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Ecology

Soil Protection and Water Regulation of Georgia's Wetland Mountain Forests

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ABSTRACT. Mountain forests take the first place among the natural resources with regard to multifunctional benefit. Our conception about rational consumption and protection of Adjara forest is based on the current views of woodland as one of the most important and necessary components of biosphere, which fulfill the entire complex of ecological functions, including the global area. We proceed from the fact that the technological raw materials such as timber producing trees, precious and aboriginal trees and bushes in terms of plant introduction, medicine, food, insecticidal and other unique species of plants are concentrated in the forest resources of Georgia. All this reserve of potential resource is to be used rationally to satisfy the growing needs of the society. This paper presents the results of study of the ecological role of the most wetland region in Georgia – Adjara mountain forests. It deals with the issues regarding optimal sustainability of various forest complexes, balance of ecological optimization, maintenance and improvement of environment. *© 2019 Bull. Georg. Natl. Acad. Sci.*

Key words: water collecting pools, bottom sediment, weighted particles

Almost all the forest arrays (98%) are located on the mountain slopes in Georgia. Thus, Adjara forests, whose area equals to 65% of the whole republic territory are situated on the slopes with different angles of inclination or in the deep ravines and play important social and ecological role. These forests provide the greatest soil and water protection, regulate and recover water and climate system of our country, support multi-functioning agricultural development, protect from negative natural phenomena (erosions, floods, snow slides etc.). In terms of economic, water and soil protective functions, the forests are invaluable and they exceed the benefit received directly from timber usage.

Due to historical reasons, in particular, land fund restriction, excessive and nonsystematic forest cutting, disproportion between forest recovery and consumption for decades, insufficiency of natural hay and pastures, development of subtropical agriculture, expansion of territories due to the recreational goals and need for growing urbanization, uncontrolled cattle grazing, have considerably damaged the ecological stabilization of regional forests [1-4]. According to the results of our research, it is proved that the above mentioned changes have negative influence on the forest

arrays, which is basically revealed in modification of groves, replacement of valuable and highly productive trees with the species of producing phyto-cenosis, lowing the frequency of groves, creation of low quality, less productive and simple structural groves, losing the restoration ability of forest breeders. The optimal forestry of watersheds is violated in the forest complex with vertical tailoring, while subalpine forest climate boundary is gradually lowing and degrading.

The general state of Ajara forests directly or indirectly has impact on the subtropical Agriculture development. Separate regions of republic, particularly subalpine zone and pastures are extensively used for cattle grazing, which in some zones exceeds the norm 10-15 times. As a result, we get decomposition of natural soil structure and losing the self-regeneration ability, which cause the activation of conditions for landslides and avalanches, and hydrological system of Mountain Rivers is violated.

Scientists and experts have frequently warned that ecosystems are very sensitive, weak and fast decomposed in terms of mountain regions, particularly in areas under humid conditions caused by the sea climate. We have been standing on the mountainous system, on the edge of anthropologic consumption, where we need the common effort in order to reduce and end excessive human impact on the nature, otherwise, the progressive ecosystem ruining processes will lead to more extensive and devastating consequences in other regions of republic.

It is remarkable that long-lasting and intense sediments are not rare for Adjara yet catastrophic consequences of separate natural ecosystem cannot be explained by extreme weather conditions. Even more important role is played by anthropogenic impact on extremely low frequency of mountain forest. Apart from the factors mentioned above that cause failure of mountain ecosystem, we should be attentive towards unsystematic settlements, usage of heavy machinery, setting up the unwary, unordered, frequent and primitive roadways in mountain conditions, etc.

Among the most versatile social-ecological functions performed by Adjara forests, the most important ones are: soil protection, water regulatory, water resistance, anti-erosion, erosion, as well as recreational-resort and other useful features. Based on our latest stationary trial-experimental research, we have learned the protective functions of the most widespread mountain forests in Ajara, whose comparative data became the basics to create scientifically accepted concept of improving the state of Ajara mountain forests. Typological, taxation and forestry researches on forest sections, changes caused by anthropogenic loading on forest ecosystems as well as the major hydrological parameters in water-collecting basins will be conducted and determined with universally acknowledged methods. Physical properties of water-collecting basins were studied with the Wagner method. Soil was taken in 1000 cm/q cylinders whereas the low underdeveloped soils – 250cm/q volume cylinders. On the objects under study, the main physical features of the soil was studied in surface (0-20 cm) and lower (20 and more cm) horizons, because these are the layers that accept rain and wastewater. In addition, we have studied aggregation, mechanical composition, humus, nitrogen, PH-volume weight and humidity of the above mentioned layers.

In order to determine what type of mountainous forests provide soil-protective, water-regulatory and water-protective functions (that may avoid erosion, avalanches, landslides and other natural catastrophes), the characteristic features of widespread mountainous forests protective functions were studied on the example of ten rivers, applying recent methods of stationery testing-experimental research. To this end, each one was provided with water-passages, recording devices of "valdai" type for identifying water level, and other measuring devices. The obtained digital data was processed with variation statistics analysis, with

special attention to the essential difference data (t) and data validity (W %). The essential difference is calculated with the formula $t = \frac{M_1^2 - M_2^2}{\sqrt{M_1^2 + M_2^2}}$ and validity chance – in W%.

The problem of soil protection from water erosion gains special importance in mountainous regions of Ajara, which is characterized by great inclination of slope, large partition of terrain, intense and long rainfall.

The essence of soil protection function for Ajara mountain forests means to protect the soil from water and wind erosion and improve its fertility periodically.

According to the results of long and versatile stationary research based on the example of small drainage basin in natural climate conditions of various vertical girdles in Ajara (foothills, highly wet- subtropical girdle, village of Chakhati, Kobuleti region; slightly wet-broad-leaved forests girdle of the central mountain zone, village of Tsoniarisi, Keda region and high mountain dark coniferous forest girdle-Village of Naghvarevi, Shuakhevi region) we can clearly see features of solid river sediment in regards to humidity of drainage basin and human's agricultural activities. Georgian and foreign researchers mention in their works about the forests on the slopes of the mountains as a soil preservation, water regulation and water storage factor [5,6].

With the help of perennial stationary researches held in the eastern Georgia (insufficiently wet region), it is proven that 70% of river sediments in the forest drainage basin are formed at the expense of suspended sediment particles, in 50% of forestry basins bottom sediment is 24% of total amount of sediment (bottom and solid resident), 30-37% of forestry, based on reductions of drainage basin forestry, increased solid and bottom sediments was noticed.

In addition, it is remarkable that the sudden mudslide sometimes produces 89-90% of the entire volume of annual solid sediment.

The researches carried out by us in West Georgia (wetland region) have shown that solid sediment formation principles are the same for Eastern Georgia as well, more precisely, the higher the percentage of basin forestry is, the less amount of sediment generates. But if in Eastern Georgia (less wet region) the formation of sediment can be occurred with leaf matters and bottom sediment only in low forest watersheds, the great amount of bottom sediment is formed in higher forest watersheds of Western Georgia (highly wet region) as well. For example: in 10% of forest basin bottom sediment equals to 50.4 t/ha, in 37% of forest basin – 34.7 t/ha, in 80% of forestry watersheds – 13.7 t/ha, and in 90% forest basin – 5.0 t/ha.

The appropriate data was obtained for moderately humid regions (middle mountain zone, broad-leaved forest girdle), which is characterized by reduced magnitude of river sediment (20% of forestry in watershed, 25 t/ha; 80%-16.5 t/ha; 90%-4.9 t/ha).

Even higher, the drainage basins of various forest zones located in dark coniferous forest girdle (village of Naghvarevi), solid sediment is changing within wider boundaries, particularly, bottom sediment in watersheds with 35% of forestry is 39,0 t/ha, 50%-20.5 t/ha, 80%-5.05 t/ha. These data prove that weight difference of bottom sediments between 35% and 50% of forestry watersheds is small. But bottom sediment in 80% of forestry watershed compared to up-mentioned data is even less. The most remarkable fact is increased specific share of solid sediment in wetland drainage basins compared to bottom sediment data. The middle zone of broad-leaved forest in the middle mountainous Adjara is characterized by reduced solid sediment while the data are significantly growing in the dark coniferous forest basin of high mountainous region, but do not exceed the number of solid sediments in highly wet drainage basins of subtropical zone.

Generally, we can conclude that the highest indicators of total solid sediments are reached in the

low mountainous zone and highly wet conditions, these results are significantly increasing in the middle mountainous zone and it is growing again in high mountainous conditions, though not with the same amount, as it is in subtropical and highly wet areas.

Water Regulation Functions of Ajara

The essence of water regulation is to grow the infiltration, as well as to distribute intensively atmospheric precipitation and runoff water balance. Effectiveness of the above mentioned function is clearly shown with preservation of sustainable regime for the rivers during spring floods and lack of water in summer, as well as increase of water scarcity nourishment based on swing grading description of water spending amplitude.

In the wet regions of Ajara Autonomous Republic, we studied the main issues of runoff from different watersheds during the heavy rains (and floods caused by rains), we analyzed and developed general rules and regularities of forest water regulation function.

By analyzing runoff level coefficient and maximum model data, we determined decreased tendency of these parameters in case of high forest watersheds(yet the regulatory effect is not so clearly shown as in the less wet region drainage basins of East Georgia). The highest level of runoff module indexes in this region, in terms of their reductive tendency, carries the same character in connection with increased forestry for different forest basins. For example, in case of maximum 24-hour rainfall arrival (189 mm) the runoff level for 10% of forest watersheds was 111.3 mm; from 38% of forest watersheds – 110.8 mm; in 80% of forest watersheds and from 90% of forest watersheds – 11.89 mm. Other parameters, particularly runoff coefficient change with the same order, which was mentioned above, with some small deviations (In case of 10% forest watershed – 0.59 mm; 35% – 0.58 mm; 60% – 0.58 mm; 90% – 0.54 mm; The maximum level of runoff watershed is equal to 12.99 l/sec/ha; 12.83 l/sec/ha; 13.08 l/sec/ha; 11.8 l/sec/ha).

Researches held by us in the broad-leaved (Village of Tsoniarisi), middle mountainous girdle) and dark coniferous (Naghvarevi, high mountainous girdle) moderate wet zone prove that runoff height index coefficient and maximal modules, at the stage of research there is a little difference from similar indicators of this survey conducted in highly wet regions, particularly we are dealing with the decrease of runoff detain regards to forestry increase.

But it cannot be ignored that here, difference among the mentioned data, connected, has relatively similar tendencies, regarding forestry of drainage basin.

Complex researches of water regulation functions conducted in small watersheds of mountainous Adjara in highly and moderate regions showed that water regulatory functions of forest ecosystem are significantly lowered at the background of systematically intensive precipitations. It is noteworthy, that water regulation role is insignificant in the dark coniferous and broad-leaved forest girdle of moderately humid zone in Adjara region.

Water Protection Function of Ajara Mountain Forests

The complexity and versatility of water protection in mountain forest is based on unique ability of mountain forest groves which proves the fact that researchers do not have the same view regarding the essence of this function. Some researchers think that the essence of water protection function is the ability of forest massif to preserve hydrological regime of the area within optimal boundaries and its essence is generated from the water regulation role. According to other researchers of wider hydrological profile, the essence of forest protection function should be effective usage of water on forest-covered slopes

and the maximal amount of runoff obtainability in separate areas.

The majority of researchers consider that the runoff from forestry drainage basin, increase with growth of forestry. According to small group of researchers (and others), the annual runoff increases with the reduction of forestry.

It's worthy of mention that this issue that is quite important for public agriculture, is not sufficiently studied. It was first studied by us for moderately wet region of inner mountainous Adjara.

It is already known that the mechanism of forest influence on the surface runoff is caused by many different factors; among them are physical and watery characteristics of soil(capillary and non-capillary porosity, water-permeability, water-proofness of aggregates). They change based on quality of forestry in watersheds, better farming management features and forestry growing tendency in drainage basins.

In wet subtropical zone of Adjara, where the annual amount of precipitation is 2700 mm, in the watersheds with 10, 35, 80 and 90 percent of forestry the annual average rates of runoff height were – 2009, 1910, 1898, 1928 mm.

These data once again indicate the grown forestry in watersheds the runoff has a slight tendency towards height reduction that is considered to be a fairly regular process.

The same indicators are in the middle mountainous girdle of Adjara, where average amount of annual precipitation equaled to 1705mm, annual average runoff height of watersheds in 20, 60 and 80 % of forestry were 921, 905, 900 mm. In dark coniferous girdle of high mountainous zone, where annual average precipitation was 1833mm, in the watersheds with 35, 50, 80 percent of forestry, annual average data were – 1210, 1195, and 1240 mm.

Thus, long-term and numerous stationary experimental data clearly show that the tendency to increase the height of runoff in watersheds of highly wet and subtropical region of Adjara is not suspicious regarding to reduction of forestry, as for the moderately wet regions in inner mountainous Adjara there are no significant difference between the same data.

The results of conducted researches give us right to say that in high and moderate wet regions of Adjara, water protection functions of rivers are first revealed in reduction of bedload and bottom sediment from high wet watersheds. Water regulating effect of these forests or extra runoff fluctuation amplitude is insignificantly reduced and water protection function is revealed in maintenance of water quality in highly wet watersheds. The basic protective features in broad-leaved forests of subtropical and middle mountainous zone are being revealed in their soil protection function, as for dark coniferous forests in high mountainous girdle, they perform the soil and avalanche protection function as well.

We consider that the forest is a strong avalanche protection factor, but it should be admitted that all kinds of forests are not able to perform an interfering role and leveling process of an avalanche. Therefore, in our researches, we paid considerable attention to restoration of optimal avalanche protection structure in Adjara forests. Studies have proven that, most of all avalanche protection functions are performed by mixed composition of groves; the social functions performed by mountain forests have particular importance for usage of recreational forest, which means the bilateral relationship, the act of recreation on the forest and forest on the recreants [7, 8].

Surveys conducted in Adjara forests showed that social and ecological functions of forests, based on a result of recreational forest usage, can be positive and negative, but in modern conditions the specialists (20) think that recreation has negative impact on the forest (ecological function) but the influence of the forest itself on the

recreants (social function) is rather positive. Negative results of recreation are especially visible in near zones (up to 500 mm), around the sport, tourism, medical and recreational complexes. In the middle (from 500 to 1000 mm radius) and in the high (over 1000 mm) zones, negative ecological results are gradually reduced in terms of recreational load.

The social consequences of positive forest action on recreants have global nature and it is a reliable guarantee of life expectancy throughout the planet.

ეკოლოგია

საქართველოს ჭარბტენიანი მთის ტყეების ნიადაგდაცვითი და წყლის შესწავლის შედეგები

ვ. პაპუნიძე

აკადემიის წევრი, ბათუმის შოთა რუსთაველის სახელმწიფო უნივერსიტეტი; საქართველოს მეცნიერებათა ეროვნული აკადემიის აჭარის ავტონომიური რესპუბლიკის რეგიონული სამეცნიერო ცენტრი, ბათუმი, საქართველო

ჩვენ მიერ შესწავლილ იქნა აჭარაში, სტაციონარულ საცდელ-ექსპერიმენტული კვლევის უახლეს მეთოდებზე დაყრდნობით, ფართოდ გავრცელებული მთის ტყეების დაცვითი ფუნქციების მახასიათებლები, რომელთა შედარებითი მონაცემები საფუძვლად დაედო აჭარის მთის ტყეების მდგომარეობის გაუმჯობესების მეცნიერულად დასაბუთებული კონცეფციის შემუშავებას. აჭარის მთის ტყეების ჭარბ და ზომიერი ტენიანობის რეგიონების მცირე წყალშემკრებ აუზებში ჩატარებულმა წყალმარეგულირებელი ფუნქციების კომპლექსურმა კვლევებმა გვიჩვენა, რომ ინტენსიური ნალექების მოსვლის ფონზე ტყის ეკოსისტემების წყალმარეგულირებელი ფუნქციები, მთლიანობაში, მნიშვნელოვნად დაწეულია. ხოლო აჭარის ზომიერად ტენიანი ზონის მუქწიწვიან და ფართოფოთლოვან სარტყლის ტყეების წყალმარეგულირებელი ფუნქციების როლი საერთოდ უმნიშვნელოა. ზვავსაწინააღმდეგო ფუნქციას, ყველაზე მეტად, ასრულებს შერეული შემადგენლობის კორომები; სოციალური ფუნქციებიდან, რომლებსაც ასრულებს მთის ტყეები, განსაკუთრებულ მნიშვნელობას იძენს რეკრეაციული ტყის გამოყენება, რომლის არსი მდგომარეობს ორმხრივ კავშირში, – რეკრეაციის მოქმედება ტყეზე და ტყისა – რეკრეანტებზე. მთის ტყეების როგორც ეკოლოგიური, ასევე სოციალური ფუნქციები, რეკრეაციული ტყის გამოყენების შედეგად, პრინციპში, შეიძლება იყოს დადებითიც და უარყოფითიც. მაგრამ თანამედროვე პირობებში სპეციალისტების აზრით, რეკრეაციის მოქმედება ტყეზე (ეკოლოგიური ფუნქცია) ატარებს ნეგატიურ ხასიათს, ტყის მოქმედება რეკრეანტებზე (სოციალური ფუნქცია) კი პირიქით – პოზიტიურს. რეკრეაციის ნეგატიური შედეგები განსაკუთრებით თვალსაჩინოა ახლო ზონებში (500 მ-მდე რადიუსში) – სპორტული, ტურისტული, სამკურნალო-გამაჯანსაღებელი და სხვა კომპლექსების ირგვლივ. შუა (500-დან 1000 მ-მდე რადიუსში) და მაღალ (>1000მ) ზონებში ნეგატიური ეკოლოგიური

შედეგები, რეკრეაციული დატვირთვის თვალსაზრისით, თანდათან მცირდება. ტყის პოზიტიური მოქმედების სოციალურ შედეგებს რეკრეანტებზე აქვს გლობალური ხასიათი და იგი წარმოადგენს მოსახლეობის სიცოცხლის გახანგრძლივების საიმედო გარანტს პლანეტის მასშტაბით.

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