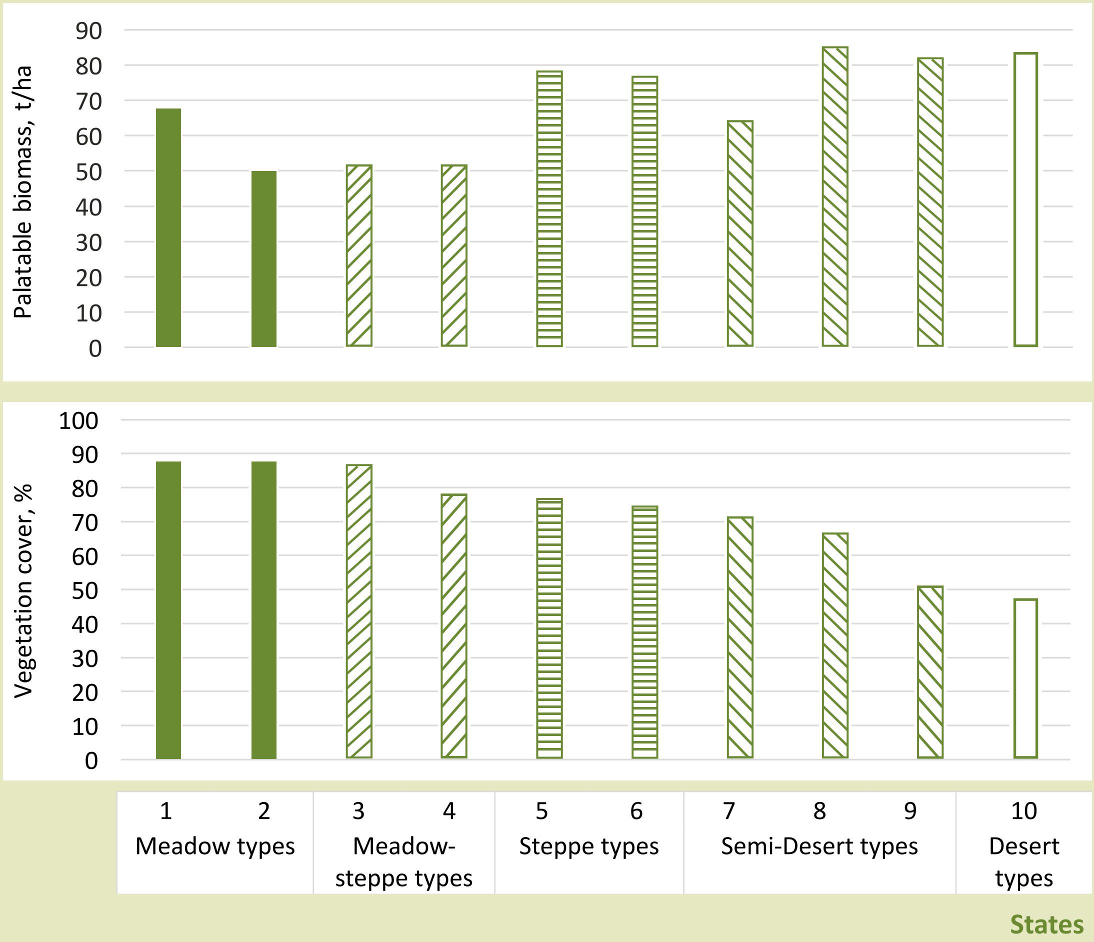


Fig. 6. *Distributions of biomass, palatable biomass in t/ha and % and vegetative cover of the states within the different types of pastures. Vertical bars represent ±1SE.*

4.1. Influence of different stocking rates on pasture condition

Regulation of the stocking rate is one of the most important elements of sustainable pasture use and allows to keep high productivity of pastures on the long run. According to reports from the State Agency on Environment Protection and Forestry of the Kyrgyz, the grazing pressure on pastures is growing (Atadjanov et al. 2012). Land use beyond optimal stocking rates causes an amplification of degradation processes, reduction of pasture productivity and eventually makes them unusable for agriculture. The stocking rate is the only tool available to all Kyrgyz range managers that can be used to adjust the successional trend of vegetation, see e.g. L. Penkina (2004) and A. Abdurasulov (2011) among others. However, it has been argued that grazing has minimal or no influence on the vegetation dynamics of arid environments, because of pronounced interannual rainfall variability, such that these grazing systems are considered to be non-equilibrial (Ellis & Swift 1988, Fernandez-Gimenez & Allen-Diaz 1999). The notion that grazing has a minimal impact on vegetation has been extended to the pastoral systems of the semi-arid savannas of Africa where rainfall has the most marked effect on variability in herbaceous production. The depletion of biomass by heavy grazing is more pronounced with combination of drought (Fynn and O'connor, 2010). W. Bayer and A. Waters-Bayer (2003) believe that the non-equilibrium nature of vegetation in arid areas are deliberately avoided. Similar opinion is shared by Kerven et. al. (2012).

Against the background of the dispute going on over the impact of livestock grazing on pasture conditions in the arid zone, it is interesting to study the effect of pressure on the transition from one state to another. The current grazing pressure on pastures of Jergetal A/O was assessed in 2011 (see Appendix 2). The results are shown in Fig. 7.

The results indicated that meadow and meadow steppe types are more productive under optimal grazing pressure. Two different trends are noteworthy. First there is an increase in biomass, as the grazing pressure increases from <1 to the optimal stocking rate of 1. This trend can be described by the linear equation: y =015x +0.36 (R^2 = 0.89). Further increase of the grazing pressure leads to a reduction of biomass, which can be described by another linear relationship, y =-0.133x +1.151 (R^2 = 0.77) (Fig. 7). Grazing may temporary provoke the increasing of biomass in states 1 and 3. At low level of pressure pastures reduces biomass, as well as when pressure is increasing. In a condition with optimal grazing pressure, the states 1 and 3 dominated, by low pressure pasture is dominated by the states 2 and 4 (Fig. 8). Increasing the grazing pressure leads to domination of states 4 and 2, in extreme pressure conditions there is a variety of states from 2 to 6.

Pastures of arid and semi-arid zone (steppe, semi-desert and desert pastures types) follow a different pattern. There biomass decreases constantly with increasing grazing pressure. This trend can be described by the linear equation: y =-0.543x +0.5976 (R^2 = 0.99). Here pastures have highest biomass under low grazing pressures. They are presented by state 7 (SD-S1) in the STM (Fig. 4). Starting at an equal level of stocking rate with carrying capacity, biomass is gradually reduced (Fig. 8).

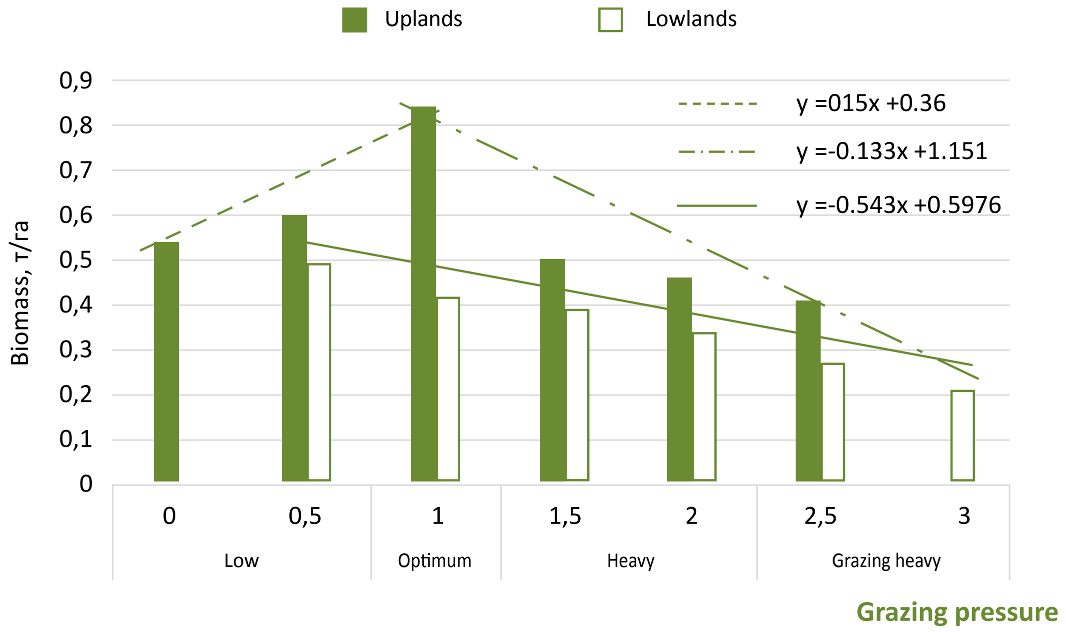


Fig. 7. *The Influence of grazing pressure on pasture biomass ——— (linear function of lowlands; linear - - - - - - function of uplands, the state of lack of grazing to the optimal grazing pressure – 1 and ·—·—·- linear function of uplands were allowed exceeding of carrying capacity. Pastures were arranged into groups based on similar pasture ecosystems. Thus, meadow and meadow steppe pastures were combined into an upland pasture ecosystems group. Steppe, semi desert and desert types were combined into pasture ecosystems of dry areas or lowlands. The upland pastures are generally characterized as having higher humidity and more fertile soils than the lowland pastures.*

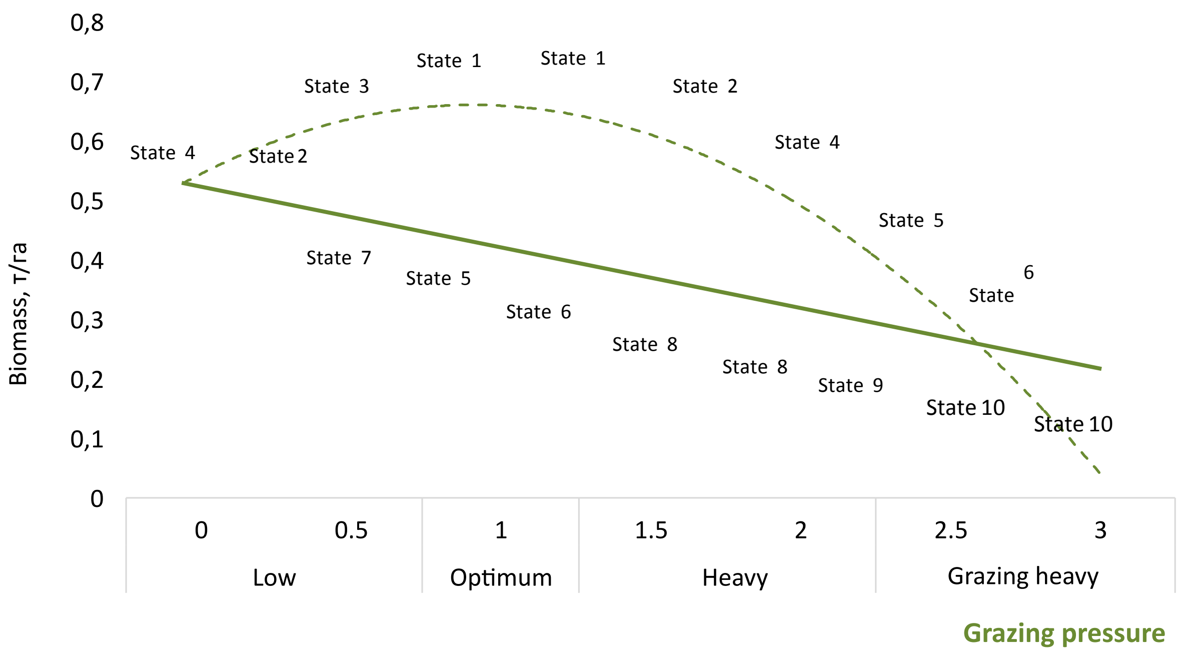


Fig. 8. *Suggested trajectories of biomass production for upland pastures (dashed line) and lowland pastures (solid line) under varying grazing pressures. States as proposed in Fig. 4 have been superimposed on the figure based on their biomass production and expected location in the STM framework.*

The results suggest that the semi-arid areas are mostly controlled by abiotic factors such as rainfall, temperature and soil conditions. Those factors have a major impact on the vegetation, species composition and biomass. However, if there is sufficient moisture, such as in the upland pastures, then biotic factors, here grazing, is the most influential factor on biomass production.

4.2. The possibility of applying STM in practice

In 2009, the parliament of Kyrgyz Republic issued the Law on Pasture (N 30), which shifted the responsibility for managing pastures to new community-based user organizations. According to the law, all pasture users must now form Pasture User Unions (PUU), which elects its own executive body, called pasture committee. These bodies are obligated to govern the use of pastures independently from state administrative control. The PUUs hold a bundle of rights and responsibilities. They have to develop and implement a community pasture management plan and an annual pasture use plan, they issue pasture use right certificates and collect payments for pasture use, resolve disputes among pasture users, and carry out investments in pasture infrastructure and maintenance.

However, the implementation of the above commitments is difficult for pasture committees. As members of the pasture committee are elected from the local pasture users, some do not have the appropriate education and most of them even lack practical experience in pasture management planning as the planning was organized by the State Land Management Committee (Giprozem) during the Soviet time. There is a considerable need for pasture use and management plans in the Kyrgyz Republic that rest on scientific base. Using STM could serve as a basis for pasture management plans for Jergetal A/O, as is now obligatory for the local pasture committees according to the new law.

If this approach is taken, then it will be necessary to take into account the fact that the current carrying capacity of the pastures as well as the potential carrying capacity has a very high and often unpredictable coefficient of variation (Table 5).

Therefore, planning of the pasture use should be started with a minimal stocking rate on the pasture, for example for the pasture unit 35 (Table 5) would amount to 100-120 LU. The pasture condition would then have to be assessed at the end of every year, both through monitoring of the pastures themselves, but also through the assessment of the condition of the livestock grazing on the site. In addition, it is necessary to include the projected future effect of each year's weather conditions on the coming years. If there were deviations from the normal year, for example, heavy rains or drought or high temperature deviations, then it may be necessary to continue with the same or even lower, stocking rate the next year. On the other hand, if the pasture condition is good after the grazing season, livestock condition is better than in the previous years and the weather conditions were not abnormal, it can be assumed that the stocking rate is not to high and therefore it is possible to increase the stocking rate cautiously.

Thus, referring again to Table 5, it might be possible to increase the grazing pressure on site 35 (Fig. 5), as there is no grazing and it is covered mostly by unpalatable vegetation. Adjustable grazing can increase the productivity of pastures. A lack of grazing during several years on pastures in uplands leads to creation of thick senescent litter layers formed by *Ligularia alpigena* and *Phlomoides oreophila*, which reduces regeneration or growth of new seedlings. Moderate grazing of pastures will prevent formation of this layer and rather create conditions allowing growth the of more desired vegetation species such as *Carex stenophylloides, Carex stenocarpa, Agrostis alba* (Penkina 2004). In such cases the transitions between states 1 and 2 would occur (Fig. 4).

Table 5. *Planning pasture use according to pasture current carrying capacity and its variability of Jergetal A/O.*

№ of pasture unit	S of pasture, ha	Season of use	Current stocking rate	Current carrying capacity, LU	Potential carrying capacity, LU	Management activities
35	662	Summer	0	100 - 230	240 - 560	1. This pasture unit is out of use, which led to lower yields. To achieve the potential carrying capacity this pasture unit has to be under grazing. In the early years should not graze more than 110-120 LU, followed by an adjustment of livestock to 400-500 LU. 2. Need to find out the reasons for non-use of the site and plan actions to address the issue in a pasture management plan
3	290	Summer	0.5	40 - 100	100 - 230	3. Low stocking rate on pasture, number of livestock has to be increased on this site.
5	596	Summer	1	230 - 530	400 - 940	4. The stocking rate is optimal. However, the potential carrying capacity is not reached, it is necessary to introduce a rotation grazing within in the pasture unit.
24	243	Summer	2.8	36 - 85	50 - 110	5. Because of the proximity of this site to the village, the pasture is overused. It is necessary to reduce the stocking rate. Look for opportunities to move livestock to pasture unit 35. 6. Increase the pasture ticket cost for this site 7. Due to continuous grazing, pastures feature the steppe states. Transition within the pasture types does not give the desired increase in the potential carrying capacity. For significant improvement of the pasture condition, the site should be excluded from grazing for several years.
40	1125	Spring – autumn	0.5	260 - 430	330 - 560	8. The area of pasture is too big. It is suggested to introduce a rotation of pastures within the pasture unit to help improve the condition. 9. The reason of under-utilization is lack of livestock watering points. Water points have to be installed.
59	392	Spring – autumn	2.3	100 - 165	145 - 240	10. Allowed overgrazing. Stocking rate should be decreased 11. Look for opportunities to irrigate pastures to achieve the desired state

4.3. Quotas on numbers of livestock as a way of combating the degradation of pastures

4.3.1. *Dynamics of livestock number*

In Kyrgyz Republic, the number of livestock is gradually increasing. Officially, in the last 12 years the number of livestock has increased by 45.3%. Currently there are 13.8 million LU (Atadjanov et al. 2012). However, it is well known that farmers dont reveal the real number of livestock as they fear losing various subsidies from the state. It is estimated that the actual number of livestock is at least by 30-50% higher than reported (CAMP Alatoo Public Foundation 2012). In six of seven regions of Kyrgyz Republic, livestock number exceeds the permissible pasture grazing pressure (Atadjanov et al. 2012). Jergetal A/O can be taken as an example of this trend (Fig. 9).

Labour migration is also one of the reasons for the increasing livestock number. Close to 20% of the population are seeking better economic opportunities in Russia and Kazakhstan, sending back remittances (Sadowskaja 2008). Most of the remittances are used to buy livestock - in rural areas the wealth is usually measured in terms of how many livestock each household owns. Livestock serves as an investment fund that increases through natural reproduction, unlike the remittances. Livestock can also be sold whenever cash is needed. Furthermore, livestock is important for traditional celebrations when people butcher animals in order to serve to guests or to offer gifts (Schoch et al. 2010). Owning livestock is thus of greater importance for the local people than money.

Fig. 9. *Changes of livestock numbers in Jergetal A/O in Kyrgyz Republic from 2000 to 2013 years (adopted from S. Bussler, 2010).*

4.3.2. *Livestock distribution between households*

The distribution of livestock is extremely unequal. 1.1% of households of Jergetal A/O owned 16.8% of the livestock, or 161 LU per household. At the same time, 61% of households owned only 39% of the livestock, or an average 7 LU (Table 6).

Table 6. *Distribution of livestock in groups of households in Jergetal aiyl okrug in Kyrgyz Republic (unpublished data).*

№ of group	Households		Possessing		Avarege LU number per household
	number	%	LU number	%	
1	13	1.1	2,063	16.8	161
2	28	2.4	1,636	13.3	59
3	193	16.6	3,506	28.5	18
4	710	61	4,797	39	7
5	172	14.8	299	2.4	2
6	48	4.1	0	0	0
Total	1,164	100	12,300	100	

According to the interviews conducted in more than 30 A/Os in Kyrgyz Republic such distribution of livestock as in Jergetal A/O is typical for the vast majority of rural communities. Livestock owners have gradually increased their herds. This leads to overexploitation of the common pastures. In Jergetal A/O, the current carrying capacity of pastures is already exceeded (Table 7).

Table 7. *Estimated carrying capacity of Jergetal A/O pastures within different STM states. Current LU number adopted from CAMP Alatoo Public Foundation (2012), current and potential carrying capacity derived from equation 1. A last column shows the potential capacity of the pastures at the appropriate moisture content of pasture land. The calculation is based on the yield of state 7 where the moisture content is high. (Fig. 4).*

Pastures	Current livestock number, LU	Current carrying capacity	Potential carrying capacity with appropriate management	Improvement of hydrological conditions of pasture
Spring pastures	13,000	4,400-7,300	5,000-8,400	5,800-9,600
Summer pasture	11,700	3,150-7,400	5,500-12,800	5,500-12,800
Autumn pastures	10,400	6,300-10,000	7,300-12,000	8,600-14,000
Winter pastures	12,300	2,000-3,500	2,300-3,900	2,700-4,400

In all seasons, the number of livestock exceeds the current carrying capacity. However, it must be noted that around 3,000 LU registered in Jergetal A/O are grazed offsite of Jergetal's pastures. They are grazed on pastures belonging to the Forestry Agency or other A/O's. It is estimated that about 9,300 LU graze on Jergetal pastures (CAMP Alatoo Public Foundation 2012). This amount of livestock can only be kept without further degradation, when carrying capacity is increased. Farmers are well aware of what is happening:

> "Currently the number of livestock is increasing; all of us are trying to get more income from livestock products, thus mercilessly using natural resources. We rarely think that these resources will start to be exhausted and, in my opinion, it will occur very soon. Therefore, we should make all efforts to not make it happen. For this we need to unite efforts and introduce pasture use rules"(farmer, 54 years old, Jergetal village, 2012).

As a workaround, farmers see the improvement of pasture conditions, including improvement of remote pastures' infrastructure, increased production of winter forage for winter-feeding. However, there are those who are suggesting measures that are more drastic:

> "There is an increase in livestock, which has an impact on the state of pastures. According to the law on pastures, we are members of the pasture committee (PC) and have to control the livestock number according to the capacity of pastures. This means that we are authorized to limit livestock numbers. However, I see that the number of livestock exceeds the capacity of the pastures, but how can I come and tell the farmer that he should reduce the number of livestock? They will not listen, because there is no mechanism for this. We need at least a decision of the local parliament on quotas, only then we can do something". (50 years old chair of PC of Yrys A/O. 2012).
>
> "We urgently need to introduce quotas and reduce livestock. In the past, mudflow occurred in the early spring, when the grass has not grown, nowadays mudflow occurs even in autumn! All this because we are overusing pastures. There is no vegetation on pastures in autumn, so pastures are not able to infiltrate even the small amount of precipitation. Even in Soviet times, there were not such mudflows when pastures were considered as degraded! "(55 years old chair of PC of Aflatun, 2012).

Obviously, an increasing livestock number is a serious problem for the sustainable management of pastures in Kyrgyz Republic. There is not any precedent in Central Asia for this kind of reference quotas for livestock. On the contrary, in Kazakhstan and Uzbekistan, increasing the number of livestock is encouraged (Golovina 2011). The approach taken by European countries (Arnalds & Barkarson 2003; Bayer & Waters-Bayer 2003; Arnalds et al. 2011) is also not representative for Kyrgyz Republic, because there animal husbandry is subsidized. That is not planned in the near future in the Kyrgyz Republic.

Many farmers believe that quotas the most suitable tool for regulating the livestock number. However, the government is not ready to take that step, fearing that limitation of the livestock number can lead to confusion on the part of farmers so they will not support such step. Instead, the state has delegated authority on these issues to the local administrative levels (A. Egemberdiev, 21 November 2012, Pasture Department of Kyrgyz Republic, personal communication).

4.3.3. *Suggested quota system, case of Jergetal A/O*

The only tool currently available to control the livestock number in Kyrgyz Republic is the quota of livestock at local governmental level. Jergetal A/O can be taken as an example. As already mentioned above, in Jergetal A/O there are 12,300 LU, but 3,000 of them graze offsite. The carrying capacity of pastures is presented in Table 7: the lowest carrying capacity of pastures is in the winter time, but many farmers harvest winter fodder and keep animals in barns for the winter months, hence the winter capacity may not be decisive for the quota. Spring and summer carrying capacity is approximately the same, while both are below the autumn carrying capacity. As has already been said, determining the stocking rate must take into account the conservation of nature. This could result in a total quota for Jergetal A/O of about 3,000-3,500 LU. However, such a drastic reduction of livestock number can face a lack of understanding among farmers; as a result, the risk that the system will not work, will increase dramatically. Therefore, the initial quota could be set at 7,400 LU (Table 7). Even in this case, it would be possible to reduce the livestock number by 20%, and, if the land is managed appropriately, its carrying capacity could increase.

There are 1,164 households and respectively, each household is entitled to keep up to seven LU. The 930 or 80% of households (groups 4-6, Table 6) have livestock according to the quota or less, respectively, 234 or 20% of households (groups 1-3) exceed the limit (Table 6). If the pastures can be improved, then the quota could be increased to as much as 12 LU per household.

At present, the amount of livestock that each household can own is not regulated. One village household may not be able to purchase livestock due to lack of funds, but at the same time another household may own 300 LU. However, both households have the same rights to grazing, as the pastures are common resource - a recipe for a classical example of tragedy of the commons (Hardin 1968). However, none is responsible for the improvement of the common pasture condition. The introduction of payment for exceeding the quota will help to create a fund for restoration of the pastures and hopefully increase land use responsibility. The following options for households that exceeded quota are suggested:

1. Households exceeding their quota can rent quota from households that have less livestock than their set quota allows (from groups of 5 and 6).
2. Local parliament fines households that exceed their quota. The cost could be different for different groups. For example, group one would have to pay more than the groups two or three (Table 6). In addition, on the cost of the payments should be adapted to the remoteness of pastures and private contributions of farmers for the improvement of infrastructure and pasture conditions. Under such circumstances, the payment should be minimal.

The government has no intention to allocate any funds to pasture improvement measures. Local funding is thus the only option and must be based on numbers of livestock r of each household. In the case of Jergetal A/O, 80% of the population has less livestock than the quota would permit. It is hoped that 80% of the population will be able to convince the remaining 20% to invest proportionally in pasture improvement. In addition, there is a hope that the big livestock owners will start investing in other sources of income not related to grazing. They already have accumulated sufficient capital in the form of livestock in order to start a private business, thereby enabling fellow villagers to improve their welfare.

5. CONCLUSIONS

Kyrgyz Republic's landscapes are diverse. They range from lowlands to mountainous ranges with steep slopes of varying aspects and exposures. Pasture types are equally diverse, requiring different approaches and flexibility in land management. A conceptual tool for management that has been suggested under such circumstances is the STM. They are flexible and easily adaptable to various management approaches, different landscapes and pastures of varying conditions. STMs models are based on land condition (states) and transition between states given certain disturbances or conditions. The developed model can be used to predict pasture responses under certain management criteria.

The assessment presented here of the current and potential carrying capacity of Jergetal A/O's pastures indicates that the current carrying capacity accounts for about 40-50% of what could be the potential carrying capacity, if the land was managed in an optimal way. Long term exploitation has locked the pastures in a degradation cycle which must be broken.

The lowlands and the uplands possess different properties with respect to system resilience. The lowland areas are dry with vegetation well adapted to climate driven disturbances, e.g. long term droughts. Such systems can also show resilience for grazing as shown by Milchunas et al. (1988). It appears indeed that grazing is not the driver in the land condition in the lowlands, but the climate.

The situation is different for the upland pastures. They are less resilient than the lowlands and consequently affected to a larger extent by the land management. These peculiarities must be taken into account when management planning takes place in the region. Regulation of stocking rate should prevail in this zone as the most effective approach to control the degradation of pastures.

Land use planning based on the STM approach can help to achieve sustainable pasture management. Regulation of livestock will help to achieve a potentially higher carrying capacity of pastures. The introduction of the quota system for livestock and payments of households exceeding their quota will create funds at the local government level, which can be used to restore pastures and the area's infrastructure. Trading of quota between households will also help to improve their financial situation.

Land management needs to be based on opportunistic approaches that rest firmly on an understanding of the ecosystems response to disturbances, including climatic and anthropogenic. Using STM as a tool for land management meets those goals and provides, additionally, a comprehensive way to identify landscapes at risk.

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APPENDICES

APPENDIX I. Description of pastures types

Meadow type pastures

A sedgy poaceous meadow pastures types (state 1) are mostly located on the upper mountain zone within altitudes 2,600 – 3,100 m.a.s.l. (Fig. 10). The state 1 is a referent site for the meadow type of vegetation and dominated by grasses - *Carex stenophylloides* and *Carex stenocarpa*. This state is most productive and gives more than one t/ha biomass, of which about 67% or 0.77 t/ha are palatable. Presenting of bare soil is the smallest, about 12% (Fig. 6). The state is achievable by regulation of stocking rate, which should be appropriate to carrying capacity of pastures. High or low level of stocking rate leads to a state 2.

Fig. 10. *Kobresia stenocarpa meadowes of Jergetal A/O on 3,050 m.a.s.l., Son-Kol valley.*

The state 2 dominated by *Carex stenocarpa*. Continued high level of grazing leads to increasing number of hard plants as *Ligularia alpigena and Phlomoides oreophila*. Such changing of species composition still keeps high vegetation cover (87.7%) but less biomass 0.52 t/ha and only 50% of them palatable species.

Meadow steppe pastures

Meadow steppe pastures located at the altitudes from 2,400 up to 3,000 m.a.s.l. and mostly on south, south-west and southeast facing slopes of mountains (Fig. 11). They occupy large areas and are one of the productive pastures types. Meadow steppe pastures have two states – state 3 (but it is state 1 within the meadow steppe types or MS-S1) and state 4 (state 2 within the meadow steppe types or MS-S2). The state 4 is named “poaceous with miscellaneous herbs” and dominated by *Poaceous* presented by *Festuca valesiaca, Helictotrichon desertorum* and *miscellaneous herbs* presented by *Geranium collinum*. Total biomass about 0.6 t/ha and 52% of them palatable (Fig. 6). Continues overgrazing can lead to transition state 4 into state 5. The soil trampling together with a decreasing of precipitation and increasing of temperature in the middle zone (2,400-2,700 m.a.s.l.) gradually can change vegetation and finally vegetation composition from meadow steppe to steppe types.

Fig. 11. *The motley grass meadow steppes of Jergetal A/O on 2,900 m.a.s.l., Sarjonsuu valley.*

Steppe pastures

Steppe pastures located within the altitudes 2,000 up to 2,700 m.a.s.l. (Fig. 12). This pastures mostly used by farmers as a spring and autumn pastures. They able to grove in dry areas (180 mm) with high average temperature of vegetation period – 15º C. State 5 (or S-S1) dominated by *Festuca valesiaca*, which is typical for steppe and meadow steppe pastures. The dominance of *Stipa caucasica* in the later stages indicates a lack of enough grazing pressure on these areas in the spring, because *Stipa caucasica* is quite well palatable in spring, unpalatable in summer, and autumn. Total biomass of the state is 0.47 t dry matter per hectare. Steppe type of pasture has a high percentage of palatable biomass (78.5%) and almost the same percentage of vegetation cover with previous state (77%) (Fig. 6). Mismanagement and climatic condition like luck of the precipitation main thresholds for transition state 5 into state 6 (S-S2). High stocking rate on the state with dry summer can lead to transition from state 6 – steppe pastures into the state 8 – semi desert type of pasture.

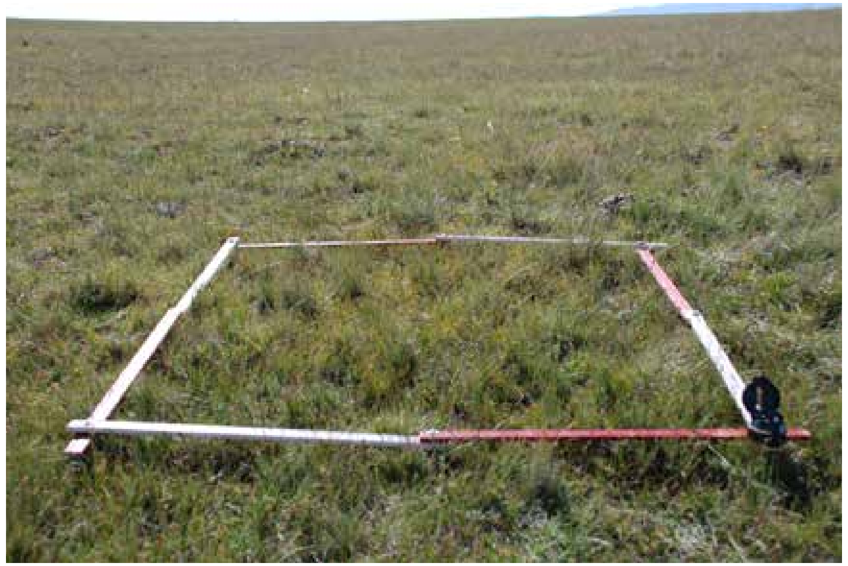

Fig. 12. *The steppes pastures of Jergetal A/O on 2,450 m.a.s.l., Teshik valley.*

Semi desert pastures

Semi desert pastures occupied lowlands within the altitudes 2,000-2,400 m.a.s.l., with low precipitation (180 – 220 mm) (Fig. 13). State 7 (or SD-S1) - the sagebrush-herbs occupied a few land with good humidity due to rivers located not far from them. The state 7 able to give high total biomass about 0.7 t dry matter per hectare which is second high biomass after state 1 but smallest percentage of palatable biomass within the semi desert types (Fig 6). It shows potential of land in appropriate hydrological condition. However, the state 7 is not typical for region due to small area of distribution and we should to try avoid overestimations of pastures potential. The state 7 dominated by perennial vegetation and presented by *Artemisia tianschanica* and *Artemisia serotina*. Grass layer is dominated by *Stipa capillata*, *Stipa caucasica* and *Elytrigia repens*. Excluding hydrological well condition and overgrazing in state 7 and overgrazing and several dry summers in state 6 will lead to state 8. The sagebrush-grass types of pastures or state 8 (SD-S2) are dominated by *Artemisia tianschanica* and *Artemisia serotina* as the state 7. Additionally *Festuca valesiaca* appears, which is valuable species in terms of grazing and characterized by the ability to withstand heavy pressure. In moderate intensity of grazing *Festuca valesiaca* can survive for many years. Total biomass almost two time less then in state 7, but percentage of palatable biomass is high (85%).

Fig. 13. *The semi-desert pastures of Jergetal A/O on 2,200 m.a.s.l., Tarsuu valley.*

State 9 (SD-S3) creates due to continuous overgrazing in state 8. *Ceratocarphus utriculosus* appears – palatable species but it is a typical representative of the desert vegetation. In the last step dominant plant changes, instead of perennial plant *Artemisia tianschanica* comes an annual - *Salsola oppositifolia*. In this state total biomass decreasing (0.27 t/ha) as well as vegetation cover. Percentage of palatable biomass remaining relatively high – 82%.

Desert pastures

Desert types of vegetation occupies a fairly large are around villages on low altitudes (2,000-2,300 m.a.s.l.). Desert types of pasture consist one state – state 10 (D-S1) which is dominated by annual species like *Salsola oppositifolia, Anisantha tectorum* and *Trigonella arcuata*. State has lowest biomass (0.21 t/ha), lowest percentage of vegetation cover (47%) but high percentage of palatable biomass (Fig 6).

Fig. 14. *Desert type of pastureof Jergetal A/O, 2014*

APPENDIX II. Pressure on pasture unit and states‘ distrubition

Pasture unit nomber	***Pressure on paster unite***	***Dominating states***					***Accupated %***				
		1	***2***	***3***	***4***	***5***	***1***	***2***	***3***	***4***	***5***
1	*0.97*	*State 1*	*State 4*				*58*	*42*			
2	*0.66*	*State 4*	*State 2*	*State 1*			*60*	*30*	*10*		
3	*0.50*	*State 2*	*State 4*				*51*	*49*			
4	*0.70*	*State 2*	*State 1*	*State 4*			*60*	*30*	*10*		
5	*1.03*	*State 1*	*State 2*	*State 4*			*70*	*16*	*14*		
6	*1.56*	*State 4*	*State 2*	*State 1*			*45*	*30*	*25*		
7	*1.56*	*State 2*	*State 1*				*60*	*40*			
8	*1.56*	*State 2*	*State 1*				*55*	*45*			
9	*2.87*	*State 4*	*State 1*				*70*	*30*			
10	*1.37*	*State 3*	*State 4*	*State 2*			*69*	*19*	*12*		
11	*0.60*	*State 2*	*State 4*	*State 1*			*59*	*24*	*17*		
12	*1.30*	*State 1*	*State 3*	*State 2*	*State 4*		*35*	*25*	*22*	*18*	
13	*1.25*	*State 3*	*State 4*	*State 2*			*61*	*21*	*18*		
14	*1.10*	*State 1*	*State 5*	*State 6*			*40*	*35*	*25*		
15	*1.91*	*State 6*	*State 4*	*State 5*	*State 2*	*State 3*	*30*	*25*	*15*	*15*	*15*
16	*0.93*	*State 3*	*State 2*	*State 4*			*70*	*16*	*14*		
17	*1.19*	*State 2*	*State 3*	*State 6*			*50*	*30*	*20*		
18	*0.00*	*State 3*	*State 2*	*State 1*			*40*	*35*	*25*		
19	*0.50*	*State 2*	*State 4*	*State 2*	*State 3*		*45*	*34*	*13*	*8*	
21	*0.90*	*State 3*	*State 4*	*State 5*			*40*	*35*	*25*		
22	*1.20*	*State 6*	*State 2*	*State 4*	*State 3*		*34*	*29*	*22*	*15*	
23	*2.07*	*State 2*	*State 4*	*State 6*	*State 1*		*35*	*30*	*20*	*15*	
24	*2.78*	*State 4*	*State 6*	*State 3*			*45*	*33*	*22*		
26	*1.03*	*State 3*	*State 4*	*State 2*	*State 1*		*34*	*26*	*24*	*16*	
27	*1.14*	*State 3*	*State 1*	*State 2*			*50*	*30*	*20*		
28	*0.00*	*State 2*	*State 4*	*State 1*			*45*	*40*	*15*		
29	*0.73*	*State 2*	*State 3*	*State 4*			*67*	*19*	*14*		

30	1.79	State 2	State 3	State 4			50	40	10		
31	1.00	State 1					100				
32	0.40	State 2	State 4				53	47			
33	2.29	State 4					100				
34	1.09	State 3	State 2	State 4			44	31	25		
35	0.00	State 2	State 4				60	40			
36	1.15	State 1	State 2	State 4			42	34	24		
37	0.95	State 3	State 6	State 5			64	25	11		
38	0.80	State 6	State 7	State 8	State 5	State 1	30	20	21	19	10
39	3.19	State 4	State 6	State 5			40	38	22		
40	0.60	State 8	State 9	State 1			50	35	15		
41	1.30	State 9	State 8	State 7			63	22	15		
42	2.01	State 10	State 5				70	30			
44	5.74	State 10	State 6	State 5	State 9		50	25	15	10	
45	3.19	State 4	State 5	State 3	State 2		30	27	22	21	
46	1.74	State 10	State 9	State 7	State 6		49	21	16	14	
47	0.50	State 7	State 8				83	17			
49	3.19	State 6	State 5	State 4	State 8	State 8	29	27	20	18	6
50	0.70	State 5	State 6	State 4	State 2		43	29	18	10	
52	0.45	State 10	State 6	State 9	State 4	State 7	28	22	20	19	11
53	0.52	State 8	State 6	State 5			45	40	15		
54	2.30	State 10	State 9	State 8	State 5		50	25	15	10	
56	1.07	State 6	State 8	State 5			42	31	27		
58	2.20	State 9	State 6	State 10			56	23	21		
59	2.28	State 10	State 9	State 6	State 5		49	22	18	11	
60	2.50	State 10	State 6	State 9	State 8		30	25	25	20	
61	1.18	State 9	State 10	State 7	State 5	State 6	45	35	8	7	5
63	2.59	State 9	State 6	State 5			51	28	21		

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Responsible
Dr. Stepan Uncovsky
stepan.uncovsky@giz.de

Author/Editors
Azamat Isakov, Dr. Johann Thorsson

Layout
Aleksander Gorbatovskij

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