

Assessment of aboveground biomass and carbon accumulation in natural cenoses on the terraces of the northern slope of Khoysko-the Makazhoy (Cheberloy) basin

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Abstract. Carbon exists as carbon dioxide in the atmosphere and makes up about 0.04% of the atmosphere. In the recent past, it has attracted a lot of attention as a greenhouse gas because it can influence the climate model of the world. Anthropogenic activities such as industrialization, deforestation, forest degradation and the burning of fossil fuels have caused an increase in atmospheric carbon levels and disrupted the global carbon cycle. The Climate Change Expert Group has identified five carbon pools of the terrestrial ecosystem that include biomass, namely aboveground biomass, underground biomass, debris, woody debris and soil organic matter. Among all carbon pools, aboveground biomass constitutes the major part of the carbon pool.

1 Introduction

Carbon plays an important role in supporting life on earth. During photosynthesis, plants absorb carbon dioxide from the atmosphere, converting it into carbohydrates and releasing oxygen into the atmosphere. When these plants or trees die or burn down, the carbon stored in them is released back into the atmosphere. This natural carbon cycle has been maintained and controlled by a dynamic balance between biological and inorganic processes since the Earth's geological history.

The purpose of this study was to perform measurements of carbon stocks in biomass pools. The selection of plant biomass was carried out from the end of April to September 2023 at the sites of the carbon landfill of the Kadyrov Chechen State University.

The carbon cycle has attracted a lot of attention because carbon dioxide is the main greenhouse gas, has the potential to influence the global climate model, and also has a relatively long residence time in the atmosphere. About 60% of the observed global climate change is associated with an increase in the concentration of carbon dioxide in the atmosphere [6].

According to the IPCC, there are five carbon pools of terrestrial ecosystems that include biomass, namely aboveground biomass, underground biomass, dead mass litter, wood debris and soil organic matter. Carbon dioxide captured by plants during photosynthesis is

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transported through various carbon pools. Underground biomass, which makes up all living roots, plays an important role in the carbon cycle by transferring and storing carbon in the soil. As a rule, the calculated components of biomass are aboveground living biomass, which includes trees, shrubs, herbaceous plants, excluding roots, dead aboveground biomass such as litter and fallen branches or stems, and underground biomass consisting of roots [6].

Subalpine meadows have been formed for thousands of years as a result of human agricultural activity combined with special mountain climatic conditions. According to some studies, people began grazing in European Alpine areas starting from the Early Neolithic [13].

The movement of the herd to high pastures in the summer was carried out by university staff and ensured the preservation of these productive ecosystems below the tree line [13]. Sustainable grazing can increase the photosynthetic potential of Alpine plants by providing nitrogen and light availability and promote carbon sequestration. Instead, overgrazing will have negative impacts on vegetation productivity, greenhouse gas balances, biodiversity and SOC levels. One method that can be applied locally is improved seasonal grazing on several isolated sites and maintaining varying grazing intensity to maintain biodiversity. The traditional seasonal method of grazing livestock in mountainous areas includes many of these features. However, there are few studies evaluating the effect of the alpeggio and its abandonment on vegetation and soil properties [13].

2 Materials and methods

According to Golovlev A.A. and others. (1990), the climatic conditions of the Veden region can be characterized by data from the Veden and Khoyskaya Barracks weather stations. Let's use the data of multi-time instrumental observations in the village of Veden as average climatic indicators for the forested and mountainous part of the region. According to A. G. Sanin (1926) and V. V. Akimtsev (1928), an average of 819 mm of precipitation falls here per year, with a maximum in June (148 mm) and a minimum in February (23 mm). The average annual air temperature is 8.1°. The coldest month is January (-4.6°). The warmest July (+19.5°). The data [1, 2] are somewhat different: the average annual air temperature is 7.6°, the average annual precipitation is 45 mm with approximately the same values of maxima and minima of temperatures and precipitation in summer and winter. The absolute minimum temperature is -33°. There are 88 days with snow cover. In general, the climate of the Black Mountains strip is cool and excessively humid. However, it should be borne in mind that in the lower horizons of the mountains it is always warmer, and probably less humid. A colder and wetter climate is typical for the middle and high mountainous parts of the area, where there are no weather stations. The climate of the Makazhoi Basin, the valley of the Akhkete River, and the southern and southwestern shores of Lake Kezenoi-Am differs markedly from the climate of the entire region. According to the Khoyskaya Barracks weather station (1615 m), 463 mm of precipitation falls here on average per year. The most precipitation is in June (111 mm), the least in January (11 mm), December and November (14-15 mm). Dryness of air, low cloudiness, significant duration of sunshine, as well as anomalously low amount of precipitation are associated with the orographic influence of the Kashkerlam Ridge and the Andi Ridge, which prevent cold and moisture-bearing air masses from penetrating into this part of the Veden district. The surface waters of the area are represented by small rivers and lakes. The rivers Kaukha and Khorsum, flowing into Lake Kezenoi Am, and the Mior-su River, formed by underground runoff from it, merging with the Akhkete River, belong to the basin of the Sulak River. The Mior-su River, which merges with the Akhkete River, belongs to the Sulak River basin. The waters of Lake Kezenoi-Am are also poorly

mineralized; by chemical composition they are of carbonate-calcium type. According to G.P. Mikhailovsky (1907), the lake was formed as a result of a natural dam in the southern part of the present coast [7].

According to modern data, climatic conditions of the study area can be characterized as follows: 787 mm of precipitation falls here on average per year. The average annual air temperature is 9.14. The average January temperature is -2.3 and the average July temperature is +20.7.

3 Results and discussion

The study area is characterized by natural subalpine vegetation. Human activities have altered the landscape, which is still dominated by grasslands and pastures. But over the past 28 years (from 1995 to 2023), grazing and haying activities have been suspended in the study area.

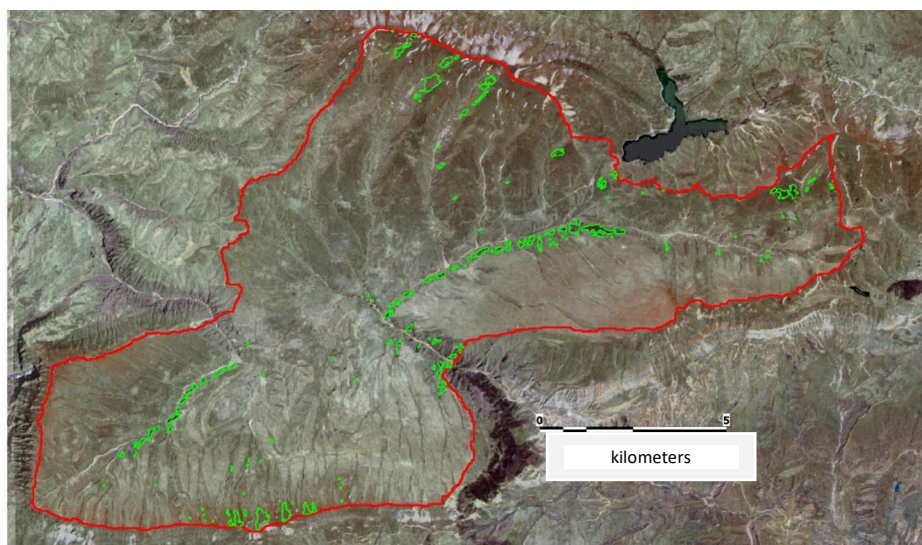


Fig.1. Photo of green growth on the northern slope of Khoisko-Makazhoi (Cheberloi) basin, June 2002g.

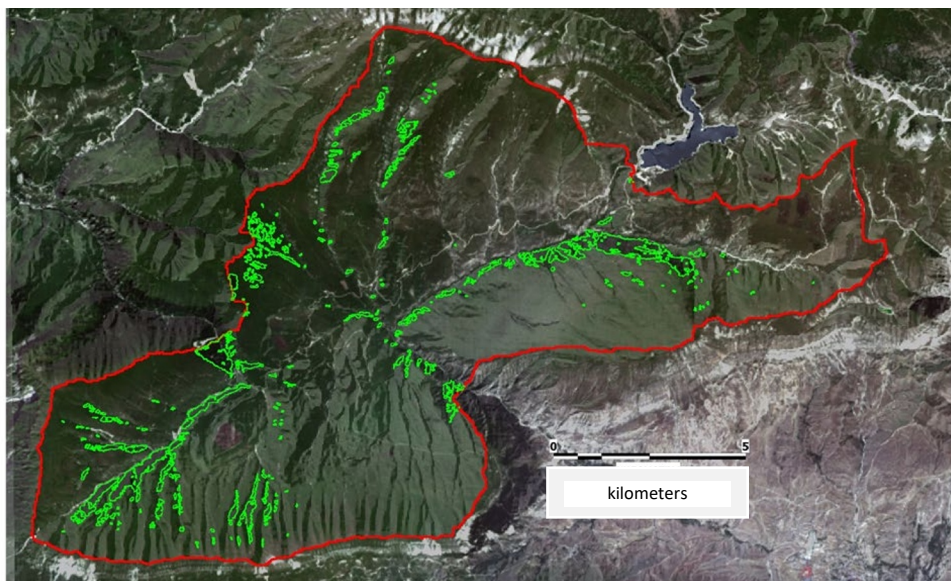


Fig.2. Photo of green growth on the northern slope of Khoisko-Makazhoi (Cheberloi) basin, July 2020.

The plots of the Carboniferous polygon for regenerative animal husbandry are located on the slope of the Khoisko-Makazhoi (Cheberloi) basin in the Vedensky district at altitudes of 1800-2200 m above sea level [10]. Long-term grazing before 1995 has greatly changed the appearance of meadows, which are represented by grass-grass-grass communities in varying degrees of digression. Mountain-meadow landscapes are represented by two groups of landscapes - indigenous and natural-anthropogenic, which occupy relatively inaccessible areas of steep slopes and gorges for distant pastoralism. Reduced grazing intensity has resulted in pine and birch overgrowth in the laid out areas as well. Mountain-forest-meadow-steppe landscapes are the product of long-term activity and soil domestication, changes in relief (terracing of slopes) [9,4]. According to the soil map of Russia, the dominant soil type is mountain-meadow chernozem-like soils on carbonate rocks [22].

According to A.A. Golovlev et al. (1990), the study area is characterized by mountain meadow subalpine dark-colored medium loamy soils. Dark brown soils with a brown tinge, moist, loose. The transition is gradual. 3-22 cm. Dark gray with a brownish tinge, moist, imperfectly lumpy, many roots, compacted, medium loamy. Dark gray, moist, imperfectly cloddy, poorly compacted, heavy loam, many roots. No boiling from 10% hydrochloric acid. The granulometric composition of soils becomes heavier downward; accumulation of fine particles was noted in the middle part of the profile (Table 2). Relatively high hygroscopic water correlates with high humus content and calcium saturation of the soil absorption complex (Table 1). The salt solution reaction is acidic (pH 4.5.2) and the hydrolytic acidity does not exceed 10 mg-eq. Among the soils of the contour there are spots of meadow alpine dark-colored soils, meadow subalpine dark-colored soils of different granulometric composition, as well as forest-meadow and bog soils. All these soils, except marsh soils, should be expediently used for pastures and hayfields, not forgetting their susceptibility to erosion processes [7].

Table 1. Agrochemical indicators of soils east of Makazhoi village. Makazhoi [8].

Dept h, cm	pH		Hydro lytic acidity , mg,eq	Absorbed bases, mg, eq./100		Degree of saturati on with bases, %	Humus accordi ng to Tyurin, %	Carbonates, %		Absorpti on capacity , mg, eq./100
	water	saline		Ca	Mg			CO ₂	CaCO ₃	
1	2	3	4	5	6	7	8	9	10	11
3-22 30- 40	und efin ed	5.2 4.8	8.53 8.97	27.16 17.78	7.71 4.44	undefin ed.	12.2 5.9	undef ined.	undefin ed	undefine d

Modern studies of the chemical composition of these sites conducted on the soil analyzer Shimadzu in the center of collective use show that the dominant element is calcium, the second place is iron, then in descending order there are silicon, potassium, aluminum, manganese, copper, zinc and other metals in small quantities.

The area of the site allocated for regenerative livestock farming is 1,054 hectares. Research sites were selected on the terraces of the slope of the northern exposure slope: reference site, moderate and intensive grazing.

Meadow subalpine cenoses are dominated by grass-grass groupings dominated by mottled fescue, mottled brome, mountain timothy, mountain hedgehog, glade, sad sedge, pink pyrethrum, high-mountain ramsons, bunch-grass, large-flowered bouquet, eastern elecampane, alpine forget-me-not, Caucasian scabiosa, Caucasian buttercup. Rhododendron yellows occurs in clumps in mountain meadows, occupying stonelands, steep slopes and also penetrating into pastures and hayfields. Curtains of this rhododendron well fix slopes due to strong and branched root plexuses that retain fine soil and stones, and non-eating of shrubs by cattle contributes to the growth of their thickets [7].

Based on our own research, it can be seen that members of the Astro family are represented by a numerous group in terms of biomass in all three study sites - ETALON, UM and INT. The second place is occupied by species of the Mentaceae (Cereals) family. The third place is occupied by representatives of the families of Legumes, Gentians, Berryaceae.

Table 2. Relative abundance of botanical families at sites ETALON, UM and INT

Family	species	region		
		ETALON	UM	INT
<i>Asteraceae</i> Dumort. (<i>Comnositae</i>)	1. <i>Achillea millefolium</i> L. –	+	+	+
	2. <i>Achillea setacea</i> Waldst. et Kit.	+	+	+
	3. <i>Artemisia campestris</i> L.	+	+	+
	4. <i>Centaurea adpressa</i> Ledeb.	+	+	+
	5. <i>Centaurea cheiranthifolia</i> Willd.	+	+	+
	6. <i>Cichorium inthybus</i> L.	+	+	+
	7. <i>Cirsium canum</i> (L.) (C. <i>Biebersteinii</i> Charadze)	+	+	+

	8. <i>Cirsium obvallatnm</i> (Bieb.) Fisch.	+	+	+
	9. <i>Hieracium. umbellatum</i> L.	+	+	+
	10. <i>Inula orientalis</i> Lam.	+	+	+
	11. <i>Onopordum acanthium</i> L.	+	+	+
	12. <i>Scorzonera filifolia</i> Boiss.	+	+	+
	13. <i>Senecio taraxacifolius</i> (Bieb.) DC.	+	+	+
	14. <i>Tanacetum vulgare</i> L.	+	+	+
	15. <i>Taraxacum officinale</i> Wigg.	+	+	+
	16. <i>Tussilago farfara</i> L.	+	+	+
Poaceae Barnhart	1. <i>Agrostis gigantean</i> Roth (<i>A. alba</i> L.)	+	+	+
	2. <i>Anthoxanthum odoratum</i> L. (<i>A. alpinum</i> A.et D. Love)	+	+	+
	3. <i>Bromopsis variegata</i> (Bieb.) Holub (<i>Z. variegata</i> (Bieb.) Nevski)	+	+	+
	4. <i>Dactylis glomerata</i> L.	+	+	+
	5. <i>Deschampsia caespitosa</i> (L.) Beauv.	+	+	+
	6. <i>Carex tristis</i> Bieb. (<i>C. meinshauseniana</i> V.Krecz.)	+	+	+
	7. <i>Festuca pratensis</i> Huds.	+	+	+
	8. <i>Phleum montanum</i> C. Koch	+	+	+
Fabaceae Lintl.	1. <i>Amoria ambigua</i> (Bieb.) Sojak (<i>T. ambiguum</i> Bieb.)	+	+	+
	2. <i>A. repens</i> (L.) C. Presl (<i>T. repens</i> L.)	+	+	+
	3. <i>Lotus corniculatus</i> L.	+	+	+
	4. <i>Medicago falcate</i> L.	+	+	+
	5. <i>Melilotus officinalis</i> (L.) Pall.	+	+	+
	6. <i>Onobrychis biebersteinii</i> Sirj.	+	+	+
	7. <i>Trifolium pretense</i> L.	+	+	+

<i>Gentianaceae</i> Juss. Горечавковые	1. <i>Gentiana angulosa</i> Bieb.	+	+	+
	2. <i>Gentiana cruciata</i> L.	+	+	+
	3. <i>Gentiana dshimilensis</i> C.Koch	+	+	+
	4. <i>Gentiana grossheimii</i> Doluch.	+	+	+
	5. <i>Gentiana. septemfida</i> Pall.	+	+	+
	6. <i>Gentiana schistocalyx</i> (C. Koch)	+	+	+
	7. <i>Gentiana</i> C. Koch	+	+	+
<i>Laimiaceae</i> Until.	1. <i>Betonica macrantha</i> C. Koch (B. <i>Grandiflora</i> Willd.)	+	+	+
	2. <i>Salvia verticillata</i> L.	+	+	+
	3. <i>Teucrium polium</i> L.	+	+	+
	4. <i>Thymus caucasicus</i> Willd.	+	+	+
	5. <i>Thymus collinus</i> Bieb.	+	+	+
	6. <i>Thymus. daghestanicus</i> Klok.et Shost. (77г. <i>mashukensis</i> Klok.)	+	+	+
	7. <i>Thymus nummularius</i> Bieb.	+	+	+

The absolute dominance of representatives of the Astro family over other forage grasses in pasture plots is probably related to the inability to adapt pasture management to an earlier start of the growing season.

The measurement of carbon stock dynamics in biomass pools involves the establishment of permanent sample plots, within which sampling is carried out throughout the duration of the project.Plant biomass sampling was conducted from late April through September 2023.

At each site, 10 plots of 0.5 × 0.5 m were randomly selected. Aboveground herbaceous vegetation was sampled. Samples of herbaceous vegetation were dried to a completely dry state and weighed. The method consists of drying the biomass at 80 °C for 8 hours. The collected biomass is weighed before immersion in the drying cabinet and after 8 hours of drying on analytical scales (laboratory VK-600).

Productivity under model grazing is determined.

Mowed biomass per square meter for the entire growing season is summed, multiplied by 0.45, the carbon fraction of dry biomass. The sum obtained is divided by 100, the primary productivity under model grazing is obtained, i.e. hectare of pasture under grazing biomass (in kg) per 1 ha. Productivity in model grazing is the mowing of plant biomass on the same square completely.The reference site is one of the areas designated for regenerative livestock production, but no sheep grazing is anticipated on this site. The reference site is designed for continuous measurements of CO2, CH4 and water vapor. The reference plot is the basis from which it is proposed to base the comparative analysis. The moderate grazing plots are intended for sheep grazing. The shepherd will move the sheep

from cage to cage at regular intervals (1 individual per 1 ha). The reference site is located at an elevation of 1970-2024 m asl. Moderate grazing is located at an altitude of 1943-1986 m asl. [4].

Areas of intensive grazing. There are two such plots on the territory. These plots are also, like the moderate grazing plots, intended for sheep grazing, but with more frequent grazing (2 individuals per 1 ha). But research should also pay attention to CH₄, as methane is one of the main greenhouse gases emitted by ruminants, including sheep [8]. Since the terrain is mountainous and the altitude is different, we chose an altitude approximately equal for conducting measurements of greenhouse gas emissions using the chamber method. Intensive - 1958-1994 m a.s.l. [4].

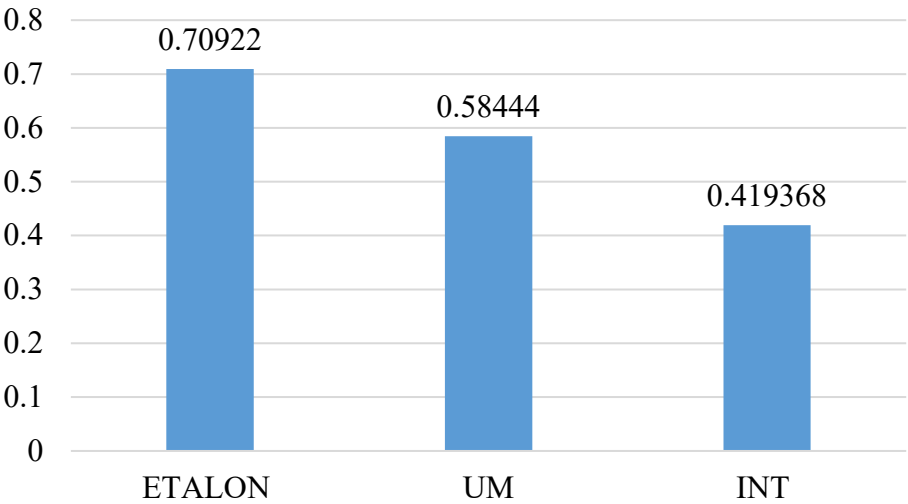


Fig. 3. Primary productivity under model grazing in t ha⁻¹ g⁻¹ biomass carbon⁻¹ (tonnes /(hectare * year) at carbon range plots.

4 Conclusion

Above-ground plant biomass is the largest carbon pool on Earth. It acts as a major source and sink of carbon in nature. Thus, it can be a major component of global warming mitigation and climate change adaptation. Estimating the carbon stocks of grassland subalpine cenoses will allow us to estimate the amount of carbon. Although numerous studies have been conducted to estimate biomass and carbon stocks, there is a need to develop reliable methods to better quantify the biomass of all grassland components and carbon stocks. Studies initiated in 2022 have developed a methodological framework for measuring carbon stock dynamics in aboveground biomass pools.

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