



Role of the subalpine forest ecosystems (on example of the southern slope of Great Caucasus)

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ABSTRACT

The current situation of subalpine forest ecosystem is discussed in this article. Investigations were carried out in the typical Duruji river basin, where because of anthropogenic influence occurred degradation of forest and grass cover, followed by deterioration of physical characteristics of soil, increasing of surface runoff and soil erosion causing significant decreasing of the upper boundary of forest from 2500-2600 m to 2100-2200 m above sea level.

The main physical characteristics of soil: such as dispersivity, hydrofiltration, indexes of erosion was studied for the Duruji River muflow basin. Soils of subalpine forests ecosystem characterized by good water regulation functions and they are natural mechanisms for runoff regulation. Afforestation-melioration activities should be carried out for the deforested areas resulted from anthropogenic influence which are under serious threat of erosion. Recommendations are developed according to the selected species, soil conditions and slope declinations.

Keywords: Subalpine, Ecosystem, Soil erosion, Restoration, Forest, Measure.

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Introduction

Sub-alpine forests are significantly important among the Georgian mountain forests. According to V.Gulisashvili [1], subalpine zone in Georgia located at different altitudes, on steep slopes of the Greater and Lesser Caucasus. In the sea climate conditions it occurs at the altitude from 1900-2000 m. to 2100-2150 m., in the continental climate conditions at the altitude 2150-2300 m.

Subalpine forest ecosystems according to L.Makhatadze [2] are divided into three categories: colhic, boreal and transcaucasian.

Colhic subalpine forest ecosystems occurs in the west part of Georgia and creates kroomm-

holzed beech, birch and Pontus Oak stands. Subalpine stands are presented by acer, birch, spruce, in understory there are following species: *Rhododendron luteum*, *Prunus laurocerasus* and *Vaccinium arctostaphylos*.

Boreal forest ecosystems spread on the north slopes of the Caucasus – in Kazbegi region, Mta-tusheti, near to Enguri, Kodori, Bzipi river basin. Above mentioned forest ecosystems are presented by *Betula* spp. and *Pine* spp. subalpine low density stands.

Transcaucasus forest ecosystems are presented mainly by subalpine low density stands, sometimes beech kroommholzed stands. These type of forests occurs in Meskheta and Trialeti ranges. In Kartli and Kakheti there are stands of the following

species, such as *Betula* spp, *Acer trautvetteri medw.*, *Quercus macranthera*, *Fagus orientalis L* and *Pinus* spp. [3].

Beech and birch kroommholzed stands are not more then 3-4 meter and mainly located in the upper part of natural range, near to alpine zone [4].

Climate of subalpine zone is moderately cold [5]. It is characterized by short and warm summer, severe and long winter, with variations in temperature, reduced vegetation period, early autumn and late summer frosts, resulted in development of woody plants in wervtical direction, above which forest doesn't occur and replaced by meadow vegetation.

Vegetation of subalpine zone formed by forest, shrubs and meadow type of species. Subalpine forest charachterized by low growth and low productivity. As a result of anthropogenic influence (unreasonable selective cuttings, unsustaible grazing induced degradation of forest and grass cover, furtthemore often ocured deterioration of physical characteristics of soil, encreasing of surface runoff and soil erosian processes, negatively affecting on the development of plants.

As a result of above mentioned processes the upper boundary of forest range decreased from 2500-2600 m above sea level, causing significant erosive processes and formation of dramatic mudflows in mountain river basins [6-11].

Protection of existed vegetation and planned reforestation activities is a major chalange in the above mentioned ecosystems.

Reseach objectives

Studies were conducted in typical Duruji River mudflow basin. There are three zones in this basin: 1. The lower zone (from 450-1000 m. above sea

level); 2. The middle zone (from 1000-1800 m. above sea level); 3. The upper zone (1800-2200 or 2300 m).

Researches were carried out for this purpose in typical Duruji River mudflow basin, where the forest zone strating from 450 m and reache to 2200-2300 m. There are three basins: 1. The lower zone (from 450-1000 m. above sea level); 2. The middle zone (from 1000-1800 m. above sea level); 3. The upper zone (1800-2200 or sometimes 2300 m).

The first and the second zone are charachterized by high density (0.6 and 0.7) forest ecosystems, which distinguished by their protective-ecological and erosian resistant functions.

The third zone, sublapine zone presented by the following forest types:

1. Fagus forest with bracken;
2. High mountain Quercus;
3. Acer forest with high grass cover;
4. Rare Betula.

According to the data of G.Kharaishvili [12]; T.Urushadze, T.Kvrivishvili [13]; T.Urushadze [14] subalpine zone mainly are presented by mountainous-forest-meadow type soils.

Woody and grassy vegetation support formation of stable soil structure, which improving its characteristics and prevent development of erosion processes. After destruction of vegetative cover soil loses stability and by the influence of water easily fall into the pieces. This enhance blocking of capillary pores of the soils and reduce water permeability. As a result, liquid runoff will be developed and depletion of soil will be occurred.

Studies of the physical characteristics of soil show that soil have good physical properties in Duruji River mudflow basin and in subalpine zone low density stands. (Table 1).

Table 1. Physical properties of the soils of Duruji Basin

| Altitude, m | Exposition | Vegetation | Depth, cm | Porosity (%) | | | |
|-------------|------------|--------------------------|-----------|--------------|-----------|---------------|---|
| | | | | Total | Capillary | Non capillary | Conduct of the 10 cm water pillar (min) |
| 1930 | N-W | Fagus forest+A | 0-10 | 57.6 | 45.8 | 11.2 | 0.7 |
| 2050 | NN-W | Acer forest + F,B | 0-10 | 60.4 | 47.9 | 12.5 | 0.7 |
| 2100 | W | Betula forest with grass | 0-10 | 55.5 | 41.4 | 14.1 | 0.8 |

| | | | | | | | |
|------|------|---------------------------------|------|------|------|------|---|
| 2180 | N-E. | Betula forest with Rhododendron | 0-10 | 47.3 | 29.2 | 18.1 | - |
| 1900 | E | Quercus + Acer + Ulmus | 0-10 | 47.7 | 36.2 | 11.5 | - |

In beech, birch and acer forest ecosystem non-capillarity of soil is varied from 11.8-14.1 %, water permeability – 0.7-0.8 min. Birch forest with its *Rhododendron caucasicum* understory is also very important, where non-capillarity of soil is about 18%.

The soil erosion indicators (Table 2) studied by us show the following results: upper soils of headwaters of Duruji River, where dispersion index is - D = 0.68, belongs to the group of mean dispersion indicator [15]), and the lower layers belongs to the high dispersion indicator (D = 0.96).

Table 2. Erosion proof of river Duruji Basin

| Altitude | Vegetation | Depth, cm | Dispersion | | | Hidrof. | | | | Unit | | |
|----------|---|-----------|------------------------------------|--------------------------------|------------|-----------------|-------------------------|-------------------------|--------------------------|-------------------|-----------------------------|------|
| | | | <0,05 sm without chemical farm (%) | 0,05 cm with chemical farm (%) | Dispersion | Max hygros. (%) | Content of colloids (%) | Equivalent humidity (%) | Indicator of hydrof. (C) | >0,25 mm unit (%) | Indicator of aggregates (a) | (E) |
| 1930 | Fagus forest with Acer and Sorbus | 3-18 | 63.81 | 92.22 | 0.68 | 10.16 | 38.86 | 33.68 | 0.99 | 91.48 | 0.63 | 1.06 |
| 2050 | Acer forest with Fagus, Betula and Sorbus | 2-15 | 70.05 | 86.61 | 0.80 | 14.05 | 46.83 | 44.33 | 0.94 | 92.88 | 0.43 | 1.77 |
| | | 20-45 | 78.87 | 94.39 | 0.83 | 9.95 | 33.16 | 42.17 | 1.17 | 88.80 | 0.52 | 2.03 |
| 2300 | Subalpine meadow without pastures | 0-10 | 61.13 | 75.37 | 0.81 | 12.79 | 42.95 | 59.39 | 1.38 | 81.20 | 0.33 | 3.38 |
| | | 15-40 | 64.80 | 76.14 | 0.95 | 10.00 | 33.33 | 47.98 | 1.43 | 78.40 | 0.39 | 5.27 |
| 2400 | Subalpine meadow without pastures | 0-10 | 65.92 | 80.89 | 0.81 | 13.89 | 46.30 | 88.99 | 1.92 | 77.08 | 0.30 | 5.18 |
| | | 15-25 | 70.63 | 84.12 | 0.84 | 8.60 | 28.66 | 70.47 | 2.45 | 76.92 | 0.39 | 5.27 |

The upper layers of beech forest soil are much less susceptible to the erosion processes than the lower ones, index of dispersion ranges from 0.81-0.85. These soils belong to the high desperation rate.

According to the hydrophilicity parameters the upper soil layers in Duruji river headwaters and subalpine zone belongs to the low range ($H < 1.0$), but lower layers belong to the average ($H = 1.0-1.25$). Soils in the alpine are more susceptible to the erosion than in subalpine zone. Furthermore, plots where occurred unsustainable grazing tend to be more susceptible than the areas without grazing.

According to the aggregate index investigated soils (a) can be grouped in the following maner: the soils of beech forest where $a > 0.60$ belong to the group of very high aggregate index, the soils of subalpine low density stands and alpine meadows, where $a = 0.30-0.60$ belong to the group of high aggregate index.

So, the highest aggregate index have forest soils ($a = 0.60-0.64$), followed by forest soils of subalpine zone ($a = 0.43-0.52$) and the lowest index have the soils of alpine zone where occurred unsustainable grazing.

Indicator of soil erosion (E) for investigated soils varies between (1.06 -5.27). This indicator is different for the soils in forest areas and for non-forest areas. For example, indicator of soil erosion in the upper layers in beech and acer forest ecosystems is about $E = 1.06 - 5.27$ and in the upper layers of alpine zone is - $E = 3.88 - 5.18$.

Investigations showed that the soils of subalpine forest ecosystem have good water regulative functions and act as a natural protective mechanism to regulate both: liquid and solid runoff. Namely, stands of evergreen *Rhododendron caucasicum* and low density birch stands.

Other forest stands according to water regulation functions are grouped in the following order: birch stands, birch, pine and oak low density stands.

Soils of stands of *Rhododendron caucasicum*, *Betula spp* and *Ulmus spp*. of subalpine zone of the Greater Caucasus mountain range are characterized by the best water regulation functions.

Other formations of subalpine forest ecosystems according to the water regulations functions are grouped in the following order: birch stands, kroomholzed birch stands, birch low density stands and stands of *Pinus sosnowskyi*.

The above mentioned beneficial functions of forest ecosystems, such as water regulative, soil protective and other ecological functions should

become basis for formation of targeted forest stands against soil erosion, which as a result anthropogenic influence are deforested and now there is serious threat of development of erosive processes.

Therefore one of the main activities should be considered banning of cattle grazing, implementation of forest-melioration activities, considering increasing of the upper boundary up to its natural range (2500-2600 m.above sea level).

Forest ecosystems against soil erosion in Subalpine zone should be compound with *Shade-tolerant species* in the second floor. For the good water regulation purposes are recommended to use the following species:

1. Tree -shrub type, with oak dominant species
 1. Tree -shrub type, with oak dominant species
 2. Tree -shrub type, with pine dominant species;
 3. Tree -shrub type, with beech dominant species;

Shrub type for the following types the following species will be selected:

- East Georgia:
- 1 – type: trees – birch (*Betula spp*), *Acer pseudoplatanus*, *Sorbus aucupa*;
Shrubs – nut, *Viburnum lantana*, *Caucasian Honeysuckle*
 - 2 – type: trees - *Quercus macranthera*, *Acer trautvetteri*, birch Shrubs: nuts, *Viburnum lantana*, *Caucasian Honeysuckle*
 - 3 – type: trees - *Pinus sosnowskyi*, birch, *Acer trautvetteri*;
shrubs: nuts, *Ribes nigrum*, *Viburnum lantana*.
 - 4 –type: trees - *Fagus orientalis L.*, *Sorbus aucupa*, *Acer trautvetteri*;
shrubs: *Caucasian Honeysuckle*, *Viburnum lantana*, *Ribes nigrum*.
 - 5 – type: trees – nuts, *Ribes nigrum*, *Rhododendron caucasicum*, *Azalea pontica L.*,
Salix caprea and other local shrub species.

On the slopes with inclination $< 6^\circ$ m, soil should be completely cultivated with belts varies between 6° 12° and terraces from 12° 20° . For the slope with inclination 20° and more should be made pits with chess layout.

On the slopes with inclination ($20^\circ <$) it is reasonable planting of forest plantations in the total area of watershes (at least 10,000 hectares per 1 ha).

Selection of woody species should be made according to the inclination and erosion rate: for the steep inclination (20° and $>$) – 50% of total number of selected plants, for the medium inclination ($< 20^\circ$) – 40 %.

In terms of guarantee the best water regulation

functions it is recommended used equal ratio (50-50%) of coniferous and broadleaf species.

Natural regeneration activities should be carried out in the low density subalpine forest ecosystems where are not *Rhododendron caucasicum* and *Rhododendron luteum*. It is recommended planting in pits with chess layout.

During carrying out melioration activities special attention should be paid to the to preserving of existing forest ecosystems and restoring of degraded. For this purpose new established forest plantations in the future should give us at least medium (0.5-0.6) dense stands [16-18].

Tending of forest plantations depends on local natural-climatic conditions and is recommended to be continued for 4-5 years. Namely, in the first year number of activities should be 5, in the second year 4, in the third year 3, in the fourth – 2, in the fifth – 1.

Tending of forest plantations usually involves soil timely cultivation, weeding. However, on the slopes where forest plantations are established, grazing should be banned until fully formation of stands.

Conclusion

1. Subalpine forest ecosystems of River Duruji with higher density (0,8) are natural mechanism of regulating of liquid and solid runoff.
2. Grove of evergreen azaleas and low density stands of subalpine birch croomholz with *Sorbus aucuparia* and with undersory (*Rhododendron caucasicum*) characterized by the best water regulation functions.
3. Uncontrolled grazing negatively impacted on the development of Subalpine forest ecosystems.

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