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STABILITY OF LANDSCAPES OF THE CENTRAL CAUCASUS IN RELATION TO GRAZING STRAINS

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Abstract

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Assessment of stability of landscapes in relation to grazing strains was performed using statistical methods. Mechanisms of transformation of landscape structure differ between altitudinal belts. In steppe landscapes the main reaction is the change of collection of species without decrease of their number and phytomass. The most typical process of degradation is erosion. In meadow steppe and meadow landscapes, on the contrary, number of species and phytomass change their values quickly and control the state of turf. Degradation usually develop through disturbance of the circle of organic substance without active lateral transport of solid substance. The least stability is characteristic for steppe landscapes. The components are usually not balanced because they fail to adapt to increase of grazing strains. The meadow steppe landscapes possess the most balanced structure and the best ability to adapt to grazing strains. The potential of their recovery is rather high due to stability of soils. Meadow landscapes have medium stability.

Introduction

The Central Caucasus can be characterized as a region with contradiction of unique natural landscapes and heavy anthropogenic impact. The typical economic activity of indigenous population is pasturage of sheeps and cattle being the only source of profit. Present-day increase of private live-stock causes irreversible changes of landscapes resulting in erosion and complete loss of productivity. Diversity of landscapes represents an excellent possibility to compare stability and mechanisms of landscape transformation in different altitudinal belts. Strategy of harmonization of interrelation between nature and economy must be based on assessment of landscapes stability. Stability is interpreted as reliability of landscape being an object of economic activity for the period of several decades. This period is comparable with average duration of high-mountain landscape state with the same parameters of component i. e. vertical (Isachenko, 1973) structure. Stability can be realized in 3 forms: 1. resistance, i. e. ability not to change under exterior influence, 2. recovery, i. e. ability to return to former state after influence, 3. plasticity, i. e. existance of several stable states which succeed each other during increase of exterior influence (Grodzinsky, 1987; Forman, Godron, 1986; Gigon, 1983). Potential of stability depends on the distance of the landscape state from the critical one. As the critical such values of landscape parameters were accepted, over which the lateral flow of solid substance begins to prevail over radial biotic flows. As the indicator of degradation of landscape structure the content of humus and composition of soil profile can be used.

The main questions of the research are the following. How grazing strains are reflected in properties of phytocoenosis and soil in different altitudinal belts? Which combinations of states of landscape components can be evaluated as stable or unstable? What is the sequence of stable and unstable states?

Materials and methodology

Field material for the research was collected in the valley of the Baksan river which has its source in the glaciers of the Elbrus mountain (5462 m). Landscape structure is represented by glaciers, alpine and subalpine meadows, dwarf birch, pine and broad-leaved forests, meadow steppes, typical and dry steppes which succeed each other with decrease of altitude and dependently on solar exposition. Geological basis of the landscapes is formed in the upper part of the valley by Pleistocene volcanic rocks of Elbrus, Proterozoic cristalline schists and Paleozoic granites. Glaciers, meadows and forests prevail there. In the middle and lower parts, where steppes prevail, Jurassic sandstones, shales and limestones are spread.

Assessment of stability in relation to grazing strains was performed for steppe, meadow steppe and meadow landscapes using statistical methods. The basic concept is the following. Transformation of the vertical structure of landscape can be divided into several stages. Firstly almost immediately such quantitative parameters as height and projective cover of grass vegetation change their values. The amplitude of cover changes depends on steepness of slope. So these parameters can be used as indicators of grazing strains. At the second stage if grazing strains are constant qualitative transformation of phytocoenosis take place. It includes functional effects indicated by changes in phytomass, number and composition of species, number of layers. Potential of landscape recovery at this stage is promoted by supply of nutrients and seeds in unchanged soil. Further increase of grazing strains leads to the third stage – transformation of the most inert components, namely soil and microrelief. This means simplification of soil profile, loss in humus and mineral nutrients content, development of carbonate horizon. Destruction of soil profile and changes of microrelief mean, that lateral abiotic flows of solid substance are more significant than radial biotic ones. This stage of transformation was treated as complete and irreversible degradation of vertical landscape structure.

Classification of landscapes by grazing strains was performed with the help of cluster analysis separately for different altitudinal belts. Projective cover and height of grass vegetation in combination with steepness of slope were used as indicators of grazing strains. No more, than three gradations, are significantly differentiated by discriminant analysis. Discriminant analysis also enables to determine those parameters of soils and phytocoenosis, which significantly change their values with increase of grazing strains, i. e. differ between defined classes of grazing strains. Previously this problem was analized by Romashkevich et al. (1993) in qualitative aspect. Combination of revealed indicators makes possible comparison of mechanisms of transformation of landscapes structure in different altitudinal belts. Probabilities of correspondence of values of parameters of phytocoenosis and soil to each degree of grazing strains were calculated for each landscape site. These probabilities were used for calculation of uncertainly (entropy) of state of components. Combination of three scores (1. grazing strains, 2. state of phytocoenosis, 3. state of soil) characterizes distance of the state of the landscape from the critical one. Ideal coincidence of these scores and entropy close to 0 mean, that all the components are in equilibrium, i. e. adapted to each other and to grazing strains. It was appreciated as one of possible stable states of landscape with reliable economic properties. High entropy indicates unequilibrium of the landscape and less stability.

Results and discussion

Landscapes of the Central Caucasus subject to grazing strains possess at least three stable state with equilibrium of components corresponding to different degrees of pasturable digression. The first stable state is characteristic for undisturbed landscapes. They possess high resistance and recovery. The second one testifies existance of plasticity. This property of landscape becomes apparent, when the limits of its resistance and recovery in the first stable state are reached. The components are adapted to new level of grazing strains. The third stable state corresponds to complete degradation of the soil due to development of talus and erosion. This state should be better called the state of degradation of structure because of complete loss of resistance and recovery. Stable states alternate with transitional unstable ones. It means, that parameters of components do not correspond to each other: some of them have already changed their values and the others have not yet. Usually the state of phytocoenosis much more corresponds to grazing strains, than that of soil due to inertness of the former. But sometimes both components are in the state of synchronic shift. Unstable state of the landscape can be assessed as unreliable for economic activity.

Mechanisms of transformation of landscape structure differ between altitudinal belts. In steppe landscapes the main reaction is the change of collection of species without decrease of their number and phytomass. Extinction of valuable fodder species (*Phleum phleoides, Kochia prostrata, Stipa capillata* etc.) vacates ecological niches, which are occupied immediately by weeds, mainly *Labiatae* species (*Salvia canescens, Thymus collinus, Marrubium leonuroides, Scutellaria raddeana, Teucrium polium* etc.). Increase of proportion of *Labiatae* causes general growth of ash and moisture content in phytomass. High productivity of these species almost exclude decrease of aboveground phytomass in dry steppes. So the quantitative parameters of biological circle are not transformed. More significant changes are found out to exist in steppe soils. Degradation of soils is controlled by vegetation: content of humus correlates with vegetation cover. At the same time striking simplification of soil profile at the expence of turf and humus horizons takes place. It is accompanied by alkalinization and carbonatization of soil especially on steep slopes (more than 25°) with vegetation cover less than 40 %, because reduction of CO_2 input to soils by roots upset the balance of carbonates. Such changes in landscape prove development of active erosion, which in turn prevents recovery of natural vegetation due to loss of mineral nutrients and organic substance (McIvor et al., 1995). Positive feedback loop is formed leading to the progressing loss of economic reliability and natural stability of the landscape.

In meadow steppe landscapes, unlike dry steppe ones, number of species and aboveground phytomass are the most sensitive indicators of grazing strains. Decrease of species diversity occurs mainly at the expense of mesophytes which have ecological optimum in meadows: *Avenastrum asiaticum, Filipendula hexapetala, Primula macrocalix, Lilium monadelphum* etc. Proportion of xerophytes grows. At the slopes with southern exposition with high digression species composition becomes similar to that of dry steppe petrophyte phytocoenosis. This testifies levelling of ecological conditions in landscapes of different altitudinal belts subject to intensive grazing strains. There is nevertheless a group of species with high resistance, such as *Carex humilis, Festuca sulcata, Trifolium repens, Plantago media, Alchimilla sericata*. Some of them can be considered rather valuable fodder grass. Soil changes include decrease of thickness of turf horizon. This parameter control pH conditions and depth of carbonate horizon, though alkalinization processes are displayed not so obviously as in dry steppes. Content of humus is less sensitive parameter, than in dry steppe landscapes, but it also depends both on thickness of turf horizon and projective cover of vegetation. It proves, that losses of humus occur not only through erosion, but also through disturbance of biological circle. Content of Ca, Mg, K exchangeable ions in soils of disturbed landscapes in 2-3 times lower, than in undisturbed one; at the same time contents of Na, Fe do not alter. The reason is different degree of participation in biological circles: Ca, Mg, K depend on humus content, unlike Ti and Fe.

Meadow landscapes are characterized by the highest sensitivity of aboveground phytomass and number of phytocoenosis layers to grazing strains. Simultaneous decrease of projective cover of vegetation and height of grass causes sharp decrease of species diversity (from 35-50 to 15-20 species per 100 m^2). Grazing strains promote forming of monodominant phytocoenosis with striking prevalence of *Festuca varia* – species with low fodder quality. Aridization of subalpine pastures results in decrease of moisture content in grass and in appearance *of steppe species – Phleum phleoides, Thymus collinus, Festuca sulcata, Artemisia chamaelifolia*. The main feature of soils reaction in subalpine and alpine belts is indifference of humus content to grazing strains. The most sensitive indicators o soil state are thickness of turf horizon and complexity of soil profile. Lateral flows of soi particles do not have great influence on state of soil – erosion is not characteristic due t dense root system. At the same time input of organic substance to soil within biologica circle determines humus content.

Knowledge of mechanisms of landscape vertical structure transformation under gra zing strains enabled to evaluate stability of landscapes in different altitudinal belts.

The least stability is characteristic for steppe landscapes. Most of them are in trans tional unstable states or in the state of degradation. The components are usually not b lanced, because they fail to adapt to increase of grazing strains. So their present-day sta can be changed easily and reliability for economic activity is low. Most of these landscap are close to the state of degradation. Unfortunately, majority of populated areas and cons quently the heaviest grazing strains are located in steppe belt. Landscapes in the first stal state are almost absent.

The meadow steppe landscapes possess the most balanced vertical structure and t best ability to adapt quickly to grazing strains. Majority of them are in the first or in second stable state. Transitional unstable states are rare. State of degradation usually curs on the southern slopes, but much more rare, than in steppe landscapes. Plasticity is most characteristic feature of meadow steppe landscapes. The potential of their recover rather high due to stability of soils.

Stability of subalpine and alpine meadow landscapes is in general higher, than in ste belt, but lower, than in meadow steppe one. Transitional unstable state are rather frequ

at states of degradation are rare. Proportion of undisturbed stable landscapes is slightly higher in alpine belt than in subalpine one due to lower grazing strains. The most stable subalpine landscapes occur on the northern slopes.

Conclusion

1. Mechanisms of transformation of landscape structure differ between altitudinal belts. In steppe landscapes the main reaction is the change of collection of species without decrease of their number and aboveground phytomass. Degradation of soils in controlled by projective cover of vegetation. The most typical process of degradation is erosion. In meadow steppe and meadow landscapes, on the contrary, number of species and phytomass change their values quickly and control the state of turf. Degradation usually develop through disturbance of the circle of organic substance without active lateral transport of solid substance.

2. The least stability is characteristic for steppe landscapes due to inability of the components to adapt quickly to grazing strains. Most of these landscapes are close to the state of degradation. The meadow steppe landscapes possess the most balanced structure and the best ability to adapt to grazing strains. The potential of their recovery is rather high due to stability of soils. Stability of landscapes of subalpine and alpine meadows is higher, than in steppe belt, but lower, than in meadow steppe one.

Translated by the author

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Khotoshev A. V.: **Stabilita krajiny Stredného Kaukazu vo vzťahu k spásaniu.**

Stabilitu krajiny z hľadiska spásania sme hodnotili pomocou štatistických metód. Mechanika transformácie krajinnej štruktúry sa medzi jednotlivými výškovými pásmami líši. V stepnej krajine hlavnou reakciou je zmena zloženia druhov bez zvyšovania sa ich počtu a fytomasy. Najtypickejším procesom degradácie je erózia. V lúčnej stepi a v lúčnatej krajine, naopak, počet druhov a fytomasa rýchlo menia svoje hodnoty a regulujú stav porastu. Degradácia sa obyčajne vyvíja narušením kolobehu organických látok bez aktívneho laterálneho transportu tuhých látok. Pre stepnú krajinu je charakteristická najmenšia stabilita. Zložky obyčajne nie sú vyvážené, pretože sa im nepodarilo prispôsobiť sa spásaniu. Najviac vyváženú štruktúru a najlepšiu schopnosť prispôsobiť sa spásaniu má lúčnatá stepná krajina. Potenciál ich uzdravenia je vďaka stabilite pôdy dosť vysoký. Prostredná stabilitu má lúčnatá krajina.