Georgia: Pilot Programme to Deliver a Carbon Neutral and Sustainable Hydropower Project

Project number: C30272/AUS1-2014-08-04

Interim Report

FS Consult

Envi Consulting LLC

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1. INTRODUCTION

1.1. Project cornerstones

The overall objective of the project is to develop a readily implementable plan for a reforestation project in Dariali hydropower plant catchment area.

The presented Interim Report according to the Inception Report for the project serves the purpose to present the results of Project Phase 1 - Analysis and Options Phase and to be the basis for Phase 2 - Discussion and strategic decision phase, including a stakeholder meeting. The Draft Feasibility Report is structured according to work packages (WP) and includes results of WP 1.1, WP 1.2, WP 1.3, WP 1.4 and WP 2.1.

To fulfil the objectives as stated in the Inception Report for the project the following project partners (P1-P2), subcontractors, and experts are contributing to the project work:

P1: FS Consult

- Otto Glaser (Austria; project management (administration, forestry expert)
    - **Subcontractor 1: Peter Herbst**
        - Peter Herbst (Austria; socio economist)
    - **Subcontractor 2: Institute of Silviculture, University of Natural Resources and Life Sciences [BOKU], Austria, Team Eduard Hochbichler [Subcontractor]**
        - Eduard Hochbichler (Austria; forestry carbon management**;** team leader, project manager (forest management), key contact**]**
        - Elisabeth Pötzelsberger (Austria; mountain forestry; field surveys and analysis; assistance for project management)
        - Roland Koeck (Austria; socio-ecological silviculture, erosion control specialist)
    - **Subcontractor 3: Posch&Partner**
        - Giorgi Kuprashvili (Georgia; GIS specialist)

P2: Envi Consulting LLC

- Mariam Kimeridze (Georgia; Caucasus/Georgia terrestrial biodiversity specialist)
- Sofia Roinishvili (Georgia; legal and institutional regulatory advisor)
- Ivane Tarasashivili (Georgia; local forestry expert)
- Maia Akhalkatsi (Georgia, ecology and botany expert)
- David Chelidze (Georgia, botany expert)

1.2. General characteristics of the Kazbegi district area

1.2.1. Kazbegi district

Kazbegi district is located in the northern part of Eastern Georgia of the Mtskheta-Tianeti province which also includes the districts of Akhalgori, Dusheti, Tianeti and Mtskheta, comprising a total of 6,786.2 km^2. The territory of Kazbegi district by historical name "Khevi" covers 1,081.7 km^2, or 15.9 % of the total area of the province and 1.55 % of the area of Georgia.

1.2.2. Geomorphology

Kazbegi is one of the highest districts in Georgia, with an average terrain altitude of 2,850 m.a.s.l. Rivers form a deeply dissected topographic surface. The lowest point, 1,210 m.a.s.l., is located in the Daryal Gorge, and the highest ice peak is Mount Kazbegi at 5,033 m.a.s.l. Relative ground elevations of the area vary from 400-450 m on the section from Kobi to the Cross Pass, to as high as 3,300-3,500 m on the Daryal-Kazbegi section. The main morphometric and morphological elements of the Kazbegi district relief mainly originate from interaction of tectonic, erosive and accumulation processes. The general background of the tectonogenic-erosive relief is complicated by forms of glacial, volcanic, gravitational, karst, humogenic and other origins. Due to the high relative altitude amplitudes and steep slopes relief energy is very high, causing an extremely high potential and danger of avalanches, rock- and landslides.

1.2.3. Geology

Grey granitoids of the Paleozoic age are the oldest in the geology of Kazbegi district, and are exposed by erosion in the vicinity of the Daryal and Gveleti Rivers. Jurassic sediments are most widespread. The Quaternary period is represented by volcanic lavas, glacial alluvial, prolluvial and colluvial sediments. Kazbegi district has complex tectonics: tectonic units are separated by faults or thrusts. Against the overall rise, the contemporary relief has a different movement. A high rate of rising (10-15 mm per year) is typical for lateral and major divides.

1.2.4. Soils

The geographic location of Kazbegi district, the diversity of relief, geology, vegetation and climate altogether determine the soil characteristics there. The soils of Kazbegi district generally belong to the type of mountain-forest grey impoverished grey and mountain-meadow soils. The following types and subtypes of soils are spread in the Kazbegi district area:

1. Delluvial-prolluvial soils;
2. Mountain-forest grey, medium-depth and shallow skeletal soils, occasionally with stones and boulders;
3. Mountain-forest light-grey, medium-depth and shallow skeletal soils, with stones and boulders;
4. Poor, medium-depth and shallow skeletal soils;
5. Poor forest and secondary meadow soils;
6. Mountain-meadow grassland-skeletal soils;
7. Weakly developed primitive soils, occasionally with exposed rock;
8. Eroded and semi-eroded shallow skeletal soils;

9. Strongly eroded areas, ravines, exposed rocks, stone fills, rockslips and bedrock outcrops.

1.2.5. **Mineral resources**

Ore metals are represented by copper, pyrite, chalcopyrite, pyrotine, sphalerite, and galena. Andesite is also mined in the Kazbegi district. For building materials gravel and sand are exploited only for local use within the district of Kazbegi. Some decorative rock materials such as dolerite are also exploited in Kazbegi district. Kazbegi district is very rich in mineral waters, which are found almost everywhere in the area and often come to surface naturally. Carbon dioxide is intended to be exploited in the near future from subsurface sources.

1.2.6. **Climate**

The high hypsometry of the Kazbegi district relief, complex morphological conditions and positioning on the northern macroslope of the Greater Caucasus are the lead factors that determine vertical climate zoning.

(a) **The zone up to 1900 m.a.s.l.** has moderately humid climate with rather dry cold winter and long summer. In the coldest months (December, January), the mean air temperature varies between -3^0C and -6^0C, the absolute minimum temperature being -28^0C. In the warmest months (July, August), the mean air temperature is 14-18^{0}C, the absolute maximum temperature being 31^{0}C. The mean annual air temperature is 4.7^{0}C. The stable snow cover remains for 3-5 months, the average snow depth being 20-40 cm. The mean air humidity in summer (70-75 %) is almost twice as much as in winter. The precipitation in summer is 90-100 mm; the precipitation is the highest in May (100-120 mm), and the smallest in December (20-25 mm). Northern and southern winds prevail. Strong northern winds are recorded in February and March, and southern winds mainly occur in August.

(b) **In the zone between 1900 to 2600 m a.s.l** the climate is moderately humid, with rather dry, cold winter and short summer. In the warmest months (July, August), the mean air temperature is 10-14^{0}C, the absolute maximum temperature being 30^{0}C. In the coldest month (January), the mean air temperature varies is -11^0C, the absolute minimum temperature being -30^0C. The stable snow cover remains for 5-7 months. Mean annual precipitation is 1,000-1,200 mm.

(c) **In the zone between 2600 and 3400 m.a.s.l.** the climate is moderately humid, with actually no real summer. Alpine and subnival zones are represented there. The mean temperature in January-February is -14^0C. The snow cover remains for 7-8 months, the snow depth exceeding 2 meters. In depressions, snow remains throughout the year. Strong west-to-east winds prevail. In July and August, the mean air temperature does not exceed 10^{0}C. At the elevation of about 2,000 m.a.s.l. it frequently snows, with night and morning frosts. Frequent and fast changes in weather are typical for the zone.

(d) **Above 3400 m.a.s.l.** the climate is moderately humid, with permanent snow cover and glaciers. There are two natural zones at that altitude: the nival zone (3,400-4,300 m), and the glacial zone (above 4,300 m). The number of days with precipitation is 170 days per year. In the glacial zone, the precipitation is always snow. In the nival zone, the mean air temperature is –100C in winter, the absolute minimum temperature being -33^{0}C; and in 2.2^{0}C in summer, the absolute maximum being 15^{0}C. The average annual wind speed is 6.2

m/s. Storms at a speed of 20-25 m/s are frequent; in winter the average number of windy days is 12 days.

1.2.7. **Glaciers**

The Kazbegi massif is the major area of glaciers in Kazbegi district. Separate glaciers are found on peaks of the main divide that exceed 3,800 m.a.s.l. – the Khde Gorde at the Kuro and Shavana ridges. According to data from the most recent studies, there are 99 glaciers in the Terek catchment, with a total area of 67.2 km^2. The glacier of Devdoraki, with an area of 7.55 km^2 and a length of 7 km. The most serious recent collapse blocked the Terek River, stopping the flow there for 8 hours. In the recent 150 years the glaciers in Kazbegi district have moved back: ice streams (glacier tongues) have shortened by 1-1.5 km, and small glaciers located high in the mountains have shortened by 0.3-0.5 km. Some minor glaciers have completely disappeared. In the last 100 years the total area under the glaciers has decreased by 21.8 km^2.

1.2.8. **Rivers**

The Tergi is the main river in the hydrographic system of Kazbegi district, originating from a glacier located at 3,200 m above sea level and exiting the territory of Georgia in the Daryal Ravine, at 1,200 m.a.s.l. Left tributaries of the Tergi River, including the Amali, Chkheri, Mna, Suatisi, Devdoraki and others, flow on the slopes of the massif, whereas its right tributaries: Tnostskali, Kistaura or Khdestskali, Bidara and others run on the main and lateral watersheds of the Caucasus Ridge. There are a total of 48 rivers and numerous small streams in Kazbegi district. These are mainly Mountain Rivers with typical high difference in the riverbed elevations and fast velocity of flow. The rivers form rather high waterfalls. The Amali, Chkheri and Kistaura are the fastest rivers; and the Terek and Snostskali are the widest ones. The rivers of Kazbegi district are not deep: the depth of the Tergi exceeds 1.5 meters, of the Snostskali 1 m, of Chkheri and Bidara 0.5 m and of Devdoraki and Kistaura 0.4 m. The rivers of the Tergi basin feed from melting water (18 %), melting snow (29 %), rainfall (13 %) and underground waters (40 %).

1.2.9. **Lakes**

There are many lakes in Kazbegi district, all of them very small. The lakes are found in the volcanic and glacial relief. A mineral lake in the Truso gorge, near the village of Abano, is of particular interest: a spring with carbonic acid water originating from carbonate rock forms a small lake that produces small 10-15 cm high fountains and causes the impression of „boiling" water. There are four small lakes at 3,832 m.a.s.l. in the Truso gorge, with a total area of about 1 ha.

1.2.10. **Landscapes**

The following main landscapes are represented in Kazbegi district:

1. Canyon-like gorges with rocky and collapsed vegetation, eroded soils;
2. Medium-high mountains with covered with aspen and beech, with forest light-gray soils;
3. Mountain-valley landscape with forest-meadow (floodplain) vegetation and alluvial soils;
4. Subalpine birch sparse and crooked forests, shrubs, high grass, mountain-forest soils;
5. Alpine meadows and alpine mats with mountain-meadow soils;

6. Subnival landscapes with weakly developed soil and vegetation cover;
7. Nival-glacial landscape – the kingdom of permafrost and glaciers. With moss and separate flowering plants.

1.2.11. **Fauna**

The fauna of Kazbegi district calls for attention because of some rare and endemic species inhabit the area and the main migration routes of certain migratory birds pass through the district.

(a) **Amphibians** populating the subalpine and alpine zones include the Caucasian frog (*Rana macrocnemis*) and green toad (*Bufo viridis*). Puddles even in villages are full of these species in their spring mating time. The Caucasian rock lizard is the most widespread species of the **reptiles**, found at the highest altitude among the rock lizards of Georgia. Common water snake (*Natrix natrix*) is found on the banks of small rivers. There is also a poisonous snake species (*Vipera dinnikii*) populating the area.

(b) **Birds:** Bird species found in the vicinity of Terek river include *Motacilla cinerea*, yellow wagtail (*Motacilla flava*), chaffinch (*Fringilla* spp.), *Aegithalos caudatus*, crested lark (*Galerida cristata*), rock swallow (*Ptyonoprogne rupestris*), gray shrike, water thrush, nightingale, and others; Among birds populating floodplain forests, most widespread species include chaffinch, *Aegithalos caudatus*, *Parus major*, common magpie, Crag Martin, Caucasian shrike, hoopoe (*Upupa epops*), turtle-dove (*Streptopelia*), wild pigeon (*Columba livia*), and others; Migratory birds include common heron (*Ardea cinerea*), great white heron (*Egretta alba*), demoiselle crane (*Anthropoides virgo*), common crane (*Grus grus*), common snipe (*Gallinago gallinago*), Caracias garrulous, bee-eater (*Merops apiaster*), and others.

(c) **Mammalian fauna**: The *Insectivores* are represented by Colchic mole (a Caucasus endemic species) that is found in small quantities in Truso gorge, in the proximity of Gudauri and the Cross Pass, also by common shrew (*Sorex araneus*), small shrew (*Sorex minutus L.*) is occurring as high as at 3,200 m.a.s.l., long-tailed shrew, white-toothed shrew (found in forests up to 2,200 m.a.s.l.), and others.

There are numerous species of rodents, including the Caucasus birch mouse (*Sicista caucasica*), the Kazbegi birch mouse (*Sicista kazbegica*), the field mouse (*Apodemus spp.*), migratory hamster (*Cricetulus migratorius*), water vole (*Arvicola terrestris*), common vole (*Microtus arvalis*) and bush vole, snow mouse (*Microtus nivalis*), hare, and common squirrel (*Sciurus vulgaris*). The squirrel acclimatized in the area of the Klukhori Pass and widely spread in different areas of the Caucasus, including Kazbegi district, in 1960, which resulted in a sharp reduction of the Caucasus squirrel (*Sciurus anomalus*) range. Today the species is a rare one. Thus, there are a lot of rare and critically endangered species of mammals in the area of Kazbegi district; these primarily include the Caucasus birch mouse (*Sicista caucasica*), the Kazgebi birch mouse (*Sicista kazbegica*), the Gudauri vole, Prometheus' mouse (*Prometheomys* spp.), snow mouse (*Microtus nivalis*), Transcaucasian hamster (*Cricetus* spp.), and others.

In Kazbegi district the following predators' occur: badger (*Meles meles*), forest marten (*Martes martes*), stone marten (*Martes foina*), weasel (*Mustela nivalis*), brown bear (*Ursus arctos*), wolf (*Canis lupus*), fox (*Vulpes vulpes*), wild cat (*Felis sylvestris*) and the red-listed lynx (*Lynx lynx*).

Among artiodactyls, Kazbegi district is a home to the chamois *(Rupicapra rupicapra),* which is a critically endangered species in the Caucasus, and the East Caucasian Tur *(Capra cylindricornis)*, a Caucasus endemic species found nowhere else but in the Caucasus. *Rupicapra rupicapra* and *Capra cylindricornis* have different habitats, e.g. the left slope of the Truso gorge is populated by the chamois, and the right one – by the tur. The East Caucasian tur populates the Khde, Shino, Kuro, Daryal and Truso gorges, also glacier slopes and other places. It is found in subalpine, alpine, subnival and nival zones.

The forest zone is populated by the Caucasus jay, chaffinch, black redstart (*Phoenicurus ochruros*), *Prunela*, goldfinch, falcon, goshawk, kite, and others;

Species found in the subalpine and alpine zones include mountain pipit, meadow pipit, *Erythrina* sp., Caucasian snowcock (*Tetraogalus caspius*), crow (*Corvus corvus*), kite, griffon (*Gyps fulvus*), golden eagle *(Aquila chrysaetos)*, lammergeyer *(Gypaetus barbatus)*, and others; The large raptor species and their nesting and resting niches in steep rock faces can easily be watched, e.g. along the Georgian military road north of Stephantsminda.

1.2.12. Flora and Vegetation

The flora of the Kazbegi District contains ca. 1,100 species of vascular plants. The following vegetation zones are represented in the region: middle-mountain (1,200–1,500 m.a.s.l.), upper- mountain (1,500–1,750 m.a.s.l.), subalpine (1,750–2,500 m.a.s.l.), alpine (2,500–3,000 m.a.s.l.), subnival (3,000–3,600 m.a.s.l.), and nival (above 3600 m.a.s.l.). Alpine rivers and the herbaceous vegetation in the Dariali Gorge is at the altitude up to 1200-1700 meters and subalpine birch forest (*Betula litwinowii*) is mainly represented on Mountans near this gorge by founded only on north-facing slopes till 2,550 m and subalpine shrubbery located on higher elevations 2,100-2,900 m with *Rhododendron caucasicum*, Vaccinium *myrtillus, Empetrum caucasicum*, etc.,. The secondary shrubbery and subalpine meadows are located in degraded birch forest areas on the same north slopes. The southern slopes of the rocky ridges are held by pine (*Pinus kochiana)* forest habitat. The rocky scrubs are mainly represented by juniper (*Juniper communis* var. *depressa, J. sabina*).

The vegetation in Kazbegi District is represented by the following habitats (sensitive habitats are marked with asterisk [*]):

1. 3220 Alpine rivers and the herbaceous vegetation along their banks
2. 4060 Alpine and boreal heaths
3. 50GE1 mountain xerophytic scrubs
4. 50GE3 Tragacanthic scrub
5. 61GE01 Sub-alpine high herbaceous vegetation
6. 61GE02 Sub-alpine meadows
7. 6150 Siliceous alpine and boreal grasslands
8. 62GE04 Vegetation of urban and rural areas
9. 62GE05 Vegetation of pastures
10. 70GE02* Low grass marshes
11. 8110 Siliceous scree of the montane to snow levels

12. 8220 Siliceous rocky slopes with chasmophytic vegetation
13. 8310* Caves
14. 8340* Rock and true glaciers
15. 91PK-GE Caucasian Pine forest (*Pinus kochiana*)
16. 9BF-GE* Subalpine birch krummholz (*Betula litwinowii*)

The Dariali Hydropower Plant Territory and Compensation Sites ((Natural monument of Abano Mineral Lake, Natural Monument of Trusso Travertines, Natural Monument of Sakhiznari Cliffs)) are covered with subalpine and alpine meadows.

The subalpine meadows are represented by the following sub-types of habitat (Code 61GE02-01):

1. Grass meadows (Bromopsieto) with the dominant species: *Bromopsis variegata*, *Agrostis tenuis, A. planifolia.* This community holds both dry and moist habitats. Appropriate species of the community are *Trifolium ambiguum, Lotus caucasicus, Alchemilla sericata,* etc*.* It is distributed up to the altitude of 2700 meters a.s.l. It is used for mowing*.*
2. *Agrostieta* meadows with the dominant species – *Agrostis tenuis, A.planifolia.* This community holds moist river banks.
3. Festuca ovina meadows which hold the southern slope. Characteristic species are: Koeleria albovii, Bromopsis riparia, Agrostis tenuis, Carex buschiorum, Pulsatilla violacea, Thymus collinus.
4. Fescue-grass *(Festuca varia)* contains many grass and herbaceous species and represents the grass forbs community.

The sub-types of alpine meadow habitats (Code 6150-01):

Festuceta ovinae
Festuceta supinae
Nardeta strictae
Festuceta supinae + Carex meinshauseniana
Kobresieta humilis

6150-02. Alpine snowbed (Code 6150-02)

Alpine snowbeds can be found in plain places between large stone sand moraines at the upper border of the alpine zone, where snow melt is late and vegetation is late. It consists of the following grasses: *Poa alpina, Phleum alpinum, Festuca supina,* etc. and herbaceous species: *Campanula biebersteiniana, Carum caucasicum, Veronica gentianoides, Gnaphalium supinum, Pedicularis crassirostris, P.armena, Poa alpina, Taraxacum stevenii, Sibbaldi asemiglabra*, etc.

2. REVIEW OF LEGAL AND INSTITUTIONAL FRAMEWORK OF FORESTED AREAS AND LAND-USE/OWNERSHIP IN GEORGIA

2.1. Laws and codes applicable to a reforestation programme

Forest Code of Georgia

The main law providing regulations for forestry activities, including reforestation is the Forest Code of Georgia adopted in 1999. The forest under the code is determined as a part of geographical landscape, comprising trees attributed to forest by Georgian legislation, land under these trees, as well as shrubs, grass, animals, and other components biologically linked in the process of their development, affecting each other and the environment. Further to the mentioned definition and other regulations of the Forest Code of Georgia, forest is an area with geographically identified borders. In accordance with the Law on Public Registry, the Forest Fund borders and lands attributed to the Forest Fund are subject to registration in the Public Registry as Forest Fund lands and Forest Fund borders.

Under the Forest Code, the following is attributed to the area(s) identified as forest:

- Forest Fund of Georgia – integrity of forests and their resources owned by the State Forest Fund;
- State Forest Fund – integrity of state owned forests in Georgia and lands and resources attributed to the state owned forests;
- Local (Municipality) Forest Fund – part of the commercial State Forest Fund, subject to regulation by the local municipalities.

Definition of reforestation is provided under Article 95, Paragraph 1 of the Forest Code of Georgia, stating that reforestation is a multi-year cycle of activities, carried out with the purpose of restoration and afforestation of the bare land plots under the Forest Fund or the open stands of the Forest Fund. Reforestation on the lands of the State Forest Fund is planned annually based on the availability of resources, existing forest management plans, and research data by the National Forestry Agency and the Agency of the Protected Areas.

In accordance with Article 95, Paragraph 4 of the Forest Code of Georgia, measures of reforestations include:

- thinning or removing underbrush with the purpose of stimulating natural regeneration of forests, also carrying out tending, protecting, cleaning, planting, and sowing in the forests, forest edges, and subalpine open woodlands;
- improving species composition, age structure, quality, productivity, protecting capacity and other values of the forests.

In accordance with its defined scope, the Forest Code of Georgia does not consider any regulation on afforestation of areas that are not within the borders of the Forest Fund of Georgia.

2. Review of the legal and institutional framework of forested areas and land-use/ownership in Georgia

It should be taken into consideration that the Forest Code just like any other laws of the Republic of Georgia do not provide any administrative or procedural mechanisms for approval of afforestation of areas that are not within the geographically established borders of the Forest Fund.

Law on Management of the Forest Fund

The Law on Management of the Forest Fund adopted in 2010 provides grounds for competence, authorities and liabilities of the National Forestry Agency. Under Article 5, Paragraph 1(a) tending the forest and reforestation are objects of the National Forestry Agency.

Code of Local Self Government

Under Article 24, Paragraph 1 of the Code of Local Self Government adopted in 2014, local municipalities are authorized to establish rules on management of resources of the forests that are in ownership of that municipalities.

The Law on State Property

The Law on State Property was adopted in 2010. Under Article 4, Paragraph 1(e) the state forest fund shall not be subject to privatization, unless this is a territory within administrative borders of local settlement. Privatization of state forest areas within administrative borders of the local settlement is allowed only in case it is a land formerly owned by collective farms (kolkhoz) and soviet farms.

Laws on Protected Areas

Main laws regulating management of the protected areas are the Law on System of Protected Areas adopted 1996 and Law on Status of Protected areas adopted in 2007. As mentioned above, reforestation on the land plots of the State Forest Fund is to be planned by Agency of Protected Areas if a relevant land plot is within the borders of a protected area.

Under the Law on System of Protected Areas, the following territories are deemed to be protected:

- State reserve – a territory established for preserving the nature, natural process and genetic resources in a dynamic and untouched state;
- National park – a territory established for the protection of nationally or internationally important, relatively large and distinctive by their natural charms ecosystems, preservation of living environment, conducting of scientific and research, educational and recreational activities.
- Natural monument – a territory established for the protection of natural/cultural formations of national importance, relatively less unique natural territories and rare natural formations.
- Prohibited area – a territory established for the protection of those natural conditions, which are necessary for the preservation of living organisms of national importance, wild species, groups of species, biocenoses, and formations of inorganic nature and, which require special restoration and caring efforts on the part of a human.
- Protected landscape – a territory established for the protection of nationally important, aesthetically distinctive, natural landscapes, or those of natural/cultural character,

established as a result of harmonious correlation of nature and a human; as well as to protect living nature and to conduct recreational/tourist and traditional economic activities.

- Territory of multi-purpose use – a territory established in conformity with environmental needs and to conduct economic activities oriented to the exploitation of natural resources.
- Biosphere reserve – a territory established for the protection of the nature, natural resources and biological diversity in their dynamic and self-regulated status; to preserve a living environment; to implement global monitoring of environment; and to conduct scientific research, recreational and educational activities.
- Site of world heritage – a territory established for the protection of natural and natural/cultural territories and formations of universal importance and to conduct scientific research, educational and monitoring activities.

Under Article 12, Paragraph 2 of the Law of Georgia on System of Protected Areas, the territories of all state reserves, national parks, natural monuments and the prohibited areas shall be an exclusive property of the State. Hereby is prohibited the transfer of natural resources located in such territories to individuals or legal entities, with the exception of traditional usage zones of national parks and certain sites of the prohibited areas.

As the probable territory of reforestation under this project includes areas within the borders of Kazbegi municipality, it should be noted, that the Law of Georgia on Status of Protected Areas, Article 6 recognizes existence of Kazbegi protected area that includes:

- National Park of Kazbegi;
- Natural Monument of Sakhiznari cliff;
- Natural Monument of mineral lake of Abano;
- Natural Monument of Truso's travertine.

2.2. Requirements to obtain approvals to implement a reforestation programme

Environment Impact Assessment

The Law of Georgia on Permit on Environmental Impact adopted in 2008 provides a list of permits that can be issued on the ground of environment impact assessment (Art. 4). Reforestation activities are not in the list of those permits.

Following Art. 2 (2) b, the objectives of that Law include protection of the environment and natural resources from irreversible quantitative and qualitative changes, and their rational use. It could be argued that afforestation of alpine grasslands and other non-forest ecosystems would inflict such damage on the environment and natural resources including restrictions on their traditional rational use (pasture). However, the Law mainly refers to construction and development activities. Even the environmental technical procedures to which that Law refers to (Art. 5) do not consider any related regulations. Reforestation activities mainly are within the competence of certain state authorities (cf.

below), and therefore are subject to their internal regulations. The Law of Georgia on Permit on Environmental Impact is not applicable in that context.

Land Regulations

The Law on Public Registry adopted in 2008 provides grounds for registration of established borders of the Forest Fund. According to Article 15, Paragraph 1 of the Law, borders of the Forest Fund are registered on the basis of decision of the Government of Georgia. Under Paragraph 2 of the same Article changes of the borders are registered by registration of the corrections of the borders. Corrections of the borders are carried out on the basis of applications of the Ministry of Economy and Sustainable Development of Georgia.

It should be noted that further to the information we received from the National Forestry Agency the land plots that are outside the Forest Fund, never have been attributed to the Forest Fund as no respective detailed regulations are provided by the Laws of Georgia.

As mentioned previously, the laws of Georgia do not provide any regulations of afforestation of the areas that are not within the geographically established borders of the Forest Fund. Though, as the law on Public Registry considers possibility of correction of the Forest Fund borders on the basis of application of the Ministry of Economy and Sustainable Development, in case of afforestation of areas that are not within the borders of the Forest Fund, it would be possible to attribute afforested territory to the Forest Fund by correction of the Forest Fund borders.

2.3. Roles of the ministries and other state bodies involved in reforestation activities

The following state authorities may be involved in reforestation activities:

The Government of Georgia

On the basis of decision of the Government of Georgia the borders of the Forest Fund are established and registered within the Public Registry.

The Ministry of Economy and Sustainable Development

The role of the Ministry of Economy and Sustainable Development is important in the process of correction of the borders of the Forest Fund. Under the Law on the Public Registry the borders of the existing Forest Fund can be changed on the ground of application by the Ministry.

The Ministry of Environment Protection

The Ministry of Environment Protection approves plans for forestry management and forest use (Article 4, Decree #98 of the Government of Georgia from 23 April 2013).

National Forestry Agency

2. Review of the legal and institutional framework of forested areas and land-use/ownership in Georgia

The National Forestry Agency is a legal entity of public law (LEPL) existing within the system of the Ministry of Environment Protection. Under the Law of Georgia on Forest Fund Management the National Forestry Agency's authorities include forest tending and reforestation and carrying out forest cuts for these purposes.

Agency of Protected Areas

LEPL Agency of Protected Areas exists within the system of the Ministry of Environment Protection. Protected areas, including forests within borders of the protected areas, are managed by the Agency of Protected Areas. As mentioned previously under the Forest Code of Georgia reforestation on the lands within the borders of the protected areas can be carried out based on the forest management plans annually approved by the Agency of Protected Areas.

Local Municipalities

Local municipalities are mainly in charge of management of forests owned by them.

2.4. **Registration of land plots in the ownership of Self Government units**

The Code of Local Self Government, Article 19 allows local municipalities to purchase landed property and have it in their ownership. The procedures for registration of land plots in the ownership of self-governing units i.e. municipalities are provided under the Law of Georgia on the State Property. Under the Law of Georgia on the State Property, Article 18, Paragraph 1 non-agricultural land owned by the state can be directly sold by the National Agency of the State Property to the municipalities, as direct sale is considered as one of the options for privatization of the land.

Under Article 18, Paragraph 3 of the Law on the State Property the property can be sold to the municipality on the basis of the decision of the government of Georgia. Free of charge transfer of the state owned property to the local municipalities is considered under Article 112 the Code of Local Self Government.

Procedures on transferring of land plots in the ownership of self-governing units under Article 113, Paragraph 1 of the Code of Local Self Government may start on the basis of grounded and reasonable application of the Head of the Municipality to the National Agency of the State Property. Under Article 113, Paragraph 2 the National Agency of the State Property issues a decision on transferring the property to the local self-governing unit within 45 days after submission of the application and submits this decision for the Government's approval within 10 days after issuance of the decision. The Government has 45 days for approving the decision of the National Agency of the State Property. As we were informed during phone conversation by the officials of the National Agency of the State Property, generally the final decision on transferring the state property to the municipality is issued in shorter terms and may take approximately 2 or 3 weeks.

2. Review of the legal and institutional framework of forested areas and land-use/ownership in Georgia

2.5. EBRD Environmental and Social Policy 2014 and Performance Requirements

The project should be implemented in compliance with the following Performance Requirements (PR) of EBRD:

- *PR 1. Assessment and management of Environmental and Social Impacts and Issues*

This PR establishes the importance of integrated assessments to identify the environmental and social impacts and issues associated with the reforestation project and management of environmental and social performance throughout the life of the project. This PR applies to all projects directly financed by EBRD.

For compliance with this PR the following objectives should be achieved:

- Identification and evaluation of environmental and social impacts of the reforestation in Kazbegi region;
- Adoption of a mitigation hierarchy approach to address adverse environmental and social impacts and issues to workers, local community, and the environment from the reforestation;
- Promotion of improved environmental and social performance through the effective use of management systems;
- Development of Environmental and Social Management System for assessing and managing environmental and social issues and impacts in a manner consistent with relevant PRs.

Although, the Laws of Georgia do not consider obligatory Environmental Impact Assessment for such activities, in accordance with this PR environmental and social assessment of the reforestation project should be performed based on recent information including detailed description and delineation of the reforestation project and activities associated with the reforestation, and social and environmental baseline data.

Projects which are planned to be carried out are likely to have a perceptible impact on sensitive locations of international, national or regional importance are listed as Category A. Such sensitive projects include nature protected areas designated under national or international law. In case Kazbegi National Park areas would be included into the reforestation project, due to potentially significant future environmental or social impacts (thus conforming to requirements for Category A areas), a comprehensive Environmental and Social Impact Assessment (ESIA) would be required. The ESIA process would include a scoping stage to identify the potential future environmental and social impacts associated with the project. The ESIA would further include an examination of technically and financially feasible alternatives to the source of such impacts, including the "non-project" alternative, and document the rationale for selecting the particular course of action proposed. It would also identify potential improvement opportunities and recommend any measures needed to avoid, or where avoidance is not possible, minimise and mitigate adverse impacts. At this stage, the

principal decision is made not to carry out any reforestation activities in Kazbegi National Park area. Therefore, no ESIA is required. With respect to reforestation project requirements for Category B projects, it should be considered that potential adverse future environmental and social impacts are site specific and or readily identified or addressed through mitigation measures. Accordingly, environmental and social assessment should be proportionate to the reforestation project, its nature, size, location and characteristics of the potential impacts and risks.

- *PR 2. Labour and Working Conditions*

In accordance with the general requirement of a PR, reforestation activities should be in compliance, at a minimum, with national labour, social security and occupational health and safety laws, as well as the fundamental principles and standards under the International Labour Organisation Conventions.

Under the Labour Code of Georgia, Article 35, Paragraphs 1 and 2 the client – employer is obliged to provide the employees with a maximally safe working environment and reasonable timeframe with full objective and clear information on all factors affecting employees' life and health. Taking into consideration that the reforestation project is connected with working in dangerous environments respective Performance Requirements on protection of work safety requirements should be followed during the project implementation as reforestation is carried out in mountainous landscape.

- *PR 4. Health and Safety*

This PR recognises the importance of avoiding or mitigating adverse health and safety impacts and issues associated with project activities on workers, project-affected communities and consumers.

One of the objectives of this PR is protection and promotion of the workers' safety and health by ensuring safe and healthy working conditions and implementing health and safety management system. As in case with the previously discussed PR reforestation of the mountainous areas should be carried out in full compliance of work safety requirements.

- *PR 5. Land Acquisition, Involuntary Resettlement and Economic Displacement*

Involuntary resettlement refers both to physical displacement (relocation or loss of shelter) and economic displacement (loss of assets or resources, and/or loss of access to assets or resources that leads to loss of income sources or means of livelihood) as a result of project-related land acquisition and/or restrictions on land use.

Resettlement is considered involuntary when affected individuals or communities do not have the right to refuse land acquisition, or restrictions on land use, that result in displacement. Involuntary resettlement occurs in the following cases:

- Lawful expropriation or restrictions on land use based on eminent domain; and
- Negotiated settlements in which the buyer can resort to expropriation or impose legal restrictions on land use if negotiations with the seller fail.

The objectives of this PR that may be applicable to the project are as follows:

- Avoidance or minimization of involuntary resettlement by exploring alternative project designs;

- Mitigation of adverse social and economic impacts from land acquisition or restrictions on affected persons' use of land access to assets and land by providing compensation for loss of assets at replacement cost and ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation and informed participation;

According to this PR the following steps should be undertaken for purposes of reforestation:

- The land plots for reforestation should be identified through negotiation settlements with the local communities, as members of local communities have traditional use rights over the state owned lands. Locals traditionally use them as pasture lands.

- Taking into consideration the threat of landslides, erosion and avalanches, the reforestation can be carried out also for purposes of minimization of above risks. Accordingly, affected communities will benefit from reforestation.

➢ *PR 6. Biodiversity Conservation and Sustainable Management of Living Natural Resources*

This PR recognises that the conservation of biodiversity and sustainable management of living natural resources are fundamental to environmental and social sustainability; recognises the importance of maintaining core ecological functions of ecosystems and the biodiversity they support. All ecosystems support a complexity of living organisms and vary in terms richness, abundance and importance of species.

The objective of biodiversity conservation and sustainable management of living resources must be balanced with the potential for utilising the multiple economic, social and cultural values of biodiversity and living natural resources in an optimised manner.

It is recognised that: (i) the livelihood of affected communities whose access to, or use of, biodiversity or living natural resources may be affected by project activities; and (ii) they may have a positive role in biodiversity conservation and sustainable management of living natural resources.

The objectives of this PR are to:

- protect and conserve biodiversity using a precautionary approach

- adopt the mitigation hierarchy 3 approach, with the aim of achieving no net loss of biodiversity, and where appropriate, a net gain of biodiversity

- promote good international practice (GIP) in the sustainable management and use of living natural resources.

In order to be in compliance with the mentioned PR and its main objectives the following steps should be undertaken for purposes of afforestation:

- Be based on planting of tree and plant species that are native of endemic to the project area avoiding mono-culture as well as on internationally recognised sustainable forest management standards with the aim to enhance the biodiversity in the project area.

- To take in due consideration the livelihood of affected communities whose access to, or use of, biodiversity or living natural resources may be affected by project activities.

- To carry out reforestation activities based good international practice (GIP) in the sustainable management and use of living natural resources.

- To ensure careful management of risk and the best possible outcomes for the project and local communities, without compromising the health, function and integrity of the ecological system.

➢ *PR 10. Information Disclosure and Stakeholder Engagement*

This PR recognises the importance of an open and transparent engagement between the client, its workers, local communities directly affected by the project and, where appropriate, other stakeholders as an essential element of good international practice (GIP) and corporate citizenship.

This PR identifies GIP relating to ongoing stakeholder engagement as an ongoing process, which involves: (i) public disclosure of appropriate information; (ii) consultation with stakeholders; and (iii) an effective procedure or mechanism by which people can make comments or raise grievances. The process of stakeholder engagement should begin at the earliest stage of project planning and continue throughout the life of the project.

This PR applies to all projects that are likely to have adverse environmental and social impacts and issues on the environment, workers or the local communities directly affected by the project.

The reforestation component has to date been developed in close liaison with the local population and its representatives. During the reforestation programme preparation phase (and especially during the field studies), informal discussions were held with the population and representatives in the villages where reforestation possibilities were identified. Through these consultations, the sites that would best suit reforestation works were identified. The information received from the population was used to tailor the reforestation programme and ensure that reforestation works are actually planned in areas that would preferably benefit to the population (erosion control, avalanche protection) and also to ensure that livelihoods (for example hay fields) are not affected. A scoping-level public consultation was organised in Stepantsminda in September 2015, during which a presentation of the reforestation principles and objectives was done. The participants were positively interested by the reforestation program, and asked a number of questions regarding the practical arrangements for the reforestation programme. A second public consultation describing the way forward will be held on [insert date] and specific engagement with the concerned ministries is also planned, in order to present the reforestation programme initiative and ensure political support. Overall, the level of public consultation held for the reforestation programme will be equivalent to what is done for A category projects, which exceeds the requirement of PR10 for this specific activity.

During the programme implementation phase, interested stakeholders will be able to get information locally (directly through Dariali Energy company) or on the dedicated webpage that will

be developed to ensure availability of information for the public at large. The detailed communication strategy for the implementation period is yet to be defined in the final report.

During the cycle of the project meetings with the local communities and the state authorities should be held systematically, where their representatives should be encouraged to provide their comments about the project implementation.

2.6. Existing Georgian and international reforestation initiatives and outputs/lessons learned

The latest reforestation initiative is related to restoration of forest areas in National Park of Borjomi-Kharagauli, destroyed as a result of forest fires during an armed conflict in Georgia in 2008. After fires, the forests fully or partially were destroyed on 950 hectares. Reforestation activities started in 2013 on 20 hectares of destroyed forest land in 2013 with the initiative of Government of Georgia, Government of Finland and UNDP[1]. In addition to that, also ÖBf/BFW carried out reforestation of approximately 20 hectares on the territory of the National Park of Borjomi-Kharagauli. On additional 20 hectares of the National Park, measures for reforestation have been undertaken by the National Forestry Agency.

With the assistance and participation of international organizations some other reforestation measures have been carried out in Georgia:

In 2008 restoration of the forest after sanitary clear cutting on 7.5 hectares took place in Samtskhe-Javakheti Region with participation of the Bank of Georgia and the Forest Agency.
In 2010 measures for natural reforestation were carried out on up to 239 hectares on Samtskhe-Javakheti and Kakheti regions with participation of WWF, GIZ and the Forest Agency. In Samtskhe-Javakehti reforestation took place on open areas of the forest.
In 2010 the National Forestry Agency cultivated Caucasian pine-tree and crab apple through planting on 1.7 hectares of Samtskhe-Javakheti Region;
In 2011 the National Forestry Agency cultivated forest species through planting on 0.5 hectares of Mtskheta-Mtianeti region.

All above-mentioned reforestation activities took place on the lands of the Forest Fund.

With that reforestation, forests are being restored which had been removed very recently. That reforestation therefore can be considered a regular silvicultural measure, as e.g. following a (regular) clear cut. In Kazbegi area, however, areas to be (re-)forested have been cleared from forests long times ago, in the meanwhile allowing non-forest alpine ecosystems to develop on former forest sites. Experiences therefore are not transferable, including the legal-sociological context.

[1] http://www.ge.undp.org/content/georgia/ka/home/presscenter/pressreleases/2014/08/08/borjomi-forest-comes-back-to-life.html

Reforestation and afforestation measures implemented during 2003-2014 in the state forest fund under the management of LEPL National Forestry Agency

Brief review

This section contains a brief review of the reforestation and afforestation measures carried out during 2003-2014 in the state forest under the management of National Forestry Agency (Picture 1, Appendix: Table 77). It does not contain the information about the small scale actions of planting of trees (landscaping) carried out during different period of time, also about the compensation activities for the special use of forest fund.

2003

In the framework of the World Bank financed project "Forest sector development" there were carried out afforestation activities/establishment of plantations through planting in 9 regions, on the 29.8 ha area of the State Forest Fund. Among them:

- Kakheti – 5.5 ha;
- Kvemo Kartli – 2.0 ha;
- Shida Kartli – 4.1 ha;
- Mtskheta-Mtianeti- 0.1 ha;
- Imereti – 8.5 ha;
- Guria – 1.5 ha;
- Samegrelo Zemo Svaneti – 3.0 ha;
- Racha-Lechkhumi Kvemo Svaneti – 2.1 ha;
- Samtskhe-Javakheti – 3.0 ha.

2004

In 2004 in the framework of the same project the afforestation activities/establishment of plantations were continued in the following regions:

- Kakheti – 14.6 ha;
- Kvemo Kartli – 60.5 ha;
- Shida Kartli – 20.0 ha;
- Mtskheta-Mtianeti – 18.4 ha.

In total during 2003-2004 with the financial support of the World Bank there was afforested (establishment of plantations) 143.3 ha area. As the documents show the area that were to be afforested were representing the territories not covered with forest (edges of forests), in some regions – degraded forest stand and clearings. Mainly there were planted: ash tree, sycamore, sycamore maple, yellow pine, and acacia.

The state of artificial plantations/ afforested territories during the following years was assessed as unsatisfactory. The percentage of tree survival rate was between 30-45%, the rest of the planted trees were considered damped off and were discarded. Unsatisfactory results according to the data were in most cases caused by not caring for the plantations, in some cases wrong choice of the area

and the species of the plant. *(It is impossible to find accurate information because of the absence of the documentation of that period*).

In 2005-2007 and 2012 there were not carried out any reforestation measures on the territories of the State Forest Fund either through the financing from the budget or any donor.

2008

Kakheti – afforestation/establishment of plantation were carried out on 0.5 ha area through planting. The territory to be afforested represented an open, not covered with forest area (clearing) and there was planted ash-tree. Afforestation was carried out by the Kakheti Forestry Service, with their forces. The state of the plants during the following years was assessed as satisfactory, additional plants were not planted, but as the care was rather good the survival of the trees was maintained.

Imereti – on 1.0 ha of area in the degraded chestnut stand the Agency carried out the supportive measures of the forest natural reforestation– pick off together with sowing. During the following years the state was assessed as fraught. The growing plants developed well and the desirable conditions for their growth were created.

Samtskhe-Javakheti – Afforestation/establishment of plantation activities were carried out on the area of 7.5 ha with the financial support of the Georgian Bank and participation of Forestry Agency. The selected area was located in Borjomi-Bakuriani forest neighbourhood and the territory represented a degraded forest area. Namely, in 80-ies the mentioned territory was under complete sanitary cutting because the stand was completely damaged by bark beetle. There were planted: Caucasian pine-tree, fir-tree, cedar, maple, and ash-tree.

On the basis of a contract with the Georgian Bank the work of planting and further caring of the established plantations was carried out by Gulisashvili Forestry Institute. As a result of it the project was assessed as successful and during the second year of planting and during the following years there was defined high percentage of the trees/seedlings survival.

2009

Kakheti – In the framework of the WWF project there was cultivated grove oak-tree on 36.0 ha area. The project implementing territory represented a degraded floodplain forest. During the following years, because of the distortion of the fence and also because of the flooding of the neighbouring river during different period of time the state of the plantations/ afforested territory is assessed as unsatisfactory.

Samegrelo Zemo Svaneti – there was conducted a supportive measure for natural reforestation on the area of 1.0 ha – in the degraded chestnut grove through fencing. The project was assessed as satisfactory during the following years due to the care provided to the young seedlings/coppice.

Samtskhe-Javakheti – on 6.1 ha area Georgian Bank continued the reforestation project of the degraded forest. There were planted pine-trees, fir-trees, ash-trees. The territory was selected on the area where trees had been cut down and during the following years because of good care, and right selection of species and planting scheme the project was assessed as successful.

2010

Kakheti – 237 ha

WWF continued the reforestation project of floodplain forests. on 109 ha of the area there was carried out planting and sowing, and on 118 ha area – supportive measures for natural reforestation. There were planted and sown the following species: grove oak-tree, ash-tree, maple, lime-tree, and phloem. During the following years due to different reasons the state of the area was not assessed. According to the not verified information was more or less satisfactory on the sown territories; however the planted trees did not show high percentage of survival. Unsatisfactory results of the project were partly caused by the non-protection of the territory (distortion of the fence and overgrazing), and partly by frequent flooding of the area.

In **Dedoplistskaro** region by the financial support of GIZ afforestation/establishment of plantations were carried out on 10 ha area. The area represented a clearing, is located close to the road of internal purposes and in future will be a forest with protecting function. There were planted ash-trees, crab-apples, crab tree, acacia and others. The percentage of survival of planted seedlings was very good (90%), although their partial withering was caused by the fire of adjacent field. In total the project is assessed as successful.

Mtskheta-Mtianeti – by the financial support of the Constanta Bank rehabilitation/restoration of wind break stripe was carried out on 0.33 ha area. There were planted ash-trees, maples on the open area. During the following years the project was assessed as satisfactory. Although, due to the negligence of the local population and uncontrolled grazing, small part of the seedlings was damaged.

Imereti – WWF carried out promoting of natural reforestation on 30 ha area, planting and sowing. The promotion measures of natural reforestation were carried out on the territory of degraded forest stand, while planting and sowing – on open area (clearings in forest). There were planted and sown oak-trees, beech, chestnut, ash-trees, maple, nuts, crab tree, crab-apple. The results of planting was assessed as positive during the following years, but the cases of the damage of fence by the local population and the damage of the plants by the cattle were rather frequent.

Samtskhe-Javakheti – The forest Agency carried out the afforestation/ plantation establishment of 1, 7 ha area. There was planted Caucasian pine which was mixed with crab-apple and crab tree (for an experiment). The area represented an open clearing; old territory of forest plantation adjacent to Paravani Lake, where the majority of the established plantations during earlier years were lost presumably because of severe climate. The following year after their survival percentage amounted to 76%, the lost plants were replaced and today the project is assessed as very successful. The positive results were conditioned by the correct selection of species and correctness of planting scheme, 5 years of intensive caring of the plants and territory protection.

2011

Shida Kartli – WWF carried out monoculture transformation project on 79.7 ha area. The territory represented an artificially cultivated pinewood (monoculture) which had the traces of degradation caused by anthropogenic and natural factors impact. The territory was fenced and deciduous plants

were planted to create close to the natural forest stand. There were planted oak-trees, ash-trees and maples, beech (in small quantity). During the first year the percentage of survival was low for oak-tree and beech, though after replacing the damaged ones and correctly carried out care work the project was assessed as successful.

Mtskheta-Mtianeti – At the initiative of Georgia-Ukraine Club and with the participation of the Forestry Agency there was plated Caucasian pine on the area of 0.5 ha. The state of the plantation is assessed as satisfactory. The partial damage was caused by the distortion of the fence and overgrazing.

Racha-Lechkhumi Kvemo Svaneti – In the framework of REC project there was carried out a natural reforestation promotion on 62 ha area and cultivation on 3.3 ha area. Taking into account that the Racha forests are distinguished by their high self-regeneration/restoration capacity, in this case there was fenced the section of the degraded forest were naturally grown plants were in a big quantity. The project was positively assessed.

Samtskhe-Javakheti – The Forestry Agency carried out the planting of Caucasian pine on 0.3 ha area. The area represented a clearing (at the edge of a forest) were grazing became limited and the established plantations were cared for. As a result the state of the afforested territory was assessed positively.

2013

Samtskhe-Javaxeti – in the framework of UNDP project "Sustainable Development and Responsibility for the Environment" on the area of 16.3 ha on the territory of Borjomi-Bakuriani forest section there were carried out a fire-stricken forest restoration/reforestation measures:

- cleaning of the territory (cleaning and collecting of the fire-stricken trees and setting erosion barriers on the slopes with the obtained wastes);
- full fencing of the territory;
- planting – spruce, fir-tree, pine-tree, beech, highland oak-tree, crab-apple and crab-tree;
- sowing – spruce, fir-tree, beech, highland oak-tree, Caucasian pine-tree, lime-tree, crab-apple, crab-tree, maple.

The work was conducted by the LEPL Forest Base Nursery (on the basis of a contract between the UNDP and the Forest Nursery). The territory represented by 100% devastated by the fire area. The established plantations were intensively cared after, according to the interim monitoring results (June 2013) the survival percentage of the plants was high (75%), the drought that set in August influenced the plants (particularly the fir-tree). Also, the rodents damaged the big sown seeds.

On the basis of the inventory carried out in September 2013 and having taken into account the state of the area earlier and the extreme climatic conditions which set in during the year of plantation establishment (prolonged high temperature during the summer time) the carried out works were considered as satisfactory and on the basis of the results there were planned the measures for being carried out in 2014. Namely, decision was made to continue the forest restoration measures on the territory adjacent to the afforested area and to fill in the additional 78.8 ha of studied territory. At the same time, to take away sowing measures from the planned activities and replace it with

planting. Also, there were changed some species and their distribution – according to the survival percentage defined by the registry.

2014

Samtskhe-Javakheti – on the area of 60.0 ha by the financial support of UNDP (20.0 ha), BFW (Austria) (20.0 ha) and National Forestry Agency (20.0 ha) there was carried out the reforestation measures of the forest fire-stricken in 2008.

There were planted: Caucasian pine-trees, spruce oriental, fir-trees, oak-tree oriental, oak-tree Georgian, ash-trees, field maple (sycamore), crab-trees, crab-apple, and wall-nuts. The reforested area is intensively looked after; the whole area is fenced and is protected against grazing. According to the interim monitoring results there was defined 75% of seedlings survival. The project taken into account the extreme environmental conditions on the territory, is considered as very successful, which is conditioned by the correct selection of the species that were to be planted, the correct mixture of the species and distribution and intensive caring.

Forest temporary nurseries

LEPL National Forestry Agency created 6 temporary forest nurseries in 5 regions with the whole area of 1.76 ha:

Kakheti – Acacia temporary nursery – 0.1 ha;

0.3 ha – Chestnut nursery.

Mtskheta-Mtianeti

0.3 ha – field maple, black pine-tree, junipers.

Samtskhe-Javakheti

0.17 ha – Caucasian pine-tree.

Imereti

0.3 ha – Ash-tree, Imereti oak-tree, black/Austrian pine-tree.

Guria

0.46 ha – chestnut, field maple (sycamore), Imereti oak-tree, chestnut leaf oak-tree.

There were chosen open areas for nurseries on the territory of the State Forest Fund satisfying the relevant conditions. The nurseries inventory according to the set rules will be carried out in the autumn of 2015. According to the interim monitoring results the state of sown plants in the nurseries is good except for the chestnut nursery in Kakheti which was damaged by the high flood of the Kabala River. From nurseries the obtained plants will be moved to the adjacent territories for afforestation in 2016-2017. From acacia nursery located in Kakheti region the establishment of plantation on an open area of 6.5 ha will be carried out in the autumn of 2015.

2015

Samtskhe-Javakheti – the promotion measure of natural reforestation on 3.4 ha area was carried out through fencing. The project was implemented by LEPL National Forestry Agency with the financial support of BFW. The area to be recovered represents a degraded forest section (cut down territory).

Ongoing

Samtskhe-Javakheti – on 4.3 ha fire-stricken territory in 2008 there is being carried out the afforestation/ establishment of plantations; the project is carried out by LEPL National Forestry Agency with the financial support of BFW. The area represents 100% devastated by the fire forest territory. The species to be planted: Caucasian pine-tree, ash-tree, maple (sycamore).

0.5 ha forest temporary nursery – close to the fire-stricken forest, in the nursery arranged on the territory of State Forest Fund breeding of plants will be carried out for the replacement of trees in the fire-stricken forest. The species: Caucasian pine-tree, Caucasian fir-tree, spruce oriental, oak-tree oriental, field maple, highland maple (sycamore).

Planned

Kvemo Kartli – 0.33 ha area forest temporary nursery.

- *Pinus eldarica*
- *Celtis caucasica*
- *Fraxinus excelsior*
- *Acer campestre*
- *Elaeagnus angustifolia*
- *Tilia caucasica*

The project area is represented as a type of a clearing/meadow on the south-west exposition of the slope in the middle of the deciduous stand which is composed of the following species: maple, mulberry tree, wild plum, hawthorn (red, black), asps, fig, hornbeam, willow; in sub-forest - blackberry and elder.

Forest cultures cultivation on 3.2 ha will be carried out by Bolnisi Municipality Administration. The project territory represents a State Forest Fund; the area is represented by vast clearings where there occur sub-forest groups (like whitethorn and others). Intensive grazing is noticed on the territory (particularly cattle). The area occupied by coppice amounts to the 15% of the whole territory.

The species to be planted:

- *Pinus eldarica*
- *Acer campestre*
- *Quercus iberica*
- *Celtis caucasica*

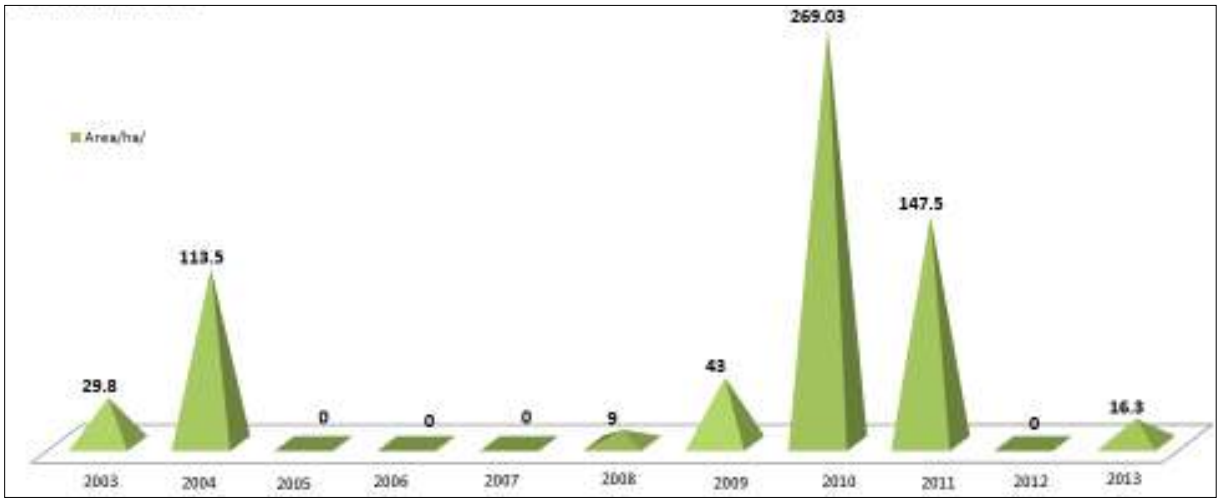
- *Koelreueteria paniculata*
- *Fraxinus exelsior*
- *Elaeagnus angustifolia*
- *Cotinus coggygria*

Shida Kartli – 0.2 ha temporary forest nursery

The area selected for the arrangement of temporary forest nursery is located on the adjacent territory to the Forestry Service Administrative building. The mentioned territory the owner of which is the State is given under the right of use to the National Forestry Agency in two plots.

The species to be sown:

- *Pinus kochiana*
- *Abies nordmanniana*
- *Picea orientalis*
- *Quercus iberica*
- *Fraxinus excelsior*
- *Tilia caucasica*



Picture 1: Annual afforestation activities in Georgia carried out in 2003-2013, given in ha.

2.7. Forest rehabilitation/reforestation and cultivation/afforestation in Georgia - History, practice, experience

Cultivation of forest wood species in Georgia has been practiced from times immemorial; however 1891 is recognized as the beginning of forest rehabilitation and creation of artificial forests when there was established Tbilisi Pilot Mountainous Cultures Forest Institute which laid foundation for landscaping and forestation of dry and eroded side-hills of the capital outskirts.

2. Review of the legal and institutional framework of forested areas and land-use/ownership in Georgia

Forest culture activities were starting actually from zero and particular importance was given to which species ensured timely fixation of the side-hill. Forest culture activities began in Ortachala and Okrokana with the arrangement of nursery gardens for wood species to be nurtured.

Before the Revolution the scope of artificial cultivation of forest in Georgia was more or less small. From 1844 to 1914 (that is during 70 years) the forest was cultivated across 891 thousand hectares (about 13 thousand ha per year). However, from 1951 to 1955 (that is during five years) the forest was cultivated across 2817 thousand hectares (approximately 564 thousand ha per year), that is on the area which 43 times exceeded the first one.

Georgia is also recognized as the motherland of shelter belts (wind breaks) cultivation, during the above mentioned period there was cultivated about 3, 0 thousand hectares of wind breaks and protecting forest plants on the eroded area of over 49.0 thousand hectares.

As it is well known 98% of the Georgian forests are located on the mountain sides due to which the distribution of forest wood species in these forests are characterized with drastic zonality. Disturbance of the plants zonality is accompanied with big negative results; hence, forests rehabilitation was preceded with the creation of strong nursery base both in Eastern and Western Georgia. Young plants upbringing in the nurseries was carried out in accordance with the zonality. In the nurseries there were always registered 40-50 million multi-species seedlings and saplings (young plants). Forests cultivation was mainly carried out with seedling which gave satisfactory results.

Majority of artificially created forests are located in Tbilisi, Khashuri-Surami, Dmanisi, Tsalka-Akhalkalaki, Kutaisi and Tskaltubo outskirts. Out of successful projects particularly shall be distinguished forest cultivation by the foresters around Tbilisi city.

Historically it is known that Tbilisi city and its outskirts was covered by natural forests; however, due to definite historical facts by the second half of the 19th century Tbilisi outskirts was represented by bare (mainly eroded) hills which was creating hazard not only to the population in the city but also to the inhabitants of adjacent to the city settlements.

In 1891 there was created Tbilisi Forestry and in the outskirts of Tbilisi there was cultivated about 150 hectares of area from 1891 to 1914. Despite the fact that the cultivated area was rather small these cultivation works largely contributed to the development of forest rehabilitation and cultivation practice.

After the establishment of Soviet rule particular attention was paid to the afforestation of the mountainsides around Tbilisi. In 1922 by the leadership of Professor I.I Roschin there was developed forest cultivation measures project which envisaged forest cultivation on 1000 hectares on Mtatsminda from the village Okrokana to the Turtle Lake and from the left side – from Khudadovi forest to the Makhata Mountain. Due to the particularly dry climate in Tbilisi, the forest cultivation was connected with various problems. In the brochure published in 1980 “Forest is coming back to Tbilisi” which eloquently tells the history about the cultivation of artificial forests in Tbilisi outskirts we read about these difficulties: “… if you want to see one of the biggest wonders… you should visit Krtsanisi side-hills. Deep ravines and abysses, cliffs made inaccessible these places. .. And something unimaginable started: - foresters on the descent which was jagged with steep ravines and yet pathless started to lay a road. You could hear thunder and volley everywhere, it was thundering

during the whole day. The "spurt" of stones and dust was going up high into the sky. …. The first kilometre of the road was briefly laid. Now the foresters were detonating fossas in stones and holes for plants. Then they were filling these holes with brought soil and were planting the forests future inhabitants. This was how 6 kilometre road was laid on the Krtsanisi rock scarps, this was how 150 hectares of emerald was created." From the same brochure we learn that big contribution in the afforestation of Tbilisi outskirts belonged to volunteers who came from different regions of the country for this very purpose. There were arranged Saturday working days, schoolchildren were brought, and students came who directly participated in the forest cultivation process.

Success of the project was conditioned by the correct selection of species and cultivation/afforestation scheme. Taking into account that the territory which was to be afforested was represented by eroded slopes and cliffs the main species which was selected was pine. It is well known that pine is one of the species which has capability to grow on poor rocky soil, stratify and facilitate to the soil formation process. In the bio-ecological characteristics of *Pinus nigra* and *Pinus eldarica* we read that these species may be cultivated in all zones up to the altitude of 2000 meters from the sea level.

As for the planting agro-technique, the cultivation/afforestation scheme was chosen according to the climate, soil, zones and other natural factors – with high density, in most cases 1mX1m. Around Tbilisi the forest cultures cultivated according to this rule for over 70 years was distinguished by stability and as intended carried out soil protection and other ecological functions which confirms that the measures during their cultivation were correctly planned and implemented, though the mistakes made during their further management, namely non-implementation of proper care measures during their management for many years, for example tending – which in artificial plantations implies the cut of untoward plants periodical removal for the preservation of the stability of these plants – caused the degradation of the plants and by today a big portion of them have been withered.

As a successful example of forest cultivation is considered artificial forests of coniferous species in Kvemo Kartli and Samtskhe-Javakheti regions. Kvemo Kartli is generally considered as poor in forests (forest covers only about 21, 7% of the territory, which is the lowest index all over the country), poor in forest is also Samtskhe-Javakheti tableland. Particularly are distinguished Marneuli, Tsalka, Ninotsminda and Akhalkalaki regions.

Despite the fact that according to the historical information the above mentioned regions were represented with areas covered with natural forest, during many centuries due to the destruction of forests climatic and natural conditions were significantly changed. By today, the existing green coverage here is mainly represented with artificially cultivated forests the majority of which were cultivated in 40s of the 20th century. Artificial forests are mainly represented with mono-cultures, in the area of Marneuli mainly with *Pinus nigra*, and the rest of the territories with *Pinus kochiana* species.

Out of the artificially cultivated coniferous forest the dominating species in the region is pine (area of about 5335 hectares), while out of deciduous – beech (25332 hectares). Significant area is occupied by oak (21564 hectares), hornbeam and *Carpinus caucasica*, out of softwood deciduous – *Populus*

canadiens (260 hectares). There is rather big area of almond-trees, apricot-trees and crab-apples plantations.

As for Akhalkalaki area, here only *Pinus kochiana* has been used for cultivation.

In Georgia in the practice of forest rehabilitation/reforestation and cultivation/afforestation distinguished place belongs to the forest cultures cultivated in Kazbegi. Natural forest on the territory of the municipality is not very well distributed. In the natural forest rather big area is occupied by mountain pine and birch forest stands. In the areas of relatively small mountains there occur beech forests, rhododendron scrubs, *Hippophaë rhamnoides*, aspen, nut-tree, barberries, willow, juniper, mountain ash and others.

Out of artificial massifs there should be noted artificial forest of Gergeti village, which starts at the altitude of 1700 meters from the sea level and goes up to 2000 meters.

Forest cultivation/afforestation started 65-70 years ago, and as leading species was chosen pine- which was mixed with birch and aspen. On the one hand this was exactly the factor which gave successful results, since birch and aspen due to their bio-ecology are characterized with good index of natural recovery even under the conditions of artificial cultivation and by today just because of seeding from this very forest, the adjacent areas became rather rich in birch and aspen's rather good shoots, which after some certain time is transformed into natural forest.

In general, the main factors of the success of above mentioned works were the following:

- The species to be cultivated were chosen by taking into account their bio-ecology and local environmental conditions;
- The material to be planted was of good quality – standard plants or seedlings (2-3-4 year old coniferous, 4-5 year old deciduous), which were grown from good quality seeds collected in the same region;
- There were observed cultivation/afforestation schemes and the parameters of agro-technical measures;
- Mostly growing of saplings was carried out just very close to the areas that were to be afforested, or in the temporary forest nurseries arranged in the zone relevant to such area.

As it was noted, when carrying out forest cultivation/rehabilitation, particular attention was paid to the planted material, according to their quality and selection of species.

Because of this until the 90s in Georgia there were functioning three important establishments not only for Georgia but the whole Transcaucasian region:

- Forest Selection Seed-Nursery – "SakTkeTeslSeleqtsia";
- Forest Teaching Center of State Department of Dendrology of Georgian Forestry;
- Monitoring Station of Georgian Forest Species Seeds.

In parallel to the above mentioned establishments there was also functioning V.Z. Gulisashvili Mountain Forestry Institute where there were carried out permanent studies of forest species genetics as well as the introduction of the best practice of their use in the natural environment.

During that period there was also created methodological base, quite a lot manuals on the forest recovery/reforestation, cultivation/afforestation and further care/tending in Georgia.

When carrying out forestry, important part was assigned to the creation of fast-growing and nut species plantations, which where to recover not only eroded soil but also had the important function of the reduction of impact (pressure) on the forest. For this purpose, in Kakheti region on the significant part of the forest fund there was cultivated acacia (introduced species), chestnut and nut plantations.

By today, the legislation regulating the forestry sphere admits the possibility of the use of introduced (non-invasive) species for fast-growing plantations.

It should be noted that during many years the approach of the creation of artificial forest cultures has changed with regard to the selection of species. If during the Soviet times the most part of the created cultures was represented by coniferous mono-cultures (composed from one species), where mainly was used *Pinus nigra, Pinus eldarica, Pinus kochiana (=Pinus sosnowsky),* during the coming years there was widely accepted the cultivation of forest cultures composed of two or more species (among them by mixture of deciduous species). Such stands, in addition that they are maximally transformed to the almost natural forest, are far more resistant against fires, illnesses and other negative environmental factors.

It should also be noted that for Georgian conditions in most cases it is expedient to facilitate the natural recovery measures and not cultivation/afforestation through planting. It is confirmed by the studies carried out during many years that the forests in Georgia are characterized with high index of self-recovery/regeneration as compared to Europe. That's why here during the planning of the forest rehabilitation/reforestation measures (on the basis of preliminary study), prevalence is given to the natural recovery facilitation measures.

Generally the fact that in Georgia significant importance was given and until today exists both the scientific and practical base for forest management, its care and recovery-cultivation is testified by the fact that as back as 1921 on Tbilisi State University Agronomical base there was established Forestry Department which by that time already had two independent faculties – Forestry and Silviculture. In 1924 for the first time there were specialists who had graduated from the higher Forestry education.

In 1929 there was separately and independently established Forestry Faculty (Department). In 1930 on the base of this Faculty there was established Transcaucasian Technical Forestry Institute which in 1933 was named Tbilisi Technical Forestry Institute.

Also, in 1933 there was established Botany Institute and the methodological instructions, technical regulations and other rulebooks developed by the above mentioned institutes, scientists and practitioners have not lost their significance until today.

3. IDENTIFICATION OF THE LOCAL PLAYERS/USERS OF THE FOREST SECTOR AND LAND-USE AND NATURAL RESOURCES MAPS

The goals of this WP were to i) Identification of the local players/land-users, land-users interests and/or land-use conflicts; and ii) Local survey and mapping of land ownership, land-use categories/ vegetation and biomes and impact of various land utilization on sites using available records.

Local players and land-users were identified as:

- Agency of Protected Areas under the Ministry of Environment and Natural Recourses Protection, governing the Kazbegi National Park
- National Forestry Agency also under the Ministry of Environment and Natural Recourses Protection
- Municipality of Stepantsminda
- Farmers, local, owners of cattle and sheep
- Shepherds, migrating

The major conflict in land-use interests exists between the livestock grazing and the forest regeneration. This applies on the one hand to existing forests, where the regeneration is grazed, and on the other hand also to future afforestation projects. Due to the construction of the hydropower plant certain areas were also lost for livestock grazing, however the actual impact is negligible due to the small area occupied by the hydropower plant (and the road along the pipeline) compared to the total area available for grazing.

The following maps of the project area were compiled to fulfil the requirements of the inception report:

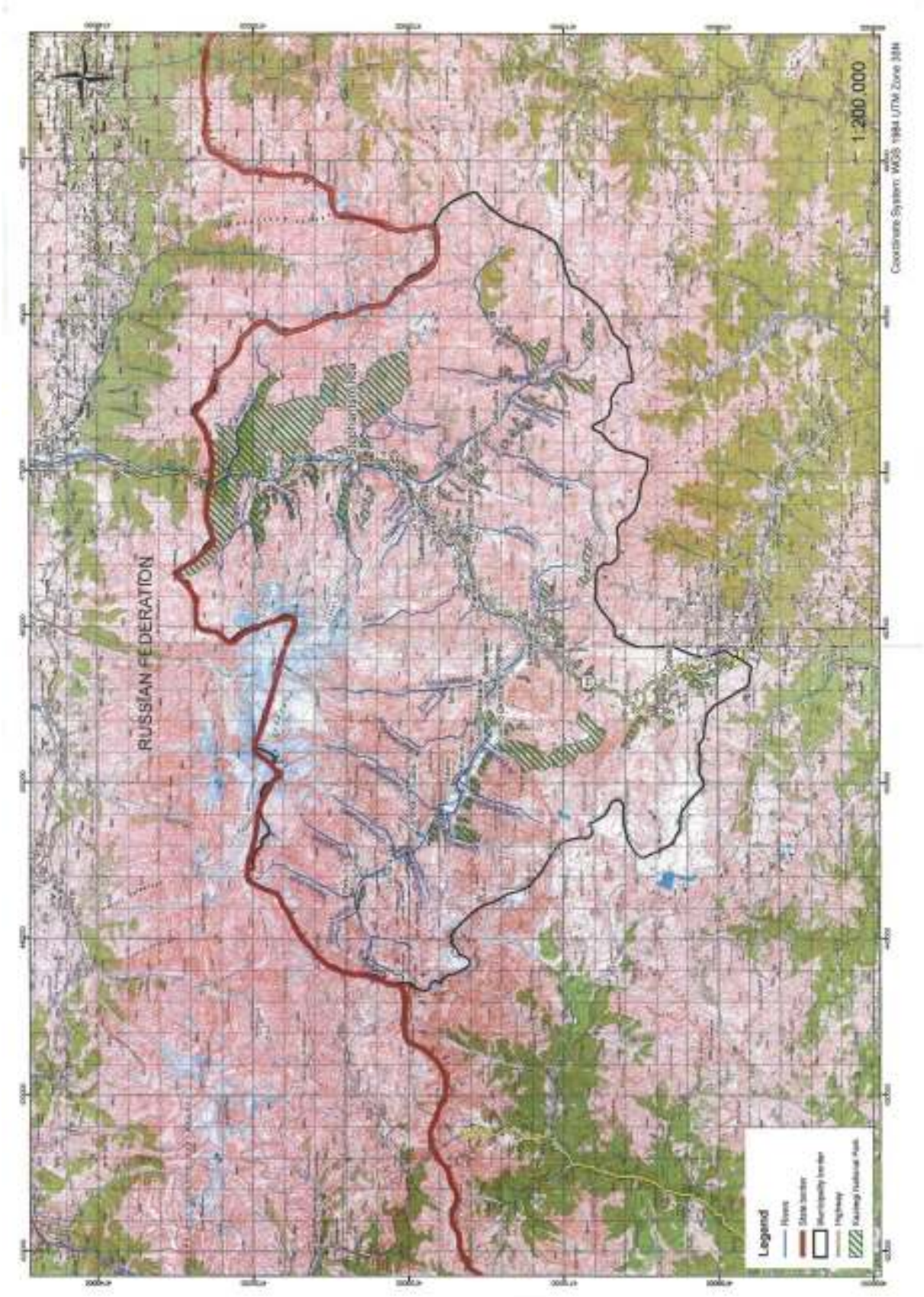
- Protected areas (National Park, Picture 2, Picture 3)
- Cadastre (Picture 4)
- Geology (Source: Geology Department of Georgia, Picture 5)
- Soil (Source: Horizonti Foundation, Picture 6)
- Vegetation (Source: Horizonti Foundation, Picture 7)

The cadastre mostly covers the settlement areas and agricultural areas in the close surroundings. Vast areas reaching up into the mountainous terrain are not covered by the cadastre.

The geology map was done by the Geology Department of Georgia, today part of the Georgian National Environment Agency and the then existing National Oil Company 'Saknavtobi' in 2003.

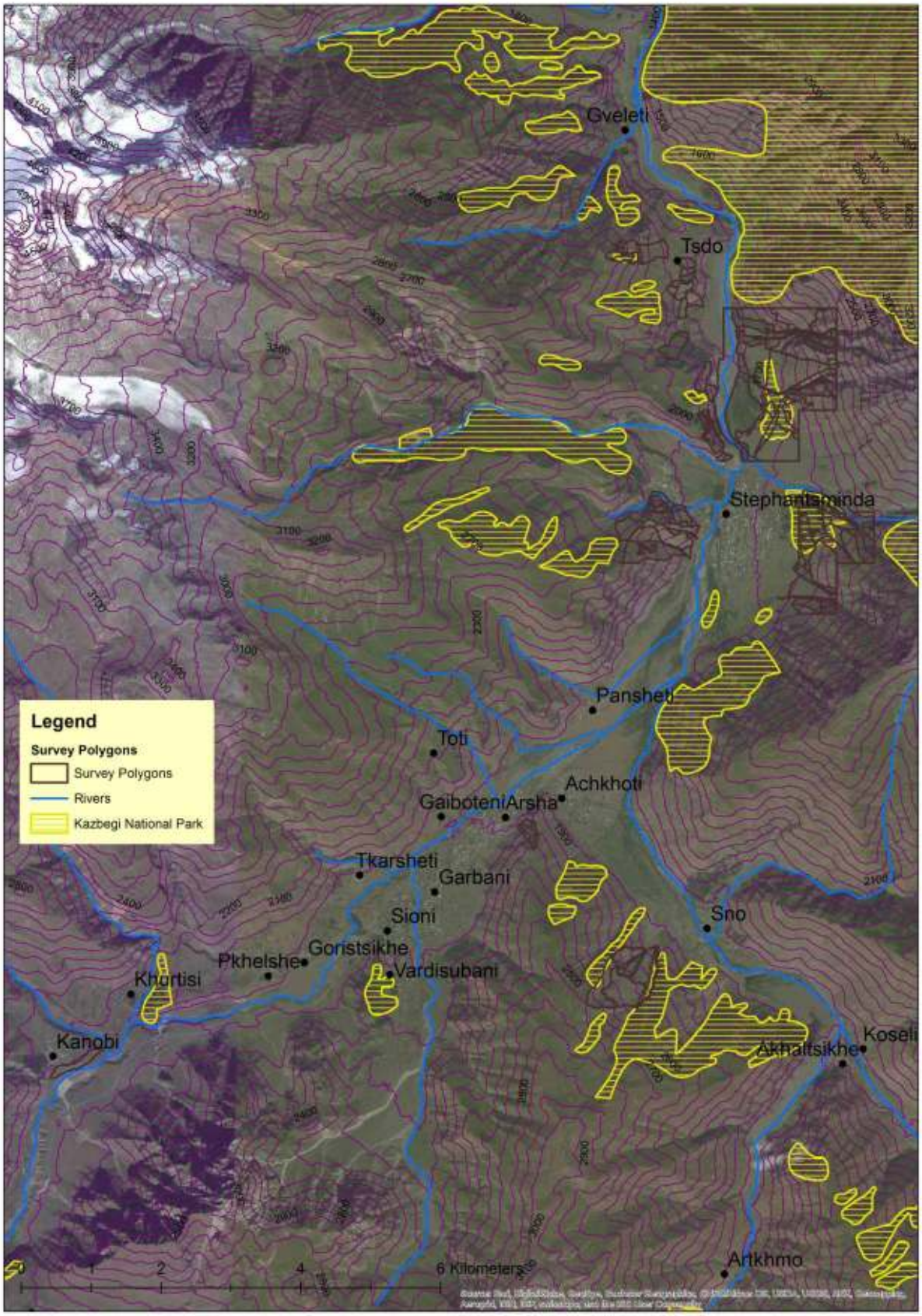
The soil and the vegetation maps were developed within a project entitled 'Elaboration of Sustainable Development Model for Aragvi River Basin Region 2002-2003'. The project was founded by Horizonti Foundation.

3. Identification of the local players/users of the forest sector and land-use and natural resources maps



Picture 2: Preliminary National Park areas in the Kazbegi district, scale not appropriate.

3. Identification of the local players/users of the forest sector and land-use and natural resources maps

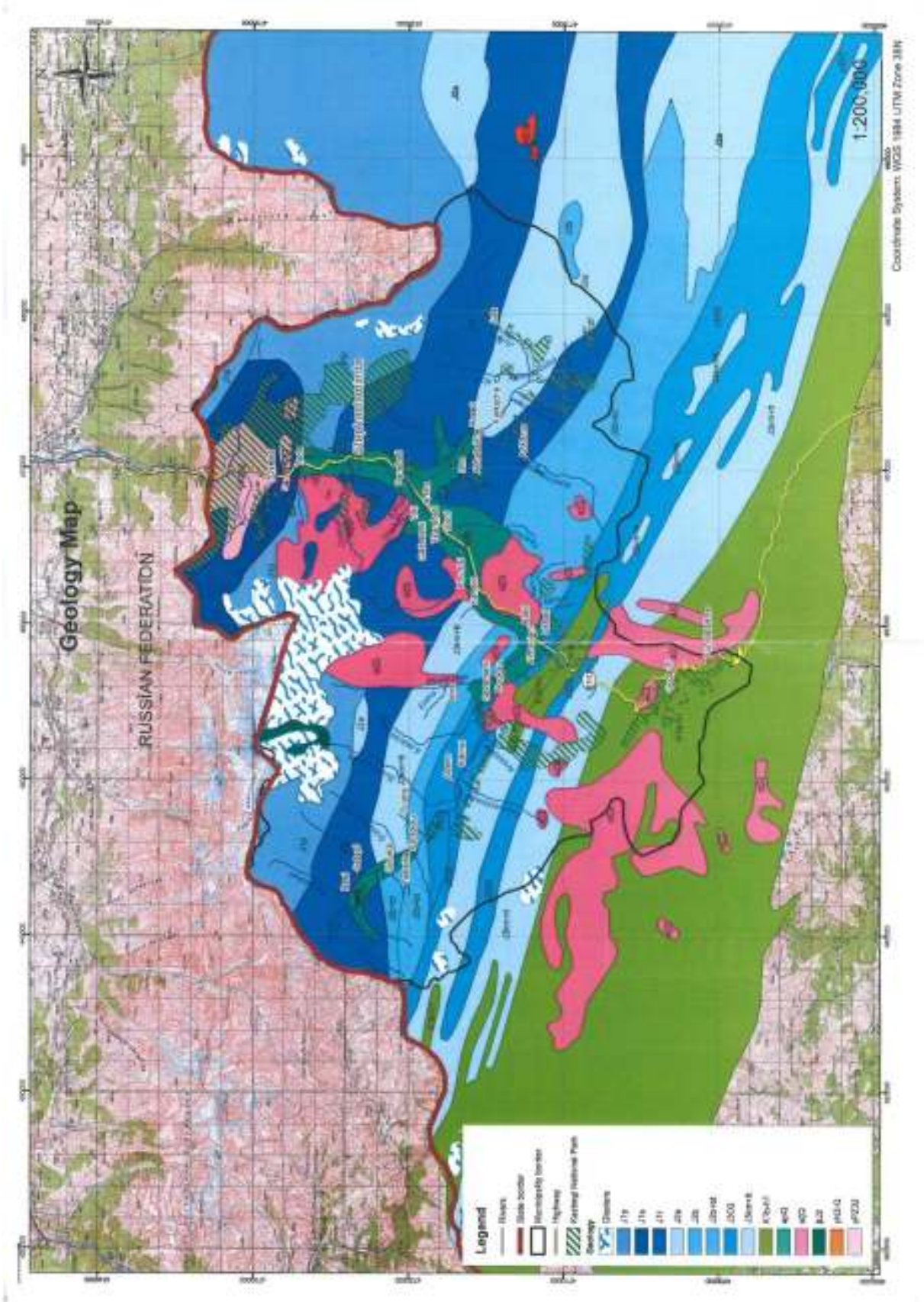


Picture 3: Project area with preliminary National Park boundaries.

3. Identification of the local players/users of the forest sector and land-use and natural resources maps

Picture 4: Cadastre parcels in the project region, distinguished by land-use.

3. Identification of the local players/users of the forest sector and land-use and natural resources maps



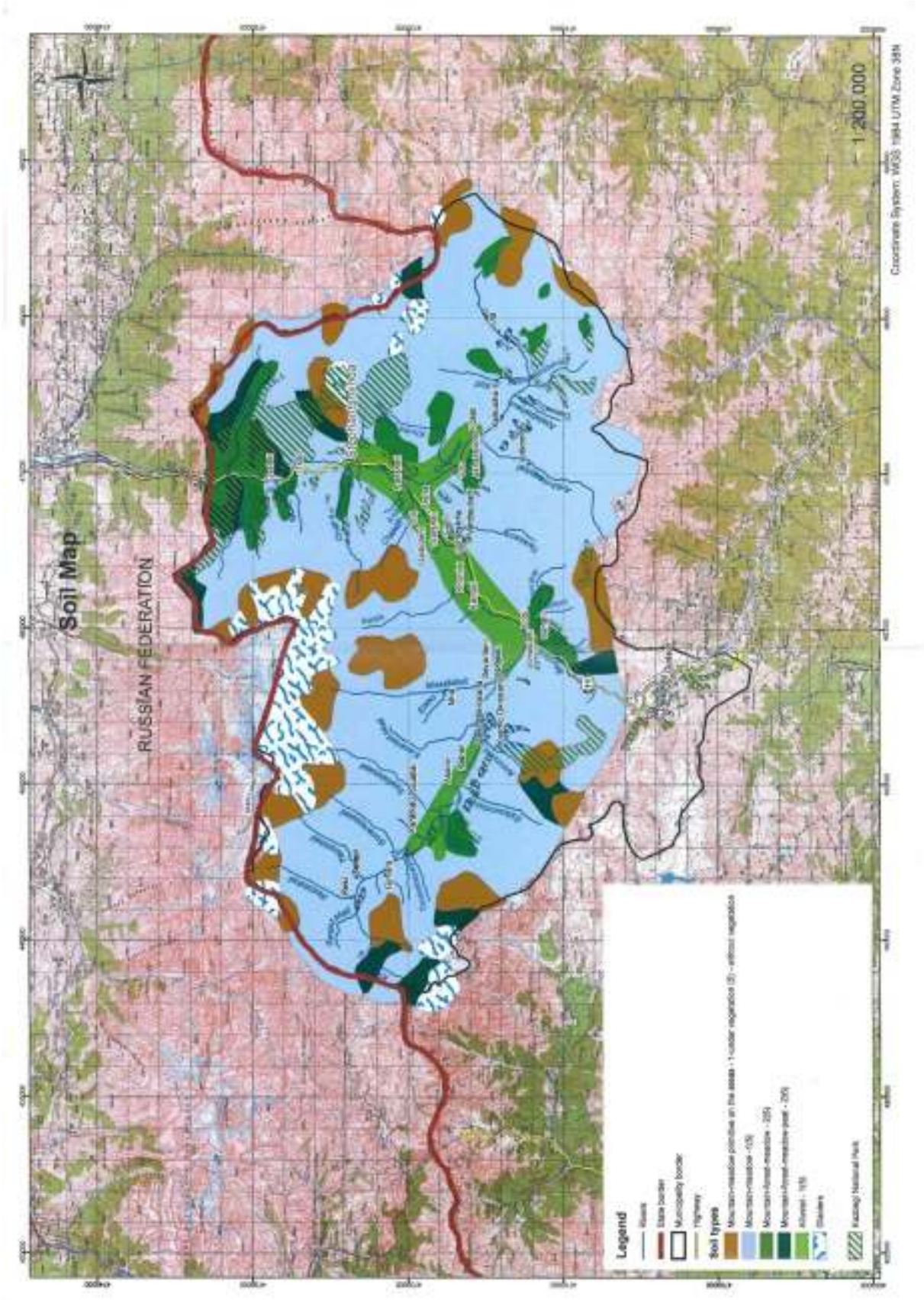
Picture 5: Geology map covering the Kazbegi district, scale not appropriate (Source: Geology Department of Georgia).

3. Identification of the local players/users of the forest sector and land-use and natural resources maps

Table 1 Key for the geology map (Picture 5)

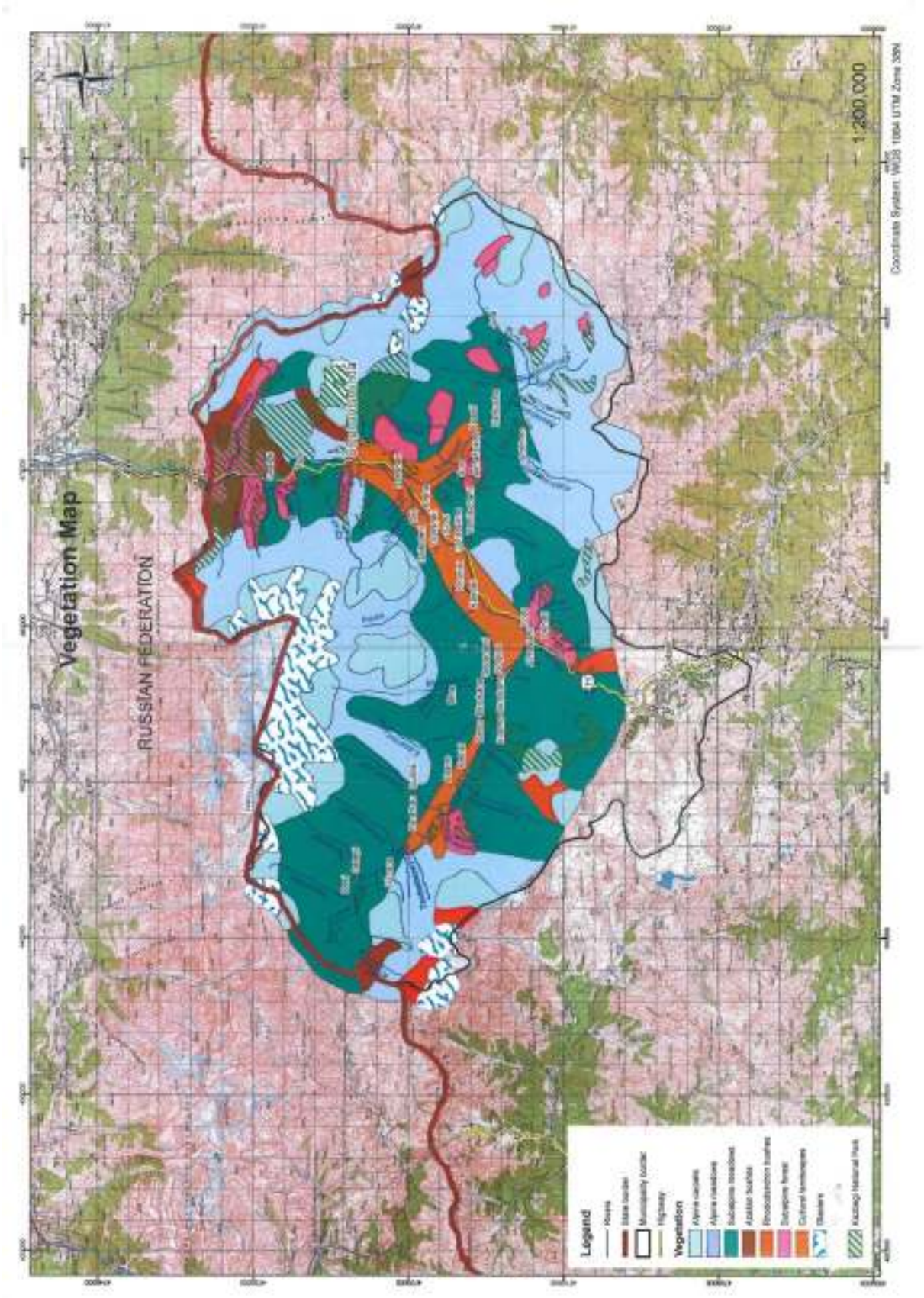
Key 1	Key 2	Geology
alfazetaQ	αζQ	quaternary
apQ	apQ	quaternary, alluvial-proalluvial
betaJ2	βJ2	gabro-diabases, diabase-porphirites, middlearyan granitoids.
gammaN2-Q	γN2-Q	granite-porphyries pliocene-quaternary
gammaPZ32	γPZ32	microcline granites, granodyorites upperpaleosoic (late herzinian)
Glaciers	Glaciers	
J1p	J1p	pliensbachian level. Main ridge and Kazbegi-Lagodekhi zones: slates and schists with interim layers of siltstones and fine sandstones, intraformational conglomerate lenses, toleitbasalt lavas (piloulavas) and pyroclastics. In case of transgressive overlapping (main ridge, Svaneti) basal conglomerates and rough sandstones.
J1s	J1s	synemerian level. Main ridge zone: bazal conglomerates and gravellites, sandstones, siltstones, sanstone turbidites, claly schists, quartzites, in some places lime-alkali rhyiolites and rhyodacite lavas and pyroclastics Kazbegi-Lagodekhi zone (West Racha-Svaneti Part): Bazal conglomerates, clayly schists with rare interim layers of sandstones and siltstones, in some places dacite and rhyolite lavas and voulcanic clastolites, diabase along layer bodies and veins.
J1t	J1t	toarcian level. Main ridge, Kazbegi-Lagodekhi and Chkhalta-Laili zones: black clayly schists, siltstones, rarely intraformational conglomerate lenses and interim layers. In some places - thick layers and massive stacks of limestone.
J2a	J2a	aalenian level. Kazbegi-Lagodekhi zone: black clayly schists with clayly siderite concretions and interim layers of sandston turbidites. In the bottom part of the section in some places basaltes and their pyroclastolites.
J2b	J2b	bajocian level. Mestia-Tianeti zone (Ksani-Arakali Parautochthonics), Gagra-Java Zone, Georgian belt and Lok-Karabagh zone: lime-alkali basaltes, andesite-basalt, andesite, more rareli dacite and rhyolite lavas, lava breccias and pyroclastolites, tufites, in some places tefroturbidites and tefroargilites, and in top part of the section - tufa-conglomerates, tufasandstones, tufa-siltstones, conglomerates, sandstones and clays (porphirate series)
J2b+bt	J2b+bt	bajocian an bathonian levels.
J3km+tt	J3km+tt	kimmeridgian and tithonian levels.
J3O2	J3O2	oxfordian level upper sublevel. Mestia-Tianeti zone: clastic-limeston flysch. Clastic-limestone, and rarely sand-gravel gavellite turbidites, pelagic marles and clayly schists
K1b-h1	K1b-h1	beriassian and valangian levels and and lower sublevel hauterivian level. Mestia-Tianeti zone: clastic-limestone and sand-gravel turbidites, pelagic marles, limestones, argillites, clayly schists

3. Identification of the local players/users of the forest sector and land-use and natural resources maps



Picture 6: Soil map covering the Kazbegi district, scale not appropriate (Source: Horizonti Foundation).

3. Identification of the local players/users of the forest sector and land-use and natural resources maps



Picture 7: Vegetation map covering the Kazbegi district, scale not appropriate (Source: Horizonti Foundation).

4. ECOLOGICAL CHARACTERISATION OF THE TREE AND SHRUB SPECIES AND OVERVIEW OF FLORA AND VEGETATION (HABITAT ASSESSMENT ACCORDING TO NATURA 2000)

Picture 8

4.1. Introduction

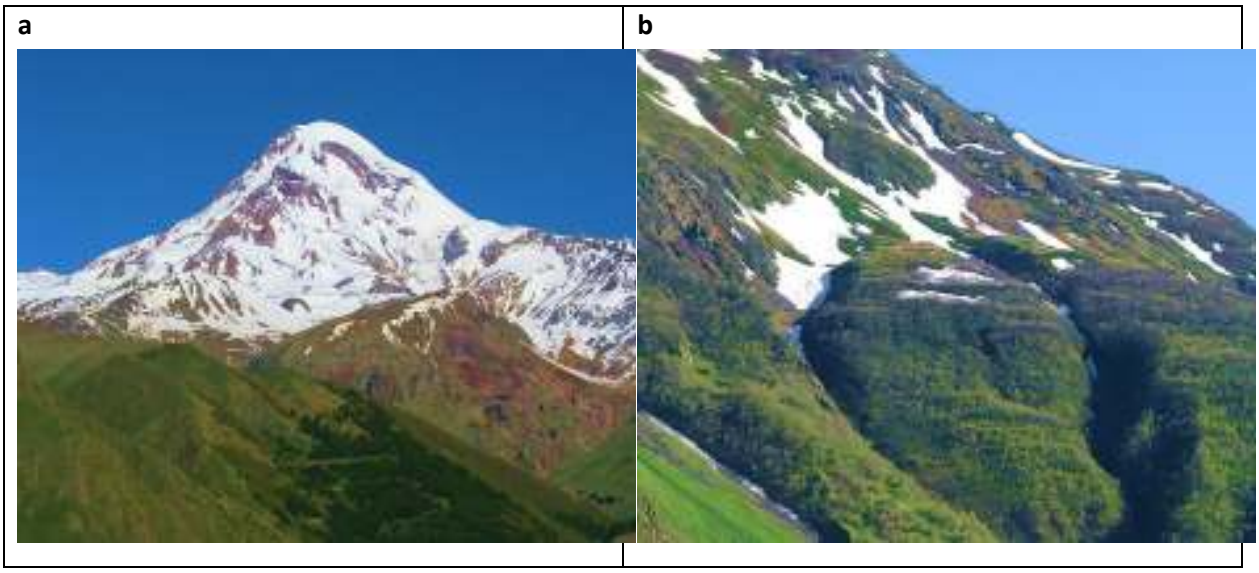
Trees plantation is oriented on species growing in the area of Kazbegi district and it will be acceptable to determine their characters where can grow these trees. The significance of tree planting will be oriented on protection of slopes erosion and trees can be growing in degraded areas. Other interest will be for human population of this area to use the non-wood forest products. Therefore, the planted trees should be containing some resources.

In the mountains of Georgia, within the forest belt, three sub-zones can be outlined: low-mountain, mid-mountain and high-mountain (from 500 to 1,900 m.a.s.l.). Polydominance is one of the most striking features of mountain forests. Timberline today varies in altitude between 2,200 - 2,750 m, but almost everywhere it has been lowered by man. In the western part of the Greater Caucasus the upper limit of woody vegetation is decreased to 350-400 m, whereas in central and eastern parts - to 500-600 m. The same situation is in the Lesser Caucasus. Due to the impact of anthropogenic factors,

the forest vegetation of the Kazbegi region (eastern part of the Central Caucasus) has almost completely been destroyed. The Kazbegi region is located just north of the main watershed for the Central Greater Caucasus Mountains, in the valley of the Tergi River (42.489N; 44.399E) near the Russian border. This range is one of the most geomorphologically complex, high-mountain ecosystems of this region and is composed of alternating ridges and valleys that extend from the valley flow to the higher peaks above (e.g., Kazbegi) in an east-west direction.

Project Implementation Territories are located in Kazbegi District, which is situated in the north of the main watershed for the Central Greater Caucasus Mountains, in the valley of the Tergi River (42°48´N; 44°39´E) near the Russian border. The elevations of these mountains range between ~1,210 and 5,033 m (highest peak is Mt. Mkinvartsveri, or Kazbegi) with a mean elevation of 2850 m. The geology of Kazbegi District mainly contains the Palaeozoic schist of sediment rocks and Jurassic limestone and marl rocks. A great role in its geology is also played by igneous rocks. Soils of this area consist of Jurassic rocks, Palaeozoic and older granites, along with younger lava and moraine deposits. The main soils in the region are mountain-meadow. About 50 soil types have been described on the territory of Georgia and the following specific soil types are found at subalpine zones: 1) mountain-forest brown skeleton soils of middle and small depth; 2) mountain-forest light brown skeleton soils of middle and small depth; and 3) degraded forest and secondary meadow soils.

The main river of the district is Tergi with its right tributaries Snotskali (Gudushauris Aragvi), Esikomi, Armkhi, Arkhadoni, Bidara, Desikomidoni and Brolistskali (Khdistskali) and left tributaries Amali, Tifidoni, Chkheri, Chkhati, Suatisi, Mniasistskali, Kesia, Resistskali, Kabakhi, Jimaristskali and Devdaraki. Three rivers are originated from glaciers on Mt. Mkinvartsveri: R. Chkheri – Ortsveri; R. Khdistskali – Kibishi; R. Devdaraki - Devdaraki. The climate of the Kazbegi district is conditioned by the rugged topography, vicinity of glaciers and high altitude. Along with the vertical zonality the air temperature and precipitation vary. The average annual temperature is 4.9 °C. January is the coldest month with an average temperature of –5.2 °C and the lowest temperature is –30 °C. The maximum average temperature of the warmest months (July and August) is about 14.4 °C (the highest temperature is 30 °C). The annual precipitation is 1,000-1,200 mm. During a year, one maximum precipitation is in May-June (100-200 mm) and one minimum in January (50-60 mm). Stable snow cover persists for 5–7 months from November to May and reaches its maximum depth (115–120 cm) in March. Fog is frequent in this zone (135 foggy days per year), especially in the summer. Winds of the mountain-gorge type prevail.



Picture 9: a) Kazbegi Mountain 5,033 m; b) *Betula litwinowii* forest with treeline at 2,500 m in Kuro Mountain.

4.2. **Tree and shrub species for planting in the forest**

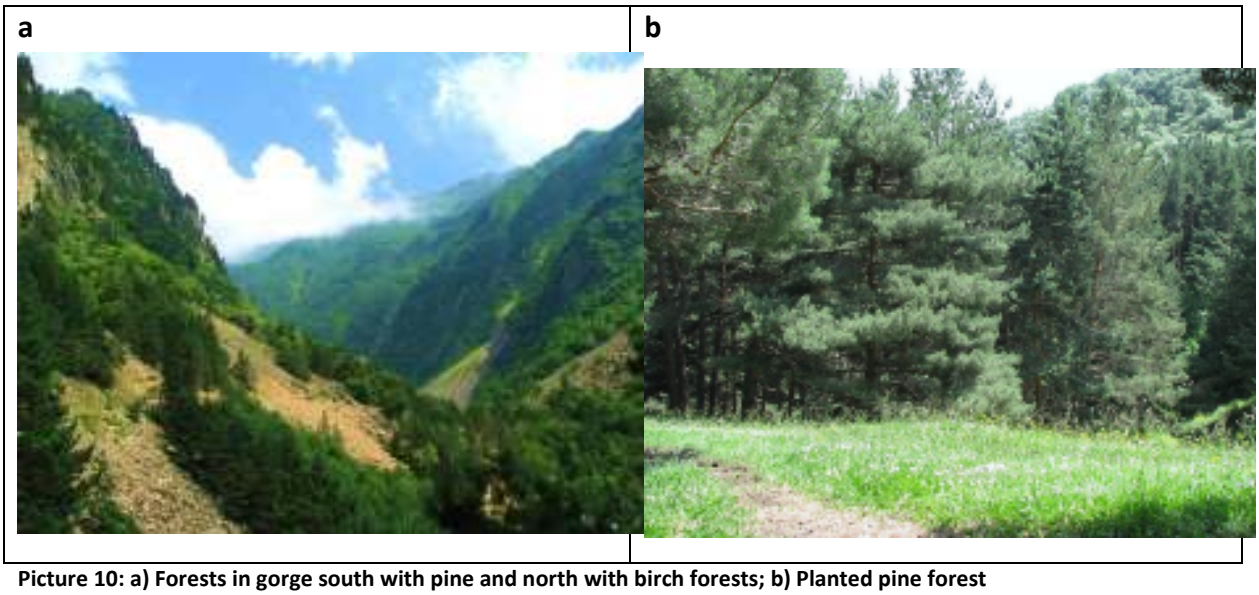
The task was to determine the tolerances of the existing trees regarding soil, subsoil, slope, orientation, altitude range, water availability and exposition to sun.

Kazbegi district contains two forest habitat types: birch and pine forests. First, subalpine birch forest is dominated by *Betula litwinowii* Doluch. growing from 1,700 to 2,550 m only on north facing slopes (10-25° inclination) and it has no possibility to grow on E, W and S slopes. This forest contains other trees growing in the same habitat and they are oriented again to northern slopes. These trees are: *Betula raddeana* Trautv., *Populus tremula* L., *Salix caprea* L., *S. kazbekensis* A. K. Skvortsov, and *Sorbus caucasigena* Kom. ex. Gatsch. At the treeline ecotone to birch forest trees are added subalpine shrubland with dominant species *Rhododendron caucasicum* Pall., distributed from 2,100 to 2,900 m. Other shrubs are *Vaccinium myrtillus* L., *V. vitis-idaea* L., *V. uliginosum* L., *Empetrum caucasicum* Juz., *Daphne glomerata* Lam., Skvortsov and *Juniper sabina* L. Two krummholz trees are added to the subalpine scrubland - *Betula litwinowii* and *Salix kazbekensis.* Additionally subalpine forest contains herbs and grasses - *Aconitum nasutum, A. orientale, Anemone fasciculata, Aquilegia caucasica, Calamagrostis arundinacea, Campanula latifolia, Caphalanthera longifolia, Cicerbita racemosa, Daphne glomerata, D. mezereum, Dolichorrhiza caucasica, D. renifolia, Festuca drymeja, Geranium sylvaticum, Heracleum roseum, Lathyrus roseus, Polygonatum verticillatum, Senecio propinquus, Swertia iberica, Vicia balansae, Gymnadenia conopsea, Platanthera montana.*

Second, pine forest is with dominant species *Pinus kochiana* Klotzsch ex K. Koch. located on E, W and S slopes and growing on rocks from 1,500 to 2,300 m (10-35° inclination). This forest contains only one another tree - *Salix kuznetzowii* Laksch. ex Goerz and shrubs - *Juniper sabina, J. depressa, Berberis vulgaris* L., *Hippophaë rhamnoides* L. Herbal cover is represented by - *Parietaria judaica, Anthemis marschalliana* subsp. *marschalliana, Saxifraga cartilaginea, Saxifraga juniperifolia, Asplenium septentrionale,* etc.

Climate in this area contains annual temperature data as follows: maximum air temperature, 29.2°C; minimum air temperature, -21.2°C; mean daily maximum of warmest month, 19.8°C; mean daily minimum of coldest month, -8.6°C. Soils are deep and slightly skeletal brown soil. Humus content in the upper 10-20 cm layer is about 7%. Soil pH of birch forest is 5,478±0,38 and at subalpine shrubland 4,7±0,18. Humid north-facing slopes is with stable snow cover and soil moisture is 10.72±1.1 mm, wind ~2,6 m/sec, air moisture ~50%. The range of wavelengths that plants use is called Photosynthetic Active Radiation (PAR) and at 1,850 m, on midday in midsummer the sun can reach around exposition in open space as 1,460 (µmol/m^2/s) and in birch forest understory PAR is lower 80 (µmol/m^2/s), PAR-energy 200 (W/m^2), Global energy 400 (W/m^2). At 2,350 m PAR is 140 (µmol/m^2/s), PAR-energy 25 (W/m^2), Global energy 600 (W/m^2).

Fragments of mountain forests primarily remain in the northern part of Kazbegi district, namely, in the Khde gorge. As a rule, these are mixed forests, mainly with very small numbers of tree individuals as Caucasian oak (*Quercus macranthera*), beech (*Fagus orientalis*) and maple trees (*Acer trautweterii*), also remains birch subalpine forest on north slopes with birch (*Betula litwinowii, B. raddeana*), ash (*Sorbus aucuparia)*, aspen (*Populus tremula),* willow (*Salix caprea, S. kazbekensis, S. kuznetzowii*), and several shrubs Spirea *(Spiraea hypericifolia)*, sea-buckthorn (*Hippophaë rhamnoides*), barberries (*Berberis vulgaris*), rose (*Rosa canina*), etc. As well, there remained pine forest on rocks with native species (*Pinus kochiana*) and some pine forests are planted.



Picture 10: a) Forests in gorge south with pine and north with birch forests; b) Planted pine forest

In particular, this area has one of the greatest diversity of endemic species for any mountain region worldwide. The vegetation diversity is primarily conditioned by genetically totally different landscapes and specific local natural conditions, namely the very complex dissected relief and hence the diversity of habitats. The vegetation varies from one gorge to another gorge, also between different vertical zones. Forests, bush and shrub vegetation have been under high anthropogenic impact for a long time, first of all by overgrazing and firewood consumption. Therefore forests and alpine bush vegetation are to a very high grade degraded and remained just in hardly accessible and in strictly protected areas. Pine and Poplar species have been used for reforestation on several small

sites, some with quite good success. All together less than 10,000 hectares are still under forest cover at present.

The accepted trees for planting are several 5 species – *Pinus kochiana, Populus tremula, Fagus orientalis, Quercus micranthera* and *Sorbus aucuparia* and the list shows the direction in which the tree is acceptable. Other tree species are not good oriented to be planted in degraded areas and they have much information on correction with climate, biota's, soil etc. These species are growing in special areas oriented on exposition and elevation of the degraded areas and it will be depended on their position. E.g. these species: *Betula litwinowii, B. raddeana, Salix caprea, S. kazbekensis, S. kuznetzowii* etc. are oriented on north slopes or growing on shadowing areas. Other species, *Acer trautvetteri* and *Quercus micranthera* is oriented on south slopes till treeline. Therefore, it should be determined which trees might be planted in degraded areas of the high mountain region of Central Great Caucasus. Otherwise, some shrubs - *Berberis vulgaris, Hippophae rhamnoides, Juniperus communis* var. *depressa, J. sabina, Ribes biebersteinii, Rosa canina* and *Spiraea hypericifolia*, are possible to be planted and they are for edible or medicinal use as resources to be used by local population of Kazbegi. Additionally, two tree species – *Pyrus caucasica and Malus orientalis* are good used as resources and are planting well in many habitats including subalpine zone but not growing in Kazbegi district area. However, some pear and apples varieties are growing in villages of Kazbegi district.

The pine and birch forest habitats are degraded by cutting and fires historically in the Kazbegi district. Reforestation of birch forest is very difficult and last periods were planted only pine and common aspen trees near Stepantsminda. Natural reforestation of birch forest is starting last period after suspended the grazing and agriculture. Birch seeds are located in soil in many areas and the seed germination is possible only at northern slopes. Seed germination of all tree species is oriented on soil humidity, minerals and mycorrhizal fungi. However, there are no investigations on soil quality supporting seed germination and seedling growth program. So far two trees planting (*Pinus kochiana* and *Populus tremula*) are possible to do by supporting nursery materials. Support to birch forest natural restoration needs more investigations and reforestation time will be 20-30 years and there is no possibility to planted birch trees.

4.2.1. *Pinus kochiana* Klotzsch ex K. Koch, კავკასიური ფიჭვი, Caucasian pine, Pinaceae

Site characteristics: Caucasian pine trees growing in slopes with all exposition and are oriented as well on high inclination till 90^0. Natural habitat of this species is oriented on rocks and as well on other slopes with different geological rocks. The elevation is from 0 to 2,100 m.a.s.l. Caucasian pine tree up to 35 m tall and only to 15-20 m high in Kazbegi high mountain areas. Snow cover is <0.3 m. Sunny edge is low on North Slope; dappled shade is more not only on North Slope: North Wall, East Wall, and West Wall. Suitable for: light (sandy) and medium (loamy) soils, prefers well-drained soil and can grow in nutritionally poor soil. Suitable pH: acid, neutral and basic (alkaline) soils and can grow in very acid and very alkaline soils. It can grow in semi-shade (light woodland) or no shade. It prefers dry moist or wet soil and can tolerate drought. The plant can tolerate maritime exposure. It can tolerate atmospheric pollution.

Other, planted pine species are migrated from Russia in Kazbegi in 1970s and this is mainly *Pinus sylvestris* L. and some other individuals' *P. nigra* subsp. *pallasiana* (D. Don) Holmboe. These planted species are in all regions, from the subarctic to the forest steppe zone, it forms pure pine forests in the mountains, on sandy soils of the plains and mixed forests on loamy soils and podzols.

Picture 11: a) *Pinus kochiana* forest; b) Male cone; c) Female cone.

Reproduction and growth characteristics: Caucasian pine tree with whorled branches and two types of shoots: long shoots appearing in spring and becoming woody, and dwarf shoots growing from the axils of scale-like leaves and also bearing scale-like and true acicular leaves, in clusters of two, three, or five. Caucasian pine has crown wide, twigs spreading and directed upright. Bark dark greyish-dark browns or dark browns.

Needles greyish-green, margins fringed, 3.5-5 or 5-8 cm long, to two, rarely to three of tree. Leaves in clusters of two or three;

Male cone is round or oblong-cylindrical, clustered into globose or broadly ovoid racemes. Male strobilus develops at the base of young long shoots in the axils of scale leaves. Female cones woody, maturing in two to three years, bract scales coriaceous, shorter than the broad ovuliferous scales; seeds winged, less often nut-like, wingless.

Female cones opening at seed maturity; mature female cones 3-7 cm long, dull, light brown or gray 6 seeds winged 4. Seed cones ovate, solitary, pink-brown or yellowish when mature, glossy, directed horizontally or upright. Seed scales with pyramidal and hooked apophysis. Seed obovate, acute, 4.5

mm long, wing with brown stripes. Needles persisting for four to eight years, yellowing in winter, 3—3.5 cm long; cones 3—3.5 cm long.

Flowering period of this species is April-May and seeds are matured in September-October. It forms woods forests or grows as single trees on rocks, reaches tree line.

Ecosystem services: Pine is an umbrella species for squirrel. Umbrella species determines conservation of other species in the habitat conditions where there are species communities and one umbrella species will have a protection due to their conditions. It is oriented on mycorrhizas and pH is lower 4-5. Non-wood products are seeds used as recourses in Italian food and people can use this as resources. Pine has quite a wide range of medicinal uses, being valued especially for its antiseptic action and beneficial effect upon the respiratory system. It should not be used by people who are prone to allergic skin reactions whilst the essential oil should not be used internally unless under professional supervision. The turpentine obtained from the resin is antirheumatic, antiseptic, balsamic, diuretic, expectorant, rubefacient and vermifuge. It is a valuable remedy in the treatment of kidney, bladder and rheumatic affections, and also in diseases of the mucous membranes and the treatment of respiratory complaints. Externally it is used in the form of liniment plasters and inhalers. The leaves and young shoots are antiseptic, diuretic and expectorant. They are harvested in the spring and dried for later use. They are used internally for their mildly antiseptic effect within the chest and are also used to treat rheumatism and arthritis. They can be added to the bath water for treating fatigue, nervous exhaustion, sleeplessness, skin irritations. They can also be used as an inhalant in the treatment of various chest complaints. The essential oil from the leaves is used in the treatment of asthma, bronchitis and other respiratory infections, and also for digestive disorders such as wind. An essential oil obtained from the seed has diuretic and respiratory-stimulant properties. The seeds are used in the treatment of bronchitis, tuberculosis and bladder infections. A decoction of the seeds can be applied externally to help suppress excessive vaginal discharge. The plant is used in Bach flower remedies - the keywords for prescribing it are 'Self-reproach', 'Guilt feelings' and 'Despondency'. The essential oil is used in aromatherapy. Its keyword is 'Invigorating'.

A tan or green dye is obtained from the needles. The needles contain a substance called terpene, this is released when rain washes over the needles and it has a negative effect on the germination of some plants, including wheat. A reddish yellow dye is obtained from the cones. This tree yields resin and turpentine. Oleo-resins are present in the tissues of all species of pines, but these are often not present in sufficient quantity to make their extraction economically worthwhile. The resins are obtained by tapping the trunk, or by destructive distillation of the wood. In general, trees from warmer areas of distribution give the higher yields. Turpentine consists of an average of 20% of the oleo-resin and is separated by distillation. Turpentine has a wide range of uses including as a solvent for waxes etc. for making varnish, medicinal etc. Rosin is the substance left after turpentine is removed. This is used by violinists on their bows and also in making sealing wax, varnish etc. Pitch can also be obtained from the resin and is used for waterproofing, as a wood preservative etc. An essential oil obtained from the leaves is used in perfumery and medicinally. A fibre from the inner bark is used to make ropes. The roots are very resinous and burn well. They can be used as a candle substitute. The leaves are used as a packing material. The fibrous material is stripped out of the leaves and is used to fill pillows, cushions and as a packing material. Trees are very wind resistant and quite fast growing. They can be planted as a shelterbelt, succeeding in maritime exposure. Wood -

light, soft, not strong, elastic, durable, rich in resin. Used in construction, furniture, paper manufacture etc. A good fuel but it is somewhat smokey.

Thrives in a light well-drained sandy or gravelly loam. Trees grow well on poor dry sandy soils. Fairly shade tolerant. Prefers a light acid soil, becoming chlorotic at a pH higher than 6.5. Trees can succeed for many years on shallow soils over chalk. Tolerates chalk for a while, but trees are then short-lived. Tolerates some water-logging. Dislikes poorly drained moorland soils. Established plants tolerate drought. Very wind resistant, tolerating maritime exposure. Tolerates atmospheric pollution. Fairly long-lived, to 200 years or more and quite fast growing, but trees are very slow growing in wet soils. Young trees can make new growth of 1 metre a year though growth slows down rapidly by the time the tree is 18 metres tall. This species is extensively used in cool temperate forestry as a timber tree. Plants are strongly outbreeding, self-fertilized seed usually grows poorly. They hybridize freely with other members of this genus. Cones take two seasons to ripen. Plants are easily killed by fire and cannot regenerate from the roots. A good food plant for the caterpillars of several species of butterflies. This tree has over 50 species of associated insects. Leaf secretions inhibit the germination of seeds, thereby reducing the amount of plants that can grow under the trees. There are several named forms selected for their ornamental value. Plants in this genus are notably susceptible to honey fungus.

It is best to sow the seed in individual pots in a cold frame as soon as it is ripe if this is possible otherwise in late winter. A short stratification of 6 weeks at 4°C can improve the germination of stored seed. Plant seedlings out into their permanent positions as soon as possible and protect them for their first winter or two. Plants have a very sparse root system and the sooner they are planted into their permanent positions the better they will grow. Trees should be planted into their permanent positions when they are quite small, between 30 and 90 cm. We actually plant them out when they are about-10 cm tall. So long as they are given very good weed-excluding mulch they establish very well larger trees will check badly and hardly put on any growth for several years. This also badly affects root development and wind resistance. Cuttings. This method only works when taken from very young trees less than 10 years old. Use single leaf fascicles with the base of the short shoot. Disbudding the shoots some weeks before taking the cuttings can help. Cuttings are normally slow to grow away.

Geographic distribution: *P. kochiana* is native to Caucasus, additionally in Chaneti of Asia Minor Turkey territory of Caucasus ecoregion.

4.2.2. *Fagus orientalis* Lipsky, წიფელი, Beech, Fagaceae

Site characteristics: It represents one of the main components of deciduous forests. Grows up to between 1900 and 2200 m. It forms krumholz at treeline in 2,200-2,380 m.a.s.l., 20-56 m tall tree, with smooth light gray bark. Snow cover is <1 m. The exposition is for all directions and inclination till 40°. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Suitable for: light (sandy) and medium (loamy) soils and prefers well-drained soil. Suitable pH: acid, neutral and basic (alkaline) soils. It can grow in full shade (deep woodland) semi-shade (light woodland) or no shade. It prefers dry or moist soil.

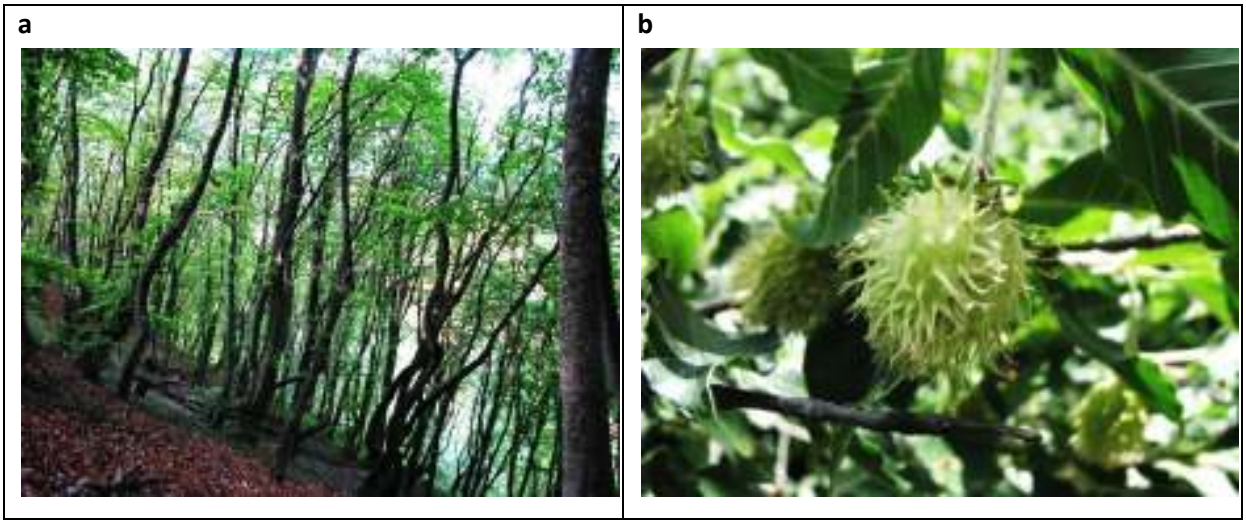
Reproduction and growth characteristics: Trees with smooth gray bark; leaves alternate, coriaceous, lustrous, entire or sometimes sparingly toothed, pubescent on the margin and along the veins beneath. Bark smooth, grey. Leaves alternate in two rows, 5-12 cm long, elliptic, sometimes ovate, narrows towards the base, acuminate. Upper surface glabrous and dark green, lower more pale, petiole and veins covered with long soft hairs.

Leaves in 2 ranks, elliptic or ovate -elliptic, acuminate, rounded or more or less cuneate at base, (1.7-) 5-15 (-20) cm long, (1.3-) 2.4-8 (-11.6) cm broad, apprised pubescent beneath especially along the veins; Perianth of staminate flowers broadly campanulate, its lobes broad-ovate or almost round (very rarely elongate lanceolate), (0.6) 0.8 - 3 (3.6) mm long, about as long as or shorter than the perianth tube, this (l) 1.4-4 (-4.4) mm long, often with a black spot at apex, the margin beset with black or white hairs; stamens to 12, (0.3-) 1-6.8 (-7.6) mm, anthers (0.8) - 1 -2 mm long; appendages of involucre of two kinds, the lower ones leaflike, green, many-nerved, (2.6) -4.2 - 15 -(17) mm long and 0.4-2-(4) mm broad, the upper ones subulate, (1.2) -2 -6.8 -(8.2) mm long; stalk of involucre (0.9) 1.4-4.5 - (9- 7) cm long, appressed-pubescent; nut triquetrous, (1.2) 1.3 - 1.9 (2.2) cm long, (0.5) 0.6-1 (l . 15) broad, not exceeding the involucres. Perianth of the staminate flowers broadly bell-shaped. Pistillate flowers give rise to 2-3 edging nut, enclosed within hard bur covered with bristle-like outgrowths. It opens along 4 sutures when mature. Flowers unisexual, monoecious, with a simple inconspicuous perianth; staminate flowers in many -flowered heads, the perianth 5-lobed; stamens 8-12, at anthesis greatly exceeding the perianth; anthers elongated, obtuse or pointed at base; pistillate flowers 2-4, surrounded by an involucre (cupule); perianth adnate to ovary, with a short 4- or 5-lobed limb; ovary inferior, 3 -locular; styles 3, elongated, hairy; ovules anatropous, 2 in each locule; involucre (cupule) becoming woody in fruit, covered outside with leaflike or subulate appendages; nuts 2—4 in each involucre, sharp-edged; seeds 1 or rarely 2 in each nut; cotyledons reniform.

Flowering in April-May (with appearing of the leaves), fruit are in September-October.

Ecosystem services: The value of beech consists chiefly in its wood. This takes one of the first places as regards caloric value. On dry distillation it yields alcohol and creosote. It is widely used for a variety of woodwork, such as bent (so-called Viennese) cabinet work, oars, shoe lasts, small articles for domestic use, spoons, trays, etc. It is also employed in boat construction (keels) and carriage construction (wheel spokes, etc.). Beech staves are made into containers for oil. For this purpose only so-called "white" beech is used, since "red" beech imparts to the oil a bitter taste and a dark color. These differences in the wood are due to the formation of so-called false heartwood as a result

of fungal infection. Such modified wood (normally no heartwood is produced) becomes permeated with tannic substances that bring about the darkening. In recent times beech wood has been used for the production of railroad ties, which are impregnated with creosote or other chemical compounds. Wood with strongly developed false heartwood impedes the penetration of chemicals, as cellular pores become blocked by tyloses. Beech nuts contain a considerable amount of valuable oil which is extracted by pressing. Apart from its applications for food and burning, this oil is used as adulterant for walnut, poppy, or olive oil. Large yields of seed are not obtainable annually but rather in 5— 10 -year cycles. The foliage provides feed for goats and cattle. It is also used to replace straw as bedding for livestock. The genus attained extensive development in Tertiary formations of both hemispheres, especially in regions of temperate forest flora.



Picture 12: a) *Fagus orientalis* forest; b) Pistillate flowers in May.

Young leaves - raw. A very nice mild flavour, but the leaves quickly become tough so only the youngest should be used. New growth is usually produced for 2 periods of 3 weeks each year, one in spring and one in mid-summer. Seed - raw or cooked. Rich in oil. The seed should not be eaten raw in large quantities. It can be dried and ground into a powder and then used with cereal flours when making bread, cakes etc. An edible semi-drying oil is obtained from the seed.

Thrives on a light or medium soil, doing well on chalk, but ill-adapted for heavy wet soil. Fairly tolerant of most conditions, this is the most successful native species of *Fagus orientalis* in Caucasus. Young trees are very shade tolerant, but are subject to frost damage so are best grown in a woodland position which will protect them. Trees have surface-feeding roots and also cast a dense shade. This greatly inhibits the growth of other plants and, especially where a number of the trees are growing together, the ground beneath them is often almost devoid of vegetation.

Seed - the seed has a short viability and is best sown as soon as it is ripe in the autumn in a cold frame. Protect the seed from mice. Germination takes place in the spring. When they are large enough to handle, prick the seedlings out into individual pots and grow them on in the greenhouse for at least their first winter. Plant them out into their permanent positions in late spring or early summer, after the last expected frosts. The seedlings are slow growing for the first few years and are very susceptible to damage by late frosts. The seed can also be sown in an outdoor seedbed in the

autumn. The seedlings can be left in the open ground for three years before transplanting, but do best if put into their final positions as soon as possible and given some protection from spring frosts.

Geographic distribution: Native to Balkan, Crimea, Caucasus, Asia Minor, Iran.

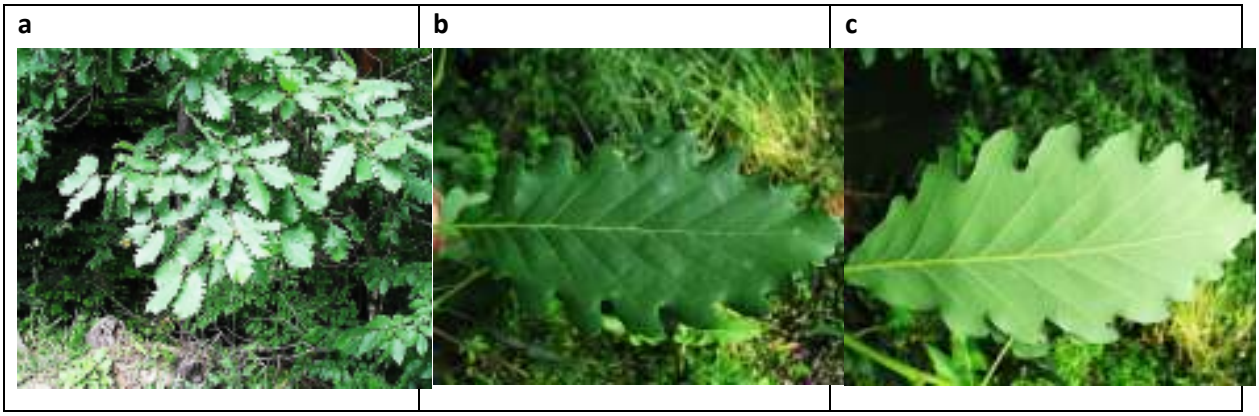
4.2.3. *Quercus macranthera* Fisch. & C.A.Mey. ex Hohen., კავკასიის მუხა, Caucasian oak, Fagaceae

Site characteristics: A hardy and, above all, drought -resistant oak that constitutes the only high-mountain forest-forming species in arid areas of East and South Caucasus. Forming forests in the mountains, on dry, mostly southern slopes, at altitudes between 800 and 2,400 m above sea level. A tree to 20 m, but usually lower, the short stout trunk covered with thick fissured bark. Snow cover is >2 m. The exposition is for all directions and inclination till 60°. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. The wood is used like that of other oaks. The leaves often display very large spherical long-villous galls that need study as to their tannin content. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and can grow in heavy clay soil. Suitable pH: acid, neutral and basic (alkaline) soils and can grow in very alkaline soils.

Reproduction and growth characteristics: Shoots densely shaggy with long yellowish -gray hairs, the 1- and 2 -year old branchlets gradually glabrescent; buds 5-6 mm long, obtuse, ovaloid, with few heavily gray -pubescent scales; stipules to 1.5 cm long, densely villous; leaf petioles 1-2 cm long, subcoriaceous, 6-18 cm, on the average ca. 10 cm, long and 3-12 cm broad, dark green and at first sparingly puberulous above, becoming glabrate with pubescence confined to the veins, yellowish -gray beneath with dense sometimes partly disappearing pubescence, oboval or elongate, commonly cuneate or rarelytruncate or subcordate at base, with a short obtuse terminal lobe and 8 -12 pairs of short, obtuse entire or coarsely toothed lateral lobes, the sinuses one-fifth to one-sixth the breadth of the blade; the lobes sometimes longer, the sinuses thus attaining one -third to one -fourth the breadth of the blade, and then they are commonly narrowed and rather pointed; lateral veins as many as and directed only toward the lobes, straight or arched, parallel, intermediate veins none or 1 or 2 faint ones in the lower part of the blade; Staminate flowers in long pendulous slender -stalked aments; perianth 4-7 -parted (mostly 6-parted) to the middle or almost down to base; stamens 4-12, mostly 6;

Staminate inflorescence to 10-15 cm long, with a densely pubescent peduncle; anthers large, to 1.5 mm long; ovary 3- or sometimes 4-locular, with 2 ovules in each locule, surrounded by a cup-shaped cupule covered outside with numerous scales; styles 3; stigma large, completely covering the upper face of the style; pistillate flowers and fruits 1-5, sessile or borne on a stalk to 2 cm long; Cupule hemispherical, to 1.5 cm long and 1.5-2 cm in diameter, enclosing the acorn to between one-half and one-third; lower scales and those of young fruits somewhat spreading, the middle and upper ones appressed, narrowly lanceolate, gray -pubescent, with a brown glabrous tip; acorns 2-2.5 cm long, initially appressed-pubescent, finally glabrous. Fruit a 1-celled 1-seeded acorn, with rudiments of abortive seeds in upper or lower part; shell of the acorn thin, glabrous within, or else thick 3-layered May.

Flowering in May, fruit are in September-October.



Picture 13: a) Quercus macranthera; b) leaf above; c) leaf below.

Ecosystem services: Most oaks are important and widely distributed species, yielding durable hard lumber used for a variety of purposes. The bark contains tannin and is extensively used for leather tanning; of similar use are the cups of certain species and galls formed by the puncture of insects. The bark of the cork oak and of some other species is the principal source of cork. The acorns are used as a coffee substitute and as feed for swine; in some species they are sweet and edible in raw condition. Many oak species are eminently suited for pleasure-ground, street and avenue planting, etc. and are recommended for extensive ornamental use. The drought resistance of some of the species and their modest soil requirements enable their use for afforestation of arid regions. Fossils of *Quercus* occur in the earliest Cretaceous layers which contain remnants of dicotyledonous plants. Oaks were widely distributed through the Upper Cretaceous and all the Tertiary floras, although the geographical distribution of the sections was quite different than it is at the present time. Oak fossils have also been found in Tertiary formations. Gradual transition to European forms took place in the course of the Tertiary period. Unidentified, reported for many distribution areas in Tertiary and Postpliocene formations, e. g., in the Paleocene. Deserves attention as a valuable tree for afforestation and ornamental planting in the dry parts of Transcaucasia.

Prefers a good deep fertile loam which can be on the stiff side. Dislikes heavy clay. Young plants tolerate reasonable levels of side shade. Found mainly on acid soils in the wild. Thrives in well drained soils but is also tolerant of periodic flooding. Tolerates exposure and strong winds if these are not salt-laden. A very important timber tree in Britain, it is also a food plant for the caterpillars of many species of butterfly, and there are 284 insect species associated with this tree. Trees were often coppiced or pollarded in the past for their wood, though this is best done on a long rotation of perhaps 50 years. The tree flowers on new growth produced in spring, the seed ripening in its first year. Older trees have a thick corky bark and this can protect them from forest fires, young trees will often regenerate from the base if cut down or killed back by a fire. Trees transplant badly unless moved regularly. Hybridizes freely with other members of the genus. Immune to attacks by the Tortix moth. This species is notably resistant to honey fungus.

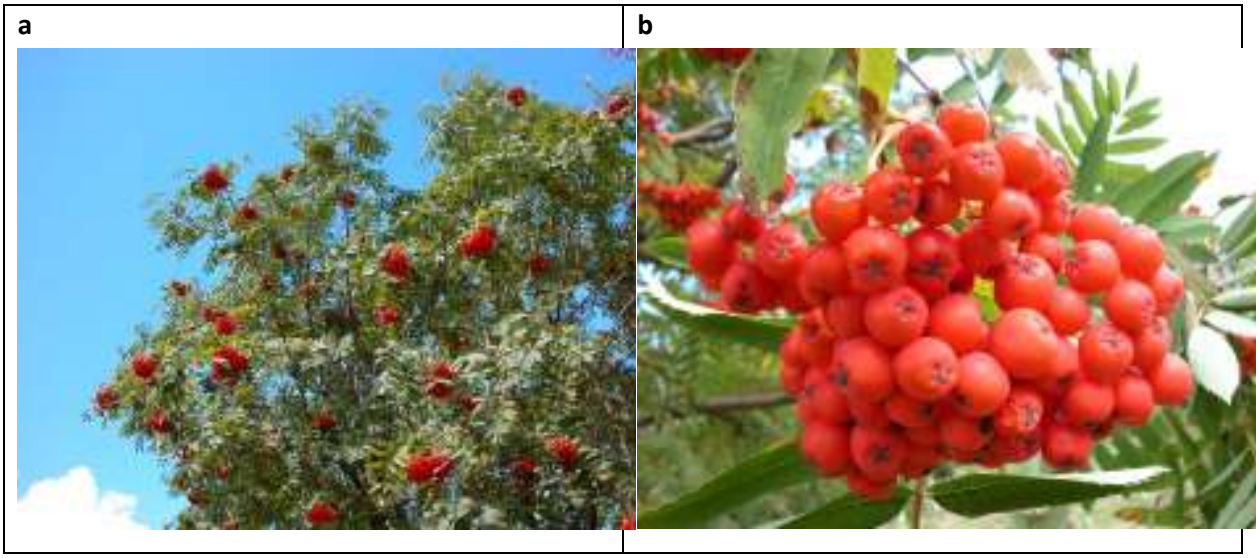
Seed - it quickly loses viability if it is allowed to dry out. It can be stored moist and cool overwinter but is best sown as soon as it is ripe in an outdoor seed bed, though it must be protected from mice, squirrels etc. Small quantities of seed can be sown in deep pots in a cold frame. Plants produce a deep taproot and need to be planted out into their permanent positions as soon as possible, in fact

seed sown in situ will produce the best trees. Trees should not be left in a nursery bed for more than 2 growing seasons without being moved or they will transplant very badly.

Geographic distribution: Caucasus South and Eest, Armenia, Talysh, Dagestan, Iran.

4.2.4. **Sorbus aucuparia L. (=Sorbus caucasigena Kom. ex Gatsch.)** ცირცელი, **Mountain ash, Rosaceae**

Site characteristics: Trees or shrubs, mostly with deciduous stipulate leaves. Grows in subalpine krumholz forests at 1,600-2,400 m.a.s.l., sometimes lower. 4-20 m tall tree or shrub with gray, smooth bark and pubescent young branches. Snow cover is >1 m. The exposition is for all directions and inclination till 30°. Sunny edge not in North Slope for this species; dappled shade is in North Wall, East Wall, and West Wall. Widespread in the Temperate Zone of the northern hemisphere. Forest edges, glades, undergrowth, less often meadows, also rocky or stony sites, riverbanks bluffs, etc.; often planted near houses and in orchards. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils, prefers well-drained soil and can grow in heavy clay soil. Suitable pH: acid, neutral and basic (alkaline) soils and can grow in very acid and very alkaline soils. It can grow in semi-shade (light woodland) or no shade. It prefers moist soil. The plant can tolerate maritime exposure. It can tolerate atmospheric pollution.



Picture 14: a) Sorbus aucuparia in Kazbegi; b) Fruits.

Reproduction and growth characteristics: Crown broad. Bark of the trunk dark brown. buds tomentose; Leaves odd pinnate with 4-7-paired, the leaflets oblong or oblong-lanceolate, entire in lower part, serrate higher, mat-green above, glaucous or grayish below, more or less hairy. Upper surface of the leaflet glabrous, dark green, lower surface glaucescent. Apical leaflet elliptical-lanceolate, middle – lanceolate or oval-lanceolate, asymmetrical, lower leaflets narrow-lanceolate. All leaflets sharply serrate either from base or above the middle of the blade. Inflorescences pubescent, less often inflorescence branches glabrous, 5-10 cm in diameter;

Flowers in more or less many-flowered, corymbiform inflorescences. Flowers white or whitish-rose, in corymb. Flowers 0.8-1.5 cm in diameter, with a rather sharp odor of trimethylamine; Hypanthium

urn-shaped; calyx more or less lanate, later glabrescent, its teeth with glandular cilia on the margin; sepals 5, triangular; petals orbicular or ovate, with or without short claw, white, less often pink. orbicular, 4-5 mm long, the upper surface lanate, pubescent from base; Stamens 20. as long as petals; styles 3 (less often 2, 4, or 5), free, hairy in lower part; Carpels 2-5, adnate by the back to the urn-shaped hypanthium, each carpel with 2 ovules, one of which usually does not reach maturity. Stigma flat, not broader than style. Fruit bright red, subglobose, bright red at maturity, 9-10 mm in diameter narrowly oblong, acute, reddish; seeds usually 3, globose, ovate or pear-shaped. Seeds are oblong, triangular, acute at both ends.

Flowering is in Mai-July, fruits are in September-October.

Ecosystem services: Wood fine-grained, reddish, lustrous, hard, polishes well, furnishes good material for turning and furniture, etc., mainly for machine parts such as blocks, rollers, and cogs, requiring great strength. The bark contains 7.26% tannin compounds, the fruits malic and citric acids, 4 - 8% dextrose, also traces of hydrocyanic acids, (harmless); used for infusions, vinegar, vodka, marmalade, jam, pastilles, etc. The seeds contain 21.9% fatty oils and the glucoside amygdalin; the young branches furnish a black dye. Reproduces in cultivation by roots suckers. The Caucasian *Sorbus* with smooth, rather firm leaves forms "islands" among *S. aucuparia*, and will be separated as an independent species if distinguishing characters can be ascertained. Fruit - raw or cooked.

The fruit is very acid and large quantities of the raw fruit can caused stomach upsets. It can be used to make delicious, if slightly acidulous, jams and preserves; the fruit can also be dried and used as flour mixed with cereals. The fruit is about 7.5 mm in diameter and is produced in quite large bunches making harvest easy. The leaves and flowers are used as a tea substitute. Young leaves are said to be a famine food but they contain a cyanogenic glycoside so you should be very hungry before even thinking of eating them. A coffee is substitute. The report was referring to the fruit; it probably means the roasted seed. The bark is astringent; it is used in the treatment of diarrhoea and as a vaginal injection for leucorrhoea etc.

The fruit is antiscorbutic and astringent. It is normally used as a jam or an infusion to treat diarrhoea and haemorrhoids. An infusion can also be used as a gargle for sore throats and as a wash to treat haemorrhoids and excessive vaginal discharge. The seeds contain cyanogenic glycosides which, in reaction with water, produce the extremely toxic prussic acid. In small quantities this acts as a stimulant to the respiratory system but in larger doses can cause respiratory failure and death. It is therefore best to remove the seeds when using the fruit medicinally or as a food. Both the flowers and the fruit are aperient, mildly diuretic, laxative and emmenagogue. An infusion is used in the treatment of painful menstruation, constipation and kidney disorders. Oil is obtained from the seed. A cosmetic face-mask is made from the fruits and is used to combat wrinkled skin. A black dye is obtained from the young branches. All parts of the plant contain tannin and can be used as a black dye. Trees are very wind resistant and can be used in shelterbelt plantings. Wood - hard, fine grained, compact and elastic. It is highly recommended by wood turners and is also used to make hoops for barrels, cogs and furniture.

Succeeds in most reasonably good soils in an open sunny position. Grows well in heavy clay soils. Tolerates some shade, though it fruits better in a sunny position. Prefers a cool moist position and a lighter neutral to slightly acid soil. Dislikes shallow soils or drought. Succeeds on chalk or acid peats. A

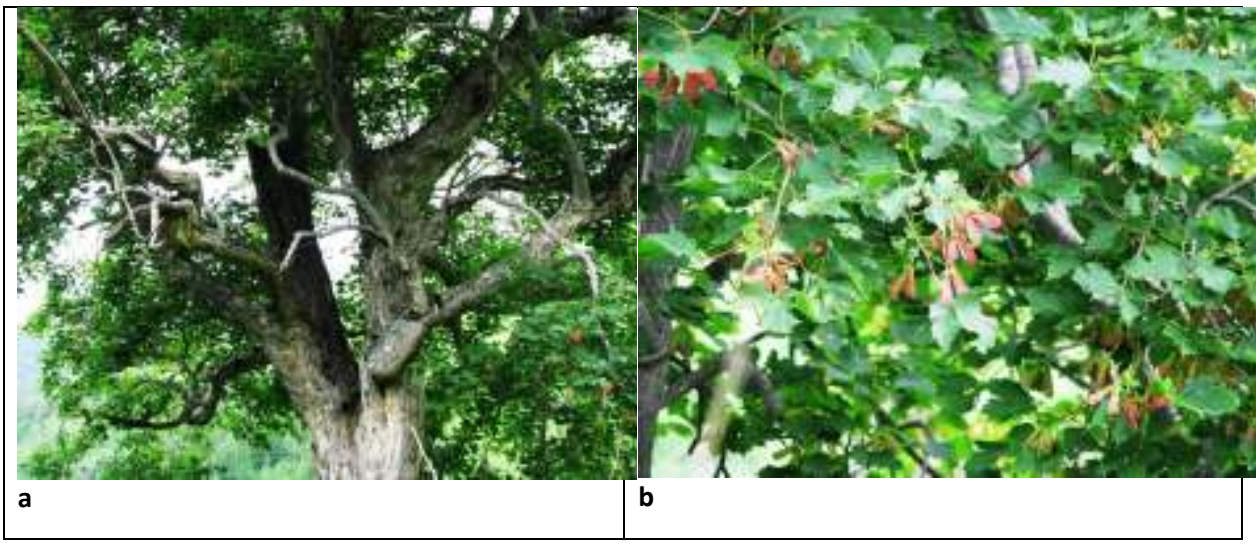
very wind firm tree tolerating very exposed and maritime positions. Tolerates atmospheric pollution. Some named varieties have been developed for their improved fruits which are larger and sweeter than the type. Plants, and especially young seedlings, are quite fast growing. The fruit is very attractive to birds. 28 species of insects are associated with this tree. Responds well to coppicing. Plants are susceptible to fireblight. Special

Seed - best sown as soon as it is ripe in a cold frame. If you have sufficient seed it can be sown in an outdoor seedbed. Stored seed germinates better if given 2 weeks warm then 14 - 16 weeks cold stratification, so sow it as early in the year as possible. Prick out the seedlings into individual pots when they are large enough to handle. Seedlings are very slow to put on top-growth for their first year or two, but they are busy building up a good root system. It is best to keep them in pots in a cold frame for their first winter and then plant them out into their permanent positions in late spring.

Geographic distribution: Native to Caucasus, Europe.

4.2.5. ***Acer trautvetteri*** **Medwed.,** მაღალმთის ბოკვი, *Trautvetter's* **Maple, Aceraceae**

Site characteristics: Trees of average size with broad crown and straight trunk covered with smooth gray bark, but often growing as a knotty sapling or even shrub; Subalpine zone up to 1800-2500 m, more often in community with birch, *Sorbus* and high mountain shrubs; sometimes in the upper belt of spruce-fir forests, near forest edges, extending beyond the area of forest vegetation; occurs individually or colonial. Snow cover is <0.5 m in subalpine forest areas and Snow cover is >2 m in treeline of 2500 m. The exposition is for all directions and inclination till 30°. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall.Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and can grow in heavy clay soil. Suitable pH: acid, neutral and basic (alkaline) soils and can grow in very alkaline soils.



a **b**

Picture 15: a) *Acer trautweterii*; b) Inflorescence a long- pedunculate small corymbiform panicle.

Reproduction and growth characteristics: Juvenile shoots glabrous, brown or reddish-brown; outer bud-scales glabrous, brown, the inner large, carmine-red; leaves 9-14 cm long, 11-16 cm wide, dark green above, glabrous, pale, yellowish beneath, the juvenile hairy, later with tufts of rufous or rust-

colored hairs only at angles of nerves at base of leaves, cordate at base, sometimes base of leaves on short shoots rounded; dissected for into 5 lobes; lobes acuminate, the lateral nearly as long as the terminal, usually declinate outwardly above, the lower small, horizontal or recurved below, irregularly acutely dentate at margin, median lobe nearly always with 2 pairs of large teeth above, lower teeth much larger than the upper, lobes widest at level of teeth, cuneately tapering to base.

Inflorescence a long- pedunculate small corymbiform panicle; rhachis and pedicels glabrous except for base beset with bundles of rufous hairs; bracts up to 1.8 cm long, not deciduous; Flowers usually bisexual, the staminate with or without rudimentary ovary, stamens of pistillate flowers absent or with sterile anthers, plants monoecious or dioecious or polygamous; samaras with elongated wing developing from the outer side of cell; inflorescences racemiform or corymbiform at ends of short branches; flowers ca. 1 cm in diameter, whitish-green; sepals broadly oval; petals nearly as long as sepals, narrower, both hairy at base inside, slightly ciliate at margin; stamens with glabrous filaments; samaras large, 3.5-7 cm long, with vertical wings often partly overlapping each other or slightly diverging, reddish when young, rarely bright carminered , ripe nuts brown, broadly ovoid, inflated, hairy when young, usually glabrous when ripe with internal walls lined with hairs.

Flowering in June. Fruits are in September.

Ecosystem services: A cold-resistant, ornamental plant grown very often in parks. All the species of maple are ornamental trees or shrubs notable for the shapes of the leaves and crowns, especially in the fall when the leaves turn yellow, orange, bronze and red. Good nectar plants. Maple wood possesses all the qualities of good timber: density, uniform structure, durability, well-polished, splitting evenly, finegrained and beautiful color. For these reasons it is widely used in carpentry and woodwork and some species are even used in the building industry. *A. velutinum* and *A. pseudoplatanus* are especially valued for the fine resonant qualities of the timber which is used as sounding boards for musical instruments. They also yield firewood and high-quality charcoal. The sap of the trunk of all species contains sugar, some in such abundant quantity (especially the American species *A. saccharum* Marsh and *A. saccharinum* L. it is made into the popular favorite maple syrup. The species rich in sugar are *A. platanoides* L., *A. pseudoplatanus* L., *A. trautveterii* and *A. tataricum* L. Maple leaves contain properties that yield black, brown and yellow dyes. The leaves are also used to feed cattle. The leaves are packed around apples, root crops etc. to help preserve them. A fast growing plant and bearing clipping well, it makes an excellent clipped hedge and can also be used as part of a native wildlife hedge where it is only trimmed every 3 - 4 years. It has also been used in topiary. Wood - fine-grained, tough, elastic, hard to split, takes a high polish and is seldom attacked by insects. Trees are seldom large enough to supply much usable timber, but when available it is much valued by cabinet makers. It is also used for cups bowls etc. The wood of the roots is often knotted and is valued for small objects of cabinet work. The wood is an excellent fuel. A charcoal made from the wood is a good fuel.

Landscape is in Firewood, Pollard, Screen, Standard, Superior hedge, Specimen, Street tree. Of easy cultivation, it prefers a good moist well-drained soil in a sunny position but tolerates some shade. Does well on chalky soils, tolerating a pH as high as 8, but becoming a shrub in such conditions. Does not thrive in soils with a pH much below 6. Grows well in heavy clay soils. Tolerates atmospheric pollution. Growth is fast once the trees are established, but this later slows down and trees take

about 50 years to reach maturity. Frequently found as a shrub in light woodland, especially under oak. It is one of the first trees to colonize chalk grassland. The field maple is a bad companion plant, inhibiting the growth of nearby plants. A good bee plant. This species has often been coppiced in the past for its wood. Trees produce seed in about 10 years from sowing.

Seed - best sown as soon as it is ripe in a cold frame, it usually germinates in the following spring. Pre-soak stored seed for 24 hours and then stratify for 2 - 4 months at 1 - 8°C. It can be slow to germinate. The seed can be harvested 'green' (when it has fully developed but before it has dried and produced any germination inhibitors) and sown immediately. It should germinate in late winter. If the seed is harvested too soon it will produce very weak plants or no plants at all. When large enough to handle, prick the seedlings out into individual pots and grow them on until they are 20 cm or more tall before planting them out in their permanent positions. Layering, which takes about 12 months, is successful with most species in this genus. Cuttings of young shoots in June or July. The cuttings should have 2 - 3 pairs of leaves, plus one pair of buds at the base. Remove a very thin slice of bark at the base of the cutting, rooting is improved if a rooting hormone is used. The rooted cuttings must show new growth during the summer before being potted up otherwise they are unlikely to survive the winter.

Geographic distribution: Caucasus Mountains, Transcaucasus, Dagestan.

4.2.6. ***Betula litwinowii*** **Doluch., *B. raddeana*** **Trautv., არყი, Birch, Betulaceae**

Site characteristics: These birch species are growing in Upper Mountain and subalpine belts at 1,900-2,500 m.a.s.l. as subalpine birch groves. 15-18 m tall tree. Snow cover is <0.5 m. The exposition is for all directions and inclination till 40°. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Sometimes on rocky or stony slopes. On treeline forms peculiar subalpine krumholz. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils, prefers well-drained soil and can grow in heavy clay and nutritionally poor soils. Suitable pH: acid, neutral and basic (alkaline) soils and can grow in very acid soils. It cannot grow in the shade. It prefers dry or moist soil. The plant can tolerates strong winds but not maritime exposure.

Reproduction and growth characteristics: *B. litwinowii* has stem mostly crooked, crown loose, bark whitish, often slightly roseate. Leaf thin, ovate or ovate-rhomboid, narrows at the base to a wedge-shaped petiole, acute, margins double serrate. leaves ovate or rarely rhombic -ovate, at base rounded or rarely cordate, acuminate, rather sharply toothed on the margin, firm, lustrous above, paler beneath, 4-6 cm long, 2.5-5 cm broad; young leaves and shoot leaves glutinous, rather heavily pubescent, finally pubescent only beneath, with warts in the axils of veins; petiole pubescent, one-fourth to one-half the length of the blade; Petiole 3-4-times shorter than the blade, mostly slightly pubescent. Monoecious. Inflorescence catkin, flowers clustered like cylindrical spike. staminate aments 2 or 3 together at the ends of branches, pendulous, 5-6 cm long; fruiting aments solitary on short 2- or 3 -leaved lateral branchlets, 2.5-3 cm long and 9 -10 mm thick, borne on a pubescent peduncle; bracts 3- 5 mm broad, covered in upper part with short hairs, ciliate on the margin; median lobe elongate -oblong; lateral lobes spreading, broad, round-tipped or obtuse to subtruncate; nutlet oblong-ellipsoid, ca. 2 mm long, the wings 1.5 times as broad as the nutlet and reaching tips of

stigmas. Pistillate catkins are drooping, on 8-12 mm long peduncle. Fruit very small, one seeded samara with lateral wings.

B. raddeana is a small tree, with pinkish, white, or brownish bark; the bark of branches dark brownish, with lenticels; annotinous branchlets yellowish-brown, velutinous, with scattered glands; leaves petiolate, ovate to ovate-oblong, cuneate or rounded at base, acuminate, unequally sharp-toothed on the margin, with 6 or 7 pairs of veins, green and glabrous above, paler and pubescent in the axils of veins beneath, 3-4.5 cm long, 2 -3.5 cm broad, the densely puberulous petiole 10 -15 cm long; staminate aments 2 or 3 together, slender, elongate -cylindric, 2-2.5 cm long and 10 - 14 mm in diameter, the pubescent peduncle 5-6 mm long or rarely longer; bracts caducous, long-cuneate, ca. 8 mm long, puberulous on the margin, the straight oblong or ovate median lobe narrowed toward base, the lateral lobes half to two-thirds as long, oval, acutish to obtusish, slightly divergent; nutlet obovoid, ca. 3 mm long, pubescent at apex, often pointed at base, the wings about as broad as the nutlet.

Both species flowering in April-May, fruits are in July-August.

Picture 16: *Betula litwinowii* forest; b) *Betula litwinowii* leaf; c) *Betula litwinowii* male and female inflorescence.

Ecosystem services: Owing to its quality, the wood provides valuable material for various jobs, especially in carriage construction. The wood of *Betula* differs little in quality from that of *B. litwinowii* and is similarly used in cart construction, etc. Valuable carving material is furnished by the "birch burls," excrescences formed about the root or more rarely on the trunk or on sucker growth. The wood represents a variant of normal birch wood in having irregular twisted annual rings and medullary rays. This wood is highly valued for carpentry and turning jobs and also for veneers.

Considerable use is also made of birch bark, especially in the North, sometimes stitching together two or three layers, use it as waterproof cover for their tents, etc.; to increase its flexibility they sometimes scour it with fat. It is also used for canoes and for tar production. Inner bark - cooked or dried and ground into a meal. It can be added as a thickener to soups etc. or can be mixed with flour for making bread, biscuits etc. Inner bark is generally only seen as a famine food, used when other forms of starch are not available or are in short supply. Sap - raw or cooked. A sweet flavour. It is harvested in early spring, before the leaves unfurl, by tapping the trunk. It makes a pleasant drink. It is often concentrated into a syrup by boiling off the water. Between 4 and 7 litres can be drawn off a mature tree in a day and this will not kill the tree so long as the tap hole is filled up afterwards. However, prolonged or heavy tapping will kill the tree. The flow is best on sunny days following a

frost. The sap can be fermented into a beer. Young leaves - raw or cooked. Young catkins. No more details are given. A tea is made from the leaves and another tea is made from the essential oil in the inner bark.

Anti-inflammatory, cholagogue, diaphoretic. The bark is diuretic and laxative. An oil obtained from the inner bark is astringent and is used in the treatment of various skin afflictions, especially eczema and psoriasis. The bark is usually obtained from trees that have been felled for timber and can be distilled at any time of the year. The inner bark is bitter and astringent, it is used in treating intermittent fevers. The vernal sap is diuretic. The buds are balsamic. The young shoots and leaves secrete a resinous substance which has acid properties, when combined with alkalis it is a tonic laxative. The leaves are anticholesterolemic and diuretic. They also contain phytosides, which are effective germicides. An infusion of the leaves is used in the treatment of gout, dropsy and rheumatism, and is recommended as a reliable solvent of kidney stones. The young leaves and leaf buds are harvested in the spring and dried for later use. A decoction of the leaves and bark is used for bathing skin eruptions. Moxa is made from the yellow fungous excrescences of the wood, which sometimes swell out of the fissures. The German Commission E Monographs, a therapeutic guide to herbal medicine, approve *Betula* species for infections of the urinary tract, kidney and bladder stones, rheumatism.

The bark is used to make drinking vessels, canoe skins, roofing tiles etc. It is waterproof, durable, tough and resinous. Only the outer bark is removed, this does not kill the tree. It is most easily removed in late spring to early summer. A pioneer species, it readily invades old fields, cleared or burnt-over land and creates conditions suitable for other woodland trees to become established. Since it is relatively short-lived and intolerant of shade, it is eventually out-competed by these trees. A tar-oil is obtained from the white bark in spring. It has fungicidal properties and is also used as an insect repellent. It makes a good shoe polish. Another report says that an essential oil is obtained from the bark and this, called 'Russian Leather' has been used as a perfume. A decoction of the inner bark is used to preserve cordage, it contains up to 16% tannin. An oil similar to Wintergreen oil (obtained from Gaultheria procumbens) is obtained from the inner bark. It is used medicinally and also makes a refreshing tea. The resin glands (the report does not say where these glands are found) are used to make a hair lotion. A brown dye is obtained from the inner bark A glue is made from the sap. Cordage can be made from the fibres of the inner bark. This inner bark can also be separated into thin layers and used as a substitute for oiled paper. The young branches are very flexible and are used to make whisks, besoms etc. They are also used in thatching and to make wattles. The leaves are a good addition to the compost heap, improving fermentation. Wood - soft, light, durable. It is used for a wide range of purposes including furniture, tool handles, toys and carving. A high quality charcoal is obtained from the bark. It is used by artists, painters etc. The wood is also pulped and used for making paper.

A very easily grown plant, it tolerates most soils including poor ones, sandy soils and heavy clays. It prefers a well-drained loamy soil in a sunny position. It is occasionally found on calcareous soils in the wild but it generally prefers a pH below 6.5, doing well on acid soils. Fairly wind tolerant though it becomes wind shaped when exposed to strong winds. The silver birch is a very ornamental tree with many named varieties. It also has a very wide range of economic uses. It is a fast growing tree, increasing by up to 1 metre a year, but is short-lived. It is often one of the first trees to colonize open

land and it creates a suitable environment for other woodland trees to follow. These trees eventually out-compete and shade out the birch trees. It makes an excellent nurse tree for seedling trees, though its fine branches can cause damage to nearby trees when blown into them by the wind. Trees take about 15 years from seed to produce their own seed. A superb tree for encouraging wildlife, it has 229 associated insect species. A good plant to grow near the compost heap, aiding the fermentation process. It is also a good companion plant, its root action working to improve the soil. Trees are notably susceptible to honey fungus.

Seed - best sown as soon as it is ripe in a light position in a cold frame. Only just cover the seed and place the pot in a sunny position. Spring sown seed should be surface sown in a sunny position in a cold frame. If the germination is poor, raising the temperature by covering the seed with glass can help. When they are large enough to handle, prick the seedlings out into individual pots and grow them on in a cold frame for at least their first winter. Plant them out into their permanent positions in late spring or early summer, after the last expected frosts. If you have sufficient seed, it can be sown in an outdoor seedbed, either as soon as it is ripe or in the early spring - do not cover the spring sown seed. Grow the plants on in the seedbed for 2 years before planting them out into their permanent positions in the winter.

Geographic distribution: *B. litwinowii* is native to Caucasus, Asia Minor, and Eastern Anatolia. *B. raddeana* is in central part of the Greater Caucasus and Dagestan as endemic species.

4.2.7. ***Populus tremula*** **L., მთრთოლავი ვერხვი, Aspen, Salicaceae**

Site characteristics: Aspen is growing in many different forest habitats and mainly it grows in degraded forest areas. Birch forest as native habitat in Kazbegi contains many individuals of *Populus tremula* in degraded forest successions. It grows from lower to upper mountain belts from 100 to 2,300 m.a.s.l. along riverbanks, in disturbed forests and on open slopes. Aspen tree to 25-50 m high and to 5 m in circumference. The exposition is for all directions and inclination till 30°. Snow cover is <0.5 m. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and can grow in heavy clay and nutritionally poor soils. Suitable pH: acid and neutral soils. It can grow in semi-shade (light woodland) or no shade. It prefers moist or wet soil. The plants can tolerate strong winds but not maritime exposure.

Reproduction and growth characteristics: A fast growing dioecious tree; terminal and lateral buds protected by numerous scales, often profusely resinous; Bark greenish-dark grey, smooth on young tree, later deeply furrowed; Young branches glabrous;

Leaves of short branches orbicular, minutely point-tipped, rather coarsely dentate; Leaves of shoots large, deltoid or deltoid-elliptic, slightly cordate or straight at base, distinctly apiculate, the margins denticulate; expanding leaves ciliate, covered with scattered hairs. Leaves of short shoots are round or rounded-ovate, apiculate, margins coarsely toothed. Leaf is drooping, on long petiole and trembling. Pale green above, glaucous beneath. leaves of branches glabrous or obscurely 179 rounded -deltoid or orbicular, minutely apiculate, with clearly dentate margin; occasional specimens have leaves cuneate at base; stipules soon caducous, whitish, linear; petiole about as long as the leaf blade, strongly compressed in upper part; Leaves of long and root shoots are ovate to deltoid and

apiculate, blade with cordate base, 7 cm long, 8 cm wide, catkins 4 -14 cm long and 2 cm thick, villous;

Flowers clustered into pistillate and staminate catkins. Anthers purplish-red, becoming paler; Ovary pale green, conical, with 2 purple stigmas; Disk pale, glabrous or more or less ciliate on the margin, pedicel very short. Nectariferous glands present at the base of young leaf blades (extranuptial nectaries). Fruit is many-seeded capsule.

Reproduction time is April-May (flowering before the leaves). Fruits are in June-July.

a **b**

Picture 17: a) and b) *Populus tremula* in birch forest.

Ecosystem services: The mycorrhizas are only 4 species and this tree might be growing in degraded soil with little number of biota. Woods of this type, most often at wood margins, clearings, and in places where trees have been broken by the wind, often as part of birch forests or in small pure stands, especially on felling sites, etc., as forerunners of natural reforestation; also gullies, shores, and swamp margins. Generally a species requiring light, but the seedlings prefer a certain amount of shade. This species wood is white, without heartwood, soft, easily cleft, in dry condition rather durable; suitable for paper manufacture (cellulose) for match production (exported in blocks to Japan), for turning roof shingles, hoops, bobbins, rural dishware, etc. The trunks are made in some places into canoes and small boats.

The shavings provide good packing material. The bitter bark is used in tanning and in medicine. The wood contains, in addition to cellulose (ca. 50%) lignin, galactan, and pentosan; yields on distillation 4.17% acetic acid. The bark contains the glucosides salicin and populin, and the enzyme salicase. Easily propagated by seed and within twenty years reaching mature condition at 12 m height. A tree to 20 m high, with rather thin oval or round head; bark smooth, greenish or pale gray, that of old trees dark gray and fissured in the lower part of the trunk; the leaves differing from those of common aspen in the finer and shallower dentation; they are often orbicular, terminating in a small point; catkins so far not studied. The bark and the leaves are mildly diuretic, expectorant and stimulant. The plant is seldom used medicinally, but is sometimes included in propriety medicines for chronic prostate and bladder disorders. Although no specific mention has been seen for this species, the bark of most, if not all members of the genus contain salicin, a glycoside that probably

decomposes into salicylic acid (aspirin) in the body. The bark is therefore anodyne, anti-inflammatory and febrifuge. It is used especially in treating rheumatism and fevers, and also to relieve the pain of menstrual cramps. The plant is used in Bach flower remedies - the keywords for prescribing it are 'Vague fears of unknown origin', 'Anxiety' and 'Apprehension'.

A very fast growing and wind resistant tree, it can be planted to provide a shelterbelt. Trees can also be planted to improve heavy clay soils in neglected woodlands. Wood - very soft, elastic, easily split, rather woolly in texture, without smell or taste, of low flammability, not durable, very resistant to abrasion. It makes a high quality paper and is also used to make a very good charcoa.

A very easily grown plant, it does well in a heavy cold damp soil, preferring a neutral to acid soil, and avoiding calcareous soils. The species generally prefers a deep rich well-drained circumneutral soil. Growth is much less on wet soils, on poor acid soils and on thin dry soils. This species grows well on poor soils, probably because of its intolerance of competition. Plants are very tolerant of exposure, doing well in cold exposed sites so long as sufficient moisture is present. Plants dislike shade, and are intolerant of root or branch competition. A fast growing tree but it is short-lived. Trees produce suckers freely and can form dense thickets. The aspen is a very good wildlife plant; it has over 90 associated insect species and is a food plant for the green hairstreak butterfly. Poplars have very extensive and aggressive root systems that can invade and damage drainage systems. Especially when grown on clay soils, they should not be planted within 12 m of buildings since the root system can damage the building's foundations by drying out the soil. Can be planted to improve heavy clay soils in neglected woodlands. Dioecious. Male and female plants must be grown if seed is required.

Seed - must be sown as soon as it is ripe in spring. Poplar seed has an extremely short period of viability and needs to be sown within a few days of ripening. Surface sow or just lightly cover the seed in trays in a cold frame. Prick out the seedlings into individual pots when they are large enough to handle and grow them on in the old frame. If sufficient growth is made, it might be possible to plant them out in late summer into their permanent positions, otherwise keep them in the cold frame until the following late spring and then plant them out. Most poplar species hybridize freely with each other, so the seed may not come true unless it is collected from the wild in areas with no other poplar species growing. Cuttings of mature wood in Nov./Dec. in a sheltered outdoor bed. The species is rather difficult from cuttings. Suckers in early spring. Root cuttings in winter.

Geographic distribution: Native to Eurasia.

4.2.8. **1) *Salix caprea* L.; 2) *S. kazbekensis* A.K. Skvortsov 3) *S. kusnetzowii* Laksch. ex Goerz., მდგნალი, Willow, Salicaceae**

Site characteristics: These species are in the alpine zone and mainly on north, east and western slopes and not in southern exposition. Wood margins, coppices, and mixed woods. A fast-growing tree of ***S. caprea*** is to 6-10 m tall and to 0.75 m in diameter, or a fairly low arboraceous shrub. It is distributed from 900 to 2,000 m. Snow cover is >0.5-1 m. Grows at edges of the forests and along streams, up to 2,400 m.a.s.l., reaches subalpine krumholz. Snow cover is >2-3 m. The exposition is for all directions and inclination till 70°.

S. kazbekensis is more shrubs till 3 m and growing in alpine zone from 1,900 to 3,300 m. It is growing on rocks, high inclined slopes, near river and lake banks as well in birch forest coasts.Snow cover in subnival zone 2,900-3,300 m is >5-6 m. The exposition is for all directions and inclination till 70°.

S. kusnetzowii is endemic species, 3-5 m high in of the Caucasus and distributed in subalpine coppices, birch and beech woods, at 1,800-2,400 m. The exposition is for all directions and inclination till 30°.

Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and can grow in heavy clay soil. Suitable pH: acid, neutral and basic (alkaline) soils. It can grow in semi-shade (light woodland) or no shade. It prefers dry moist or wet soil. The plant can tolerate maritime exposure. It can tolerate atmospheric pollution.

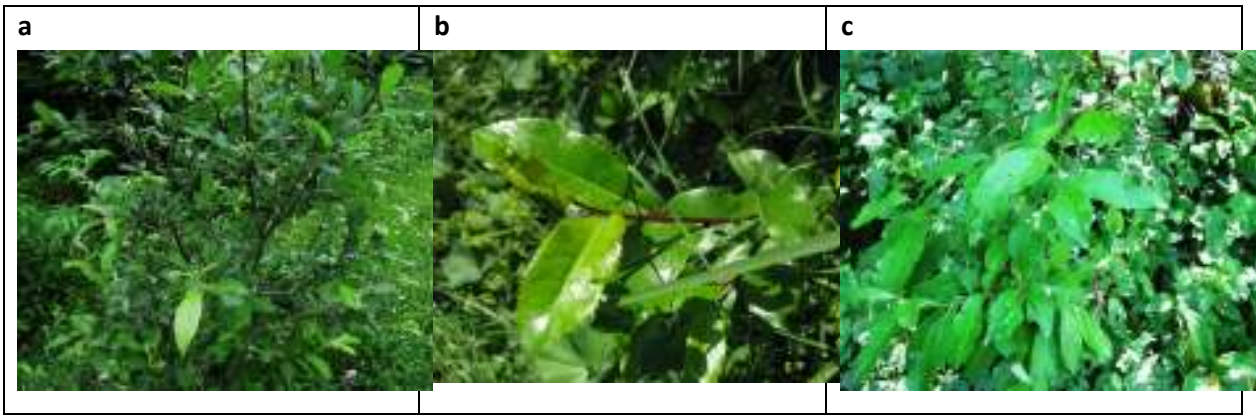
Reproduction and growth characteristics:

Salix caprea has bark smooth, greenish-gray, often splitting near the base of the trunk; exposed wood smooth, without striations, reddening; branches stout, spreading, gray -pubescent when young, at length dark, brown or gray, knotty, brittle; buds very large (especially the flower buds), glabrous, brown, ca. 5 mm long and 3 mm broad; stipules reniform, 4-7 mm long, serrate and lobed, soon caducous; petioles to 2 cm long, sturdy, dilated toward base; leaves varying in size and shape: ovate, suborbicular, subcordate, elliptic, oblonglanceolate, obovate -oblong, or rarely lanceolate, to 11-18 cm long and 5 - 8 cm broad, the margin hairy, irregularly dentate, the upper surface glabrous, rugose, dark green, the lower gray-tomentose, rarely diffusely puberulent or glabrate, with a lurid network of veins; lateral veins 6—9, forming wide round loops at the margin; network of veins prominent, with large alveoles; midrib and lateral veins mostly densely hairy; expanding leaves flat; hairs on the lower surface recurved; young leaves silky -pubescent; catkins precocious, dense, large, the staminate sessile, subtended by few small bracts, 5-6 cm long and 1.6-2 cm broad; pistillate short-stalked, numerous, littering the soil when shedding, in fruit to 10 cm long, the rachis pubescent; scales lanceolate, blackish or dark brown at apex, covered with long white hairs; stamens 2, glabrous (in f. borealis Enand. hairy), 2-3 times as long as the scale; anthers yellow; ovary ovoid -conical, villous -tomentose, the stipe one -half to two -thirds the length of ovary; style short or very short, yellow as the stigma lobes; gland 1, posterior, one-third as long as the stipe. Flowering in April; fruits in May.

S. kazbekensis is depressed or prostrate, with a short, often half-subterranean stem; branches glabrous, lustrous, castaneous, yellowish-brown or greenish-yellow; buds glabrous, small, acute, reddish-yellow; wood under the bark not ridged; stipules semiovate or ovate -lanceolate, small, glandular -dentate, soon caducous; petioles short, glabrous; leaf blades 2-5 cm long and to 2 cm broad, ovate to broadly ovate or oblong to lanceolate, obtusish at apex and at base, remotely dentate to subentire, not blackening, dark green and glossy above, glaucescent or green with a yellow midrib beneath; lateral veins slender and rather inconspicuous; vesture none or young leaves with long hairs, mainly beneath; catkins with or after the leaves, the staminate subsessile, to 2.5 cm long, the pistillate on lateral branchlets, borne on a fairly long leafy -bracted stalk, at first 2-3 cm long, elongating to 5 - 7 cm, upright or spreading, dense; scales elliptic or obovate, obtuse and dark brown at apex, light at base, covered with crisped white hairs, in pistillate flowers covering the ovary

up to the middle; stamens 2, distinct, glabrous; anthers golden-reddish; ovary thickish, ovoid-conical, silky, rarely glabrate, brownish or reddish, subsessile; style one -third the length of ovary, commonly deeply 2 -parted; stigma with linear-lobes; gland 1, posterior, filiform or clavate, about as long as the stipe. Flowering in June. Fruits in June-July.

S. kusnetzowii is a shrub, apparently fairly tall; exposed wood without striations; branches stout, in age ranging from rich brown to dark brown, glabrous, when young tomentose-pilose with white hairs; buds yellowish-brown or fulvous, glabrous or more or less pubescent, to 5 mm long and 4 mm broad, subacute; stipules only at the ends of vigorous shoots, very small, semicordate, densely hairy, sometimes tomentose as the midrib beneath; leaf blades oblong, obovate, or rarely narrowly elliptic, 7-13 cm long and 3-4.2 cm broad, 3-3.5 times as long as broad, the margins entire or irregularly dentate or undulate, somewhat revolute; expanding leaves strongly involute, densely white -tomentose; grown leaves dark green whitish -veined above, more or less glaucescent and grayish-tomentose beneath with recurved hairs; veins very prominent beneath, rather insignificant above; lateral veins 10 - 12 pairs; catkins after the leaves, borne on a leafy -bracted hairy stalk to 2 cm long; staminate ovoid, to 3 cm long; pistillate cylindric, 4-6.5 cm long and 1.5 cm broad, in fruit to 12-14 cm long and 2.5 cm broad, flexuous, loose, interrupted below; rachis densely hairy; scales to 2 -3 mm long, liguliform, light brown, sometimes fulvous at apex, more or less hairy, the staminate more heavily; stamens 2, distinct, hairy at base; anthers oblong, yellow; ovary ca. 5 mm long, white -tomentose, ovoid -conical, the stipe 3- 4 mm long; style ca. 0.5 mm long, reddish-brown; stigma with 4 spreading lobes, ca. 0.5 mm long, reddish-brown like the style; gland interior, oblong, ca. 0.6 mm long; capsule valves helically twisted after dehiscence. Flowering in June; fruits in June-July.



Picture 18: a) *Salix caprea*; b) *Salix kazbekensis*; c) Salix *kusnetzowii.*

Ecosystem services: Family of great economic importance as a source of timber, carpentry wood, fuel, fodder, best, tanning agents, and medicinal products. Many of the arboraceous species make very rapid growth and are easily propagated by cuttings. Not fastidious as regards soil but mostly dependent on good supply of moisture. Willows are of outstanding importance to man, furnishing timber, fuel, and wood for carpentry, material for basket making, tanning agents, and medicaments. They are also of importance as ornamental plants and as a source of fodder for domestic animals. The presence of willow thickets is biologically associated with certain lignivorous ruminants, such as reindeer, red deer, elk, etc., which feed upon the bark, branches, and leaves. The bark is also eaten by hares, squirrels, beavers, and water voles. Certain species of Lagomyidae collect and dry willow leaves. Birds, such as rock ptarmigan, willow grouse, hazel hen, blackcock, etc., feed in winter and

spring upon willow buds and catkins. Willow thickets provide stations for various animals and birds of economic importance that find in them refuge and food. The kinds yielding material for basketry are of outstanding value; they are collected and cultivated both for home use and for export. An outstanding early nectariferous plant. Bark is used as tanning agent (tannin content 5.24 -13.1%) and for production of a black dye. Employed in popular medicine as an astringent remedy for scurvy and fever. The foliage is used as feed for sheep and goats and as an adulterant for tea. Leaves eaten by deer and domestic stock, and buds by arctic partridge and rock ptarmigan. The bark contains up to 8-9% tannins. The twigs are used for charcoal making and for fuel; they are not suitable for wickerwork. The wood is reddish or yellowish -brown, shiny, rather firm and tough; harder, heavier, and more tensile than that of many other European species of willow; it splinters easily. It can be used as firewood, as a source of charcoal, as a component of gunpowder, and as construction timber.

The willow is propagated only by seed. Cuttings are difficult to root. The plant is frost-resistant. It consolidates the soil and is used for planting on slopes. Its hybrids are distinguished by strong growth and are used as rootstocks for weeping varieties. Most species are in subarctic region; alpine and subalpine zone; moss-and-lichen tundra and banks of mountain streams. The stems are very flexible and are used in basket making. The plant is usually coppiced annually when grown for basket making, though it is possible to coppice it every two years if thick poles are required as uprights. The bark is tough and flexible, it is used as a substitute for leather. The bark contains around 10% tannin. The plant is fast growing and tolerant of maritime exposure, it can be used as a windbreak hedge and shelterbelt though it is of untidy habit. The seeds are very light and so can travel some distance in the wind. The plant is therefore able to find its way to areas such as cleared woodland where the soil has been disturbed. Seedlings will grow away quickly, even in exposed conditions and the plant will provide good shelter for the establishment of woodland plants. Thus it makes a good pioneer species and, except in wetter and moorland-type soils, will eventually be largely out-competed by the other woodland trees. Its main disadvantage as a pioneer plant is that it has an extensive root system and is quite a greedy plant, thus it will not help as much in enriching the soil for the other woodland plants as other pioneer species such as the alders, *Alnus* species. Some cultivars can be grown as ground cover. Wood - soft, elastic, easily split. Used for baskets, rugs etc. A good quality charcoal is made from the wood.

Succeeds in most soils, including wet, ill-drained or intermittently flooded soils, but prefers a damp, heavy soil in a sunny position. Grows in drier soils than any other British species of Salix. Rarely thrives on chalk. Plants are found most frequently on basic soils in the wild. Tolerates atmospheric pollution and exposed positions, including maritime exposure. A fast growing tree, it establishes well. The tree has an untidy habit. A light demanding tree, it becomes tall and drawn when grown in woodland, though it grows well along the sunnier edges. Hybridizes freely with other members of this genus. Although the flowers are produced in catkins early in the year, they are pollinated by bees and other insects rather than by the wind. Trees are very tolerant of cutting, they coppice well. Plants in this genus are notably susceptible to honey fungus. Dioecious. Male and female plants must be grown if seed is required.

Seed - must be surface sown as soon as it is ripe in late spring. It has a very short viability, perhaps as little as a few days. Cuttings of mature wood of the current year's growth, November to February in a sheltered outdoor bed or planted straight into their permanent position and given a good weed-

suppressing mulch. Cuttings of this species do not root well. Plant into their permanent positions in the autumn. Cuttings of half-ripe wood, June to August in a frame. Cuttings of this species do not root well.

Geographic distribution: *S. caprea* is in Europe, Caucasus and Central Asia on arctic and mountain areas. *S. kazbekensis* and *S. kusnetzowii* are mainly in Great Caucasus birch forest of high mountain areas.

4.2.9. *Pyrus caucasica* Fed., ბანტა, Caucasian wild pear, Rosaceae

Site characteristics: Grows in lower and middle montane belts, sometimes higher, mainly in broad-leaved forest. Tree to 20-30 m high, sometimes a shrub; Deciduous, sometimes coniferous forests and shrub thickets, in deep soils; sometimes forming pure stands; in the Caucasus from 100 m to 2,000 m. Snow cover is <1 m. The exposition is for all directions and inclination till 30°. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils, prefers well-drained soil and can grow in heavy clay soil. Suitable pH: acid, neutral and basic (alkaline) soils. It can grow in semi-shade (light woodland) or no shade. It prefers moist soil and can tolerate drought. It can tolerate atmospheric pollution.

Picture 19: a) *Pyrus caucasica* planted at 1800 m; b) Fruits are similar to this wild species.

Reproduction and growth characteristics: Crown is of pyramidal form. Branches with or without spines; Young branches glabrous, bark grey, thorny. buds and shoots glabrous, less often pubescent;

Leaves glabrous or densely pubescent at the lower surface, somewhat leathery, upper surface glossy, round or broadly ovate, sometimes oblong, rarely rhomboid, with a long petiole, entire, margins covered with ciliate hairs. petioles about as long as the leaf blade, 2-5-7 cm long, initially moJ*e or less pubescent, later glabrous; leaves 2-5-7 cm long, 1.5-2.5 cm broad, suborbicular or oval, rounded or obscurely cuneate at base, short -tapering, acuminate apex, entire or serrulate or crenate on

whole or part of margin, initially white-arachnoid-pubescent, especially below, later quite glabrous or subglabrous, with a stronger pubescence - masking the teeth - only along the veins and the leaf margin, lustrous green, lighter below, drying black; pedicels 3.5 cm long, pubescent or glabrous;

Flowers white, clustered into corymbs. Flowers 2.5-3 cm in diameter; sepals triangular -lanceolate, densely pubescent like the ovary, erect; petals short -clawed, ca. 1.5 cm long, 1 cm broad; Fruit mostly globose pome, flattened at both poles, glabrous, on long stalk. fruits pyriform or subglobose, very variable in size and shape, to 3-4 cm long, 1.5-2 cm broad, green, sometimes reddening, less often yellow.

Flowering in April- May, fruits from September-October.

Ecosystem services: The Caucasian pear is the ancestor of up to 15 cultivated forms. The most ancient of these, which have changed little, are derived directly from this species; most varieties, however, are the result of hybridization with other species. Pear trees were first cultivated in ancient Georgia, then penetrated into Greece and Italy, and later became widespread in Europe. Wild pear fruits are usually tart, becoming sweeter if stored. They are used in various ways depending on their gustatory qualities: they are eaten raw or dried, stewed, or used for making of drinks (kvass, cider) or as fodder for cattle. The utilization of wild pear fruits is of great importance in Ciscaucasia, where in the Krasnodar Territory alone, according to Trusevich, pear forests with an admixture of apple 261 trees occupy 30,347 hectares, and the possible yield (together with the apples) is estimated at 139 thousand tons. Wild pear fruits contain 70—85% water, 6—13% sugar, 0.1—0.2% acids (mainly citric and malic), 0.29% ash, tannins, etc. The seeds contain 12—21% fatty oils. The wood is heavy, specific gravity 0.72, fine-grained, solid, reddish brown, an excellent imitation of ebony when covered with black varnish; used for lathework, cabinet -making, and musical instruments. A light brown dye is obtained from the bark. Fruit - raw or cooked. The flavour ranges from rather harsh and astringent (cultivars used for making alcoholic drinks) through to soft, sweet and very juicy. The best dessert fruits have an exquisite sweet flavour, usually with a very soft flesh, whilst cooking varieties have harder less sweet flesh. A yellow-tan dye is obtained from the leaves. Wood - heavy, tough, durable, fine grained, hard. Used by cabinet and instrument makers. When covered with black varnish it is an excellent ebony substitute.

Prefers a good well-drained loam in full sun. Grows well in heavy clay soils. Tolerates light shade but does not fruit so well in such a position. Tolerates atmospheric pollution, excessive moisture and a range of soil types, if they are moderately fertile, avoiding only the most acid soils[186]. Dislikes very exposed positions. Established plants are drought tolerant. A very hardy plant, tolerating temperatures down to below -15°c. Plants often sucker and can form dense thickets. A parent of the cultivated pear, possibly by crossing with *P. nivalis* and *P. cordata*. There are many hundreds of varieties of cultivated pears and they are widely cultivated in the temperate zone for their edible fruits. By selection of varieties fresh fruits can be obtained from late July to April or May of the following year. Special Features: Edible, Naturalizing, Attractive flowers or blooms.

Seed - best sown in a cold frame as soon as it is ripe in the autumn, it will then usually germinate in mid to late winter. Stored seed requires 8 - 10 weeks cold stratification at 1°C and should be sown as early in the year as possible. Temperatures over 15 - 20°C induce a secondary dormancy in the seed. Prick out the seedlings into individual pots when they are large enough to handle and grow them on

in light shade in a cold frame or greenhouse for their first year. Plant them out in late spring or early summer of the following year.

Geographic distribution: Caucasian endemic. Caucasus, Anatolia and Iran.

4.2.10. *Malus orientalis* Uglitzk., მაჟალო, Wild apple, Rosaceae

Site characteristics: Grows in forests, scrubs, forest margins, in lower and middle montane belts, sometimes reaches higher elevations 0 – 2,000 m. Medium- sized or more or less tall tree, to 10-11 m high; Deciduous (especially broadleaf) mountain forests, forest edges, among shrubs, on riverbanks. Snow cover is <1m. The exposition is for all directions and inclination till 30°. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils, prefers well-drained soil and can grow in heavy clay soil. Suitable pH: acid, neutral and basic (alkaline) soils. It can grow in semi-shade (light woodland) or no shade. It prefers moist soil. Woodland Garden Secondary; Sunny Edge; Dappled Shade; North Wall. By. East Wall. By. South Wall. By. West Wall. By.

Reproduction and growth characteristics: Young branches brown, densely pubescent. Twigs dark grey. Branches usually unarmed; young shoots dark brown, somewhat tomentose, when adult dark gray with sparse lenticels;

Leaves 3-8 cm long, 1,5-3,5 cm wide of variable shape, ovate-lanceolate, oblong elliptical or almost round, entire at the base, the other parts of the margin serrate. Usually cuneately tapering at base, obtuse, less often acuminate with inconspicuous or rather short mucro, entire at base, otherwise serratedentate, less often crenate-serrate, usually with very large acute or subobtuse teeth in upper part, thickish; Upper surface of young leaves scarcely pubescent, lower surface densely puberulence, later upper surface becomes glabrous. young leaves scattered-hairy above, densely white-tomentose below, the adult hairy above only along the veins, otherwise quite glabrous, with strongly impressed lateral veins, rather densely, sometimes rather sparsely grayish tomentose below, usually very prominently veined;

Flowers of 4-6 per inflorescence ca. 4 cm in diameter, with densely tomentose -villous pedicels 8—12 mm long; Pedicles densely tomentose, petioles 0.5-3 cm long, thickish or rather slender, more or less tomentose; hypanthium obconical, very densely tomentose; sepals rather short, narrowly triangular, acute, spreading, densely tomentose outside, subglabrous or slightly tomentose inside; petals obovate, narrowing to a conspicuous claw; styles about as long as stamens, tomentose at base, otherwise glabrous; stigmas clavate, narrow; Fruit rounded pome, flattened at both poles, globose, 2-3 cm in diameter with short, densely tomentose pedicels 1-2.5 cm long.

Flowering in April- May, fruits from September.

a **b**

Picture 20: a) *Malus orientalis* is wild native species in Georgia; b) Fruits are very similar to varieties of apple.

Ecosystem services: The fruits of the species belonging to this group are edible, but those of the wild-growing varieties are seldom eaten raw owing to their high acidity; they are usually dried (for stewed fruit, etc.) or for the preparation of drinks. Nectariferous. The wood of some forms finds applications in carpentry and turnery, but is less valuable than pearwood, because it warps and splits. See also economic importance data cited for the individual species. Fruit - raw, cooked or dried for later use. Apples are one of the most common and widely grown fruits of the temperate zone. There are a great many named varieties with differing flavours ranging from sour to sweet and textures from dry and mealy to crisp and juicy. There is also a wide range in the seasons of ripening with the first fruits being ready in late July whilst other cultivars are not picked until late autumn and will store for 12 months or sometimes more. See individual records for more details.

The fruit of some cultivars is rich in pectin and can be used in helping other fruits to set when making jam etc. Pectin is also said to protect the body against radiation. An edible oil can be obtained from the seed. It would only really be viable to use these seeds as an oil source if the fruit was being used for some purpose such as making cider and then the seeds could be extracted from the remaining pulp. The fruit is astringent and laxative. The bark, and especially the root bark, is anthelmintic, refrigerant and soporific. An infusion is used in the treatment of intermittent, remittent and bilious fevers. The leaves contain up to 2.4% of an antibacterial substance called 'phloretin'. This inhibits the growth of a number of gram-positive and gram-negative bacteria in as low a concentration as 30 ppm. A ripe raw apple is one of the easiest foods for the stomach to deal with, the whole process of digestion taking about 85 minutes.

The apple juice will reduce the acidity of the stomach, it becomes changed into alkaline carbonates and thus corrects sour fermentation. The apple is also an excellent dentifrice, the mechanical action of eating a fruit serving to clean both the teeth and the gums. The fruit is a source of pectin. Pectin is used as a thickener in jams etc and as a culture medium in laboratories. The apple is also an excellent dentifrice, the mechanical action of eating a fruit serving to clean both the teeth and the gums. The oil from the seed has been used as an illuminant. Wood - hard, compact, fine-grained. Used for turnery, tool handles, canes etc. It makes an excellent fuel.

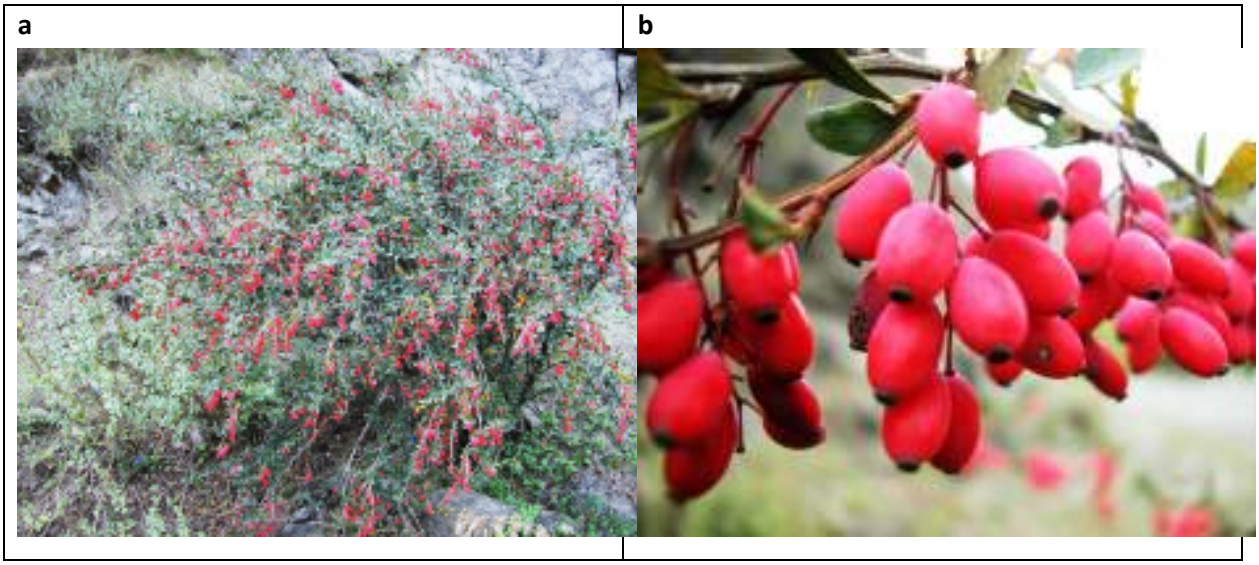
An easily grown plant, it succeeds in most fertile soils, preferring a moisture retentive well-drained loamy soil. Grows well in heavy clay soils, though if these are poorly drained there could be problems with diseases such as canker. Prefers a sunny position but succeeds in partial shade though it fruits less well in such a situation. Tolerates a pH range from 6 to 7, preferring a range of 6.5 to 6.8. The apple is one of the most commonly cultivated fruit crops in the temperate zone. The primary climatic requirements for the production of good quality fruit are warm summer temperatures, relative freedom from spring frosts, reasonable protection from the wind (especially cold north and east winds) and an evenly distributed rainfall of about 600 – 800 mm per annum. Good apple production has been achieved as far north as 65°, whilst about 1000 hours of winter temperatures below 7°C are necessary to initiate flower production. However good quality apples can still be produced in other areas with careful management and choice of cultivars. Even in tropical latitudes, the plant has succeeded at high elevations, producing fruit at elevations over 3000 metres in Ecuador for example. Where space is at a premium, or at the limits of their climatic range, apples can be grown against a wall. Most cultivars will grow well against a sunny south or west facing wall, an east facing wall will suit many of the tougher cultivars and even a north facing wall can be used for early culinary cultivars. A hybrid of mixed origins, including *M. dasyphylla, M. praecox, M. pumila, M. sieversii* and *M. sylvestris*, this species is very commonly cultivated in temperate areas for its edible fruit. There are very many named varieties and with careful choice of these varieties it is possible to provide freshly harvested fruit from July to December and stored fruit for the rest of the year. When chives (*Allium schoenoprasum*) or other alliums are grown under apple trees it can prevent or cure scab. A spray of the infused leaves of Equisetum spp can also be used against scab. If climbing nasturtiums (*Tropaeolum majus*) are grown into the tree they can repel woolly aphis. Apples lose their flavour if they are stored with potatoes. They will also impart a bitter flavour to carrots or potatoes if they are stored in the same area. Growing apples near potatoes makes the potatoes more susceptible to blight. Wrapping maple leaves (*Acer* spp.) around apples in store helps to preserve the apples. Apples store better if they are grown in a sward that contains a high percentage of clover. Apple trees grow better and produce better quality fruit when foxgloves (*Digitalis* spp.) and wallflowers (*Erysimum cheiri*) are growing in the orchard. Dandelions (*Taraxacum* spp.) produce ethylene gas and this can cause earlier ripening of fruit if plants are growing in an orchard. The fruit is a good wildlife food source, especially for birds. Hybridizes freely with other members of this genus. Plants in this genus are notably susceptible to honey fungus.

Seed - this species is a hybrid and will not breed true from seed, though some interesting new fruiting cultivars can be produced. It is best sown as soon as it is ripe in the autumn in a cold frame. It usually germinates in late winter. Stored seed requires stratification for 3 months at 1°C and should be sown in a cold frame as soon as it is received. It might not germinate for 12 months or more. Prick out the seedlings into individual pots as soon as they are large enough to handle. If given a rich compost they usually grow away quickly and can be large enough to plant out in late summer, though consider giving them some protection from the cold in their first winter. Otherwise, keep them in pots in a cold frame and plant them out in late spring of the following year. Cuttings of mature wood, November in a frame.

Geographic distribution: Native to Caucasus, Asia Minor, Iran.

4.2.11. *Berberis vulgaris* L. კოწახური, Common barberry, Berberidaceae

Site characteristics: Grows from lower up to upper montane belt 0 - 2,300 m, in forests, edges of the forests, in gorges. Shrub up to 2,5 m tall, rarelly higher tree. Snow cover is <0.3 m. The exposition is for all directions and inclination till 30°. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and can grow in heavy clay and nutritionally poor soils. Suitable pH: acid, neutral and basic (alkaline) soils. It can grow in semi-shade (light woodland) or no shade. It prefers dry or moist soil.



Picture 21: a) ***Berberis vulgaris;*** **b)** ***Fruits.***

Reproduction and growth characteristics: Young branches greyish-green, at flowering become greyish or yellowish. Second year twigs grey with 3-pronged spine, on younger branches upper spines are single. Strongly branching, with markedly elongated branches, yellowish or yellowish -purple when young; in the second year turning gray; spines usually tripartite, 2 cm long;

Leaves 4 cm long, thin, glabrous, both surfaces green, from elliptical to oblong lanceolate, obtuse, rarely acute, narrows towars the base, margins serrate, tapering into a petiole, greenish and distinctly reticular beneath; inflorescence racemiform, 6 cm long, with 15-25 flowers; pedicels 5-12 mm long; flowers clustered in multifloral drooping racemes; sepals and petals obovate; berries ellipsoidal or ellipsoidal- oblong, 12 mm long, bright red. Fruit elliptic, usually red, rarelly yellow or rose. Flowering in May-June. Fruits in September-October.

Ecosystem services: Most species of *Berberis* are of economic importance, since the berries of all the species are delicious raw and as preserves. The widely cultivated *B. vulgaris* is particularly well known in this respect. Species of *Berberis* are equally important as producers of nectar and as a source of yellow dye. At the same time they are notorious as intermediate hosts of rust fungi. The wood of this species is hard, and has bright yellow sapwood. It is used in the manufacture of cobbler's nails and tools for lathework; the berries contain malic acid, which is used in confectionery, and also both yield a good dye used to color hides and wools a lemon yellow. It is a fine nectar plant and a very striking ornamental shrub, due to the variety of its red foliage. It is notorious as the host of the aecial stage of the rust *Puccinia graminis* Pers., which in turn infects wheat and other grasses that develop in the late summer and fall. Although it is recommended that barberry be destroyed we are against this

since the most dangerous form of rust and the yellow rust of grain *Puccinia glumarum*, does not develop on barberry. Fruit - raw or cooked.

Rich in vitamin C, the fruit has a very acid flavour and is mainly used in preserves, though children and some adults seem to like it raw when it is fully ripe. A refreshing lemon-like drink can be made from the fruit. The fruits are about 10 mm long. Young leaves - used as flavouring or as an acid nibble. They can be used in much the same way as sorrel (*Rumex acetosa*). The dried young leaves and shoot tips make a refreshing tea. Barberries have long been used as a herbal remedy for the treatment of a variety of complaints. All parts of the plant can be used though the yellow root bark is the most concentrated source of active ingredients. The plant is mainly used nowadays as a tonic to the gallbladder to improve the flow of bile and ameliorate conditions such as gallbladder pain, gallstones and jaundice. The bark and root bark are antiseptic, astringent, cholagogue, hepatic, purgative, refrigerant, stomachic and tonic. The bark is harvested in the summer and can be dried for storing. It is especially useful in cases of jaundice, general debility and biliousness, but should be used with caution. The flowers and the stem bark are antirheumatic.

The roots are astringent and antiseptic. They have been pulverized in a little water and used to treat mouth ulcers. A tea of the roots and stems has been used to treat stomach ulcers. The root bark has also been used as a purgative and treatment for diarrhoea and is diaphoretic. A tincture of the root bark has been used in the treatment of rheumatism, sciatica etc. The root bark is a rich source of the alkaloid berberine -about 6%. Berberine, universally present in rhizomes of *Berberis* species, has marked antibacterial effects. Since it is not appreciably absorbed by the body, it is used orally in the treatment of various enteric infections, especially bacterial dysentery. It should not be used with *Glycyrrhiza* species (Liquorice) because this nullifies the effects of the berberine. Berberine has also shown antitumour activity and is also effective in the treatment of hypersensitive eyes, inflamed lids and conjunctivitis. A tea made from the fruits is antipruritic, antiseptic, appetizer, astringent, diuretic, expectorant and laxative. It is also used as a febrifuge. The fruit, or freshly pressed juice, is used in the treatment of liver and gall bladder problems, kidney stones, menstrual pains etc. The leaves are astringent and antiscorbutic. A tea made from the leaves is used in the treatment of coughs. The plant (probably the inner bark) is used by homeopaths as a valuable remedy for kidney and liver insufficiency. Other uses include malaria, and opium and morphine withdrawal.

Plants can be grown as a medium-size hedge in exposed positions but they cannot tolerate extreme maritime exposure. They are very tolerant of trimming but can also be left untrimmed if required. A good quality yellow dye is obtained from the roots, bark and stem. As well as being used on cloth, it is also used to stain wood. The unripe fruit is dried and used as beads. Wood - soft, very hard, fine grained, yellow. Used for carving, toothpicks, mosaics etc. It is also used as a fuel.

Prefers a warm moist loamy soil but it is by no means fastidious, succeeding in thin, dry and shallow soils. Prefers a light rich rather dry soil according to another report. Grows well in heavy clay soils. Succeeds in full sun or light shade but requires a moist soil when grown in the shade of trees. Hardy to about -35°c. A very ornamental plant, the barberry was at one time cultivated for its edible fruit, there are several named varieties. 'Dulcis' the fruit of which is sweet or slightly sour. 'Asperma' is a seedless form that was often used in France to make a jam. An alternate host of 'black-stem rust' of wheat so it has been extensively grubbed up from its habitats. Hybridizes freely with other members

of this genus, though it usually breeds fairly true to type. Can be pruned back quite severely, it resprouts well from the base.

Seed - best sown as soon as it is ripe in a cold frame, when it should germinate in late winter or early spring. Seed from over-ripe fruit will take longer to germinate, whilst stored seed may require cold stratification and should be sown in a cold frame as early in the year as possible. The seedlings are subject to damping off, so should be kept well ventilated. When the seedlings are large enough to handle, prick them out into individual pots and grow them on in a cold frame. If growth is sufficient, it can be possible to plant them out into their permanent positions in the autumn, but generally it is best to leave them in the cold frame for the winter and plant them out in late spring or early summer of the following year. Germination averages out at about 90%. Cuttings of half-ripe wood, July/August in a frame. Cuttings of mature wood of the current season's growth, preferably with a heel, October/November in a frame. Suckers, removed in late autumn/early winter and planted out in situ or potted up and planted out in late spring.

Geographic distribution: Native to Central Europe, Mediterranean, Caucasus.

4.2.12. *Hippophaë rhamnoides* L., ქაცვი, Sea buckthorn, Elaeagnaceae

Site characteristics: Coasts, banks of lakes, mountain streams and brooks; riverside pebbles, pebbly springs, riverside shingle, tugais, willow and poplar woods on sands, upper limit of deciduous and lower limit of coniferous trees (up to 300-2,100 m), ravines, slopes, rocks and bluffs.Grows up to middle, sometimes subalpine belt, mostly on riverbanks and in gorges. Occurs solitary or in small groups or forms thickets. 1.5- 5 m high tall shrub, rarely tree, strongly branched, with spreading crown. Snow cover is <1-2 m. The exposition is for all directions and inclination till 10°. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Twigs greyish and spine tipped. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and can grow in nutritionally poor soil. Suitable pH: acid, neutral and basic (alkaline) soils. It cannot grow in the shade. It prefers dry moist or wet soil and can tolerate drought. The plant can tolerate maritime exposure.

a **b**

Picture 22: a) *Hippophaë rhamnoides;* b) Fruits from female flowers.

Reproduction and growth characteristics: Leaves linear or linear-lanceolate, 2-8 cm long, 0.2-0.8 cm broad, subobtuse, more or less narrowed at base, subsessile, with more or less revolute margins, dark grayish-green above, silvery-white suffused with brown or yellow beneath, clothed with white and brown stellate scales;

Staminate flowers in short minute spikes, 5- 8 mm long and 4-6 mm broad, with 2-parted perianth, lobes ovate-orbicular, 3-4 mm long, 3-3.5 mm broad, concave, greenish-brown, covered outside with numerous brown and sparse white stellate scales; stamens 4, half to two-thirds as long as perianth; anthers 1.5 mm long, oblong-linear, almost sessile anthers with very short filaments; pistillate flowers 2-5 in axils of branchlets, on pedicels 0.5 mm long; perianth of pistillate flowers tubular, oblong-obovate, 2.5-4 mm long, 1-1.5 mm broad, brown, covered outside with stellate brown and few white scales, lobes obtuse, covered inside (densely in upper part) with rather long white hairs; pistil in lower part of perianth-tube; ovary glabrous, globoseovaloid, 1-2 mm long, about half length of perianth; style 0.5 mm long; stigma oblong, 0.5-1 mm long, 1 -sided, exserted; ripe drupe globose, ovaloid, globose -ovaloid or short-ellipsoid, 0.8—1 cm long and 0.3-0.6 cm broad, or ellipsoid, 5-7 mm long and 3 mm broad, glabrous, orange or reddish, succulent and aromatic; stone ovoid-oblong, 4-7 mm long and 4-5 mm broad, or oblong-ellipsoid, 4-5 mm long and 1.5-2 mm broad, dark brown, sometimes almost black, lustrous.

Flowering in April-May, fruits are in August-October.

Ecosystem services: A handsome ornamental plant grown in gardens and parks, either singly or in hedges. An invaluable plant for fixing sands, landslides, railroad embankments and protection of railway lines against snow drifts. The wood is fine-grained yellow, with brownish -yellow heartwood, tough, rather hard, heavy, very durable. It is suitable for fine carpentry and turning. Used for staking grapevines. The ash has a high potash content. The fruit has a sourish, aromatic flavor; the drupes are a favorite food of pheasants; they are considered by the local population to be a dainty and are made into infusions, liqueurs and jams. Young shoots and leaves produce a blackish-brown dye, and fruit a yellow dye, with iron salts. The foliage contains 10% tannin and provides tanning material.

The plant is used in popular medicine. The fruit is very succulent, slightly mucilaginous; it has an agreeable sourish flavor and a pineapplelike aroma. Frozen fruit (without stones) contains up to 3.56% sugar (glucose 1.96%, fructose 1.0%), acids (including malic acid) 2.64%). The pulp contains 8% oil. The fruit is eaten raw, especially after frost; it is added to flour to make a special kind of bread; it is also made into jellies, deserts and candies. Pectin has to be added to the fruit juice for jelly making. The fruit is also used for making jam which resembles barberry jam in flavor. Reserves of sea buckthorn are considerable. It is a valuable honey plant. The vitamin C (ascorbic acid) content is as follows: in leaves 230—262 mg%, in fruit 120 mg%) (according to other data 172.8— 198.6 mg%)), in fruit juice 200 mg% (according to other data 500—900mg%). The ascorbic acid is very stable and keeps well. Sea buckthorn deserves attention as a source of vitamin C. Sea buckthorn oil was found to contain 90 mg% carotene (provitamin A). Very tolerant of maritime exposure, it can be used as a shelter hedge. It dislikes much trimming. A very thorny plant, it quickly makes an impenetrable barrier.

Sea buckthorn has an extensive root system and suckers vigorously and so has been used in soil conservation schemes, especially on sandy soils. The fibrous and suckering root system acts to bind

the sand. Because the plant grows quickly, even in very exposed conditions, and also adds nitrogen to the soil, it can be used as a pioneer species to help the re-establishment of woodland in difficult areas. Because the plant is very light-demanding it will eventually be out-competed by the woodland trees and so will not out-stay its welcome. The seeds contain 12 - 13% of a slow-drying oil. The vitamin-rich fruit juice is used cosmetically in face-masks etc. A yellow dye is obtained from the fruit. A yellow dye is obtained from the stems, root and foliage. A blackish-brown dye is obtained from the young leaves and shoots. Wood - tough, hard, very durable, fine-grained. Used for fine carpentry, turning etc. The wood is also used for fuel and charcoal.

Landscape is Border, Seashore, and Specimen. Succeeds in most soils, including poor ones, so long as they are not too dry. Grows well by water and in fairly wet soils. Established plants are very drought resistant. Requires a sunny position, seedlings failing to grow in a shady position and mature shrubs quickly dying if overshadowed by taller plants. Does well in very sandy soils. Very tolerant of maritime exposure. Plants are fairly slow growing. Although usually found near the coast in the wild, they thrive when grown inland and are hardy to about -25°C. A very ornamental plant, it is occasionally cultivated, especially in N. Europe, for its edible fruit, there are some named varieties. 'Leikora' is a free-fruiting form, developed for its ornamental value. Members of this genus are attracting considerable interest from breeding institutes for their nutrient-rich fruits that can promote the general health of the body (see edible and medicinal uses below). This species has a symbiotic relationship with certain soil bacteria, these bacteria form nodules on the roots and fix atmospheric nitrogen. Some of this nitrogen is utilized by the growing plant but some can also be used by other plants growing nearby. Plants produce abundant suckers, especially when grown on sandy soils. Dioecious. Male and female plants must be grown if seed is required. The sexes of plants cannot be distinguished before flowering, but on flowering plants the buds of male plants in winter are conical and conspicuous whilst female buds are smaller and rounded. Plants in this genus are notably resistant to honey fungus.

Seed - sow spring in a sunny position in a cold frame. Germination is usually quick and good although 3 months cold stratification may improve the germination rate. Alternatively the seed can be sown in a cold frame as soon as it is ripe in the autumn. Prick out the seedlings into individual pots when they are large enough to handle and grow on in a greenhouse for their first winter. Plant out in late spring into their permanent positions. Male seedlings, in spring, have very prominent axillary buds whilst females are clear and smooth at this time. Cuttings of half-ripe wood, June/July in a frame. Difficult. This is the easiest method of vegetative propagation. Cuttings of mature wood in autumn. Difficult. The cuttings should be taken at the end of autumn or very early in the spring before the buds burst. Store them in sand and peat until April, cut into 7- 9 cm lengths and plant them in a plastic tent with bottom heat. Rooting should take place within 2 months and they can be put in their permanent positions in the autumn. Division of suckers in the winter. They can be planted out direct into their permanent positions and usually establish well and quickly. Layering in Autumn.

Geographic distribution: Native to Eurasia.

4.2.13. *Juniperus* communis var. depressa Pursh, ღვია, Juniper, J. *Sabina* L., კაზაკური ღვია, **Savin** Juniper, **Cupressaceae**

Site characteristics: These species growing in the entire forest zone to the forest steppes, on forest edges, in pine groves, moorlands, rocks and pastures. Erect, small trees or shrubs 1-5 m. *J. communis* var. depressa is distributed in alpine zone of Central Caucasus 1,500-2,800 m.a.s.l.. Snow cover is <1 m. The exposition is for all directions and inclination till 30°. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Sometimes forming extensive thickets; growing in the zone of alpine meadows and pastures. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils, prefers well-drained soil and can grow in heavy clay and nutritionally poor soils. Suitable pH: acid, neutral and basic (alkaline) soils and can grow in very acid and very alkaline soils. It can grow in semi-shade (light woodland) or no shade. It prefers dry or moist soil and can tolerate drought. The plant can tolerate maritime exposure.

J. sabina is alpine species from 1800 to 2800 m.a.s.l.. Growing on wind-blown sand, chalk, rocks, exposed southern slopes, and stony slopes of hills and low mountains, more often in the steppe than in the forest belt. Snow cover is <3 m. The exposition is for all directions and inclination till 70°. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and prefers well-drained soil. Suitable pH: acid, neutral and basic (alkaline) soils and can grow in very alkaline soils. It cannot grow in the shade. It prefers dry or moist soil and can tolerate drought. The plant can tolerate maritime exposure.

a **b**

Picture 23: a) *Juniperus* communis var. depressa; b) J. *sabina*.

Reproduction and growth characteristics: Small evergreen trees or shrubs with needle-like leaves, three each in a whorl, or with opposite and decussate, scale-like leaves, young shrubs sometimes with juvenile needle like leaves. Female cones (galbuluses) maturing in two to three years, globose, with fleshy fused scales. Seeds one to eight in each cone, oblong-ovoid, wingless.

J. communis var. depressa is a prostrate shrub with decumbent rooting branches; bark dark gray; branchlets yellowish- red; leaves straight, short, linear- subulate, 8-10 mm long and 1.5 mm broad, pruinose above, keeled beneath, the keel decurrent onto the bark of the branch and forming there

an inflated pyriform resiniferous gland; male cones shorter than leaves; fruit black, pruinose, subsessile, shorter than leaves; seeds 2 or 3, trigonous, light brown, wrinkled. 2n = 22.

J. sabina is trailing shrub, dioecious, low, procumbent shrubs, 0.5—0.8 m high; female cones blackish-brown, 5—8 mm wide; young shoots green; 7. 2n = 22. Branches partly decumbent, partly ascending; leaves strongly odoriferous; acicular leaves lance-linear, spiny-pointed; leaves on adult plants about 1 .2 mm long, scale-like, sometimes needlelike on low branches, 2.5—8 mm long. Imbricated leaves lustrous, rhombic to rhombic-lanceolate, acute to subobtuse, with a keel and an oval gland on the black; aments ovaloid, with round scales, pale yellow; fruits solitary, profuse, small, 6—8 mm long and 5—6 mm broad, rounded- ovate, brownish, pruinose, of 4—6 scales; seeds mostly 2, though occasionally 1, 3, 4, or 6, ovoid, prominently keeled on the abaxial side.

Ecosystem services: Wood reddish, agreeably scented, used for lathework and sculpture, e. g., for furniture decoration. The fruit contains sugar and essential oil, used as diuretic and also in the liqueur industry (for export). Dry distillation of the wood yields empyreumatic juniper oil. Oleum cadinum, used against skin irritants. The resin gives sandarac and is used for the production of white varnish. Suitable for low hedges. Of medicinal value are the green branchlets Summitates Sabinae (Herba Sabinae, Ramuli Sabinae, Frondes Sabinae), containing 2—5 and up to 17% of volatile Savin oil, sabinol *Cio Hi5(OH),* used as emmenagogue and abortive agent. The action is so strong that in Germany, where it is considered to be a beautiful ornamental shrub, it is banned from general-purpose gardens, as being toxic.

Fruit - raw or cooked. It is usually harvested in the autumn when fully ripe and then dried for later use. A soft, mealy, sweet, resinous flesh. The fruit is often used as flavouring in sauerkraut, stuffings, vegetable pates etc, and is an essential ingredient of gin. The aromatic fruit is used as a pepper substitute according to one report. An essential oil is sometimes distilled from the fruit to be used as a flavouring. Average yields are around 1%. The cones are about 4 - 8 mm in diameter and take 2 - 3 years to mature. Some caution is advised when using the fruit, see the notes above on toxicity. The roasted seed is a coffee substitute. A tea is made by boiling the leaves and stems. A tea made from the berries has a spicy gin-like flavour.

Juniper fruits are commonly used in herbal medicine, as a household remedy, and also in some commercial preparations. They are especially useful in the treatment of digestive disorders plus kidney and bladder problems. The fully ripe fruits are strongly antiseptic, aromatic, carminative, diaphoretic, strongly diuretic, rubefacient, stomachic and tonic. They are used in the treatment of cystitis, digestive problems, chronic arthritis, gout and rheumatic conditions. They can be eaten raw or used in a tea, but some caution is advised since large doses can irritate the urinary passage. Externally, it is applied as a diluted essential oil, having a slightly warming effect upon the skin and is thought to promote the removal of waste products from underlying tissues. It is, therefore, helpful when applied to arthritic joints etc. The fruits should not be used internally by pregnant women since this can cause an abortion. The fruits also increase menstrual bleeding so should not be used by women with heavy periods. When made into an ointment, they are applied to exposed wounds and prevent irritation by flies. The essential oil is used in aromatherapy. Its keyword is 'Toxin elimination'.

A decoction of the branches is used as an anti-dandruff shampoo. The essential oil distilled from the fruits is used in perfumes with spicy fragrances. In hot countries the tree yields the resin 'Sandarac'

from incisions in the trunk. This is used in the production of a white varnish. The stems were at one time used as a strewing herb to sweeten the smell of rooms. The whole plant can be burnt as an incense and fumigant. It was used during epidemics in the belief that it would purify the air and cleanse it of infection. Fresh or dried juniper branches also make a good insect repellent. Many forms of this species are good ground cover plants for sunny situations. Forms to try include 'Depressa Aurea', 'Dumosa', 'Effusa', and 'Repanda'. 'Prostrata' can also be used. The bark is used as cordage and as a tinder. Wood - strong, hard, fragrant, very durable in contact with the soil and very close-grained, but usually too small to be of much use. It makes an excellent fuel.

Landscape is Specimen. An easily grown plant, it succeeds in hot dry soils and in poor soils. Succeeds in most soils so long as they are well drained, preferring a neutral or slightly alkaline soil. Does well in chalky soils. Grows well in heavy clay soils. Tolerates a pH range from 4 to 8. Succeeds in light woodland but dislikes heavy shade. Established plants are very tolerant of drought. Although the fully dormant plant is cold-tolerant throughout Britain, the young growth in spring can be damaged by late frosts. All parts of the plant are very aromatic. Juniper is a very polymorphic species that has a long history of culinary and medicinal use. It is frequently grown in the ornamental and herb garden, there is a huge range of cultivars of widely diverse habits. At least some forms tolerate maritime exposure, there is a thriving colony in an exposed position at Land's End in Cornwall. The fruits take 2 - 3 years to ripen on the plant. Plants are usually very slow growing, often only a few centimetres a year. Resists honey fungus. Plants are sometimes attacked by a rust, this fungus has an aecidial stage on hawthorn (*Crataegus* spp.) Dioecious. Male and female plants must be grown if seed is required.

The seed requires a period of cold stratification. The seed has a hard seedcoat and can be very slow to germinate, requiring a cold period followed by a warm period and then another cold spell, each of 2 - 3 months duration. Soaking the seed for 3 - 6 seconds in boiling water may speed up the germination process. The seed is best sown as soon as it is ripe in a cold frame. Some might germinate in the following spring, though most will take another year. Another possibility is to harvest the seed 'green' (when the embryo has fully formed but before the seed coat has hardened). The seedlings can be potted up into individual pots when they are large enough to handle. Grow on in pots until large enough, then plant out in early summer. When stored dry, the seed can remain viable for several years. Cuttings of mature wood, 5 - 10cm with a heel, September/October in a cold frame. Plant out in the following autumn. Layering in September/October. Takes 12 months.

J. sabina leaves are used as an insect repellent, a decoction of them is used against lice. An essential oil from the leaves and shoots has strong diuretic properties and is also used in perfumery. Yields of around 4% are obtained, this oil is also used as an insecticide. A good dense ground cover plant, though it is slow to cover the ground. The species type eventually forms a high ground cover, but there are many named forms that are lower-growing. Plants should be spaced about 1.2 metres apart each way. The taller forms of this species make a good hedge.

Landscape is Alpine garden, Erosion control, Ground cover, Massing, Rock garden. Succeeds in most soils if they are well drained, preferring a neutral or slightly alkaline soil. Prefers a limestone soil. Succeeds in poor soils and in light shade. Established plants are drought tolerant, succeeding in hot dry positions. Tolerates maritime exposure. A very ornamental plant, there are many named varieties. All parts of the plant have a powerful pungent smell. Plants can be dioecious or

monoecious. Male and female plants must be grown if fruit and seed are required. The plant is sometimes attacked by rust; this is a fungus with an aecidial stage on the leaves of pear trees. Plants are resistant to honey fungus.

The seed requires a period of cold stratification. The seed has a hard seedcoat and can be very slow to germinate, requiring a cold period followed by a warm period and then another cold spell, each of 2 - 3 months duration. Soaking the seed for 3 - 6 seconds in boiling water may speed up the germination process. The seed is best sown as soon as it is ripe in a cold frame. Some might germinate in the following spring, though most will take another year. Another possibility is to harvest the seed 'green' (when the embryo has fully formed but before the seedcoat has hardened). The seedlings can be potted up into individual pots when they are large enough to handle. Grow on in pots until large enough, then plant out in early summer. When stored dry, the seed can remain viable for several years. Cuttings of mature wood, 5 – 10 cm with a heel, September/October in a cold frame. Plant out in the following autumn. Layering in September/October. Takes 12 months.

Geographic distribution: *J. communis* var. depressa in Caucasus, Bulgaria, Crimea, Turkey, Iran and Talysh mountains. *J. sabina* is in Caucasus: in the mountains of the Greater Caucasus and on Adzhar-Imeretian and Trialeti ranges, avoiding Armenia and Talysh. Es well in Europe, Asia: Sibiria, Mongolia, Altai.

4.2.14. ***Ribes biebersteinii*** **Berl., კლდის მოცხარი, Stone gooseberry, Grossulariaceae**

Site characteristics: Grows in forests of middle and upper montane belts, sometimes reaches subaline zone from 900 to 2,100 m.a.s.l.. *Ribes biebersteinii* is a deciduous shrub growing to 1.5-2 m high with light, glabrous shoots; it is hardy to subalpine zone and is not frost tender. Snow cover is <1 m. The exposition is for all directions and inclination till 30°. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils, prefers well-drained soil and can grow in nutritionally poor soil. Suitable pH: acid, neutral and basic (alkaline) soils. It can grow in semi-shade (light woodland) or no shade. It prefers moist soil.

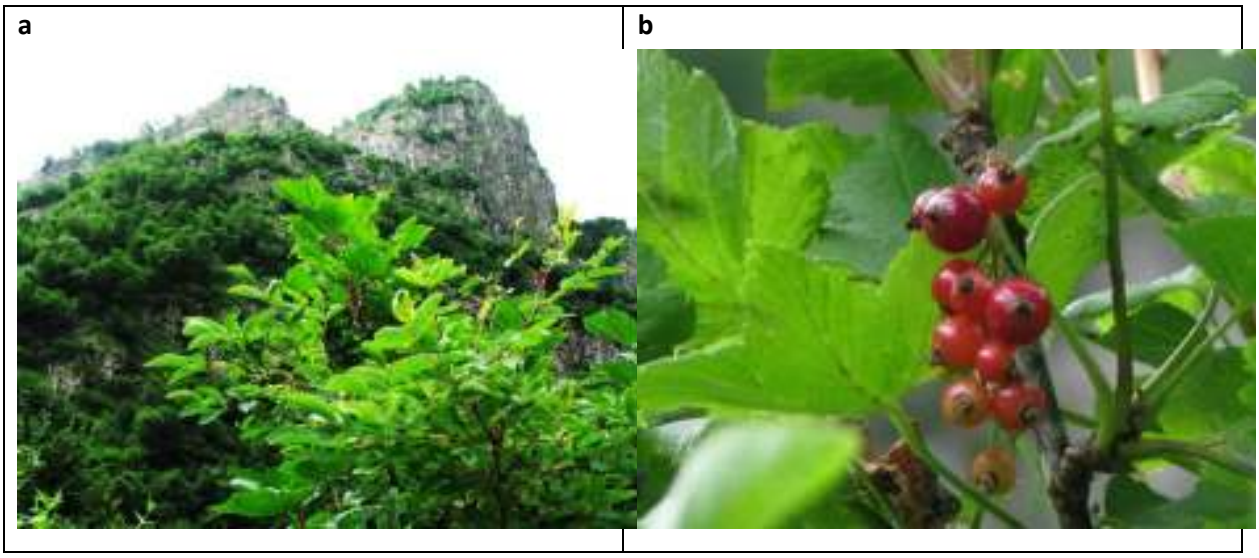
Reproduction and growth characteristics: Shoots densely covered with acicular spines and, in addition, with larger spines at the nodes, 7-15 in each verticillaster; Young branches greenish-dark grey, glossy, older twigs with dark greyish-dark brown bark shredding into stripes. leaves rigid-hispid; flowers flat; berries black, glandular-hispid berry dark red or cherry-red 12. Leaf glabrous above, pubescent beneath, lobes acuminate, margins toothed.

Leaves thin, deeply cordate, large 10 cm long and 13 cm wide, usually 5-lobed with cordate base, either glabrous on both sides, or densely hairy below, rarely with scattered glandular bristles above and with hairs along the veins below and on the petioles; racemes 4-12 cm long,horizontal, nodding in fruit, loose, 15-50 -flowered;

Flowers reddish or purple in drooping racemes of 15-20 per inflorescence. Hypanthium with fleshy excrescences below the petals; flowers purple; pedicels 2-3 mm long; flowers 5-6 mm long, dark purple; sepals recurved; hypanthium with conspicuous excrescences below petals; styles broadly

conical; berry small, 6-7 (8) mm in diameter, dark red or black -purple. Fruit deep purple. Fruit a succulent berry with dried perianth at the apex, at maturity disarticulating from pedicel; seeds with interior hard endopleura and gelatinous testa.

Flowering in June. Fruits in July-August.



Picture 24: *Ribes biebersteinii* in Gveleti; b) Fruits.

Ecosystem services: Because all *Ribes* species are alternative hosts of the destructive blister rust fungus, which also attacks white pines, there are local prohibitions to growing *Ribes* near any white pine plantations. The flowers are hermaphrodite (have both male and female organs) and are pollinated by Insects. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and prefers well-drained soil. Suitable pH: acid, neutral and basic (alkaline) soils. It can grow in semi-shade (light woodland) or no shade. It prefers moist soil. Fruit - raw or cooked. A good-sized red currant, (though it is almost black in colour), but plants only had a small crop. The flavour is rather tart, but acceptable raw. It is probably best as a cooked fruit, making a good jam or preserve. Its main drawback is the large number of seeds in each fruit. Plants for A future cannot take any responsibility for any adverse effects from the use of plants. Always seek advice from a professional before using a plant medicinally. Easily grown in a moisture retentive but well-drained loamy soil of at least moderate quality. Plants are quite tolerant of shade though do not fruit so well in such a position. Hardy to about -20°C. Plants can harbour a stage of 'white pine blister rust', so they should not be grown in the vicinity of pine trees. Plants in this genus are notably susceptible to honey fungus. Seed - best sown as soon as it is ripe in the autumn in a cold frame. Stored seed requires 3 months cold stratification at between 0 and 5°C and should be sown as early in the year as possible. Under normal storage conditions the seed can remain viable for 17 years or more. Prick out the seedlings into individual pots when they are large enough to handle and grow them on in a cold frame for their first winter, planting them out in late spring of the following year. Cuttings of half-ripe wood, 10-15 cm with a heel, July/August in a frame. Cuttings of mature wood of the current year's growth, preferably with a heel of the previous year's growth, November to February in a cold frame or sheltered bed outdoors.

Landscape is Erosion control, Foundation, Ground cover, Massing, Rock garden, Seashore. Easily grown in a moisture retentive but well-drained loamy soil of at least moderate quality. This species

succeeds on poor soils. Does well in shade though it does not fruit so well in such a position. A very hardy plant, tolerating temperatures down to about -25°C. A number of named varieties have been developed for their ornamental value. The flowers are sweetly fragrant. Plants are dioecious. At least one male plant must be grown in the vicinity of up to 5 females if fruit is required. Plants can harbour a stage of white pine blister rust, so should not be grown in the vicinity of pine trees. Plants in this genus are notably susceptible to honey fungus.

Seed - best sown as soon as it is ripe in the autumn in a cold frame. Stored seed requires 3 months cold stratification at 0 - 9°c and should be sown as early in the year as possible. Under normal storage conditions the seed can remain viable for 17 years or more. Prick out the seedlings into individual pots when they are large enough to handle and grow them on in a cold frame for their first winter, planting them out in late spring of the following year. Cuttings of half-ripe wood, July/August in a frame. Cuttings of mature wood of the current year's growth, preferably with a heel of the previous year's growth, November to February in a cold frame or sheltered bed outdoors.

Geographic distribution: Native to Caucasus, Northern Anatolia, North-Western Iran.

4.2.15. ***Rosa canina*** **L., ასკილო, Common briar, Rosaceae**

Site characteristics: Grows on roadsides, in open slopes, disturbed forests, at edges of the forests and in fields, from lowland up to upper montane belt. 1,5-3 m tall shrub, sometimes scrambling. Forest edges and thinned-out forests, shrubs, open slopes, banks of mountain streams and brooks, felled areas, pastures, roadsides, fences. *Rosa canina* is a deciduous shrub growing to 3 m by 3 m at a fast rate. The flowers are hermaphrodite (have both male and female organs) and are pollinated by Bees, flies, beetles, lepidoptera, self, apomictic. The plant is self-fertile. It is noted for attracting wildlife. Snow cover is <0.3 m. The exposition is for all directions and inclination till 30°. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils, prefers well-drained soil and can grow in heavy clay soil. Suitable pH: acid, neutral and basic (alkaline) soils. It can grow in semi-shade (light woodland) or no shade. It prefers moist or wet soil. The plant can tolerates strong winds but not maritime exposure.

Picture 25: ***Rosa canina.***

Reproduction and growth characteristics: Twigs often arching, covered with hooked prickles. High, sparse, branching shrub with arcuate branches; bark green or red -brown, usually without glaucous bloomj prickles often sparse or remote, on main shoots, in pairs or whorled, with very broad base, compressed, falcately curved (very rarely suberect), smaller on fertile shoots and usually rather abundant;

Leaves usually with 7- elliptic or ovate leaflets, simple or doube serrate, 1,5-4 cm long and 1-2 cm wide, stipules narrow, with infrastipular acute prickles. leaves glabrous or with few hairs on rachis above, green or glaucescent; stipules narrow, only in terminal leaves slightly broadened, with distally divergent auricles, glandular -ciliate; leaflets of different shapes, often elliptic, 1.5-6 cm long, acuminate, acutely serrate, with thin –acuminate teeth curving upward, simple or with 1-2 secondary teeth terminating in a gland, smooth or at times sparsely glandular along veins beneath.

Flowers solitary or clustered into many-flowered inflorescence, rose, sometimes red or white. Hip elliptic, rarely nearly globose, mostly red, sometimes dark grey or yellow. Flowers solitary, 3, 4 or 5(20) in corymbiform inflorescence, on more or less long, glabrous or sparingly pubescent pedicels, as long to twice as long as hypanthium, often as long as fruit, 0.5-2.5 cm long, smooth (rarely with sparse stalked glands); sepals medium-sized, with lateral pinnules and terminal appendage, recurved after flowering and usually caducous long before ripening of fruit, well separated from disk; corolla 2-8 cm in diameter; petals usually pale pink or white, sometimes rather bright pink; disk flat or concave, sometimes distinctly conical; hypanthium mouth not exceeding one -fourth the diameter of

the disk; style long, sparsely hairy or glabrous, folded in a raceme; style heads often conical; fruit globose, or elongate -ovoid, smooth, bright or pale red.

Flowering in May-July. Fruits in October-December.

Ecosystem services: This species is a widely used stock for cultivated roses. Various parts of the plant contain tannins. An officinal plant with astringent properties. The ripe fruit is used in the treatment of diarrhea. In Caucasus the fruit pulp of R. canina has been found to contain in percent of dry weight: sugars 8.09, pectin 2.74, pentosans 2.18, nitrogenous substances 3.58, tannins and dye stuffs 3.58, acids 1.31, etc. Its vitamin content is low, 0.24-0.85% ascorbic acid per dry weight of pulp.

Fruit - raw or cooked. It can be used in making delicious jams, syrups etc. The syrup is used as a nutritional supplement, especially for babies. The fruit can also be dried and used as a tea. Frost softens and sweetens the flesh. The fruit is up to 30 mm in diameter, but there is only a thin layer of flesh surrounding the many seeds. Some care has to be taken when eating this fruit, see the notes above on known hazards. The seed is a good source of vitamin E, it can be ground and mixed with flour or added to other foods as a supplement. Be sure to remove the seed hairs. The dried leaves are used as a tea substitute. A coffee substitute according to another report. Petals - raw or cooked. The base of the petal may be bitter so is best removed. The petals are also used to make an unusual scented jam.

The petals, hips and galls are astringent, carminative, diuretic, laxative, ophthalmic and tonic. The hips are taken internally in the treatment of colds, influenza, minor infectious diseases, scurvy, diarrhoea and gastritis. A syrup made from the hips is used as a pleasant flavouring in medicines and is added to cough mixtures. A distilled water made from the plant is slightly astringent and is used as a lotion for delicate skins. The seeds have been used as a vermifuge. The plant is used in Bach flower remedies - the keywords for prescribing it are 'Resignation' and 'Apathy'. The fruit of many members of this genus is a very rich source of vitamins and minerals, especially in vitamins A, C and E, flavanoids and other bio-active compounds. It is also a fairly good source of essential fatty acids, which is fairly unusual for a fruit. It is being investigated as a food that is capable of reducing the incidence of cancer and also as a means of halting or reversing the growth of cancers. Ascorbic acid in Dog Rose shells (vitamin C, 0.2 to 2.4%). Plants make a dense and stock-proof hedge, especially when trimmed.

Succeeds in most soils. Grows well in heavy clay soils. Prefers a circumneutral soil and a sunny position with its roots in the shade. When grown in deep shade it usually fails to flower and fruit. Succeeds in wet soils but dislikes water-logged soils or very dry sites. Tolerates maritime exposure. The fruit attracts many species of birds, several gall wasps and other insects use the plant as a host A very polymorphic species, it is divided into a great number of closely related species by some botanists. The leaves, when bruised, have a delicious fragrance. The flowers are also fragrant. Grows well with alliums, parsley, mignonette and lupins. Garlic planted nearby can help protect the plant from disease and insect predation. Grows badly with boxwood. Hybridizes freely with other members of this genus. Plants in this genus are notably susceptible to honey fungus.

Rose seed often takes two years to germinate. This is because it may need a warm spell of weather after a cold spell in order to mature the embryo and reduce the seed coat. One possible way to reduce this time is to scarify the seed and then place it for 2 - 3 weeks in damp peat at a temperature

of 27 - 32°C (by which time the seed should have imbibed). It is then kept at 3°C for the next 4 months by which time it should be starting to germinate. Alternatively, it is possible that seed harvested 'green' (when it is fully developed but before it has dried on the plant) and sown immediately will germinate in the late winter. This method has not as yet been fully tested. Seed sown as soon as it is ripe in a cold frame sometimes germinates in spring though it may take 18 months. Stored seed can be sown as early in the year as possible and stratified for 6 weeks at 5°C. It may take 2 years to germinate. Prick out the seedlings into individual pots when they are large enough to handle. Plant out in the summer if the plants are more than 25 cm tall, otherwise grow on in a cold frame for the winter and plant out in late spring. Cuttings of half-ripe wood with a heel, July in a shaded frame. Overwinter the plants in the frame and plant out in late spring. High percentage. Cuttings of mature wood of the current season's growth. Select pencil thick shoots in early autumn that are about 20 – 25 cm long and plant them in a sheltered position outdoors or in a cold frame. The cuttings can take 12 months to establish but a high percentage of them normally succeed. Division of suckers in the dormant season. Plant them out direct into their permanent positions. Layering. Takes 12 months.

Geographic distribution: Native to Europe, Northern Africa, Caucasus, Asia.

4.2.16. *Spiraea hypericifolia* L., გრაკლა, Spiraea, Rosaceae

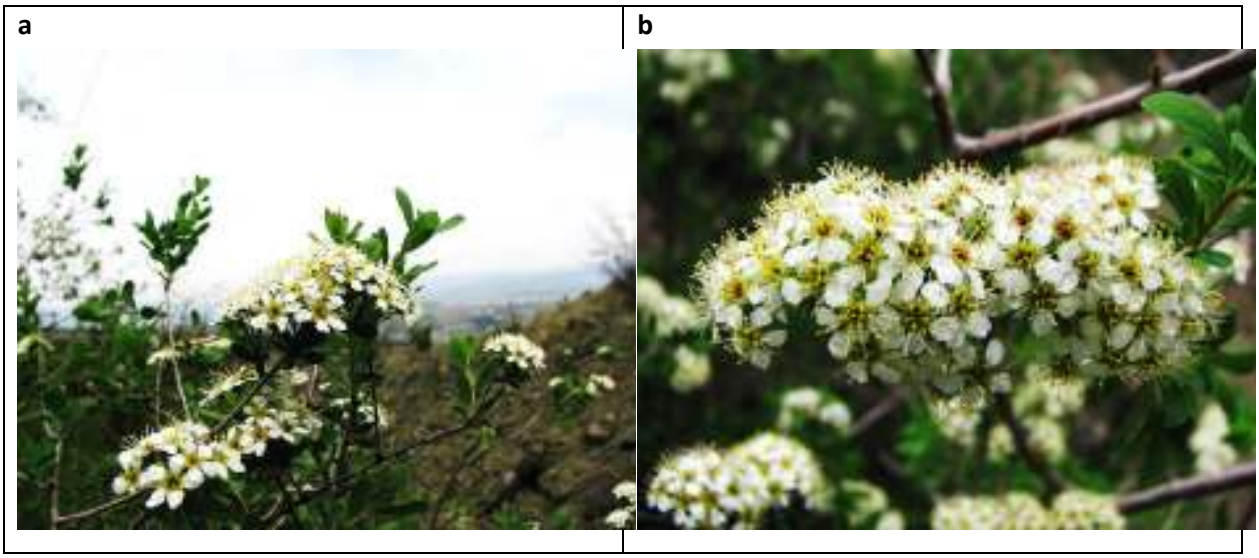
Site characteristics: Grows from lowland to subalpine belts in shrublands 100-2,100 m. Shrub 50—150 cm high; Snow cover is <0.3 m. The exposition is for all directions and inclination till 30°. Sunny edge is normal; dappled shade is in North Wall, East Wall, and West Wall. Steppe and forest -steppe zone where, together with other steppe shrubs, it forms thickets; also gully slopes and open, often also stony slopes; in mountain regions of Caucasus in the shrub zone, on open slopes, in juniper woods, and on mountain riverbanks; in the Caucasus in shrubthickets on mountain slopes, penetrating to alpine meadows where it grows as a small, low, much branched shrub, often with broader leaves.

Reproduction and growth characteristics: branches light brown, often long, virgate, with numerous, crowded sessile umbels; young shoots glabrous or tomentose pubescent;

Leaves glabrous or short hairy when young. Leaf is obovate, oblong-elliptic or lanceolate, obtuse or rarely acute, entire. Leaves of sterile shoot tipped in 2-5 teeth, leaf blade narrows to a wedge-shaped base. leaves 10-25 mm long, 1.5-8 mm broad, glabrous or puberulent when young, oboval, oblong - elliptic or lanceolate, obtuse or acute, entire, those on sterile shoots sometimes with 2-5 teeth at the apex, cuneately tapering to short, 1.5-5 mm petiole;

Flowers white, inflorescences 4-10 flowers clustered into umbel. pedicels glabrous or slightly pubescent, 5-15 mm long, to 18 mm long in fruit; flowers 5-8 (9) mm in diameter, with oboval or ovate petals and triangular sepals 1,3- l,2 as long as follicles, the latter glabrous or pubescent. Fruit glabrous or pubescent follicle, dehiscent on one side.

Flowering in April —June, fruits from July.



Picture 26: Flowering period of *Spiraea hypericifolia'* was in 20 April in Tbilisi 540 m.

Ecosystem services: Used for fastening of sands; ornamental and nectariferous. Spiraea species are used as food plants by the larvae of many Lepidoptera species, including the Brown-tail, the Small Emperor Moth, the Grey Dagger, the Setaceous Hebrew character, and the moth *Hypercompe indecisa*.

Seed - we have no information for this species but suggest sowing the seed as soon as it is ripe in a cold frame if possible. It is likely to require stratification before it germinates, so stored seed should be sown in a cold frame as early in the year as you receive it. Prick out the seedlings into individual pots when they are large enough to handle, and grow them on in a cold frame for their first winter. Plant them out in late spring or early summer of the following year. Cuttings of half-ripe wood, July/August in a light sandy soil a frame. Cuttings of mature wood of the current seasons growth, 15cm long, October/November in an outdoor frame. Another report says that September is a good time to do this. Division of suckers in early spring. They can be planted out straight into their permanent positions.

Geographic distribution: Native to Eurasia.

5. SUITABILITY OF SITES FOR THE DEFINED LAND USE INTEREST

5.1. Method

The goal was to identify suitable afforestation areas and develop an afforestation management plan. To identify a site as suitable for afforestation, a wide range of socio-ecological, socioeconomic and legal information is required. The decision on afforestation in a specific area also requires information on the erosion and avalanche dynamics to derive potential constraints for afforestation or the mitigation potential on erosion dynamics. As a socioeconomic constraint for any afforestation activity, the land use interests of the local population and especially of local farmers and shepherds were of crucial interest.

For the field survey two teams with different task were planned. One team was responsible for screening the afforestation suitability (ARS) of sites, map the different land cover/land-use types and describe the erosion dynamics in the area and the erosion or avalanche mitigation potential. The second team was responsible to assess the current forest situation.

ARS Field Survey based on socio-ecological data:

In order to describe the afforestation suitability of a site it is necessary to integrate various data. The biome type (Table 2) and water balance class (Table 5) of a site are the reflection of the integral site parameters, which were screened in the course of the field survey (Table 3).

Forest growth depends on various site factors, out of which the most crucial ones are geographical position, geology, soil type, soil depth, elevation above sea level, exposition, inclination, relief, water balance class, biome type (in terms of actually growing vegetation), etc. All those factors result in the formation of the potential natural vegetation, which in some cases can be forest vegetation.

In advance to the field trip, the area around Stepantsminda below an elevation of 2500 m was separated into rectangular survey units with a size of 0.005° x 0.005° (about 500 m x 700 m), which where continuously numbered (Picture 28). For every survey unit we printed the aerial photo as available in ArcGIS 10 on A4 paper. Later in the field, the land cover polygons were drawn on transparent foils laid over the aerial photos.

Essential site parameters are elevation, inclination and exposition, being decisive for the temperature and irradiation regime, and water budget, and thus fundamentally affecting the growing conditions. These parameters can either be determined in the field with the suitable equipment or in the office with a sufficiently detailed digital elevation model (Table 4). The digital elevation model (DEM) used as a source for altitude information was the ASTER global digital elevation model (ASTER GDEM) with an elevation grid resolution of 1 arc second. ASTER GDEM is a product of METI and NASA. For the project area this mean a grid cell size of about 23 m x 30 m. The Georeferenced Tagged Image File Format (GeoTIFF) file 'ASTGTM2_N42E044_DEM.tif' contains the whole project area (Picture 29). Slope and aspect were calculated from the DEM using ArcGIS 10.2 using the Spatial Analyst tools 'Slope' and 'Aspect' (Picture 30, Picture 31).

Table 2: Biome Type/land cover key used for the field survey

Broadleaved Forest Communities:	
101	Birch Forest (*Betula litwinowii*)
102	Elfin crooked-stemmed birch forest (*Betula litwinowii*)
Coniferous Forest Communities:	
201	Pine Forest (*Pinus kochiana*)
202	Patchy Pine Forest on Rock Sites (*Pinus kochiana*)
Shrub Communities:	
301	*Rhododendron caucasicum* Community
302	*Dryas caucasica* Community
303	*Hippophae rhamnoides* Community
304	*Salix sp.* Community
Meadow Communities:	
401	*Bromopsis variegata* Community
402	*Agrostis tenuis* Community
403	*Festuca varia* Community
404	*Trollius ranunculinus* Community
405	*Anemone fasciculata* Community
406	*Nardus stricta* Community
407	*Carex tristi*s Community
408	*Kobresia capilliformis* Community
409	*Calamagrostis arundinacea* Community
410	Meadow sp.
Subalpine high herbaceous vegetation (Hochstauden):	
501	*Heracleum sosnowskyi, Aconitum nasatum, Cicerbita macrophylla*, etc.
Rocks, Scree, Ditches and Riverbeds:	
601	Biotopes on Moist Rocks: *Parietaria micranta, Dryopteris pumilis,* etc.
602	Biotopes on marly and slaty scree: *Silene lacera, Erysimum ibericum, Linaria vulgaris*, etc.
603	Biotopes on stones: *Sempervivum pumilum, Thymus collinus, Campanula bellidifolia*
604	Rock sites with herbaceous vegetation
605	Pure Rock Sites
606	Riverbeds and Brook-Beds without established perennial vegetation (gravel, scree and rocks)
607	Ditches without vegetation
608	Ditches with soil vegetation cover
609	Ditches with soil vegetation and woody vegetation (trees and/or shrubs)
610	Scree
611	Settlements with vegetation

5. Suitability of sites for the defined land-use interest

Table 3: Field survey data explanation

Date:	dd.mm.yyyy
Map-No.:	1 – N
Polygon-No.:	1 – N
Biome Type:	(See Admission Key)
GPS-data:	WGS84
Elevation:	Units of 100 m: 1=100 m; 18=1800 m, 21=2100 m,…
Exposition:	N-NW-W-SW-S-SE-E-NE-FLAT
Inclination:	Units in °
Relief:	Upper Slope (U), Backslope (B), Footslope (F), Crest/Ridge (R), Trench (T), Flat (A), Scree Area (CR), Boulder Areas (BA), Rock Sites (KS), Ditch (DI), Consolidated Slope (SL), Debris Cone (SR),…
Water-Class:	too dry for Vegetation (td/1), dry (dy/2), medium dry (my/3), medium fresh (mf/4), fresh (fr/5), very fresh (vf/6), moist (mo/7), wet (we/8), too wet for Vegetation (tw/9), changing moisture (cm/0)
Geology:	Silicatic (SI), Slate (SA), Volcanic (VO), Carbonatic (CA)
Soil Type:	taxation: Braunerde (BE), Parabraunerde (PB), Pseudogley (PG), Gley (GY), Ranker (RA), Semipodsol (SP), Podsol (PO), Scree (SE), etc.
Soil Depth:	Units in cm
Soil Depth Class:	1 = 0 – <15cm, 2 = 15 – <30cm, 3 = 30 – <60cm, 4 = 60 – 120cm, 5 = >120cm
Land-Use Type:	Forest, (FO), Hayfield (HF), Pasture (PA), abandoned Pasture or Hayfield (AB), Shrubs (SH), No Use (NU)
Crown Cover Trees:	Percentage (%), Whole Tree Cover, Tree Height > 2 m
Crown Cover Shrubs:	Percentage (%), Height < 2 m
Cover Herbal Vegetation:	Percentage (%)
Rock Cover:	Percentage (%)
Tree Species and Share:	Tree/Shrub Species and Share (X = <5%, 1 = 5 – 15%, 2 = 15 – 25%,...)
Regeneration:	Yes or No; If Yes, Species and Share (X = <5%, 1 = 5 – 15%,...)
Distance seed tree:	Distance to next Seed Tree, Units in m
Erosion Areas:	Percentage (%) of the Polygon or % of the side length where lateral slope erosion
Erosion Type:	Open Erosion (OE), Tree Root Erosion (TE), Lateral Slope Erosion (LS), etc.
Erosion Tendency:	Stagnant (st), Decreasing (dc), Increasing (in)
Constraints for AR:	Rock Areas (RA), Avalanche Strips (AS), Mowing of Grassland (MG), Snow Creeping (SC), Wind Erosion (WE), Dry Site (DS), Remote Location (RL), Pasture Land (PL), Steep Site (ST), High herbal Vegetation (HV), Too shallow soil (SO), Erosion Dynamics (ED), Shrub Land (SL), Forest (FO) etc.
Facilitation of AR:	Excellent Site Conditions (EX), Proximity to Village (PV), Already existing young Trees (YT), Out of Reach of Livestock (OL), etc.
ARS:	Very high (V), High (H), Medium (M), Difficult (D), Impossible (I)
Erosion Mitigation Potential of AR:	YES or NO
Recommended tree species:	(…), Natural Regeneration Dynamics (NRD)

5. Suitability of sites for the defined land-use interest

In order to compile the most important data for the tree species recommendations, the field survey data sheet was created (Table 3). The ecological site factors were gathered with specific professional tools (Table 4). It has to be highlighted that the high quality of the field survey became possible through the cooperation of Georgian and Austrian experts, by the way providing an integration of the expertises.

Table 4: Site parameters and survey tools

Forest Site Parameter	**Survey-Tool**
Elevation	Digital elevation model (DEM)
Exposition	Compass or DEM
Inclination	Compass or DEM
Geology	Maps, screening in the field
Soil Type, Soil Depth	Soil Probe ("Schlagbohrer")
Water Balance Class	Plants as Indicator Species
Relief	Survey Expertise
Erosion Type, Tendency, Percentage	Survey Expertise
Biome Type	Survey Expertise
Recommended Tree Species	Integration of all parameters

In a certain survey area the relevant land-use/land cover polygons were distinguished, drawn on the aerial photograph and described according to the field survey data sheet (Table 3). To determine the water-balance-class, indicator plants can be utilised (Ellenberg et al. 1992). Such indicator plants were selected for the study region during the field work (Table 5, for example Picture 27). The biome type was selected from the biome type/land cover key (Table 2), which had been derived from Nakhutsrishvili, Abdaladze and Akhalkatsi (2005) and extended during the field work. For the survey areas Arsha, Sno and Kanobi no rectangular survey units had been predefined and thus no aerial photograph had been printed. Thus sketches of the area were drawn and drawn on an aerial photograph when back in office. After the field work the land cover polygons were digitised in ArcGIS. The results of this work are described in the subchapter 2 Field survey areas. In the beginning two maps showing land-use and erosion percentage for all polygons are presented (Picture 36, Picture 37).

Table 5: Water-Classes (water balance classes) and indicator plants as determined for the study region

Water-Class	**Indicator plants**
Dry	*Artemisia absinthium*
Medium Dry	*Rhinanthus sp.*
Medium Fresh	*Alchemilla sp.*
Fresh	*Betonica grandiflora (Betonica macrantha)*
Very Fresh	*Heracleum sosnowskyi, Cicerbita macrophylla, Aconitum nasatum*
Moist	*Equisetum sp.*
Wet	*Sphagnum sp.*

Picture 27: *Betonica grandiflora* (*Betonica macrantha*). Source: Roland Koeck

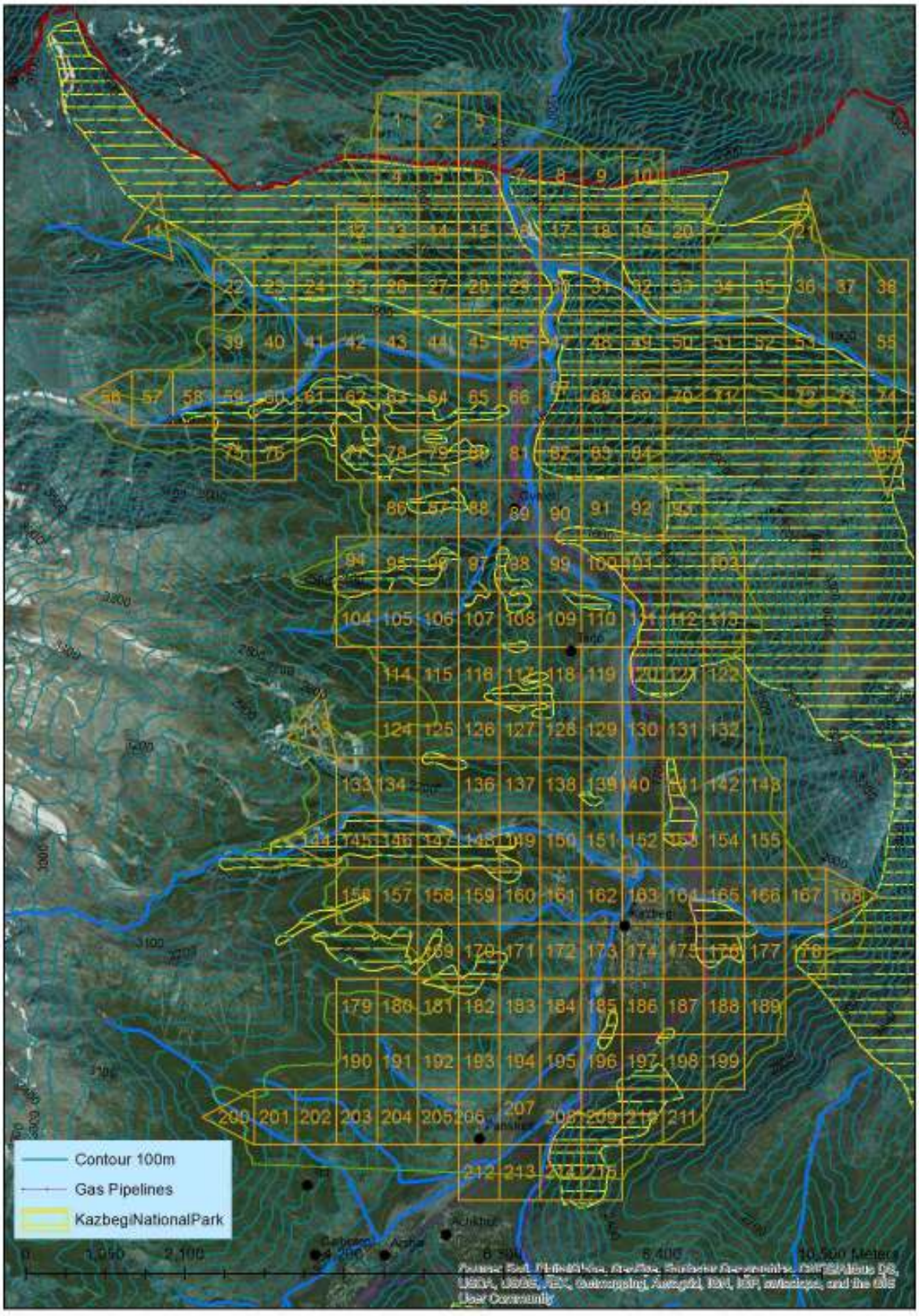
The outcome was for each survey site the description of the ecological conditions, including erosion type and tendency and as most important factor the recommendation of the tree species set for afforestation measures (Table 4). The recommendation of the tree species set was defined on the socio-ecological data of the survey. The sociological behaviour of the autochthonous tree species in the Kazbegi region was a crucial aspect for the recommendations. The whole ecological survey data set provided the possibility to define the well-founded recommendations for each afforestation site.

Table 6: Site-Index: Forest growth rate according to site conditions

Site Index - Forest Growth Rate		
Good	Medium	Bad

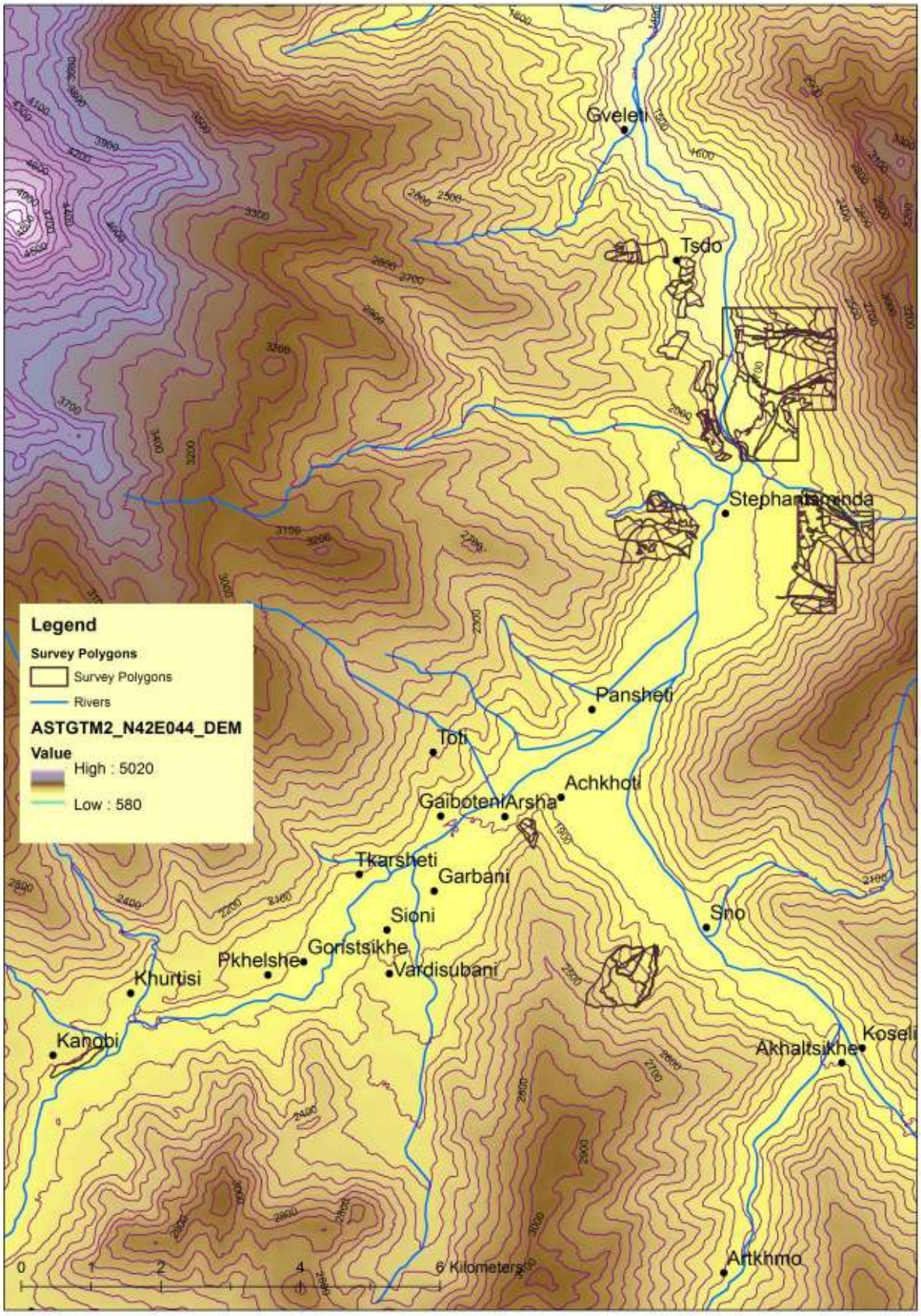
For each afforestation site, the site index was rated, based on the parameters soil type, soil depth, water balance class and elevation above sea level. The site index is used for the calculation of carbon sequestration. On sites with the index ‘good’ forest trees show high increments, those with ‘medium’ are in the middle and those with the index ‘bad’ show only a low increment (Table 6).

5. Suitability of sites for the defined land-use interest



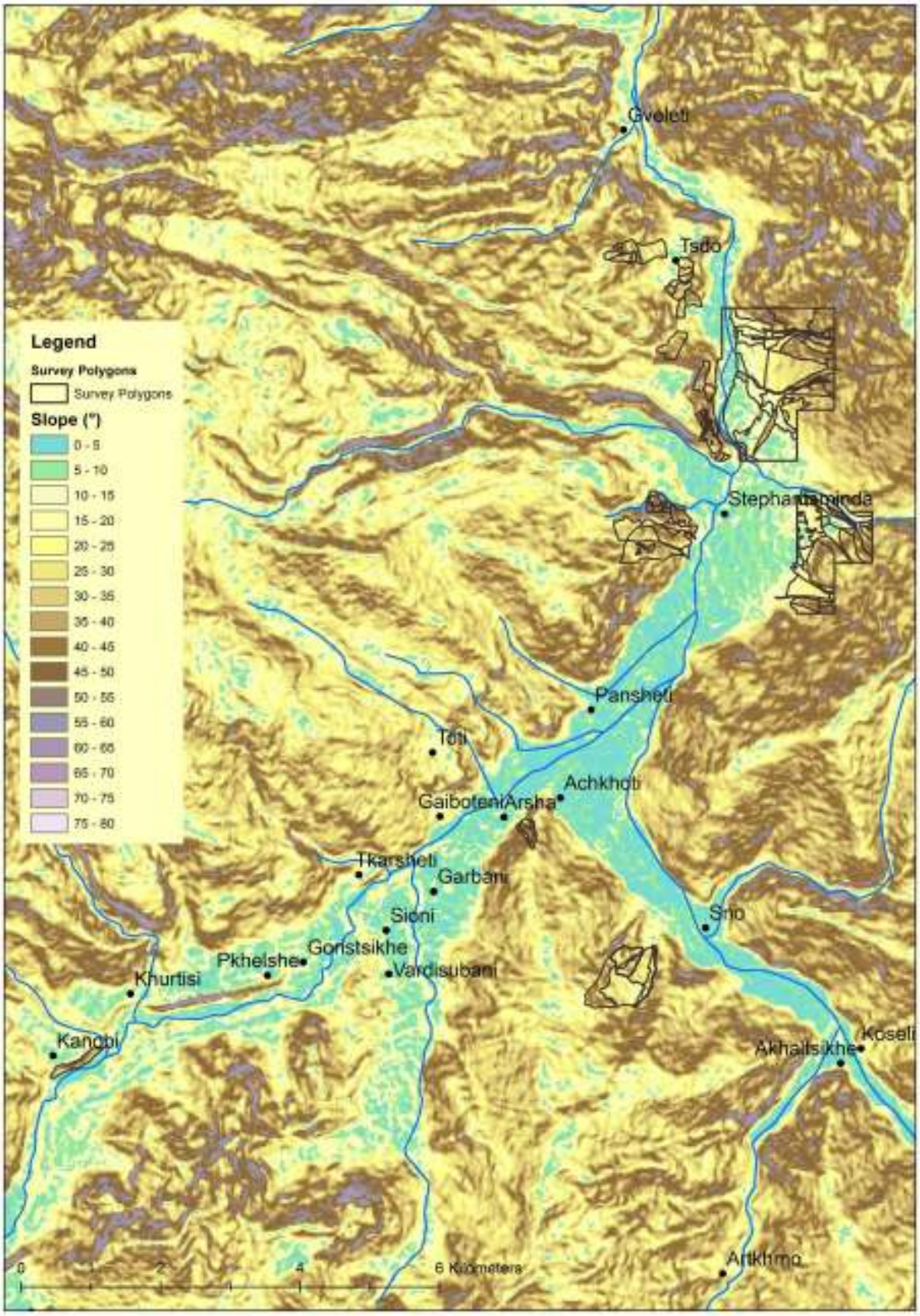
Picture 28: Map with numbered survey units as basis for the field work in July 2015.

5. Suitability of sites for the defined land-use interest



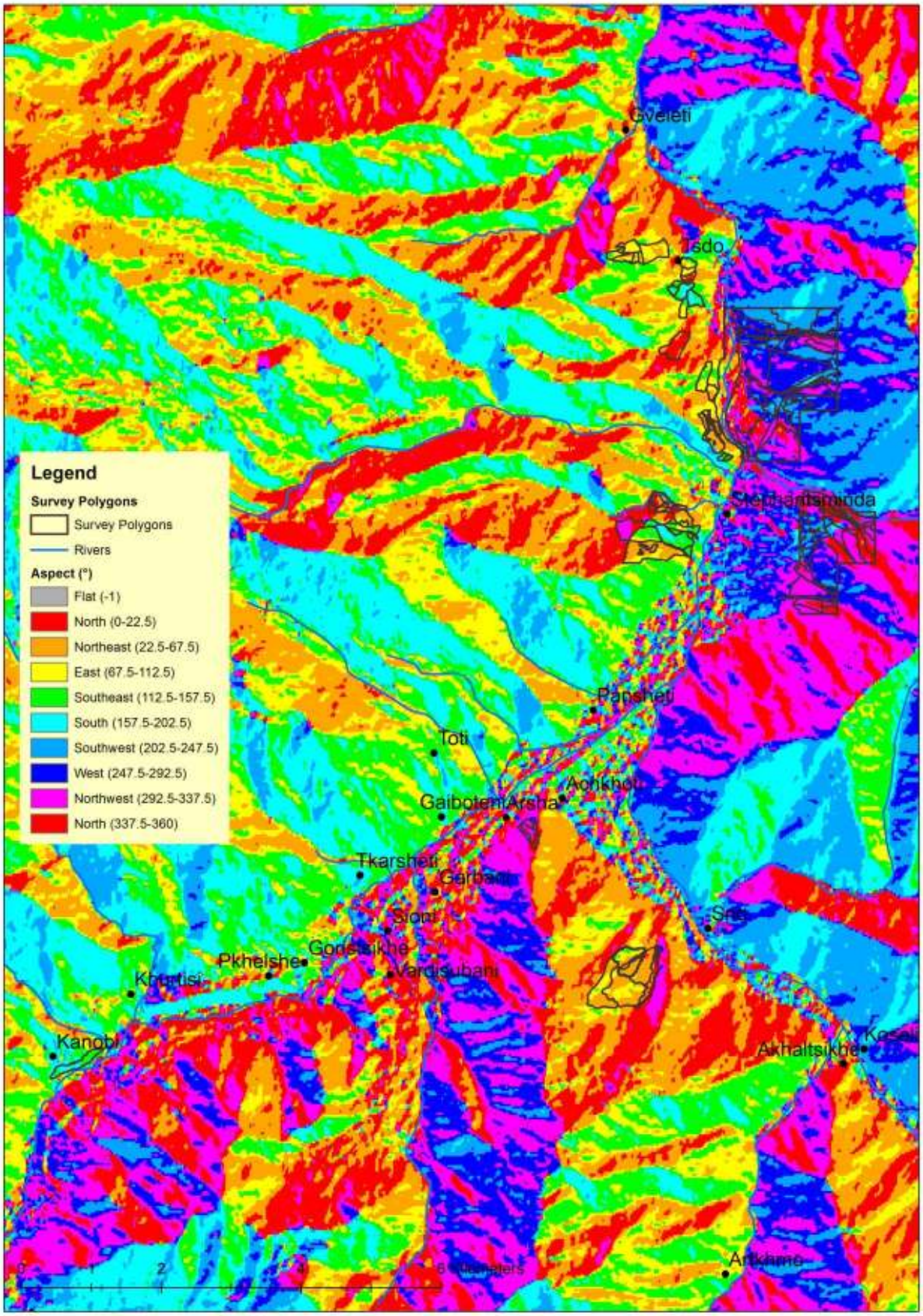
Picture 29: Elevation information for the project area from ASTER GDEM and field survey areas.

5. Suitability of sites for the defined land-use interest



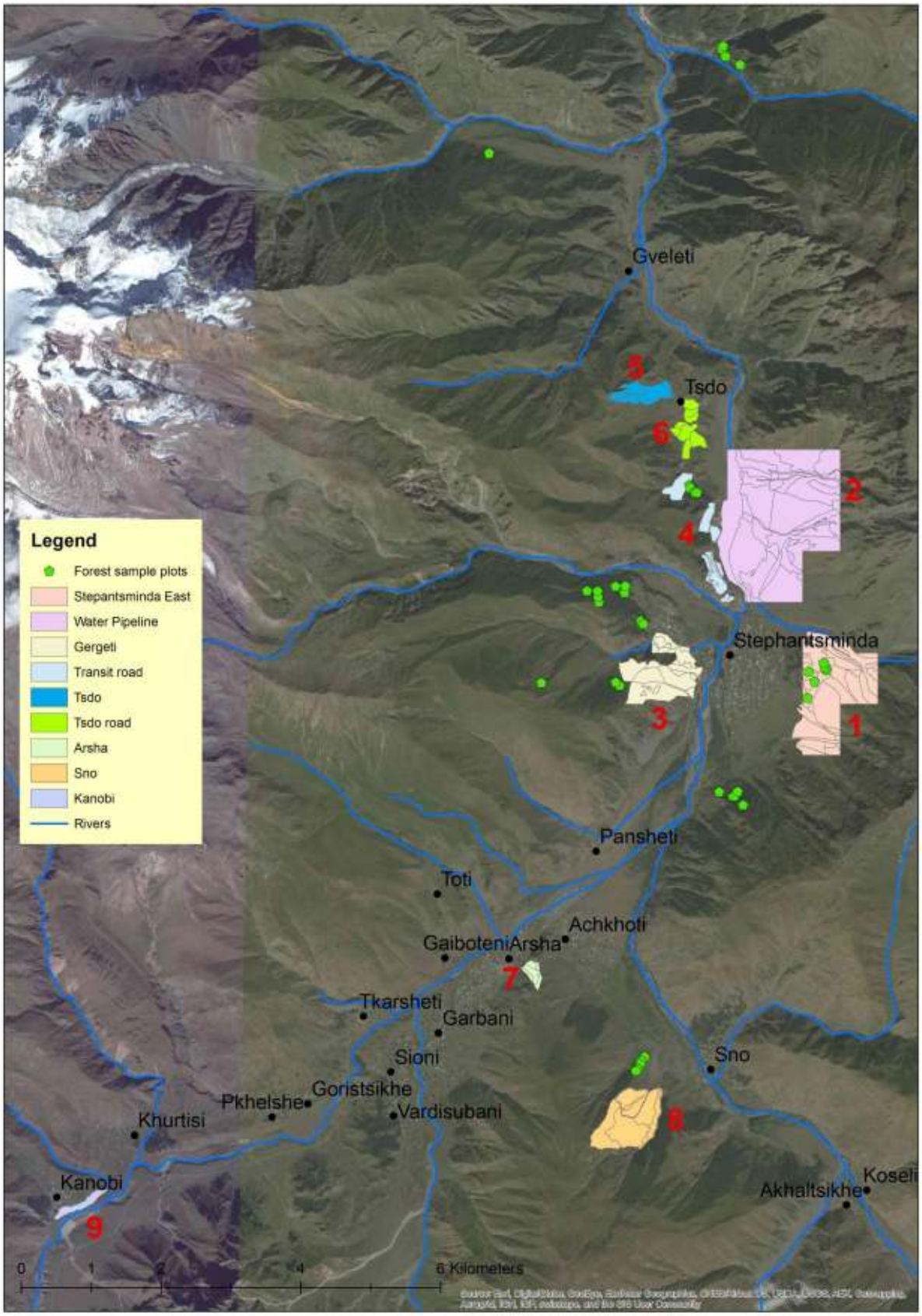
Picture 30: Slope (°) for the project area calculated with ArcGIS from the available digital elevation model, displayed in 5° categories.

5. Suitability of sites for the defined land-use interest



Picture 31: Aspect (°) for the project area calculated with ArcGIS from the available digital elevation model, displayed in 10 categories.

5. Suitability of sites for the defined land-use interest



Picture 32: The GIS-map, displaying the nine field survey areas with the single land cover polygons and the forest survey sample plots in the area of Stephantsminda.

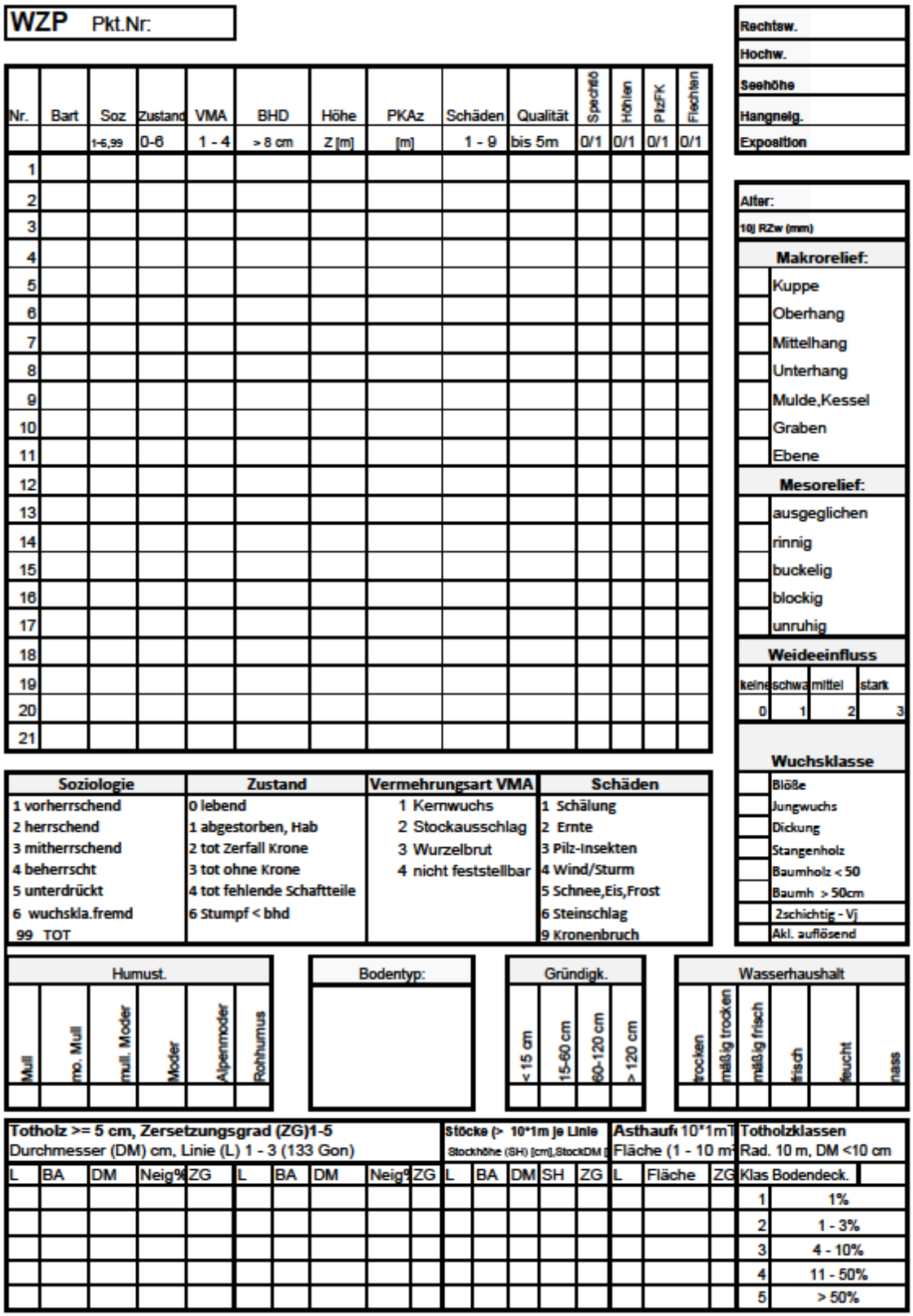
Forest situation:

The actual forest situation was investigated in the study region. The focus was put on covering the existing different forest types and the full range of forest age classes. The location of the investigated forest stands is shown in Picture 32. In every forest stand several angle count samples were taken and forest damage, the amount of dead wood and the tree regeneration were determined (Picture 33, Picture 34, Picture 35). Tree diameter (dbh) and tree height were recorded. A tree core was taken from the average diameter tree for every tree species.

The average quadratic mean diameter per stand type was calculated from the single tree basal areas. The number of trees per hectare was derived from the basal area of the single trees and the basal area factor (giving the representative basal area per hectare for every tree in the sample, here 4). The total basal per hectare was derived from the number of trees in the angle count sample and the basal area factor (4). The ten year radial increment was determined from the tree core taken in the field. The single tree volume was calculated from dbh, height and a species and tree specific form factor. Volume per hectare was calculated from single tree volume and the representative number of trees. Stand volume was converted into above ground woody biomass by multiplying it with a species specific dry wood density taken from the literature. A generic value of 20% of above ground woody biomass was taken as an estimate for root biomass. Carbon content was assumed to be 50% to calculate carbon stored in biomass. Eventually carbon stocks were converted into CO_2 by considering the weight content of carbon in CO_2.

The data from the different sites were grouped into different forest ecosystem types, age classes, past forest management and major site characteristics. The summarised results for these groups are shown in chapter 5.3.

5. Suitability of sites for the defined land-use interest



WZP Pkt.Nr:

Nr.	Bart	Soz	Zustand	VMA	BHD	Höhe	PKAz	Schäden	Qualität	Spechtlö	Höhlen	PlzFK	Flechten
		1-6,99	0-6	1 - 4	> 8 cm	Z [m]	[m]	1 - 9	bis 5m	0/1	0/1	0/1	0/1
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													

Rechtsw.
Hochw.
Seehöhe
Hangneig.
Exposition

Alter:
10J RZw (mm)

Makrorelief:
Kuppe
Oberhang
Mittelhang
Unterhang
Mulde,Kessel
Graben
Ebene

Mesorelief:
ausgeglichen
rinnig
buckelig
blockig
unruhig

Weideeinfluss

keine	schwa	mittel	stark
0	1	2	3

Wuchsklasse
Blöße
Jungwuchs
Dickung
Stangenholz
Baumholz < 50
Baumh > 50cm
Zschichtig - Vj
Akl. auflösend

Soziologie	Zustand	Vermehrungsart VMA	Schäden
1 vorherrschend	0 lebend	1 Kernwuchs	1 Schälung
2 herrschend	1 abgestorben, Hab	2 Stockausschlag	2 Ernte
3 mitherrschend	2 tot Zerfall Krone	3 Wurzelbrut	3 Pilz-Insekten
4 beherrscht	3 tot ohne Krone	4 nicht feststellbar	4 Wind/Sturm
5 unterdrückt	4 tot fehlende Schaftteile		5 Schnee,Eis,Frost
6 wuchskla.fremd	6 Stumpf < bhd		6 Steinschlag
99 TOT			9 Kronenbruch

Humust.

Mull	mo. Mull	mull. Moder	Moder	Alpenmoder	Rohhumus

Bodentyp:

Gründigk.

< 15 cm	15-60 cm	60-120 cm	> 120 cm

Wasserhaushalt

trocken	mäßig trocken	mäßig frisch	frisch	feucht	nass

Totholz >= 5 cm, Zersetzungsgrad (ZG)1-5
Durchmesser (DM) cm, Linie (L) 1 - 3 (133 Gon)

L	BA	DM	Neig%	ZG	L	BA	DM	Neig%	ZG

Stöcke (> 10*1m je Linie
Stockhöhe (SH) [cm],StockDM [

L	BA	DM	SH	ZG

Asthauf 10*1mT
Fläche (1 - 10 m²

L	Fläche	ZG

Totholzklassen
Rad. 10 m, DM <10 cm

Klas	Bodendeck.
1	1%
2	1 - 3%
3	4 - 10%
4	11 - 50%
5	> 50%

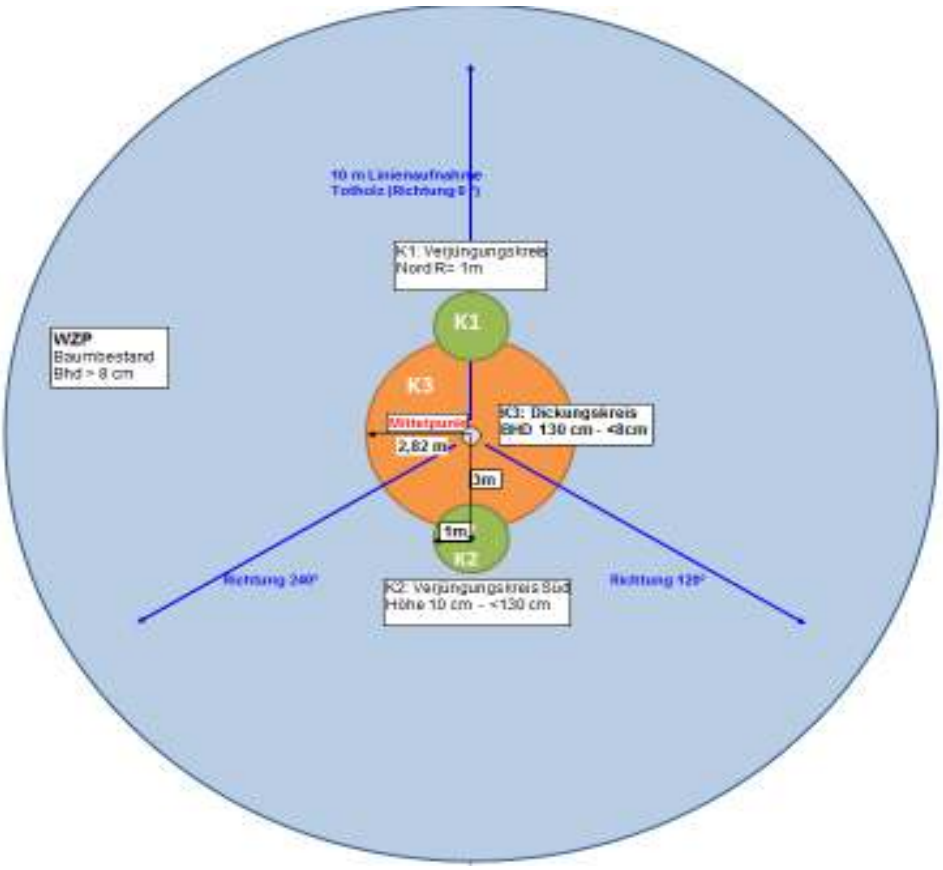
Picture 33: Forest sampling sheet, for angle count sample and description of site and forest damage, in German.

5. Suitability of sites for the defined land-use interest

Kreis 1	Mittelpunkt 3m Nord	**Radius: 1 m**	bis Höhe <130 cm	
Kreis 2	Mittelpunkt 3m Süd	**Radius: 1 m**	bis Höhe <130 cm	**PktNR:**
Kreis 3	am Mittelpunkt	**Radius: 2,82 m**	130 cm Höhe - 8 cm BHD	**Seite:**

	Höhe 10 - 30 cm				Bäume > 30 cm						
Kreis 1/2/3	Bart	d10	Anz. Verbissen	Anz. Unverbissen	Bart	d10	Höhe	BHD	Kern 1 / St 2 / Wb 3/ nf 4	Verbiss Hauptrieb 0/1	Schaden
		[mm]				[mm]	[cm]	[mm]	1 / 2 / 3 / 4	0 I 1	0 / 1

Picture 34: Forest sampling sheet for tree regeneration measurement in German.



Picture 35: Scheme of tree regeneration measurement in German.

5.2. **Field survey areas**

5.2.1. **Overview of the field survey results and general afforestation recommendations:**

The field survey for describing the afforestation suitability (ARS) of the sites was carried out in July 2015.

During the field survey in total we described 146 polygons according to the scheme described above (Table 3).The focus of the survey was on areas recommended by the municipality knowing of existing interest of the local population in afforestation and on areas along the transit road and the hydro power plant water pipeline. The investigated sites can be summarised as nine different field survey areas (Picture 32). The total area of the investigated sites is 650 ha.

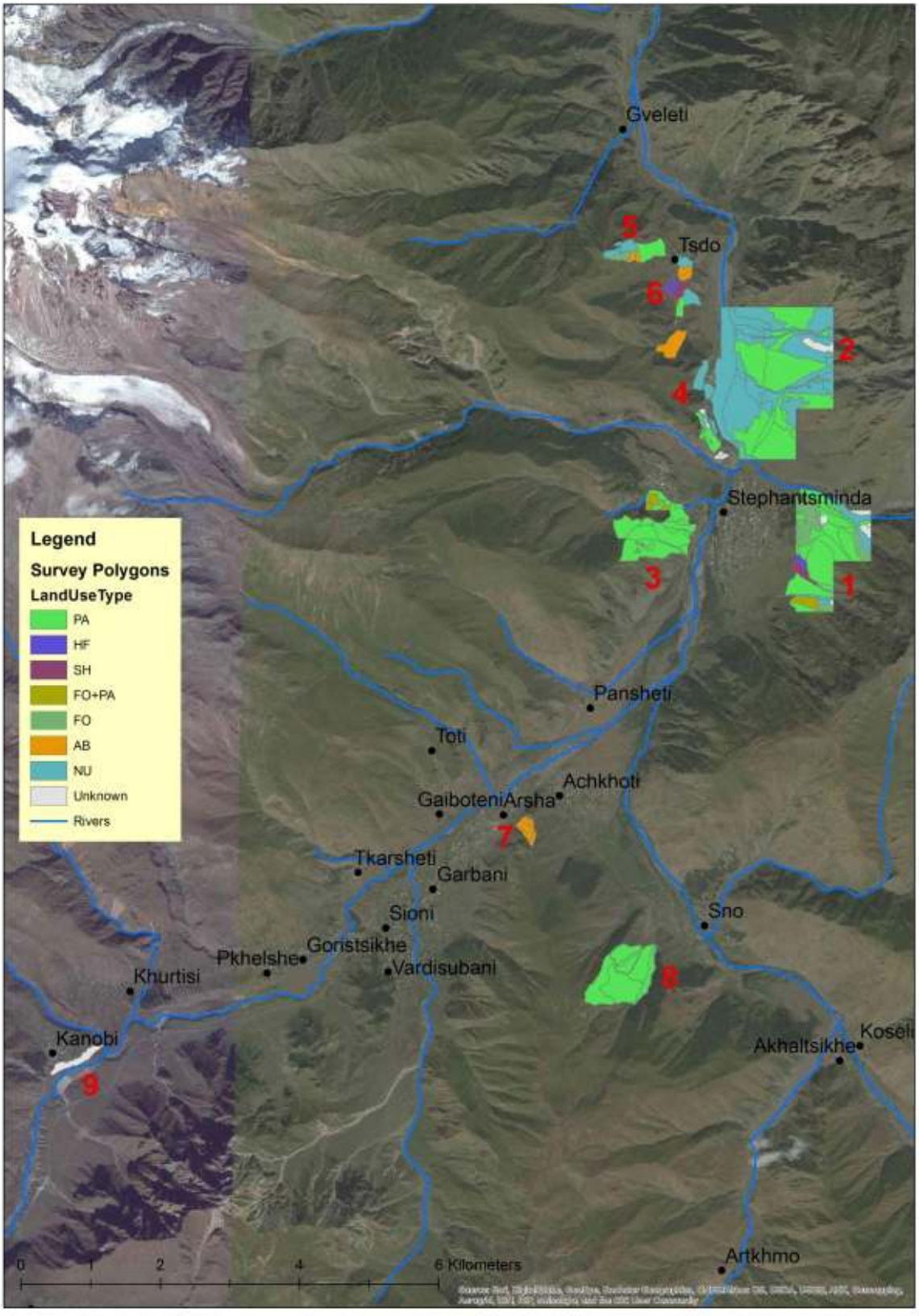
The land-use type categorisation for the polygons is shown in Picture 36. The erosion percentage for the areas is shown in Picture 37. Of the investigated areas only small areas are covered by the cadastre (Picture 38).

Out of the investigated sites 52 areas were considered as suitable for afforestation measures, considering site characteristics and land-use interests. The total area of these 52 sites is 207 ha. Due to the fact that in some areas rocks reach the surface the area that effectively can be afforested is reduced by the area covered by rocks. In addition, where there is already regeneration or single trees, the area for afforestation is reduced by the regeneration, tree and shrub coverage, because existing tree and shrub vegetation in any case needs to be secured and integrated into the afforestation measure. Thus, the total area where effectively trees can be planted is 168 ha (Table 8).

At various site there was already identified an established regeneration process of trees. Any existing tree and shrub regeneration has to be kept and integrated into the afforestation measures. Those naturally established tree individuals show high stability and provide a matrix for the afforestation process.

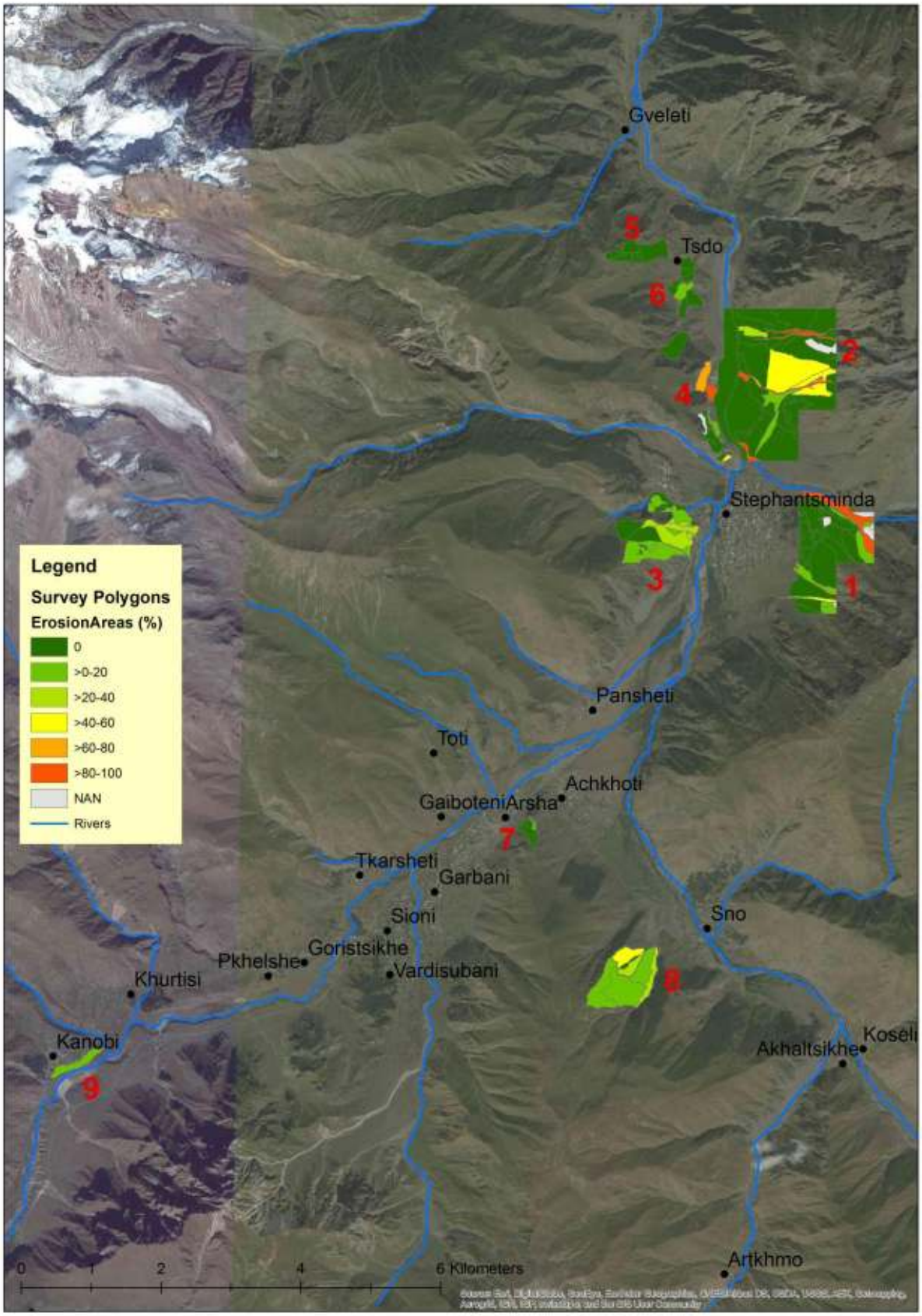
Generally, we recommend mixed species plantations. The species, however, shall be planted in groups of single species (several individuals) and not homogenously mixed. This shall reflect natural recruiting and forest structure.

5. Suitability of sites for the defined land-use interest



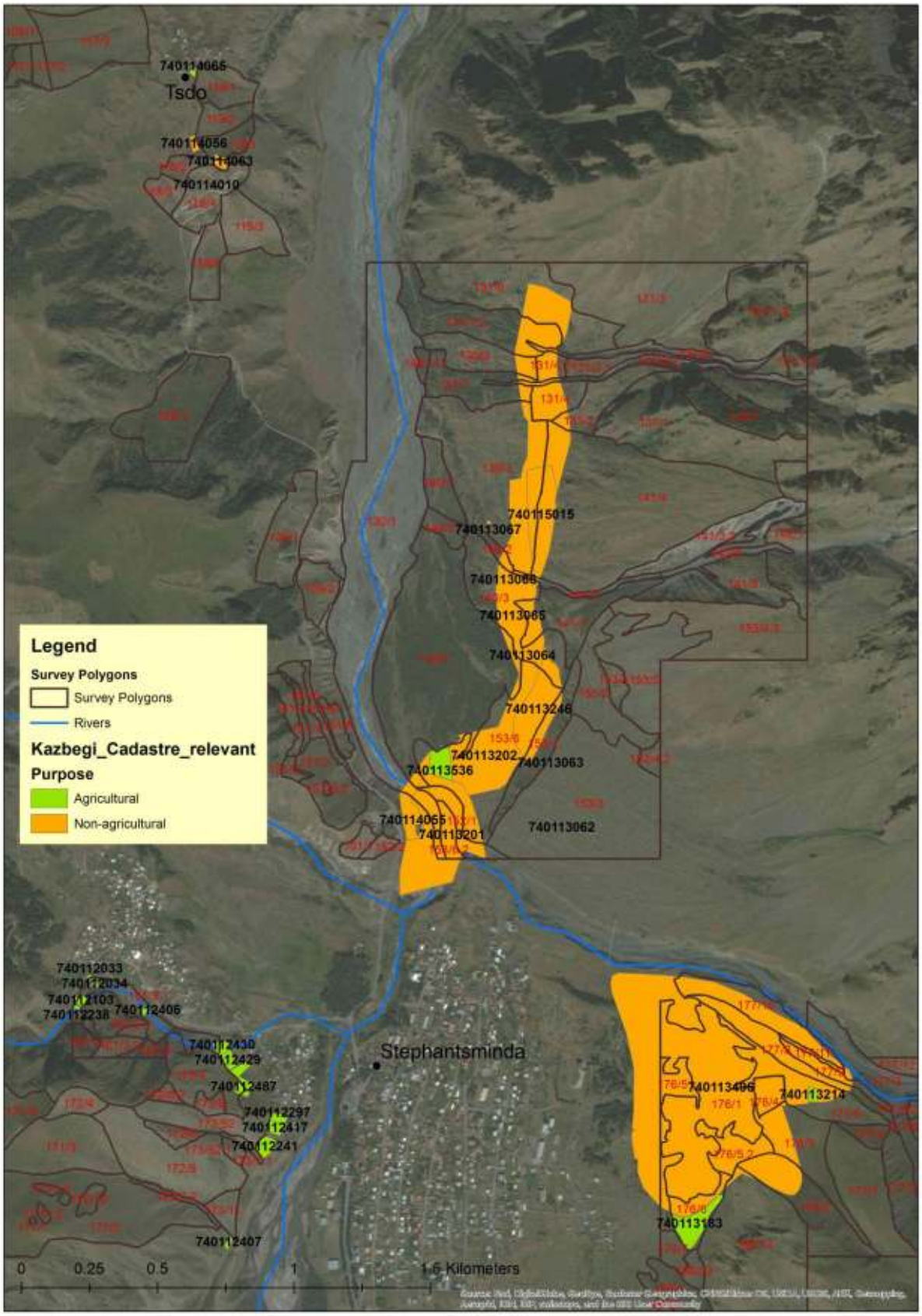
Picture 36: Land-use type as determined for the land cover polygons during the field work in July 2015, abbreviations as explained in Table 3.

5. Suitability of sites for the defined land-use interest



Picture 37: Percent of areal erosion (open erosion) or erosion along the edge (lateral slope erosion) for the land cover polygons as determined during the field work in July 2015.

5. Suitability of sites for the defined land-use interest



Picture 38: Cadastre parcels in the project region intersecting with the land cover polygons.

5. Suitability of sites for the defined land-use interest

Table 7: Cadastre parcels, area, land-use, owner and ownership (private, state) intersecting with the land cover polygons

Parcel	Area (m^2)	Land-use	Owner	Ownership
740114010	36	Non-agricultural	Georgian State Electrosystem	state
740115015	32,778	Non-agricultural	JSC ""Dariali Energy""	private
740112033	364	Agricultural	Berdia Tsiklauri	private
740112034	373	Agricultural	Berdia Tsiklauri	private
740114055	14,855	Non-agricultural	no data in public register	no data
740114056	1,382	Non-agricultural	Kazbegi Municipality	state
740113062	49	Non-agricultural	Georgian State Electrosystem	state
740113063	36	Non-agricultural	Georgian State Electrosystem	state
740114063	2,176	Non-agricultural	Kazbegi Municipality	state
740113064	36	Non-agricultural	Georgian State Electrosystem	state
740113065	36	Non-agricultural	Georgian State Electrosystem	state
740114065	621	Agricultural	no data in public register	no data
740113066	36	Non-agricultural	Georgian State Electrosystem	state
740113067	196	Non-agricultural	Georgian State Electrosystem	state
740112103	1,687	Agricultural	Viktor Sujashvili	private
740113183	13,220	Agricultural	no data in public register	no data
740113201	84,997	Non-agricultural	State	state
740113202	240,972	Non-agricultural	JSC ""Dariali Energy""	private
740113214	1,600	Agricultural	no data in public register	no data
740112238	269	Agricultural	Davit Sujashvili	private
740112241	4,059	Agricultural	Beglar Khutsishvili	private
740113246	37,637	Non-agricultural	JSC ""Dariali Energy""	private
740112297	1,925	Agricultural	Ivane Sujashvili	private
740112403	2,130	Agricultural	Shota Sujashvili	private
740112406	600	Agricultural	Tamar Gujaraidze	private
740112407	815	Agricultural	Guram Sujashvili	private
740112417	2,380	Agricultural	Anzor Chibashvili	private
740112429	2,570	Agricultural	no data in public register	no data
740112430	2,280	Agricultural	Makvala Chibashvili	private
740112487	3,140	Agricultural	Elguja Khutsishvili	private
740113496	490,000	Non-agricultural	Kazbegi National Park	state
740113536	8,000	Agricultural	no data in public register	no data

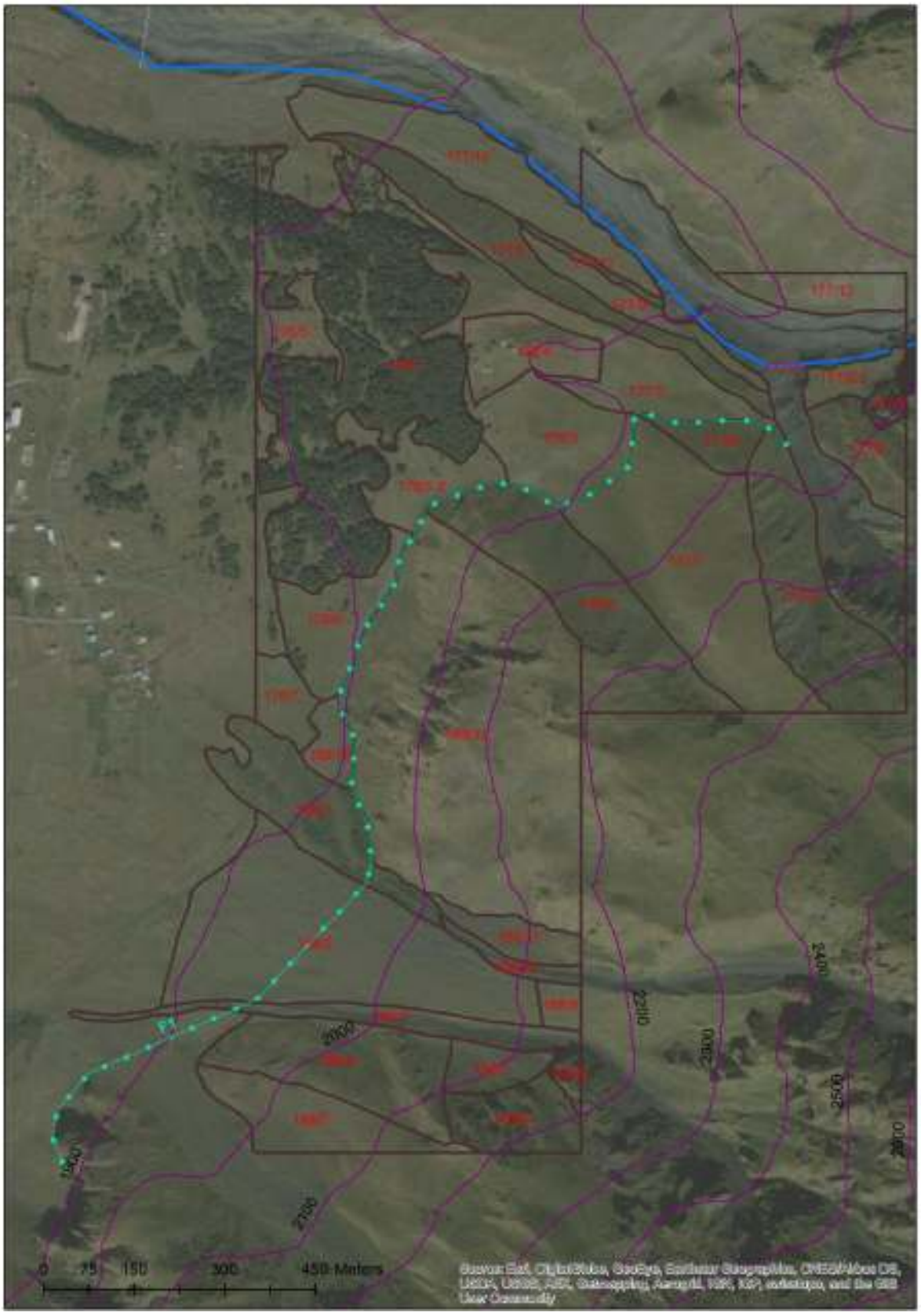
Table 8 Potential reforestation sites, the total area of a site (Area_tot) and the effective afforestation area (Area_eff) in hectare, which is smaller due to already existing trees, shrubs or due to surface rock areas; and the share of species recommended for planting given in one-tenth proportions; species codes are composed of the first three letters of the genus and the and the first two letters of the specific epithet.

Polygon	Area_tot	Area_eff	Pinko	Quema	Sorau	Betli	Poptr	Acetr	Salca	Salsp	Malor	Pyrca	Fagor	Hiprh
176/2	6.7	5.4	—	—	5	—	—	5	—	—	—	—	—	—
177/1	9.2	9.2	8	—	2	—	—	—	—	—	—	—	—	—
177/4	1.0	1.0	—	—	1	5	—	3	—	1	—	—	—	—
188/12	20.1	8.1	8	2	—	—	—	—	—	—	—	—	—	—
188/4	4.8	4.8	—	—	3	—	—	3	—	—	—	—	4	—
188/5	3.0	3.0	6	—	—	—	—	1	—	—	—	—	3	—
141/4	30.5	25.9	6	2	1	—	—	—	—	—	—	—	—	1
161/3.2	1.0	1.0	—	—	—	3	—	3	—	1	—	—	3	—
161/3.3	0.4	0.4	—	—	—	3	—	3	—	1	—	—	3	—
171/2	17.2	16.4	4	—	—	3	—	3	—	—	—	—	—	—
171/3	7.3	6.4	7	3	—	—	—	—	—	—	—	—	—	—
171/9	7.8	7.0	—	—	2	2	—	3	—	—	—	—	3	—
172/10	0.7	0.5	4	—	3	3	—	—	—	—	—	—	—	—
172/4	1.6	0.8	7	3	—	—	—	—	—	—	—	—	—	—
172/5	9.8	8.8	8	2	—	—	—	—	—	—	—	—	—	—
172/6	1.0	0.4	8	2	—	—	—	—	—	—	—	—	—	—
172/8	0.7	0.5	6	3	1	—	—	—	—	—	—	—	—	—
172/8.2	0.5	0.4	6	3	1	—	—	—	—	—	—	—	—	—
173/11	1.2	1.2	—	—	—	—	—	5	—	—	—	—	5	—
173/4	4.7	4.4	6	—	—	1	—	3	—	—	—	—	—	—
173/52	3.8	3.4	6	4	—	—	—	—	—	—	—	—	—	—
173/52.1	0.5	0.4	6	4	—	—	—	—	—	—	—	—	—	—
129/1	8.1	5.3	3	—	—	2	—	3	—	—	—	—	2	—
139/2	2.5	1.9	—	—	3	—	3	4	—	—	—	—	—	—
151/1	0.9	0.8	7	2	1	—	—	—	—	—	—	—	—	—
151/2	4.7	4.2	5	—	—	3	—	2	—	—	—	—	—	—

Table 8 (continued): Potential reforestation sites, the total area of a site (Area_tot) and the effective afforestation area (Area_eff) in hectare, which is smaller due to already existing trees, shrubs or due to surface rock areas; and the share of species recommended for planting given in one-tenth proportions; species codes are composed of the first three letters of the genus and the and the first two letters of the specific epithet.

Polygon	Area_tot	Area_eff	Pinko	Quema	Sorau	Betli	Poptr	Acetr	Salca	Salsp	Malor	Pyrca	Fagor	Hiprh
151/3	0.5	0.4	—	—	—	—	—	5	—	—	—	—	5	—
151/4	1.5	1.1	8	—	2	—	—	—	—	—	—	—	—	—
151/5	1.2	1.1	5	—	2	—	—	3	—	—	—	—	—	—
151/7	1.1	0.6	—	—	—	—	—	—	—	—	—	—	—	1—
151/8	1.1	0.9	8	—	1	—	—	—	—	—	—	—	—	1
152/2	0.7	0.4	7	2	1	—	—	—	—	—	—	—	—	—
108/1	3.8	3.5	7	—	—	1	—	2	—	—	—	—	—	—
108/2	2.1	2.1	7	—	—	1	—	2	—	—	—	—	—	—
117/1	1.2	1.1	4	—	—	2	—	2	—	—	—	—	2	—
117/2	0.9	0.8	4	—	—	2	—	2	—	—	—	—	2	—
118/1	2.6	2.5	8	—	2	—	—	—	—	—	—	—	—	—
118/3	1.3	1.1	7	3	—	—	—	—	—	—	—	—	—	—
118/4	3.9	1.6	2	—	—	—	—	—	—	—	4	4	—	—
119/1	1.7	1.5	—	—	—	3	—	3	1	—	—	—	3	—
119/2	1.8	1.7	8	2	—	—	—	—	—	—	—	—	—	—
119/3	3.9	1.6	8	2	—	—	—	—	—	—	—	—	—	—
119/4	2.7	2.0	8	—	2	—	—	—	—	—	—	—	—	—
302/1	2.5	2.5	—	—	2	2	—	3	—	—	—	—	3	—
302/2	0.2	0.2	6	—	—	—	—	4	—	—	—	—	—	—
302/4	0.6	0.4	6	—	—	—	—	4	—	—	—	—	—	—
302/5	1.1	1.0	—	—	2	1	—	4	—	—	—	—	3	—
302/6	1.2	1.1	4	—	3	—	—	3	—	—	—	—	—	—
303/10	1.6	1.6	10	—	—	—	—	—	—	—	—	—	—	—
303/4	9.5	8.1	2	—	2	—	—	3	—	—	—	—	3	—
303/8	1.1	1.1	3	—	2	3	—	2	—	—	—	—	—	—
301/1	7.6	7.4	—	—	—	—	—	9	—	1	—	—	—	—
Sum	**207.1**	**168.4**												

5.2.2. **Survey Area I: Stepantsminda East**



Picture 39: The GIS-map of survey area I, displaying the field survey sites to the East of Stepantsminda, and recommended fencing (F1)

5. Suitability of sites for the defined land-use interest

Location:

The survey area is situated eastward from Stepantsminda at the foot of the Mount Khuro range. It ranges from 1800 m.a.s.l. to 2200 m.a.s.l. and is characterized by the black schist as geological substrate, which in many cases allows the formation of deep soils. The sites which were surveyed are spreading from the St. Elias Church to the Khuro River and towards the southern edge of the huge avalanche strip above the village.

The purpose of the afforestation measures in this area is erosion mitigation, avalanche protection and CO_2 sequestration.

Afforestation Suitability (ARS)

Survey area I is characterized by a mixture between sites with afforestation suitability, with existing natural regeneration dynamics and without any given afforestation suitability (ARS). Sites without ARS are not described here. The causes for missing ARS are manifold mostly an increased demand of the area for the use as pasture land or constraints with regard to erosion dynamics like avalanches can be highlighted as such.

Site 1: Western slope above St. Elias Church

The western slope above St. Elias Church (Polygon 177/1, Picture 39) shows very high afforestation suitability (ARS), as the deep soil formation and medium fresh as water balance class form excellent site conditions for tree growth (Table 9). The suggested tree species distribution is 80 % *Pinus kochiana* and 20 % *Sorbus aucuparia*. Actually there is no natural regeneration dynamic which could be integrated into the afforestation measures (Picture 40).

Table 9: Site conditions at the afforestation area 177/1 with regard to ARS

Exposition of the site	West	**Erosion Types**	---
Elevation above sea level	1900-2200 m	**Erosion Tendency**	---
Inclination of the slope	35°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	EX
Soil Depth	100 cm +	**Actual Biome type**	401
Relief	Backslope/SL	**ARS**	Very High
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Pinus kochiana (8), Sorbus aucuparia (2)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…Pasture Land, EX…excellent site conditions, 401…Meadow community *'Bromopsis variegata',* SL…Consolidated Slope

Picture 40: View on polygon 177/2, the western slope above St. Elias Church (in the centre) and the neighbouring northern slope (left – Polygon 177/4).

Site 2: Northern slope above the St. Elias Church

The northern slope above the St. Elias Church (Polygon 177/4, Picture 39) shows already some sporadically growing individuals of *Betula litwinowii*, which can be integrated into the afforestation (Picture 40). It is recommended to plant the tree species *Betula litwinowii* (50 %), *Acer trautvetteri* (30 %), *Sorbus aucuparia* (10 %) and *Salix sp.* (10 %). The site conditions with the deep Cambisol formation and the already existing young trees of *Betula* facilitate the afforestation measures (Table 10).

Table 10: Site conditions at the afforestation area 177/4 with regard to ARS

Exposition of the site	North	**Erosion Types**	---
Elevation above sea level	2000-2100 m	**Erosion Tendency**	---
Inclination of the slope	35°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	YT
Soil Depth	100 cm +	**Actual Biome type**	403
Relief	Backslope/SL	**ARS**	Medium
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Betula litwinowii (5), Acer trautvetteri (3), Sorbus aucuparia (2), Salix sp. (1)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…Pasture Land, YT…already existing young trees, 403…Meadow community '*Festuca varia',* SL…Consolidated Slope

Site 3: Northern slope above the St. Elias Pine forest

The northern slope above the St. Elias pine forest (Polygon 176/2, Picture 39) shows already existing wide spread natural regeneration dynamics of *Betula litwinowii* and of some sporadic *Salix caprea*. In order to increase the tree species diversity and to support the forest growth process at this site, it is recommended to plant the species *Acer trautvetteri* (50 %) and *Sorbus aucuparia* (50 %) (Table 11). The existing *Betula litwinowii* and *Salix caprea* species have to be kept, what would result in a target forest with approximately 50 % *Betula*, 30 % *Acer*, 30 % *Sorbus* and some scattered *Salix*. The excellent site conditions facilitate the afforestation measures as well as the existing natural regeneration of the both mentioned tree species, what results in a 'very high' ARS (Table 11).

Table 11: Site conditions at the afforestation area 176/2 with regard to ARS

Exposition of the site	North	**Erosion Types**	---
Elevation above sea level	1900-2100 m	**Erosion Tendency**	---
Inclination of the slope	35°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	YT, EX
Soil Depth	100 cm +	**Actual Biome type**	403
Relief	Backslope/SL	**ARS**	Very High
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Acer trautvetteri (5), Sorbus aucuparia (5)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…Pasture Land, YT…already existing young trees, EX…excellent site conditions, 403…Meadow community '*Festuca varia',* SL…Consolidated Slope

Site 4: Backslope above Stepantsminda-East

The backslope above Stepantsminda-East (Polygon 188/12, Picture 39) shows differing site conditions. Very steep areas with rocks intermingle with less inclined areas with deep Cambisol formations of about 100 cm (Table 12 and Picture 41). At the less inclined micro-sites with deep soil formations it is recommended to plant the tree species *Pinus kochiana* (80 %) and *Quercus macranthera* (20 %) (Table 12). Those sites provide excellent site conditions for afforestation measures, what is mainly due to their deep soil formations and smaller inclination. About 40 % of the total site area hence can be afforested.

Table 12: Site conditions at the afforestation area 188/12 with regard to ARS

Exposition of the site	West-South-West	**Erosion Types**	---
Elevation above sea level	1800-2200 m	**Erosion Tendency**	---
Inclination of the slope	20-40°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	YT, EX
Soil Depth	0-100 cm +	**Actual Biome type**	401
Relief	Backslope/SL	**ARS**	Very High
Water balance class	Medium Dry	**Site-Index**	Bad/Good
Land Use	PL	**Recommended Trees**	*Pinus kochiana (8), Quercus macranthera (5)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…Pasture Land, YT…already existing young trees, EX…excellent site conditions, 401…Meadow community *'Bromopsis variegata',* SL…Consolidated Slope

Picture 41: View to intermingle of rocky sites with the less inclined areas which provide the potential sites for afforestation measures (Polygon 188/12). Source: Roland Koeck.

Site 5: Backslope above the avalanche-cone

The backslope above the avalanche-cone (Polygon 188/4, Picture 39) shows already some established *Betula litwinowii* regeneration. In order to facilitate and speed-up the forest formation, it is recommended to plant *Acer trautvetteri* (30 %), *Sorbus aucuparia* (30 %) and *Fagus orientalis* (40 %) (Table 13). As the recent natural regeneration of *Betula litwinowii* has to be kept, the resulting target forest will show the tree species distribution of 30 % *Betula*, 30 % *Fagus,* 20 % *Acer* and 20 % *Sorbus*.

Table 13: Site conditions at the afforestation area 188/4 with regard to ARS

Exposition of the site	North	**Erosion Types**	---
Elevation above sea level	1900-2100 m	**Erosion Tendency**	---
Inclination of the slope	35-40°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	YT, EX
Soil Depth	70-100 cm	**Actual Biome type**	403
Relief	Backslope/SL	**ARS**	Very High
Water balance class	Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Fagus orientalis (4), Acer trautvetteri (3), Sorbus aucuparia (3)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…Pasture Land, YT…already existing young trees, EX…excellent site conditions, 403…Meadow community '*Festuca varia',* SL…Consolidated Slope

Picture 42: Natural regeneration dynamics of *Betula litwinowii* within polygon 188/4 (right part of the picture), which should be supported by additional planting of *Acer, Sorbus* and *Fagus*. Within the rock-forest (polygon 188/6, left corner of the picture) the *Betula* trees are already higher, what is due to less browsing damages in this steep terrain. Source: Roland Koeck.

Site 6: Southernmost Backslope

The southernmost backslope of the survey area I (Polygon 188/5, Picture 39) shows excellent site conditions for afforestation, again created by the deep Cambisol formations and the moderate water balance class 'medium fresh' (Table 14). Due to the western exposition of the site the recommended

tree species for afforestation are *Pinus kochiana* (60 %), *Fagus orientalis* (30 %) and *Acer trautvetteri* (10 %). Actually there does not exist any natural regeneration at this site.

Table 14: Site conditions at the afforestation area 188/5 with regard to ARS

Exposition of the site	West	**Erosion Types**	---
Elevation above sea level	1800-2200 m	**Erosion Tendency**	---
Inclination of the slope	35°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	EX
Soil Depth	60-100 cm	**Actual Biome type**	403
Relief	Backslope/SL	**ARS**	Very High
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Pinus kochiana (6), Fagus orientalis (3), Acer trautvetteri (1)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…Pasture Land, EX…excellent site conditions, 403…Meadow community '*Festuca varia',* SL…Consolidated Slope

The Fence in survey area I

The fence for the survey area I (F1, Picture 39) protects both the afforestation areas and the sites with natural regeneration dynamics (NRD). The afforestation areas have to be protected by the fence against all types of browsing damages. Without fences above all sheep would endanger the young planted trees (Picture 43).

But within survey area I also the natural regeneration of forest trees will be protected by this fence. It has to be highlighted that especially the natural regeneration at Polygon 177/2 (Picture 39) can develop an efficient erosion mitigation potential, if the browsing damages created by sheep will stop. Actually there is growing *Betula litwinowii* at this site, covering an area of 5 %. The fence will support and speed-up the forest establishment and by the way mitigate the lateral slope erosion of the neighbouring ditch site (Polygon 177/3, Picture 39). This ditch is a tributary of the Khuro-River. Only a stable forest will be able to mitigate or prevent further erosion processes (Picture 44) at the specific site (177/2), if the forest establishment would not occur at this site, the whole area could become prone to erosion processes and finally would enter the Khuro-River and subsequently also the power station.

Picture 43: Sheep within polygon 188/4 (Picture 39). This picture highlights the still existing pressure of sheep on forest establishment. Source: Elisabeth Pötzelsberger.

Picture 44: The natural regeneration dynamic (NRD) of *Betula litwinowii* is still in such an early state, that it is hardly visible on this picture (Polygon 177/2). In contrast the erosion dynamic caused by the neighbouring ditch site is obvious and highlights the urgency of forest establishment at this part of the Khuro-River watershed. Source: Roland Koeck.

5.2.3. **Survey Area II: Stepantsminda North, Power Plant Line – Khuro Range**

Location:

The survey area covers the sites from the power plant line down to the valley of the River Tergi and uphill to the altitude of about 2200 m.a.s.l., until the line enters the tunnel into the Khuro Range. All the sites within this area are characterized by the bedrock type schist (black clayey schists). The area is characterized by the currently prevalent land use type pasture land. Only some extreme sites, like the riverbed of the River Tergi, scree areas, sea buckthorn shrub-land (*Hippophae rhamnoides*) or ditch-sites are not available for livestock grazing.

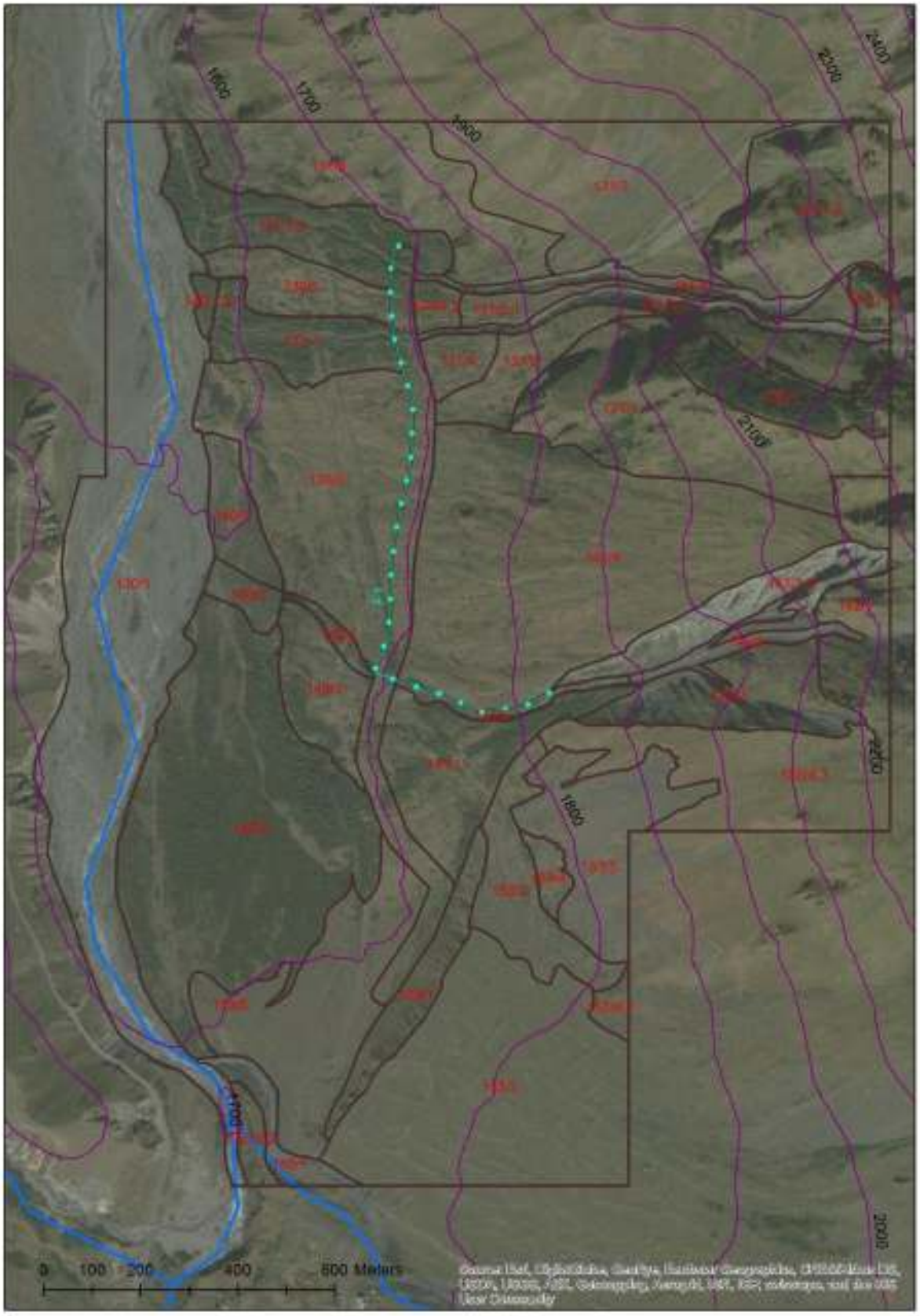
The purpose of the survey in this area was to define areas, where afforestation measures could be possible and which of those also could establish an erosion mitigation effect.

Afforestation Suitability (ARS)

Many sites of the survey area do not show any suitability for afforestation measures, like e.g. intensively used pasture land, ditch sites with dominant scree, avalanche strips or boulder-scree areas. All those sites are excluded from any considerations for strategic afforestation measures, as due to major constraints it never would be possible to reach a desirable outcome.

In contrast to those, three major sites (the direct area of the power plant line excluded) with a given afforestation suitability (ARS) were identified in the course of the field survey.

5. Suitability of sites for the defined land-use interest



Picture 45: The GIS-map of survey area II, displaying the field survey data along the hydro power plant water pipeline, and recommended fencing (F1).

Site 1: Backslope above the northern power plant line.

This backslope above the power plant line (Picture 45, map polygon 141/4) shows a high ARS, as the site conditions for afforestation measures are excellent, given through e.g. medium deep soils and a water balance class of medium fresh. But the fact that this site is situated on a slope of the Khuro massif, which shows no or only slight tendency to snow avalanches, is the basic condition for the high ARS. This can be explained by the fact that site 1 and also the sites above do not show the tendency to snow avalanches, given through the specific relief conditions (Picture 45). This can be regarded as substantial difference to most of the neighbouring sites in survey area II on the Khuro-Range.

The fact why afforestation measures should be undertaken can be explained with the situation of an increasing erosion dynamic towards the neighbouring ditch site (Picture 45, map polygon 141/3.2), which was identified as lateral slope erosion (LSE). Central patches of the area (Polygon 141/4) should be afforested with *Pinus kochiana*. Especially the sites close to Polygon 141/3.2 (5) should be afforested with *Hippophae rhamnoides*, as this shrub species could also establish downwards into the area of polygon 141/3.2. The stabilization of the actual lateral slope erosion (LSE) in this area could eventually be achieved with *Hippophae*. It is the only species with specific adaptability for this site and should be planted in a strip with about 10 m width along the border between Polygon 141/4 and 141/3.2, what is exactly the area exposed to LSE.

The overall tree species distribution for the afforestation measures is Pinus kochiana (60 %), Quercus macranthera (20 %), Sorbus aucuparia (10 %) and *Hippophae rhamnoides* (10 %) (Table 15).

Table 15: Site conditions at the afforestation area 141/4 with regard to ARS

Exposition of the site	West	**Erosion Types**	LSE
Elevation above sea level	1700-2200 m	**Erosion Tendency**	increasing
Inclination of the slope	20-25°	**Erosion Mitigation**	YES (LSE)
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	EX
Soil Depth	40-50 cm	**Actual Biome type**	401
Relief	Backslope/SR	**ARS**	High
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Pinus kochiana (6), Quercus macranthera (2), Sorbus aucuparia (1), Hippophae rhamnoides (1)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…Pasture Land, LSE…lateral slope erosion, EX…excellent site conditions, 401…Meadow community *'Bromopsis variegata',* SR…Scree Cone

Picture 46: The potential afforestation site of map polygon 141/4. At the edge towards the polygon 141/3.2 (ditch) *Hippophae rhamnoides* should be planted in a strip (minimum variant). The site of 141/4 is actually used as pasture land, what also becomes visible by the livestock-paths. Similar on the other side of the ditch, where in polygon 153/4.3 *Hippophae rhamnoides* should be planted in a strip along the edge to polygon 141/3 (ditch). Source: Roland Koeck

Site 2: Southern Edge of the huge Gully System

The backslope at the southern edge of the huge Gully System (Picture 45, map polygon 153/4.3) is already endangered by avalanche dynamics, but the contact zone to the Gully site (map polygon 141/3) could be afforested with *Hippophae rhamnoides,* as this shrub does not grow too high for being endangered by snow avalanches. Also the potential to stabilize the LSE (lateral slope erosion) towards the gully system could be given. It has to be highlighted that the *Hippophae* afforestation should be placed in a strip with about 10 m width along the edge between the polygons 141/3 and 153/4.3 (Picture 46). This strategy also secures limited afforestation expenses. The afforestation suitability (ARS) was rated with 'Medium' (Table 16), what only can be related to the selected species *Hippophae,* for all other tree species ARS has to be assigned with impossible or difficult.

Table 16: Site conditions at the afforestation area 153/4.3 with regard to ARS

Exposition of the site	North-West	**Erosion Types**	LSE
Elevation above sea level	1800-2000 m	**Erosion Tendency**	increasing
Inclination of the slope	30-35°	**Erosion Mitigation**	YES (LSE)
Bedrock Type	Schist	**Constraints for AR**	AS, PL
Soil Type	Cambisol	**Facilitation of AR**	EX
Soil Depth	20-50 cm	**Actual Biome type**	401
Relief	Backslope	**ARS**	Medium/Difficult
Water balance class	Medium Fresh	**Site-Index**	Medium
Land Use	PL	**Recommended Trees**	*Hippophae rhamnoides (10)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, AS…avalanche strip, PL…Pasture Land, LSE…lateral slope erosion, EX…excellent site conditions, 401…Meadow community *'Bromopsis variegata'*

Erosion Mitigation Potential of the afforestation

With the afforestation measures the open erosion process at site 1 (Picture 45, map polygon 153/1) could be mitigated and the power plant line could be secured via this management measure.

At sites 2 and 3 the lateral slope erosion (LSE) between map polygons 141/4 and 141/3.2 and also between 153/4.3 and 141/3 (Picture 45) could be mitigated through afforestation measures, using *Hippophae rhamnoides* as fitting species.

Through the erosion mitigation potential of all afforestation areas the power plant line receives improved security. But it has to be highlighted that the erosion potential of the gully system (Picture 45, map polygons 141/3, 141/3.2, 142/2, 141/2) could potentially endanger the power plant line and hence the cross-section between the constructions and the ditch related to the gully system (45, map polygon 141/2) maybe has to be secured with adequate construction measures. This can be explained with the huge watershed, which is drained by this ditch (Picture 46). During strong precipitation events the danger of deep erosion processes could arise there (Picture 48). This question should be subject of discussion for the technical experts of the power plant construction team.

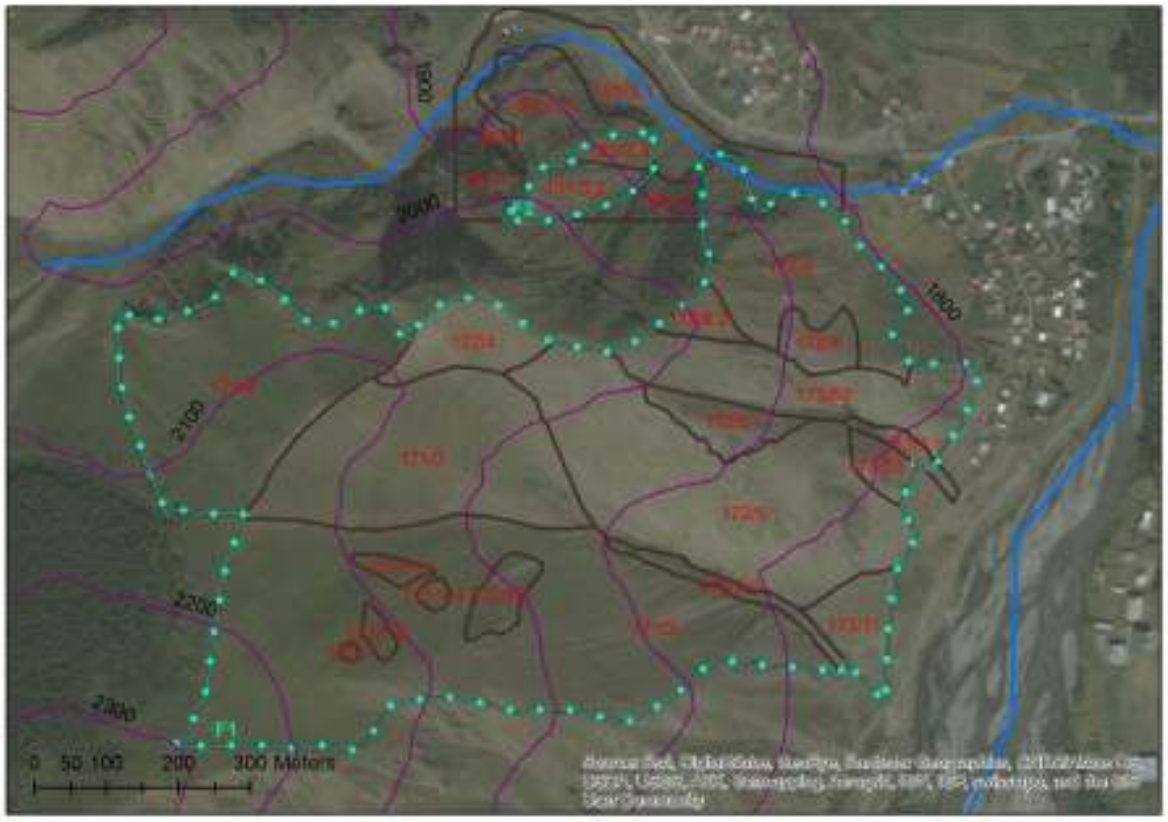
Strategic Afforestation Recommendation

The most important strategic issues for the afforestation measures are the focus on the strip of *Hippophae rhamnoides* along both sides of the gully system, which should show about 10 m width. The *Hippophae* strips along the gully system could eventually help to stop the lateral slope erosion (LSE) in this area. There can be defined two possible variants of afforestation at this site. The minimum variant would have to cover the strip-afforestation, forming a 'V-strip' around the ditch with *Hippophae.* The recommended extended variant would additionally cover the whole polygon area (Picture 45, 141/4), using the patch afforestation technique with *Pinus kochiana* and the other recommended species. It has to be mentioned that the afforestation strips with *Hippophae rhamnoides* do not need the protection by fencing, as this shrub is not browsed by livestock.

Picture 47: The extension of the watershed of the gully system, seen from the Mkinvartsveri-Range, is huge. It is the reason for the erosive force of ditch 141/2. Source: Roland Koeck

Picture 48: The effect of the erosive force of this gully system becomes visible by the creation of the scree area at the mouth of the ditch towards River Tergi (Picture 1, map polygon 140/5), which did not exist at the time of the creation of the aerial photos. Source: Roland Koeck

5.2.4. **Survey Area III: Gergeti**



Picture 49: The GIS-map of survey area III, displaying the field survey data in the area of Gergeti, and recommended fencing (F1, F2).

Location

The survey area III close to Gergeti is characterized by steep slopes which consist of Schist as bedrock, despite the fact that this area is situated at the foothill of the volcanic Mount Mkinvartsveri Range. In the past this area was intensively used as pasture and hayfield land. The present time demands forest establishment at most of the sites. This can be argued with erosion mitigation or prevention and also with the fact that some of the sites do not provide high quality grassland for grazing, as they are dry and rich in gravel or rocks.

Some of the survey sites already show natural forest establishment, in most of the times dominated by *Betula litwinowii.*

Afforestation Suitability (ARS)

For afforestation measures more than 12 sites were identified. Those are differing strongly on the level of site conditions and hence also on the level of tree species recommendations.

5. Suitability of sites for the defined land-use interest

Site 1: Southernmost site

The southernmost site of survey area III (polygon 171/2, Picture 49) shows high afforestation suitability (ARS), what is mainly due to the Cambisol formations and to the water balance class at this site (Table 17). This site is also shown on Picture 50. The recommended tree species for afforestation are *Pinus kochiana* (40 %), *Acer trautvetteri* (30 %) and *Betula litwinowii* (30 %).

Table 17: Site conditions at the afforestation area 171/2 with regard to ARS

Exposition of the site	North-East	**Erosion Types**	OE
Elevation above sea level	1800-2300 m	**Erosion Tendency**	stagnant
Inclination of the slope	25-30°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	EX
Soil Depth	30-90 cm	**Actual Biome type**	409
Relief	Backslope	**ARS**	High
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Pinus kochiana (4), Acer trautvetteri (3), Betula litwinowii (3)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, AS…avalanche strip, PL…Pasture Land, OE…open erosion, EX…excellent site conditions, 409…Meadow community *'Calamagrostis arundinacea'*

Picture 50: Lower part of the North-East facing polygon 171/2. Source: Elisabeth Pötzelsberger.

Site 2: Polygon 171/3

The south-eastern exposed backslope (polygon 171/3, Picture 49) shows a high ARS. Due to the medium dry water balance class and the exposition (Table 18), the recommended tree species are *Pinus kochiana* (70 %) and *Quercus macranthera* (30 %).

Table 18: Site conditions at the afforestation area 171/3 with regard to ARS

Exposition of the site	South-East	**Erosion Types**	---
Elevation above sea level	2100-2300 m	**Erosion Tendency**	---
Inclination of the slope	25-30°	**Erosion Mitigation**	NO
Bedrock Type	Schist	**Constraints for AR**	NO
Soil Type	Cambisol	**Facilitation of AR**	EX
Soil Depth	30-60 cm	**Actual Biome type**	409
Relief	Backslope	**ARS**	High
Water balance class	Medium Dry	**Site-Index**	Medium
Land Use	PL	**Recommended Trees**	*Pinus kochiana (7), Quercus macranthera (3)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…Pasture Land, EX…excellent site conditions, 409…Meadow community *'Calamagrostis arundinacea'*

Site 3: Polygon 171/9

At the north-western exposed site, displayed by polygon 171/9 (Picture 49), the site conditions provide very high ARS. The already existing *Betula litwinowii* regeneration on 10 % of the site has to be integrated into the afforestation outline, for which it is recommended to plant *Fagus orientalis* (30 %)*, Acer trautvetteri* (30 %), *Sorbus aucuparia* (20 %) and *Betula litwinowii* (20 %) (see Table 19).

Table 19: Site conditions at the afforestation area 171/9 with regard to ARS

Exposition of the site	North-West	**Erosion Types**	---
Elevation above sea level	2100-2200 m	**Erosion Tendency**	---
Inclination of the slope	15-20°	**Erosion Mitigation**	NO
Bedrock Type	Schist	**Constraints for AR**	NO
Soil Type	Cambisol	**Facilitation of AR**	EX
Soil Depth	60 cm	**Actual Biome type**	101
Relief	Backslope	**ARS**	Very High
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Fagus orientalis (3), Acer trautvetteri (3), Sorbus aucuparia (2), Betula litwinowii (2)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…Pasture Land, EX…excellent site conditions, 101…Birch forest

Site 4: Polygon 172/10

At the north-eastern exposed site, displayed by polygon 172/10 (Picture 49), the site conditions provide very high ARS. The already existing *Betula litwinowii* and *Pinus kochiana* regeneration on 20 % of the site has to be integrated into the afforestation outline, for which it is recommended to plant *Pinus kochiana* (40 %), *Sorbus aucuparia* (30 %), *Betula litwinowii* (30 %) (see Table 20).

Table 20: Site conditions at the afforestation area 172/10 with regard to ARS

Exposition of the site	North-East	**Erosion Types**	OE
Elevation above sea level	2000 m	**Erosion Tendency**	stagnant
Inclination of the slope	35-40°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	EX
Soil Depth	60-90 cm	**Actual Biome type**	101
Relief	Backslope	**ARS**	Very High
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Pinus kochiana (4), Sorbus aucuparia (3), Betula litwinowii (3)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, OE…Open Erosion, PL…Pasture Land, EX…excellent site conditions, 101…Birch forest

Site 5: Polygon 172/4

At the south-eastern exposed site, displayed by polygon 172/4 (Picture 49), the site conditions provide high ARS. The already existing *Juniperus* regeneration has to be integrated into the afforestation outline, but will disappear in course of forest succession. It is recommended to plant *Pinus kochiana* (70 %) and *Quercus macranthera* (30 %) (see Table 21).

Table 21: Site conditions at the afforestation area 172/4 with regard to ARS

Exposition of the site	South-East	**Erosion Types**	OE
Elevation above sea level	2000-2100 m	**Erosion Tendency**	increasing
Inclination of the slope	35°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Leptosol	**Facilitation of AR**	EX
Soil Depth	30-50 cm	**Actual Biome type**	401
Relief	Backslope	**ARS**	High
Water balance class	Medium Dry	**Site-Index**	Medium
Land Use	PL	**Recommended Trees**	*Pinus kochiana (7), Quercus macranthera (3)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, OE…Open Erosion, PL…Pasture Land, EX…excellent site conditions, 401…Meadow community *'Bromopsis variegata'*

5. Suitability of sites for the defined land-use interest

Site 6: Polygon 172/5

At the south-south-eastern exposed site, displayed by polygon 172/5 (Picture 49), the site conditions provide a medium ARS. The already existing *Juniperus* regeneration has to be integrated into the afforestation outline, but will disappear in course of forest succession. It is recommended to plant *Pinus kochiana* (80 %) and *Quercus macranthera* (20 %) (see Table 22). Picture 51 describes clearly the specific site conditions.

Table 22: Site conditions at the afforestation area 172/5 with regard to ARS

Exposition of the site	South-South-East	**Erosion Types**	OE
Elevation above sea level	1800-2000 m	**Erosion Tendency**	increasing
Inclination of the slope	35°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	DS
Soil Type	Leptosol	**Facilitation of AR**	PV
Soil Depth	10-30 cm	**Actual Biome type**	401/604
Relief	Backslope	**ARS**	Medium
Water balance class	Medium Dry	**Site-Index**	Bad
Land Use	PL	**Recommended Trees**	*Pinus kochiana (8), Quercus macranthera (2)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, OE…Open Erosion, PL…Pasture Land, DS…Dry Site, PV…proximity to the village, 401…Meadow community *'Bromopsis variegata',* 604…Rock sites with herbaceous vegetation

Picture 51: View at the afforestation site described by polygon 172/5. The high rock content at the site is clearly visible, also the existing *Juniperus* shrubs. Source: Elisabeth Pötzelsberger.

Site 7: Polygon 172/6

At the south-eastern exposed site, displayed by polygon 172/6 (Picture 49), the site conditions provide a medium ARS. The high content of rock areas is a constraint for afforestation measures, but by selecting the suitable microsites with deeper soil formations it will become possible. It is recommended to plant *Pinus kochiana (8)* and *Quercus macranthera (2)* (see Table 23).

Table 23: Site conditions at the afforestation area 172/6 with regard to ARS

Exposition of the site	South-East	**Erosion Types**	OE
Elevation above sea level	1900-2000 m	**Erosion Tendency**	stagnant
Inclination of the slope	25-30°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	RA
Soil Type	Leptosol	**Facilitation of AR**	PV
Soil Depth	30-60 cm	**Actual Biome type**	401/604
Relief	Backslope	**ARS**	Medium
Water balance class	Medium Dry	**Site-Index**	Bad
Land Use	PL	**Recommended Trees**	*Pinus kochiana (8), Quercus macranthera (2)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, OE…Open Erosion, PL…Pasture Land, RA…Rock areas, PV…proximity to the village, 401…Meadow community *'Bromopsis variegata',* 604…Rock sites with herbaceous vegetation

Site 8: Polygons 172/8 and 172/8.2

At the eastern exposed sites, displayed by polygon 172/8 and 172/8.2 (Picture 49), the site conditions provide a high ARS. The already existing *Juniperus* regeneration on 10 % of the site has to be integrated into the afforestation outline, but will disappear in course of forest succession. It is recommended to plant *Pinus kochiana (60 %), Quercus macranthera (20 %)* and *Sorbus aucuparia* (10 %) (see Table 24).

Table 24: Site conditions at the afforestation areas 172/8 and 172/8.2 with regard to ARS

Exposition of the site	East	**Erosion Types**	OE
Elevation above sea level	1900-2000 m	**Erosion Tendency**	increasing
Inclination of the slope	30°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Leptosol & Cambisol	**Facilitation of AR**	EX/PV
Soil Depth	30-60 cm	**Actual Biome type**	403
Relief	Backslope	**ARS**	High
Water balance class	Medium Fresh	**Site-Index**	Medium
Land Use	PL	**Recommended Trees**	*Pinus kochiana (6), Quercus macranthera (3), Sorbus aucuparia (1)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, OE…Open Erosion, PL…Pasture Land, EX…excellent site conditions, PV…proximity to the village, 403…Meadow community *'Festuca varia'*

Site 9: Polygon 173/4

At the north-north-eastern exposed site, displayed by polygon 173/4 (Picture 49), the site conditions provide a very high ARS. It is recommended to plant *Pinus kochiana* (60 %)*, Acer trautvetteri* (30 %) and *Betula litwinowii* (10 %) (see Table 25).

Table 25: Site conditions at the afforestation area 173/4 with regard to ARS

Exposition of the site	North-North-East	**Erosion Types**	OE
Elevation above sea level	1800-1900 m	**Erosion Tendency**	stagnant
Inclination of the slope	15-20°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL/RO
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	30-80 cm	**Actual Biome type**	403
Relief	Backslope	**ARS**	Very High
Water balance class	Medium Fresh	**Site-Index**	Medium
Land Use	PL	**Recommended Trees**	*Pinus kochiana (6), Acer trautvetteri (3), Betula litwinowii (1)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, OE…Open Erosion, PL…Pasture Land, RO…Rock areas, PV…proximity to the village, 403…Meadow community *'Festuca varia'*

Site 10: Polygon 173/11

At the north-north-eastern exposed site, displayed by polygon 173/11 (Picture 49), the site conditions provide a very high ARS. It is recommended to plant *Fagus orientalis* (50 %) and *Acer trautvetteri* (50 %) (see Table 26).

Table 26: Site conditions at the afforestation area 173/11 with regard to ARS

Exposition of the site	South-East	**Erosion Types**	OE
Elevation above sea level	1800 m	**Erosion Tendency**	stagnant
Inclination of the slope	10°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	EX/PV
Soil Depth	60-80 cm	**Actual Biome type**	403
Relief	Footslope	**ARS**	Very High
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Fagus orientalis (5), Acer trautvetteri (5)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, OE…Open Erosion, PL…Pasture Land, RO…Rock areas, EX…excellent site conditions, PV…proximity to the village, 403…Meadow community *'Festuca varia'*

Site 11: Polygons 173/52 and 173/52.1

At the north-eastern and south-eastern exposed sites, displayed by the polygons 173/52 and 173/52.1 (Picture 49), the site conditions provide a high ARS. It is recommended to plant *Pinus kochiana* (60 %) and *Quercus macranthera* (40 %) (see Table 27).

Table 27: Site conditions at the afforestation areas 173/52 and 173/52.1 with regard to ARS

Exposition of the site	North-East/South-East	**Erosion Types**	OE
Elevation above sea level	1800-2000 m	**Erosion Tendency**	increasing
Inclination of the slope	25°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Leptosol & Cambisol	**Facilitation of AR**	PV
Soil Depth	20-60 cm	**Actual Biome type**	401 & 403
Relief	Backslope	**ARS**	High
Water balance class	Medium Fresh	**Site-Index**	Medium
Land Use	PL	**Recommended Trees**	*Pinus kochiana (6), Quercus macranthera (4)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, OE…Open Erosion, PL…Pasture Land, PV…proximity to the village, 401…Meadow community *'Bromopsis variegata',* 403…Meadow community *'Festuca varia'*

Site 12: Polygons 161/3.2 and 161/3.3

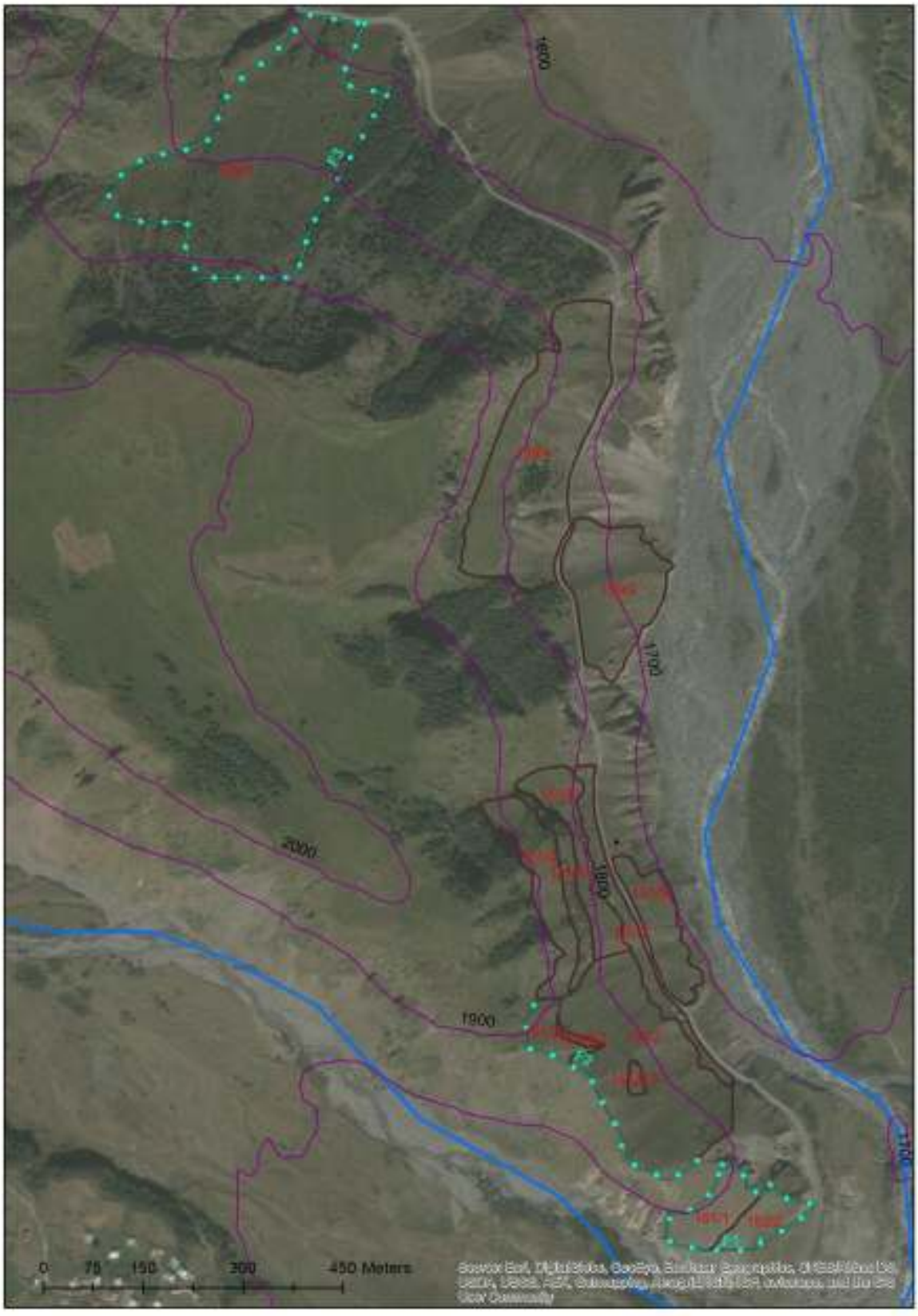
At the north-eastern exposed site, displayed by the polygons 161/3.2 and 161/3.3 (Picture 49), the site conditions provide a very high ARS. It is recommended to plant *Fagus orientalis* (30 %), *Acer trautvetteri* (30 %), *Betula litwinowii* (30 %) and *Salix sp.* (10 %) (see Table 28).

Table 28: Site conditions at the afforestation areas 161/3.2 and 161/3.3 with regard to ARS

Exposition of the site	North-East	**Erosion Types**	---
Elevation above sea level	1800-2000 m	**Erosion Tendency**	---
Inclination of the slope	20-25°	**Erosion Mitigation**	NO
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	EX/PV
Soil Depth	60 cm	**Actual Biome type**	403 & 501
Relief	Footslope	**ARS**	Very High
Water balance class	Fresh/Very Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Fagus orientalis (3), Acer trautvetteri (3), Betula litwinowii (3), Salix sp. (1)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, OE…Open Erosion, PL…Pasture Land, EX…excellent site conditions, PV…proximity to the village, 403…Meadow community *'Festuca varia',* 501…subalpine herbaceous vegetation (Hochstauden)

5.2.5. **Survey Area IV: Stepantsminda North, Transit road**



Picture 52: The GIS-map of survey area IV, displaying the field survey data along the transit road to the North of Stepantsminda, and recommended fencing (F1-F3).

Location

The survey area IV (Picture 53) is situated above and below the Kazbegi transit road. The security of the road could be improved by afforestation measures, as e.g. snow creeping or avalanche dynamics could be mitigated by an established forest cover. Most of the afforestation sites are situated above the transit road, due to the prevalent rocky site conditions below it (Picture 52 and Picture 53).

Picture 53: ARS-Survey area IV situated around at the Kazbegi transit road, Mount Mkinvartsveri Range. At the left side of the picture the moraine site (Gergeti glacier, historic extension) with its prevalent erosion dynamics is visible. Source: Roland Koeck

Afforestation Suitability (ARS)

For afforestation measures several different sites were identified. Most of them are situated above the transit road, only two of them below it. The areas above the road show additionally to carbon storage the potential of avalanche mitigation.

Site 1: Polygon 129/1

At the north-eastern exposed site displayed by polygon 129/1 (Picture 52) ARS was rated as high. The excellent site conditions provide high growth rates and it is recommended to plant *Pinus kochiana* (30 %), *Populus tremula* (30 %), *Betula litwinowii* (20 %) *and Acer trautvetteri* (20 %) (see Table 29). The already existing tree cover has to be integrated into the afforested stand, there are growing actually *Pinus kochiana* and *Betula litwinowii*. The whole afforestation area is displayed in Picture 54.

Table 29: Site conditions at the afforestation area 129/1 with regard to ARS

Exposition of the site	North-East	**Erosion Types**	---
Elevation above sea level	1700-1900 m	**Erosion Tendency**	---
Inclination of the slope	25°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	HV
Soil Type	Cambisol	**Facilitation of AR**	EX/PV
Soil Depth	100 cm +	**Actual Biome type**	403
Relief	Backslope	**ARS**	High
Water balance class	Fresh	**Site-Index**	Good
Land Use	HF/AB	**Recommended Trees**	*Pinus kochiana (3), Populus tremula (3), Betula litwinowii (2), Acer trautvetteri (2)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, OE…Open Erosion, HF/AB…abandoned hayfield, HV…high herbal vegetation, EX…excellent site conditions, PV…proximity to the village, 403…Meadow community *'Festuca varia'*

Picture 54: View at polygon 129/1 above the transit road where the already established tree individuals of *Pinus kochiana* and *Betula litwinowii* form an excellent basis for the afforestation measures, which will guarantee a closed forest canopy (Mount Mkinvartsveri Range, Foothill - Volcanic bedrock). Source: Roland Koeck.

Site 2: Polygon 139/2

At the eastern exposed site displayed by polygon 139/2 (Picture 52) ARS was rated as difficult, what is due to the steep terrain. The recommended tree species set for planting is *Betula litwinowii* (30 %), *Acer trautvetteri* (30 %), *Sorbus aucuparia* (20 %) and *Populus tremula* (20 %) (see Table 30).

Table 30: Site conditions at the afforestation area 139/2 with regard to ARS

Exposition of the site	East	**Erosion Types**	LSE
Elevation above sea level	1650-1750 m	**Erosion Tendency**	increasing
Inclination of the slope	40°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	ST
Soil Type	Cambisol	**Facilitation of AR**	---
Soil Depth	30-100 cm	**Actual Biome type**	403
Relief	Footslope	**ARS**	Difficult
Water balance class	Fresh	**Site-Index**	Medium
Land Use	NU	**Recommended Trees**	*Betula litwinowii (3), Acer trautvetteri (3), Sorbus aucuparia (2) Populus tremula (2),*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, LSE…Lateral Slope Erosion, NU…No Use, ST…steep terrain, 403…Meadow community *'Festuca varia'*

Site 3: Polygon 152/2

At the south-eastern exposed moraine site displayed by polygon 152/2 (Picture 52) ARS was rated as medium, what is due to the partly shallow soil and relatively dry site conditions. The recommended tree species for the afforestation measures are *Pinus kochiana* (70 %), *Quercus macranthera* (20 %) and *Sorbus aucuparia* (10 %) (see Table 31). Moraine sites are especially prone to erosion processes, what highlights the positive effects of the afforestation measures on erosion mitigation.

Table 31: Site conditions at the afforestation area 152/2 with regard to ARS

Exposition of the site	South-East	**Erosion Types**	OE
Elevation above sea level	1700 m	**Erosion Tendency**	stagnant
Inclination of the slope	35°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	DS
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	5-50 cm	**Actual Biome type**	401
Relief	Backslope/MO	**ARS**	Medium
Water balance class	Medium Dry	**Site-Index**	Medium
Land Use	HF/AB	**Recommended Trees**	*Pinus kochiana (7), Quercus macranthera (2), Sorbus aucuparia (1)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, MO…Moraine, OE…Open Erosion, HF/AB…abandoned hayfield, DS…Dry Site, PV…proximity to the village, 401…Meadow community *'Bromopsis variegata'*

5. Suitability of sites for the defined land-use interest

Site 4: Polygon 151/1

At the south-eastern exposed moraine site displayed by polygon 151/1 (Picture 52) ARS was rated as

Table 32: Site conditions at the afforestation area 151/1 with regard to ARS

Exposition of the site	South-East	**Erosion Types**	---
Elevation above sea level	1800 m	**Erosion Tendency**	---
Inclination of the slope	25°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	---
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	30-50 cm	**Actual Biome type**	401
Relief	Upper Slope/MO	**ARS**	High
Water balance class	Medium Dry	**Site-Index**	Medium
Land Use	HF/AB	**Recommended Trees**	*Pinus kochiana (7), Quercus macranthera (2), Sorbus aucuparia (1)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, MO…Moraine, HF/AB…abandoned hayfield, Proximity to the village, 401…Meadow community *'Bromopsis variegata'*

high. The recommended tree species for the afforestation measures are *Pinus kochiana* (70 %), *Quercus macranthera* (20 %) and *Sorbus aucuparia* (10 %) (see Table 32). Moraine sites are especially prone to erosion processes, what again highlights the positive effects of the afforestation measures on erosion mitigation, despite the fact that actually this specific site does not show any erosion processes. It is hence a precautionary measure.

Site 5: Polygon 151/2

At the north-eastern exposed site displayed by polygon 151/2 (Picture 52) ARS was rated as high. The recommended tree species for afforestation measures are *Pinus kochiana* (50 %), *Betula litwinowii* (30 %) and *Acer trautvetteri* (20 %) (see Table 33). The steep inclination of the site (Picture 55) highlights the necessity of the creation of a stable forest cover for the prevention of avalanche dynamics during winter seasons, what will provide more security for the transit road.

Picture 55: The steep site (polygon 151/2) situated above the Kazbegi transit road. Source: Roland Koeck

Table 33: Site conditions at the afforestation area 151/2 with regard to ARS

Exposition of the site	North-East	**Erosion Types**	---
Elevation above sea level	1800-1900 m	**Erosion Tendency**	---
Inclination of the slope	35-40°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	HV/PL
Soil Type	Cambisol	**Facilitation of AR**	EX/PV
Soil Depth	80 cm	**Actual Biome type**	403
Relief	Backslope	**ARS**	High
Water balance class	Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Pinus kochiana (5), Betula litwinowii (3), Acer trautvetteri (2)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…Pasture Land, HV…high herbal vegetation, EX…excellent site conditions, PV…proximity to the village, 403…Meadow community *'Festuca varia'*

Site 6: Polygon 151/3

At the north-eastern exposed site displayed by polygon 151/3 (Picture 52) ARS was rated as medium. The recommended tree species for afforestation measures are *Fagus orientalis* (50 %) and *Acer trautvetteri* (50 %) (see Table 34).

Table 34: Site conditions at the afforestation area 151/3 with regard to ARS

Exposition of the site	North-East	**Erosion Types**	---
Elevation above sea level	1900 m	**Erosion Tendency**	---
Inclination of the slope	35-40°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	EX/PV
Soil Depth	70 cm	**Actual Biome type**	403
Relief	Backslope	**ARS**	Medium
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Fagus orientalis (5), Acer trautvetteri (5)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…Pasture Land, HV…high herbal vegetation, EX…excellent site conditions, PV…proximity to the village, 403…Meadow community *'Festuca varia'*

Site 7: Polygon 151/4

At the eastern exposed site displayed by polygon 151/4 (Picture 52) ARS was rated as difficult, what is due to the steep site (see Picture 56). The recommended tree species for afforestation measures are *Pinus kochiana* (80 %) and *Sorbus aucuparia* (20 %) (see Table 35). Despite the difficult afforestation conditions, a stable forest cover at this site would increase the protection against potential avalanches in winter. During the afforestation measures the security of the working personal has to be guaranteed, maybe by application of special securing devices (rock belt below the site, see Picture 56).

Table 35: Site conditions at the afforestation area 151/4 with regard to ARS

Exposition of the site	East	**Erosion Types**	---
Elevation above sea level	1900 m	**Erosion Tendency**	---
Inclination of the slope	30-40°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	ST
Soil Type	Cambisol	**Facilitation of AR**	---
Soil Depth	30-70 cm	**Actual Biome type**	403
Relief	Backslope	**ARS**	Difficult
Water balance class	Medium Fresh	**Site-Index**	Medium
Land Use	PL	**Recommended Trees**	*Fagus orientalis (5), Acer trautvetteri (5)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…Pasture Land, ST…Steep Site, 403…Meadow community *'Festuca varia'*

Picture 56: This picture shows the steep site conditions above the Kazbegi transit road. Left above the rock belt (polygon 151/6) the steep and difficult ARS site of polygon 151/4 is situated, right below the sites 151/5 for tree afforestation and 151/7 for Hippophae shrubs afforestation. Source: Roland Koeck

Site 8: Polygon 151/5

At the east-north-eastern exposed site displayed by polygon 151/5 (Picture 52) ARS was rated as high, what is due to the excellent site conditions. The steep site is still a challenge for the afforestation works (see Picture 56). The recommended tree species for afforestation measures are *Pinus kochiana* (50 %), *Acer trautvetteri* (30 %) and *Sorbus aucuparia* (20 %) (see Table 36).

Table 36: Site conditions at the afforestation area 151/5 with regard to ARS

Exposition of the site	East-North-East	**Erosion Types**	---
Elevation above sea level	1800 m	**Erosion Tendency**	---
Inclination of the slope	35-40°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	EX/PV
Soil Depth	100 cm +	**Actual Biome type**	403
Relief	Backslope	**ARS**	High
Water balance class	Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Trees**	*Pinus kochiana (5), Acer trautvetteri (3), Sorbus aucuparia (2)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…Pasture Land, HV…high herbal vegetation, EX…excellent site conditions, PV…proximity to the village, 403…Meadow community *'Festuca varia'*

Site 9: Polygon 151/7

At the east-north-eastern exposed site displayed by polygon 151/7 (Picture 52) ARS was rated as difficult, what is due to the steep site and the soil conditions, which are inhomogeneous. Actually there are already growing the shrub species *Hippophae rhamnoides*, *Juniperus depressa* and *Juniperus sabina* (see Picture 57). Those should be kept and integrated in the future shrub cover. The recommended species for afforestation is *Hippophae rhamnoides* (see Table 37), as shrubs are the best solution for the area directly above the transit road. They do not create any danger in case of storm events or snow breakage and stabilize the site efficiently. It has to be highlighted that a strip of 3 m directly beside the road should be kept free of any shrubs for facilitating all works for the road maintenance.

Picture 57: Polygon 151/7 is situated directly above the transit road. Shrub cover with 3 m distance to the road is the best solution for this site. Source: Roland Koeck

Table 37: Site conditions at the afforestation area 151/7 with regard to ARS

Exposition of the site	East-North-East	**Erosion Types**	OE
Elevation above sea level	1800 m	**Erosion Tendency**	Stagnant
Inclination of the slope	35-45°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	ST
Soil Type	Ranker + Cambisol	**Facilitation of AR**	PV
Soil Depth	5-50 cm	**Actual Biome type**	303 + 401
Relief	Backslope	**ARS**	Difficult
Water balance class	Medium Fresh	**Site-Index**	Bad
Land Use	NU	**Recommended Shrubs**	*Hippophae rhamnoides (10)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, NU…no land-use, OE…open erosion, ST…steep site, PV…proximity to the village, 303…*Hippophae rhamnoides* community, 401…Meadow community *'Bromopsis variegata'*

Site 10: Polygon 151/8

At the east-north-eastern exposed site below the transit road displayed by polygon 151/8 (Picture 52) ARS was rated as difficult, what is due to the very steep site. The steepness of the site is a challenge for the afforestation works and the labourers have hence to be secured during the tasks. The recommended tree species for afforestation measures are *Pinus kochiana* (80 %), *Sorbus aucuparia* (10 %) and *Hippophae rhamnoides* (10 %) (see Table 38).

Table 38: Site conditions at the afforestation area 151/8 with regard to ARS

Exposition of the site	East-North-East	**Erosion Types**	OE
Elevation above sea level	1700 m	**Erosion Tendency**	Increasing
Inclination of the slope	40-45°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	ST
Soil Type	Ranker + Cambisol	**Facilitation of AR**	PV
Soil Depth	15-50 cm	**Actual Biome type**	401
Relief	Footslope	**ARS**	Difficult
Water balance class	Medium Dry	**Site-Index**	Bad
Land Use	NU	**Recommended Shrubs**	*Pinus kochiana (8), Sorbus aucuparia (1), Hippophae rhamnoides (1)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, NU…no land-use, OE…open erosion, ST…steep site, PV…proximity to the village, 401…Meadow community *'Bromopsis variegata'*

Site 11: Polygon 139/2

At the north-eastern exposed site below the transit road displayed by polygon 139/2 (Picture 52) ARS was rated as difficult, what is due to the very steep site. The recommended tree species for afforestation measures are *Acer trautvetteri* (40 %), *Sorbus aucuparia* (30 %) and *Populus tremula* (30 %) (see Table 39).

Table 39: Site conditions at the afforestation area 139/2 with regard to ARS

Exposition of the site	North-East	**Erosion Types**	LSE
Elevation above sea level	1700 m	**Erosion Tendency**	Increasing
Inclination of the slope	40°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	ST
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	30-100 cm	**Actual Biome type**	403
Relief	Footslope	**ARS**	Difficult
Water balance class	Fresh	**Site-Index**	Medium
Land Use	NU	**Recommended Shrubs**	*Acer trautvetteri (4), Sorbus aucuparia (3), Populus tremula (3)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, NU…no land-use, LSE…lateral slope erosion, ST…steep site, PV…proximity to the village, 403…Meadow community *'Festuca varia'*

5.2.6. **Survey Area V: Tsdo – Sites above the village – Mkinvartsveri-Range**

Location

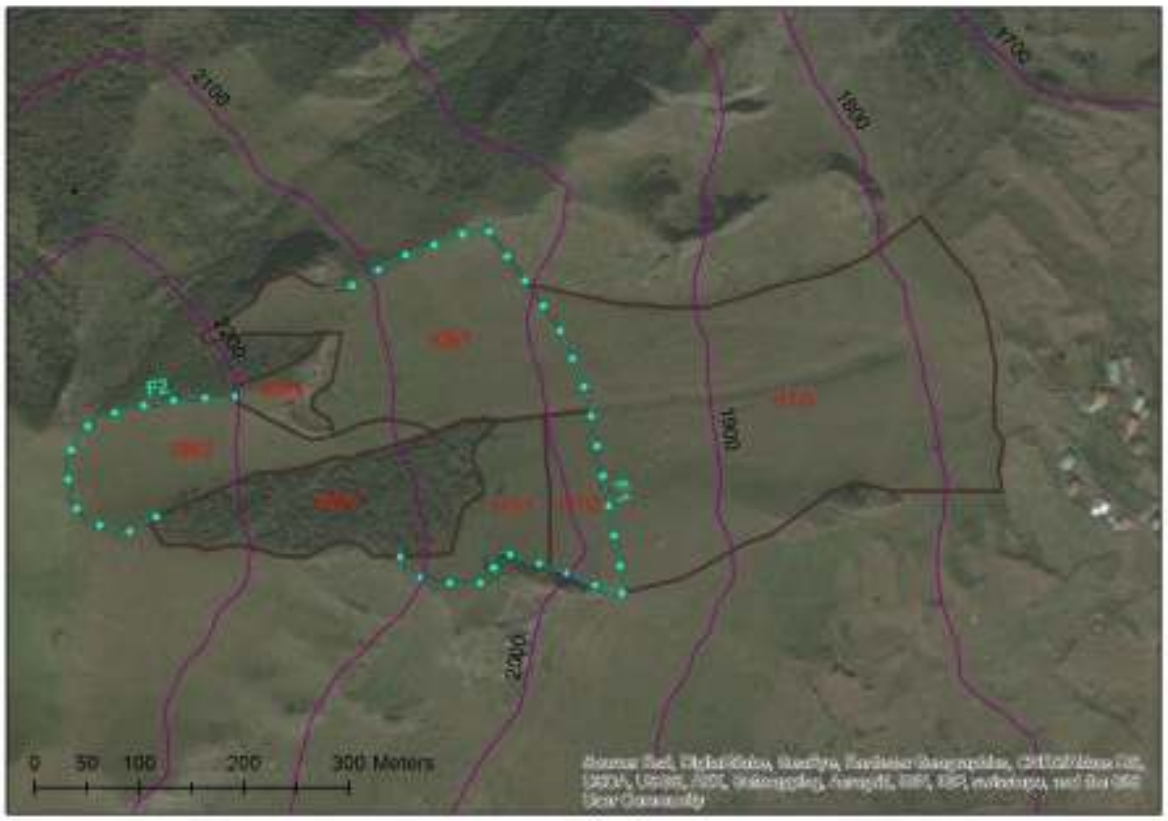
The village Tsdo is situated on the eastern footslope of the Mount Mkinvartsveri-Range. Above the small village occurred a forest fire about 50 years ago (information according to the local population) and destroyed parts of the existing forest cover. Since that event snow avalanche dynamics have been occurring frequently during winter seasons. Some of the avalanches pose a threat to the people and infrastructure of the village (houses, hayfields, gardens, etc.). The afforestation of the former forested areas was communicated to the survey team as specific desire of the local population.

The area from which the avalanches originate shows afforestation potential hence the avalanche dynamics could be mitigated and even prevented by an established forest cover (Picture 58).

Picture 58: View towards the slopes with actual avalanche dynamics above Tsdo. Source: Roland Koeck

The specific locations of the afforestation sites can be seen in Picture 59, where all in the course of the field survey mapped polygons are displayed in the GIS-map. All the following descriptions can be related to this map

5. Suitability of sites for the defined land-use interest



Picture 59: The GIS-map of survey area V, displaying the field survey data from Tsdo (sites above the village), and recommended fencing (F1, F2).

Afforestation Suitability (ARS)

For afforestation measures four different sites were identified. All of those show potential for mitigating the avalanche dynamics during winter season and are currently not used as pasture land (information according to the local population). For all afforestation activities, the installation of fences will be mandatory (see Picture 59).

Site 1: Upper Slope of the northern avalanche section

The upper slope of the northern avalanche section (Picture 59, map polygon 108/2) shows difficult afforestation suitability (ARS) (Table 40). This situation can be explained with the steep slope, where snow creeping processes, avalanche dynamics and also high ground cover vegetation form constraints for afforestation measures (Table 40). On the other hand the excellent site conditions defined by soil type and depth and the water balance class fresh form facilitating conditions for the afforestation (Table 40).

It has to be highlighted that due to the upper slope situation within an avalanche strip the mitigation and prevention potential towards the avalanche dynamics is very high.

Table 40: Site conditions at the afforestation area 108/2 with regard to ARS

Exposition of the site	East-South-East	**Erosion Types**	No Erosion
Elevation above sea level	2100-2200 m	**Erosion Tendency**	---
Inclination of the slope	40°	**Erosion Mitigation**	YES (avalanche)
Bedrock Type	Volcanic	**Constraints for AR**	AS, HV, SC
Soil Type	Cambisol	**Facilitation of AR**	PV, EX
Soil Depth	70-100 cm	**Actual Biome type**	403
Relief	Upper Slope	**ARS**	Difficult
Water balance class	Fresh	**Site-Index**	Good
Land Use	NU	**Recommended Trees**	*Pinus kochiana (7), Acer trautvetteri (2), Betula litwinowii (1)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, NU…No Land Use, AS…Avalanche Strip, HV…High Vegetation, SC…Snow Creeping, PV…Proximity to the Village, EX…excellent site conditions, 403…Meadow community '*Festuca varia*'

If the afforestation measures are carried out starting from the top of this slope, the prevention process for the avalanches can be started.

Maybe it will be necessary (depending on the winter snowpack conditions) to carry out the afforestation measures in 3-4 time-steps (during 4-8 years), starting from the top of the slope, in order to secure the survival of the planted trees. The recommended tree species are *Pinus kochiana* (70 %), *Acer trautvetteri* (20 %), *Betula litwinowii* (10 %). The efficiency of Pine species within the context of avalanche prevention is higher than this of broadleaved tree species, what can be explained with their evergreen needle crowns.

Picture 60: The avalanche strips above Tsdo, map polygons 108/2, 108/1 and 117/1, seen from the bottom of the slope. Source: Roland Koeck

Site 2: Backslope of the northern avalanche section

The backslope of the northern avalanche section (Picture 59, map polygon 108/1) shows again difficult afforestation suitability (ARS) (Table 41). This situation can be explained with the steep slope, where snow creeping processes, avalanche dynamics and also high ground cover vegetation form constraints for afforestation measures (Table 41). On the other hand the excellent site conditions defined by soil type and depth and the water balance class medium fresh form facilitating conditions for the afforestation (Table 41).

Table 41: Site conditions at the afforestation area 108/1 with regard to ARS

Exposition of the site	East	**Erosion Types**	No Erosion
Elevation above sea level	2000-2200 m	**Erosion Tendency**	---
Inclination of the slope	35-40°	**Erosion Mitigation**	YES (avalanche)
Bedrock Type	Volcanic	**Constraints for AR**	AS, HV, SC
Soil Type	Cambisol	**Facilitation of AR**	PV, EX
Soil Depth	100 cm	**Actual Biome type**	403
Relief	Backslope	**ARS**	Difficult
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	NU	**Recommended Trees**	*Pinus kochiana (7), Acer trautvetteri (2), Betula litwinowii (1)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, NU…No Land Use AS…Avalanche Strip, HV…High Vegetation, SC…Snow Creeping, PV…Proximity to the Village, EX…excellent site conditions, 403…Meadow community '*Festuca varia*'

Despite the difficult conditions for afforestation measures the situation calls for the creation of a forest. Again it is possible to start the afforestation measures at the top of the backslope, in this way securing the survival of the planted trees. Maybe it will be necessary (according to the winter snowpack conditions) to carry out the afforestation measures in 3-4 time-steps (during 4-8 years), starting from the top of the slope, in order to secure the survival of the planted trees. The recommended tree species are again *Pinus kochiana* (70 %), *Acer trautvetteri* (20 %), *Betula litwinowii* (10 %).

Site 3: Upper backslope of the southern avalanche section

This site (Picture 59, map polygon 117/1) is situated directly beneath an existing forest stand which is dominated by *Betula litwinowii, Salix caprea* and *Acer trautvetteri*. The proximity of this forest could facilitate the establishment of natural regeneration dynamics by the neighbouring tree species. Again the ARS was rated as difficult, what is caused by the steep slope, where snow creeping processes, avalanche dynamics and also high ground cover vegetation form constraints for afforestation measures (Table 42). On the other hand the excellent site conditions defined by soil type and depth and the water balance class fresh form facilitating conditions for the afforestation (Table 42).

Also at this site the effects of the afforestation can be huge in terms of avalanche prevention, hence the creation of forest cover becomes a valuable and by the local population desired task (Picture 61). The recommended tree species are in this case *Pinus kochiana* (40 %), *Acer trautvetteri* (20 %), *Fagus orientalis* (20 %) and *Sorbus aucuparia* (20 %) (Table 42). The whole area of Polygon 117/1 can be afforested at the same time.

Table 42: Site conditions at the afforestation area 117/1 with regard to ARS

Exposition of the site	North-East	**Erosion Types**	No Erosion
Elevation above sea level	2000-2100 m	**Erosion Tendency**	---
Inclination of the slope	35-40°	**Erosion Mitigation**	YES (avalanche)
Bedrock Type	Volcanic	**Constraints for AR**	AS, HV, SC
Soil Type	Cambisol	**Facilitation of AR**	PV, EX
Soil Depth	70 cm	**Actual Biome type**	403
Relief	Backslope	**ARS**	Difficult
Water balance class	Fresh	**Site-Index**	Good
Land Use	AB	**Recommended Trees**	*Pinus kochiana (4), Acer trautvetteri (2), Fagus orientalis (2), Sorbus aucuparia (2)*

Acronyms: AB…abandoned pasture, AR…Afforestation, ARS…Afforestation Suitability, AS…Avalanche Strip, HV…High Vegetation, SC…Snow Creeping, PV…Proximity to the Village, EX…excellent site conditions, 403…Meadow community '*Festuca varia*'

Site 4: Lower backslope of the southern avalanche section

The lower backslope of the southern avalanche section (Picture 59, map polygon 117/2) shows already less inclination than the upper slope, but still the ARS was rated with difficult (Table 43). The

cause for this situation can be found in the avalanche dynamics and the snow creeping processes during winter season (Table 43). The proximity to the village facilitates the afforestation activities (Picture 61).

The recommended tree species for the afforestation measures is *Pinus kochiana* (40 %) *Acer trautvetteri* (20 %), *Fagus orientalis* (20 %) and *Sorbus aucuparia (20 %)* (Table 43). The whole area of Polygon 117/2 (Picture 59) can be afforested in one step.

Table 43: Site conditions at the afforestation area 117/2 with regard to ARS

Exposition of the site	East	**Erosion Types**	No Erosion
Elevation above sea level	2000 m	**Erosion Tendency**	---
Inclination of the slope	35°	**Erosion Mitigation**	YES (avalanche)
Bedrock Type	Volcanic	**Constraints for AR**	AS, SC
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	30-100 cm	**Actual Biome type**	403
Relief	Backslope	**ARS**	Difficult
Water balance class	Medium Fresh	**Site-Index**	Medium
Land Use	AB	**Recommended Trees**	*Pinus kochiana (4), Acer trautvetteri (2), Fagus orientalis (2), Sorbus aucuparia (2)*

Acronyms: AB…abandoned pasture, AR…Afforestation, ARS…Afforestation Suitability, AS…Avalanche Strip, SC…Snow Creeping, PV…Proximity to the Village, 403…Meadow community '*Festuca varia*'

Picture 61: The village Tsdo seen from the sites with avalanche dynamics (polygons 117/1 and 117/2). Source: Roland Koeck

Erosion Mitigation Potential of the afforestation

The afforestation of forest stands in the area above the village Tsdo has a specific erosion mitigation potential, what is the prevention of snow avalanches. Actually there does not take place any open erosion within all four above described polygons, but the prevention of avalanches also prevents the creation of potential future erosion processes. Hence the prevention of avalanches also has to be seen as the prevention of potential future erosion processes.

Strategic Afforestation Recommendation

For all four afforestation sites above the village of Tsdo, the creation of protection fences for the planted trees is mandatory in order to protect the young trees from browsing damages created by livestock. Due to the snow creeping processes in winter the fence should be an electric one (solar energy driven), which has to be removed during winter season in order to prevent the fence from being damaged by creeping snow.

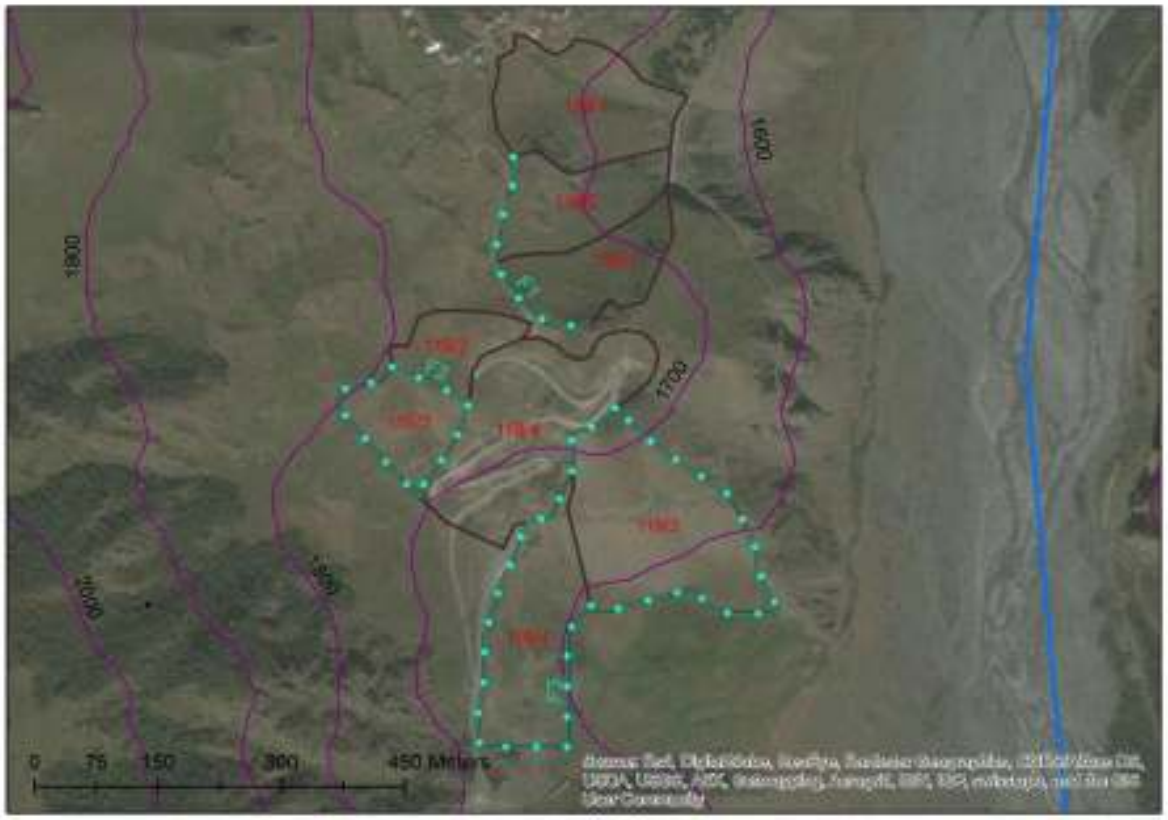
The recommended tree species for all four sites were described in the specific sections above. It has to be highlighted that all afforestation areas have to be mowed during the first years of tree establishment in order to guarantee the survival of the young trees.

At the afforestation sites 108/1 and 108/2 the planting of the recommended tree species should start at the top of the slope. After the establishment of this first belt of planted trees, the next belt can be created, eventually two or three years later. The whole site could be afforested in three time-steps (belts). This strategy can secure a successful afforestation process despite the snow creeping processes and the avalanche dynamics during winter season.

5.2.7. Survey Area VI: Tsdo, sites close to the transit road – Mount Mkinvartsveri - Range

Location:

Above and below the transit road of the Kazbegi District close to the village Tsdo, some sites were identified, where afforestation measures should be carried out. The whole area is situated at the Footslope of the volcanic Mkinvartsveri-Range. The slopes are steep and the embankments of the road often show old erosion areas which were created by the road-construction process. Most of those old erosion processes are already stagnant or decreasing, mitigated by the establishment of vegetation or construction measures. Despite this fact some still existing open erosion areas and above all potential snow creeping processes or even small avalanches can be mitigated or prevented by strategic afforestation measures. The highest priority for afforestation measures hence can be defined for the sites above the transit road.



Picture 62: The GIS-map of survey area VI, displaying the field survey data from Tsdo (sites close to the transit road), and recommended fencing (F1-F3).

Afforestation Suitability (ARS)

In the course of the field survey there were identified 6 different sites with existing afforestation suitability. Two of them are located directly above the transit road of the Kazbegi District, two next to the road leading to the village of Tsdo and two below the transit road. There were identified strong differences on the level of site conditions and resulting afforestation recommendations.

Site 1: Backslope close to the northern tunnel portal

The backslope close to the northern tunnel-portal (Picture 62, map polygon 119/2) has an ARS of 'High', if *Pinus kochiana* is used for afforestation (Table 44). The good conditions are created by the deep soil depth (soil type Cambisol, WRB 2014) and the proximity to the village. By creating a forest at this site the security of the transit road can be improved, as avalanches will be prevented by the established Pine and Oak stand. Actually the whole area of polygon 119/2 can be afforested, but close to the transit road a strip of about 20 m width should be kept free in order to avoid trees falling on the street. The specific site conditions (water balance class medium dry and the exposition south-east) only allow *Pinus kochiana* (80 %) and *Quercus macranthera* (20 %) being used for afforestation (Table 44, Picture 63).

Table 44: Site conditions at the afforestation area 119/2 with regard to ARS

Exposition of the site	South-East	**Erosion Types**	No Erosion
Elevation above sea level	1700-1800 m	**Erosion Tendency**	---
Inclination of the slope	30°	**Erosion Mitigation**	YES (snow creep.)
Bedrock Type	Volcanic	**Constraints for AR**	---
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	60-70 cm	**Actual Biome type**	401
Relief	Backslope	**ARS**	High
Water balance class	Medium Dry	**Site-Index**	Medium
Land Use	AB/H	**Recommended Trees**	*Pinus kochiana (8), Quercus macranthera (2)*

Acronyms: AB/H…abandoned hayfield, AR…Afforestation, ARS…Afforestation Suitability, PV…Proximity to the Village, 401…Meadow community '*Bromopsis variegata'*

Picture 63: This picture shows the afforestation site 119/2 above the Kazbegi transit road, the vegetation indicates the water balance class 'medium dry'. Source: Roland Koeck

Site 2: Backslope directly above the tunnel-portal

The backslope directly above the tunnel portal (Picture 62, map polygon 119/1) has also an ARS of 'High', what can be explained with the deep Cambisol, which has a water balance class of 'very fresh'. There was identified only one constraint for afforestation, which is the high vegetation at the site (Table 45), a fact which is typical for the specific type of subalpine herbaceous vegetation there. This situation calls for mowing before and for at least 3-4 years after the planting of the young trees. The recommended tree species for afforestation are *Betula litwinowii* (30 %), *Acer trautvetteri* (30 %), *Fagus orientalis* (30 %) and *Salix caprea* (10 %) (see Table 45).

Table 45: Site conditions at the afforestation area 119/1 with regard to ARS

Exposition of the site	North	**Erosion Types**	No Erosion
Elevation above sea level	1700-1800 m	**Erosion Tendency**	---
Inclination of the slope	40-45°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	HV
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	100 cm	**Actual Biome type**	501
Relief	Backslope	**ARS**	High
Water balance class	Very Fresh	**Site-Index**	Good
Land Use	AB/H	**Recommended Trees**	*Betula litwinowii (3), Acer trautvetteri (3), Fagus orientalis (3), Salix caprea (1)*

Acronyms: AB/H…abandoned hayfield, AR…Afforestation, ARS…Afforestation Suitability, HV…High Vegetation, PV…Proximity to the Village, 501, subalpine herbaceous vegetation (Hochstauden)

Picture 64: The afforestation site directly above the tunnel portal of the transit road shows already some patches of established trees, like *Betula litwinowii*. Source: Roland Koeck

Site 3: Sites around the road towards Tsdo

The sites around the road towards Tsdo (Picture 62, map polygon 118/4) are already populated with *Hippophae rhamnoides*, but this shrub cover is limited to the direct embankments at both sides of the road. It serves as excellent mitigation of the embankment-erosion processes and was established during the last decades. Between the areas currently covered by *Hippophae rhamnoides* additional trees can be planted. The ARS was rated as 'Medium'; the best facilitation of the afforestation measures is the proximity to the village (Table 46). Due to the dry site conditions the best fitting tree species is *Pinus kochiana* (20 %). The local population also would like to plant fruit trees like *Malus orientalis* (40 %) *and Pyrus caucasica* (40 %). Planting of fruit trees close to the road to Tsdo would make sense, if the local population uses this additional agricultural plant close to their housing locations. The erosion mitigation potential of the afforestation measure is given, as still some open erosion areas are existent.

Table 46: Site conditions at the afforestation area 118/4 with regard to ARS

Exposition of the site	South	**Erosion Types**	Open Erosion
Elevation above sea level	1600-1700 m	**Erosion Tendency**	Decreasing
Inclination of the slope	5-25°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	---
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	25-50 cm	**Actual Biome type**	303 + 401
Relief	Backslope	**ARS**	Medium
Water balance class	Dry	**Site-Index**	Bad
Land Use	AB/H	**Recommended Trees**	*Pinus kochiana (2), Malus orientalis (4), Pyrus caucasica (4)*

Acronyms: AB/H…abandoned hayfield, AR…Afforestation, ARS…Afforestation Suitability, PV…Proximity to the Village, 303…*Hippophae rhamnoides* shrubland, 401…Meadow community '*Bromopsis variegata'*

Picture 65: The sites around the road leading towards Tsdo (polygon 118/4) are already partly covered with *Hippophae rhamnoides*, the areas between those patches could be afforested with the assigned tree species. Source: Roland Koeck

Site 4: Backslope above the road to Tsdo

Above the road towards Tsdo is situated a backslope (Picture 62, map polygon 118/3) with a water balance class between medium dry and dry (Table 47, Picture 66). This situation explains why this site is not very interesting for being a hayfield or pasture land. Afforestation measures are desired by the local population. There are no constraints towards them and the proximity to the village facilitates all endeavours. Actually there are already growing shrubs like *Juniperus depressa, Juniperus sabina* and *Berberis vulgaris*, all of them indicating the dry site conditions. Hence the fitting tree species for afforestation at this site are *Pinus kochiana* (70 %) and *Quercus macranthera* (30 %) (see Table 47).

Table 47: Site conditions at the afforestation area 118/3 with regard to ARS

Exposition of the site	South	**Erosion Types**	---
Elevation above sea level	1700-1800 m	**Erosion Tendency**	---
Inclination of the slope	30°	**Erosion Mitigation**	NO
Bedrock Type	Volcanic	**Constraints for AR**	---
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	25-60 cm	**Actual Biome type**	401
Relief	Backslope	**ARS**	High
Water balance class	Medium Dry -Dry	**Site-Index**	Medium
Land Use	AB/H	**Recommended Trees**	*Pinus kochiana (7), Quercus macranthera (3)*

Acronyms: AB/H…abandoned hayfield, AR…Afforestation, ARS…Afforestation Suitability, PV…Proximity to the Village, 401…Meadow community '*Bromopsis variegata'*

Picture 66: The medium dry to dry site 118/3 where *Pinus kochiana* and *Quercus macranthera* would fit very well to be afforested. Source: Roland Koeck

Site 5: Site around the old route of the transit road

The southern-facing slope around the old route of the transit road (Picture 62, map polygon 119/3) shows shallow to medium soil depth and a water balance class of dry (Table 48). The dry site conditions could cause difficulties for the afforestation measures, hence the timing of the work (humid period of the year) and the adequate species selection (*Pinus kochiana* 80 % and *Quercus macranthera* 20 %) becomes very important. Due to the variable soil depth (5-40 cm, Table 48) and the given rock content on the soil surface (Picture 67) the selection of the adequate micro-sites for the planting holes has to be carried out.

Table 48: Site conditions at the afforestation area 119/3 with regard to ARS

Exposition of the site	South	**Erosion Types**	---
Elevation above sea level	1600-1700 m	**Erosion Tendency**	---
Inclination of the slope	35°	**Erosion Mitigation**	NO
Bedrock Type	Volcanic	**Constraints for AR**	DS
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	5-40 cm	**Actual Biome type**	401
Relief	Backslope	**ARS**	Medium
Water balance class	Dry	**Site-Index**	Bad
Land Use	NU	**Recommended Trees**	*Pinus kochiana (8), Quercus macranthera (2)*

Acronyms: NU…no land use, AR…Afforestation, ARS…Afforestation Suitability, DS…dry site, PV…Proximity to the Village, 401…Meadow community '*Bromopsis variegata'*

Picture 67: The dry site conditions at 119/3 with some rocks at the soil surface become apparent on this picture. Source: Roland Koeck

Site 6: Backslope below the Kazbegi transit road

Below the Kazbegi transit road afforestation measures would be possible at a backslope site (Picture 62, map polygon 119/4). The ARS was rated as 'Medium', what is due to the rock content on soil surface, rock areas which are stemming from the road construction are a constraint for afforestation (Picture 68), the proximity of the site to the road and the village are facilitating it (Table 49). The soil depth is variable at the site (what is also due to the rock areas), hence again the selection of the adequate micro-sites for the planting holes has to be carried out. The adequate tree species for afforestation are *Pinus kochiana* (80 %) and *Sorbus aucuparia* (20 %).

Table 49: Site conditions at the afforestation area 119/4 with regard to ARS

Exposition of the site	East	**Erosion Types**	---
Elevation above sea level	1600-1700 m	**Erosion Tendency**	---
Inclination of the slope	30°	**Erosion Mitigation**	YES
Bedrock Type	Volcanic	**Constraints for AR**	RA
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	15-50 cm	**Actual Biome type**	403 + 401
Relief	Backslope	**ARS**	Medium
Water balance class	Medium Fresh	**Site-Index**	Medium
Land Use	PL	**Recommended Trees**	*Pinus kochiana (8), Sorbus aucuparia (2)*

Acronyms: PL…Pasture Land, AR…Afforestation, ARS…Afforestation Suitability, RA…Rock Areas, PV…Proximity to the Village, 401…Meadow community '*Bromopsis variegata',* 403…Meadow community '*Festuca varia'*

Picture 68: Potential afforestation site 119/4, the rock areas are visible. Source: Roland Koeck

The afforestation site displayed by polygon 118/1 (Picture 62) is already afforested in the course of a project with the Kazbegi National Park and the local community of Tsdo.

5.2.8. **Survey Area VII: Arsha**

Picture 69: The GIS-map of survey area VII, displaying the field survey data from Arsha, and recommended fencing (F1-F3).

Picture 70: View at the survey area VII with reported avalanche dynamic, village of Arsha. Source: Elisabeth Pötzelsberger

5. Suitability of sites for the defined land-use interest

Location

Survey area VII is situated at a steep slope above the village of Arsha which shows avalanche dynamics during winter season. A sport school building was damaged by an avalanche, what was the reason for proposing the site for afforestation measures. The steepness of the slope is visible in Picture 70.

Afforestation Suitability (ARS)

In the course of the field survey 5 sites with afforestation suitability were identified. The overall aim is the mitigation of avalanche dynamics during winter season, which can be provided by an established forest cover. Due to the snow creeping processes during winter the afforestation conditions are rather difficult, but despite this fact the creation of a stable forest cover seems to be possible.

Site 1: Polygon 302/1

At the west-south-western exposed site displayed by polygon 302/1 (Picture 69) ARS was rated as difficult, what is due to the steepness of the site and the resulting snow creeping processes and avalanches during winter (see Picture 71). On the other hand, the site with the deep soils and the fresh water balance class creates excellent conditions for plant growth. The recommended tree species for afforestation measures are *Fagus orientalis* (30 %), *Acer trautvetteri* (30 %), *Betula litwinowii* (20 %) and *Sorbus aucuparia* (20 %) (see Table 50).

Table 50: Site conditions at the afforestation area 302/1 with regard to ARS

Exposition of the site	West-South-West	**Erosion Types**	---
Elevation above sea level	1900 m	**Erosion Tendency**	---
Inclination of the slope	35-40°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	AS/SC
Soil Type	Cambisol	**Facilitation of AR**	EX/PV
Soil Depth	100 cm +	**Actual Biome type**	403
Relief	Backslope	**ARS**	Difficult
Water balance class	Fresh	**Site-Index**	Good
Land Use	AB	**Recommended Shrubs**	*Fagus orientalis (3), Acer trautvetteri (3), Betula litwinowii (2) Sorbus aucuparia (2)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, AB…abandoned land-use, OE…open erosion, AS…avalanche strip, SC…snow creeping, EX…excellent site conditions, PV…proximity to the village, 403…Meadow community *'Festuca varia'*

Picture 71: The steep site displayed by polygon 302/1, where excellent soil conditions meet snow creeping as constraint for tree growth. In the valley the school building is visible, which was damaged by an avalanche. Source: Roland Koeck

Site 2: Polygon 302/2

At the west-south-western exposed site displayed by polygon 302/2 (Picture 69) ARS was rated as medium, what is due to the relatively flat site, why snow creeping processes are not prevalent. The recommended tree species for afforestation measures are *Pinus kochiana* (60 %) and *Acer trautvetteri* (40 %) (see Table 51).

Table 51: Site conditions at the afforestation area 302/2 with regard to ARS

Exposition of the site	West-South-West	**Erosion Types**	---
Elevation above sea level	2000 m	**Erosion Tendency**	---
Inclination of the slope	5°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	AS
Soil Type	Cambisol	**Facilitation of AR**	EX/PV
Soil Depth	20-30 cm	**Actual Biome type**	403
Relief	Backslope	**ARS**	Medium
Water balance class	Fresh	**Site-Index**	Good
Land Use	AB	**Recommended Shrubs**	*Pinus kochiana (6), Acer trautvetteri (4)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, AB…abandoned land-use, OE…open erosion, AS…avalanche strip, EX…excellent site conditions, PV…proximity to the village, 403…Meadow community *'Festuca varia'*

Site 3: Polygon 302/4

At the south-western exposed site displayed by polygon 302/4 (Picture 69) ARS was rated as difficult, what is due to the steep site (see Picture 72), where snow creeping processes and avalanche dynamics are again prevalent. The recommended tree species for afforestation measures are *Pinus kochiana* (60 %) and *Acer trautvetteri* (40 %) (see Table 52).

Table 52: Site conditions at the afforestation area 302/4 with regard to ARS

Exposition of the site	South-West	**Erosion Types**	OE
Elevation above sea level	2000 m	**Erosion Tendency**	Stagnant
Inclination of the slope	40°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	AS/SC
Soil Type	Cambisol	**Facilitation of AR**	---
Soil Depth	80 cm	**Actual Biome type**	401
Relief	Backslope	**ARS**	Difficult
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	AB	**Recommended Shrubs**	*Pinus kochiana (6), Acer trautvetteri (4)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, AB…abandoned land-use, OE…open erosion, AS…avalanche strip, SC…snow creeping processes, 401…Meadow community *'Bromopsis variegata'*

Picture 72: The steep site of polygon 302/4. Source: Roland Koeck

Site 4: Polygon 302/5

At the north-western exposed site displayed by polygon 302/5 (Picture 69) ARS was rated as difficult, what is due to the steepness of the site and the resulting snow creeping processes and avalanches during winter season. On the other hand, the site with the deep soils and the fresh water balance class creates excellent conditions for plant growth. Actually there is already growing established natural regeneration of *Betula litwinowii*, by the way creating patches of forest function on the steep slope (see Picture 73), what will facilitate the afforestation measures. The recommended tree species for afforestation measures are *Acer trautvetteri* (40 %), *Fagus orientalis* (30 %), *Sorbus aucuparia* (20 %) and *Betula litwinowii* (10 %) (see Table 53).

Table 53: Site conditions at the afforestation area 302/5 with regard to ARS

Exposition of the site	North-West	**Erosion Types**	---
Elevation above sea level	2000 m	**Erosion Tendency**	---
Inclination of the slope	40°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	AS/SC
Soil Type	Cambisol	**Facilitation of AR**	EX/PV
Soil Depth	60-100 cm +	**Actual Biome type**	403
Relief	Backslope	**ARS**	Difficult
Water balance class	Fresh	**Site-Index**	Good
Land Use	AB	**Recommended Shrubs**	*Acer trautvetteri (4), Fagus orientalis (3), Sorbus aucuparia (2), Betula litwinowii (1)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, AB…abandoned land-use, AS…avalanche strip, SC…snow creeping processes, EX…excellent site conditions, PV…proximity to the village,, 403…Meadow community *'Festuca varia'*

Picture 73: The steep site of polygon 302/5 with the *Betula* individuals, Arsha is visible in the background. Source: Roland Koeck

5. Suitability of sites for the defined land-use interest

Site 5: Polygon 302/6

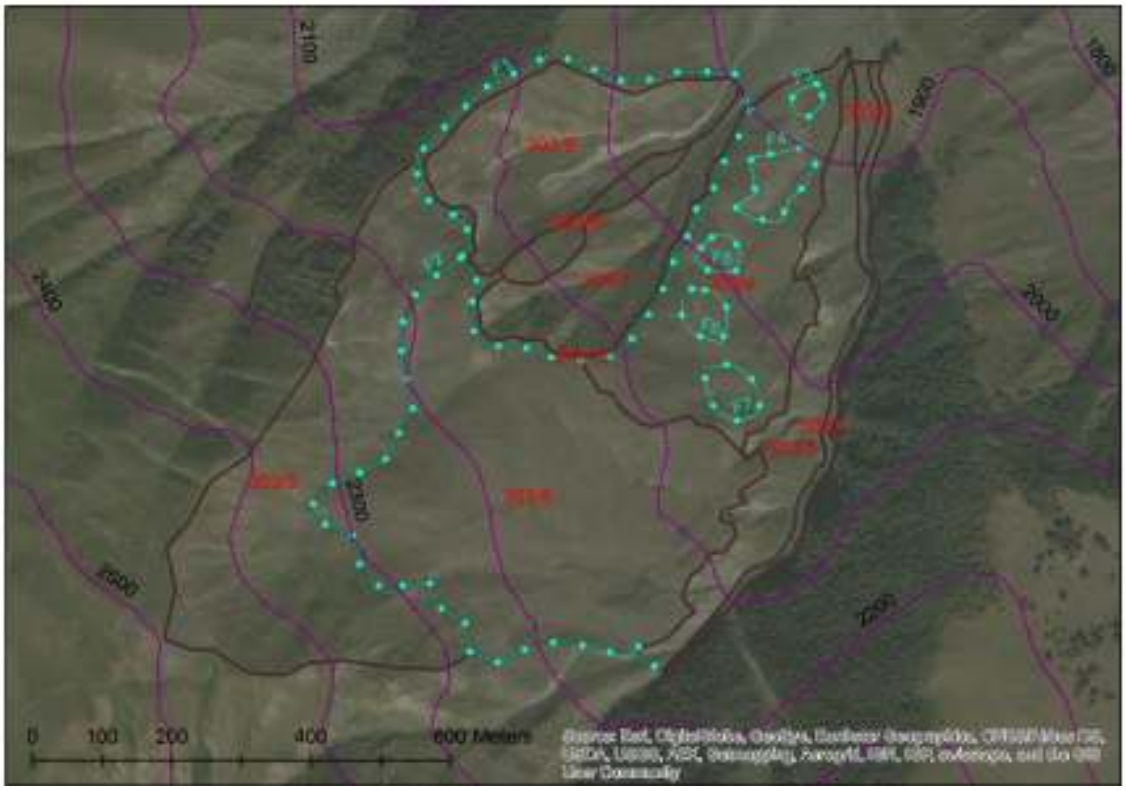
At the south-western exposed site displayed by polygon 302/6 (Picture 69) ARS was rated as difficult, what is due to the steepness of the site and the resulting snow creeping processes and avalanches during winter season. The recommended tree species for afforestation measures are *Pinus kochiana* (40 %), *Acer trautvetteri* (30 %) *and Sorbus aucuparia* (30 %) (see Table 54).

Table 54: Site conditions at the afforestation area 302/6 with regard to ARS

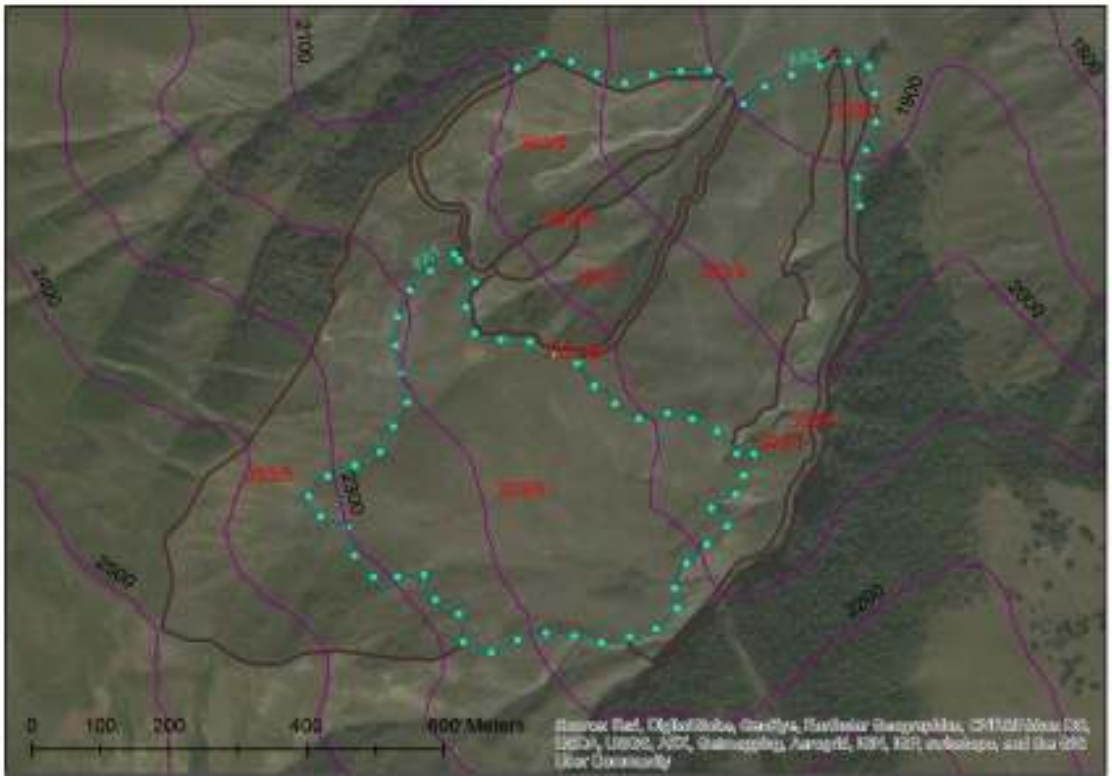
Exposition of the site	South-West	**Erosion Types**	---
Elevation above sea level	1900 m	**Erosion Tendency**	---
Inclination of the slope	35°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	AS/SC
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	5-80 cm	**Actual Biome type**	401
Relief	Backslope	**ARS**	Difficult
Water balance class	Medium Dry	**Site-Index**	Medium
Land Use	AB	**Recommended Shrubs**	*Pinus kochiana (4), Acer trautvetteri (3), Sorbus aucuparia (3)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, AB…abandoned land-use, AS…avalanche strip, SC…snow creeping processes, PV…proximity to the village, 401…Meadow community *'Bromopsis variegata'*

5.2.9. **Survey Area VIII: Sno**



Picture 74: The GIS-map of survey area VIII, displaying the field survey data from Sno, and recommended fencing (F1-F7).



Picture 75: The GIS-map of survey area VIII, displaying the field survey data from Sno, and alternative recommended fencing (FA1, FA2).

Location

The survey area VIII close to the village of Sno is situated around a gully erosion area, which is drained by two small brooks (see Picture 76). It is intended to stabilize the gully erosion site via afforestation measures and natural forest regeneration dynamics. The area around the gully system is intensively used as pasture land. Also the area of the gully erosion system was used at the outer edges as pasture land. The ARS survey provided data regarding potential afforestation sites and areas, where only the natural regeneration dynamics of the forest trees will result in an establishment of a stable forest cover.

Picture 76: Gully erosion area close to the village Sno with the two small brooks draining the two systems. Source: Roland Koeck

Afforestation Suitability (ARS)

In the course of the field survey 4 sites with afforestation suitability were identified. The overall aim of the afforestation measures is the mitigation or prevention of the erosion dynamics in this area. It has to be highlighted that the gully erosion system can only be stabilized through the facilitation of natural regeneration dynamics of trees and shrubs, as the related sites are extremely steep and inhomogeneous regarding soil conditions. The package of afforestation measures and facilitation of natural regeneration is achieved through fencing. Two variants of fencing strategies are proposed.

5. Suitability of sites for the defined land-use interest

Site 1: Polygon 303/4

At the north-eastern to north-western exposed site displayed by polygon 303/4 (Picture 74) ARS was rated as very high, what is due to the excellent site conditions regarding soil depth and water balance class. The site can be afforested in patches, as the above pasture land will still be used for cattle grazing. Afforestation in patches is a valuable alternative, as it provides erosion mitigation and prevention for this vulnerable site. The recommended tree species for afforestation measures are *Acer trautvetteri* (30 %), *Fagus orientalis* (30 %), *Pinus kochiana* (20 %) *and Sorbus aucuparia* (20 %) (see Table 55).

Table 55: Site conditions at the afforestation area 303/4 with regard to ARS

Exposition of the site	North-East/North-West	**Erosion Types**	OE
Elevation above sea level	1900-2100 m	**Erosion Tendency**	Increasing
Inclination of the slope	15-35°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	EX/PV
Soil Depth	100 cm +	**Actual Biome type**	401 + 403
Relief	Backslope	**ARS**	Very High
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Shrubs**	*Acer trautvetteri (3), Fagus orientalis (3), Pinus kochiana (2), Sorbus aucuparia (2)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…pasture land, OE…open erosion, EX…excellent site conditions, PV…proximity to the village, 401…Meadow community *'Bromopsis variegata',* 403…Meadow community *'Festuca varia'*

Site 2: Polygon 303/8

At the north-eastern to south-eastern exposed site displayed by polygon 303/8 (Picture 74) ARS was rated as high, what is due to the excellent site conditions regarding soil depth and water balance

Table 56: Site conditions at the afforestation area 303/8 with regard to ARS

Exposition of the site	North-East/South-East	**Erosion Types**	---
Elevation above sea level	2100 m	**Erosion Tendency**	---
Inclination of the slope	20-35°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	---
Soil Type	Cambisol	**Facilitation of AR**	EX
Soil Depth	80 cm +	**Actual Biome type**	401
Relief	Ridge	**ARS**	High
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Shrubs**	*Pinus kochiana (3), Betula litwinowii (3), Acer trautvetteri (2), Sorbus aucuparia (2)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, PL…pasture land, EX…excellent site conditions, 401…Meadow community *'Bromopsis variegata'*

Class (see Picture 77). The recommended tree species for afforestation measures are *Pinus kochiana* (30 %), *Betula litwinowii* (30 %), *Acer trautvetteri* (20 %) and *Sorbus aucuparia* (20 %) (see Table 56).

Picture 77: The ridge site where afforestation measures can be carried out is situated between the two gully systems. Source: Roland Koeck

Site 3: Polygon 303/10

At the north-western to south-eastern exposed site displayed by polygon 303/10 (Picture 74) ARS was rated as high, what is due to the excellent site conditions regarding soil depth and water balance class. The site which is prone to open erosion and lateral erosion has to be stabilized, what can be achieved the best with afforestation of *Pinus kochiana* (100%) (see Table 57). The afforested Pine-

Table 57: Site conditions at the afforestation area 303/10 with regard to ARS

Exposition of the site	North-West/South-East	**Erosion Types**	OE/LSE
Elevation above sea level	1900-2100 m	**Erosion Tendency**	Increasing
Inclination of the slope	0-35°	**Erosion Mitigation**	YES
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	EX
Soil Depth	80 cm +	**Actual Biome type**	401/403
Relief	Backslope	**ARS**	High
Water balance class	Medium Fresh	**Site-Index**	Good
Land Use	PL	**Recommended Shrubs**	*Pinus kochiana (10)*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability, OE…Open erosion, LSE…lateral slope erosion, PL…pasture land, EX…excellent site conditions, 401…Meadow community *'Bromopsis variegata',* 403…Meadow community *'Festuca varia'*

strip will surround the whole gully erosion systems of the two brooks (see Picture 76).

Natural Regeneration Dynamics (NRD) as erosion control

In the survey area of Sno several parts will be secured by the facilitation of natural regeneration dynamics (NRD). This becomes possible through fences, which prevent cattle or sheep from entering the desired forest development areas. For the fencing works two different options were proposed (see Picture 74 and Picture 75), the decision about which will be selected has to be made by local stakeholders.

One example is the steep slope above the central pasture area (polygon 303/5, Picture 74), where the fence will facilitate the already beginning establishment of trees like *Betula litwinowii* (see Picture 78).

Picture 78: Central pasture area – polygon 303/6 – with the intended natural regeneration area above – polygon 303/5. Source: Roland Koeck

Also the establishment of forest cover in the two gully erosion systems becomes possible through the facilitating effect of the fences on NRD. In the easternmost gully system there can be found already some tree individuals stemming from natural regeneration (see Picture 79). The westernmost gully system (polygon 303/9, Picture 74) does not show any NRD, as erosion processes are more prevalent there. An additional site which could be stabilized via NRD facilitated by fencing is polygon 303/3 (Picture 74), where again *Betula litwinowii* will become the dominating tree species (see Picture 80).

Picture 79: Already established natural regeneration of *Betula litwinowii* and *Salix caprea* in polygon 303/7. Source: Roland Koeck

Picture 80: Already beginning NRD (natural regeneration dynamics) at the site displayed by polygon 303/3, a mitigating effect on erosion processes could be achieved, if NRD would be facilitated by fences. Source: Roland Koeck

5.2.10. **Survey Area IX: Break-Off Edge of the scree cone of the village Kanobi**

Location

The village Kanobi is situated on a huge scree-cone which is stemming from the mountain range above the village. The dominant bedrock-type is schist. On the top of the scree-cone, soil formation processes occurred and formed deep and fertile soils. The eastern-most part of the scree-cone was in the past and of course is also currently cut by River Tergi, shaping a steep break-off edge (Picture 81).

This steep break-off edge towards the river Tergi was communicated by local specialists as desired afforestation site. The area covers about 8 ha.

Picture 81: The village Kanobi, situated on a huge scree-cone with a steep break-off edge towards the River Tergi. At this steep break-off edge the afforestation measures should take place. Source: Roland Koeck

Picture 82: The GIS-map of survey area IX, displaying the field survey data from Kanobi - potential afforestation site below the village, on the break-off edge of the scree-cone.

Afforestation Suitability (ARS)

The slope of the break-off edge (Picture 82, map polygon 301/1) with 35-40° has a rather steep inclination (Picture 83). The situation of the site at the Footslope of the huge schist scree-cone with deep Cambisols (WRB 2014) and fresh as water balance class (Table 58) creates the typical conditions for an *Aceretum* (maple forest community).

The most fitting species for the afforestation measures is *Acer trautvetteri.* Only this maple species can establish a stable forest cover at the specific site. The historic *Pinus kochiana* plantation may also have been damaged due to the unfavourable site conditions for pine. Only at some small dryer microsites, *Pinus kochiana* would be fitting for afforestation, but should be avoided due to the problems with this tree species during the historic afforestation attempts. Hence more than 90 % of the forest plant material should be covered by *Acer trautvetteri*, 10 % of the area can be afforested with *Salix*-species (Tab. 18).

The afforestation suitability (ARS) is medium (Table 58), as the high ground cover vegetation at the site (Picture 83) has to be mowed before planting and also has to be mowed until the young trees reach growth heights of about 1.5 m.

5. Suitability of sites for the defined land-use interest

Table 58: Site conditions at the afforestation area 301/1 with regard to ARS

Exposition of the site	South-East	**Erosion Types**	LSE, OE
Elevation above sea level	2000 m	**Erosion Tendency**	increasing
Inclination of the slope	35-40°	**Erosion Mitigation**	YES (OE)
Bedrock Type	Schist	**Constraints for AR**	HV
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	70 cm	**Actual Biome type**	403 + 501
Relief	Footslope/SR	**ARS**	Medium
Water balance class	Fresh	**Site-Index**	Good
Land Use	NU	**Recommended Trees**	*Acer trautvetteri (9), Salix sp. (1)*

Acronyms: NU…no actual land use, LSE…lateral slope erosion, OE…open erosion, HV…high vegetation, PV…proximity to the village, SR…scree cone, 403…Meadow community '*Festuca varia*', 501…subalpine herbaceous vegetation (Hochstauden)

Picture 83: This picture shows the steepness of the potential afforestation site (301/1) at the break-off edge of the scree-cone in Kanobi. The high ground-cover vegetation is also apparent. Source: Roland Koeck

A fact which is facilitating the afforestation measures is the proximity of the site to the village Kanobi. It also has to be considered that the site is very steep and that the personal which carries out the afforestation and mowing measures has to be secured, especially at the sites above the steep eroded areas close to the River Tergi.

Picture 84: Lateral Slope Erosion (LSE) caused by the River Tergi at the bottom of the break break-off edge of the scree-cone in Kanobi. Source: Roland Koeck

Erosion Mitigation Potential of the afforestation

The afforestation measures could mitigate erosion processes at the site. Actually there are occurring both open erosion (OE) and lateral slope erosion (LSE) (Table 58). The existing open erosion processes, which actually only cover very small sites, can be mitigated by the future forest cover.

On the other hand, the lateral slope erosion (LSE) which occurs at about 15 % of the contact zone between the River Tergi and the break-off edge of the scree-cone (Picture 84) cannot be mitigated by forest cover. Why is this like that? The scree-cone stemming from Kabardzhin – Volcano, which is actually the other side of the valley, moves the River Tergi towards the scree-cone where the village Kanobi is situated. This process causes the lateral slope erosion at the scree-cone of Kanobi and cannot be prevented or mitigated by the way of an established forest cover. This erosion process could only be mitigated via construction measures in the River Tergi, which move the flow-path of the river away from the Kanobi scree-cone.

Strategic Afforestation Recommendation

The afforestation measures with 90 % *Acer trautvetteri* and 10 % *Salix sp.* can be carried out within the area displayed by Polygon 301/1 of the GIS-map (Picture 82). The security of the planting personal has to be guaranteed.

5.3. **Forest situation**

The different forest types and the full range of forest age classes present in the study area were investigated. In every forest stand several angle count samples were made. The data from the different sites were grouped according to forest ecosystem type, age class, past forest management practice and major site characteristics.

Table 59 gives an overview of the 13 different stand types. Natural birch dominated forests (stands birch1 to 6) were found mainly on shallow soils within an age of 30 to 70 years. In 3 birch forests we could find single tree cuttings in the past. Poplar (polar 1and 2) and pine forests (pine 1, 2 and 3) were established by planting in the years 1950 – 1980. Poplar forests and pine forest 3 were managed by single tree cutting in the past.

Table 59: Overview of the investigation stands types

Stand ID	Stand type	Age range (y)	Historic management	Sample size	Orientation	Inclination	Soil
Birch 1	Birch-willow-coppice forest	30 - 40	no management	2	N	37	shallow soils
Birch 2	Birch forest	35 - 45	single tree cutting	4	N	31	shallow soils
Birch 3	Birch forest	55- 70	single tree cutting	4	N	31	shallow soils
Birch 4	Birch-willow-coppice forest	55 - 70	single tree cutting	3	N	36	shallow soils
Birch 5	Natural Birch-willow-maple-forest	55 -70	no management	2	NE	35	shallow soils
Birch 6	Natural birch-pine forest	55 - 70	no management	1	W	31	medium soils
Poplar 1	Artificial poplar forest	50 - 60	single tree cutting	3	SW	31	shallow soils
Poplar 2	Artificial poplar forest	60 - 65	single tree cutting	3	NE	19	deep soils
Pine 1	Artificial pine forest	35 - 45	no management	2	SW	24	deep soils
Pine 2	Artificial pine forest	35 - 45	no management	4	NE	33	medium soils
Pine 3	Artificial pine forest	55 - 65	single tree cutting	7	SW	14	deep soils
Pine 4	Natural Pine-forest	55 - 70	no management	2	S	25	medium soils

The results of dbh, ten year dbh increment, tree height, number of trees per hectare, basal area, ten year basal area increment, timber volume and biomass, above ground carbon stocks, root carbon stocks, above and below ground carbon stocks and the CO_2 equivalent of above and below ground carbon stocks are presented for the different forest types and the tree species within a forest type (Table 60, Picture 89, Picture 90).

Table 60: Summarised results of the forest stand investigations.

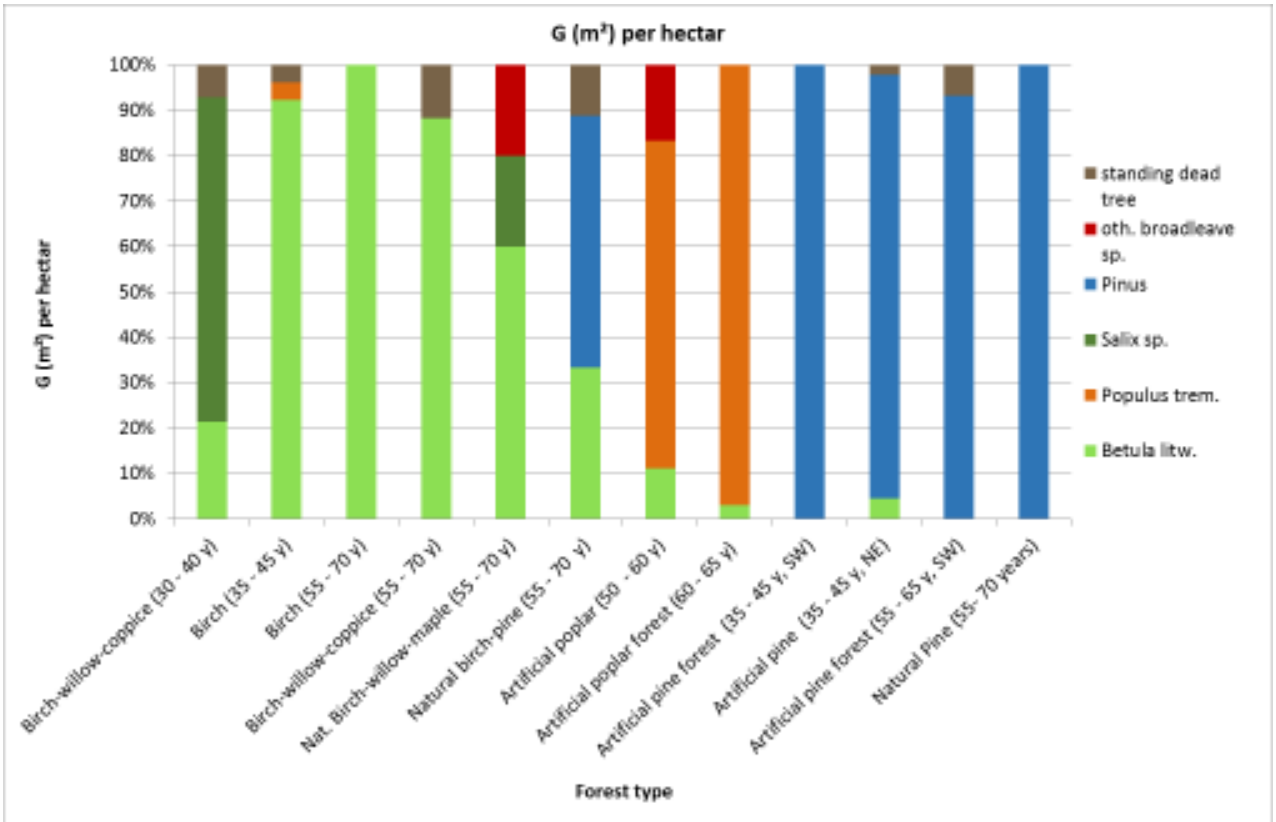
Stand ID	Stand type	Species	Average dbh (cm)	iRad10y (mm)	Tree height hL(m)	N (ha^{-1})	G ($m^2 ha^{-1}$)	iG10 (m^2)	V ($m^3 ha^{-1}$)	Above ground biomass ($t ha^{-1}$)	Above ground C stock ($t ha^{-1}$)	Root C stock ($t ha^{-1}$)	Above and below ground C stock ($t ha^{-1}$)	CO_2 (biomass stock) ($t ha^{-1}$)
Birch 1	**Birch-willow-coppice forest**	Betula litw.	9.7	9	6.1	811	6	2.02	22	13.4	6.7	1.3	8.0	29.5
		Salix ssp.	11.3	19	7.4	2002	20	11.20	94	49.1	24.5	4.9	29.4	107.9
		standing dead tree				*186*	*2*		*5*	*1.7*	*0.8*	*0.2*	1.0	*3.7*
		Sum				**2999**	**28**	**13.23**	**121**	**64**	**32**	**6.4**	**38.5**	**141.0**
Birch 2	**Birch forest**	Betula litw.	14.8	11.2	11.3	1556	24	4.67	184	112.2	56.1	11.2	67.3	246.8
		Popolus trem.	43.3	10	9	7	1	0.09	7	3.1	1.6	0.3	1.9	6.8
		standing dead tree				*50*	*1*		*2*	*0.8*	*0.4*	*0.1*	0.5	*1.7*
		Sum				**1613**	**26**	**4.76**	**193**	**116.1**	**58.1**	**11.6**	**69.7**	**255.3**
Birch 3	**Birch forest**	**Betula litw.**	**15.8**	**9.5**	**8.5**	**1168**	**21**	**3.24**	**138**	**84.4**	**42.2**	**8.4**	**50.6**	**185.5**
Birch 4	**Birch-willow-coppice forest**	Betula litw.	12.3	7.7	7.8	1820	20	3.39	103	62.5	31.3	6.3	37.5	137.5
		standing dead tree				271	3		6	2.1	1.0	0.2	1.3	4.6
		Sum				**2090**	**23**	**3.39**	**108**	**65**	**32**	**6.5**	**38.8**	**142.1**
Birch 5	**Natural Birch-willow-maple-forest**	Betula litw.	13.0	11	8.1	438	6	1.94	32	19.2	9.6	1.9	11.5	42.3
		Acer traut.	13.8	12	7.8	134	2	0.64	10	6.1	3.0	0.6	3.6	13.4
		Salix sp.	8.3	12	4.2	370	2	0.99	4	2.3	1.2	0.2	1.4	5.1
		Sum				**941**	**10**	**3.56**	**46**	**27.6**	**13.8**	**2.8**	**16.6**	**60.8**
Birch 6	**Natural birch-pine forest**	Betula litw.	20.3	13	10.9	372	12	2.88	95	58.2	29.1	5.8	34.9	128.0
		Pinus koch.	28.0	15	12.9	326	20	4.06	115	58.7	29.4	5.9	35.2	129.1
		standing dead tree				*187*	*4*		*10*	*3.5*	*1.8*	*0.4*	2.1	*7.7*
		Sum				**885**	**36**	**6.94**	**221**	**120.5**	**60.2**	**12.0**	**72.3**	**264.8**
Poplar 1	**Artificial poplar forest**	Betula litw.	15	13	8	190	3	0.53	13	8.2	4.1	0.8	4.9	18.1
		Popolus trem.	27	18	15	312	17	3.75	195	87.6	43.8	8.8	52.6	192.6
		Sorbus sp.	11	7	6	416	4	0.95	16	10.6	5.3	1.1	6.4	23.4
		Sum				**918**	**24**	**5.24**	**225**	**106**	**53**	**10.6**	**63.9**	**234.0**
Poplar 2	**Artificial poplar forest**	Betula litw.	15.6	12	12.9	70	1	0.38	12	7.5	3.7	0.7	4.5	16.4
		Popolus trem.	26.7	13.3	19.5	820	43	5.35	648	291.6	145.8	29.2	174.9	641.0
		Sum				**890**	**44**	**5.73**	**660**	**299**	**150**	**29.9**	**179.4**	**657.4**
Pine 1	**Artificial pine forest**	**Pinus koch.**	**23.3**	**17.0**	**15.1**	**1172**	**50**	**13.51**	**344**	**175.3**	**87.7**	**17.5**	**105.2**	**385.4**
Pine 2	**Artificial pine forest**	Betula litw.	15.5	19.0	13.0	105	2	0.86	19	11.3	5.6	1.1	6.8	24.8
		Pinus koch.	22.5	19.8	16.5	848	31	8.01	229	116.9	58.4	11.7	70.1	256.9
		Pinus nigra	19.1	20.0	13.4	428	11	3.31	70	35.9	17.9	3.6	21.5	78.9
		standing dead tree				*35*	*1*		*3*	*1.1*	*0.6*	*0.1*	0.7	*2.5*
		Sum				**1416**	**45**	**12.18**	**321**	**165.2**	**82.6**	**16.5**	**99.1**	**363.1**
Pine 3	**Artificial pine forest**	Pinus koch.	27.4	10.4	17.3	1075	62	8.37	493	251.4	125.7	25.1	150.9	552.8
		standing dead tree				*110*	*5*		*30*	*10.5*	*5.2*	1.0	6.3	23.1
		Sum				**1185**	**67**	**8.37**	**523**	**262**	**131**	**26.2**	**157.2**	**575.8**
Pine 4	**Natural Pine-forest**	**Pinus koch.**	**20**	**12**	**13**	**1225**	**36**	**6.47**	**201**	**102.5**	**51.2**	**10.2**	**61.5**	**225.2**
Average of living trees						**1293**	**36**	**8.47**	**287**	**147.9**	**73.9**	**14.8**	**88.7**	**325.1**
Average of stumps						**67**	**2**		**7**	**2.5**	**1.3**	**0.3**	**1.5**	**5.6**

Picture 85: Vegetative regeneration of birch trees.

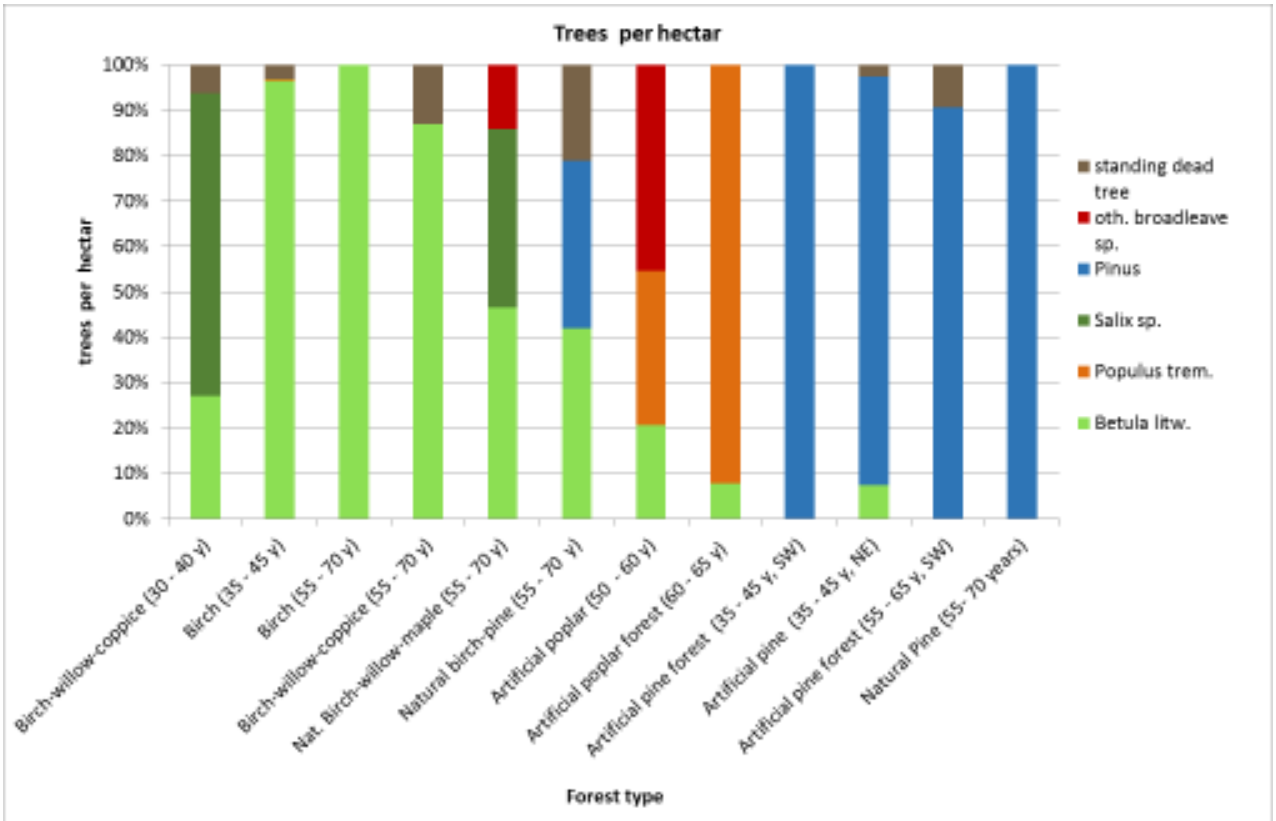
Picture 86: Planted pine forest, example for stand type Pine 3 according to Table 59.

Tree divesity

The different species occurring in the forests and their frequency are shown in Picture 87 and Picture 88. The tree species distrubution is presented in percentage of basal aerea and stem number. More than expected the forests are characterised by a diversity of species as evolved from natural regeneration. The most dominant tree species are birch in the stands birch 2 to 5 with 60 to 100% and pine in the stands pine 1 to 4 with 95 to 100%. Percentage of birch is lower in birch stand 1 (20%) and birch stand 6 (33%). Both natural birch forests and artificial poplar and pine forests are mixed with willow (*Salix* sp.), rowan (*Sorbus* sp.), oak (*Quercus* sp.) and maple (*Acer* sp.). Willow instead dominates the tree species distribution in the forest stand 1.



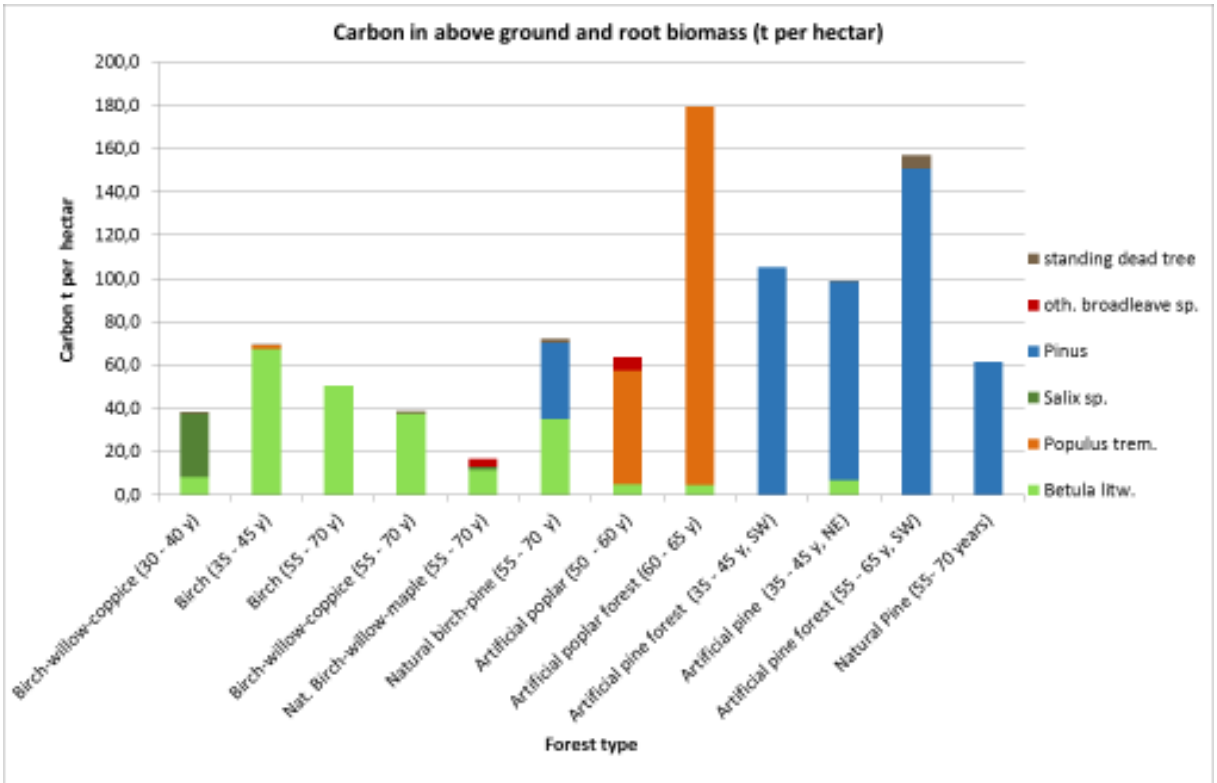
Picture 87: Tree spicies diversity [tree species distribution [%] based on basal area [$m^2.ha^{-1}$] of the different stand types.



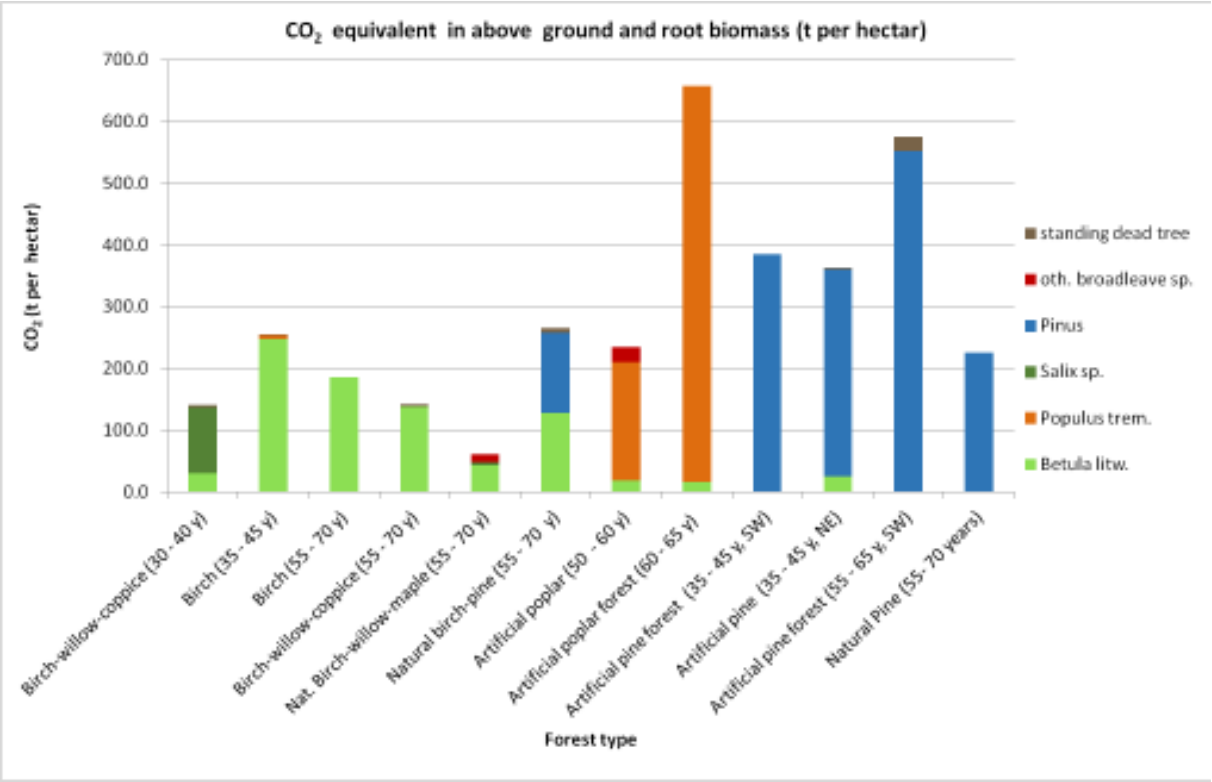
Picture 88: Tree spicies diversity [tree species distribution (%) based on stem number (N ha^{-1}) of the different stand types].

The carbon stock of above ground and root biomass in the birch forests (birch 1 to 4) ranges between 39 and 70 t ha^{-1} (birch 5: 17 t ha^{-1}, Table 60, Picture 89). Poplar forest 2 and pine forest 3 showed highest carbon storage in living forest biomass (aboveground and roots) with 180 t ha^{-1} and 160 t ha^{-1} after 65 years (Table 60). For calculation of carbon sequestration potential mean annual increment rates can also be regarded. The mean annual increment for birch stands range between 0.5 (after 40 years) and 1.8 t ha^{-1} y^{-1} (after 45 years). The mean annual increment is sharply higher in the artificial poplar and pine stands (2.8 and 2.5 t ha^{-1} y^{-1}).

This complies a carbon dioxide equivalent of about 141 to 265 t ha^{-1} for the birch forests and 576 to 660 t ha^{-1} for the poplar forest and pine forest (Table 60, Picture 90). The mean annual increment of the carbon dioxide value ranges between 2 to 6 t ha^{-1} y^{-1} in birch stands and 8 to 10 t ha^{-1} y^{-1} in poplar and pine stands. Therefore afforestation of one hectare with pine or poplar in areas of well growing conditions compensate about 8 to 10 t ha^{-1} y^{-1} (GHG emission) up to a growing period of 65 years.



Picture 89: Above and below ground carbon (t per hectare) of the different tree species for the different forest types.



Picture 90: CO_2 equivalent of above and below ground carbon (t per hectare) of the different tree species for the different forest types.

6. DEVELOPMENT, ANALYSIS AND EVALUATION OF DIFFERENT LAND-USE MANAGEMENT STRATEGIES/OPTIONS

The suitability for afforestation of an area and the need for afforestation in a first step consider socio-economic aspects (chapter 1). In a second step, the ecological aspects of afforestation facilitation/limitation are considered (chapter 2). Considering both, socio-economic and ecological aspects, the decision if afforestation shall be pursued can be taken. The last step in the planning face is the planning of the actual afforestation measures, the species selection and management requirements and options (chapter 3).

6.1. Afforestation suitability

Land-use:

Different land-use types, together with different suitability for certain land-use types (pasture, hayfield) get different scoring.

Table 61: Current land-use

Criterion	Score
No present or historic use	5
Abandoned pasture or hayfield	4
Pasture far (>2 km) from village and/or slope <5° or >35°	3
Pasture close (<2 km) to village and/or slope 5°-35°	2
Hayfield far (>1 km) from village and/or slope >25°	2
Hayfield close (<1 km) to village and/or slope <25°	1
Arable land	0

buckthorn shrubs

Protection aspects:

Forests can have various protection functions by protecting people, objects and sites against different natural hazards. Forests may protect settlements and roads, and therewith directly people, and other infrastructure such as length of gas pipelines or water pipelines and power supply lines, or agricultural areas against avalanches and landslides, debris flows and areal open erosion.

Table 62: Forest protection function, protection of different objects

Criterion	Score
Settlements	5
Roads	4
Length of gas pipeline, length of water pipeline	3
Source of drinking water	3
Power supply lines	2
Arable land, hay fields	1
Meadows	1
Nothing	0

Table 63: Forest protection function, protection against different natural hazards

Criterion	Score
Landslides	4
Avalanches with afforestation potential in starting zone	4
Rockfall	3
Areal open erosion: large scale, with the potential for gully creation	2
Avalanche strips	1
Areal open erosion: small scale	1
Lateral slope erosion	1
Debris flow	2
Nothing	0

This scoring describes the potential of afforestation to act against a certain natural hazard, in combination with the severity of the natural hazard. The highest protection potential of forests is evident against landslides, areal open erosion and avalanches with a broad starting zone where there is an afforestation potential in the starting zone. Areal open erosion, however, gets a lower score, because the negative impact of areal erosion is lower than of landslides and avalanches, which endanger people and infrastructure, a.s.o. Lateral slope erosion and debris flow have a high potential to severe damage, but the score is low, because the chance to lower the risk with afforestation measures is low.

Table 64: Current erosion situation, urgency of afforestation

Criterion	Score
Damage to grass sod, soil erosion already observable	3
Damage to grass sod, soil erosion not observable	2
Livestock paths, intact grass sod	1
No indication for erosion	0

Typically, high livestock density and too heavy animals, after creating discernible paths on the meadow, cause a damage of the grass sod, where the bare soil becomes visible.

Additional benefits besides forest protection function:

In addition to the forest protection functions, afforested areas can yield benefits for the local population, their livestock, and the environment. Forests e.g. provide to the animals (I) shade during summer, when cattle preferably roam the forest while ruminating, and (II) shelter during bad weather conditions.

Table 65: Additional benefits besides protection

Criterion	Forest >2ha	Small forest patches, distributed across landscape	Light meadow, tree cover <20-30%
Construction wood	4	2	1
Fire wood	2	2	2
Non-wood forest products (berries, mushrooms,...)	2	2	1
Beneficial conditions for livestock	3	3	2
Fodder quality	1	1	4
Biodiversity	1	3	2
Structure			

Acceptance by stakeholders:

Multiple selections are possible.

Table 66: Acceptance by stakeholders

Criterion	Score
Farmers (owner of livestock)	1 – 5
Habitants	1 – 5
Municipality	1 – 5
Ministry of Environment and Natural Resources Protection	1 – 5
Agency of Protected Areas, National Park	1 – 5
Dariali Energy	1 – 5

6.2. Ecological afforestation facilitation/limitation

Elevation:

The altitude changes the growing conditions for trees. It influences air and soil temperature, precipitation, type of precipitation, amount of snow, irradiation, wind speed and pattern, soil development, relief and the CO_2 partial pressure. Overall, growing conditions get harsher with elevation and the importance of the micro-relief increases.

Table 67: Suitability of artificial regeneration depending on elevation

Elevation (m.a.s.l.)	Score
1300-2100	3
2100-2500	2
2500-2700	1
>2700	0

Inclination:

Table 68: Suitability of artificial regeneration depending on the inclination

Inclination (°)	Score	Measures required
0-3	1	---
3-20	3	---
20-30	2	---
30-40	1	Bermen
>40	0	Natural regeneration

Water class:

Not suitable for afforestation are permanently water logged soils, and on the other hand very dry rocky sites or scree sites. Within the range of habitable water classes different species shall be considered at different water regime classes (Table 71).

6.3. **Management options and issues**

Once the decision to initiate afforestation has been taken, the afforestation planning has to consider the type of regeneration (artificial or natural regeneration, Table 69, Picture 91), if there is already natural regeneration (Table 70), the tree and shrub species to be planted (Table 71), source of seedlings or source of seeds, organisation of nursery, land-use type (pure forest, light pasture, Picture 92, Picture 93), planting design (uniform, cluster, species mixture), fencing options and fence maintenance and the requirement for mowing (against snow creeping and competition).

Table 69: Selection of regeneration type depending on soil depth, rock content and inclination

Criterion	Artificial regeneration	Natural regeneration
Soil depth	> 10 cm	< 10 cm
Rock content	< 70%	> 70%
Inclination	< 40°	> 40°

Table 70: Natural regeneration potential

Criterion	Score
Already existing regeneration and seed trees on the site	4
Already existing regeneration	3
Seed trees on the site	2
Seed trees <1 km away	1
Seed trees >1 km away	0

Picture 91: Natural regeneration (succession) of birch-willow forests.

Picture 92: Light pasture in Kazbegi region, also showing an example for cluster afforestation as planting design.

Picture 93: Light pasture type in mountain region Brandenberg (Austria).

Table 71: Key for tree and shrub species selection considering elevation, water class, soil depth; species codes are composed of the first three letters of the genus and the and the first two letters of the specific epithet.

Elevation (m.a.s.l.)	Water class	Soil depth (cm)	Aspect	Species options
1300-1800	dry-medium dry	0-15	NW-E	Bervu, Hiprh, Junde, Rosca, Spihy
	dry-medium dry	0-15	SE-W	Pinko, Bervu, Hiprh, Junde, Rosca, Spihy
	dry-medium dry	>15	NW-E	Fagor, Picor, Pyrca, Quema, Bervu, Hiprh, Junde, Rosca, Spihy
	dry-medium dry	>15	SE-W	Fagor, Picor, Pinko, Pyrca, Quema, Salca, Bervu, Hiprh, Junde, Rosca, Spihy
	medium fresh-very fresh	0-15	NW-E	Bervu, Hiprh, Junde, Ribuc, Rosca, Spihy
	medium fresh-very fresh	0-15	SE-W	Pinko, Bervu, Hiprh, Junde, Ribuc, Rosca, Spihy
	medium fresh-very fresh	>15	NW-E	Fagor, Malor, Picor, Poptr, Pyrca, Quema, Salca, Bervu, Hiprh, Junde, Ribuc, Rosca, Spihy
	medium fresh-very fresh	>15	SE-W	Fagor, Malor, Picor, Pinko, Poptr, Pyrca, Quema, Salca, Bervu, Hiprh, Junde, Ribuc, Rosca, Spihy
	moist-wet	0-15	NW-E	Hiprh, Salca
	moist-wet	0-15	SE-W	Hiprh, Salca
	moist-wet	>15	NW-E	Poptr, Salca, Hiprh
	moist-wet	>15	SE-W	Pinko, Poptr, Salca, Hiprh
1800-2100	dry-medium dry	0-15	NW-E	Bervu, Hiprh, Junde, Junsa, Rosca, Spihy
	dry-medium dry	0-15	SE-W	Pinko, Bervu, Hiprh, Junde, Junsa, Rosca, Spihy
	dry-medium dry	>15	NW-E	Betli, Fagor, Picor, Pyrca, Quema, Bervu, Hiprh, Junde, Junsa, Rosca, Spihy
	dry-medium dry	>15	SE-W	Fagor, Picor, Pinko, Pyrca, Quema, Bervu, Hiprh, Junde, Junsa, Rosca, Spihy
	medium fresh-very fresh	0-15	NW-E	Bervu, Hiprh, Junde, Junsa, Ribuc, Rosca, Spihy
	medium fresh-very fresh	0-15	SE-W	Pinko, Bervu, Hiprh, Junde, Junsa, Ribuc, Rosca, Spihy
	medium fresh-very fresh	>15	NW-E	Acetr, Betli, Fagor, Malor, Picor, Poptr, Pyrca, Quema, Salca, Salka, Salkz, Sorau, Bervu, Hiprh, Junde, Junsa, Ribuc, Rosca, Spihy
	medium fresh-very fresh	>15	SE-W	Acetr, Fagor, Malor, Picor, Pinko, Poptr, Pyrca, Quema, Salca, Salka, Salkz, Sorau, Bervu, Hiprh, Junde, Junsa, Ribuc, Rosca, Spihy
	moist-wet	0-15	NW-E	Hiprh, Salca, Salkz, Sorau
	moist-wet	0-15	SE-W	Hiprh, Salca, Salkz, Sorau
	moist-wet	>15	NW-E	Acetr, Betli, Poptr, Salca, Salka, Salkz, Sorau, Hiprh
	moist-wet	>15	SE-W	Acetr, Pinko, Poptr, Salca, Salka, Salkz, Sorau, Hiprh

Table 71: (continued): Key for tree and shrub species selection considering elevation, water class, soil depth; species codes are composed of the first three letters of the genus and the and the first two letters of the specific epithet.

Elevation (m.a.s.l.)	Water class	Soil depth (cm)	Aspect	Species options
2100-2400	dry-medium dry	0-15	NW-E	Bervu, Junde, Junsa, Rosca
	dry-medium dry	0-15	SE-W	Pinko, Bervu, Junde, Junsa, Rosca
	dry-medium dry	>15	NW-E	Betli, Fagor, Quema, Bervu, Junde, Junsa, Rosca
	dry-medium dry	>15	SE-W	Fagor, Pinko, Quema, Bervu, Junde, Junsa, Rosca
	medium fresh-very fresh	0-15	NW-E	Bervu, Junde, Junsa, Rosca
	medium fresh-very fresh	0-15	SE-W	Pinko, Bervu, Junde, Junsa, Rosca
	medium fresh-very fresh	>15	NW-E	Acetr, Betli, Fagor, Poptr, Quema, Salca, Salka, Salkz, Sorau, Bervu, Junde, Junsa, Rosca
	medium fresh-very fresh	>15	SE-W	Acetr, Fagor, Pinko, Poptr, Quema, Salca, Salka, Salkz, Sorau, Bervu, Junde, Junsa, Rosca
	moist-wet	0-15	NW-E	Salca, Salka, Salkz
	moist-wet	0-15	SE-W	Pinko, Salca, Salka, Salkz
	moist-wet	>15	NW-E	Acetr, Betli, Poptr, Salca, Salka, Salkz, Sorau
	moist-wet	>15	SE-W	Acetr, Pinko, Poptr, Salca, Salka, Salkz, Sorau
2400-2550	dry-medium dry	0-15	NW-E	Junde, Junsa
	dry-medium dry	0-15	SE-W	Junde, Junsa
	dry-medium dry	>15	NW-E	Betli, (Quema), Junde, Junsa
	dry-medium dry	>15	SE-W	(Quema), Junde, Junsa
	medium fresh-very fresh	0-15	NW-E	Junde, Junsa
	medium fresh-very fresh	0-15	SE-W	Junde, Junsa
	medium fresh-very fresh	>15	NW-E	Acetr, Betli, (Quema), Salka, Sorau, Junde, Junsa
	medium fresh-very fresh	>15	SE-W	Acetr, (Quema), Salka, Sorau, Junde, Junsa
	moist-wet	0-15	NW-E	Salka
	moist-wet	0-15	SE-W	Salka
	moist-wet	>15	NW-E	Acetr, Betli, Salka, Sorau, Junsa
	moist-wet	>15	SE-W	Acetr, Salka, Sorau, Junsa

6.4. **Cost planning**

Taking account of pre-existing natural regeneration and further natural regeneration potential, especially on `birch`-sites, the base for artificial reforestation programme is a reduced planting area of 119 ha (in total 168 ha will be reforested). For artificial reforestation 350.000 – 360.000 plants (pine 320.000; birch, poplar and hardwood species 30.000, supplementary purchase from other plant producers; seabuckthorn 3.000) will have to be produced. The cost planning for plant production includes the nursery operation (seed + plant production); the transportation costs are included in planting activities. In total (plant production; site preparation, fencing; planting, weeding) the calculated average costs per hectare are about 5.700 €/ha [119 ha] or 4.100 €/ha [168 ha], where about 40% of the costs are for fencing measures; in total the average cost per plant is calculated with about 2 €/plant; for control and controlling of reforestation area till 2030 the cost are calculated with 22.000 €/y (Table 72).

Table 72: Preliminary cost planning for reforestation programme

cost planning		YEAR						
		2016	2017	2018	2019	2020	SUM 2016-2020	2020-2030
seed production	€	2.000	2.000	2.000	1.000	0	7.000	
plant production								
material; tools		5.000	5.000	5.000	5.000	2.000		
person month [operative worker	n	24	48	48	60	24		
	€/month	640	640	640	640	640		
	€	15.360	30.720	30.720	38.400	15.360	130.560	
reforestation								
site preperation	h/ha	100	100	100	100	100		
fence [material]								
fence [construction]	h/ha	60	60	60	60	60		
fence [maintaining]	h/ha	30	30	30	30	30		
planting	h/ha	120	120	120	120	120		
weeding	h/ha	30	30	30	30	30		
site preperation	€/ha	600	600	600	600	600		
fence [material]	€/ha	600	600	600	600	600		
fence [establishing]	€/ha	360	360	360	360	360		
fence [maintaining]	€/ha	180	180	180	180	180		
planting	€/ha	720	720	720	720	720		
weeding [2 times]	€/ha	360	360	360	360	360		
		2.820	2.820	2.820	2.820	2.820		

		YEAR						
		2016	2017	2018	2019	2020	SUM 2016-2020	SUM 2020-2030
plant production		17.360	32.720	32.720	39.400	15.360	137.560	
reforestation [birch, hardwood; 70 % natural regeneration]	ha	3	17	32	57	10	119	
	€	8.460	47.940	90.240	160.740	28.200	335.580	
forest manager	€	24.000	24.000	24.000	24.000	24.000	120.000	
		49.820	**104.660**	**146.960**	**224.140**	**67.560**	**593.140**	
risk add-on [15 %]							**682.111**	
fence [maintaining] 2020-2030; 22.000 €/year								**220.000**
								902.111

7. GREENHOUSE GAS COMPENSATION

7.1. Greenhouse gas emissions of Dariali Energy Hydropower plant

The greenhouse gas emission calculations of Dariali Energy hydropower plant consider earthworks, rockworks, concrete usage, steel usage, reinforcements and fuel (diesel) consumption. The quantities consumed were provided by Dariali Energy with minimum and maximum of possible consumption. The CO_2 equivalents of a unit used was taken from international literature. As a minimum of CO_2 equivalent emissions 43,000 t CO_2eq were calculated, the maximum is 55,000 t CO_2eq (Table 73).

Table 73: Recalculation of the GHG emissions (in t CO_2eq) to be compensated

item	Quantity (min)	Quantity (max)	unit	t CO_2eq per unit	t CO_2eq total (min)	t CO_2eq total (max)
Earthworks	520,000	550,000	m^3	0.011	5,720	6,050
Rockworks	330,000	350,000	m^3	0.011	3,630	3,850
Concrete	50,000	74,000	m^3	0.4774	23,870	35,328
Steel	2,700	2,700	t	1.6	4,320	4,320
Reinforcement bars	2,500	2,500	t	1.95	4,875	4,875
Fuel (diesel)	1,100	1,200	m^3	0.713	784	856
					43,199	**55,278**

7.2. Greenhouse gas compensation by the proposed afforestation measures

The potential storage of CO_2 by the tree and shrub species was derived from the results of our forest measurements (chapter 5.3) and available yield tables (Table 74). The CO_2 storage was calculated for 60-70 years old stands. This means that the CO_2 compensation of the CO_2 emissions of the hydropower plant construction will be accomplished after 60-70 years, if the proposed afforestation measures are taken.

Site quality influences the CO_2 storage potential. Thus, the CO_2 was calculated separately for the site quality classes good, medium, bad (compare chapter 5.1, Table 6). Forest tree and shrub species also have different CO_2 storage potentials due to their different growth rates and wood densities. For simplicity in CO_2 calculations, species groups with reasonably similar properties for CO_2 calculations can be formed. These are the group of birch and other hardwood species, including *Betula litwinowii, Fagus orientalis, Quercus macranthera, Sorbus aucuparia, Acer trautvetteri, Pyrus caucasica,* and *Malus orientalis*. The second group consist of the fast growing softwood species Populus tremula and Salix sp.. The third group in our case only consist of the single coniferous tree species *Pinus kochiana*. The last group comprises the shrub species.

From the proposed species mixtures at the 52 proposed afforestation sites we summed up the proposed afforestation area for the different species groups, separated by the site quality (Table 75).

Table 74: Estimated CO_2 storage potential (t CO_2 ha^{-1}) at an age of 60 - 70 years for the different species groups and different site qualities.

Species groups	good	medium	bad
Birch, hardwood	280	215	150
Poplar, willow	460	390	320
Pine	550	475	400
Shrubs	5	4	3

Table 75: Afforestation area (ha) of the 52 recommended afforestation sites (compare chapter 5.2), separated by site quality (good, medium, bad) and recommended species/species groups.

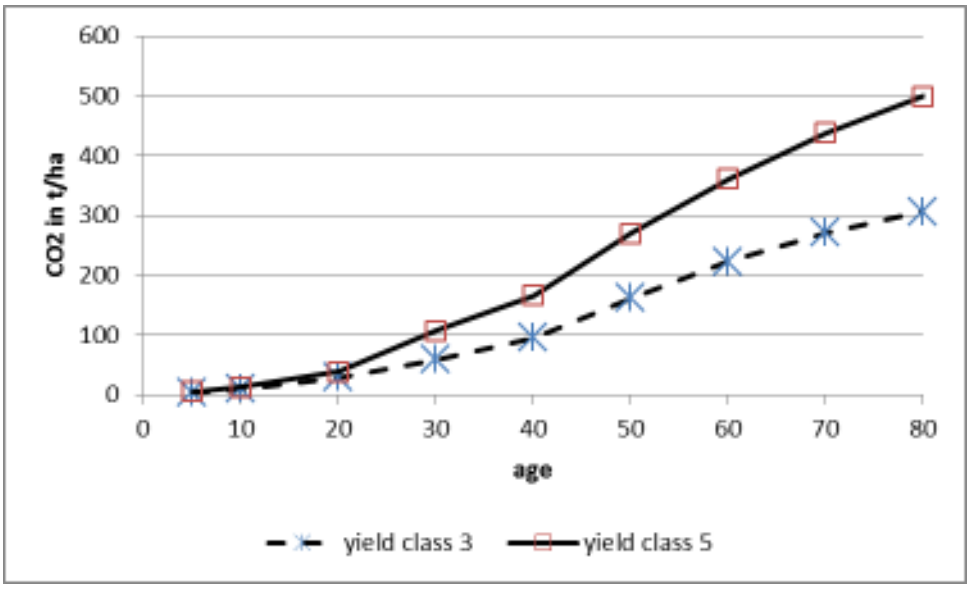
Species groups	good	medium	bad	total
Birch, hardwoods	69.4	12.0	3.5	84.9
Poplar, willow	1.1	0.6	0.0	1.7
Pine	43.9	25.1	9.6	78.6
Shrubs	2.6	0.0	0.7	3.3
	117.0	37.6	13.8	168.4

Table 76: CO_2 storage potential due to our proposed afforestation measures after 60 - 70 years, calculated by species groups and site quality, based on the data from Table 74 and Table 75.

Species groups	good	medium	bad	total
Birch, hardwood	19,430	2,577	523	22,530
Poplar, willow	518	226	0	744
Pine	24,143	11,906	3,841	39,890
Shrubs	13	0	2	15
	44,104	14,709	4,365	**63,179**

The results show, that with our proposed afforestation measures 63,000 tonnes of CO_2 can be stored after 60 - 70 years (Table 76). Development of CO_2 storage depends on site index, age and tree species. The relation of CO_2 mitigation potential per hectare and age for pine stands is shown in Picture 94. The range of growth performance of pine (yield class 3 and 4) matches with the average site index of the defined reforestation sites.

This value constitutes a **115 % compensation** of the maximum calculated emissions of CO_2 equivalents from the construction of the Dariali Energy hydropower plant (Table 73). This is an optimal safety margin for a CO_2 neutral construction project.



Picture 94: Relation of CO_2 storage potential (CO_2/t/ha) and stand age for the pine [growth model for yield class 3 and 4]

7.3. **Potential of carbon credits**

As an alternative to the afforestation project the CO_2 emission of the hydropower plant construction (Table 73) may also be compensated by purchasing carbon credits on the carbon credits market. The highest quality carbon credits available on the Voluntary Carbon Market are provided by carbon mitigation projects that follow the Gold Standard. Gold Standard certifies measured and verified renewable energy, energy efficiency, waste management and land use and forest carbon offset projects for permanent greenhouse gas reduction and sustainable development benefits for local communities. The price of a CO_2 equivalent on the market depends on the standard and the project. For Gold Standard certificates a price of **8 to 12 € per t CO_2 equivalent** can be assumed, what would result in costs of **440,000 € to 660,000 €** to compensate the maximum CO_2 equivalent emissions.

8. JOB DESCRIPTIONS

At this stage we provide a job description of the person who should be in charge of organising the nursery and the afforestation measures. In the final report we will also include the description of all persons who will be employed at least part time, i.e. people working in the nursery, in afforestation, in setting up and maintaining the fences, in weeding.

The responsible person for the afforestation activities shall be well trained in forest management with experience in operating afforestations (planting, weeding, protection) and running a nursery (seed collection and preparation; planting). He shall also have good social skills to be able to guide the workers hired for the afforestation activities and to communicate well with the local population. The responsible person shall secure the training of all the workers.

9. RISK AND FEASIBILITY ASSESSMENT

- *PR 1. Assessment and management of Environmental and Social Impacts and Issues*

The Environmental impact in an afforestation project may constitute an impact on biodiversity, on habitat structure and on the major ecosystem cycles (carbon, water, nutrients). The social impact may be on the land-use options, income opportunities and on the well-being.

Extensive field work, literature research and compilation of expert knowledge served the assessment of the current vegetation community mixture/habitat diversity and plant species diversity. During the field visit we investigated 650 ha of potential afforestation areas and areas covering the major land-cover types, of which less than one third eventually were recommended for afforestation. The species composition and structure of the forests in the project area were also investigated in detail. The information on the vegetation type coverage collected during the field work, enabled us to make sure that areas recommend for afforestation are not covered by rare vegetation types. Due to the extensive deforestation during the last centuries and the consequently low forest coverage this afforestation project will increase vegetation type and habitat type diversity. For the afforestations all major tree species that are considered to be natural in the area are recommended in natural species mixtures. No single-tree species plantations are recommended. Structural diversity in the landscape devoid of the natural forest coverage will be increased. This will have a positive impact on animals that need both open land and shelter from the forest. Also the cattle prefer to evade the summer heat or rainfall by seeking shelter in the forest.

Afforestations in this project area prone to erosion will improve and stabilise the major ecosystem cycles. Carbon storage will be increased due to the high carbon storage in the wood. The water cycle will be balanced since forests consume and store water that than cannot contribute to flood and debris flow events. Surface runoff is also reduced under forest cover compared to grass cover, since the tree root system enhances infiltration. The forest plantations will also contribute to the storage of snow and a reduction of the threat from avalanches. However it is important to note, that no full avalanche protection can be achieved and thus expected from the afforestations!

We also paid attention to areas with protection status (Kazbegi National Park). We obtained a map with the current delineation of the national park. No areas within the boundaries of the national park are recommended in the first afforestation management plan. However a procedure is under development to find agreement between the goals of the national park and proposed afforestation measures.

With our afforestation design we try to maximise the positive social impact and try to minimise the negative social impact. In chapter 6.1 'Afforestation suitability' we introduce several scoring criteria that are aimed at minimising the negative social impact and maximising the positive impact. For example the current land-use is considered, such that arable land and hayfields close to the village have the highest value and thus the lowest suitability for afforestation. Also, amongst others, the protection function is valued, the erosion mitigation potential, other benefits from the forest (construction wood, fire wood, non-wood forest products,...) and the acceptance by the stakeholders. We deliberately included fruit trees and shrubs that also possess medicinal value in our

afforestation plan. Job opportunities in the course afforestation activities will be manifold. People will be hired for work in the nursery, for collecting seeds, planting the trees, establishing and maintaining the fences, weeding and for organising all these activities.

- *PR 2. Labour and Working Conditions*

Time and scope of the work will be clearly defined in the management plan. The selection of a highly qualified person responsible for the organisation of the afforestation activities is central in our management plan. The responsible person for the afforestation activities shall be well trained in forest management with experience in operating afforestations (planting, weeding, protection) and running a nursery (seed collection and preparation; planting). He shall also have good social skills to be able to guide the workers hired for the afforestation activities and to communicate well with the local population. The responsible person shall secure the training of all the workers.

- *PR 4. Health and Safety*

Guidelines to increase safety during the work will be included in the management plan (recommendation to be on the rope on steep slopes above cliffs, compare chapter 5.2.5 'Survey Area IV: Stepantsminda North, Transit road').

- *PR 5. Land Acquisition, Involuntary Resettlement and Economic Displacement*

The areas proposed for afforestation will be presented to the local population who have their traditional use-rights on the land. The presentation will take place during the third consultation and during final discussions with the representatives of the local communities (see PR 10).

- *PR 6. Biodiversity Conservation and Sustainable Management of Living Natural Resources*

Compare PR 1.

- *PR 10. Information Disclosure and Stakeholder Engagement*

To engage the local population and to fulfil the requirements of PR 10 a three stage consultation process was chosen to inform the local population about the project. The first consultation took place at the beginning of the field work period. At a meeting with the head of the municipality, the vice heads, responsible persons for land use management and the head of the Kazbegi National Park it was proposed to meet representatives of several communities, where there is known interest in afforestation measures. We agreed, and met with the representatives in six different communities, where they showed us their areas of main concern or highest interest for afforestation.

Representatives of the main communities in the municipality of Kazbegi were invited to the first informative meeting. The identification and invitation of the representatives was done by the head of the municipality. We supported the head of the municipality in the identification procedure as we provided contacts of representatives of single communities which we had met during the field work. The informative meeting was conducted at the municipality in a meeting room. About 20 representatives joined the meeting, as well as the whole project team, the director of Dariali Energy and Pierre Biedermann of EBRD. Power point slides were presented and additional information was given by the project members and the director of Dariali Energy. We explained the project goals, the past (field work), ongoing (selection of the afforestation sites, planning of the management) and

planned activities (nursery, afforestation), the benefits for the local population, the utilization opportunities of the afforestations and job opportunities. The presentations of the Georgian project team were given in Georgian language, whereas the presentations of the Austrian team was given in English and simultaneously translated by Georgian project team members. The stakeholders then discussed the presented opportunities and asked questions.

During the third consultation, the final informative meeting, which is planned after the afforestation plan has been finished, the results of the afforestation planning will be presented. This will include the exact location of the sites, the proposed tree species, fencing design and details on the job opportunities related to the operation of the nursery, the collection of the seed materials, planting, fencing and weeding.

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11. APPENDIX

11.1. Afforestation activities 2003-2014

Table 77: Afforestation activities carried out in 2003-2014 and ongoing/planned activities for 2015 on the forest fund territory subordinated to the management of LEPL National Forestry Agency

N	Region	Area (ha)	Activity	Plant name	Note ongoing
2003					
1	Kakheti	5.5	forest cultivation through planting		in the framework of the World Bank project
2	Kvemo Kartli	2			
3	Shida Kartli	4.1			
4	Mtskheta-Mtianeti	0.1			
5	Imereti	8.5			
6	Guria	1.5			
7	Samegrelo Zemo Svaneti	3			
8	Racha-Lechkhumi Kvemo Svaneti	2.1			
9	Samtskhe-Javakheti	3			
	in total	**29.8**			
2004					
1	Kakheti	14.6	forest cultivation through planting		in the framework of the World Bank project
2	Kvemo Kartli	60.5			
3	Shida Kartli	20			
4	Mtskheta-Mtianeti	18.4			
5	Imereti	0			
6	Guria	0			
7	Samegrelo Zemo Svaneti	0			
8	Racha-Lechkhumi Kvemo Svaneti	0			
9	Samtskhe-Javakheti	0			
	in total	**113.5**			
2005					
		0			
2006					
		0			

2007					
		0			
2008					
1	Kakheti	0.5	forest cultivation through planting		open area
2	Kvemo Kartli	0			
3	Shida Kartli	0			
4	Mtskheta-Mtianeti	0			
5	Imereti	1	promotion of natural renovation, sowing	chestnuttree	forest restoration
6	Guria	0			
7	Samegrelo Zemo Svaneti	0			
8	Racha-Lechkhumi Kvemo Svaneti	0			
9	Samtskhe-Javakheti	7.5	forest cultivation through planting	pine-tree, fir-tree, maple, ash-tree	Bank of Georgia and Forestry Agency
	in total	**9**			
2009					
1	Kakheti	36	crops cultivation	grove oak-tree	WWF - rehabilitation of Chiauri forest
2	Kvemo Kartli				
3	Shida Kartli				
4	Mtskheta-Mtianeti				
5	Imereti				
6	Guria				
7	Samegrelo Zemo Svaneti	1	promotion of natural renovation		
8	Racha-Lechkhumi Kvemo Svaneti				
9	Samtskhe-Javakheti	6	forest cultivation through planting	pine-tree, fir-tree, ash-tree	Bank of Georgia.
	in total	**43**			

2010					
1	Kakheti	237	crops cultivation through planting and sowing on 109 ha, promotion of natural renovation of 118 ha	grove oak-tree, ash-tree, maple, lime-tree, phloem, crab-apple, crab-tree, acacia	227 ha WWF-rehabilitation of Chiauri forest, 10 ha GIZ cultivation of open area through sowing
2	Kvemo Kartli	0			
3	Shida Kartli	0			
4	Mtskheta-Mtianeti	0.33	wind strip restoration through planting	ash-tree, maple	constanta. open area. Restoration of destroyed wind strip
5	Imereti	30	promotion of natural renovation, planting, sowing	oak-tree, beech, chestnut, ash-tree, maple, nut-tree, crabtree, crab-apple	WWF part of open area
6	Guria	0			
7	Samegrelo Zemo Svaneti	0			
8	Racha-Lechkhumi Kvemo Svaneti	0			
9	Samtskhe-Javakheti	1.7	crops cultivation through planting	Caucasian pine-tree, crab-apple	Forestry Agency
	in total	**269.03**			
2011					
1	Kakheti	0			
2	Kvemo Kartli	0			
3	Shida Kartli	79.7	monocrops transformation/promotion of natural renovation, planting	oak-tree, ash-tree, maple	WWF cultivated pine-trees transformation into natural forest - ongoing process
4	Mtskheta-Mtianeti	0.5	forest species cultivation through planting		Forestry Agency
5	Imereti	0			
6	Guria	0			
7	Samegrelo Zemo Svaneti	0			

8	Racha-Lechkhumi Kvemo Svaneti	67			promotion of 62 ha natural renovation, 3.3 ha cultivation in the framework of REC project
9	Samtskhe-Javakheti	0.3	forest species cultivation through planting	pine-tree	Forestry Agency
	in total	**147.5**			
2012					
		0	0		
2013					
9	Samtskhe-Javakheti	16.3	promotion of natural renovation, planting, sowing	spruce, fir-tree, Caucasian pine-tree, beech, highland oak-tree, crab-apple, crabtree	UNDP Borjomi forest destroyed by fire
	in total	**16.3**			
2014					
1	Kakheti	0.5	nursery		Forestry Agency
2	Kvemo Kartli	0			
3	Shida Kartli	0			
4	Mtskheta-Mtianeti	0.3	nursery		Forestry Agency
5	Imereti	0.33	nursery		Forestry Agency
6	Guria	0.46	nursery		Forestry Agency
7	Samegrelo Zemo Svaneti	0			
8	Racha-Lechkhumi Kvemo Svaneti	0			
9	Samtskhe-Javakheti	60	planting	spruce, fir-tree, Caucasian pine-tree, beech, highland oak-tree, crab-apple, crabtree	20 ha UNDP, 20 ha BFW/OBF, 20 ha LEPL National Feorestry Agency, Borjomi forest destroyed by fire
		0.17	nursery		Forestry Agency
	in total	**61.76**			

11. Appendix

2015					
1	Kakheti		Grove forest restoration		planned
3	2 Kvemo Kartli	0.21	nursery		Forestry Agency
	Shida Kartli	3.2	nursery		Forestry Agency, Bolnisi Management
4	Mtskheta-Mtianeti	0.2	nursery		Forestry Agency
5	Imereti		cultivation		planned
6	Guria				
7	Samegrelo Zemo Svaneti		promotion of natural renovation, planting		planned
8	Racha-Lechkhumi Kvemo Svaneti				
9	Samtskhe-Javakheti				
		4.3	planting	spruce, fir-tree, Caucasian pine-tree, beech, highland oak-tree, crab-apple, crabtree	BFW/OBF,
		3.4	promotion of natural renovation		BFW/OBF,
	in total	**8.11**			

11.2. Overview of flora and vegetation (habitat assessment according to Natura 2000) of the project implementation sites

The flora of the Kazbegi District contains ca. 1,100 species of vascular plants. The following vegetation zones are represented in the region: middle-mountain (1,200–1,500 m.a.s.l.), upper-mountain (1,500–1,750 m.a.s.l.), subalpine (1,750–2,500 m.a.s.l.), alpine (2,500–3,000 m.a.s.l.), subnival (3,000–3,600 m.a.s.l.), and nival (above 3600 m.a.s.l.). Alpine rivers and the herbaceous vegetation in the Dariali Gorge is at the altitude up to 1200-1700 meters and subalpine birch forest (*Betula litwinowii*) is mainly represented on Mountans near this gorge by founded only on north-facing slopes till 2,550 m and subalpine shrubbery located on higher elevations 2,100-2,900 m with *Rhododendron caucasicum*, Vaccinium *myrtillus, Empetrum caucasicum*, etc.,. The secondary shrubbery and subalpine meadows are located in degraded birch forest areas on the same north slopes. The southern slopes of the rocky ridges are held by pine (*Pinus kochiana)* forest habitat. The rocky scrubs are mainly represented by juniper (*Juniper communis* var. *depressa, J. sabina*).

The vegetation in Kazbegi District is represented by the following habitats (sensitive habitats are marked with asterisk [*]):

3220 Alpine rivers and the herbaceous vegetation along their banks

PAL.CLASS.: 24.221 and 24.222

Sedge (*Carex oreophila*) and other such characteristic species as *Swertia iberica, Pedicularis crassirostris* appear in the alpine zone on the bank of the stream. In the places of melting snow we can encounter *Bellevalia paradoxa, Scilla rosenii, Corydalis erdelii, C. emanuelii,* etc. On the banks of those rivers that start at the glacier the following communities can be found: *Caltha polypetala, Cardamine uliginosa, Parnasia palustris, Alchemilla tredecimloba, Heracleum apiifolium, Primula auriculata, Cirsium simplex, Papaver oreophilum, Saxifraga sibirica, Vicia varriegata, Chamaenerion hirsutum;*

The following can be found of the moistened sandy ground of quartz - *Juncus bufonius, Sagina saxatilis.* On the banks of the stream in marshy places there are - *Juncus alpigenus, J. atratus, Carex canescens, C. stellulata, C. contigua, C. leporina, C. rigida, Eriphorum latifolium, Heleocharis palustris.*

323GE Alpine rivers and their ligneous vegetation

There are 4 sub-types of this habitat:

Sub-types:

323GE-01. On river banks covered with silt or mud thin scrub can be found - hawthorn (*Crataegus kyrtostyla*), oriental hornbeam (*Carpinus orientalis*), sea buckthorn (*Hippophaë rhamnoides*) and Jerusalem thorn (*Paliurus spina-christi*).

323GE-02. The sandy bank of the riparian is covered with vegetation of thick undergrowth type. *Agrostis verticillata, Calamagrostis glauca, Juncus articulatus, J. bufonius, Pulicaria uliginosa,* etc. can be found from the grasses.

323GE-03. Riverside rock vegetation is under the influence of floods during which it can completely disappear and then revive again. Mainly the following annual plants can be found: *Carex capillaris, Agrostis verticillata, Chamaenerion hirsutum, Verbascum gnaphalodes.* However, grasses and perennial dicotyledons given below also take part in creating this community: *Poa glauca, Cyperus fuscus, Pycreus flavescens, Heleocharis palustris, Fimbristylis bisumbellata, Juncus articulatus, J. tenageia;* as for dycotyledons - *Pulicaria dysenterica, Mentha aquatica, Eupatorium cannabinum.*

323GE-04. Boggy places on the banks of rivers, streams and narrow mountain valleys are covered with triangular rush (*Juncus bufonius*), which expel primary hydrophillic vegetation: *Glyceria plicata, Carex remota, Alopecurus arundinaceus*. The following are named together with triangular rush: *Deschampsia caespitosa, Iris sibirica, Filipendula ulmaria,* etc. Real marshes can be found in the coastal line of the lower stream of river Mtkvari. Marshes here are covered with grasses and moor-grass - *Calamagrostis arundinacea, Beckmannia eruciformis, Typha minima, T. laxmannii, Sparganium microcarpum, Cladium mariscus,* etc. *Iris carthaliniae* grows on less moist places.

4060 Alpine and **boreal heaths**

PAL.CLASS.: 31.4

Low or dwarf sprawling scrub widespread in the alpine and subalpine areas, with dominating genera of Ericaceae: *Rhododendron, Epigaea, Arctostaphylos, Erica*, with the inclusion of *Vaccinium, Dryas, Daphne, Empetrum, Juniperus*.

Sub-types:

4060-01. Subalpine shrubland of Caucasian Rhododendron (*Rhododendron caucasicum*): evergreen dwarf shrubland, which creates subalpine scrub throughout the Caucasus, from the upper forest line (1,800-1,900 m. a.s.l.) to the upper border of the alpine zone (2,300 – 2,900 m). This type of vegetation covers slopes of the northern exposition. The life cycle of the plant is linked with the dynamics of the snow cover, which makes this species extremely sensitive to the climate change. Characteristic species are: *Vaccinium myrtillus, V. vitis-idaea, Arctostaphylos uva-ursi* subsp. *caucasica, Empetrum caucasicum, Daphne glomerata, Pyrola minor, P. rotundifolia, Anemone fasciculata, Calamagrostis arundinacea.* Occasionally *Juniperus sabina, Salix kazbegensis* are also found. In Abkhazia, grove of the Rhododendron is not found on granite rather than limestone soils. In this area, the rowan (*Sorbus boissieri, Geranium sylvaticum, Anemone aurea, Trollius patulus*) grows along with the grove of evergreen Rhododendron. In Svaneti, the Rhododendron is commonly associated with a fern *Athyrium alpestre.* Mountain wild garlic (*Allium victorialis)* creates association together with mountain blueberry and the grove of evergreen azaleas in small and central Caucasus.

4060-02. Mountain evens (***Dryas caucasica***): This type of scrub is rare and holds a small territory on rocky and stony slopes at the northern and north-west exposition, at the height of 2000 – 2600 meters a.s.l. Typical to limestone and moistened slopes with incline up to 20 – 50 degrees. Strongly affected by a negative impact of excessive grazing and climatic changes. Characteristic species are: *Daphne glomerata, Vaccinium vitis-idaea, Selaginella helvatica, Deschampsia flexuosa, Primula amoena, Polygonum viviparum, Leontodon danubialis, Parnassia palustris.*

4060-03. Crowberry – blueberry (***Vaccinium*** and ***Empetrum*** can be found together) tickets are typical for the Alpine belt, where there are growing on the thin-layer rocky biotope. This co-

community belongs to the *Empetrum-Vaccinium* scrub type of western-eastern European high mountains.

4060-04. Juniper thicket (*Juniperus* spp.) dwarf juniper shrubs (*Juniperus hemisphaerica* and *J. sabina*) are found throughout the Caucasus mountains. In western Caucasus, juniper shrubs intrude in the grove of evergreen Rhododendrons (*Rhododendron*). *Woronowia speciosa* (= *Geum speciosum*) is a species typical to the community of juniper of limestone habitat. The juniper thicket community in **Svaneti** is dominated by *Juniperus depressa.* Associated species are: *Empetrum caucasicum, Vaccinium vitis-idaea, V. myrtillus, Rosa svanetica.*

4060-05. Azalea thicket (***Rhododendron luteum***) consists of a scrub of deciduous species of azalea with yellow flowers. Different from the grove of evergreen Rhododendrons, it does not form a bound scrub. Species composition varies dependent on the soil type. The habitat is formed by admixture of the azaleas and subalpine grasses. The following plants are common: *Geranium psilostemon, Achillea latiloba, Cirsium obvalatum, Campanula hemschinica.*

50GE1 Mountain xerophytic scrubs

Secondary meadows after forest degradation including edificatory species include sea-buckthorn (*Hippopaë* rhamnoides), barberry (*Berberis vulgaris*), sweet briar (*Rosa canina*) scrub, rockred currant (*Ribes biebersteinii*), goat willow, (*Salix caprea*) in ravines and juniper (*Juniperus depressa, J. sabina*). The herbaceous vegetation is represented by the following species: *Galium album, Artemisia absinthium, Cirsium caucasicum, Urtica dioica.* The habitat is of low conservation value. Herbal species are *Oxytropis cyanea, Cerastium arvense*, *Fesstuca varia, Moehringia trinervia, Pyrethrum roseum*, *Tussilago farfara, Taraxacum officinale, Trifolium spadiceum, Artemisia absinthium, Senecio sosnovskyi*.

50GE3 Tragacanth scrub

In the central Greater Caucasus, (Kazbegi District) Tragacanth communities with *Astracantha denudata* are dominating. The scrub grows in the subalpine zone, at the altitude 1,800-2,000 m. a.s.l., at the slopes of dry gorges. The following species comprise the community: *Elytrigia gracillima, Allium albidum, Allium ruprechtii, Alopecurus vaginatus, Artemisia chamaemelifolia, A. marschalliana, A. splenders, Asperula albovii, Astragalus kazbeki, Berberis vulgaris, Bromopsis riparia, Campanula hohenackeri, Carex buschiorum, Dianthus cretaceus, Ephedra procera, Festuca sulcata, Juniperus hemisphaerica, Koeleria cristata, Melica transsilvanica, Myosotis arvense, Onosma armeniaca, Oxytropis cyanea, Scutellaria leptostegia, Spiraea hypericifolia, Stipa caucasica, Stipa tirsa.*

61GE01 Subalpine high herbaceous vegetation

Subalpine tall herbaceous vegetation is widespread in the subalpine zone at the treeline ecotone (2,350-2,500 m). Characteristic climatic conditions of the habitat are optimal temperature of air and soil, high humidity of air and high sun radiation. Tall herbaceous vegetation consists of plants of 3-4 meters the majority of which is dicotyledons. They are characterized by short tap root or rhizome. The overall number of species in this habitat is about 90 and the community itself involves 70 species: *Aconitum nasutum, A.orientale, A.adzharica, A.pachyptera, A.tatianae, Angelica purpurascens*, *Anthriscus nemorosa, Cephalaria gigantea, C. procera, Cicerbita bourgaei, Campanula*

latifolia, *Chaerophyllum maculatum*, *Cicerbita deltoidea, C. macrophylla, C. olgae, C. petiolata, C. prenanthoides, Cirsium aggregatum, C. albowianum, C. buschianum, C. czerkessicum, C. gagnidzei, C. kuznetsowianum, C. oblongifolium, C. svaneticum, C. sychnosanthum, Delphinium bracteosum, D. dasycarpum, D. dzavakhischvilii, D. fedorovii, D. flexuosum, D. ironorum, D. osseticum, D. pyramidatum, D. speciosum, D. thamarae, Doronicum macrophyllum, Euphorbia macroceras, Gadelia lactiflora, Geranium kemulariae, Heracleum aconitifolium, H. asperum, H. cyclocarpum, H. grossheimii, H. mantegazzianum, H. ponticum, H. sosnowskyi, H. wilhelmsii, Inula magnifica, Knautia montana, Ligusticum alatum, L. arafoe, L. physospermifolium, Lilium georgicum, L. kesselringianum, L. monadelphum, L. szovitisianum, Milium effusum, M. schmidtianum, Petasites albus, Prenanthes abietina, Pyrethrum macrophyllum, Senecio othonnae, S. phatyphylloides, S. pojarkovae, S. propinquus, S. rhombifolius, S. similiflorus, Telekia speciosa, Tephroseris cladobotrys, T. subfloccosus*, *Valeriana alliariifolia, V. colchica, V. tiliifolia, Veratrum lobelianum*.

61GE02 Subalpine meadows

Subalpine meadows (1800-2700 m) are distinguished by a great floristic and phyto-sociological variety.

Sub-types:

61GE02-01. Grass meadows:

1. *Bromopsis variegata*, *Agrostis tenuis, A. planifolia* community holds both dry and moist habitats. Appropriate species of the community are *Trifolium ambiguum, Lotus caucasicus, Alchemilla sericata,* etc. It is distributed in whole Caucasus mountain up to the altitude of 2,700 meters. It is used for mowing.

2. *Hordeum violaceum* community holds the lower part of the subalpine zone (2,000 – 2,200 m). Together with barley, tall herbaceous vegetation elements can be found here - *Heracleum asperum, Anthriscus nemorosa, Seseli transcaucasica*.

3. *Calamagrostis arundinacea* community holds moist slopes and is associated with the subalpine scrub of Caucasian evergreen Rhododendron. It can be common in places emerging as a result of cutting down the forest. It also creates the grass cover in the high mountain oak (*Quercus macranthera*) forest and is associated with the fescue-grass (*Festuca varia*) communities. *Festuca djimilensis* dominates in the westerns Caucasus mountain in this community.

4. *Poa longifolia* community occupies the forest edges, openness and moist slopes. The typical place is in Lagodekhi natural reserve. Related species are: *Calamagrostis arundinacea, Festuca varia, Agrostis planifolia, Geranium ibericum, Stachys macrantha,* etc.

5. *Deschampsia caespitosa* community is common on the river banks and flooded places. Typical plants are: *Equisetum arvense, Carex canescens, C. hirta, C. irrigua, Parnassia palustris*, etc.

6. Fescue-grass (*Festuca varia*) meadows hold the biggest part of the subalpine zone. It is distributed on grazed northern slopes in the mountainous part of southern Georgia where they create the first stage of succession. Calamagrostis arundinacea communities ruined as a result of intensive grazing are replaced by fescue-grass meadows. Their species are large and other ones can also be observed

on placed between them: *Helictotrichon adzharicum, H. pubescens, Agrostis planifolia, Carex meinshauseniana, Stachys macrantha, Polygonum carneum*, etc.

7. Festuca ovina meadows hold the southern slope. It is low, with the low rate of cover and limited composition of species. Characteristic species are: *Koeleria albovii, Bromopsis riparia, Agrostis tenuis, Carex buschiorum, Pulsatilla violacea, Thymus collinus.*

61GE02-02. Herbal and grass-herbal meadows:

1. *Trollius patulus* meadows are typical in forests, thinned out planted forests and long crevices, sub-dominant species being *Ranunculus caucasicus*. As a result of strong grazing, only this species is preserved on the meadows whereas *Trollius patulus* is to become extinct.

2. *Geranium* spp. - 1) Geranium gymnocaulon communities can mainly be found in the alpine zone of western Caucasus mountain. It rarely comes to the subalpine zone. 2) *Geranium platypetalum* community is widely distributed both in small and big Caucasus. It is not found in south Kolkheti but is observed in stony and moraine places. 3) *Geranium ibericum* holds the forest, slopes of average incline and the straight place. The sub-dominant species is *Calamagrostis arundinacea, Inula orientalis, Rhododendron caucasicum.*

3. Inula orientalis community is created by the pure growth. However, this species can be found in another community as well. For example, Geranium ibericum and Stachys macrantha. In west Georgia Inula grandiflora community can be found.

4. *Scabiosa caucasica* community on small Caucasus is rich with various species: *Helictotrichon pubescens, Inula orientalis, Agrostis planifolia, Stachys macrantha,* etc. They are also widely distributed on Javakheti mountain plateau

5. *Stachys macrantha* community is the typical variant of the subalpine meadow. It is represented in the central and eastern parts of great Caucasus mountain.

6. *Anemone fasciculate* community occupies the slope of optimal moistness and a straight place. It is replaced by Hedysarum caucasicum on sunny and dry places.

7. Subalpine meadow *Veratrum lobelianum* is found in the western and central parts of Great Caucasus and small Caucasian mountians. It is a toxic plant which can not be grazed and, therefore, is preserved in intensively grazed places. It can be found in Trollius patulus and *Ranunculus caucasicus* communities.

8. *Pulsatilla violacea* community is widely represented in small Caucasus mountains and Javakheti. It creates small fragments in central Caucasus on slopes of Northern exposition. Here it is associated with the following species: *Festuca ovina, Koeleria albovii, Carex buschiorum. Pulsatilla aurea and P. albana* can be found in north-western Kolkheti

9. Astragalus captiosus creates community on grazed southern slopes in central Caucasus.

6150 Siliceous alpine and boreal grasslands

PAL.CLASS.: 36.11, 36.32, 36.34

Alpine meadows are distributed between 2,500-2,900 m.a.s.l. in the Caucasus mountains. Special type of vegetation accurs on alpine snowbeds, which is covered by snow much longer than adjacent habitats.

Sub-types:

6150-01. Alpine meadows

Alpine meadows occupy **slopes** of all expositions in high mountains at the altitude of 2,500-2,900 meters. The following plant communities are described:

1. Fescue-grass *Festuca varia (F. woronowii)* communities can be found on inclined slopes of southern exposition. They **are** more frequently found in eastern Caucasus. Fescue-grass meadows are mainly in subalpine zones. However, they reach the alpine zone as well if climatic and relief conditions are favourable for their distribution.

2. *Nardus stricta* communities are widely distributed in the whole Caucasus. They occur on slopes of all expositions. Secondary **mat**-grass communities emerge on extensively grazed meadows where they replace primary communities. Mat-grass - Fescue-grass mixed community Festucetum variae can be found in central and western Caucasus. Mat-grass is adapted to moist areas and is the indicator of identifying moist areas on the meadow. Frequently, it follows the deepened crevice where the level of moisture is higher than on the even place.

3. *Carex tristis* community is widely distributed in the alpine zone of Caucasus. It occupies embossed slopes where **in** winter there is a significant influence of wind and the sweeping of the snow cover takes place. It is associated with *Festuca supine, Alchemilla caucasica* and *Kobresia capilliformis* can also be found.

4. *Kobresia capilliformis* community can be found in the central and western parts of Caucasus. They are observed on limestone and weeds in central Caucasus. In stony places *Kobresieta schoenoidis* is observed.

5. *Festuca djimilensis* belongs to the number of shrub-like grass of herbal-grass meadows. Mainly, they are found in the subalpine zone. However, it reaches the alpine zone as well. It is mostly common in the Caucasus.

6. *Bromopsis variegata* is distributed on the southern slopes of the Alpine zone. In Kolkheti dry meadows are observed on limestone. *Sesleria anatolica* is the species characteristic to this meadow, which is characterized by the creeping root.

7. *Geranium gymnocaulon* community in western Caucasus is intruded from the subalpine zone and reaches the upper border of vegetation of dense cover. Sometimes, it goes into the subnival zone.

8. *Sibbaldia semiglabra* community is the same as the one of *S. parviflora*. The composition of its species is very poor.

6150-02. Alpine snowbed habitats

Alpine snowbeds can be found in straight places between large stones and moraines at the upper border of the alpine zone, where snow melts late and vegetation is late. It constists of the following grasses: *Poa alpina, Phleum alpinum, Festuca supina,* etc. and herbal species: *Campanula*

biebersteiniana, Carum caucasicum, Veronica gentianoides, Gnaphalium supinum, Pedicularis crassirostris, P. armena, Poa alpina, Taraxacum stevenii, Sibbaldia semiglabra, etc.

Growth similar to alpine snowbeds are observed in the zone of melting snow and the side of the glacier, where *Carum caucasicum* sometimes creates a pure growth. Often it is associated with other species *Taraxacum stevenii, Campanula biebersteiniana, Plantago saxatilis, Minuartia aizoides*, etc. It also rarely contains *Ranunculus oreophilus, R. baidarae, Primula algida, Gentiana djimilensis (=G. pyrenaica), G. angulosa, G. nivalis, Minuartia aizoides, Cerastium cerastoides. Pedicularis crassirostris, P. nodrmanniana, Primula auriculata, Poa alpina,* etc. can be found at the side of the stream.

62GE04 Vegetation of urban and rural areas

Vegetation of village settlements and cultivable land is extremely interesting from the point of view of plants of economic importance. In this habitat there are various species of aborigine, invasive and adventive cosmopolitan plants related to wild relatives of cultural plants and those used in traditional (people's) and scientific medicine, including, Chicory - *Cichorium intybus*, meliot - *Melilotus officinalis*, yarrow - *Achillea milllefolium,* agrimony – *Agrimonia eupatoria,* creeping couch-grass - *Agropyron repens,* white briony - *Bryonia dioica,* shepherd's purse - *Capsella bursa-pastoris,* greater calistine - *Chelidonium majus,* European dodder - *Cuscuta europaea,* henbane - *Hyoscyamus niger,* mother of nettle - *Lamium album,* forest mallow - *Malva sylvestris,* mint – *Mentha arvensis,* great plantain - *Plantago major,* chickweed - *Stellaria media,* dandelion - *Taraxacum officinale,* coltsfoot - *Tussilago farfara,* nettle -*Urtica dioica,* etc. These plants are distributed on the territories of the city and village settlements, roadsides and transformed habitats. Most of them, as pioneer plants, create primary successions on eroded slopes as a result of industrial activities and construction works.

62GE05 Vegetation of pastures

Subalpine and alpine meadows are mainly used for summer pastures for sheep and livestock. Grass, sedge and polydominant grass-herbal meadows are characteristic to this type of vegetation. Grass-herbal communities are characterized by a great variety. Namely, in each community more than 30 species are presented. We encounter grass-herbal meadows with the following dominant species: sheep fescue - *Festuca ovina,* colourful brome - *Bromopsis variegata,* Alpine meadow-grass - *Poa alpina,* crested hair-grass - *Koeleria caucasica,* mat-grass - *Nardus stricta* or colourful fescue - *Festuca woronowii*. In this community the following are associated: butter cup - *Ranunculus oreophilus,* Ajara brome - *Bromopsis adjaricus,* sheep clover - *Trifolium ambiguum,* clover - *T. trichocephalum, T. alpestre,* mountain betony - *Stachys macrantha,* narcissus anemone - *Anemone albana,* Caucasian gentian - *Gentianella caucasea,* Alpine aster - *Aster alpinus,* Alpine timothy grass - *Phleum alpinus,* gentian-type Buxbaum's speed well - *Veronica gentianoides,* etc. The following are dominant species in sedge meadows: sedge - *Carex humilis* an *C. brevicollis*; As for associated species, they are as follows: crested hair-grass – *Koeleria caucasica,* Caucasian decampane - *Inula glandulosa,* Alpine forget-me-not - *Myosotis alpestris,* sedge -*Carex tristis,* Alpine meadow grass - *Poa alpina,* Alpine dropwort - *Phleum alpinum,* lousewort - *Pedicularis caucasica,* whitlow-grass - *Draba nemorosa*, mountain scabious - *Scabiosa caucasica,* checkweed - *Cerastium purpurescens,* etc. The following are

dominant species on meadows composed of herbs: sheep clover - *Trifolium ambiguum,* to which the following are associated: sedge - *Carex humilis,* Ajara brome - *Bromopsis adjaricus,* Alpine meadow-grass - *Poa alpina,* Arenaria - *Arenaria steveniana,* yarrow - *Achillea setacea,* oats - *Avena versicolor*,colourful brome - *Bromopsis variegata,* Fischer's cornflower - *Centaurea fischeri,*centaury - *Gentiana septemfida.* etc. Species participating in creating the polydominant various grass meadow are: sibbaldia- *Sibbaldia procumbens,* fox-tail - *Alopecurus vaginatus,* colourful brome - *Bromopsis variegata,* Alpine timothy grass - *Phleum alpinum,* sheep clover - *Trifolium ambiguum,* sheep fescue - *Festuca ovina,* lady-s bedstraw - *Galium verum,* mountain betony - *Stachys macrantha,* etc. Those represented on polydominant Alpine meadows are: sheep fescue - *Festuca ovina,* Alpine creeping cinquefoil - *Potentilla alpestris,* centaury - *Gentiana septemfida,* caraway - *Carum caucasicum,* hare's foot clover - *Trifolium repens,* Alpine aster – *Aster alpinus,* woodrush - *Luzula spicata,* creeping bellflower - *Campanula collina,* creeping cinquefoil - *Potentilla gelida,* etc. Indicator of degradation of pastures weed plant agaric is distributed on almost the whole territory of pastures. This is a poisonous plant which is not grased by domestic animals and, therefore, it is widely distributed on subalpine and alpine meadows.

70GE02* Low grass marshes

Low grass swamps are distributed up to 2,300 meters a.s.l.. Communities with the horse tail - *Equisetum* heleocharis*, E. palustris, E. ramosissimum* dominate in the lowland and low zone of the mountain. *Hyppuris vulgaris* is a rare obligatory hellophyte. *Sparganium erectum* (*S. polyedrum*) or *S. simplex* creates the most widely distributed community. *Butomus umbellatus* is rare in various places of Georgia. The composition of species is as follows - *Equisetum palustre, Juncus articulatus, J. inflexus, Carex acuta, C. rostrata (=C. inflata), Ranunculus repens, Heleocharis palustris.*

8110 Siliceous scree of the montane to snow levels

PAL.CLASS.: 61.1

Vegetation is rare in alpine zone on the crushed rock ridge and creates an open cover. Characteristic features are: *Astragalus incertus, Oxytropis lazica, Gypsophila silenoide, Coronilla balansae.* The system of *deep* roots is characteristic to plants developed on the landslide, with which the total crushed rock system is criss-crossed. Such a root system is characteristic to the following - *Dentaria bipinnata, Saxifraga laevis, Valeriana saxicola, Viola minuta, Lamium tomentosum, Trisetum distichophyllum.* Other forms also appear on landslides and cliffs - *Astragalus incertus, Draba polytricha, Campanula aucheri.* The following developed on landslides belong to another ecological type chasmophytes - *Saxifraga sibirica, S. flagellaris, Senecio renifollius, Viola biflora, V. caucasica, Omphalodes rupestris, Saxifraga cartilaginea, S. kolenatiana. Campanula hypopolia* and *Primula nivalis* are endemic species. The following vegetation is developed on landslides and crushed rock - *Alopecurus sericeus, Thalictrum foetidum, Sedum opositifollium, Sempervivum tectorum, Saxifraga kolenatiana, Genista svanetica, Hypericum orientale, Digitalis ciliata, Thymus nummularius, Anthemis rudolphiana.* Only several species are common on the non-stable landslide in the subnival zone - *Cerastium kazbek, Delphinium caucasicum;* on the slightly moving remains *Veronica minuta, V. telephiifolia, Scrophularia minima, Lamium tomentosum* can be found whereas *Aetheopappus caucasicus, Symphyoloma graveolens, Jurinella subacaulis, Minuartia inamoena* are common on the hard remains. *Primula bayernii, Draba bryoides, Saxifraga moschata, S. exarata* grow on cliffs.

8220 Siliceous rocky slopes with chasmophytic vegetation

Rocky areas can be found in all mountainous regions. Rocks of volcanic origin are more common. However, there are a lor of slate rocks as well. Rock vegetation, as a rule, is adapted to the dry environment. However, there exist moistened cliffs where ground water seeps. Grasses - *Festuca sulcata, Helictotrichon adzharicum,* and tall herb elements - *Heracleum* spp., *Cirsium* spp., *Petasites* spp., *Hesperis matronalis* grow here. *Anthemis macroglossa, Dianthus* spp is characteristic to the subalpine zone. On cliffs in the alpine and subnival zone grow pillow-type plants - *Draba bryoides, Saxifraga cartilagiena, Sempervivum pumilum, Sedum* spp.

8310* Caves

Caves contain many endemic amphibians. There are bat populations. Flora in karst caves is representing by mossess, Lichens and algaes. The cave flora is rather poor, represented by mosses - *Campylophyllum halleri, Dicranum bonjeanii, Neckera besseri, Trichostomum crispulum, Schistostega pennata,* Lichens and algaes, only in relatively illuminated parts of the caves.

8340* Rock and true glaciers

Habitats adjacent to glaciers are subnival (2,900-3,750 m) and nival (3,700-4,000 m) vegetation zones. The heighest level of vascular plant distribution is 4,000 m.a.s.l. in the Central Greater Caucasus where endemic species *Cerastium kazbek* is found on the Mt. Kazbegi. In the altitudinal zone 3800-4000 m is discribed only 9 vascular plant species from the 300 total species found in the subnival zone. The heighest distributional level have the following species: *Saxifraga moschata, S. exarata, S. flagellaris, Tripleurospermum subnivale, Colpodium versicolor, Alopecurus dasyanthus, Draba supranivalis, Veronica minuta, V. telephiifoliaa, Senecio karjagini, Cerastium pseudokasbek, Pseudovesicaria digitata.*

91PK-GE Caucasian Pine forest (*Pinus kochiana*)

A widely distributed species of the pine in Georgia is - *Pinus kochiana* (=*P. hamata, P. sosnowskyi*). It is the species related to the European pine (*Pinus sylvestris*). The area of its common distribution is Caucasus, Crimea and western part of small Asia, Ponto mountains. In Georgia pine forests are mainly common in the mountains. Optimum conditions for the distribution are at the altitude of 1,000-2,200 meters. In certain places pine is found at the altitude of 2,500-2,600 meters. The pine grows in Kazbegi District on rocks of volcanic layers. The pine rocky forest is especially distinguished in terms of the great variety of species. Caucasian pine rock-scree forest is distributed on the slopes of rocky southern exposition dry ecotone or limestone layers. Rock pine forest with scattered herbal cover (*Pineta rariherbosa*) grows on clear rocky slopes with a thin soil layer where herbal cover is rare due to the washing out of the soil.

9BF-GE* Subalpine birch krummholz (*Betula litwinowii*)

The treeline on moist slopes of the northern exposition of the Great and Minor Caucasus is formed by the subalpine forest of birch elfin trees at the altitude of 2,400-2,500 meters. However, separate trees are common at the altitude of up to 2,550 meters. Inclination of slopes does not exceed 10-25º that determines stable cover of snow during winter. The mountain brown soil is characteristic, mainly on volcanic rock layers with the humus layer of 10-20 cm thick. The forest of this type is found

in the Central Caucasus. Namely, Kazbegi region as well as in the Minor Caucasus. In this type of habitat the border of the forest is lowered by 200-400 meters as a result of anthropogenic impact, which is caused by excessive grazing and cutting of trees. However, as a result of recent global warming and decrease of grazing, the slopes where the birch grove had to be present earlier were repeatedly reforested. Those forests on the Great Caucasus that are considered to be the so-called "forests of the church" and where grazing and cutting has not taken place for ages, are well preserved.

Above 1,800 meters up to 2,300 meters tall birch trees with closed canopy form forest occupied the slopes of northern exposition. The timberline is situated at the altitude of 2,400-2,500 meters where 2-3 meter tall elfin birch and mountain ashes are found and Caucasian evergreen rhododendron (*Rhododendron caucasicum*) and other evergreen shrubs are introduced as a understory. The treeline reaches 2,550 meters where only dwarf trees of the birch grow among Caucasian evergreen rhododendron shrubs. Characteristic species are: *Betula litwinowii, B. raddeana, B. pendula, Salix caprea, S. kazbegensis, Sorbus caucasigena, Rhododendron caucasicum, Vaccinium myrtillus, V. uliginosum, V. vitisidaea, Aconitum nasutum, A. orientale, Anemone fasciculata, Aquilegia caucasica, Calamagrostis arundinacea, Campanula latifolia, Caphalanthera longifolia, Cicerbita racemosa, Daphne glomerata, D. mezereum, Dolichorrhiza caucasica, D. renifolia, Festuca drymeja, Geranium sylvaticum, Heracleum roseum, Lathyrus roseus, Polygonatum verticillatum, Senecio propinquus, Swertia iberica, Vicia balansae, Gymnadenia conopsea, Platanthera montana.*

The Dariali Hydropower Plant Territory and Compensation Sites ((Natural monument of Abano Mineral Lake, Natural Monument of Trusso Travertines, Natural Monument of Sakhiznari Cliffs)) are covered with subalpine and alpine meadows.

I. The subalpine meadows are represented by the following sub-types of habitat (code 61GE02-01):

Grassland Bromopsis variegata is located in southern slopes between 1850-2700 m with the dominant species: *Agrostis tenuis, Anthoxanthum odoratum, Festuca ovina, Koeleria luerssenii, Ranunculus oreophilus, Trifolium ambiguum*, etc. This community holds both dry and moist habitats. Appropriate species of the community are *Alchemilla sericata, Lotus caucasicus*, etc.

Agrostis tenuis meadow is on humid slope (10°-12°) between 1,800 and 2,600 m with the dominant species *Bromopsis variegata, Festuca ovina, Koeleria luerssenii, Phleum phleoides,* etc. This community holds moist river banks.

Grass meadows Festuca ovina hold the southern slope. Characteristic species are Agrostis tenuis, Bromopsis riparia, Carex buschiorum, Koeleria albovii, Pulsatilla violacea, Thymus collinus.

Humid broad-leaved meadow with Trollius ranunculinus is located on slightly sloping hillsides (10°-12°) in Tergi gorges between 1,500 and 2,800 m with dominant species *Veratrum lobelianum*, *Dactylorhiza armeniaca, Poa alpina, Swertia iberica,* etc.

II. The alpine meadow habitats by the following sub-types of habitat (code 6150-01):

Grass meadows (*Festuca varia*) is mainly develop on very steep north-facing slopes (30°-50°) of alpine zone till subnival belt. It is grazed and growth in cold and dry environment. Dominant species are *Calamagrostis carneum, Helictotrichon asiaticus, Kobresia schoenoides,* etc.

Festuca supina + *Carex tristis* is widespread in the alpine belt till 2,900 m on moderately humid slopes with inclination (3°-15°). Dominant species are *Luzula spicata, Poa alpina,* etc.

Nardus stricta communities are located on slopes of all exposures on medium or high degree (10°-30°) till 2800 m. Dominant species are *Agrostis tenuis, Carum caucasicum, Luzula stenophylla, Phleum alpinum, Poa alpina, Sibbaldia semiglabra,* etc.

Kobresia capilliformis meadows are located near glacial relief, ridges and with snow cover between 1900-2800 m in the Truso gorge. The dominant species are *Kobresia persica, Alchemilla elisabethae, Thalictrum alpinum, Campanula biebersteiniana,* etc.

III. The alpine meadow habitats by the following sub-types of alpine snowbed (code 6150-02):

Alpine snowbeds can be found in plain places between large stone sand moraines at the upper border of the alpine zone till 3,100 m, where snow melt is late and vegetation is late. It consists of the following grasses: *Poa alpina, Phleum alpinum, Festuca supina,* etc., and herbaceous species: *Campanula biebersteiniana, Carum caucasicum, Veronica gentianoides, Gnaphalium supinum, Pedicularis crassirostris, P. armena, Sibbaldia asemiglabra*, *Taraxacum stevenii,* etc.

11.3. Survey areas summary

Table 78: Summary of survey area I, explanation see Table 3

Parameter		Percentage of area
Area	134 ha	
Biome Type	101+403	5.2
	201	11.7
	303	2.8
	401	36.3
	401+403	4.1
	403	27.9
	410	1.3
	604	0.6
	608	9.3
	611	1
Elevation	18-30	
Exposition	S-NE	
Inclination	5-60	
Relief	B	62
	CR	11
	DI	9.3
	F	7.6
	U	6.2
Water-Class	3	39.4
	4	17
	5	30.4
	8	8.9
Geology	Slate	96.1
Soil Type	BE	72.4
	RA	14.2
	RA/BE	8.6
Soil Depth Class	1-2	4
	1-3	4.6
	1-4	15
	1-5	7.3
	2-3	8.2
	3	10.7
	3-4	2.7
	4	42.4
Land-Use Type	FO	17.4
	FO+PA	3.6
	HF	1.5
	NU	10.2
	PA	60.4
	SH	2.8
Crown Cover Trees	0	63.4
	5-20	15.5
	25-75	5.2
	80-100	11.7
Crown Cover Shrubs	0	81.5
	5-20	10.6
	25-75	2.8
Cover Herbal Vegetation	5-20	22.2
	25-75	4.1

	80-100	69.5
Rock Cover	0	52.4
	>0-20	40.5
	>20-40	0.9
	>40-60	1.6
	>60-80	0.4
Tree Species and Share	Pin.koc., Bet.lit., Sal.cap., Sal.kaz., Pop.tre., Hip.rha., Ber.vul.	
Regeneration	Bet.lit., Sal.cap., Sal.kaz., Hip.rha.	
Distance Seed Tree	in	35.6
	<100	13.8
	100	8.2
	150	7.9
	200	7.4
	250	6.3
	300	15
	>1000	1.6
Erosion Area	0	70.9
	>0-20	12
	>40-60	1.6
	>60-80	0.4
	>80-100	10.9
Erosion Type	LS	5.3
	OE	19.6
Erosion Tendency	in	21.5
	st	3.4
Constraints for AR	PL	50.8
	AS	14
	RA	1.6
	SL	2.8
	FO	11.7
Facilitation for AR	EX	55.1
	PV	16.9
ARS	V	35.5
	H	5.3
	M	7.8
	D	19.9
	I	13.8
Erosion Mitigation Potential of AR	NO	27.1
	YES	69.7

Table 79: Summary of survey area II, explanation see Table 3

Parameter		Percentage of area
Area	311 ha	
Biome Type	101	1.5
	303	15.6
	304	3.9
	401	37.6
	410	5
	604	14.8
	606	12.3
	607	0.5
	608	5.3
	609	0.5
	610	3
Elevation	16-24	
Exposition	SSW-N	
Inclination	3-90	
Relief	A	21.9
	B	16
	DI	6.9
	F	33.9
	KS	14.8
	U	6.5
Water-Class	0	12.3
	1.5	2.6
	2	9.3
	3	47.3
	4	16.8
	9	11.7
Geology	Slate	100
Soil Type	BE	22.3
	RA	35.3
	SE	1
Soil Depth Class	1	6.2
	1-2	9.5
	2	2.1
	2-3	8.5
	3	17.1
	4	1.3
Land-Use Type	NU	57.1
	PA	41.4
Crown Cover Trees	0	88.3
	5-20	10.2
Crown Cover Shrubs	0	21.5
	5-20	57.3
	25-75	8.5
	80-100	11.2
Cover Herbal Vegetation	0	14.2
	5-20	18.8
	25-75	33.6
	80-100	31.9
Rock Cover	0	27.6
	>0-20	39.6
	>20-40	16.2
	>40-60	7.5

	>60-80	1.9
	>80-100	5.7
Tree and Shrub Species	Bet.lit., Sal.cap., Ber.vul., Hip.rha., Jun.dep., Jun.sab., Rib.uva-cri., Ros.can.	
Regeneration	---	
Distance Seed Tree	in	13.8
	100	9.7
	200	3.4
	300	7.7
	400	5
	500	1.2
	>1000	59.2
Erosion Area	0	76.8
	>0-20	3.1
	>20-40	1.2
	>40-60	13.7
	>60-80	0.2
	>80-100	3.4
Erosion Type	DA	0.4
	LS	12.4
	OE	8.9
Erosion Tendency	in	19.9
	st	1.8
Constraints for AR	PL	28.8
	AS	3.9
	ED	8
	RA	23.4
	RL	5
	SS	27.8
	SL	20.3
Facilitation for AR	EX	14
	PV	16.9
ARS	V	1.3
	H	10
	D	17.4
	I	18.1
Erosion Mitigation Potential of AR	NO	16
	YES	15.3

Table 80 Summary of survey area III, explanation see Table 3

Parameter	Percentage of area	
Area	68 ha	
Biome Type	101	17.3
	101+403	1
	101+501	1
	303	1.4
	401	5.7
	403	25.8
	403+501	7.6
	409	36.2
	604	3.9
Elevation	18-23	
Exposition	NW-SSE	
Inclination	10-40	
Relief	B	75.3
	DI	1.4
	F	9.5
	U	13.8
Water-Class	3	30.8
	3.5	32.1
	4	22
	4.5	6.9
	5	7.6
Geology	Slate	100
Soil Type	BE	73.3
	RA	19.2
	RA/BE	7.5
Soil Depth Class	1-2	14.5
	3	37.5
	3-4	33.7
	4	14.3
Land-Use Type	FO	1
	FO+PA	5.8
	PA	93.2
Crown Cover Trees	0	52.9
	5-20	40.3
	25-75	5.8
	80-100	1
Crown Cover Shrubs	0	29.6
	5-20	69
	25-75	0.5
	80-100	0.9
Cover Herbal Vegetation	0	0.9
	5-20	1
	25-75	33.1
	80-100	65
Rock Cover	0	53.4
	>0-20	41.4
	>20-40	3.7
	>40-60	1.5
Tree and Shrub Species	Bet.lit., Pin.koc., Sal.sp., Hip.rha., Jun.sp.	
Regeneration	Bet.lit., Pin.koc.	
Distance Seed Tree	100	2.4
	150	11.5

	200	1.9
	300	1
	400	10.8
	500	15
	550	26.5
	600	14.5
	800	0.9
	900	6.9
	1000	1.8
	>1000	7
Erosion Area	0	30.9
	>0-20	43.4
	>20-40	25.7
Erosion Type	OE	69.1
Erosion Tendency	in	26.6
	st	42.5
Constraints for AR	PL	62.3
	SC	1
	DS	14.5
Facilitation for AR	EX	69.8
	PV	42
ARS	H	48.5
	H/M	14.5
	V	36.2
	V/H	0.8
Erosion Mitigation Potential of AR	NO	37.5
	YES	62.5

Table 81: Summary of survey area IV, explanation see Table 3

Parameter		Percentage of area
Area	29 ha	
Biome Type	303+401	3.8
	401	31.2
	401+403	30.5
	403	31.6
	604	3
Elevation	17-19	
Exposition	NE-SE	
Inclination	25-90	
Relief	B	76
	F	16.4
	KS	3
	U	4.6
Water-Class	0	3
	2.5	2.3
	3	24.9
	4	10.5
	5	59.4
Geology	Moraine	21.4
	Volcanic	78.6
Soil Type	BE	71.3
	RA	21

	RA/BE	7.7
Soil Depth Class	1	3
	1-3	24
	3	3
	3-4	8.6
	4	52.4
Land-Use Type	AB	30.5
	NU	37.3
	PA	22.9
Crown Cover Trees	0	26.7
	5-20	42.8
	25-75	30.5
Crown Cover Shrubs	5-20	100
Cover Herbal Vegetation	5-20	3
	25-75	59.5
	80-100	37.5
Rock Cover	0	4.1
	>0-20	68.9
	>20-40	24
	>60-80	3
Tree and Shrub Species	Bet.lit., Pin.koc., Sal.cap., Sal.sp., Ber.vul., Hip.rha., Jun.dep., Jun.sab., Ros.can.	
Regeneration	Bet.lit., Pin.koc., Sal.sp.	
Distance Seed Tree	<100	3
	100	10.8
	>1000	5.2
	in	81
Erosion Area	0	58.3
	>0-20	7.7
	>40-60	2.3
	>60-80	18
	>80-100	8.6
Erosion Type	LS	8.6
	OE	28
Erosion Tendency	in	12.6
	st	24
Constraints for AR	PL	21.9
	HV	50.7
	DS	2.3
	RA	21
	TS	12.6
Facilitation for AR	EX	52.4
	PV	81.6
ARS	H	53.7
	M	3.9
	D	39.4
	I	3
Erosion Mitigation Potential of AR	NO	6
	YES	94

Table 82: Summary of survey area V, explanation see Table 3

Parameter	Percentage of area	
Area	20 ha	
Biome Type	101+501	12.1
	401	45.1
	403	40.3
	604	2.5
Elevation	19-22	
Exposition	NE-ESE	
Inclination	25-90	
Relief	B	68.8
	KS	2.5
	U	28.7
Water-Class	2	2.5
	4	68.8
	5	16.6
	6	12.1
Geology	Volcanic	100
Soil Type	BE	97.5
Soil Depth Class	3	45.1
	3-4	4.5
	4	47.9
Land-Use Type	AB	10.3
	FO	12.1
	NU	32.4
	PA	45.1
Crown Cover Trees	0	62.8
	5-20	25.1
	25-75	12.1
Crown Cover Shrubs	0	33.2
	5-20	66.8
Cover Herbal Vegetation	5-20	2.5
	80-100	97.5
Rock Cover	0	12.1
	>0-20	85.4
	>80-100	2.5
Tree and Shrub Species	Ace.tra., Bet.lit., Jun.dep., Ros.can., Sal.cap., Sor.kac.	
Regeneration	Bet.lit., Sal.cap., Sal.sp.	
Distance Seed Tree	<100	23.6
	200	45.1
	in	31.3
Erosion Area	0	100
Erosion Type	---	
Erosion Tendency	---	
Constraints for AR	PL	45.1
	AS	85.4
	HV	35.8
	SC	40.3
	RA	2.5
	FO	12.1
Facilitation for AR	EX	80.9
	PV	85.4
ARS	D	85.4
	I	2.5

Erosion Mitigation Potential of AR	NO	47.6
	YES	52.4

Table 83: Summary of survey area VI, explanation see Table 3

Parameter	Percentage of area	
Area	19 ha	
Biome Type	303+401	20.6
	401	56.2
	401+403	14.3
	501	8.9
Elevation	16-18	
Exposition	N-S	
Inclination	0-45	
Relief	B	94.8
	U	5.2
Water-Class	2	41.1
	2.5	7.1
	3	14.8
	4	28.2
	6	8.9
Geology	Slate	32.3
	Volcanic	67.7
Soil Type	BE	100
Soil Depth Class	1-3	20.5
	2-3	41.9
	3	13.9
	4	23.6
Land-Use Type	AB	18.4
	HF	12.3
	NU	34.4
	PA	14.3
	SH	20.6
Crown Cover Trees	0	53.4
	5-20	46.6
Crown Cover Shrubs	5-20	79.4
	25-75	20.6
Cover Herbal Vegetation	25-75	41.1
	80-100	58.9
Rock Cover	0	18.4
	>0-20	47.2
	>40-60	20.5
Tree and Shrub Species	Bet.lit., Pin.koc., Sal.cap., Sal.sp., Ber.vul., Jun.dep., Jun.sab., Hip.rha., Ros.can., Spi.hyp.	
Regeneration	Bet.lit., Sal.sp.	
Distance Seed Tree	200	23.8
	400	7.1
	500	5.2
	700	20.6
	1000	20.5
	>1000	13.9
	in	8.9
Erosion Area	>0-20	20.6
	0	79.4

Erosion Type	OE	20.6
Erosion Tendency	dc	20.6
Constraints for AR	HV	22.8
	DS	20.5
	RA	14.3
	SL	20.6
Facilitation for AR	EX	5.2
	PV	100
ARS	H	44.6
	M	55.4
Erosion Mitigation Potential of AR	NO	32.8
	YES	67.2

Table 84: Summary of survey area VII, explanation see Table 3

Parameter		Percentage of area
Area	7 ha	
Biome Type	401	26.4
	403	73.6
Elevation	19-20	
Exposition	SW-NW	
Inclination	5-40	
Relief	B	81.2
	F	2.3
	U	16.5
Water-Class	3	17.7
	4	8.7
	5	73.6
Geology	Slate	100
Soil Type	BE	100
Soil Depth Class	1-4	17.7
	2	2.3
	2-3	16.5
	4	63.5
Land-Use Type	AB	100
Crown Cover Trees	0	83.5
	5-20	16.5
Crown Cover Shrubs	0	61.7
	5-20	38.3
Cover Herbal Vegetation	25-75	8.7
	80-100	91.3
Rock Cover	0	73.6
	>0-20	17.7
	>20-40	8.7
Tree and Shrub Species	Bet.lit., Ros.can.	
Regeneration	Bet.lit.	
Distance Seed Tree	100	74.8
	200	8.7
	in	16.5
Erosion Area	>0-20	8.7
	0	91.3
Erosion Type	OE	8.7
Erosion Tendency	st	8.7
Constraints for AR	AS	100

	SC	80
Facilitation for AR	EX	57.1
	PV	74.8
ARS	M	2.3
	D	97.7
Erosion Mitigation Potential of AR	YES	100

Table 85: Summary of survey area VIII, explanation see Table 3

Parameter	Percentage of area	
Area	63 ha	
Biome Type	401	1.7
	401+403	25.9
	403	30.2
	410	22.7
	606	2.2
	609	17.3
Elevation	19-25	
Exposition	NW-SE	
Inclination	0-45	
Relief	B	56.1
	DI	19.5
	F	0.6
	R	1.7
	U	22.1
Water-Class	0	17.3
	4	58.5
	5	22.1
	9	2.2
Geology	Slate	100
Soil Type	BE	57.9
	RA	0.6
	RA/BE	39.4
Soil Depth Class	1-4	17.3
	3	0.6
	4	57.9
Land-Use Type	NU	2.2
	PA	97.8
Crown Cover Trees	0	93.1
	5-20	6.9
Crown Cover Shrubs	0	60.9
	5-20	39.1
Cover Herbal Vegetation	5-20	2.2
	25-75	25.7
	80-100	72.1
Rock Cover	0	4.2
	>0-20	67.9
	>20-40	15.3
	>40-60	10.4
	>80-100	2.2
Tree and Shrub Species	Bet.lit., Sal.cap., Jun.dep., Ros.can.	
Regeneration	Bet.lit., Sal.cap., Sal.sp., Sor.kac.	
Distance Seed Tree	100	2.3
	200	40.9

	300	47.7
	>1000	2.2
	in	6.9
Erosion Area	>0-20	69.8
	>20-40	15.3
	>40-60	11
	0	3.9
Erosion Type	LS	0.6
	OE	82.6
	OE, LS	12.9
Erosion Tendency	in	96.1
Constraints for AR	PL	85.7
	AS	9
	ED	18.9
Facilitation for AR	EX	49.4
	PV	24
ARS	V	15
	H	4.2
	M	9
	D	69.6
Erosion Mitigation Potential of AR	NO	32.4
	YES	67.6

11.4. Alternative afforestation recommendations

11.4.1. Survey Area I: Stepantsminda East

Site 1: Footslope of the huge scree-cone of Stepantsminda, which is directly situated above the power plant line

This foot slope situated at the Stepantsminda scree cone (Picture 45, map polygon 153/1) has a very high ARS, as the site conditions (soil type deep Cambisol, WRB 2014) with medium fresh as water balance class (Table 86) facilitate the afforestation measures. The only constraint towards afforestation measures is given by the actual land use activity 'pasture land'. But this could be solved with the local farmers, as the steep site is not the best location for livestock grazing in survey area II (Picture 95). The given erosion mitigation potential directly above the power plant line is a strong argument for the creation of a forest through afforestation (Picture 96). The recommended tree species at this site is *Pinus kochiana*.

Table 86: Site conditions at the afforestation area 153/1 with regard to ARS

Exposition of the site	North-West	**Erosion Types**	OE
Elevation above sea level	1750 m	**Erosion Tendency**	increasing
Inclination of the slope	25-40°	**Erosion Mitigation**	YES (OE)
Bedrock Type	Schist	**Constraints for AR**	PL
Soil Type	Cambisol	**Facilitation of AR**	PV
Soil Depth	70 cm	**Actual Biome type**	401
Relief	Footslope/SR	**ARS**	Very High
Water balance class	Medium Fresh	**ARS-Index**	
Land Use	PL	**Recommended Trees**	*Pinus kochiana*

Acronyms: AR…Afforestation, ARS…Afforestation Suitability,PL…Pasture Land, OE…open erosion, PV…proximity to the village, 401…Meadow community *'Bromopsis variegata',* SR…Scree Cone

Picture 95: The potential afforestation area of map polygon 153/1, a steep slope at the lower area of the scree-cone of Stepantsminda, situated above the power plant line, with visible areas where open erosion takes place. Source: Roland Koeck

Picture 96: View at the area related to map polygon 153/1 from above, it shows the open erosion areas there even better. Also the course of the power plant line becomes very well visible from this perspective. Source: Roland Koeck