CARBON SEQUESTRATION POTENTIAL OF THE NATURAL FOREST REGROWTH IN GEORGIA

2019

Table of Contents

Acknowledgements

This report was prepared within the project **Integration of sustainable forest management practices in Georgia by provision and analysis of key data using remote sensing technologies**, with the support of the Global Forest Watch.

The overarching objective of the project was to support the integration of sustainable forest management practices in Georgia by providing the necessary data.

The project team included:

Sophie Gogibedashvili[1], Joni Kevlishvili[1], Ivane Skhirtladze[1], Dachi Kanchaveli[1], Sandro Kolbaia[1,2] and Kakha Artsivadze[1]

[1] *Centre for Biodiversity Research and Conservation – NACRES, Tbilisi, Georgia*

[2] *National Botanical Garden of Georgia, Tbilisi, Georgia*

We would like to thank project volunteers: Nika Tsitelashvili, Michael Josefowski, Camille Raverdy-Preisel and Goga Jokhadze, for their invaluable contribution in the field data collection.

List of Abbreviations

BUR – Biennial Update Reports

C – Carbon

DBH – Diameter at breast height

GFW – Global Forest Watch

GIS – Geographic Information System

INDC – Intended Nationally Determined Contributions

IPCC – Intergovernmental Panel on Climate Change

LULUCF – Land Use, Land Use Change and Forestry

NDVI – Normalized Difference Vegetation Index

UNFCCC – United Nations Framework Convention on Climate Change

USFS – US Forest Service

WRI – World Resources Institute

WWF – World Wide Fund for Nature

Foreword

Georgia is an emerging economy on the crossroads between Europe and Asia, Russian Federation and the Asia Minor, with multiple socio-political challenges and broadly pro-Western orientation. Situated in the heart of the Caucasian biodiversity hotspot, the country is flanked by Anatolian and Mediterranean hotspots from south and west, respectively. This puts the area on a high priority for nature conservation as it has always been a corridor for the migratory species and the plant dispersal. Georgia, especially the southern regions and the Black Sea coast (Kolkheti National Park, Mtirala bottleneck), also represents a migratory route for many species of birds. Georgia is currently participant in multiple international nature conservation and research projects and is signatory of the UN conventions on nature conservation and climate change (the Caucasian branch of WWF is situated in Tbilisi).

In the former times, the biodiversity research and conservation were led in the fashion of a "naturalist" spirit. Influential botanists and zoologists have carried out multiple expeditions in the region collecting herbarium and other specimens and developing the taxonomic units for the local species, which often are closely related to Eurasian ones. Nonetheless, there is a high endemism in both flora and fauna, although, some of those species must be updated with modern systematic methods as there is a taxonomic artifact. This puts us in a situation of being ambitious enough to participate in the international efforts for nature conservation, with a very limited scientific data available for the further assessment and evaluation of priorities.

The situation is likewise in the field of forestry, where all the legislation, documentation and practices are inherited from the Soviet era and yet has to be improved and modernized. For this reason, this is the first time that the forest carbon sequestration is being calculated in Georgia. The idea of the project was to carry out both preliminary analyzes and the field survey using taxation techniques and calculate the total biomass and carbon sequestration in the newly emerging forest in the Truso valley's former pasturelands.

1. Introduction

1.1. Current knowledge in terms of carbon sequestration in Georgia

The Paris Agreement recognizes the central role of forests in achieving the goal to keep the increase in global average temperatures to well below 2°C above pre-industrial levels through mitigation options that aim to reduce emissions from deforestation and forest degradation. To date, 118 countries, including Georgia, have carried out forestry and land use measures as part of their pledges in their Nationally Determined Contributions.

Sustainable land management, planting and rehabilitation of forests can conserve or increase forest carbon stocks. Deforestation, degradation, and poor forest management have the opposite effect. Unfortunately, during last centuries extensive areas of native forest ecosystems have been cleared and converted to other land uses such as agriculture, which has had substantial and widespread negative impact on climate, hydrology, soils, and biodiversity. Human activities, through land use, land-use change and forestry (LULUCF), cause changes in carbon stocks.

Increasing of net carbon sequestration by afforestation is one way of reducing net national emissions of CO_2. The common assumption is that in addition to the perceived climate benefits, increasing forest area within its original range will also support biodiversity. Afforestation of abandoned farmlands could restore biogeochemical cycling of carbon, oxygen and nutrients in the atmosphere, improve biodiversity and increase ecological resistance to various pressures, such as that from climate change.

A better understanding of the relationship between C stocks and land use practices is required in the context of the global C balance. The impacts of the ongoing processes of land use change needs to be assessed and efforts to store more C in terrestrial ecosystems needs to be evaluated, in terms of their ability to slow down the rate of increasing the atmospheric CO_2. Therefore, all countries are obliged to collect valid data and submit their report to the United Nations Framework Convention on Climate Change (UNFCCC) providing information about sources and removals of emissions by sinks of CO_2 and other greenhouse gases, including estimates of the changes from LULUCF activities (afforestation, reforestation, deforestation and forest management). These assessments have become a major basis for the greenhouse gas reporting under UNFCCC.

1.2. Description of the study area

Truso valley is situated between the Great Caucasian ridge and Khokhi ridge. The valley starts at the Truso pass and stretches 25 kilometers. The lowest point is at 2000 m. at the Tergi riverbed and the highest at Suatis summit at 4466 m. The watershed comprises of three rivers valleys: Mne, Suatisi and Tergi. The biggest river is Tergi with confluences of Resistskali, Suatisi, Tsotsoltastskali, Kasarastskali, Arsikomidoni, Jimaristskali, Tepistskali, Desikomidoni, Esikomi and Mnaisistskali. About fifteen abandoned villages are included in the valley which are Ketrisi, Abano, Zakagori, Suatisi, Desi, Tsotsolta, Jimera, Kartsopeli, Burmasigi, Tepi and Resi.

Travertine formations sedimented from the mineral water sources, glaciers and riverine sediments can be seen in the valley. The Truso travertines are included in the Red List of Georgia as a natural monument. Those are formed at the activity areas of high debit mineral springs by sedimentation process of thin layers of calcium and other minerals from the running water. Their surface has a draped fence-like pattern, which requires an exceedingly long period to form. Truso valley is colloquially called "the mineral water treasury". Approximately sixty mineral water springs with sulfur, calcium or iron as well as non-mineral sources. In the environs of village Abano (bath) a mineral pond of karst origin can be seen called a "bubbling lake" by locals as the air bubbles are released at the surface in big amounts. Other lakes in the Truso valley are Kelitsadi, Keli (meaning "neck", the highest altitude lake in Georgia) and Archeti lake.

The population of Truso valley was 1200 families by the 1926 census. The first major exodus from the area was witnessed in 1944-46 due to the planned inhabitation of desolated Ingusheti region by the people from the neighboring regions. More specifically, 80% of the Truso population was relocated, which made the valley virtually uninhabited. The remaining population moved down to the Kobi area and village.

1.3. Relevance to the global and national priorities

In the recent period, abandonment of pastures has become a widespread trend in mountainous regions of Georgia. This encourages afforestation in formerly forested areas that have been previously transformed into artificial grasslands or hay meadows.

The rate of natural afforestation increased considerably after the breakup of Soviet Union – with the abolishment of the soviet livestock farming system, portions of grasslands were abandoned, giving way to natural succession. A higher proportion of vegetated surfaces, together with favorable climatic conditions, may result in a higher potential for C uptake in Georgia.

Understanding the long-term effects of reforestation on plant community characteristics and the subsequent impact on C dynamics can provide managers and policy makers with useful tools for maximizing C sequestration and biodiversity.

The LULUCF sector of the Kyoto Protocol requires that Georgia monitors changes in the country's carbon stocks, including those within virgin forests. According to experts and organizations operating in this field, the reports submitted by Georgia contains major shortcomings in the LULUCF, as there is no exact assessment of forest's potential to accumulate carbon, especially in timber. This is caused by the fact that there are no modern, accurate information about the rate of accumulation of carbon by the forests of different types and age in Georgia.

Additionally, Georgia's Intended Nationally Determined Contribution (INDC) submission to The UNFCCC declares afforestation as one of the national priorities. It should be stressed that significant part of the total carbon in forest ecosystems is accumulated in forest biomass, therefore detailed estimations of biomass of forests are necessary for carbon accounting as well as implementing of INDC.

1.4. Relevance to the particular needs

As a Party to the UNFCCC, Georgia is obliged to prepare and regularly update national emission inventories of greenhouse gases, for which so-called (i) National Communication to the UN Framework Convention on Climate Change and (ii) Biennial Update Reports (BUR) are submitted.

Afforested pasturelands have only recently become recognized in Georgia as a potentially important C sink source and assessing the potential of C accumulation is essential for evaluating natural increment of the forest. It is for this reason that, relatively little is known about C sequestration in such territories.

The rate of biomass accumulation in naturally regenerating forests are not quantified in mountainous regions of Georgia. The data obtained by this project will support the process of monitoring of changes in country's carbon stocks and improve reporting under the UNFCCC (sector LULUCF), especially in the process of preparation Georgia's National Communication to the UN Framework Convention on Climate Change and Biennial Update Reports (BURs).

The overall objective of the project was to quantify the carbon accumulation potential in the above-ground biomass of naturally regenerated forests in mountainous areas of Georgia and to determine how biomass stocks change after the recovery of secondary forests as a result of pasture abandonment and decreased human disturbance. This can be achieved through extrapolation of the data collected within the target region to the whole territory of Georgia, for which the results of the data collected by WRI and Forest and Land Use Atlas will be used to analyze the results of the Landsat satellite imagery.

The specific objectives of the project were to evaluate the primary productivity (natural additives) for naturally regenerated forest on abandoned pasture lands in selected target area (Truso Valley - Kazbegi region) to assess the potential of C accumulation.

The purpose of this study was to compare the data obtained from satellite image analysis and field surveys and to determine the degree of accuracy. This approach would allow us to analyze the use of open source data from the Georgian Forest Atlas and Landsat throughout Georgia. Assessment of carbon stock in the aboveground biomass can be worked out by direct sampling and remote sensing. Satellite data has a great potential for determining vegetation carbon content, as well as can be used for the assessment of carbon stocks by land cover mapping and represents a well-known method for improving broad scale estimations compared to conventional ground-based observations.

In this project, remote-sensing methods and ground-based methods were considered as part of the same procedure. The goal was to obtain data that are highly representative of the plant biodiversity and the spatial variability of aboveground biomass in the study area.

2. Implementation

Identification of naturally regenerated forests on abandoned pasturelands and assessment of carbon stock in aboveground biomass were conducted through direct sampling and remote sensing. Identifying of the target area was conducted using metadata of the GFW atlas. The use of satellite imagery from different years (Landsat satellite imagery from the 2000s to 2018) in combination with direct sampling on the ground allowed us to estimate the effects of afforestation on C dynamics in former pasturelands. Remote sensing was used as indirect estimation of aboveground biomass through some form of quantitative relationship, which can be used as a sampling framework for the location of ground observations and measurements.

2.1. Preparation phase

In the initial stage of the project, all necessary information was gathered and analyzed. All available satellite and aerial ortho imagery of the Truso valley, the project study site, taken in different years were acquired. These included:

- 1957 high resolution aerial imagery of villages Kobi and Kanobi;
- 30 m resolution multispectral imagery by Landsat 7 taken on September 1st 2001 (Georgian Forest and Land Use Atlas[1]);
- 30 m resolution multispectral imagery taken by Landsat 8 taken on September 5th 2017 (Georgian Forest and Land Use Atlas);
- 2017-2018 high resolution ortho imagery.

The project implementation team was recruited that included a forester, a botanist, field assistants and volunteers for field works.

Field data collection and analysis methods were selected; they were mainly based on the methodology suggested by the US Forest Service (USFS) (Measurement Guidelines for the Sequestration of Forest Carbon by Timothy R.H. Pearson Sandra L. Brown Richard A. Birdsey[2]). The selected methodology was analyzed by the project team.

Working closely with the Project's GIS specialists, methodology for the analysis of multispectral imagery was identified.

[1] https://atlas.mepa.gov.ge/maps/map?l=en

[2] http://ipclimatechange.trg-learning.com/wp-content/uploads/2013/11/Measurement-guidelines-for-the-sequestration-of-forest-carbon.pdf

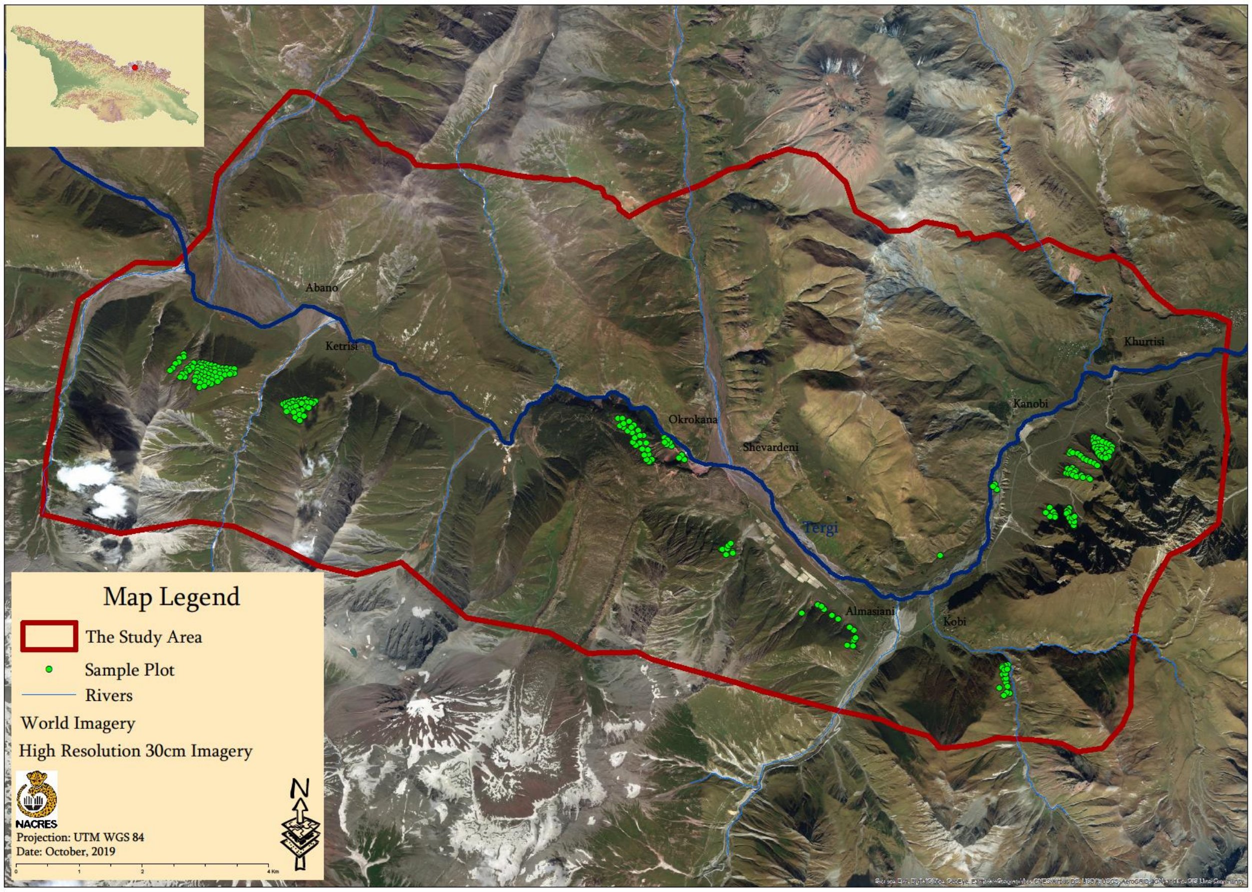


FIGURE 1: STUDY AREA SHOWING SAMPLING PLOTS.

2.2. Preliminary analyzes of the given data

As mentioned above, available satellite and aerial images from previous years were analyzed in the initial stage of the project. As a result, we were able to visualize the forest cover in the Truso valley in the years of 1957, 2001 and 2018.

Areas for ground surveys were selected (see Figure 1) and specific sites for forest inventory and for calculating carbon accumulation were pinpointed. The main criteria for selecting study areas were the evidence of expansion of forest area on lower elevations or the occurrence of a new forest growth through natural regeneration since 2001, at the sites that were formerly grazed by livestock (See Chapter 1.2).

By analyzes of the high resolution aerial and satellite imagery of different years (1957, 2001 and 2018) the digital map of Truso valley was prepared and the forest cover change was determined (see Appendix #1 Truso Valley forest map). For ground-truthing of the acquired parameters, several study areas, both at the river and the middle slope, were marked for the survey. The geolocations of before-mentioned study areas were given to the field survey team for the ground-truthing of the following:

- The accuracy of the borders of naturally regenerated forests that were mapped by satellite image analyzes;
- To verify if the areas identified based on the satellite images were indeed forest or shrubs;
- The efficiency of the selected working methods and the identification of the faults.

2.3. Selection and elaboration of the field survey methods

At the initial stage of the project, during the development of the field survey methodology, the priority was set for the methodology used under the same climatic conditions and did not include a destructive approach that would not be effective in our case (due to the limited time). Finally, the method used by the USFS was selected and adapted, "Measurement Guidelines for the Sequestration of Forest Carbon", which by definition demanded a detailed documentation of every step to be carried out in the field study. This allowed us to greatly optimize the methods to the local conditions and still gather the data with maximal precision.

According to the methodology, to reach the 95% confidence level in the acquired data, approximately 10% of the entire study area must have been surveyed. Consequentially, the total area of the territories surveyed comprised 11.8 ha. Considering the former along with the requirement to have evenly distributed forest areas, the designed plots (20x20 m squares) plots were evenly selected on the territories with identified forest cover. In total 144 sample plots have been placed (See Appendix #2 Truso Valley sample plots). As of the sampling technique, only the trees with minimum 5 cm on DBH[3] were measured and recorded (this parameter varies due to the climatic conditions of the study area; e.g. in the arid zones, where the tree growth rate is low the minimal tree diameter to be recorded would be 2.5 cm, whereas in the high humidity areas it would increase to 10 cm at DBH).

[3] Diameter at Breast Height - the diameter of the tree measured at the height of 1.3 meters above the ground.

In the above-mentioned document, the standard formula[4] for converting the DBH measurement into the net biomass of the tree is given (including the cohering coefficient used in the formula for the specific species of trees). Later the coefficient provided in the guideline of IPCC (Intergovernmental Panel on Climate Change) can be used to convert the acquired number into the net carbon sequestration value. It is mentioned, that in case no coefficient is available for the local conditions, the general coefficient of 0.5 should be applied.

Additional information gathered from the field survey is as follows: altitude above sea level, aspect, slope inclination, type of terrain and the pasture (soil) condition, as well as such characteristics of the stand as are the tree origin (seed grown/sprouts), the distribution pattern (even/groups) and the density (low/medium/high) of the forest. With all these inputs in mind, the standard field data form has been prepared (see Appendix #3 Carbon Field From).

PICTURE 1, 2, 3: FIELD SURVEY PROCESS INCLUDED ACCESS TO THE STUDY TERRITORIES, IDENTIFICATION OF THE PRE-DETERMINED PLOTS AND TAXATION OF THE TREE DBHS.

[4] Biomass equation to use in Excel: $= Exp(\beta_0 + \beta_1 Ln\, x)$, where X is a measured DBH and β_0 and β_1 coefficients given in the guidelines according to species.

3. Materials and methods

3.1. Field study process

The field studies were carried out from June to August 2019. In total 4 expeditions were carried out and five specialists and four volunteers participated in the field surveys. The data was acquired from 244 sample plots in different parts of the valley, according to the preset methodology and the points acquired from the satellite image treatment. The majority of tree species represented on the territories (DBH > 5 cm) were birch (*Betula litwinowii* Doluch.) with 91.8% part, followed by Goat willow (*Salix caprea* L.) - 7.2%, willow (*Salix sp.*) – 0.8% and Scots pine (*Pinus sylvestris* Lour.) - 0.2%. In addition, on 106 sample plots no trees with DBH above 5 cm were recorded.

PICTURE 4: SAMPLE PLOT WITH SCRUB (SALIX SP.) DHB<5 CM

PICTURE 5: SEA BUCKTHORN IN THE RIPARIAN AREA.

No major issues have been encountered in terms of data gathering or satellite image treatment methodology, nor during the preliminary assessment period or at any time after. It should be mentioned that every preselected sample plot represented a forest stand. However, at the river dell area several small sites could not be studied due to the dense scrub cover - Sea buckthorn (*Hippophae rhamnoides*) with characteristic thorns that make those areas unpassable.

3.2. Analyzes of satellite imagery

One of the aims of the following study, as mentioned earlier, was to estimate the total carbon sequestration potential in Georgia from the example of the naturally regenerated forests on the abandoned pasture lands of Truso valley. With the stated purpose, the high-resolution satellite imageries from Landsat 7 and Landsat 8, along with the selected data from the Georgia Forest and Land Use Atlas, were acquired and analyzed to highlight the change in the forest boundary. Additionally, the results gathered from the GIS analyzes were compared to the results from the field survey data. That would shed more light on the precision on the results acquired from the satellite analyzes in the mountain regions of Georgia. In case of getting highly corresponding results, the possibility would arise to use Georgia Forest and Land Use Atlas data for determining (extrapolating) the afforestation at the pastures in the mountainous regions of Georgia and in turn estimating the carbon sequestration potential value of those areas. This value could be used in the preparation process of the national report for the UNFCCC.

With the following objective, analyzes of 30 m high resolution imagery of Landsat 7 and Landsat 8 was carried out. For identification of the forest borders using satellite imageries NDVI (Normalized Difference Vegetation Index) approach was used (see Figure 2 below). This approach uses simple graphical indicators that allows analyzes of the satellite images according to vegetation cover. The algorithm uses infrared and red spectrums in the process of the vegetation cover index calculation of the given area. The higher number between interval of (-1;1) is assigned to the denser vegetation.

The only difficulty occurred with the accuracy of the spectral analyzes of the 30 m resolution Landsat 7-8 satellite imagery. In some cases, the pixels belonging to the unvegetated rock faces were identified as forested areas due to the similarity in the spectrum of those territories. Due to the northern aspect, those areas were shaded giving darker pixel colors, confusing the algorithm.

As a result of the mentioned analyzes the forest cover change maps were created for the study area (See Appendix #4 LULC Truso). The acquired results were summarized and compared to the field survey results.

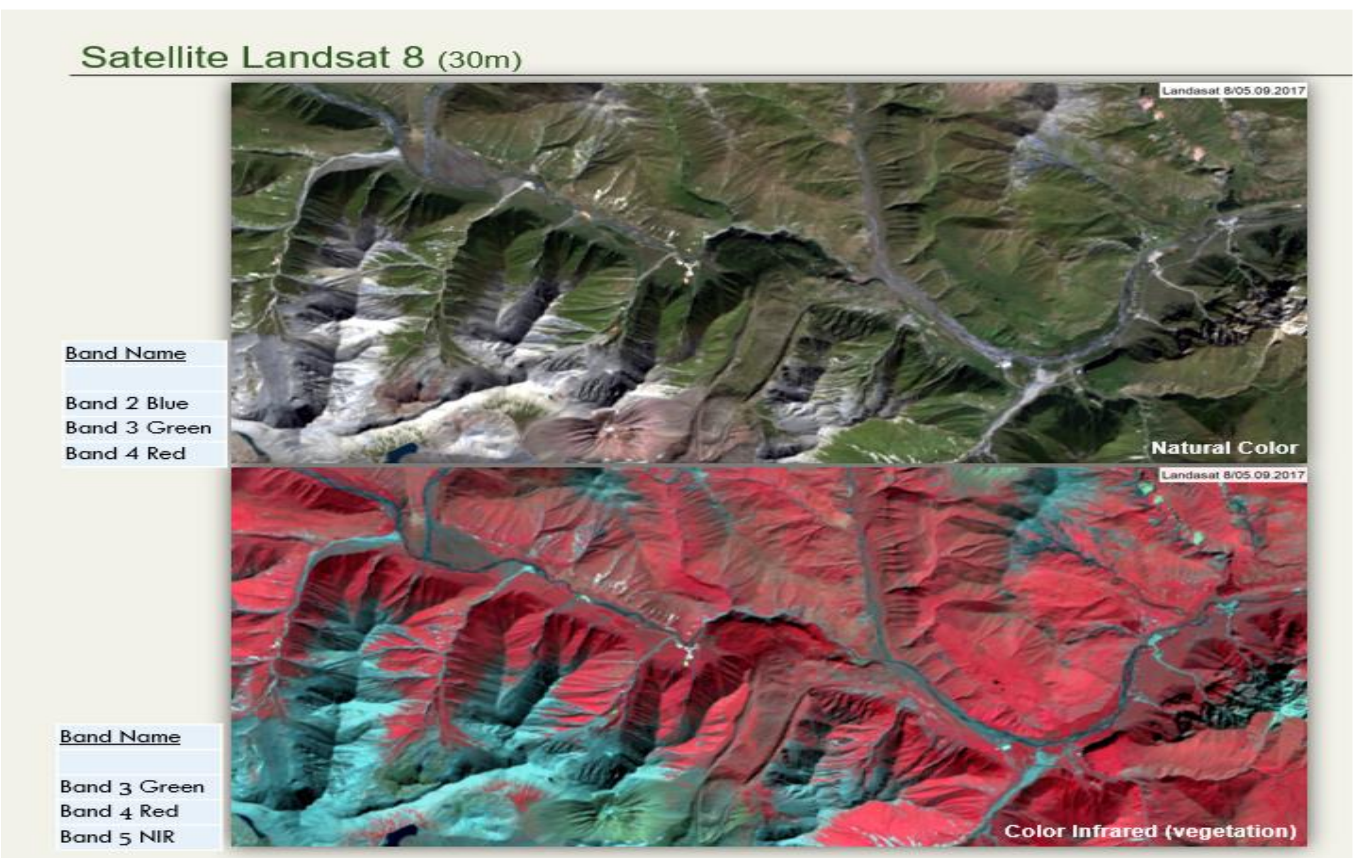


Figure 2: Initial Results of Spectral Analyzes using NDVI data

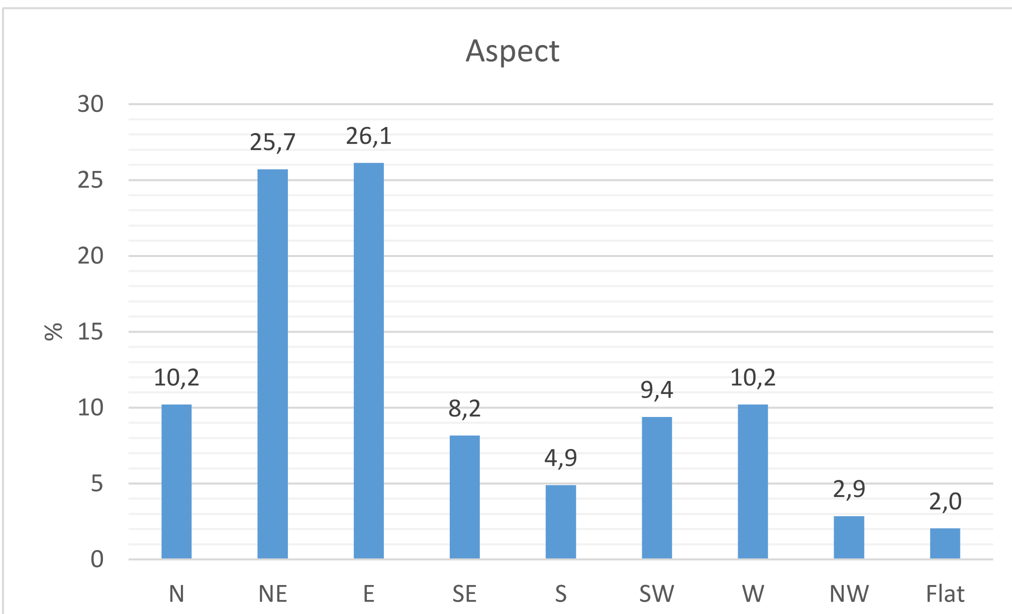
4. Treatment of the data

4.1. Statistical analyzes of the general data

Data collected from the field includes general information about the sample plots, which are altitude above sea level, aspect, slope inclination, type of terrain and the pasture (soil) condition, as well as such characteristics of the stand as are the tree origin (seed grown/sprouts), the distribution pattern (even/groups) and the density (low/medium/high) of the forest.

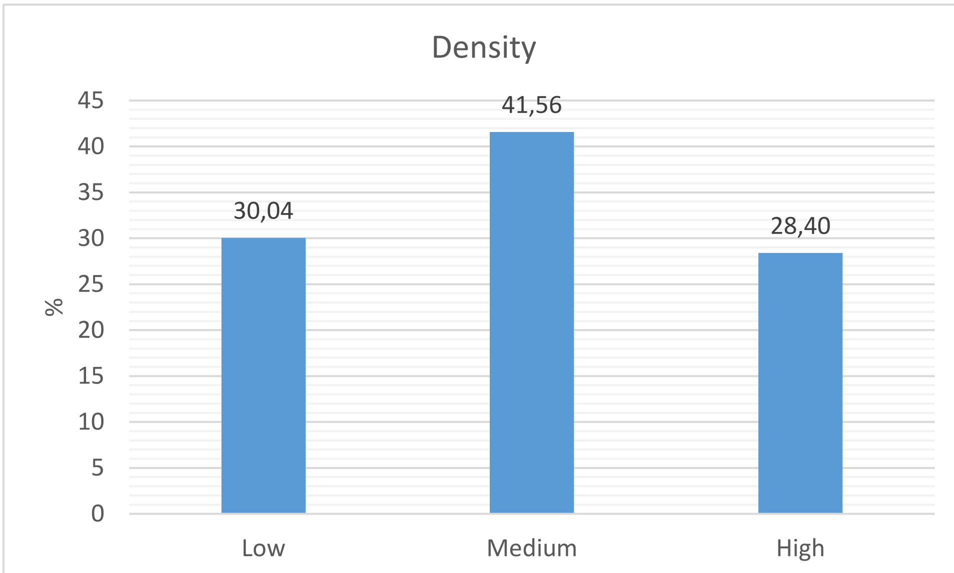
The simple statistical treatment of the gathered data from 244 sample plots gives us the following picture for the study area:

- Aspect of the sample plots:

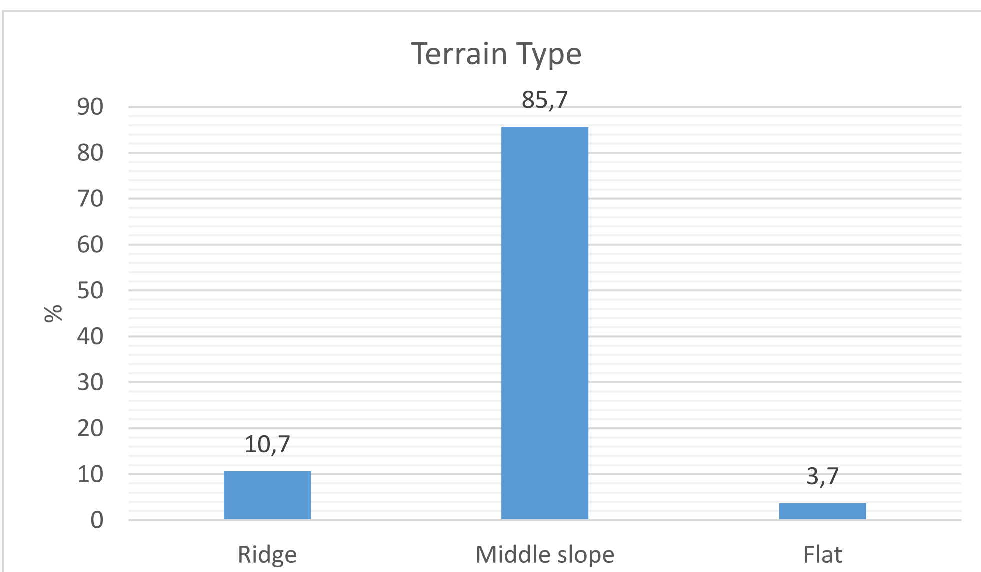


- Density of vegetation[5]:

Low – 0.1 - 0.4 *Medium* – 0.5 - 0.6 *High* – 0.7 – 1

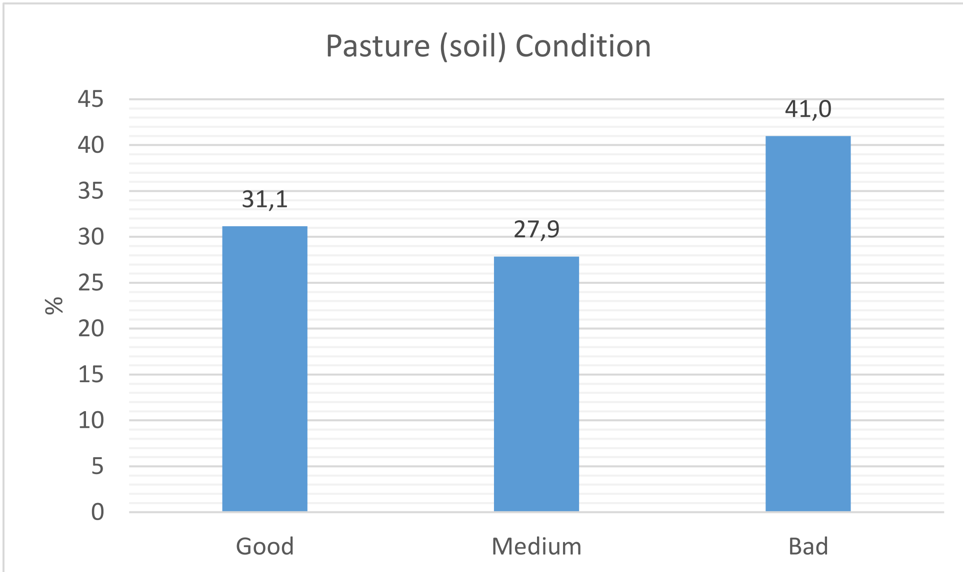


- Terrain type:

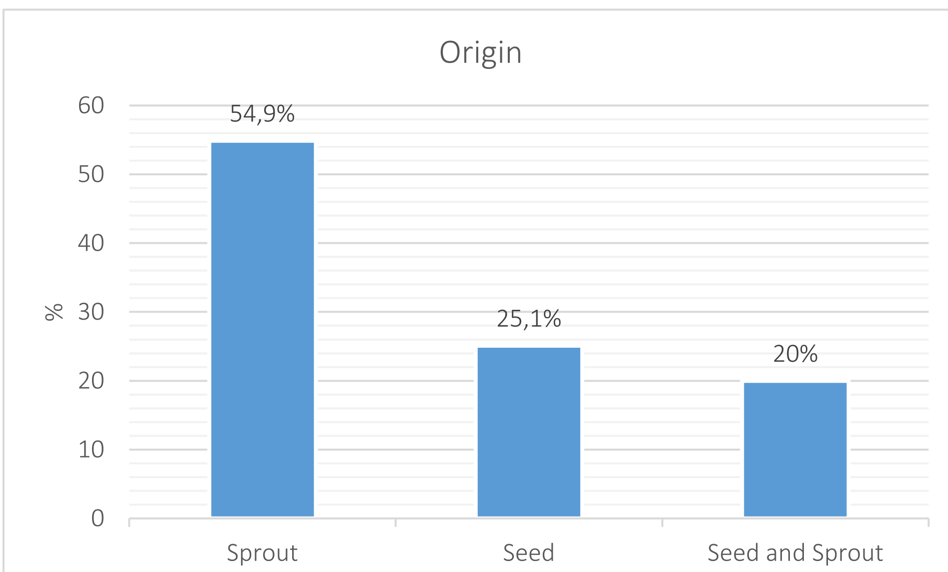


[5] Only trees with DBH>5 cm.

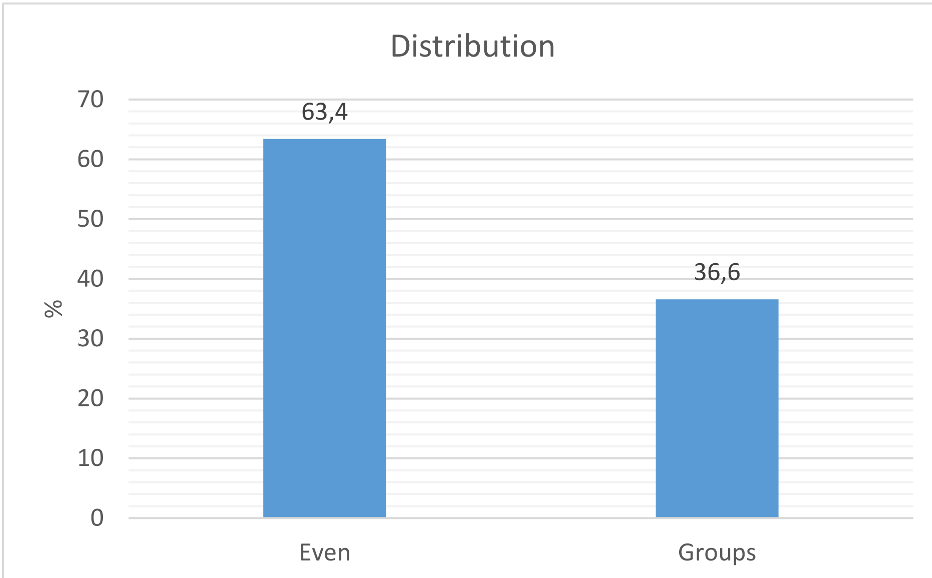
- Pasture (soil) condition:



- Origin of the vegetation:



- Distribution pattern of the vegetation:



4.2. Analyzes of tree biomass and accumulated above-ground carbon

Based on the formula and the coefficient from the selected methodology, as well as the coefficient provided by IPCC, the net biomass of each tree was calculated which was later converted to the total carbon sequestration value for each study plot and the entire survey territory. Apart from this, the carbon accumulation per area unit (Tons/Ha) was calculated. The results are shown in the Table #1 below. Also, with the acquired results the Graph #1 representing the carbon accumulation per 1 ha area in tons has been created.

ID	Total Area (ha)	Plots Total Carbon (t)	Area Total Carbon (t)	Total Carbon (t/ha)
1	34.24	11.07	276.87	8.1
2	2.93	-	-	-
3	3.83	-	-	-
4	20.96	0.36	3.62	0.2
5	14.30	0.66	6.56	0.5
6	2.03	1.66	16.58	8.2
7	0.10	0.38	3.76	37.4
8	0.68	1.01	10.11	14.8
9	2.09	-	-	-
10	1.15	1.89	18.94	16.5
11	0.75	0.93	9.25	12.3
12	0.74	1.07	10.67	14.5
13	1.32	1.52	15.19	11.5
14	0.13	0.63	6.32	48.4
15	0.08	0.21	2.09	27.5
16	4.55	6.58	65.81	14.5
17	0.82	0.16	1.58	1.9
18	1.03	1.14	11.42	11.1
20	2.21	0.20	2.00	0.9
21	3.88	0.74	7.35	1.9
22	5.46	1.61	16.11	2.9
23	3.88	2.05	20.55	5.3
24	9.60	10.87	108.72	11.3

Table 1: Accumulated carbon

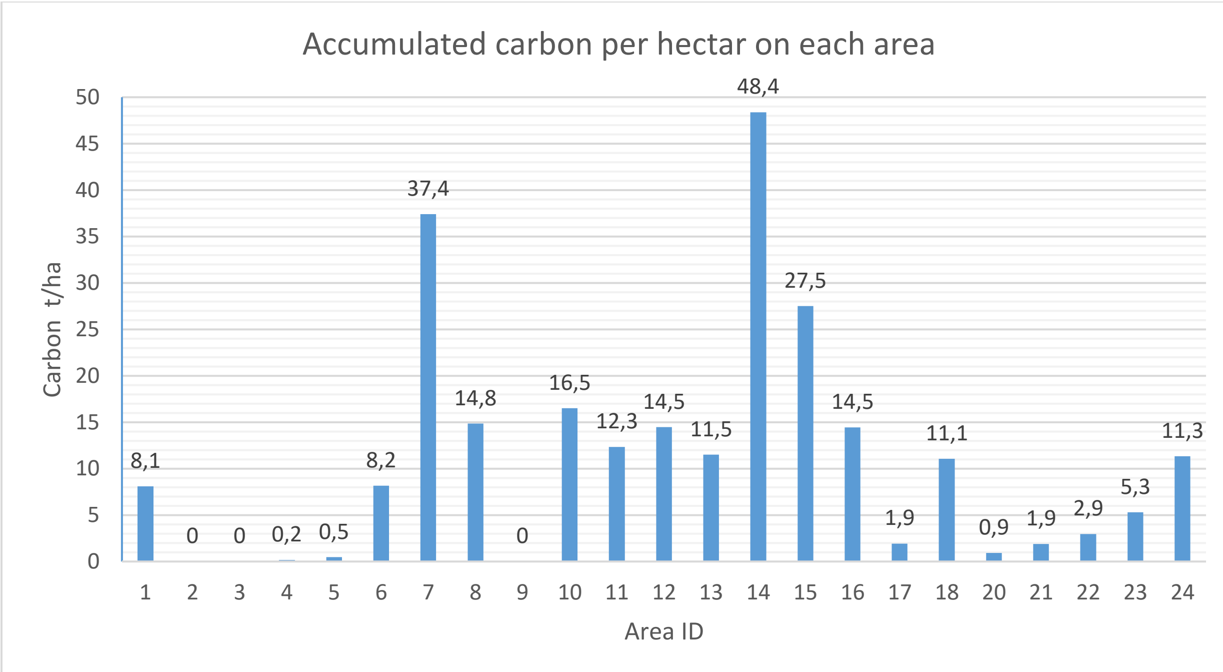


Figure 2: Carbon accumulation per hectare in tons

The given picture on the Graph #1 clearly shows three peak results for the 7th, 14th and 15th study territories. After the detailed analysis of those areas, the following method error has been detected: instead of the standardized 10% of the above-mentioned territories, 39.7%, 30.6% and 52.7% as follows were evaluated. This error was due to 10% of the total areas of those territories falling under 400 m^2 (size of the sample plot). Therefore, one plot per territory was sampled erroneously.

To make data more comparable, the homogeneous data from the three outlying areas was recalculated to represent 10%, inline with the other study areas. The results are presented in Table #2 and Graph # 2 below:

ID	Total Area (ha)	Plots Total Carbon (t)	Area Total Carbon (t)	Total Carbon (t/ha)
1	34.24	11.07	276.87	8.1
2	2.93	-	-	-
3	3.83	-	-	-
4	20.96	0.36	3.62	0.2
5	14.30	0.66	6.56	0.5
6	2.03	1.66	16.58	8.2
7	0.10	0.38	0.94	9.4
8	0.68	1.01	10.11	14.8
9	2.09	-	-	-
10	1.15	1.89	18.94	16.5
11	0.75	0.93	9.25	12.3
12	0.74	1.07	10.67	14.5
13	1.32	1.52	15.19	11.5
14	0.13	0.63	2.06	15.8
15	0.08	0.21	0.39	4.9
16	4.55	6.58	65.81	14.5
17	0.82	0.16	1.58	1.9
18	1.03	1.14	11.42	11.1
20	2.21	0.20	2.00	0.9
21	3.88	0.74	7.35	1.9
22	5.46	1.61	16.11	2.9
23	3.88	2.05	20.55	5.3
24	9.60	10.87	108.72	11.3

Table 2: Final results for Carbon Accumulation

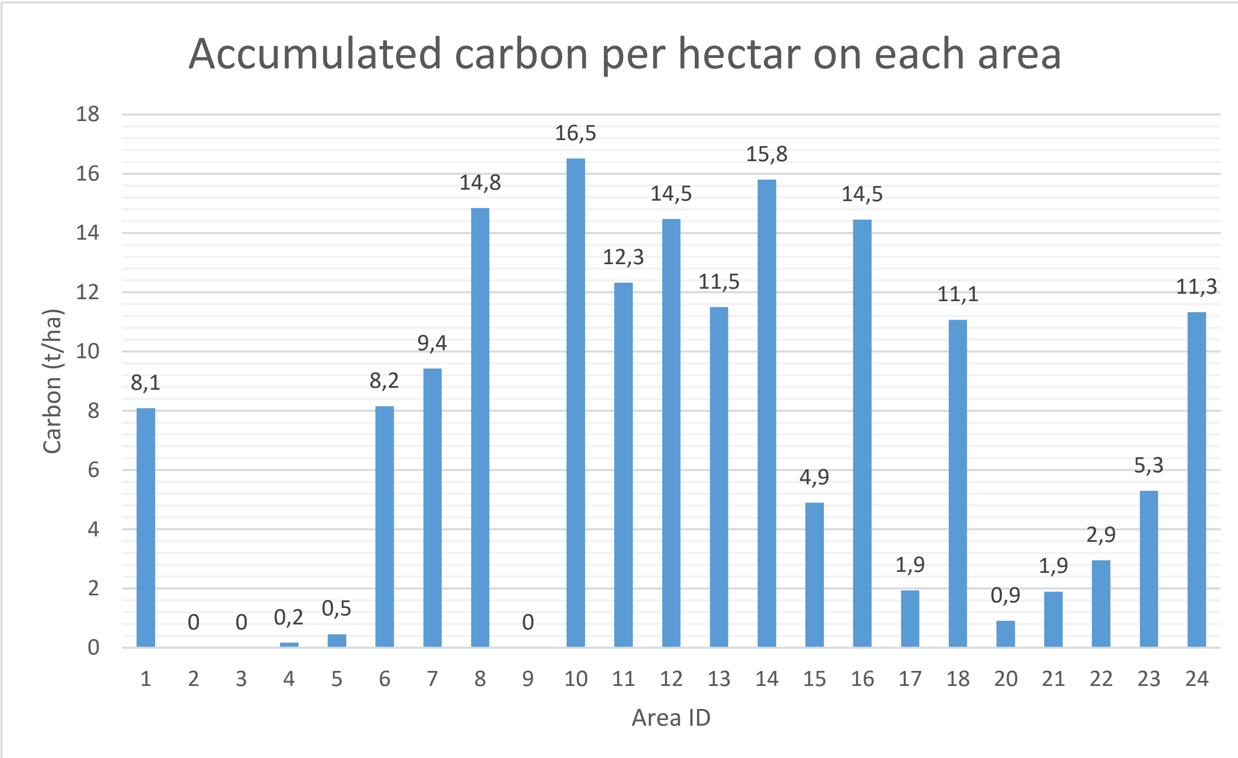


Figure 3: Carbon accumulation per hectare in tons – final

4.3. Riparian forest

It must be mentioned that two of the study territories (ID: S2 and 19) are not included in the before-mentioned calculations. The reason for this is that the following areas are in the river valley on the adjacent gravel bank of river Tergi and therefore do not represent the mountain slope forests. The majority of those areas comprise of the highly hygrophilous, wetland areas and are typically represented by the Sea Buckthorn thickets (*Hippophae rhamnoides* L.). Due to these circumstances those areas were excluded from the general analyzes. As well as, in contrast to the other study areas, not 10%, but the entire territories were surveyed and sampled.

Those hygrophilous territories have characteristic low density of the woody species of our interest (birch and willows). Additionally, the groups of Sea buckthorn scrubs are not present on the satellite images acquired from 2001. This must mean that those formations are relatively recent. As mentioned earlier, due to the thorny habit and thick growth of buckthorn scrubs, the data was impossible to gather from those areas.

From analyzes of the gathered data taken from S2 study site (total area of 0.13 Ha) the accumulated carbon amounted to 2.09 T/Ha. Such a low number is a result of absence of the right conditions for the growth of the species of our interest, the majority of the woody species were Sea buckthorn.

5. Results

The results achieved from the study are:

1. On the study territories the area of the forested lands have increased, more specifically, the border of forest is lowering in altitude. In 2001 the total area of the forest cover was represented on 1277 ha. After the natural forest increase the current forest area has increased by 118 ha which comprises 9.24% of the total. The territories of active forestation are happening on the former pasture lands.

2. The carbon sequestration at the naturally regenerated forests amounts to 613.52 ton in total (on 118 ha) and 8.3 tons/ha on average.

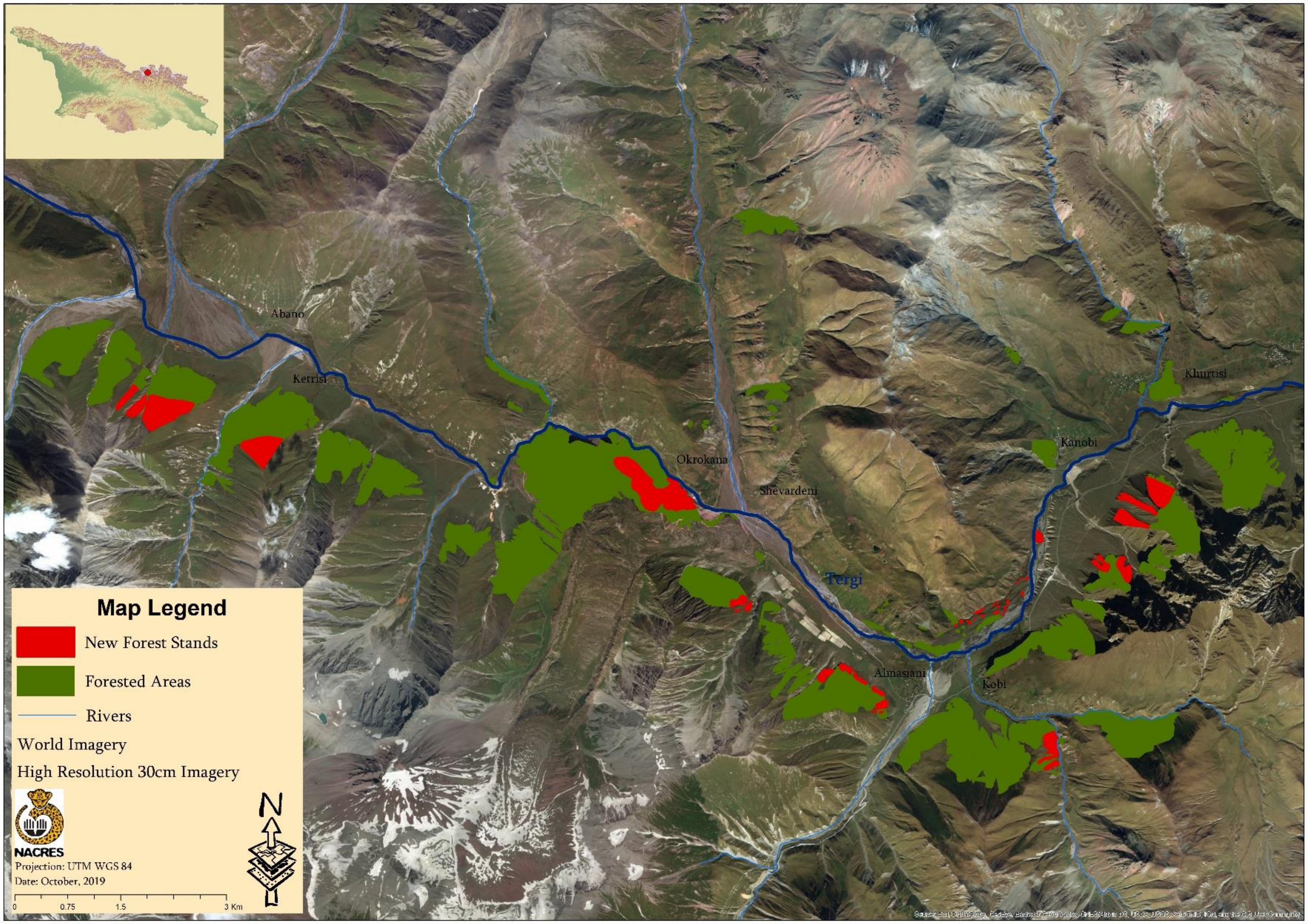
3. The majority of tree species represented on the territories (DBH>5cm) were birch (Betula litwinowii Doluch.) with 91.8% part, followed by Goat willow (Salix caprea L.) - 7.2%, willow (Salix sp.) – 0.8% and Scots pine (Pinus sylvestris Lour.) - 0.2%.

4. The comparison between the ground survey data and the satellite imagery data analyzes (NDVI) of 30 m resolution Landsat 7-8 imagery showed highly corresponding results. Therefore, it is possible to use Forest Atlas and free satellite data for conducting similar surveys in other regions. However, for increased accuracy, it is necessary to combine the two methods – field works and satellite imagery analyzes.

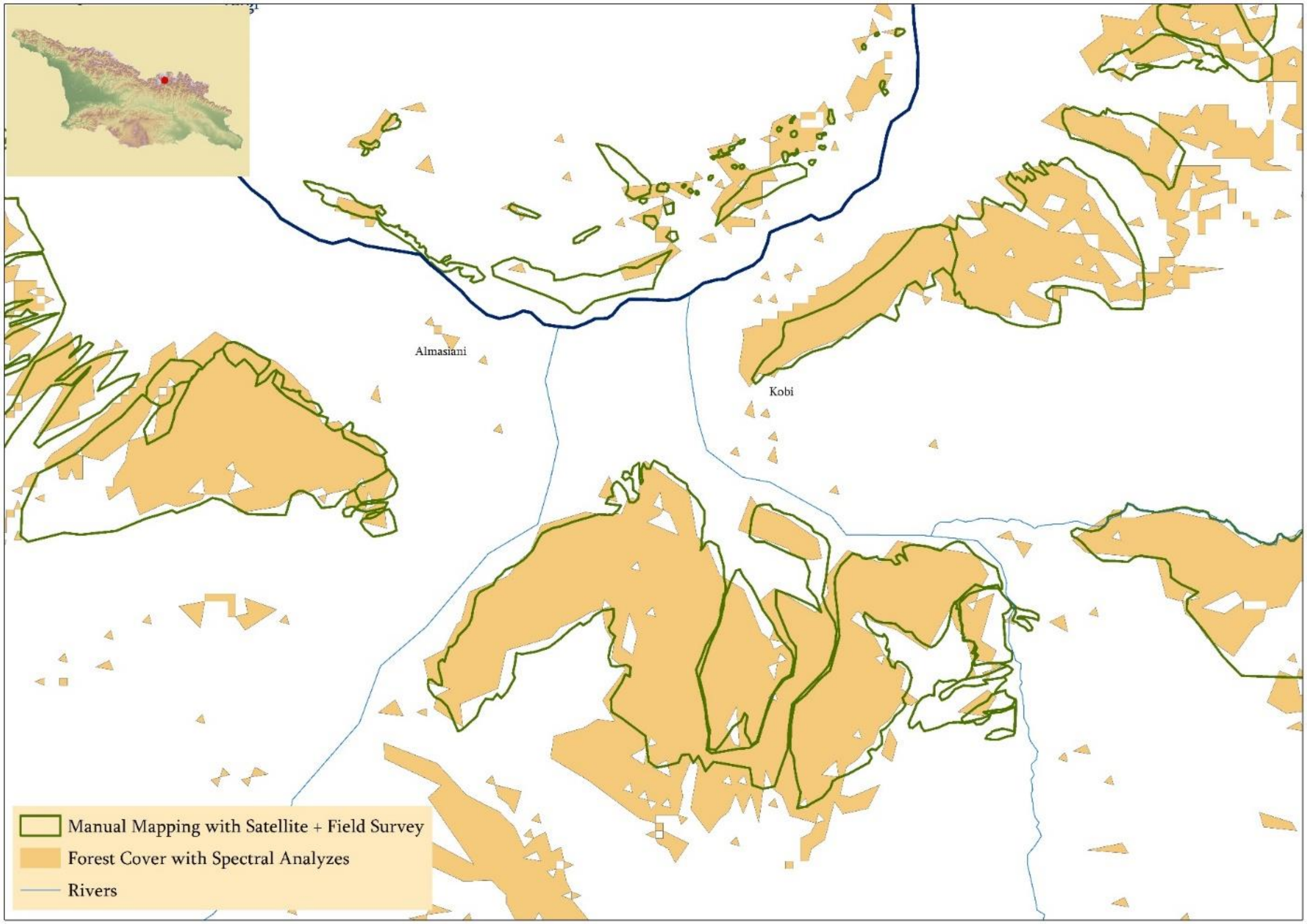
5. Satellite imagery analysis will allow us to identify abandoned pastures at relatively low cost and less human resources, where later carbon sequestration potential can be studied.

Appendix

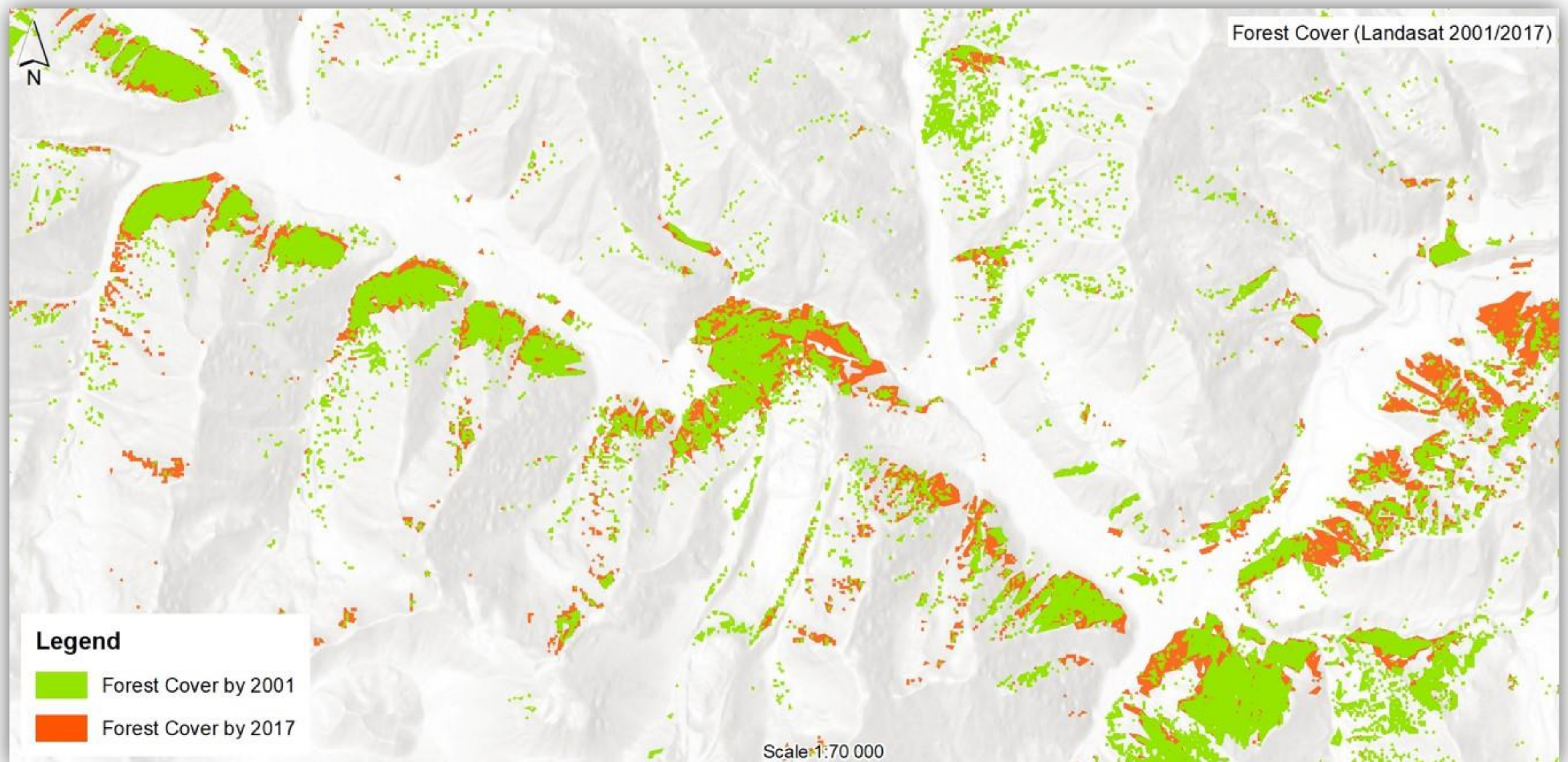
#1 Forests of the Truso valley


Map Legend
New Forest Stands
Forested Areas
Rivers
World Imagery
High Resolution 30cm Imagery
NACRES
Projection: UTM WGS 84
Date: October, 2019
0
0.75
1.5
3 Km
N
Abano
Ketrisi
Okrokana
Shevardeni
Tergi
Almasiani
Kobi
Kanobi
Khurtisi

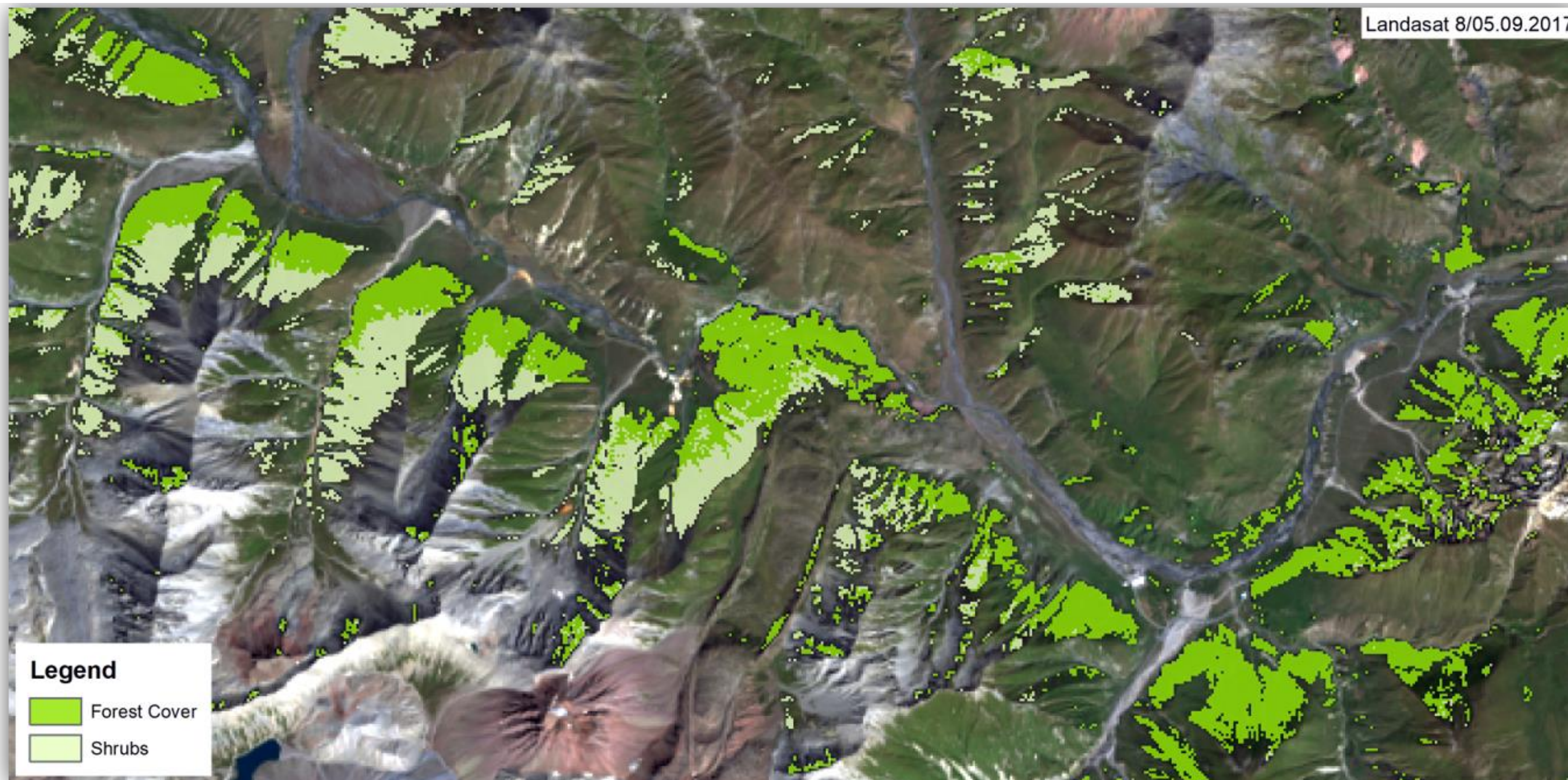
#2 COMPARISON OF MANUAL (SATELLITE IMAGERY) AND SPECTRAL ANALYZES RESULTS OF THE FOREST COVER



#3 Forest Cover Comparison Between 2001 and 2017 Years



#4 LULC of Truso Valley #5 Branches of the Tree Species Occurring at the Study Area



#5 BRANCHES OF THE TREE SPECIES OCCURRING AT THE STUDY AREA