Oppdragsrapport 12/2011

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REPORT FROM THE TERRESTRIAL ENVIRONMENTAL MONITORING PROJECT IN CENTRAL ASIA (TEMP-CA)

Establishment of monitoring reference area in Urumbash, Jalal-Abad oblast, the Kyrgyz Republic, 2009. TEMP-CA monitoring site No.9.

Tonje Økland[1], Nurbek Kuldanbaev[2], Jørn-Frode Nordbakken[1] & Odd Eilertsen[1†] (eds.)

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Sammendrag: The collapse of the Soviet Union in the Central Asian countries has led to enormous challenges for them in ensuring a sustainable environment. Weak economies and lack of expertise in environmental sciences were important reasons for the Norwegian support to the environmental sector in this region. The State Forest Service of the Kyrgyz Republic and the Norwegian Forestry Group initiated the TEMP project, later renamed TEMP-CA, in the Kyrgyz Republic in 2004. Activities in the Republic of Tajikistan were included in 2007 and in the Republic of Uzbekistan from 2008. The forestry sectors in the Kyrgyz Republic and neighbouring countries in Central Asia, surrounding the Fergana Valley, are closely linked to the environmental and emergency planning sectors. Overgrazing and overharvesting have contributed to a dramatic decline in forest cover. The TEMP-CA project contributes to a better understanding of environmental problems and sustainable forestry in Central Asia. The TEMP-CA project has promoted institutional co-operation between Norway and the Central Asian countries as well as between different institutions both within and between the countries of Central Asia. Increased expertise for scientists, fieldworkers, laboratory staff and staff in different forest departments as well as institutional development in general are important outputs from the TEMP-CA project. The Urumbash monitoring site in Jalal-Abad oblast in the Kyrgyz Republic was the ninth of ten monitoring sites established in forests in Central Asia:

1: "Kara-Koi" in the Osch oblast, the Kyrgyz Republic.
2: "Sogot in the Jalal-Abad oblast, the Kyrgyz Republic.
3: "Dugoba" in Batken oblast, the Kyrgyz Republic.
4: "Besh-Tash" Talas oblast, the Kyrgyz Republic.
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9: "Urumbash" in Jalal-Abad oblast, the Kyrgyz Republic.
10: "Umalak Teppa", Tashkent region, the Republic of Uzbekistan.

In 2009 ten plots of 30x30 m were placed subjectively in the area in order to represent the variation in the presumed most important environmental gradients. A 10x10 m plot was placed in the centre of the 30x30 m plots. Within each 10x10 m plot (macro plot) five plots of 1-m^2 were randomly placed. All trees within the ten 30x30 m plots were marked on a sketch map and a number of tree growth and tree vitality measurements were recorded. The trees at the Urumbush site consisted exclusively of deciduous species. The most common species in the monitoring plots was *Acer semenovii* (41% of the trees), followed by *Juglans regia* (16.5%), *Malus siversii* (18.5 %), *Prunus sogdiana* (11.4%) and *Crataegus turkestanica* (10%). The intermediate size classes constituted the vast majority of all the main tree species, while they all had a low proportion of individuals in the smallest size class, indicating inadequate regeneration. The average defoliation of the main species ranged from 18.6% in *Acer semenovii* to a rather high level of 34.4% in *Juglans regia*. At the same time, the proportion of discolorated trees was insignificant, only about 1% for the main species.

Two abundance measures were recorded for all species in each of the fifty 1-m^2 plots: frequency in subplots (presence/absence of all species in sixteen subplots in the 1-m^2 plots) and percentage cover. A total of 39 species of vascular plants were recorded in the 50 1-m^2 plots, no bryophytes or lichens. 31 of the vascular plants were herbs. The total number of vascular plant species in the in the 50 1-m^2 plots + ten 30x30m^2 plots was 45. Of the recorded vascular plants, five species are endemic to Central Asia: *Aegopodium tadshicorum, Galium pamiroalaicum, Lamium turkestanicum, Prunus sogdiana* and *Rubus caesius.* Detrended Correspondence Analysis (DCA ordination) of the subplot frequency data for the fifty 1-m^2 plots was performed in order to reveal the most important vegetation gradients. The ordination axes, i.e. expressing the vegetation gradients, were interpreted by means of Kendall's non-parametric correlation coefficient. Differences in aspect, aspect favorability, influence of the tree layer on light and litter conditions, as well as nutrients are important environmental factors that have influenced the species composition according to these results. Much of the variation in species composition of the ground vegetation in Urumbash is thus due to influence by differences in forest density, which affect light and litter conditions, as well as nutrients and topography.

The plots were established in 2 watersheds. Generally the site was more or less similar to the Sogot site in Arslanbob, but the soil was less developed and the walnut trees were more degraded in Urumbash. One watershed (with macro plots 1 to 6) was characterised by walnut forest in the lower part and fruit trees higher up along the stream. Further up the stream an area with both older and newer landslides was present. Active solifluction occurs. The landslides were triggered by overgrazing. The soils in the first watershed were generally characterised by Phaeozems, but also Luvisols, Regosols and Umbrisols were found. In the second watershed (macro plots 7 – 10) walnut forest was the dominating forest type. The whole area is under a very strong influence of the people living in the surrounding villages. Higher up in the watershed (macro plot 7) the walnut forest looked well developed and in good shape. The A horizon was up to 100 cm deep. All the soils found in the second watershed were generally Phaeozems that had developed in loess depositions and were calcareous.

Circum neutral pH to slightly alkaline conditions prevailed at all the sampling plots at Urumbash. As commonly found the pH increased with depth mainly, due to the decrease in organic content as measured by loss on Ignition (LOI). Strong correlation was found between LOI and the carbon content (% C_{tot}; r = 0.792), despite a high content of calcareous minerals. The main oxide composition of the mineral soils shifted from aluminium (Al) and iron (Fe) in the A and B horizon, to calcium (Ca) and Al in the C horizon. The data indicate that the soil mineral base cation content increases down through the soil profile from about 45% in the A horizon to 60% in the C horizon. This fits well with the overall high soil pH found at this site. The content of borderline elements was generally high with values that lied between the normal maximum levels and the various maximum allowable limits. The content of Fe was as usual strongly correlated to Al (r = 0.951) and with the borderline elements. Soft metals (high covalent index) were generally found to be negatively correlated to hard (Type A) elements. As usual the typical borderline elements showed the largest number of strong correlations. A Principal Component Analysis (PCA) of the metal content and chemical characteristics of the A and B horizons gave a main principal component (PCA 1), explaining only 44% of the variation in the dataset in the A horizon, and 56% in the B horizon. The PCA 1 axis was mainly explained by the Al and Fe content relative to Ca and total carbon content, reflecting variations in the calcium carbonate content of the soil. The parameter loadings along the PCA 2 axis was to a certain extent correlated to the Covalent index (CI = X^2r) of the elements (r = 0.380 in the B horizon).

Ansvarlig signatur: Jeg innestår for at denne rapporten er i samsvar med oppdragsavtalen og Skog og landskaps kvalitetssystem for oppdragsrapporter.

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Oppdragsrapport fra Skog og landskap 12/2011

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NFG NORWEGIAN FORESTRY GROUP

Cover Photo: Gauyan, Photo: Adilet Usupbaev

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ABSTRACT

The collapse of the Soviet Union in the Central Asian countries has led to enormous challenges for them in ensuring a sustainable environment. Weak economies and lack of expertise in environmental sciences were important reasons for the Norwegian support to the environmental sector in this region. The State Forest Service of the Kyrgyz Republic and the Norwegian Forestry Group initiated the TEMP project, later renamed TEMP-CA, in the Kyrgyz Republic in 2004. Activities in the Republic of Tajikistan were included in 2007 and in the Republic of Uzbekistan from 2008.

The forestry sectors in the Kyrgyz Republic and neighbouring countries in Central Asia, surrounding the Fergana Valley, are closely linked to the environmental and emergency planning sectors. Overgrazing and overharvesting have contributed to a dramatic decline in forest cover. The TEMP-CA project contributes to a better understanding of environmental problems and sustainable forestry in Central Asia.

The TEMP-CA project has promoted institutional co-operation between Norway and the Central Asian countries as well as between different institutions both within and between the countries of Central Asia. Increased expertise for scientists, fieldworkers, laboratory staff and staff in different forest departments as well as institutional development in general are important outputs from the TEMP-CA project.

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PREFACE

TEMP-CA was initiated and planned by Odd Eilertsen, who was also the project leader up to his sudden death on 19 February 2010. All involved project partners and scientists in Central Asia and Norway had been working with the data and report chapters for the ten TEMP-CA sites according to his ideas and decisions up to his death. This report has thus been completed as far as possible accordingly.

Many scientists and colleagues in Norway and Central Asia as well as myself are very grateful to Odd for giving us the possibility to co-operate in this project.

On behalf of all authors and partners in TEMP-CA I want to give special thanks to the persons mentioned below who have contributed with fieldwork, laboratory work, translations, logistics, administrative work etc.

Timur A. Arykov, Aitkul M. Burhanov, Nicholas Clarke, G.U. Karymbaeva, Antonina I. Knyaz'kova, Ol'ga M. Korjenevich, Galina A. Kornilova, Irina N. Kurochkina, Bakyt A. Mamytova, Oleg R. Mujdabaev, Saltanat R. Narynbaeva, Svetlana G. Nesterova, Anna V. Polevaya, Meerim Rakimbek kyzy, Tat'yana A. Rudenko, Lyudmila G. Sasova, Asel B. Satybaldieva, Aitbaev Djirgalbek Valievich and Lyudmila I. Zvyagina.

My very special thanks to Halvor Solheim (leader of the Forest Health Section at NFLI), who supported me and helped me, especially in the last phase of the work with completing the TEMP-CA reports. I also want to give special thanks to Dan Aamlid (head of the Department for Biology and Environment at NFLI), Arne Bardalen (Director General at NFLI), Karl Thunes (project leader after Odd Eilertsen of the Ahangaran Forest Damage Project at NFLI) and Øystein Aasaaren (Managing Director of Norwegian Forestry Group), all of whom have, in different ways, given me support in the difficult situation that occurred when Odd died. Odd Eilertsen was the initiator and project leader of TEMP-CA, but he was also my friend and colleague.

Ås, 20. January 2011

Tonje Økland

Project leader

CONTENT

INTRODUCTION

Nurbek Kuldanbaev[1], Tonje Økland[2] & Odd Eilertsen,[2†]

1: The Public Foundation Relascope, Bishkek
2: The Norwegian Forest and Landscape Institute/Norwegian Forestry Group

Various terrestrial monitoring programs in Europe, North America, East and Southeast Asia have shown that combined effects of anthropogenic and natural stresses affect soil, water, vegetation, and forests. Air, soil and water pollution as well as changes in climate are all regarded as important stress factors. The impact of pollutants and changes in climate vary geographically and with site and stand conditions. Different anthropogenic factors and their effects on terrestrial ecosystems are thus complex and difficult to isolate and quantify. A large number of stress factors that influence the ecosystem condition must therefore be taken into consideration and measured in the same plots; i.e. integrated monitoring should be carried out.

The International Co-operative Programme on Assessment and Monitoring of Air Pollution on Forests (ICP Forests) was established under the Geneva Convention - UN/ECE Convention on Long-range Trans-boundary Air Pollution (CLRTAP) in 1985. The Kyrgyz Republic, together with Kazakhstan, are the only countries in Central Asia to sign the Geneva Convention.

After the collapse of the Soviet Union the Central Asian countries have had enormous challenges in securing a sustainable environment. Weak economies and lack of human resources are two of the key factors. After the independence of the former Soviet republics in 1991 many of the Russian and other foreign scientists left Central Asia. The State Forest Service of the Kyrgyz Republic and the Norwegian Forestry Group initiated the Forest and Environmental Sector Programme in 2004. The program included the following two activities:

Activity 1 Terrestrial Environmental Monitoring Programme (TEMP). Implementation of a methodology for monitoring and studying terrestrial ecosystems in the Kyrgyz Republic.

Activity 2 Institutional Strengthening of the forestry sector including a stronger involvement of the private sector in the management of the natural resources. .

The project mandate was:

- To establish a methodological concept for monitoring effects of anthropogenic and natural stress factors on the condition and development of terrestrial ecosystems in the Kyrgyz Republic with relevance for other countries in Central Asia (the Republic of Tajikistan, and the Republic of Uzbekistan).
- To contribute to a better understanding of cause-effect relationships in terrestrial ecosystems in various parts of the Kyrgyz Republic and in Central Asia generally.
- To contribute to a better understanding of the relationships between the condition of terrestrial ecosystems and anthropogenic factors (in particular soil pollution from industrial activities) in a number of selected permanent observation plots.
- To provide policy-makers and the general public with relevant information related to the issues above, in order to reach these goals.

After the appraisal phase (2003-2004) and Phase I (2005-2006) of the project, forest and environmental activities in the Republic of Tajikistan and the Republic of Uzbekistan were included as well in Phase II, and the project was accordingly renamed TEMP-CA. The main objectives of the TEMP-CA project were to:

- Identify national expertise and make a survey of information requirements from the three Central Asian countries.
- Work out a suitable methodology for an integrated intensive monitoring based on international standards.
- Develop a framework for an integrated monitoring programme within the Fergana Valley region.

- Identify “hot spots” in the Fergana Valley and the surrounding mountains and establish monitoring sites in the Kyrgyz Republic (six from –2004-2009), in the Republic of Tajikistan (one in 2007) and in the Republic of Uzbekistan (two; in 2008 and 2009).
- Contribute with equipment to laboratories and education of personnel to undertake chemical analyses of soil, soil water, runoff water and plant samples for environmental monitoring programmes within the forest and land degradation and watershed management sectors.
- Enhance the environmental monitoring expertise and the general environmental expertise in academia.
- Prepare for the next phase of TEMP-CA, a “Programme for Environmental Risks and Security in Areas of Land Degradation” in the Fergana Valley.
- Institutional development within academia and the environmental and education sectors.
- Support to environmental reform processes aimed at strengthening co-operation and integration with the newly independent states of the former Soviet Union.
- Contribute to stabilisation and conflict prevention in the region based on establishment of transparent information on natural resources and the state of the environment.

The environmental degradation and resource scarcity has not been the catalyst of conflicts in any of the Central Asian republics, but have exacerbated existing political and social crises and ethnic tensions. In the Fergana Valley the situation is special; the area is overpopulated, the borders between the states are artificial, ethnic conflict is severe, the environmental pressure is enormous, and the struggle for natural resources make this area violent and with more tensions than any other parts of the region.

The Central Asian states face tremendous challenges to manage the process of political, economic, and social reforms towards competitive and open market economies. They still suffer from the legacy of the Soviet period, and collaboration between scientists and environmental managers from the different countries is more or less absent. The TEMP-CA project aims at bringing scientists and environmental managers from the Kyrgyz Republic, the Republic of Tajikistan, and the Republic of Uzbekistan together in a joint trans-boundary project.

The forest area of the Kyrgyz Republic is not large: forests cover c. 6.8% of the total area. The Concept for Forestry Development was approved by the Decree of the Government of the Kyrgyz Republic of May 31, 1999. Data from the TEMP-CA project gives valuable information to the State Agency on Environmental Protection and Forestry relevant for sustainable management of forests.

The forestry sector in the Kyrgyz Republic and its neighbouring countries in Central Asia, especially for the area surrounding the Fergana Valley, are closely linked to the environmental and emergency planning sectors. Excessive grazing and harvesting have contributed to a dramatic decline in forest cover. The history of forestry in the region is similar to that observed in Western Europe: The over-exploitation of the timber resources in the first half of the 20th century resulted in a dramatic decline in forest cover, and led to the establishment of institutions with a mandate to improve forest management and restore depleted mountain forests.

In contrast to Western Europe, the period of timber exploitation was followed by a period of severe overgrazing, which further degraded the forest cover and interrupted natural regeneration. Today, large areas are affected by soil erosion and land degradation. More than 50% of the 10.6 million ha of arable land in the Kyrgyz Republic are affected by soil erosion. The situation is more or less similar for the neighbouring countries around the Fergana Valley. Besides this, the main land degradation processes include salinization, swamping, chemical pollution, and destructive changes in vegetation cover.

Forest resources play an important role in water regulation, protection from soil erosion, general conservation of biological diversity, and stabilization of the ecological balance. Strong dependence on the use of wood as fuel is challenging, and alternative energy sources need to be explored to prevent further deforestation. Pastures located on slopes with steepness of more than 20 degrees are severely degraded by wind and water erosion. The prevalence of small cattle ranches has led to the transition from pasturing of cattle at a distance from settlements to primitive shepherding, which has expanded the impact area and the forest degradation.

The institutional co-operation between Norway and the Kyrgyz Republic provides the opportunity for education and training of numerous environmental field workers and scientists, laboratory engineers, forest and environmental experts and managers from the Central Asian region. The TEMP-CA project contributes to better understanding of environmental problems, as a first step to promoting a sustainable use of the forests in Central Asia. Thus, increased expertise in environmental monitoring methods and in environmental management as well as institutional development in general is the most important output from the project. This output cannot be fully expressed in a report.

Recording of ground vegetation, tree variables, soil variables and other environmental conditions in the same permanent plots enables identification of the main complex gradients in vegetation and the environmental conditions. Identifying these gradients is necessary as a basis for interpretation of changes in the forest ecosystem due to both anthropogenic and natural stress factors. Regular re-analyses of these plots may reveal changes in tree vitality, species composition in ground vegetation, biodiversity changes and changes in soil chemistry, as well as relationships between changes in these components of the forest ecosystem.

Thus, integrated monitoring in permanent plots provides: 1) a better understanding of relationships between the different components of the forest ecosystems, 2) basic knowledge and data from the forest ecosystem necessary for identifying effects of anthropogenic as well as natural stress factors and 3) a contribution to different aspects of relevance for forestry policy at national, regional and global levels, such as effects of climate change on the forests, sustainable forest management and biodiversity in forests.

In this report we present the main results from the ninth monitoring site established in the TEMP-CA project, Urumbash in Jalal-Abad oblast in the Kyrgyz Republic. This monitoring site was established and analysed in 2009. Measurements of a lot of variables for forest tree condition, forest growth, soil chemistry, and soil classification, ground vegetation, and environmental factors were performed according to manuals based on ICP Forests, ICP Integrated Monitoring and the monitoring concept used in Norway since 1988 (Økland 1996, Lawesson et al. 2000).

1 DESCRIPTION OF THE URUMBASH REFERENCE MONITORING AREA

Nurlan I. Kasymbaev[1], Adilet Usupbaev[2], Kuvanychbek S. Kasiev[2], Nurbek Kuldanbaev[1] and Farhat S. Asanov[2]

1: The Public Foundation Relascope, Bishkek
2: The National Academy of Science, Bishkek

1.1 Geographical position of the reference monitoring area

The Urumbash monitoring site is located on the south-western macro-slope of the Fergana mountain range in the Tien-Shan mountain system (Zinkova & Pushkareva 1987). This area, which according to its physical and geographical zones belongs to the south-western Tien-Shan province in the Central Asian mountain country, is characterised by a mountain-valley landscape system. The highest peaks of the Fergana Mountains reach about 5500 m a.s.l.

Administratively the study area belongs to the Bazarkorgon district of Jalal-Abad oblast, the Kyrgyz Republic.

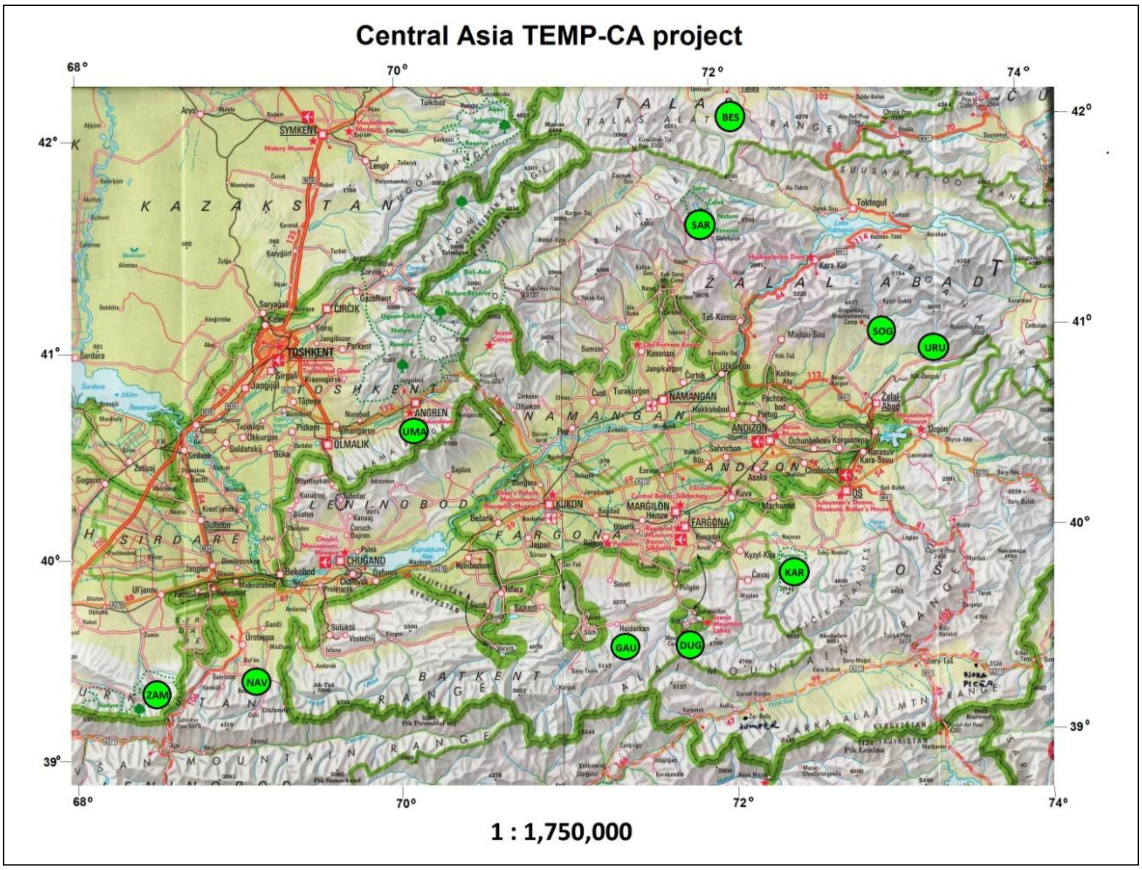

Fig. 1.1. Map of the Urumbash (URU) and the nine other TEMP-CA monitoring reference areas.

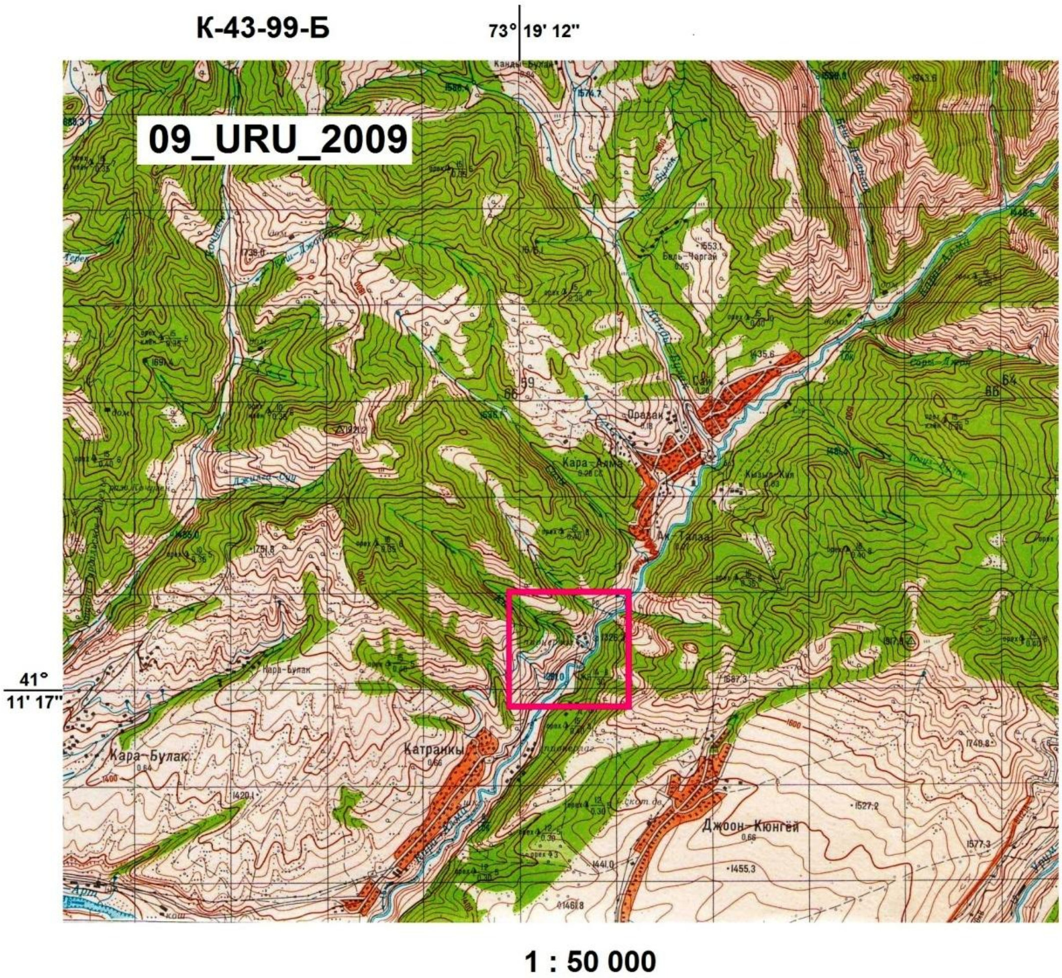

Fig. 1.2. Geographical position of the Urumbash (URU) monitoring reference area.

Tab. 1.1. gives the latitude and longitude grid reference and altitudes for the 10 macro plots.

Tab. 1.1. GPS coordinates for the ten 10x10 m macro plots (see chapter 2.1.1).

Macro plot	Elevation	N	E
1	1396 m	41°11.425′	073°19.745′
2	1404 m	41°11.442′	073°19.781′
3	1425 m	41°11.425′	073°19.823′
4	1397 m	41°11.404′	073°19.784′
5	1444 m	41°11.373′	073°19.827′
6	1479 m	41°11.403′	073°19.967′
7	1542 m	41°11.411′	073°20.015′
8	1544 m	41°11.430′	073°20.061′
9	1502 m	41°11.473′	073°20.067′
10	1518 m	41°11.520′	073°19.986′

1.2 Forest type, ownership and conservation status

The forest on the Urumbash leskhoz's territory have several fruit trees and shrubs. *Acer semenovii* , *Malus siversii* and *Juglans regia* are dominating forest forming trees in the plots, but also other species occur, as *Prunus sogdiana* and *Crataegus turkestanica* also occur. The walnut trees are well developed. Other Shrubs include cherry plum, species of honeysuckle and barberries, juneberry and *Cotoneaster*.

The leskhoz is a territorial unit of the Forestry Department. According to information from the forestry, the total leskhoz's area is 10657 ha. The forests of the Urumbash leskhoz are considered to be very important for anti-erosive protection. Industrial wood harvesting is prohibited.

1.3 Geology, topography, and quaternary deposits

The Urumbash site belongs to the tectonic region of South Tien Shan. Its main features are widely developed geo-synclinal formations from the middle and upper Paleozoic. The folding is Hercynian, with many faults; red-colored continental molasses of the Permian fill “residual red troughs”. Limited occurrence of upper-Paleozoic granitoid intrusions and alkaline magma intrusions are typical (Zinkova & Pushkareva 1987). The Paleozoic folded base is overlain with Mesozoic and Cenozoic deposits that fill inter-mountain and sub-mountain troughs.

Geo-morphologically the Urumbash site belongs to the West Tien Shan group (Fergana, Chatkal, Pskem and Kuramin ranges). The relief is worked out primarily in Palaeozoic and Proterozoic rocks, more rarely in Mesozoic-Cainozoic rocks. The type of relief is caused by tectonic-denudation and mainly erosion. The characteristic feature are deep and thick partitions (from 500 m up to 1000-1500 m, and even up to 2000 m thick). Deep V-formed canyons with large amounts of debris and landslides at the bottom are common. Relics of the ancient surface can often be found on slopes and in watersheds of the mountain ranges. The mountain ranges and mountains is predominantly formed in Pliocene and, more rarely, early Quaternary. The presence of subsurface water combined with a continental climate cause fragmentation of the rocks.

1.4 Climate

The climate in the Urumbash monitoring site is typical continental, characterized by considerable seasonal variation (Ryazantseva 1965). The main wind directions for this area are west and south-west.

1.4.1. TEMPERATURE

The average annual temperature of the forest zone of Urumbash is 11 to 13 °C (Tab. 1.2). The average monthly summer temperature is 19.3 °C, with July as the warmest month (absolute maximum 29.3 ºC). January is the coldest month (absolute minimum -22.6 ºC)

Tab. 1.2. The average temperature (°C) and precipitation (mm) at the nearest meteorological station Ak-Terek .

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des	Year
Temp. (°C)	-2.2	-1.7	2.6	9.5	13.2	17.7	20.5	19.9	15.9	9.7	4.6	0.6	9.2
Precip. (mm)	78	81	111	157	142	87	47	25	33	92	96	81	1030

1.4.2. PRECIPITATION

The maximum precipitation period for the region is from March to June, depending on the altitude (Tab. 1.2). The autumn is usually dry.

1.5 Vegetation zones

The territory of Urumbash belongs to the ancient Mediterranean sub-kingdom of the Holarctic, Western Asian province, in the Fergana Valley region of the Mountain Central Asian area (Kamelin 2002).

The vegetation cover of the investigation area, which is distributed according to the North-Fergana type of vertical zones, is characterized by walnut and fruit forests with *Juglans regia* and *Prunus sogdiana*. The vegetation includes Red Book species like *Malus sieversiana*, *M. niedzwetzkyana*, *Crataegus knorrigiana*, *Eminium regelii* and *Pyrys korshinskyi* (Red Data Book of Kyrgyz Republic 2006).

1.6 Forest history, forest structure, and external influence

1.6.1. HUMAN IMPACT

Forestry in Urumbash is under the territory of Kara-Alma village council. The population of the village is about 2400 people. There are three small villages near the monitoring site:

- Almurut village, with population about 40 persons.
- Salkyntor village, with population about 60 persons.
- Kyzyl Kyz, with population about 90 persons.

Much of the activities of the local population are connected to the forest. The village people let their cattle graze on pastures in the forest, and they harvest walnuts, wild plants, and medicinal herbs. They also cut grass for haymaking and collect firewood. Wood is the only available kind of fuel in winter (which explain illegal cutting). During summer the territory is used for recreation both by local people and visitors.

1.6.2. FOREST HISTORY

In the period from 1910 up to 1918 the Migratory Department Expedition of Russia had economic interests in the walnut-fruit forests of the Kyrgyz Republic. From 1930 to 1940 the forest departments went through a number of organizational reconstructions. The main economic interest of walnut sovkhozs were harvesting of wild fruits and improvement of growing conditions of wild trees.

From 1933 up to 1947 walnut and fruit sectors were under the authority of different ministries and departments, repeatedly turned from one ministry to another, which affected the conditions of the walnut forests. Following a 1944 USSR Governmental Order to investigate the production forces of the USSR, the Academy of Sciences sent an expedition under the general direction of Vladimir N. Sukachev to the forests of South Kirgizia. After inspecting materials from this expedition, especially with regards to the importance of walnut and fruit forests, the SNK of the USSR by its Resolution of April 30, 1945, declared walnut and fruit forests of southern Kyrgyzstan as closed fruit wood with special use conditions. In 1948 all leskhozs of southern Kyrgyzstan were passed to the Ministry of Forestry of Kirgiz SSR.

Currently, the local forest department (leskhoz) let the local population rent the walnut plantations on short-term basis (one season) for walnut harvesting. Initially the area passed for communal forest tenure for one year was 140 hectares. This area will expand year after year. In addition to contracts with the leaseholders a map of the rented areas are drawn where borders and internal situation of the different site are indicated.

1.6.3. GRAZING

Grazing is one of the most serious problems regarding the economical and ecological value of forests in Kyrgyzstan. Uncontrolled grazing, which strongly reduce natural and artificial regeneration of wood and shrubby species, leads to changes in the species composition of the vegetation.

Special territories for grazing and roads for cattle run were fixed on the forestry's territory, but the local people do not always keep these regulations. According to the leskhoz's workers, the most intensive forest grazing is in spring before the domestic animals enter the high-mountain pastures from the valley part (April-June) and during their return in autumn (September-November). The grazing activity on the forestry's territory in summer is not so intensive.

2 FOREST STATUS AND TREE CONDITION

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2.1 Methods

2.1.1 SAMPLING DESIGN

The establishment of monitoring plots and field assessments where done in accordance with the ICP-Forest manual (ICP Forests 2006), revised for Kyrgyz conditions. Briefly, at each site ten 30x30 m plots were established in which the spatial coordinates for all trees > 5 cm DBH (vitality trees) were assessed. The individual trees were numbered consecutively at breast height within each plot for later reassessments.

Within each of the plots a central macro plot of 10x10 m is defined, in which more intensive assessments were done, such as measurement of tree heights, crown projections, and crown heights.

2.1.2 TREE PARAMETERS

At each site standard crown condition parameters, such as social status, defoliation, and discoloration were recorded. The classification of the defoliation follows ICP-Forest: Class 0 shows healthy trees, with ≤ 10% defoliation; class 1, ”warning stage”, > 10 up to 25%; class 2, “moderately damaged”, > 25-60%; class 3, “severely damaged”, > 60% defoliation; and class 4, dead trees. The assessment of defoliation did not consider dead trees, trees heavily damaged by abiotic factors, or greatly suppressed trees referred to class 4 by Craft’s classification.

Diameter at breast height was recorded for all trees > 5 cm DBH, whereas tree height was only recorded within the central 10x10 m macro plot (cf. ICP Forests 2006). To take into account possible non-circular stem circumference, the diameter at breast height of all vitality trees was assessed in two directions, north-south and east-west.

In addition, regeneration (< 5 cm DBH) of all tree species were recorded as a part of the ground vegetation analysis in the five 1-m^2 plot in each of the 10x10 m macro plots, making a total of 50 m^2 for the each site.

2.2 Results

2.2.1 TREE COMPOSITION

The trees at the Urumbash site consisted exclusively by deciduous species. The most common species in the monitoring plots was *Acer semenovii* (41%), followed by *Juglans regia* (16.5%), *Malus siversii* (18.5%), *Prunus sogdiana* (11.4%) and *Crataegus turkestanica* (10%) (Fig. 2.1). *Pyrus communis* (2.3%) and *Fraxinus sogdiana* (0.3%) had a very modest occurrence.

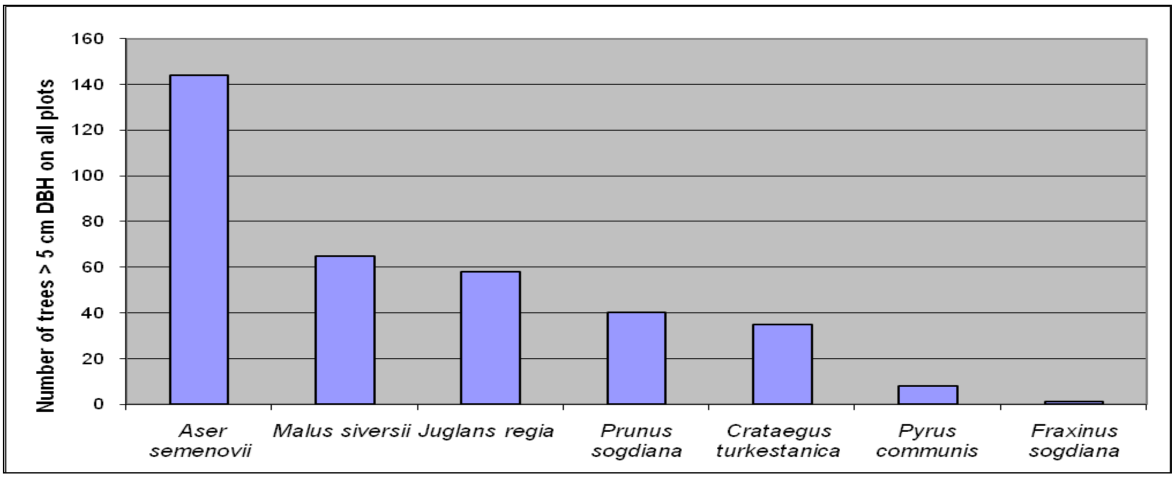

Fig. 2.1. Total number of trees of the different species > 5 cm DBH in all plots.

2.2.2 TREE CONDITION

Tree condition for the three main species with sufficient number of trees to draw sound conclusions is presented in Fig. 2.2. Defoliation in *Acer semenovii* was modest, but *Malus siversii* and particularly *Juglans regia* were moderately defoliated. The proportion of discoloration of trees was insignificant, only about 1% for the three main species.

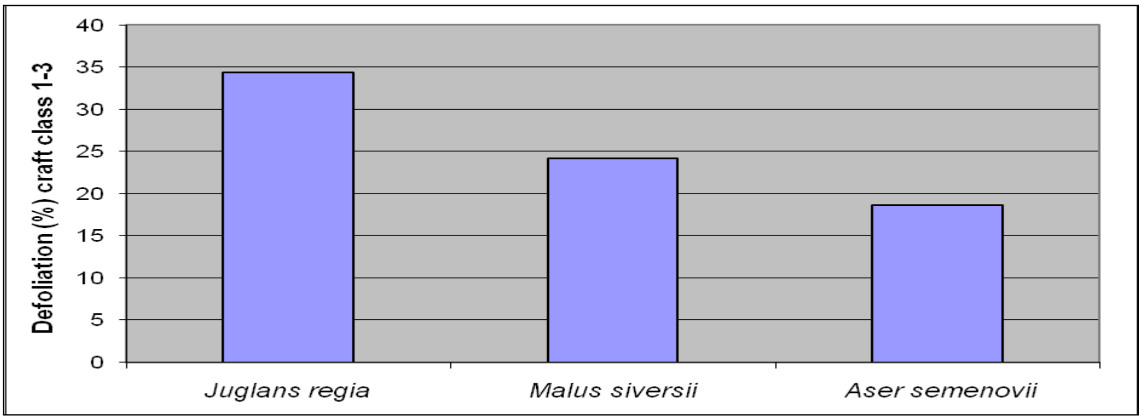

Fig. 2.2. Defoliation of the main tree species.

2.2.3. DEMOGRAPHY AND REGENERATION OF MAIN SPECIES

The DBH distributions revealed that all the main species had a low proportion of individuals in the smallest size class (Fig. 2.3, 2.4 and 2.5). In *Juglans regia*, however, five saplings (< 5 cm DBH) were found in the 1-m^2 plots for ground vegetation monitoring. The intermediate size classes constituted the vast majority of the trees, and as commonly observed the frequency of trees declined when approaching the largest DBH classes.

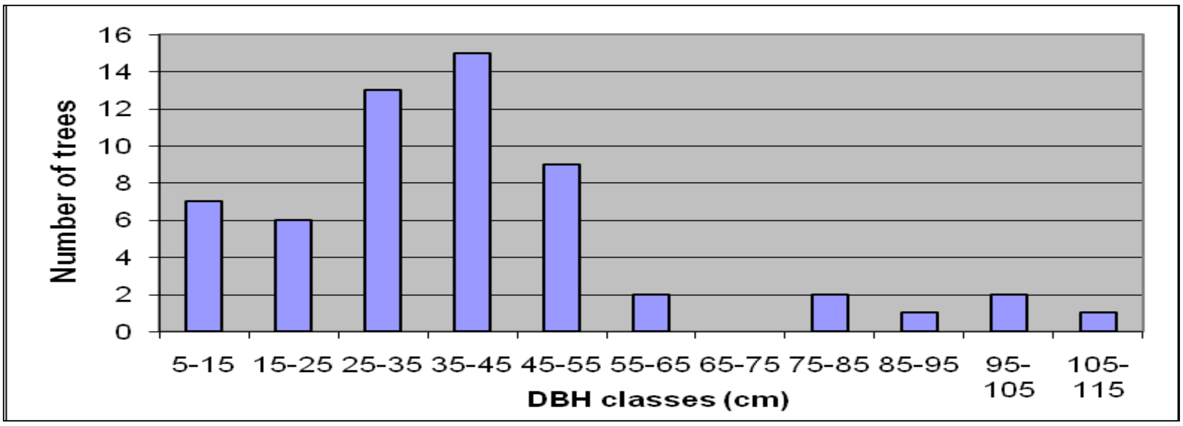

Fig 2.3. Size distribution (DBH) for *Juglans regia* across all plots.

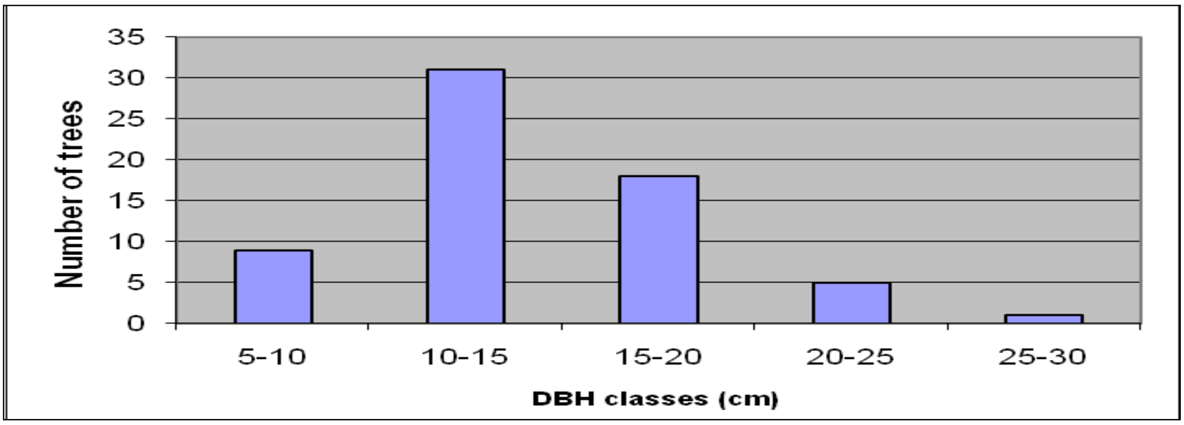

Fig. 2.4. Size distribution (DBH) for *Malus sieversii* across all plots.

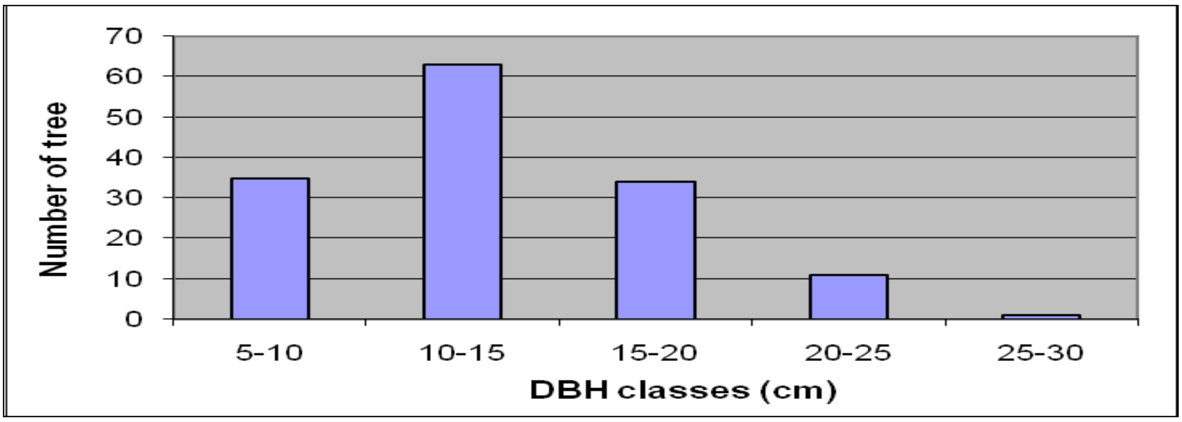

Fig. 2.5. Size distribution (DBH) for *Acer semenovii* across all plots.

2.3 Discussion

The forest condition was evaluated by the level of defoliation and the proportion of trees with discolorated needles/ leaves. These indicators are influenced by natural factors such as climate and soil condition, as well as human impacts (e.g. grazing and cutting of firewood). It is sometimes difficult to relate reduced tree vitality to specific causes based on conventional forest monitoring, not supported by experimental studies, but repeated assessments, which is the basic idea of monitoring, will always provide useful information about temporal forest development.

The average defoliation of the main species ranged from 18.6% in *Acer semenovii* to a rather high level of 34.4% in *Juglans regia*. At the same time, the frequency of trees with discoloration was very low. The tree vitality indicators do not provide any information about reasons for the variability in forest condition, and our inferences are more or less speculations. The high defoliation in *J. regia* could be due to biotic factors such as fungi attack and defoliating insects. Cutting of branches for firewood or other purposes could represent entries for rot fungi. Wood and leaf samples should be collected for pathological and entomological investigations when the injury cannot be assessed properly in the field. High defoliation could certainly also refer to climatic conditions, such as severe drought.

Sufficient regeneration is fundamental for sustainable forests. The *size distributions* of the three main species show a low abundance of the smallest size class, which suggests inadequate regeneration. The few *Juglans regia* saplings recorded in the 1-m^2 plots is not sufficient to change this impression. Since the low proportion of small age classes applies across species, it is tempting to suggest that it has a common cause, such as grazing. It is well known, however, that the valuable wood of *J. regia* could imply that the small trees are illegally removed. Similarly, the acorns are probably collected on the ground due to their high commercial value. Human exploitation is thus a highly likely explanation for the size class distribution in *J. regia*. The project did not set an objective of conducting monitoring of natural regeneration as such. To obtain scientific data on regeneration, more specific investigations are needed.

The present site shows that not only the biotic factors are of interest for interpretation of forest condition and regeneration. Rather, knowing the use and management regime is fundamental to make correct inferences. Irrespective of reason, our data suggest that natural regeneration is limited, and we thus propose more thorough assessment of saplings (< 5 cm DBH) at the site, as well as a means to uncover the different reasons for the regeneration deficit.

3 BIODIVERSITY AND GROUND VEGETATION

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3.1 Methods

The sampling design and methods follow the Norwegian concept for forest ground vegetation monitoring (Økland 1996, Lawesson et al. 2000; see also Liu et al. 2008).

The key principles are summarised below:

(1) Study areas should be selected to represent the regional variation within the entire area of interest (for example region or a country), the intensity of impact factors (for example airborne pollutants), as well as climatic and other broad-scaled environmental gradients.

(2) Similar ranges of variation along all presumably important vegetation and environmental gradients within the pre-selected habitat type should be sampled from each study area, in similar ways.

(3) Ground vegetation, tree variables, soil variables, and other local environmental conditions of importance for the vegetation should be recorded in the same, permanently marked plots.

(4) Identification and understanding of the complex relationships between species distributions, the total species composition, and the environmental conditions in each study area form a necessary basis for interpretation of changes in ground vegetation, and for hypothesising relationships between vegetation change and changes in the environment.

(5) Observed changes in nature caused by anthropogenic factors not of primary interest for the monitoring study may interfere with and obscure trends related to the factors of primary interest. The influence of such factors should be kept at a minimum, for example by selecting areas in near-natural state.

(6) The sampling scheme must take into consideration the purpose of the monitoring and meet the requirements for data analyses set by relevant statistical methods which imply constraints on plot placement, plot number and plot size.

(7) All plots should be re-analysed regularly. For most forest ecosystems yearly re-analyses will impose too much trampling impact etc. to be consistent with the purpose of monitoring. The optimal time interval between re-analyses in different ecosystems may vary among ecosystems.

3.1.1 SAMPLING DESIGN

The following sampling scheme have been used for monitoring in each of Central Asian monitoring reference areas: Ten macro sample plots, each 10x10 m were placed subjectively in order to represent the variation along presumably important ecological gradients; in aspect, nutrient conditions, light supply, topographic conditions, soil moisture, etc. Each of the ten 10x10 m sample plots was positioned in the centre of one 30x30 m plot, to be used for recording of tree parameters. All plots were confined to one catchment area. All 10x10 m plots should allow placement of 1-m^2 plots in at least 20 of the 100 possible positions. Five 1-m^2 sample plots were randomly placed in each macro sample plot.

As far as possible, sites that were not visibly affected by external impacts were preferably chosen for placement of macro plots. Sample plot positions were rejected according to a predefined set of criteria. Positions for 1-m^2 plots were rejected if they (1) had a joint corner or side edge with another plot; (2) included trees and shrubs or other plants that physically prevented placement of the aluminium frame used for vegetation analysis of the plot; (3) were physically disturbed by man (by soil scarification, extensive trampling or crossed by a path, digging of pits, etc.); (4) were disturbed by earth slides; (5) were covered by stones for more than 20% of their area; or (6) when a vertical wall of 25 cm or more would be included or situated close to the corresponding plot. In case of rejection, a new position for the 1-m^2 plot was selected according to a predefined set of criteria. All plots were permanently marked by subterranean aluminium tubes as well as with visible plastic sticks.

3.1.2 VEGETATION PARAMETERS

Frequency in subplots was used as the main species abundance measure. Each of the fifty 1-m^2 plots was divided into 16 subplots, 0.0625 m^2 each. Presence/absence of all species was recorded for each of the subplots, and frequency in subplots was calculated for each species in each 1-m^2 plot. A species was recorded as present when it covers a subplot (Fig. 3.1). In addition to frequency in subplots, visual estimates of *percentage cover* was made for each species in each plot, since this additional information are obtained with very little extra time consumption.

All vascular plant species present in the ten 10x10 m plots as well as 30x30 m plots were listed.

The number of vascular plant species within macro plots was calculated as: (a) the cumulative number of species recorded within the five 1-m^2 plots in each.

10x10 m macro plot, (b) the total number of species recorded in each 10x10 m macro plot, and (c) the total number of species in each 30x30 m extended macro plot. The ratio a/b and a/c was calculated for each macro plot.

Fig. 3.1. A typical 1-m^2 plot with the field layer dominated by herbs and graminoids.

3.1.3 EXPLANATORY VARIABLES

Explanatory variables are environmental and other variables we use for interpretation of vegetation gradients; i.e. relationships between these variables and species composition along gradients. These variables all influence the ground vegetation by influencing the species composition along gradients and biodiversity, in different ways and to variable degrees. Explanatory variables are partly measured at field work, partly measured at laboratory by analyses of soil samples and partly calculated based on measured variables.

Several explanatory variables, of five main types were measured/calculated: (1) topographical; (2) tree influence; (3) soil physical; (4) soil chemical; and (5) grazing variables.

(1) Topographical variables include:

Inclination was measured in a way that is representative for each 1-m^2 plot by a clinometer compass.

Aspect un-favourability can be expressed as deviation of the recorded aspect measured representative for each 1-m^2 plot by use of a compass (0-360º) from SSW (202.5º). In the northern hemisphere, SSW is considered to be the most favourable aspect (Heikkinen 1991) due to high incoming radiation at times of day with high temperatures. However, it is more suitable for statistical analyses to recalculate to *aspect favourability*; thus we recalculated the values according to this formula:

ABS[180-ABS(202.5-aspect value)]

From the values of inclination and aspect we calculated the heat index (Parker´s index; Parker 1988) as:

COS(202.5-aspect value)*TAN(inclination value)

Indices of *concavity/convexity* in each 1-m^2 plot were calculated by assigning to each plot an index value for concavity/convexity of each subplot on the following scale: –2 (concave), –1 (slightly concave), 0 (plane),1 (slightly convex), 2 (convex). The same scale was used for the 9 subplots in a 3x3 m plot with the 1-m^2 plot in centre. Derived indices were calculated for both the 1-m^2 plots and for the 3x3 m plots by (a) summarizing the values, (b) summarizing the absolute values and (c) calculating the variance.

Maximum inclination was measured by a clinometer as the maximum measurable slope between two points in the sample plot, situated 10 cm apart.

(2) Tree influence variables include:

- Crown cover index
- Litter index
- Basal area

All trees that were (i) rooted within the macro plot; (ii) rooted within a 2-m buffer zone bordering on the plot; or (iii) covering the plot or the buffer-zone, were marked with numbers, in the field and on a sketch map of each macro plot with positions of the 1-m^2 plots, canopy perimeters and tree stems drawn in. *Crown area* for each tree, **cai**, i.e. the area within the vertical projection of the crown perimeter, was estimated from the sketch maps. The *tree heights* were measured in dm from normal stump height to the tree top and the crown heights were measured as the difference between total tree height and the distance from the ground to the point of the stem where the lowest green branch whorl (i.e. the lowest green branch whorl which is separated from the rest of the crown by less than two dry branch whorls) emerged. *Crown cover*, **cci**, is estimated as the percentage of the crown area (visible from below) covered by living phytomass.

Crown cover index was calculated by use of crown area, **cai,** and crown cover, **cci** for all trees i = 1,...,n covering inside a 25 m^2 (5x5 m) plot around each 1-m^2 plot (the 1-m^2 plot placed in the centre of the 25 m^2 plot):

CC = ∑i **cai** • **cci** /25

Litter index is calculated by modifying the index of Økland (1990, 1996) and Økland & Eilertsen (1993):

For each tree, the part of the crown area which is inside the 1-m^2 plot, **ca**, is measured and a line is drawn on the sketch map from the stem centre through the centre of the plot.

Four different cases were distinguished, the first three relating to trees with the stem centre within the crown perimeter, the fourth addressing eccentric trees.

(i) The line has one point of intersection with the sample plot margin within the crown perimeter (it intersects the crown perimeter once within the plot). This is the most usual case.

A distance **di** measured along the line from its point of intersection with the crown perimeter to the sample plot border (within the crown perimeter), *crown radius,* **cri** measured along the line as the distance from the stem centre to the line's intersection with the crown perimeter, the fraction of the crown area that is inside the 1-m^2 plot, **cai**; *crown cover*, **cci**; crown height, chi; tree height, **hi,** were used to calculate the litter index.

The contribution of a tree i to the litter index is:

$$\mathbf{LitterIi = (di / cri) \times cci \times cai \times (hi - chi)}$$

The litter index for each 1-m^2 plot was calculated as:

$$\mathbf{LitterI = \sum i\ (di / cri) \times cci \times cai \times (hi - chi)}$$

(ii) The line intersects the sample plot twice within the sample plot before intersecting with the crown perimeter (this may be the case for plots situated below large trees). A distance **di** measured along the line from its point of intersection with the crown perimeter to the proximal sample plot border (the border closest to the stem centre), crown radius**, cri** measured along the line as the distance from the stem centre to the line's intersection with the crown perimeter, the fraction of the crown area that is inside the 1-m^2 plot**, cai;** *crown cover*, **cci**; crown height, **chi,** and tree height, **hi** were used to calculate the index.

The contribution of a tree i to the litter index is:

$$\mathbf{LitterIi = (di / cri) \times cci \times cai \times (hi - chi)}$$

The litter index for each 1-m^2 plot was calculated as:

$$\mathbf{LitterI = \sum i\ (di / cri) \times cci \times cai \times (hi - chi)}$$

(iii) The tree crown covers a minor part of the plot only, and the line intersects the sample plot margin outside its point of intersection with the crown perimeter. The contribution to the litter index is by definition set to zero; **LitterI = 0**

(iiii) Eccentric trees (rooted outside the crown perimeter). The contribution of eccentric trees is calculated as:

$$\mathbf{LitterIi = cci \times cai \times (hi - chi)}$$

The litter index for each 1-m^2 plot was calculated as:

$$\mathbf{LitterI = \sum i\ cci \times cai \times (hi - chi)}$$

Basal area (relascope sum) is an expression of tree density on a relatively broad scale around each measurement point, i.e. the complement of light supply to the understory. Basal area was measured at breast height by use of a relascope from the corner of each 1-m^2 sample plot. We calculate:

(1) The relascope sum for coniferous trees
(2) The relascope sum for deciduous trees
(3) The sum of (1) and (2)

(3) Soil physical variables include:

- *Soil depth*; calculated by measurement of the distance a steel rod can be driven into the soil in fixed positions, 10-15 cm outside the plot border, eight single measurements are made for each plot. Minimum, maximum, and median values were calculated for each plot.

- *Depth of organic layer*; measured at four fixed points for each plot. Minimum, maximum, and median values were calculated.

- *Depth of litter layer* was measured in five fixed points within each 1-m^2 plots. Minimum, maximum, and median values were calculated.

- *Estimations of % cover of litter*.

- *Loss on ignition* (gravimetric loss after combustion, determined by ashing ca.1 g of sample at 550 ℃ in a muffle furnace; for details, see method description for soil analyses Chapter 5).

- *Soil moisture* was determined for volumetric soil samples, collected from the upper 5 cm of the humus layer. The samples were collected about 10 cm from the border of each meso plot, whenever possible below the plot. All samples from one reference area were collected on the same day, preferably after a period of some days without rainfall, with the aim of representing median soil moisture conditions, i.e. the normal soil moisture at the site (cf. Økland 1990, Økland & Eilertsen 1993). The samples were stored in paper bags kept inside double plastic bags and kept frozen until they were weighed in the laboratory. After drying at 110 °C to constant weight, the samples were weighed again and percentage moisture was calculated.

(4) Soil chemical variables include:

- pH measured in aqueous *solution*,
- pH measured in $CaCl_2$

- the content of *loss on ignition, organic C, total N* and *P-AL* and *exchangeable acidity* concentrations and the cations *Ca*, *Mg*, *K*, *Na*, *Al*, *Fe*, *Mn*, and *Zn, among others.* For detailed method descriptions; see Chapter 5.

(5) Animal impact variables include:

Some of the factors could be measured directly in the 1-m^2 plot, e.g. grazing intensity and % cover animal manure/dung. Other factors must be found by interviews of locals, e.g. *date/period of scything/hay-making* for the area and/or macro plot and *grazing period* (time period for grazing by horses, cows, goats, and sheep). Parameters measured directly in field descriptions/estimation values for:

-Domestic animal grazing condition
-Grazing intensity
-Average grass height
-Average herb height
-% cover animal manure/dung
-% cover animal traces/footprints
-% cover animal tracks
-% browsing damage on woody plants for each species
-% cover of wild animal holes

Short descriptions of the *domestic animal grazing condition* and *scything/hay-making condition* and *wild animal grazing conditions* (grazing/browsing/digging) were given for each 1-m^2 plot.

Grazing intensity: Estimations were made for each 1-m^2 plot on a subjective scale with 4 levels: 0 = no grazing indications; no indications of grazing on the vegetation were seen. 1 = some grazing (patchily grazing); spots that were highly grazed and other spots that were not grazed could be seen. 2 = even grazing; even/plane grazing had removed much of the grass and herbs in the plot. 3 = extreme grazing (< 5 cm vegetation height); most of the grass- and herb-layer had been grazed and the field layer was very low, often below 5 cm.

Average grass height: The average height of the grass-cover in cm was measured for each 1-m^2 plot with a measuring rule.

Average herb height: The average height of the herb-cover in cm was measured with a measuring rule.

% cover animal manure/dung: The percentage cover of domestic animal dung/manure in the plot was estimated.

% cover animal traces/footprints: The percentage cover of domestic animal footprints in the plot was estimated.

% cover animal tracks: The percentage cover of domestic animal tracks in the plot was estimated.

Browsing damage on woody plants: A short description of the domestic browsing on each of the woody plants that were browsed upon by domestic animals was given: Species; name of the woody plant, s*tem%;* how much of the stem in % that are browsed, shoots*;* how many of the shoots that approximately have been browsed.

% cover of wild animal holes: Estimations of the percentage cover of traces and digging holes made by wild animals were performed for each 1-m^2 plot.

3.1.4 ORDINATION METHODS

Species abundances with a frequency lower than the median frequency (in the set of all species) were down-weighted by multiplying for each species the recorded abundances with the ratio of this species' frequency and the median frequency (Eilertsen et al. 1990) before ordination analyses.

Ordination methods are used to summarize the main gradients in the vegetation of the sample plots. DCA (Detrended Correspondence Analysis; Hill 1979, Hill & Gauch 1980), one of the most common used multivariate statistical methods, was performed on subplot frequency data on 50 plots by means of CANOCO Version 4.54 (ter Braak & Šmilauer 1998), which are debugged according to Oksanen & Minchin (1997). Standard options were used (i.e. no down-weighting of species, nonlinear rescaling of axes and detrending by segments).

3.1.5 INTERPRETATION OF GROUND VEGETATION GRADIENTS

Ordination axes express vegetation gradients. In order to elucidate the complex relationships between species composition and environmental conditions, these gradients were interpreted by means of the measured environmental variables. The interpretation of DCA ordination was performed by calculating Kendall's rank correlation coefficient τ between plot scores along DCA axes and environmental variables.

3.2 Results

3.2.1 GROUND VEGETATION BIODIVERSITY

The number of species, α-diversity, is reported in this chapter, while β-diversity (variation in species composition along gradients) will be reported in chapter 3.2.2 below. The total species list is given in Appendix 3.4. The number of species in the 1-m^2 plots within each macro plot was calculated as the sum of the five 1-m^2 plots in each macro plot (a), as the total number of species in each 10x10 m^2 macro plot including the species in the 1-m^2 plots (b), and as the total number of species in each 30x30 m^2 extended macro plot including the species in the 1-m^2 plots (c, Tab. 3.1). The ratio a/b and a/c was calculated for each macro plot. All together 39 species was recorded in the 50 1-m^2 plots. Of these species five are endemic to Central Asia: *Aegopodium tadshicorum, Galium pamiroalaicum, Lamium turkestanicum, Prunus sogdiana* and *Rubus caesius.*

The total number of species recorded within the 50 1-m^2 plots plots was 39. The total number of species recorded within the 50 1-m^2 plots + ten 10x10m^2 plots was 45. The total number of species in the in the 50 1-m^2 plots + ten 30x30m^2 plots was 53. The maximum number of species recorded in five 1-m^2 plots within a macro plot was 19, while the minimum number was 8. The average number of species recorded in five 1-m^2 plots within a macro plot was 12.3. The maximum number of species recorded in any of the 10x10 m macro plots (the five 1-m^2 plots included) was 24 and the minimum number was 10. The average number of species in the 10x10 m macro plots (the five 1-m^2 plots included) was 15.4. The ratio a/b varied between 0.64 and 0.92 (Tab. 3.1). The ratio a/c varied between 0.50 and 0.79 in the macro plots.

The plant species were divided into species groups, tree species and shrubs, herbs, ferns, graminoids, bryophytes and lichens (Tab. 3.2). Most species were herbs.

Tab. 3.1. Total number of vascular plant species in five 1-m^2 plots (a), five 1-m^2 plots + 10x10 m macro plot (b), five 1-m^2 plots + 30x30 m extended macro plot (c), and ratios a/b and a/c.

Plot number	a Five 1-m^2 plots	b Five 1-m^2 plots + 10x10 m plot	c Five 1-m^2 plots + 10x10 m plot + 30x30 m plot	The ratio a/b	The ratio a/c
1	9	14	17	0.64	0.53
2	19	24	28	0.79	0.68
3	16	21	23	0.76	0.70
4	12	16	19	0.75	0.63
5	12	13	23	0.92	0.52
6	16	18	22	0.89	0.73
7	8	10	16	0.80	0.50
8	9	12	14	0.75	0.64
9	11	13	16	0.85	0.69
10	11	13	14	0.85	0.79
Total number	39	45	53	0.92	0.74

Tab. 3.2. Number of species in different species groups within each 10x10 m macro plot and in total.

Plot number	Tree species	Shrubs	Herbs	Ferns	Graminoids	Bryophytes	Lichens
1	3	0	5	0	1	0	0
2	1	0	16	0	2	0	0
3	0	1	11	0	4	0	0
4	2	0	9	0	1	0	0
5	1	0	9	0	2	0	0
6	1	0	12	0	2	0	0
7	0	0	7	0	1	0	0
8	1	0	7	0	1	0	0
9	0	0	10	0	1	0	0
10	0	0	10	0	1	0	0
Total number	3	1	31	0	4	0	0

3.2.2 MAIN GROUND VEGETATION GRADIENTS

DCA ordination of 50 plots is shown in Figs. 3.2-3.5. Gradient lengths; β-diversity, and eigenvalues for DCA axes 1-4 are given in Tab. 3.3.

Tab. 3.3. Eigenvalues and gradient lengths for DCA of 50 plots.

	DCA 1	DCA 2	DCA 3	DCA 4
Eigenvalues	0.479	0.289	0.156	0.087
Gradient lengths	3.998	2.699	2.228	2.001

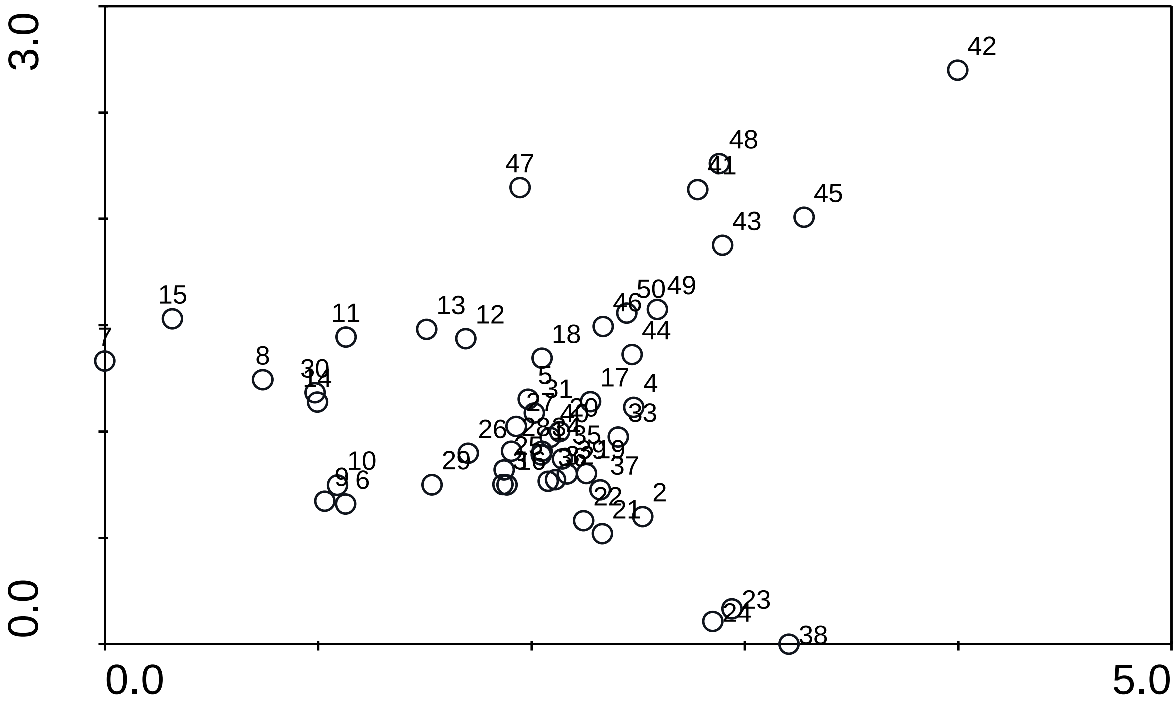

Fig. 3.2. DCA ordination of 50 1-m^2 plots, axes 1 (horizontal) and 2 (vertical). Plot numbers for the 50 1-m^2 plots are plotted onto the sample plot positions. Scaling of axes in S.D. units.

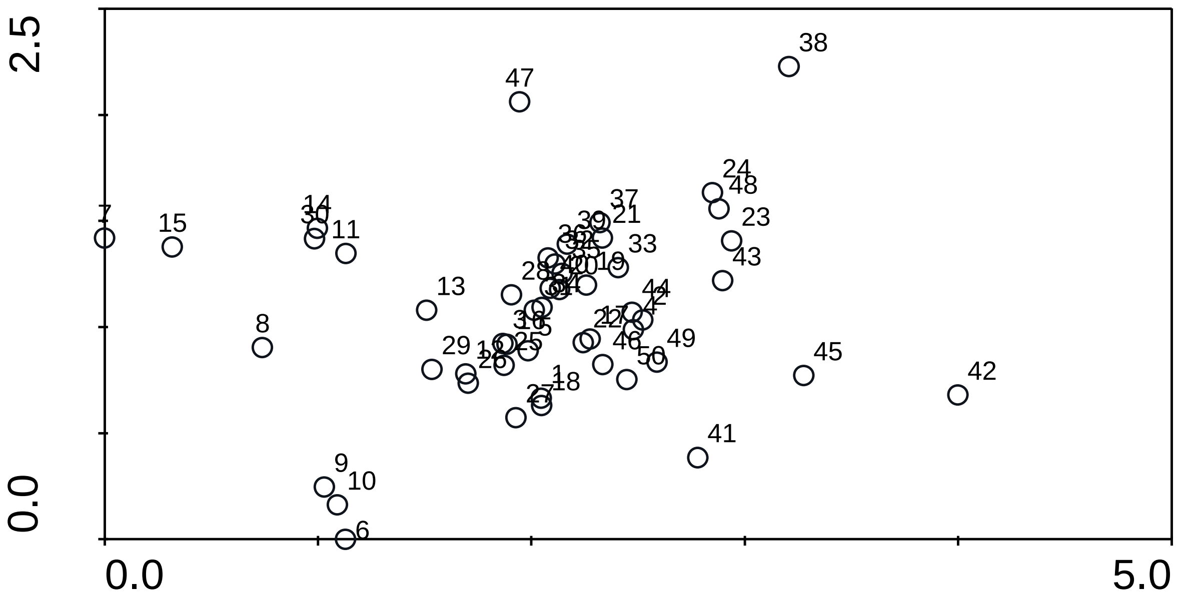

Fig. 3.3. DCA ordination of 50 1-m^2 plots, axes 1 (horizontal) and 3 (vertical). Plot numbers for the 50 1-m^2 plots are plotted onto the sample plot positions. Scaling of axes in S.D. units.

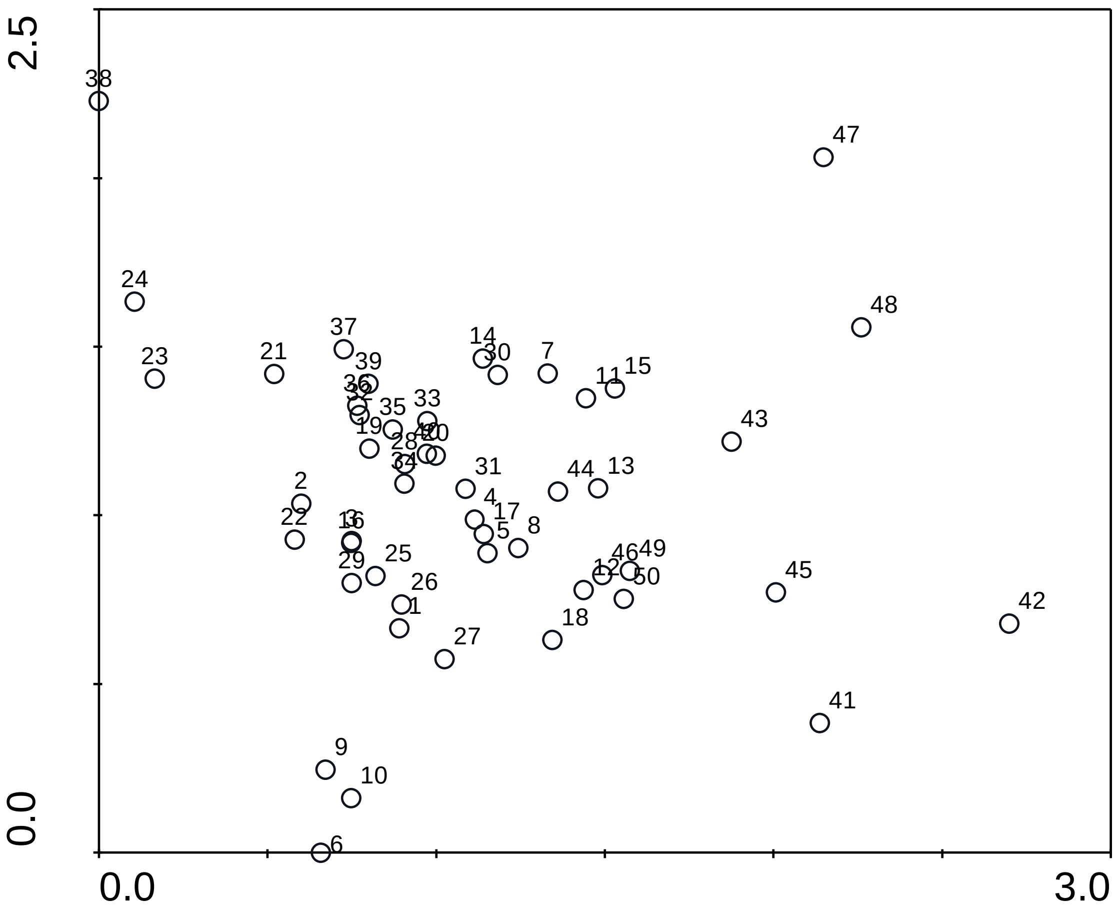

Fig. 3.4. DCA ordination of 50 1-m^2 plots, axes 2 (horizontal) and 3 (vertical). Plot numbers for the 50 1-m^2 plots are plotted onto the sample plot positions. Scaling of axes in S.D. units.

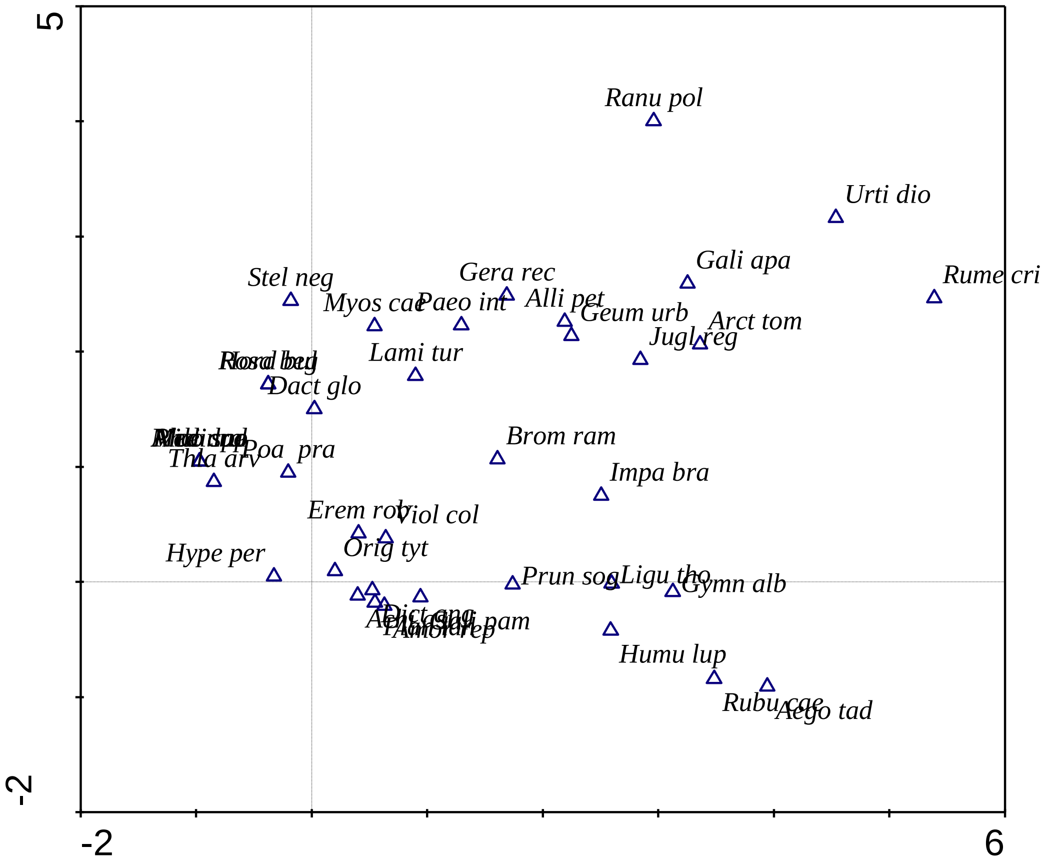

Fig. 3.5. DCA ordination of species in the 50 1-m^2 plots.

3.2.3 CORRELATION ANALYSIS BETWEEN EXPLANATORY VARIABLES AND DCA ORDINATION AXES

Kendall´s non-parametric correlation coefficient τ between DCA-axes and between DCA-axes and explanatory variables is shown in Tab. 3.4.

Tab.3.4. Kendall´s non-parametric correlation coefficient τ between DCA-axes and explanatory variables with P-values.

Variable	DCA 1	P	DCA 2	P	DCA 3	P	DCA 4	P
DCA 1	***	***	0.032	0.744	0.105	0.281	0.122	0.213
DCA 2	0.032	0.744	***	***	-0.096	0.328	-0.187	0.055
DCA 3	0.105	0.281	-0.096	0.328	***	***	0.171	0.080
DCA 4	0.122	0.213	-0.187	0.055	0.171	0.080	***	***
Soil moisture	-0.107	0.273	-0.193*	0.047	-0.123	0.207	-0.097	0.320
Inclination	**-0.291****	0.003	-0.209*	0.036	0.042	0.675	-0.002	0.987
Aspect	0.198*	0.044	**-0.348****	0.000	0.043	0.657	0.232*	0.018
Aspect favour.	0.194*	0.047	**-0.352****	0.000	0.043	0.657	0.232*	0.018
Heat index	**0.256****	0.009	**-0.268****	0.006	0.078	0.422	**0.286****	0.003
Max. inclination	-0.235*	0.018	**-0.279****	0.005	-0.057	0.568	-0.045	0.650
Sum. conc. 1x1 m	0.099	0.360	0.005	0.963	-0.263*	0.015	-0.107	0.322

Tab.3.4**.** continues: Kendall´s non-parametric correlation coefficient τ between DCA-axes and explanatory variables with P-values.

Variable	DCA 1	P	DCA 2	P	DCA 3	P	DCA 4	P
Var.conc. 1x1 m	0.137	0.200	-0.155	0.148	-0.237*	0.027	-0.206	0.055
Abs. sum conc. 1x1m	0.126	0.241	-0.156	0.148	-0.248*	0.021	-0.211	0.050
Sum conc. 3x3 m	0.095	0.362	-0.117	0.264	**-0.312****	0.003	-0.169	0.106
Var. conc 3x3 m	0.008	0.938	-0.104	0.315	-0.247*	0.017	-0.206*	0.047
Abs. sum conc. 3x3m	0.044	0.674	-0.098	0.349	-0.251*	0.016	-0.222*	0.034
Rel. deciduous trees	**0.298****	0.003	0.078	0.439	0.200*	0.047	0.188	0.062
Crown cover index	0.140	0.152	-0.053	0.586	0.045	0.645	0.002	0.980
Litter index	0.164	0.099	-0.075	0.449	0.072	0.469	0.048	0.626
Average grass height	0.175	0.083	**0.441****	0.000	0.157	0.121	-0.094	0.354
Average shrub height	0.034	0.761	**-0.365****	0.001	0.034	0.761	-0.197	0.074
Max. soil deptht	0.222*	0.025	-0.122	0.218	0.239*	0.016	0.170	0.086
Min. soil depth	0.151	0.130	-0.107	0.282	0.114	0.253	**0.314****	0.002
Med. soil depth	0.233*	0.019	-0.210*	0.034	0.137	0.169	0.142	0.154
Max. org. layer depth	0.140	0.165	0.150	0.136	0.055	0.584	0.182	0.070
Min. org. layer depth	0.175	0.088	0.156	0.129	0.114	0.266	0.241*	0.019
Med. org. layer depth	0.160	0.107	0.157	0.115	0.063	0.524	0.228*	0.022
Max. litter depth	**0.348****	0.001	0.211*	0.042	-0.077	0.459	0.091	0.381
Min. litter depth	**0.387****	0.000	0.228*	0.031	0.059	0.578	0.136	0.198
Med. litter depth	**0.378****	0.000	0.142	0.167	0.018	0.859	0.149	0.147
pH	-0.059	0.557	-0.204*	0.043	0.141	0.160	**0.282****	0.005
Dry matter	-0.039	0.696	-0.140	0.160	-0.007	0.943	0.202*	0.043
LOI	0.179	0.073	0.238*	0.017	-0.144	0.150	0.020	0.845
C_{tot}	**0.264****	0.008	0.002	0.986	-0.092	0.355	0.128	0.201
Ca	**0.326****	0.001	0.023	0.817	-0.099	0.320	0.145	0.145
Mg	0.251*	0.012	0.106	0.290	0.051	0.612	0.084	0.398
Na	-0.192	0.061	-0.022	0.830	0.015	0.886	-0.184	0.071
K	0.152	0.134	0.257*	0.011	0.255*	0.012	0.146	0.149
CEC Calc	**0.316****	0.002	0.059	0.557	-0.082	0.414	0.131	0.188
CEC	0.001	0.993	0.031	0.767	-0.012	0.907	0.111	0.286
Total N	**0.287****	0.004	0.161	0.106	-0.011	0.915	0.183	0.067
PO4	0.226*	0.025	**0.400****	0.000	-0.041	0.682	-0.011	0.915
SO4	0.156	0.126	0.019	0.851	-0.006	0.950	-0.050	0.623
Ca. ppm	0.089	0.374	**-0.257****	0.010	-0.064	0.522	0.039	0.696
Mg. ppm	-0.073	0.466	-0.037	0.709	-0.023	0.817	0.096	0.337
Na. ppm	0.004	0.965	-0.153	0.124	0.123	0.217	0.212*	0.034
K. ppm	-0.029	0.769	0.212*	0.034	0.148	0.138	0.038	0.702
Al. ppm	-0.115	0.248	0.170	0.088	0.168	0.091	0.041	0.683
Fe. ppm	-0.155	0.120	0.150	0.133	0.233*	0.019	0.095	0.342
Mn. ppm	-0.094	0.346	0.234*	0.019	0.126	0.207	0.016	0.873
P. ppm	**0.291****	0.004	**0.335****	0.001	0.011	0.915	0.209*	0.036
Zn. Ppm	-0.055	0.582	0.060	0.546	-0.140	0.160	0.158	0.114
Ca/LOI*100	0.135	0.177	**-0.356****	0.000	0.011	0.915	0.238*	0.017
Mg/LOI*100	-0.020	0.845	-0.142	0.155	0.204*	0.041	0.009	0.929
Na/LOI*100	-0.181	0.071	-0.170	0.089	0.126	0.210	-0.099	0.323
K/LOI*100	0.034	0.736	0.035	0.722	**0.332****	0.001	0.179	0.073

Tab.3.4. continues: Kendall´s non-parametric correlation coefficient τ between DCA-axes and explanatory variables with P-values.

Variable	DCA 1	P	DCA 2	P	DCA 3	P	DCA 4	P
CEC Calc/LOI*100	0.101	0.311	**-0.348****	0.000	0.055	0.582	0.236*	0.018
CEC/LOI*100	-0.230*	0.021	**-0.264****	0.008	0.050	0.619	0.025	0.803
Total N/LOI*100	0.018	0.859	-0.069	0.488	0.067	0.499	**0.298****	0.003
PO4/LOI*100	0.232*	0.020	**0.294****	0.003	0.037	0.709	0.048	0.631
SO4/LOI*100	0.039	0.696	-0.211*	0.034	0.124	0.213	0.021	0.831
Ca. ppm/LOI*100	0.044	0.657	**-0.376****	0.000	0.076	0.445	0.083	0.403
Mg. ppm/LOI*100	-0.163	0.102	-0.229*	0.022	0.131	0.188	0.004	0.972
Na. ppm/LOI*100	-0.170	0.088	**-0.261****	0.009	0.202*	0.043	0.074	0.455
K. ppm/LOI*100	-0.225*	0.024	-0.152	0.126	0.176	0.078	-0.002	0.986
Al. ppm/LOI*100	-0.207*	0.038	-0.160	0.110	0.168	0.091	0.016	0.873
Fe. ppm/LOI*100	-0.223*	0.025	-0.168	0.091	0.188	0.060	0.032	0.749
Mn. ppm/LOI*100	**-0.277****	0.006	-0.122	0.220	0.184	0.064	-0.018	0.859
P. ppm/LOI*100	0.023	0.817	0.128	0.201	0.048	0.631	0.133	0.182
Zn. ppm/LOI*100	-0.222*	0.026	-0.181	0.070	0.115	0.248	0.027	0.790
CEC Calc/LOI*100	0.101	0.311	**-0.348****	0.000	0.055	0.582	0.236*	0.018

3.3 Discussion

3.3.1 GENERAL DESCRIPTION OF VEGETATION AND GROUND VEGETATION BIODIVERSITY

The dominating tree species in the Urumbash monitoring site is *Acer semenovii, Malus sieversiana and Juglans regia,.* Other tree species in the area include, *Prunus sogdiana* and *Crataegus songorica.* A typical feature for the native vegetative communities of *Juglans regia* is a poor floristic composition.

The floristic composition of shrubs in the area includes *Lonicera lanata, Rhamnus cathartica, Euonymus semenovii* and *Rosa kokanica.*

The field layer is dominated by the grass *Bromopsis ramosa,* but species like *Dictamnus angustifolius* and *Alliaria petiolata* are also common. Other typical species in the area are *Phlomoides speciosa, Lamium turkestanicum, Geranium rectum, Geum urbanum, Lamium turkestanicum, Urtica* dioica, *Galium aparina* and *Ranunculus polyanthemus.*

The herbaceous plants consist mainly of shade tolerant species. They are often relatively tall (60-70 cm). Of the 39 species of vascular plants recorded in the 50 1-m^2 plots, 31 were herbs. Bryophytes and lichens are almost absent in the area, and were not recorded in any of the plots due to the thick layer of fallen leaves.

3.3.2 INTERPRETATION OF GROUND VEGETATION GRADIENTS

Several of the measured environmental variables were significantly correlated with the ordination axes. Several variables that were significantly positively correlated with the main ordination axis, DCA 1, included the three *litter depth* variables, the content of calcium (Ca*)* in the soil, the *cation exchange capacity* (CEC calc.), the *total nitrogen* (N) and *phosphorous* (P) content, as well as the *relascope sum* (deciduous trees) and the *heat index.* The variable most strongly negatively correlation with DCA 1 was *inclination*. This indicate that along DCA 1, from lower to higher scores, there is a tendency for deeper litter, an increase in soil nutrients, a denser forest, higher heat-index values, and a reduction in the *inclination*.

Average grass height, *P*, PO_4, and PO_4 *calculated as a fraction of loss on ignition* were all positively correlated with DCA 2, while *average shrub height*, *aspect*, *aspect favorability*, *maximum inclination*, *heat index*, and *Ca* were negatively correlated with DCA 2. Several variables calculated as a fraction of loss on ignition, including *Ca*, *cation exchange capacity*, *Na*, *P* and PO_4 also were negatively correlated with DCA 2. Thus, from lower to higher DCA 2 scores, there is a tendency for increased grass height, i.e. decreased grazing activity, increased content of *phosphate* and *phosphorous*, reduced shrub height, and less favourable *aspect* and *Ca* content.

According to these results, much of the variation in species composition of the ground vegetation in Urumbash is due to influence by differences in forest density, which affect light and litter conditions, as well as nutrients and topography.

3.4 Appendix

Appendix 3.1. Scientific (Latin), Kyrgyz and Russian names of plant species.

Latin names of species:	Kyrgyz names of species:	Russian names of species:
Achillea asiatica	Азия каз таманы	Тысячелистник азиатский
Aegopodium tadshicorum	Тажик элик балтырканы	Сныть таджикская
Alcea nudiflora	Түксүз гүлдүү гүлкайыр	Шток-роза голоцветковая
Alliaria petiolata	Дары аллиариасы	Чесночник лекарственный
Amoria repens	Сойломо амориясы	Амория ползучая
Arctium tomentosum	Тытыш түктүү угак	Лопух войлочный
Bromopsis ramosa	Бутактанган түбү бош	Костер ветвистый
Dactylis glomerata	Топтолушкан ак сокто	Ежа сборная
Dictamnus angustifolius	Ичке жалбырактуу диктамнус	Ясенец узколистный
Eremurus robustus	Кабелтең чыраш	Еремурус мощный
Galium aparine	Жабышчак галиуму	Подмаренник цепкий
Galium pamiroalaicum	памир-алайлык галиум	Галиум памиро-алайский
Geranium rectum	Түз каз таманы	Герань прямая
Geum urbanum	Шаар геуму	Гравилат городской
Gymnospermium alberti	Альберт гимноспермуму	Гимноспермум Альберта
Hordeum bulbosum	Пияз түптүү арпа	Ячмень луковичный
Humulus lupulus	Кадимки кулмак	Хмель обыкновенный

Appendix 3.1. continues: Scientific (Latin), Kyrgyz and Russian names of plant species.

Latin names of species:	Kyrgyz names of species:	Russian names of species:
Hypericum perforatum	Көзөнөкчөлүү сары чай чөп	Зверобой продырявленный
Impatiens brachycentra	Кыска текөөрлүү кына	Недотрога короткошпорцевая
Juglans regia	Грек жаңгагы	Орех грецкий
Lamium turkestanicum	Түркстан дүлөй чалканы	Яснотка туркестанская
Ligularia thomsonii	Томсон кой жалбырагы	Бузульник Томсона
Medicago lupulina	Хмель сымал беде	Люцерна хмелевидная
Myosotis caespitosa	Чымдак бото көз	Незабудка дернистая
Origanum tythanthum	Майда гүлдүү көк чай чөп	Душица мелкоцветковая
Paeonia intermedia	Ортоңку чымындык	Пион средний
Phlomoides speciosa	Кооз шимүүрчөк	Фломоидес красивый
Plantago lanceolata	Ичке бака жалбырак	Подорожник ланцетолистный
Poa pratensis	Шалбаа жылганы	Мятлик луговой
Prunus sogdiana	Согдия алчасы	Слива согдийская
Ranunculus polyanthemus	Көп гүлдүү байчечекей	Лютик многоцветковый
Rosa beggeriana	Беггер ит муруну	Роза Беггера
Rubus caesius	Көгүлтүр кара бүлдүркөн	Ежевика сизая
Rumex crispus	Тармал ат кулак	Щавель курчавый
Stellaria neglecta	Байкалбаган жылдызча	Звездочка незамеченная
Thlaspi arvense	Тала кызыл гүлү	Ярутка полевая
Urtica dioica	Эки үйлүү чалкан	Крапива двудомная
Vicia cracca	Жапайы жер буурчак	Вика мышиная
Viola collina	Чыбыр ала гүлү	Фиалка холмовая

4 SOIL CLASSIFICATION AND SOIL DESCRIPTION

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4.1 Methods

The chemical composition of the soil layers is due to the biogeochemical cycling (Fig. 4.1). In the Urumbash area the following soil data are gathered:

- Soil profile development
- Chemical characteristics per soil horizon
- Soil texture
- Soil moisture content of the top soil.

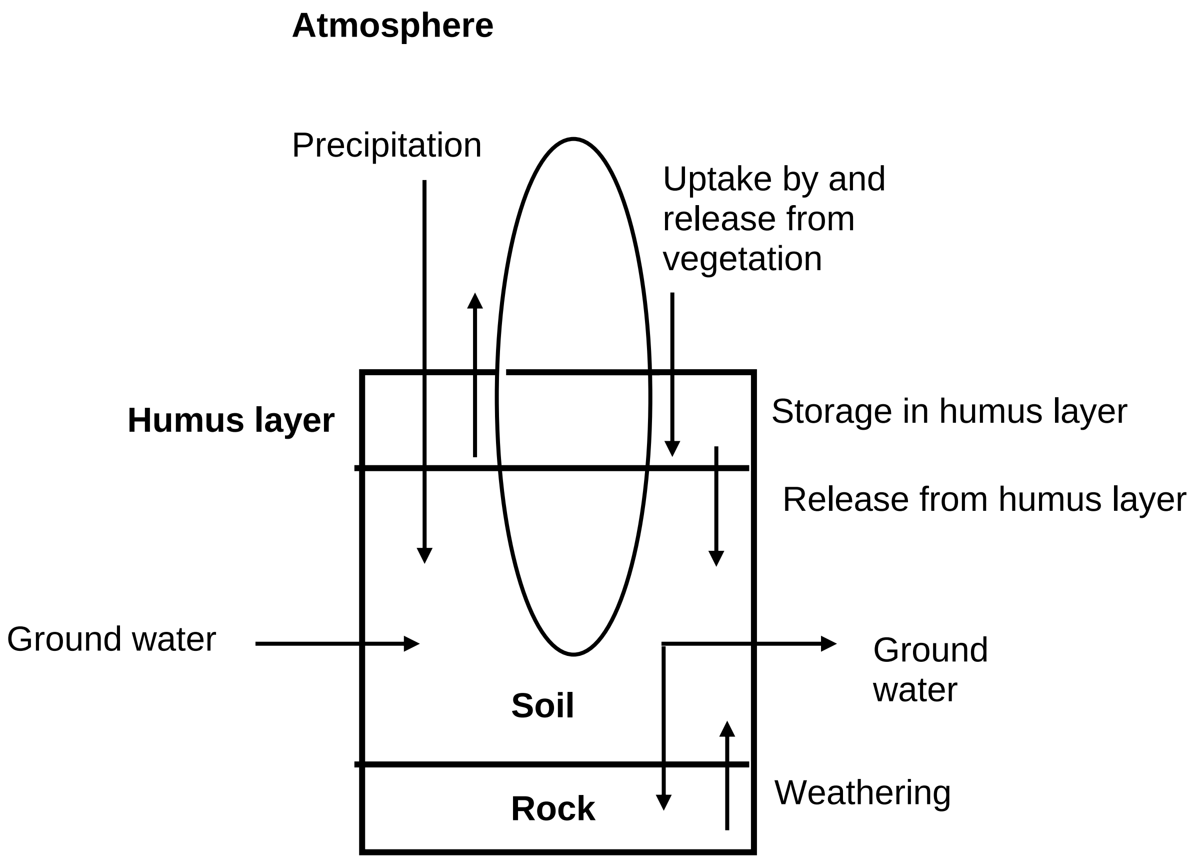

Fig. 4.1. Simplified model of biogeochemical cycling of elements.

The methodology for placing the macro plots and 1-m^2 vegetation plots is described in 3.1.1. From the 1st – 3rd of May 2009 soil samples were collected from each 1-m^2 plot. The field work was done under sunny to cloudy circumstances and temperatures around 22 °C. At the end of the 2nd of May some showers occurred in the evening. The period just before sampling was characterised by periods with heavy rain and even snow. Some frost damage was visible at the walnut trees and at the ground vegetation. For long term monitoring it is important to get information from all the soil horizons. Accordingly, the soil sampling was done per soil horizon. For each 1-m^2 plot the sampling horizon and the depth of sampling was recorded. Samples were taken (see chapter 5 for more details) from 3 sides outside each of the 1-m^2 plots. Soil samples were not collected at the slope above the 1-m^2 plots in order to avoid disturbances. Sampling was done with the help of an Edelman auger and the maximum reachable sampling depth was 1.20 m. In cases where the presence of free chalk was expected this was controlled with the aid of a solution of 1M HCl. Per 1-m^2 plot one mixed soil sample was collected and put in a 0.5 litre sample box. After field work the boxes were stored at a cool and dry place. Soil moisture samples were taken during field work in July 2009.

Outside each macro plot a simplified soil profile description was made for the soil which should be considered as characteristic for the macro plot. Data on soil texture of each soil sample were not gathered. Soil texture data from the simplified texture descriptions can be used indicative.

4.2. Results

The plots were established in 2 watersheds. In general the site looked similar to the Sogot site in Arslanbob, but the soil was much less developed and the walnut trees in Urumbash were more degraded. One watershed (with macro plots 1 to 6) was characterised by a walnut forest in the lower part and fruit trees higher up along the stream. Further up the stream an area with both older and newer landslides was observed. Active solifluction occurs. The landslides are triggered by overgrazing.

The soils in the first watershed were generally characterised by Phaeozems, but also Luvisols (macro plot 1) and Regosols (macro plot 5 and 6)) were found. The soils were developed in a loess deposit which was calcareous in at least the C horizon, but sometimes also in the A and B horizons. During snowmelt macro plot 1 was partly flooded by the nearby stream and the deposition of new soil occurs.

In the first watershed the walnut forest was better developed on the northern slope than on the southern slope. In the latter the vegetation was more dominated by shrubby vegetation (mainly species of *Acer, Prunus* and *Malus*).

In the second watershed (macro plots 7 – 10) walnut forest was the dominating forest type. The whole area was under a very strong influence of the people living in the surrounding villages. A large part of the forest showed clear signs of degradation. On the ground signs of digging can be seen on several places. Direct below macro plot 7 the walnut forest looks well developed and in a good shape. Here the A horizon was developed up to 100 cm deep. In and around macro plot 8 young walnut plants from a natural regeneration were found – a rare feature!

All the soils found in the second watershed are Phaeozems, except the one in macro plot 7 which was an Umbrisol. Also here the soils had developed in a loess deposition and were calcareous.

4.3. Discussion

Urumbash is a site with steep slopes, and an unstable soil (loess deposits). Compared to the TEMP-CA site in Sogot (in Arslanbob), dominated by walnut trees, Urumbash gives the impression of a less well developed walnut forest, with vegetation that shows all characteristics of a highly disturbed site. Two conditions that may cause degradation of the forest are:

1. The walnut trees prefer well developed loess soils with a high cation exchange capacity (CEC), high organic matter content, and a thick A horizon. At many places within the Urumbash site, however, the soil did not full fill these characteristics, especially on slopes exposed to the south.

2. The human impact on the area is very high. In spring and autumn cattle grazes in the forest and during the walnut harvesting many people camp in the forest. Signs of digging and soil transport can be found in many places, including signs of older and newer land slides.

Because the ground vegetation often has low coverage, the steep slopes are vulnerable to erosion processes.

Active measures should be taken in order to prevent further degradation. Priority should be given to an active land management that attempts to use vegetation to stabilize the soil on exposed places. It is also important to reduce the negative impact of human influence and to reduce the grazing intensity.

Because the local population depends on income from the forest, a reduction in the possibilities to get income from the forest should be compensated for by other income generating activities.

5 SOIL CHEMISTRY

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5.1 Methods

5.1.1 SAMPLING DESIGN

Soil samples were collected close to each of the 1-m^2 plots in order to produce soil data that are representative for the ground vegetation analysis. For details in sampling design, see chapter 3.1.1. The sampling design, restricted random sampling, also permits the use of statistics on the soil data.

Sampling spots were selected not to disturb leakage of water. The soil samples are therefore collected at a distance of 20-30 cm from the left, right and down-slope side of each 1-m^2 plot, i.e. not above any of the 1-m^2 plots. Apart from that, the spots were distributed evenly around the 1-m^2 plots, to make a representative sample. Soil was collected by genetic horizon, based on location and appearance. The soil from each soil horizon of the three spots at each 1-m^2 plot, were bulked into one composite sample of the soil horizon. It was attempted to collect equal amounts of soil from each spot, especially when the horizons were thick, i.e. in the B and C horizons. Two or more generic mineral soil horizons (usually A- and B horizons) are sampled. The O horizon (mixing of the fermentation (F) and humic (H) horizons) were not sampled at all sites since the O horizon was lacking in several of the 1-m^2 plots. The actual classification of the horizons at which the soil was collected can only be done after sampling and analysis. Due to the lack of data, especially regarding particle size distribution, a proper classification is still not conducted. However, an examination of the organic content, gave a good indication that the soil was collected as intended and correctly classified. The horizon notations mentioned are therefore used.

The soil from the A horizon was sampled by hand and with a small plastic spade. For the collection of B horizon samples, an Edelman auger was generally applied. There are several uncertainties connected with the soil sampling:

- It was sometimes difficult to separate the horizons due to similarities in colour or diffuse boundaries.
- Some places the A horizon was quite thin, which gives a high risk of contamination of the A horizon sample by soil from the O or B horizons.
- The use of the auger could produce mixing of horizons when they were thin.
- The bulking of the samples produces a risk of mixing of soil from different horizons due to spatial variation in soil profiles. This problem was attempted minimized by only bulking soil of equal colour.

Minimum and maximum soil horizon depths were noted, but the measurements were approximate as it was difficult to see down in the augered hole to determine where the borders between the different horizons were. Horizon colours were set subjectively using a Munsell colour chart.

5.1.2 SOIL CHEMISTRY PARAMETERS

The samples are to be analysed in duplicates (i.e. two parallels). In case of small sample size the parallels can be dropped and the parameters are to be prioritised in the listed order as given in Tab. 5.1.

Tab. 5.1. Description of chemical methods to be used for the soil analysis.

Parameters	Methods and comments	Reference
1. Dry matter	1. Gravimetric loss after drying at 105 °C	1. ISO11465
2. $pH_{H2O,KCl,CaCl2}$	2. pH in extracts of the soil	2. ISO10390
3. Total C	3. Manually or by HCN analyzer	3. ISO10694
4. Total N	4. Kjeldahl N	4. ISO11261
5. Effective exchangeable Ca,Mg,Na,K,Fe, Mn & Al and CEC	5. $BaCl_2$ at pH 8.1 extraction and the extractant analysed for Ca, Mg; Na, K, Fe, Mn and Al by FAAS. CEC found by replacing Ba with Mg and detecting loss of Mg	5. ISO13536
6. Loss on ignition (LOI)	6. Gravimetric loss after combustion	6. Krogstad 1992
7. Adsorbed PO_4	7. Extraction with H_2SO_4 and HCl or HCO_3^-; determination by CM	7. Olsen & Sommers 1982, Olsen 1953
8. Adsorbed SO_4	8. Extraction with PO_4. CM determination of SO_4	8. Tabatabai & Dick 1979
9. ICP-AES metal scan	9. Aqua regia sample digestion	9. Alex Stewart method
10. Adsorbed SO_4	10. HCl and water extracted SO_4 and the amount determined gravimetrically	10. ISO11048

Parameters 7 - 9 are only meant to be measured on mineral soil and not to be conducted on organic soils (i.e. LOI more than 20% w/w).

5.1.3 SOIL CHEMISTRY ANALYSES

Samples from Urumbash were analyzed at the Central laboratory of the Ministry of natural resources of the Kyrgyz Republic (Vogt & Wibetoe 2009).

5.1.3.1 Dry matter

The dry matter content (w_{dm}) or water content on a dry mass basis (w_{H2O}) is determined as described in ISO11465 using air-dried (20 ºC) soil passed through a 2.00 mm aperture sieve. Soil samples are dried using a Gallencamp Drying oven to constant mass at 105 ± 5º C for 12 hr. The difference in mass of an amount of soil before and after the drying procedure is used to calculate the dry matter and water contents on a mass basis. The factor w_{dm} and w_{H2O} are used in all the following methods (except: 8. Particle size distribution and 2. Soil pH) to correct for humidity in the air-dried sample.

5.1.3.2 Soil pH

A suspension of the air-dried soil passed through a 2.00 mm aperture sieve is made up in five times its volume of water. The pH of the suspension is measured using a pH meter (Mettler Toledo Seven Easy) as described in ISO10390.

5.1.3.3. Total and organic carbon (C)

Total C includes both inorganic and organic C. Inorganic C is principally found in carbonate minerals, whereas most organic C is present in the soil organic matter fraction.

The measurement of total C is conducted according to ISO10694 on air-dried soil passed through a 2.00 mm aperture sieve. This is conducted by a dry combustion technique on a LECO carbon analyzer (SC-225). The soil sample is oxidized to CO_2 at 940 ºC on CuO in a flow of oxygen-containing gas that is free from carbon dioxide; the released gases are scrubbed; and the CO_2 in the combustion gases is measured using an infrared (IR) detector.

Organic C is measured on 10% of the samples, making sure to include a broad span of LOI (see chapter. 5.1.3. 6) in the selected samples. The measurement of organic C is also conducted according to ISO10694. For the determination of organic carbon content, any carbonates present are previously removed by treating the soil with hydrochloric acid.

5.1.3.4 Total nitrogen (N)

Total N is determined as nitrogen of organic matters in the form of ammonia after digestion of organic matters by heating with sulphuric acid and mercury sulphate as catalist. Ammonium was determined using a Spectrophotometer Camspec.

5.1.3.5 Effective CEC

The potential CEC is determined as described in ISO 13536, determining also the sodium, potassium, calcium and magnesium in the barium chloride extracts of the soil. In strongly acid soils (i.e. $pH_{H2O}< 5.5$) also manganese, iron, boron and aluminium must be determined in the barium chloride extracts of the soil.

The CEC of the soil samples is determined in barium chloride solution buffered at pH = 8.1 using triethanolamine. The soil is first saturated with respect to barium by treating the soil three times with buffered barium chloride solution. Subsequently, a known excess of 0.02 M magnesium sulphate solution is added. All the barium present, in solution as well as absorbed, is precipitated in the form of highly insoluble barium sulphate and the sites with exchangeable ions are then readily occupied by magnesium. The excess magnesium is determined.

All elements were determined using an Atomic emission spectrometer with inductively coupled plasma ICP-AES Optima 5300DV.

5.1.3.6 Loss on ignition (LOI)

Procedure from Krogstad (1992):

Weigh a porcelain crucible using an analytical balance (m_1). Approx. 3 to 5 g air-dried soil passed through a 2.00 mm aperture sieve is weighted accurately using an analytical balance in the crucible (m_2) and glowed in a furnace at 550 ± 25 °C using a Carbolyte Muffle furnace for more than 3 hours. The crucible with dried soil must cool down for more than 30 minutes in an exicator before weighing (m_4).
Be aware that soils containing high amounts of organic matter easily get “blown away” when opening the exicator.

Calculations:

$$\%LOI = 100 - \frac{m_4 - m_1}{m_2} \cdot 100 - w_{H_2O}$$

Where m_1 = weight of crucible
m_2 = weight of air dried soil before heat-dried in chamber
m_4 = weight of crucible and soil after glowing
w_{H2O} = water content from (see chapter 5.1.3.1)

5.1.3.7 Available phosphate (P)

Principle:

The phosphate in acid and neutral soils (i.e. soil samples from 1-m^2 plots with an A-horizon having a pH_{H2O} < 7.5) is extracted using Mehlich's method and in alkaline soils (i.e. soil samples from 1-m^2 plots with an A-horizon having a pH_{H2O} > 7.5) using Olsen-P method.

The Mehlich's method uses a mixture of sulphuric and hydrochloric acid to de-sorb the phosphate according to the method described by Olsen & Sommers (1982). This method is effective in extracting Ca-P, Fe-P and Al-P in acid and neutral soils.

In the high pH soils (>7.5) the acid extractants become less effective. These soils contain free calcium carbonate which neutralizes the acid and prevents the extraction of P into solution. Instead, the Olsen's extractant (Olsen 1953) uses a buffered 0.5 M sodium bicarbonate solution ($NaHCO_3$ at pH 8.5) which is alkaline and designed for use on calcareous soils. This extractant suppresses Ca^{2+} by both the high HCO_3^- concentration and high pH, allowing phosphates to dissolve out of calcium phosphate minerals (by the common ion principle). This extractant is therefore excellent at extracting calcium-P, the dominant form of P in calcareous soils.

Reagents:

1. <u>Extracting solution, Mehlich's</u> :

Add 12 mL of conc. sulphuric acid (H_2SO_4) and 73 mL of conc. hydrochloric acid (HCl) to 15 litres of ion exchanged water. Dilute the solution to 18 litres with Milli-Q or double distilled ion exchanged water. This extracting solution is approximately 0.05N HCl and 0.025N H_2SO_4.

<u>Extracting solution, Olsen's</u> :

Dissolve 84.008 g dry $NaHCO_3$ with approx. 1.8 L of Milli-Q or double distilled ion exchanged water. Titrate the solution with NaOH to pH 8.5. Dilute the solution to 2 L in a volumetric flask. This extracting solution is approximately 0.5 M $NaHCO_3$.

2. <u>Molybdate-vanadate solution</u>:

Dissolve 25 g of ammonium paramolybdate [$(NH_4)_6Mo_7O_{24} \cdot 4H_2O$] in 500 mL of Milli-Q or double distilled ion exchanged water. Dissolve 1.25 g of ammonium vanadate (NH_4VO_3) in 500 mL of 1 N nitric acid (HNO_3). Mix equal volumes of these solutions. Prepare a fresh mixture each week.

3. <u>Standard phosphate solution</u>:

Dissolve 0.1098 g of potassium dihydrogen phosphate (KH_2P0_4) in 500 mL of extracting solution, and dilute the solution to 1L with the extracting solution. This solution contains 25 ppm of P.

Procedure:

<u>Mehlich's</u>

Add accurately approximately 5 g of air-dried soil passed through a 2.00 mm aperture sieve and about 200 mg of PA charcoal to a 50 mL flask or bottle, and then add 20.0 mL of the extracting solution. Shake the flask for 5 min in a mechanical shaker, and filter the mixture through Whatman No. 42 filter paper.

<u>Olsen's</u>

Add approximately 5 g of air-dried soil passed through a 2.00 mm aperture sieve and about a teaspoon of PA charcoal (carbon black) to a 200 mL flask or bottle, and then add 100.0 mL of the extracting solution. Shake the flask for 30 min in a mechanical shaker, and filter the mixture through Whatman No. 42 filter paper.

Detection:

Measure 4.00 mL of the extract into a glass vial, and add 1.00 mL of Milli-Q or double distilled ion exchanged water. Add 1.00 mL of reagent 2, and allow the tube to stand 20 min.

Prepare a standard curve from aliquots of reagent 3 in the range of 0.5 to 4 mL. Follow the same procedure described for the soil extract. Concentrations of P in the extract equal to 1 and 4 mL of reagent 3 give 25 and 100 ppm of P in the soil, respectively. Dilute the extracts ten times if the sample absorbency falls outside the standard range. Use acid washed glassware.

Use 420 nm incident light in the photoelectric colorimeter if no interference from interfering colour (e.g. from humic material). In case of organic material present in the extracts it is possible to clean the extracts by use of active coal, but the best is to measure the absorbency of the complex at 700 nm as the yellow colour of the humic material does not absorb radiation at this wavelength. Adjust the galvanometer to 100% transmission using a tube containing all the reagents except P.

Calculation:

$$\text{mmol "Adsorbed" } PO_4^{3-}\ kg^{-1} = \frac{(a-b)\cdot D \cdot V}{W \cdot \frac{w_{dm}}{100}}$$

where:

a	= concentration of PO_4^{3-} in diluted sample extract (mmol L^{-1})
b	= concentration of PO_4^{3-} in diluted blank (mmol L^{-1})
D	= dilution factor
V	= volume of extractant reagent used (20.0 or 100.0 mL)
W	= air-dry sample weight (mg)
w_{dm}	= moisture correction factor (see section 1)

5.1.3.8 Inorganic Sulphate adsorption

Principle:

The adsorbed and dissolved sulphate is extracted using 100 ppm of P (as $Ca(H_2PO_4)_2$) electrolyte according to Tabatabai & Dick (1979). The dissolved sulphate is extracted using 0.15% $CaCl_2$ described by Tabatabai (1982) Adsorbed sulphate is found by the difference between sulphate concentration in these two extracts.

Reagents:

Calcium phosphate monohydrate solution [$Ca(H_2PO_4)_2 \cdot H_2O$], 100 ppm of P:
Dissolve 0.41 g $Ca(H_2PO_4)_2 \cdot H_2O$ in about 700 mL ion exchanged water, and make to volume of 1.000L with ion exchanged water.

Calcium chloride dihydrate ($CaCl_2 \cdot 2H_2O$), 0.15%:
Dissolve 1.5 g of $CaCl_2 \cdot 2H_2O$ in about 700 mL ion exchanged water, and make to volume of 1.000 L with ion exchanged water.

Procedure:

Extract the adsorbed and soluble inorganic sulphate from the air-dried soil passed through a 2.00 mm aperture sieve by shaking 5 g of soil (< 2 mm) with 50.00 mL of 100 ppm P, and the soluble inorganic sulphate by shaking 5 g of air-dried soil (< 2mm) with 50.00 mL of 0.15% $CaCl_2$. Shake the $CaCl_2$-extracts for 30 min and the $Ca(H_2PO_4)_2$-extracts for 1 h. Filter the extracts through a Whatman no. 42 filter paper.

The sulphate in the extracts is determined using ion chromatography for major anions.

Detection:

When using IC to determine the sulphate concentration in the extracts the high concentration of organic matter and phosphate in the sample matrix will cause difficulties. Parts of the organic matter will adsorb to the analytical column and reduce its efficiency. This is avoided by pumping the sample to be run on the IC through a OnGuard cartridge that removes this organic matter. In order to separate the phosphate and sulphate peaks a more dilute (e.g. 75%) mobile phase has been found preferable.

Calculation:

$$\text{mmol "Adsorbed and soluble" } SO_4^{2-} \text{ kg}^{-1} = \frac{(a-b)\cdot D\cdot V}{W\cdot \frac{w_{dm}}{100}}$$

$$\text{mmol "Soluble" } SO_4^{2-} \text{ kg}^{-1} = \frac{(x-y)\cdot D\cdot V}{W\cdot \frac{w_{dm}}{100}}$$

$$\text{Adsorbed } SO_4^{2-} = \text{"Adsorbed and soluble" - "Soluble"}$$

where:
a = concentration of SO_4^{2-} in diluted sample calcium phosphate extract (mmol L^{-1})
b = concentration of SO_4^{2-} in diluted calcium phosphate blank (mmol L^{-1})
x = concentration of SO_4^{2-} in diluted sample calcium chloride extract (mmol L^{-1})
y = concentration of SO_4^{2-} in diluted calcium chloride blank (mmol L^{-1})
D = dilution factor
V = volume of extractant reagent used (50.0 mL)
W = air-dry sample weight (g)
w_{dm} = moisture correction factor (see section 1)

5.1.3.9. ICP-AES metal scan

The sample is dissolved in aqua regia and the solution is determined for Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, La, Mg, Mn, Mo, Na, Ni, Pb, Sb, Sc, Sr, Ti, Se, V, Y, Zn and Zr on the Atomic emission spectrometer with inductively coupled plasma ICP-AES Optima 5300DV according to the standard method used at Alex Stewart laboratories. Detection limit for Hg using ICP-AES (0.5 ppm) is similar to the maximum permitted limit in rural areas. In samples exceeding this limit (i.e. showing a significant concentration in the ICP scan) an expanded Hg analysis, using cold vapour adsorption, should be conducted.

5.1.3.10 Extractable sulphate

The water-soluble and acid-soluble sulphate is determined as described in ISO11048. The samples are extracted with dilute hydrochloric acid and water and the sulphate content in the extracts is determined by gravimetric method in which barium chloride is added to the extracts and the precipitate of barium sulphate is dried and weighted.

5.2 Results

5.2.1. SOIL CHEMISTRY DATA

Average soil chemical data for each horizon are presented in Tab. 5.2. Circum neutral to slightly alkaline pH conditions prevails at all the sampling plots, having the third highest pH among the studied TEMP sites. As commonly found the pH increases with depth mainly due to the decrease in organic content, based on Loss on Ignition (LOI). A strong correlation (i.e. $r > 0.7$) was found between LOI and the carbon content (% C_{tot}; $r = 0.792$), despite a high content of calcareous minerals (see below and chapter 4.3). Furthermore, both the LOI and % C_{tot} were as commonly found correlated to the high total nitrogen content (tot N; $r = 0.848$ and 0.822, respectively). Adsorbed sulphate (Ads. SO_4^{2-}) were the highest among the studied sites and decreased with depth along with the total N and adsorbed phosphate (Ads PO_4^{3-}) content.

Tab. 5.2. Average and quartiles of soil chemical characteristics. LOI is Loss on Ignition.

Horizon	Samples	pH_{H2O}	LOI	C total	Total N	Ads. PO_4^{3-}
	#		w/w %		µg/g	
A	48	7.43 7.49 – 8.00	12 10 – 14	6.4 5.3 – 7.61	5128 4163 – 6175	210 99 – 190
B	36	7.49 7.65 – 7.95	5.2 4.1 – 6.0	3.2 2.6 – 3.6	2155 1801 – 2538	43 20 – 50
C	27	7.70 7.69 – 7.92	3.5 2.2 – 4.0	3.6 3.3 – 3.8	1129 901 – 1358	20 15 – 23

In addition to silicates (SiO_2; not measured) the main (avg. value > 3.5 mg/g) oxide composition of the mineral soils (Fig. 5.1) shift from aluminium (Al) and iron (Fe) in the A and B horizon, to calcium (Ca) and Al in the C horizon. The data indicate that the soil mineral base cation (Ca+Mg+Na+K) content increases down through the soil profile from about 45% in the A horizon to 60% in the C horizon. This fits well with the overall high soil pH found at this site.

The content of Fe is as usual strongly correlated to Al (r = 0.951) and both Fe and Al are correlated to potassium (K; r = 0.846 and 0.840. respectively. Fe and Al are as always negatively correlated to Ca, though the correlation is poor (r = -0.664 and -0.657, respectively. K is also strongly negatively correlated to Ca (r = -0.824)

The major oxide elements presented in Fig. 5.1 are followed in abundance by titanium (Ti), manganese (Mn), phosphorous (P), and barium (Ba) (Tab. 5.3). Ti and lanthanum (La) are strongly correlated (r = 0.718), and Ti is negatively correlated to % C_{tot} (r = -0.566). Both Ti and La are as usual positively correlated to Al (r = 0.780 and 0.835) and Fe (0.712 and 0.895), in addition to the trace elements scandium (Sc; r = 0.779 and 0.811) and vanadium (V; r = 0.736 and 0.852. Ti and P have the highest values among the studied sites. Total phosphorous (P) was positively correlated to Ads. PO_4^{3-} (r = 0.705) and tot N (r = 0.712), and negatively correlated to Ca (r = -0.732). Mn was correlated to Fe (r = 0.806), Al (r = 0.795) and K (r = 0.849) as well as a number of trace elements. Mn was negatively correlated to Ca (r = 0.904) and the trace element Sr. Ba was not found to be strongly correlated to any parameters.

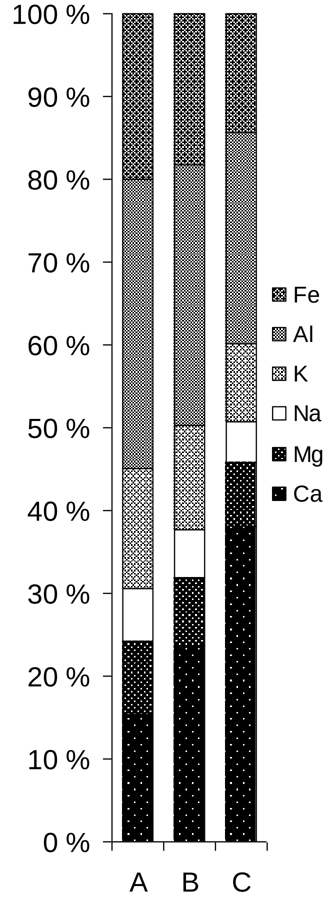

Fig. 5.1. Main (avg. value > 3.5 mg/g) oxide composition of the mineral soils.

Tab. 5.3. Average and quartile range of soil content of less abundant oxide elements in 48 A, 36 B and 27 C horizon samples from Urumbash.

Horizon	P	Mn	Ti	Ba
	mg/kg			
A	963	848	3706	568
	837 - 1059	782 - 910	3547 - 3848	513 - 607
B	831	802	4026	570
	741 - 873	706 - 903	3903 - 4229	510 - 627
C	617	676	3772	521
	554 - 687	646 - 704	3596 - 4007	487 - 547

Soil composition of measured trace elements along with the composition of continental crust (Taylor & McLennan 1985) and selected heavy metal contamination norms (Lacatusu 1998) are presented in Tab. 5.4. The bedrocks in the studied sites are generally secondary sedimentary minerals. The contents of hard (type A) trace elements (i.e. Y, Sr, Sc, V, Co and Ni) are therefore generally depleted compared to continental crust as found in all the TEMP sites. Nevertheless, the heavy metal (Cd, Cu, Cr, Zn, Ni and Co) contents are generally high relative to normal background levels typically found in soils, and the values lies between the normal maximum levels and the various maximum allowable limits (M.A.L.) adopted by different countries (see e.g. Naturvårdsverket 1997) for relevant values for forest soils) (Tab. 5.4). At Urumbash the content of Ba is below detection limit in all samples. The amount of Ti is the highest of the studied TEMP sites.

Tab.5.4. Average soil content of measured trace elements in 50 A and B horizon and 35 C horizon samples from Urumbash.

Site	Hor	As	Ba	Sr	Pb	Cd	Cu	Cr	Zn	Ni	Co	V	Sc	Y	Zr	Be	Mo
								mg/kg									
Earth crust[1]		1.0	250	260	8.0	0.1	75	185	80	105	29	230	30	20	100	1.5	1.0
Normal Min[2]					0.1	0.1	1	2	3	2	1						
Normal Max[2]					20	1.0	20	50	50	5	10						
World mean[3]		6		300	10	0.06	20	100	50	40	8						
M.A.L. (Pl) [2]					100	3	100	100	300	100	50						
Urumbash	A	14	568	158	19	1.3	35	65	118	34	15	77	11	17	65	2.2	<5
	B	15	570	182	18	1.5	34	68	110	36	16	82	11	17	73	2.2	<5
	C	13	521	230	16	1.5	29	64	93	35	15	73	10	16	72	2.0	<5

[1] Taylor & McLennan 1985.
[2] http://eusoils.jrc.it/esdb_archive/eusoils_docs/esb_rr/n04_land_information_systems/5_7.doc
[3] World mean concentration in uncontaminated soils (Allaway 1968)

The Al and Fe content are strongly correlated to 9 of the 18 measured trace elements (Fig. 5.2). As usual the soft (or type B) metals lead (Pb), cadmium (Cd) and arsenic (As) and the hard (type A) elements strontium (Sr) are especially poorly correlated (i.e. $r < 0.3$). Soft metals (high covalent index) were instead generally found to be negatively correlated to hard (Type A) metals (e.g. Ca, Mg, and Sr). The variation in the content of hard element strontium (Sr) follow the other type A elements, such as Mg levels, though the correlation was poor ($r = 0.638$). This is also found in the other TEMP sites.

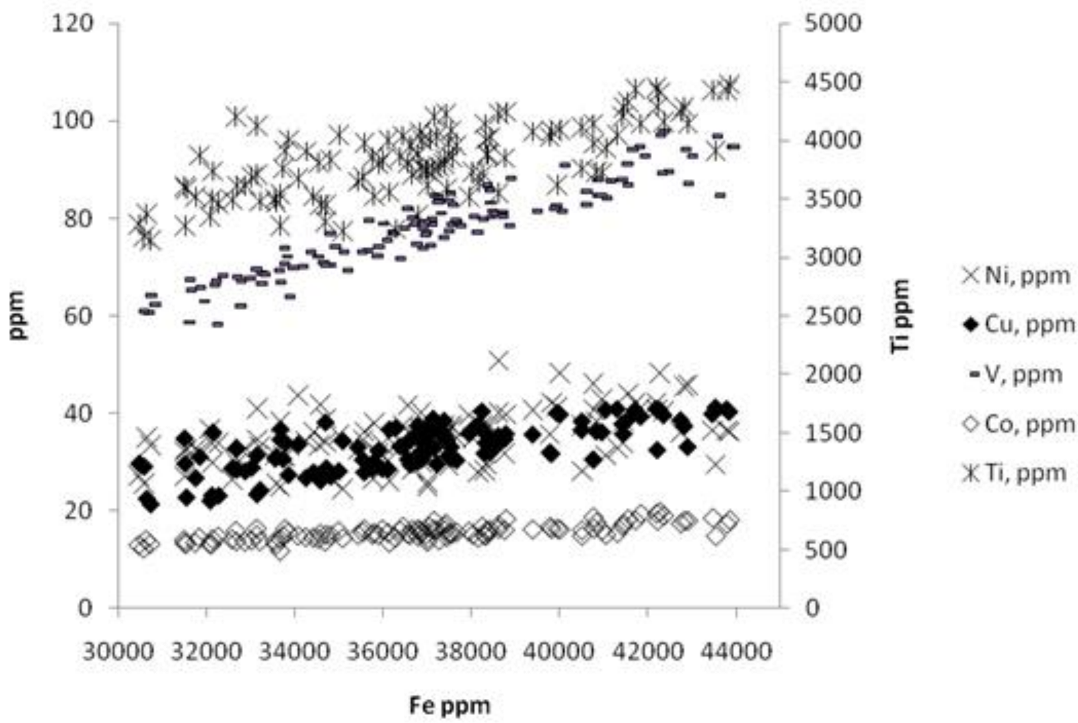

Fig. 5.2. Correlation between soil content of iron (Fe) and borderline trace elements; nickel (Ni), copper (Cu), cobolt (Co) and vanadium (V).

A number (19) of strong correlations were found between the 18 measured trace elements (Tab. 5.5). Some of the typical borderline elements Co, vanadium (V), Ti, Sc and lanthanum (La) showed the largest number of strong correlations (Tab. 5.5). The more typical soft (or type B) elements (Pb, Cd and As) and the hard (or type A) elements (Zr, Ba, Sr) were the poorest correlated to the other trace elements. The exception is as usual that few strong (r > 0.7) correlations were found for Ni. As noted above the amount of Ti was the highest among the studied sites.

Tab. 5.5. The strongest sets of correlations (i.e. r > 0.7) found for each of the measured 18 trace elements in 48 A-, 36 B horizon and 27 C horizon samples from Urumbash. The elements are sorted in the order of decreasing covalent index with type B elements on the top and type A elements in the bottom. - indicates no strong correlations (r < 0.7).

	# of corr.	Vs.	r
Pb	0	-	-
Mo	n.d.	n.d.	n.d.
Cd	0	-	-
As	0	-	-
Cu	2	Sr	-0.842
Co	4	Ti	0.814
Ni	1	Cr	0.911
Zn	0	-	-
V	6	Be	0.887
Ti	4	Co	0.814
Cr	1	Ni	0.911
Sc	7	Be	0.889
Y	3	Sc	0.849
La	5	V	0.852
Zr	0	-	-
Ba	0	-	-
Sr	1	Cu	-0.842
Be	4	Sc	0.889

5.3 Discussion

Fe has a scavenging effect on heavy metals. The role of Fe content as a governing factor for the soil chemical content of trace elements can clearly be illustrated by a Principal Component Analysis (PCA; performed byMinitab®). In the A horizon the PCA 1 and PCA 2 axes explains 44.3 and 16.5% of the variation in the data set, respectively. In the B horizon the PCA 1 and PCA 2 axes explains 55.1 and 9.8% of the variation in the data set, respectively. In the plane of the first two principal components (PCA 1 and PCA 2) in both the A and B horizons the Fe is clustered together with Al and several trace elements (Figure 5.3). Negatively loaded to this cluster along the PCA1 we find a cluster of Ca and Sr, together with $\%C_{tot}$. The PCA 1 axis is therefore mainly explained by a strong loading of Fe and Al on the one side and Ca on the other. The PCA 2 axis in the B horizon may partly be explained by the Covalent index ($CI = X^2r$) of the elements. Elements with low CI, commonly referred to as hard or type A elements, prefer to bind to carbonates, while elements with high CI, commonly referred to as soft or type B elements, forming more stable complexes, e.g. with sulphides. Type A elements (Ca, Mg, Na, K, Ba and Sr) have generally opposite loading to more Type B elements (Pb, Mo, Cd, As). Borderline metals have generally low loading along the PCA 2 axis. Instead they are strongly clustered with Fe and Al. In the B horizons PCA 2 is therefore correlated to the Covalent index with an r = 0.380.

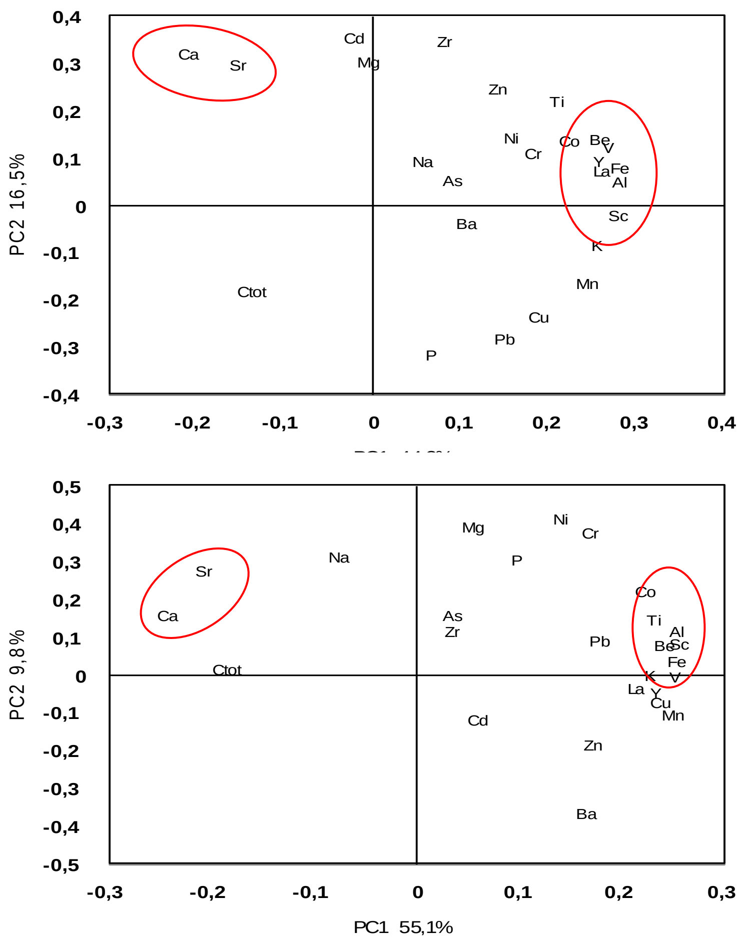

Figure 5.3. Parameter loading along the two first principal components in a PCA analysis of soil data from the A horizon (top graph) and B horizon (bottom graph), explaining 60.8% and 64.9% of the variation in soil elemental composition, respectively.

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