Hacquetia 17/1 • 2018, 61–71 DOI: 10.1515/hacq-2017-0010

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Mountain grassland ecosystems on abandoned agricultural terraces (Russia, North Caucasus)

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Keywords: abandonment, convergence, fragmentation, grazing, meadow, meadow steppe, soil.

Ključne besede: opuščanje, konvergenca, fragmentacija, paša, travniki, travniška stepa, prst.

Abstract

Terraces represent one of the most common agricultural landscape elements in the mountainous regions of the North Caucasus. In the Central and West Caucasus, most of the arable terraces were converted into grasslands for grazing and haymaking 60–70 years ago and then abandoned or underused during the last 20–25 years. The role of abandoned terraces in maintaining the diversity of grasslands of the mountain slopes was studied in the case of eight terraces of different types. Plant communities of subalpine meadows and meadow steppes were distinguished on the terraces depending mainly on slope steepness at the same altitudes and to a lesser extent on the slope aspect. In general, the grasslands of the terrace platforms and those of original unterraced slopes had similar traits. At that, the mesophilous communities on the rich soils of terrace edges and scarp communities similar to vegetation of steep slopes with eroded soils create regular patterns on the terraced slopes. Thus, former agricultural terraces conditioning geodiversity also contribute to the diversity of plant communities and landscape fragmentation. The current increase of temperature and humidity may lead to a reduction of climatic differences of the slopes, and the further convergence of grassland communities can be assumed.

Izvleček

Terease so eden najbolj običajnih elementov kmetijske krajine v gorskih predelih severnega Kavkaza. V srednjem in zahodnem Kavkazu so pred 60-70 leti večino obdelovanih teras spremenili v pašnike in košenice in jih nato pred 20-25 leti opustili ali pa z njimi neredno gospodarili. Preučevali smo vlogo opuščenih teras za ohranjanje raznolikosti travišč na gorskih pobočjih na osnovi osmih teras različnih tipov. Rastlinske združbe subalpinskih travišč in step se ločijo predvsem glede na naklon teras na istih nadmorskih višinah in manj glede na ekspozicijo. Travišča na zaravneh teras in na pobočjih brez teras imajo podobne rastlinske znake. Mezofilne združbe na robovih teras z bogatimi tlemi in združbe na terasnih stopnjah, ki so podobne vegetaciji na strminah z erozijo tvorijo jasen vzorec na terasiranih pobočjih. Geodiverziteta nekdanjih kmetijskih teras torej prispeva k raznolikosti rastlinskih združb in k fragmentiranosti krajine. Zvišanje temperature in vlažnosti pa lahko vodi v zmanjšanje klimatskih razlik med pobočji in pričakujemo lahko povečevanje podobnosti med travniškimi združbami.

Received: 29. 3. 2017
Revision received: 19. 8. 2017
Accepted: 9. 10. 2017

Co-ordinating Editor:
Orsolya Valkó

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Introduction

The grassland ecosystems play a special role in shaping the landscape and biodiversity of the Palearctic differing strongly in their traits affected by natural factors and human activity. Semi-natural grasslands, the origin and existence of which are largely a result of a millennial history of the activities of humans and their livestock, are among the richest ecosystems and host many more species than one would expect from their spatial extent (Habel et al. 2013). At the same time, the semi-natural grasslands are mainly threatened by agricultural intensification or abandonment, while the natural steppes of the Palearctic have largely been destroyed by conversion into arable land and are threatened by amelioration, pesticides and other impacts (Dengler et al. 2014, Deák et al. 2016). Unlike previous decades, when the attention of researchers was focused on the anthropogenic impact on grasslands, in recent decades the opposite problem has arisen: What are the impacts of the cessation of grazing and mowing on the grasslands? There are a number of publications concerning abandoned farmlands with many local and regional examples (e.g. Benjamin et al. 2005, Pykälä et al. 2005, Kelemen et al. 2014, Valkó et al. 2016a, Wesche et al. 2016). For instance, it was found that species diversity declined in abandoned meadows during the first years of abandonment regardless of meadow type (Csergő et al. 2013). In a series of experiments it was shown that reintroducing management in abandoned grasslands such as litter removal in combination with vegetation cutting supports the recovery of steppe grassland vegetation (Ruprecht et al. 2010). A comparison of the effectiveness of spontaneous grassland recovery and active grassland restoration by seed sowing showed that seed sowing ensures higher weed control and biomass production, but lower biodiversity compared to spontaneous recovery, and that local seed banks might play an important role for grassland recovery on croplands (Valkó et al. 2011, 2016b). At the same time, many examples have proved that for vegetation recovery site conditions are as important as management (Wesche et al. 2016).

In mountainous regions, as a consequence of the population outflow, not only unproductive grasslands, but also productive, easily accessible sites are abandoned. Among them are grasslands of terraced slopes occupying significant areas. An overview of a number of terrace systems of the world and an assessment of their anti-erosion effects is provided by Dorren & Rey (2012). Agricultural terraces are among the oldest human-made elements of mountain slopes. Correctly constructed and maintained terraces stop or reduce soil erosion, and thus, terracing is a way of soil and water saving and enlarging the agricultural area. Usually terraces were made for cereals, orchards or vineyards and only sometimes for grasslands. At present many agricultural terraces are abandoned. Even in the traditionally terraced Andes, over half of the terraces have been forgotten, and at high altitudes, many of them have already been abandoned in prehistoric time (Denevan 2001). Nowadays their abandonment is still going on.

Abandoned terraces became elements of mountain ecosystems. With time many of them were occupied by native vegetation according to the local natural factors and land use legacy (Bragg & Stephens 1979, Lasanta et al. 2013).

Depending on the construction and stability, terraces may become areas of soil destruction and sliding; thus, terrace conditions can slow the process of establishing a continuous stand of native perennial grasses (Cerda-Bolinches 1994, Harden 1996, Dorren & Rey 2012, Arnaéz et al. 2017). Secondary succession with shrubs results in homogeneous post-pastoral and post-arable ecosystems and a reduction of biodiversity; encroachment and increasing abundance and biomass of other competitor species can also lead to diversity loss in the abandoned grasslands (Hansson & Fogelfors 2000, Benjamin et al. 2005, Hillebrand et al. 2008, Lasanta et al. 2013). Thus, the state of grasslands on abandoned mountain terraces is influenced by various factors.

In the Caucasus agricultural terraces occupy large areas both in the South and in the North. According to archaeological data, the first terraces may have been built 1200–600 BC or even before, and terraces have been continuously built until the mid 20th century. Information on the construction of agricultural terraces is found in chronicles of the 6th and 7th century. Many terraces from the 10th to the 12th century are still preserved over a length of tens of kilometres (Lomkatsi & Gegechiladze 1971, Kushnareva 1997, Skripnikova et al. 2002, Borisov et al. 2012).

In the North Caucasus of Russia, agricultural terraces are widely spread from the East to the West, from the Caspian Sea to the Black Sea coast. They occupy up to 60% of the slopes of the intermontane basins, exceeding the area of the river terrace complexes (Borunov & Bochaver 1987). The oldest terraced regions, not younger than three millennia, are in the East, in Dagestan, where they occupy an area of 150 000 ha at altitudes from 400 to 2500 m a.s.l. (Idrisov 2017).

At present vast areas of agricultural terraces in the North Caucasus are abandoned. The last waves of significant abandonment occurred in the 1950s and 1960s, following the kolkhoz reforms and the development of recreation industry, and in the 1990s, after the demise of the kolkhoz system (Gracheva et al. 2012). The same periods are characteristic for some other regions of the world (Agnoletti et al. 2015, Kricsfalusy 2013, Lasanta et al. 2013, Valkó et al. 2016a). Only in the East Caucasus, some terraces located close to settlements are still used for planting fruit trees and vegetables instead of cereals, for which they have been built and used for a long time. In Central and West Caucasus, practically all agricultural terraces are abandoned.

In this paper we report a study of grasslands formed on abandoned terraces in North Ossetia (Central Caucasus). The main objective of the study was to clarify the role of abandoned agricultural terraces for the grassland diversity on mountain slopes.

Materials and Methods

North Ossetia, or North Ossetia-Alania, lies on the northern macroslope of the Caucasus. The series of the mountain ridges are divided by deep and wide intermontane basins of which slopes glaciers rise. The altitudinal zonality of the region has been described in previous articles (Gracheva & Belonovskaya 2010, Belonovskaya et al. 2016). Shortly, forests occupy slopes up to 1200–2000 m a.s.l. and are replaced by a forest-meadow steppe zone, where post-forest grasslands are widely spread. Above, subalpine and alpine grasslands follow, reaching up to the nival zone. The grasslands are home to a rich biodiversity, including many endemic plant species such as *Secale dighoricum*, *Silene akinfievi*, *Gentianella caucasea*, *Campanula dolomitica* and others (Popov & Gogaev 2004).

Figure 1: Location of study area in the Central Caucasus. (Modified from https://commons.wikimedia.org/wiki/File:Caucasus_topographic_map-ru.svg#/).
Slika 1: Lokacija preučevanega območja v srednjem Kavkazu. (Prirejeno po https://commons.wikimedia.org/wiki/File:Caucasus_topographic_map-ru.svg#/).

Grasslands of post-agricultural terraces were studied at the slopes of intermontane basins between Bokovoi Ridge (Side Ridge) and Skalistyi Ridge (Rocky Ridge) (Figure 1). Key areas were located in the Uallagkom Basin and the Tsey Basin (Iraf and Alagir districts, respectively) at altitudes of 1750–2050 m a.s.l. Those are the areas of the forest-meadow steppe zone and the transition to subalpine grasslands, where steppes occupy the driest steep and the most eroded slopes.

Eight former arable terraces of different types converted into pastures about 60 years ago and abandoned about 20–25 years ago were selected. Grassland plots of 100 m^2 size were studied in June 2015. The description of plots included general topographic features and terrace relief (platform, edges, scarp and original slope between terraces), soil description and a list of vascular plants with nomenclature according to the checklist of Cherepanov (1995). The old Braun-Blanquet coverage-abundance scale was used (Braun-Blanquet 1964). 21 relevés of grasslands were selected and analysed using the frequency and constancy concept. Diagrams of the relationship between herbaceous coverage, species richness and slope inclination were developed using accessible approaches within Microsoft Excel. Soils of all plots were described morphologically, and 10 soil profiles were sampled and analysed in the laboratory of the Department of Soil Geography and Evolution of the Institute of Geography of the Russian Academy of Sciences using routine methods recommended by the World Reference Base for Soil Resources (WRB). Based on the laboratory test results, the soils were classified according to the WRB soil classification system (IUSS Working Group 2014). Land use history and stages of land use change have been described earlier (Gracheva et al. 2012, Belonovskaya et al. 2016).

Results

Agricultural terraces are clearly distinguishable at the slopes of intermontane basins by the benched profiles of the slopes. They were mostly cultivated to compensate land shortage for the cereals and used for this purpose until the 1950s/60s. Terraces situated on high slopes and far from settlements were partially converted into grasslands about 100 years ago.

There are different types of terraces depending on construction and size (Kulumbegov 2013). All terraces are sustainable, and there are no signs of soil destruction and sliding despite the cease of maintenance. Grasslands on terraces of various sizes formed as a result of plowing and on large terraces with retaining walls were studied.

Terraces formed by plowing

Terraces formed by plowing are widely distributed. Plowed soil material gradually moves down and forms a ridge on the slope transformed into a bench by manpower. Sometimes such terraces have been formed due to low stone borders of the land plots. Grasslands on such kind of terraces were studied in the Tsey Basin and in the Uallagcom Basin.

Terraces of the Tsey Basin

In the Tsey basin, four terraces formed by plowing were studied. They rise up the gentle (10–12°) southern slope from 1870 to 1980 m a.s.l. (Figure 2). Terrace plots are square-shaped or of rectangular shape and bordered by low stone walls (< 1 m), which served as plot boundaries. Grasslands are currently used for occasional grazing. Individual young pines and *Juniperus sabina* spread in the grasslands, gradually occupying terraces downward. In the soils buried humic horizons are evidence of significant soil redistribution, especially on the lowest terraces. The grasslands are generally defined as subalpine meadows with such common species as *Festuca valesiaca*, *Anthoxanthum odoratum*, *Alchemilla caucasica*, *Galium verum*, *Polygala anatolica*, *Plantago media*, *Trifolium medium*, *Veronica chamaedrys*, *Lotus corniculatus* and *Trifolium canescens.*

The most gentle terraces at the lowest slope position with deep soils are the most mesophilous habitats. They were used for growing vegetables, and newly formed grasslands, which developed after the abandonment of the Upper Tsey village, are not older than 25 years. Soils, Mollic Umbrisols (Anthric Loamic Aric), are loose, well structured and rich in organic matter. The total grass cover is 95–100%, the grass height is 50 cm. Here, the following species enrich the plant community: *Veronica gentianoides*, *Ranunculus oreophyllus*, *Poa alpina*, *Phleum montanum*, *Seseli libanotis*, *Bromopsis variegata*, *Agrostis tenuis*, *Tragopogon reticulatus* and *Stachys macrantha*.

At the highest and more drained terraces with relatively shallow Leptic Mollic Umbrisols (Anthric Loamic/Siltic), grasslands are about 55–60 years old. After cereal cultivation, these terraces were used for haymaking. The grass cover is 70–80% and the grass height 20–30 cm. Typical species of this type of terraces are *Festuca ovina*, *Campanula hohenackeri*, *Carum carvi*, *Luzula multiflora*, *Ranunculus polyanthemos* and *Carex tristis. Artemisia chamaemelifolia* occurs at the driest places.

The mesophilous traits of the grasslands are a result of sufficient moisture conditioned by gentle slope and properties of soils that were not compacted by heavy grazing. Grassland landscapes are scattered by trees and shrubs growing on the stone and soil accumulations bordering terrace plots such as *Prunus divaricata*, *Rubus bushii* and *Rubus idaeus*, of tall herbaceous species some of which could be considered as weeds such as *Urtica dioica* and *Dactylis glomerate* and of tall herbs of the open forest edges: *Calamagrostis arundinacea*, *Phleum pratensis*, *Lamium album* and *Anthriscus sylvestris.*

Grasslands on the abandoned terraces do not differ from subalpine meadows of unterraced slopes. Subalpine traits of the grasslands of southern slope and at the studied altitudes can be explained by the proximity of glaciers of the opposite steep northern slope of Tsey valley.

Figure 2: Subalpine meadows on the small abandoned terraces formed by plowing, 1870–1980 m a.s.l. (North Ossetia, Tsey Basin). Photo E. Belonovskaya.

Slika 2: Subalpinska travišča na majhnih opuščenih terasah, nastalih z oranjem, 1870–1980 m n.m.v. (Severna Osetija, Tsey). Foto E. Belonovskaya.

Terraces of the Uallagcom Basin

West from the Tsey, in Uallagcom Basin, plant communities are generally defined as meadow steppes. Here, grasslands on the series of bench-like terraces formed by plowing and located on the steep (25–30°) northern slope were described (Figure 3). Terraces represent narrow (3–3.5 m) flat strips with steep scarps about 3 m high. The interval of original slope between terraces is about 20–25 m. About 60 years ago, terraces were converted from arable lands into haylands. During the last 25–30 years, they have been used for grazing with gradually reduced impact. Soils are defined as Someric Mollic Umbrisol (Anthric Siltic). At the described terrace platform (1884 m a.s.l.), short grasses dominate. The grass height is not more than 15–20 cm; vegetation cover is 100%. The plant community consists mainly of meadow species such as sod grasses and firm bunchgrasses (*Festuca valesiaca*, *Helictotrichon versicolor*, *Poa alpina*, *Phleum montanum* and *Anthoxanthum odoratum*) and herbs (*Alchemilla*

Figure 3: Meadow steppes on the abandoned bench-like terraces, northern slope, 1800–1900 m a.s.l. (North Ossetia, Uallagcom Basin). Photo E. Belonovskaya.

Slika 3: Travniška stepa na opuščenih terasah, podobnih klopi, severno pobočje, 1800–1900 m n.m.v. (Severna Osetija, Uallagcom). Foto E. Belonovskaya.

caucasica, *Plantago atrata*, *Veronica gentianoides*, *Myosotis alpestris*, *Galium verum*, *Ranunculus oreophyllus*, *Alchillea millefolium*, *Pulsatilla albana*, *Seseli libanotis* and *Stachys macrantha*). Species of meadow-steppe communities play a significant role (*Salvia verticillata*, *Bromopsis riparia*, *Artemisia chamaemelifolia*, *Linum nervosum* and *Linum hypericifolia*). The same communities are in general characteristic for the original slope except for the steepest plots (Table 1).

In spite of the northern slope, grasslands have more steppe components than the above-described Tsey's grasslands on the gentle southern slope due to the distance from glaciers, general slope steepness and good drainage. These grasslands are defined in general as meadow steppes.

The vegetation cover of edges separating the terrace platform from the scarp differs from the other terrace surface. Edges are covered by more mesophilous species such as *Polygonum alpinum*, *Cephalaria gigantea* and other tall herbs. The deep and rich soil that has been accumulated on the edges due to plowing provides comfortable conditions for plants. Tall mesophilous herbs including weeds and inedible plants are common on the terraces' edges regardless of terrace size and general slope steepness.

In contrast to the edges, on the scarps of the terraces, xerophilous plants dominate: *Artemisia splendens*, *Thymus collinus* and even *Stipa pulcherrima*. Disturbed, strongly eroded gravelly spots and stone fragments are characteristic features of the scarps, and petrophytes occupy these habitats: *Anthemis sosnovskyana*, *Thesium alpinum*, *Sempervivum caucasicum* and *Sedum oppositifolium*.

Grasslands of terrace platforms and originally uneroded slopes are practically similar; plant communities of the scarps are similar to those of the steep convex eroded plots of the slopes.

Large terraces with retaining walls

The large terraces were constructed by redistributing an enormous volume of soil and even bringing soil from the valley, stone removal and building of high retaining stone or wooden walls. The stony retaining walls have been preserved until today, whereas wooden supports disappeared during the past hundreds years. Terrace size and its scarp height depend on the slope relief, especially on the general steepness of the slope.

Grasslands of large terraces were studied in the Uallagcom Basin.

Grasslands of two terraces on the southern convex slopes with a steepness from 15–18 to 25° were described. Terraces have gentle platform surfaces smoothly inclined to the South, about 50 m in width and 150 m in length, and

Figure 4: Soil profile cleared of stones. Large artificial terrace, 1943 m a.s.l., meadow steppe (North Ossetia, Uallagcom Basin). Photo I. Shorkunov.

Slika 4: Talni profil z odstranjenim kamenjem. Velika umetna terasa, 1943 m n.m.v., travniška stepa (Severna Osetija, Uallagcom). Foto I. Shorkunov.

steep scarps 3–5 m in height. The intervals between terraces are 25–50 m. There were wooden retaining walls, which have not been preserved until today. Terraces have been used for grazing for about 60–70 years; at present grazing intensity is low. Soils, Calcaric Someric Phaeozems (Anthric Loamic), are cleared of stones and debris (Figure 4).

Three main groups of plant communities were described on the terraces and unterraced slopes.

The first group is common over the slope including terraces and steep uneroded slopes. It was described in the key plot on the large terrace, 1943 m a.s.l., and the neighbouring slope. The total vegetation coverage is 80–90%, vegetation height is 20–30 cm. The community consists of meadow species such as *Alchemilla caucasica, Plantago atrata, Festuca ovina, Veronica gentianoides, Pedicularis sibthorpii, Myosotis alpestris, Helictotrichon versicolor, Astragalus oreades, Ranunculus oreophyllus, Phleum montanum, Alchillea millefolium, Amoria ambigua, Onobrychis petraea, Aster alpinus* and *Polygala anatolica.* More xerophytic meadow-steppe species are also common here, such as *Salvia verticillata, Medicago furcata, Pentaphylloides fruticosa, Galium verum* and *Plantago media.*

The second group of meadow and meadow-steppe species occurs among species of the first group only on the terrace platform and gentle slopes and disappears in the steep sections: *Amoria montana, Poa alpina, Lotus corniculatus, Tragopogon reticulatus, Anthyllis vulneraria, Arenaria lychnidea, Leontondon hispidus, Campanula hohenackeri, Bupleurum polyphyllum, Silene ruprechtii, Bromopsis riparia, Artemisia marschalliana, Koeleria cristata, Carex humilis* and *Linum nervosum.*

The third group is characteristic for scarps and steep slopes between two terraces that gradually pass into the scarp of the upper terrace. Vegetation specific of these sections – especially of scarps – is clearly expressed (Figure 5). Soil surface is disturbed by cattle, and vegetation coverage is not more than 50%. A key plot, 1957 m a.s.l, 25–30° (Table 1, rel. 1), is described. The meadow and meadow-steppe species of the second group are absent, and along with the plants of the common first group, xerophytes and petrophytes are common: *Thymus collinus, Anthemis sosnovskyana, Veronica chamaedrys, Helianthemum nummularium, Potentilla crantzii, Androsace lehmanniana, Silene lychnidea, Onosma caucasica, Psephellus dealbata, Rumex scutatus, Sedum oppositifolium, Thesium alpinum* and *Draba* sp.

The terrace edge has a clearly expressed strip of mesophilous plants, the same as described above.

A large terrace with stone retaining wall was described on the northern slope, left bank of Songutidon River, 1996 m a.s.l. The vegetation cover had characteristics similar to those described on the southern slope and did not reflect the climatic differences of different slope aspects.

Figure 5: Scarps of the terraces on the southern slope, 1900–2000 m a.s.l. (North Ossetia, Uallagcom Basin). Photo R. Gracheva.

Slika 5: Terasne stopnje na južnem pobočju, 1900–2000 m n.m.v., (Severna Osetija, območje Uallagcom). Foto R. Gracheva.

In general, plant communities of the grasslands of terraced and unterraced slopes have similar traits in relatively similar sections. Communities of subalpine meadows and meadow steppes occupy terraces depending mainly on the slope topography at the same altitudes and to a lesser extent on the slope aspect. This confirms the observed plant communities' distribution, which is independent of the climatic difference between southern and northern slopes (Belonovskaya et al. 2016). However, before the background of the general similarity of the grasslands, different plant communities are characteristic for the abandoned agricultural terraces: communities common to the terrace platform and the original slope, mesophilous edge communities, and scarp communities similar to the vegetation of steep slopes. Thus, terraces create specific vegetation patterns on the slope.

Discussion

Terraced areas are characteristic elements of the mountain landscape and part of the cultural history and human-land resource relations of the rural mountain regions of the world. In spite of the progressive abandonment of rural mountain areas, terraces have remained on the slopes until now as evidence of past agricultural landscapes. There is much information on the loss of major species and biodiversity following abandonment of managed grasslands. Regarding abandoned terraces these processes are usually explained by the disintegration of the terraces (Dorren & Rey 2012, Agnoletti et al. 2015, Arnaéz et al. 2017).

As was already mentioned, in the studied areas old arable terraces were integrated in the grassland landscapes about 60–70 years ago and grazed or mown up to the 1990s. They have been abandoned (or underused in some cases) during the last 20–25 years. Terraces appear to be stable, resisting even rain storms. According to the current study, plant diversity and vegetation cover are similar on the terraces' platforms and gentle uneroded slopes and on the scarps of terraces and steep slopes. We can consider this fact as a convergence of plant communities of man-made and natural elements of mountain topography.

In a previous article, the convergence of soils and vegetation of abandoned rural mountain areas within the studied altitudinal range was shown (Belonovskaya et al. 2016). It was assumed that the legacy of past land use including the unifying role of soil cultivation, combined with a relatively short period of grassland development, plays a role in the similarity of vegetation composition. This is especially true for the grasslands on the terraces.

However, terraces contribute to the plant diversity of communities due to their construction. Elements of terraces, such as platform, edge and scarp, determine the spatial structure of communities along the terraced slopes. Thus, anthropogenic transformation of the slopes is a prerequisite for the fragmentation of vegetation cover into regular patterns. In the Caucasus this important fact has not been noted and evaluated so far, though the ecosystem fragmentation conditions the diversity of soils and mesofauna and affects the waterways. Effects of habitat fragmentation may be a major threat for species on the local scale (Habel et al. 2013).

What could the future hold for the grasslands of abandoned agricultural terraces? It is well known that heat and moisture are limiting factors of vegetation development. For the study area, an analysis of changes in heat and humidity was made using the vegetation index (NDVI), the index of vegetation conditions (VCI), the Satellite Climatic Extremes Index (SCEI) and other relevant data, estimating relations between index values and vegetation condition. It was shown that, during the last 20 years, active temperatures (a sum of temperatures for the season with daily temperatures exceeding 10 °C) and humidity have been gradually increasing in the altitudes from 1400 to 2800–3000 m a.s.l. and that the conditions for vegetation growth have improved (Vinogradova et al. 2015, 2017). An increase in temperature and humidity may lead to a reduction of climatic differences of the slopes, and a further convergence of grassland communities can be assumed.

Grasslands of abandoned agricultural terraces are appropriate and informative objects for scientific studies of the natural processes following the social and economic transformation and environmental changes. Being part of the cultural heritage and having important environmental and aesthetic functions, these grasslands should be protected by nature conservation.

Acknowledgements

Field research was supported by the Russian Foundation for Basic Research (RFBR) grant № 14-05 00233A. The analysis of data and article preparation were made under support of the Federal Program, Project 0148-2016-0003 «Geographical assessment of natural and anthropogenic evolution of soils based on the concept of soil memory for the purpose of rational nature management», and Project 0148-2014-0017 "Revealing biotic indicators of sustainable development and land use optimization, elaboration of the biogeographic principles of territory-based nature protection". The authors are very grateful to Dr. Aiko Huckauf for the linguistic edition and to Dr. Orsolya Valkó for the comments and general edition of the text.

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Appendix

Field characteristics of the relevés and coverage of the layers in Table 1 given in the following order: locality, date, relevé number, herb layer (%), altitude (m), aspect, inclination (%), number of species.

Iraf district, Uallagkom basin. The Dargonkom River valley, the right bank, 08. 06. 2010: **2)** 55; 1846; S; 17; 22 – **4)** 60; 1962; E; 27; 20 – **18)** 80; 1962; E; 5; 20. – 10. 06. 2010: **1)** 50; 1957; S; 20; 29 – **15)** 100; 1952; S; 2; 25 – **16)** 90; 1952; S; 8; 24 – **5)** 50; 1985; S; 15; 22.

The Dargonkom River valley, the left bank, 08. 06. 2010: **13)** 80; 1931; N; 20; 27. – 10. 06. 2010; **21)** 85; 1884; EN; 10; 39. – 28. 06. 2014: **19)** 85; 1943; S; 15; 47 – **20)** 80; 2034; WSS, 15; 44 – **11)** 40; 1975; S; 25; 24.

The Songutidon River valley, the left bank, 27. 06. 2014: **12)** 100; 2047; NE, 30; 47.

The Songutidon River valley, the right bank, 11. 06. 2010: **7)** 70; 1758; S; 20; 36.

The Komidon River valley, the right bank, 09. 06. 2010: **10)** 75; 1914; NE; 25; 26. – 10.06.2010: **3)** 35; 1824; S; 25; 20. – 25. 06. 2014: **6)** 30; 1834; S; 35; 21. – 26. 06. 2014: **8)** 100; 1890; WWS; 30; 21 – **17)** 80; 1923; WWS; 5; 41 – **14)** 75; 1952; WWS; 10; 38 – **9)** 65; 1890; WS; 35; 39.

Table 1: Differentiation of grasslands on the terrace platforms and scarps of the Uallagcom basin, Iraf district (North Osetia-Alania). Legend: T – terrace platforms; S - scarps. Locality, coverage of the layers, altitude, slope aspect and inclination are indicated in the Appendix.

Tabela 1: Različne oblike travišč na ravnih delih teras in na terasnih stopnjah na območju Uallagcom, regija Iraf (Severna Osetija--Alanija). Legenda: T – ravni deli teras; S – brežine teras. Lokacija, pokrovnost plasti, nadmorska višina, ekspozicija, naklon so prikazani v Dodatku.

Groups of relevés	S	S	S	S	S	S	S	S	S	S	S	S	S	T	T	T	T	T	T	T	T
№ of relevés	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
The group of grassland species																					
Alchemilla caucasica	2	.	1	.	2	.	1	+	+	+	.	.	.	1	3	2	1	1	+	.	3
Plantago atrata	1	+	1	.	+	+	+	1	.	.	1	1	+	+	1	1	+	.	+	1	1
Festuca ovina	2	1	.	2	.	.	2	2	2	1	1	1	.	3	1	2	4	1	3	3	.
Veronica gentianoides	+	+	.	+	2	.	+	+	.	+	.	+	+	+	+	+	1	+	+	+	+
Myosotis alpestris	+	+	.	.	.	+	1	+	+	+	.	+	1	+	.	.	+	+	+	+	+
Galium verum	.	.	.	+	+	+	+	1	1	+	1	+	.	1	+	+	1	.	+	1	+
Ranunculus oreophyllus	.	.	.	.	1	.	.	.		.	.	1	.	+	1	+	1	1	.	1	2
Helictotrichon versicolor	1	+	.	.	.	.	.	+	+	1	.	1	.	1	2	2	.	.	.	+	1
Amoria montana	.	.	.	.	.	.	+	.	+	3	.	3	.	.	2	.	+	+	+	1	.
Poa alpina	.	+	+	.	1	.	1	.	+	+	.	.	.	1	+	.	.	+	1	1	+
Phleum montanum	.	.	.	.	+	.	+	.		.	.	+	1	.	.	1	1	.	1	1	+
Alchillea millefolium	.	.	.	.	.	.	+	.		+	.	+	.	1	.	+	1	.	+	.	1
Amoria ambigua	.	.	+	.	2	.	+	.	.	.	.	1	1	.	.	2	+	.	+	1	.
Leontondon hispidus	.	.	.	.	+	.	.	.	.	.	.	+	.	+	.	.	1	.	+	1	.
Pedicularis sibthorpii	+	.	.	.	2	.	+	+	.	.	+	.	1	+	+	1	+	1	+	1	.
Polygala anatolica	.	.	.	+	+	.	+	+	+	+	.	.	+	.	.	1	.	.	+	1	1
Plantago medium	.	+	.	+	1	.	+	+		.	.	.	.	+	+	1	1	+	+	+	.
Campanula hohenackeri	.	+	+	.	.	.	+	2	+	.	2	.	1	1	.	.	1	.	+	+	.
Bupleurum polyphyllum	.	.	.	.	.	.	+		+	.	+	+	.	.	.	.	.	.	+	1	.
Pulsatilla albana	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	.	+	.	+	1
Silene ruprechtii	.	.	.	.	.	.	.	+	r	.	+	+	.	.	.	.	+	.	+	+	.
Scabiosa caucasica	.	.	.	.	.	.	.	1	.	.	.	1	.	1	.	.	1	.	.	1	.
Dactylorhiza species	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	+	.	.	+	.
Centaurea fischeri	.	.	.	+	.	.	.	.	.	+	.	1	1	+	.	.	.	+	.	+	.
Seseli libanotis	.	.	.	.	.	+	.	+	+	.	.	+	.	+	.	.	.	.	+	.	+
The group of meadow steppe community species																					
Salvia verticillata	+	.	+	+	1	1	+	+	1	.	1	1	.	1	+	+	.	+	+	.	+
Medicago furcata	+	+	+	+	1	+	+	+	+	+	1	+	.	.	2	1	.	.	+	.	.
Bromopsis riparia	.	.	.	1	1	+	.	2	2	2	1	3	1	2	1	.	2	4	1	2	3
Artemisia chamaemelifolia	+	1	+	1	2	.	2	.	+	2	2	2	.	.	1	1	2	1	.	1	+
Thymus collinus	1	1	1	+	.	.	+	+	+	+	1	.	.	+	.	.	1	.	.	1	.
Artemisia marschalliana	.	+	+	1	.	.	+	1	.	.	.	.	.	1	.	.	.	.	1	.	.
Astragalus oreades	2	+	.	+	.	1	.	+	2	.	+	.	.	.	.	.	1	.	+	+	.
Veronica caucasica	.	+	.	+	.	1	.	.	+	.	+	.	.	+	.	.	+	.	+	.	.
Onobrychis petraea	.	.	.	.	.	.	.	1	1	.	.	.	2	+	.	1	1	1	+	1	.
Aster alpinus	.	+	.	.	.	.	.	+	+	.	.	+	.	+	.	+	1	.	+	+	+
Pentaphylloides fruticosa	+	.	.	.	.	.	+	r		.	.	1	1	.	.	.	+	.	+	+	.
Koeleria cristata	.	.	.	.	.	.	.	2	+	.	+	1	.	1	.	.	1	.	+	.	.
Tephroseris caucasigena	.	.	.	.	.	+	.	.	.	+	.	.	.	+	.	.	+	.	.	.	1
Carex humilis	.	.	.	.	.	.	.	2	2	.	+	.	.	.	.	.	.	.	1	3	.
Linum nervosum	.	.	.	+	.	.	.	+	.	+	+	.	.	.	.	.	.	.	+	.	+
Linum hypericifolia	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	+	.	.	.	1

Groups of relevés	S	S	S	S	S	S	S	S	S	S	S	S	S	T	T	T	T	T	T	T	T
№ of relevés	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Species, related to the slopes’ habitats																					
Anthemis sosnovskyana	+	+	.	.	.	+	.	2	.	+	1	+	2	.	.	.	.	.	.	.	+
Veronica chamaedrys	+	.	1	.	+	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.
Artemisia splendens	.	.	.	.	.	1	.	.	1	.	1	.	.	.	.	.	.	.	+	.	.
Vicia alpestris	.	.	.	.	.	.	+	+	.	.	.	+	+	.	+	.	.	.	.	.	.
Stipa pulcherrima	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Helianthemum nummularium	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Potentilla crantzii	+	+	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+
Androsace lehmanniana	+	.	+	+	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.
Silene lychnidea	+	+	+	.	.	.	.	+	+		+	.	.	.	.	.	.	.	.	.	.
Onosma caucasica	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Psephellus dealbata	+	.	.	.	.	.	.	1	+	.	.	.	.	+	.	.	.	.	.	.	.
Rumex scutatus	+	.	.	.	.	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Sedum oppositifolium	+	.	1	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thesium alpinum	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sedum tenellum	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Draba sp.	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carduus sp.	.	.	.	.	+	+	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.
Cephalaria gigantea	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Allium saxatilis	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Filipendula hexapetala	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Coronilla varia	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula multiflora	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	1
Carum carvi	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	.	.	+
Trifolium medium	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Inula orientalis	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.
Accompanying species																					
Festuca valesiaca	.	.	1	.	.	.	.	.	3	.	.	1	3	.	1	.	.	.	.	1	1
Lotus corniculatus	.	.	.	.	.	.	.	.	1	.	1	+	.	1	.	.	1	.	+	.	.
Trifolium canescens	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	1	+	.	1	+
Anthoxanthum odoratum	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	+
Tragopogon reticulatus	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	1	.	+	.	.
Rhinanthus minor	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	1	.	.	.	.
Anthyllis vulneraria	.	.	.	.	1	.	+	.	1	.	.	.	.	.	+	.	+	.	+	.	.
Arenaria lychnidea	.	.	.	.	.	.	+	.	+	.	.	.	.	.	+	.	.	.	+	+	.
Stachys macrantha	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+
Primula macrocalyx	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	.
Cruciata laevigata	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	+
Alchemilla sericata	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	2	.
Nonea echioides	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Euphorbia glaberrima	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.
Scrophularia ruprechtii	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scutellaria orientalis	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	+	.	.	.	.
Heracleum sosnowskiana	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Convolvulus vulgaris	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Geranium sanguineum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.