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

Establishment of monitoring reference area in Zaamin, Djizak Region, the Republic of Uzbekistan, 2008. TEMP-CA monitoring site No.8.

Tonje Økland[1], Gulusa Vildanova[2], Nurbek Kuldanbaev[3] & 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 Republic of Uzbekistan 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 Zaamin monitoring site in Djizak region in the Republic of Uzbekistan was the eighth of total 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.
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9: "Urumbash" in Jalal-Abad oblast, the Kyrgyz Republic .
10: "Umalak Teppa", Tashkent region, the Republic of Uzbekistan.

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 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. At this site *Juniperus seravschanica* and *Juniperus semiglobosa* were the dominant tree species. However, most of them were relatively small with trunk diameters of 5-15 cm. The defoliation of the juniper species was on average 30-39% but the proportion of discolorated trees was low. *Juniperus* species may be attacked by fungi, and the frequent cutting of branches for firewood in combination with climatic stress may increase the possibility for fungal attack.

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. Seventy-five plant species were recorded in the fifty 1-m^2 plots; 67 vascular plants, six bryophytes and two lichens. Vascular plants present in the 10x10 m plots and the 30x30 m plots were listed. Altogether 71 vascular plant species have been recorded in the plots, included the 67 species recorded in the 50 1-m^2 plots. Of these species 13 are endemic to Central Asia: *Astragalus severzovii, Carex turcestanica, Cerastium tianschanicum, Cicer songaricum, Cotoneaster racemiflora, Cousinia integrifolia, Crataegus turkestanica Eremurus kaufmanii, Oxytropis lehmanni, Ribes meyeri, Rosa eccae, Rosa kokanica,* and *Thymus seravschanicus.*

The recorded plant species number in total and average per plot was relatively high, compared to many of the other TEMP-CA monitoring sites. 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. Variation in influence of conifer trees, nutrient conditions, depth of the organic soil layer, altitude, grazing and micro-topography are some of the most important environmental factors influencing the species composition according to these results.

The parent material in Zaamin is in general limestone. The soils are weathered limestone or originating from slope processes. The dominant soil type is an Umbrisol. In the dry stream beds umbric Leptosols are found. In general the A and B horizon are decalcified. C horizons are generally calcaric. In the national park grazing is prohibited and no signs of erosion were found. Also the cutting of trees has been prohibited. Soil types found are Umbric Leptosols, Umbrisols and Leptic Cambisols.

The soils at Zaamin had among the highest average pH values of the TEMP sites. Strong correlation was found between the organic content (measured as Loss on Ignition) and the carbon (C) content (% Ctot; r = 0.747), despite a high content of calcareous minerals. The soil composition in the A and B horizons are fairly similar with base cations (Ca, Mg, Na, K) accounting for 43%, with the rest made up of acid cations (Al and Fe). In the C horizon the value for base cations increased to almost 70%. This fits well with the overall high soil pH found at this site. At Zaamin the content of most borderline trace elements (Cr, Ni, V, Mo, Sc, Y and Zr) are the highest of the studied TEMP-CA sites. The levels of vanadium (V) and zirconium (Zr) are especially high.

The content of iron (Fe) is as usual strongly correlated to aluminium (Al; r = 0.799), though the Al and Fe content are strongly correlated to only 4 and 5, respectively, of the 18 measured trace elements. As usual the hard (type A) and soft (type B) elements are especially poorly correlated. Soft metals (high covalent index) were instead generally found to be negatively correlated to hard metals. A large number (32) of strong correlations were found between the 18 measured trace elements. The typical borderline elements showed the largest number of strong correlations. The more typical soft and hard elements were the poorest correlated to the other trace elements. A Principal Component Analysis (PCA) of the metal content and chemical characteristics of the A- and B-horizons gave a main principal component (PC1), explaining practically half of the variation in the dataset. The PCA 1 axis was mainly explained by the Al and Fe content relative to calcium (Ca) and total carbon content, reflecting variations in the carbonate content of the soil. The parameter loadings along the PCA 2 axis was to a certain extent correlated to the Covalent index (CI = X2r) of the elements (r = 0.542 and 0.482 in the A and B horizons, respectively)..

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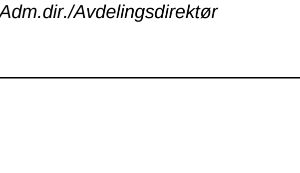

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NFG NORWEGIAN FORESTRY GROUP

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 Republic of Uzbekistan 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.

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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.
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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.:

T.A. Arykov, Aitkul M. Burhanov, , Aitbaev Djirgalbek Valievich, , Saltanat Narynbaeva, Nicholas Clarke, Muratbai Sh. Ganiev, Abdulhodi M. Halilov, Avaz Islomov, Jantoro Japarov, G.U. Karymbaeva, Abdushukur Khanazarov, Antonina, I. Knyaz'kova, Alisher Khodjaev, G.A. Kornilova, I.N. Kurochkina, Svetlana G. Nesterova, , Bakyt A. Mamytova, Oleg R. Mujdabaev, Saltanat R. Narynbaeva, Lyutsian Nikolyai, A.V. Polevaya, M. Rakimbek kyzy, T.A. Rudenko, L.G. Sasova, A.B. Satybaldieva, Beishekan Sultanova. 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, 10 November 2010

Tonje Økland

Project leader

CONTENT

INTRODUCTION

Nurbek Kuldanbaev[1], Gulusa Vildanova[2], Tonje Økland[3] & Odd Eilertsen,[3†]

1: The Public Foundation Relascope (Bishkek)
2: The National University of Uzbekistan
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Various terrestrial monitoring programs in Europe, North America and 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. Of the countries in Central Asia, only the Kyrgyz Republic and Kazakhstan have signed 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 3 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 (6 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 reform 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 Republic of Uzbekistan is not large: forests cover less than 3 % of the total area. The forestry sector in the Republic of Uzbekistan 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 broadly 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. Besides this, the main land degradation processes include salinization, 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 Republic of Uzbekistan 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 TEMP-CA 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 eighth monitoring site established in the TEMP-CA project, Zaamin in Djizak region, the Republic of Uzbekistan. This monitoring site was established in 2008. Measurements of a lot of variables for forest tree condition, forest growth, soil chemistry, and soil classification, ground vegetation, and environmental factors were performed in 2005 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 ZAAMIN REFERENCE MONITORING AREA

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Chori Turopov[5], Kuvanychbek S. Kasiev[4], Nurbek Kuldanbaev[1] and Farhat S. Asanov[4]

1: The Public Foundation Relascope (Bishkek)
2: The Uzbek Scientific Production Center for Agriculture (Tashkent)
3: The Tashkent State Agrarian University
4: The National Academy of Science (Tasjkent)
5: The Forest Protection Service, Main Forestry Department (Tashkent)

1.1 Geographical position of the reference monitoring area

1.1.1 GEOGRAPHICAL POSITION OF THE ZAAMIN NATIONAL PARK

The geographical position of the Zaamin National Park and other nine reference monitoring areas is shown in Fig. 1.1. The National Park is located in the territory of Zaamin district of Jizzak region in the southeastern part of the Republic of Uzbekistan and its territory covers 24110 hectares. The western part of the park (in the catchments of rivers Bajkungir and Guralash) has common border with the Bahmal forestry enterprise (Fig. 1.2). The northern border passes through southeast mountain range Malguzar and reaches the gorge Chorjangi. From the south it turns to the north and follows the small river Yettisu which is merging into Zaaminsu river until it reaches the Dugoba village. In the south the national park has common border with the Republic of Tajikistan on the Turkestan mountain range. On the east border the park passes through watersheds of the rivers Usmoni, Urikli and Sharildok. Some villages are located inside the territory of the National park. The biggest of them are Yettikechu, Karangisai, Takterak, Urikli.

Coordinates and altitudes for the 10 macroplots (see chapter 2.1.1) is given in Tab. 1.1.

Tab. 1.1. GPS coordinates of the 10x10 m macroplots with altitudes.

Plot number	Altitude	N	E
ZAM 1	2075 m	39°37.854′	068°30.114′
ZAM 2	2088 m	39°37.825′	068°30.179′
ZAM 3	2103 m	39°37.805′	068°30.115′
ZAM 4	2120 m	39°37.756′	068°30.140′
ZAM 5	2136 m	39°37.741′	068°30.174′
ZAM 6	2166 m	39°37.716′	068°30.217′
ZAM 7	2154 m	39°37.714′	068°30.160′
ZAM 8	2173 m	39°37.665′	068°30.142′
ZAM 9	2173 m	39°37.641′	068°30.034′
ZAM10	2173 m	39°37.665′	068°30.142′

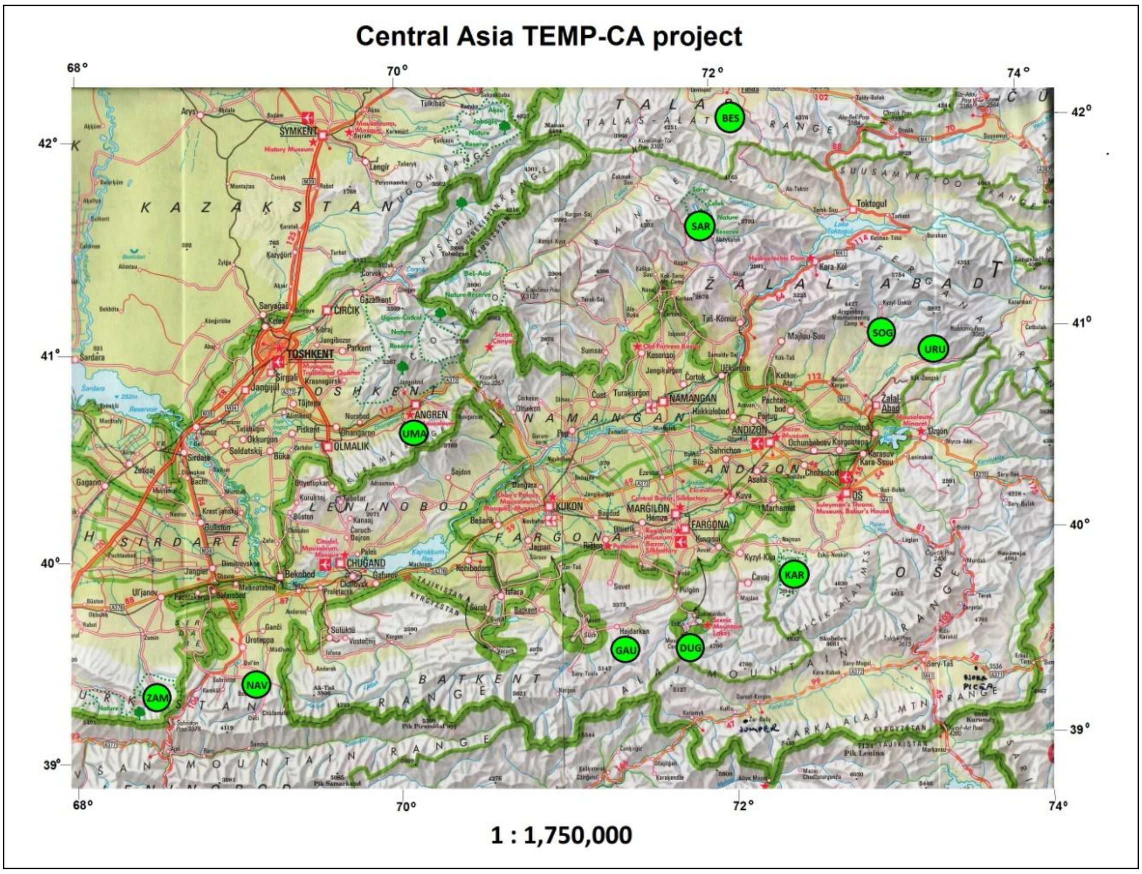

Fig. 1.1. Map of the Zaamin (ZAM) and the nine other TEMP-CA monitoring reference areas.

Fig. 1.2. Map with geographical position of the Zaamin national park.

1.2 Forest type and conservation status

Zaamin National Park is a protected area, with the purpose of protection and restoration of the natural unique juniper forests and the development of a recreational zone of the park.

The total area of the park is 24110 hectares, including 12130 hectares covered by forests, 16783 hectares of lands suitable for aforestation activity, and 7327 hectares of land not covered by forest. – non-forested lands. The territory of the national park is divided into three zones; protected zone, recreational zone and one buffer zone.

The main forest type is mountain juniper forests growing from the submountain region to the subalpine meadows. The forests are composed mainly of three species of juniper: *Juniperus turkestanica*, *J. seravschanica and J. semiglobosa*.

J. seravschanica occurs in the most xerophytic conditions. In the territory of the National Park it is found only on the southern slopes and mainly as solitary trees up to the altitudes of 2500 m. *J. semiglobosa* is found on the northern slopes up to the altitudes of 2500 m. In the lower part of this zone *J. seravschanica* is rather frequent. Up to 3000 m on the northern slopes and up to 3300 m on the southern slopes *J. turkestanica* is more frequent. In the upper part between 3000-3700 m above the sea level *J. turkestanica* forms elfin wood.

1.3 Geology, topography, and quaternary deposits

The park territory belongs to the Turkestan area of Middle-Zeravshan district of the Southern Tien-Shan province. Its landscapes are representative for all Middle Zeravshan districts.

The geological structure of the park is defined by its arrangement on the northern slope of the Turkestan range stretched in latitudinal direction almost 340 km and representing one of the largest anticlinal folds of Pamir-Alai, which was generated in Palaeogene. In the Zaamin national park there are extended metamorphized Paleozoic slates, sandstones, limestones, and rarely Mesozoic and Cainozoic deposits. It is the area of potentially high seismicity.

The high mountains are characterized structurally by a tectonic relief. The surface is strongly partitioned; rocks with abrupt slopes which are cut by narrow and deep gorges of mountain rivers prevail.

For middle mountains the structurally denudation relief is characterized by more smoothed forms. Rather high ridges are partitioned by valleys of rivers; their watersheds are cut up by streams. Valleys of rivers have fluvial relief forms, and they are expanded, their slopes are smoothened and terraced. The afforested slopes interferes the formation of mud flows.

1.4 Climate

The climate of the park is continental but influenced by the mountains of the Turkestan range on the south, south-east and the open north part. The values of day and night air temperature fluctuate considerably. The relative air humidity is low, precipitations fall mostly in winter period. The variation in topography causes the uneven distribution of solar energy and atmospheric precipitation around the territory. The annual precipitation quantity is between 450 and 560 mm, in some years up to 800 mm. The average annual air temperature in 2008 was +18 ^{0}C, maximum +32 ^{0}C in summer time and minimum -25 ^{0}C in winter time.

1.5 Vegetation zones

The vegetation of Zaamin national park consists of many species. They are replacing each other depending at altitude, slope, exposition, and soil conditions.
There are three vegetative zones on the territory of the national park:

1. Mountain steppe (plain zone)
2. Juniper zone
3. The zone of high-mountainous xerophytes

Mountain steppe (from 1300 up to 2100 m above sea level) occupies basically foothills and have small amount of precipitations. The vegetation is basically grassy plants such as xerophytes and ephemeras, rarely bushes.

The dominating tree species is *Juniperus semiglobosa*, rarely *J. turkestanica*. Acoording to Khanazarov (2003) *J. seravschanica* grows at low heights (1700-2300 m above sea level), *J. semiglobosa* occupies the middle mountain zones (2000-2500 m above sea level), and *J. turkestanica* high mountain zones (2500-3300 m above sea level). The juniper zone is rich of graminoids.

In high mountains xerophytes dominate. Due to the environmental conditions the soil layer is poorly developed, and in some places it is rocky. Rapid changes of temperature, dry air, and water erosion influence the vegetation, and the typical plants have pillow form.

1.6 Forest history, forest structure, and external influence

Zaamin National Park was established in accordance with the Decree of the Cabinet of Ministers of the Republic of Uzbekistan dated 8th September, 1976 and the appropriate Order of the Ministry of Forestry dated 29th June, 1978.

Zaamin National Park is located in Zaamin district of Djizak region on the northern slopes of Turkestan range. It was established with the purpose of preservation of the unique landscape with natural conditions almost with no human impact and with rich fauna and flora More than 800 species of plants grow here and many of them are endemic. Many plants are of great economic importance.

Before the establishment the park was included in Zaamin Forestry Enterprise. Now Zaamin national park is related to the Main Forestry Department under the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan.

Juniper forests have earlier been considered to be unmanageable for artificial reproduction. Central Asian juniper species grows very slowly and are not easily naturally reproduced. However, single trees with age exceeding a thousand and even three thousand years occur in remote mountain regions.

There are two settlements situated close to the territory of Zaamin national park. The information about settlements and population is given in Tab. 1.2.

Tab. 1.2. Settlements and population of the territory close to Zaamin National park.

Settlement name	Number of homesteads (families)	Population (persons)	Distance from the border of the park (km)
Uryukli	32	Approx. 180	18
Usmoni	42	Approx. 380	30
Total	74	560	-

The main activity of the population is cattle breeding and agriculture. On the territory close to the national park strong degradation of juniper forests and grass cover is observed. The main reasons are unemployment of local inhabitants which have resulted in increased private cattle breeding and overgrazing, illegal logging by local population due to lack of energy sources (coal, wood). The un-regulated pasturing in mountains also leads to the degradation of forests.

The personnel quantity responsible for the national park is 15 inspectors, and the park is well protected from the logging and grazing. The vegetation is thus not suffering strongly from the human activities.

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.

Diameter at breast height was recorded on 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 dominating tree species in the Zaamin area are *Juniperus seravschanica* (56.4 %) and *J. semiglobosa* (43.6 %) (Fig. 2.1).

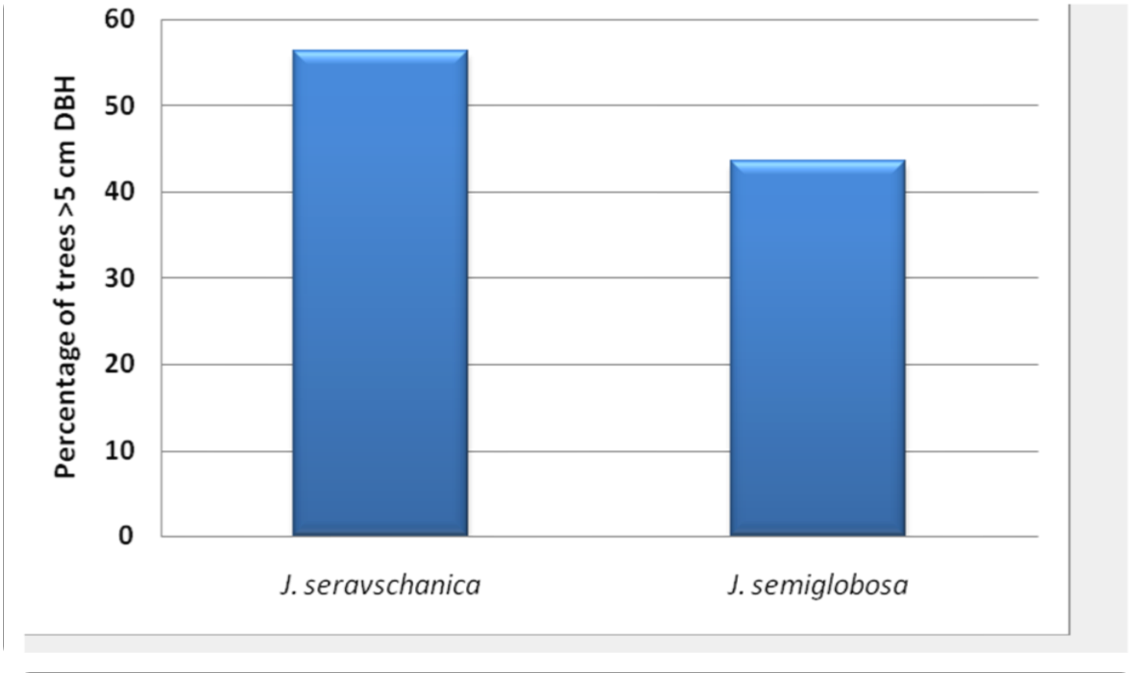

Fig. 2.1. Tree species composition across all plots.

2.2.2 TREE CONDITION

The highest defoliation was recorded for *J. seravschanica* (Fig. 2.2) where the average is about 40%. However, the defoliation of *J. semiglobosa* was also substantial, exceeding 30%. However, the proportion of trees with discoloration was very low (≤ 1.5%).

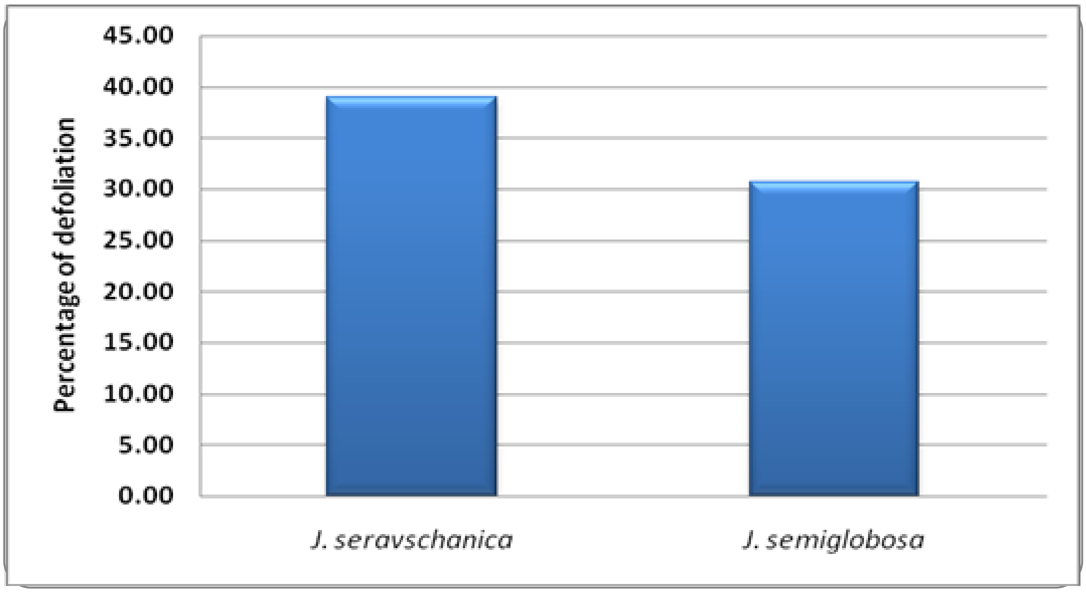

Fig. 2.2. Defoliation of the main tree species.

2.2.3. DEMOGRAPHY AND REGENERATION OF MAIN SPECIES

The size distribution (DBH) of *J. seravschanica* and *J. semiglobosa* was approximately the same, with a high proportion of small trees, and a sharply decreasing number of individuals with increasing DBH (Fig. 3. 4). The two smallest size classes (DBH < 15 cm) made up 85.1% for *J. semiglobosa,* and 70.9% for *J. seravschanica*. Conversely, trees with DBH > 20 cm constituted 14.9% for *J. semiglobosa* and 29.1% for *J. seravschanica*. Eleven saplings of *J. seravschanica* (< 5 cm DBH) were found in the macro plots for ground vegetation monitoring.

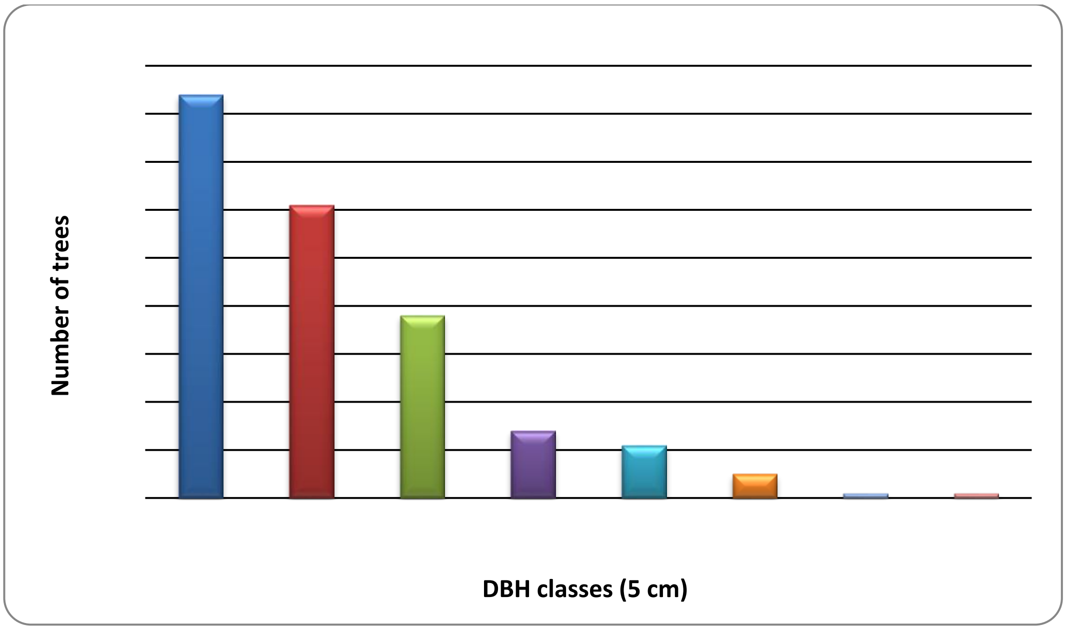

Fig. 2.3. Size distribution (DBH) of *J. semiglobosa* across all plots.

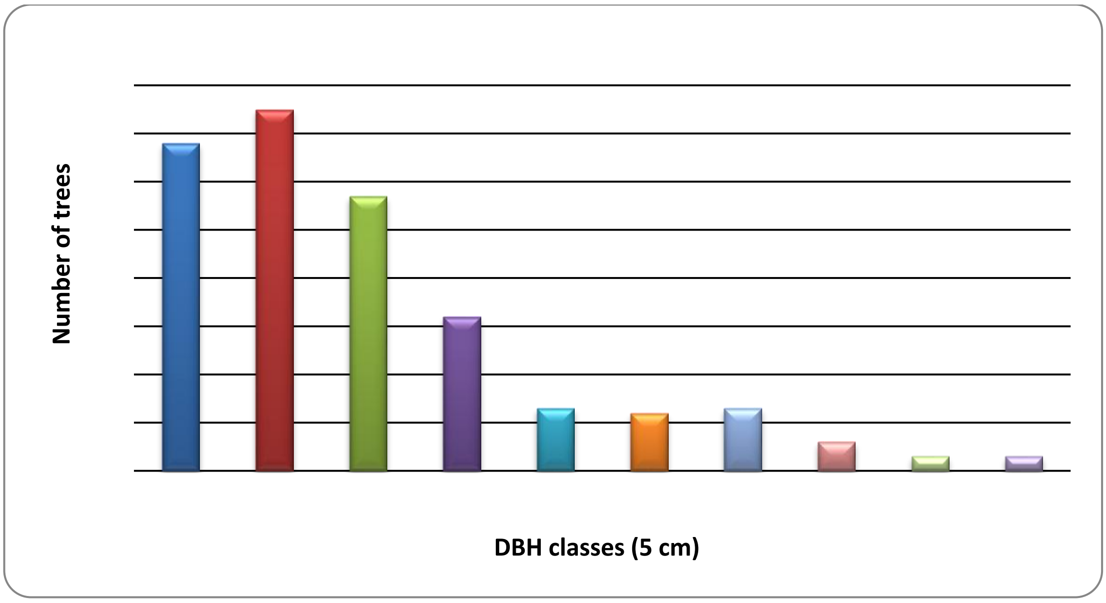

Fig 2.4. Size distribution (DBH) of *J. seravschanica* across all plots.

2.3 Discussion

Forest condition was evaluated by level of defoliation and proportion of trees with discolored needles/ leaves. These indicators are also 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. However, repeated assessments, which is the basic idea of monitoring, will always provide useful information about temporal forest development.

The defoliation of the *Juniperus* species was substantial; 30-39%. The reason for the low proportion of discolored trees could be that the discoloration preceded the defoliation, and that discolored needles/ leaves were already shed at the time of the assessment. The species might also have been attacked by fungal diseases, such as *Gymnosporangium* rusts and rot, which could affect tree vitality. Samples of needles, branches and wood should be collected for pathological and entomological investigations when the disease symptoms are observed.

Sufficient regeneration is fundamental for sustainable forests. According to the *size distributions* of the tree species at this site the greatest number of individuals was found among the smallest size classes (Fig. 2.3 and 2.4). This is particularly evident for *J. seravschanica*, for which also saplings (DBH < 5 cm) were recorded in the 1-m^2 plots for ground vegetation monitoring. Although we lack similar data for *J. semiglobosa* the high proportion of small trees (5-10 cm DBH) suggests adequate regeneration. The site has been exposed to frequent drought episodes during which saplings may be easily wiped out. Accordingly, assessment of the regeneration should be more thorough and specific, with emphasis on possible determining factors, such as drought and grazing.

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

Fig. 3.1. Recording abundance of species in a 1-m^2 plot.

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

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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.

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.

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:

LitterIi = (di / cri) × cci × cai × (hi - chi)

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

LitterI = ∑i (di / cri) × cci × cai × (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:

LitterIi = (di / cri) × cci × cai × (hi - chi)

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

LitterI = ∑i (di / cri) × cci × cai × (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:

LitterIi = cci × cai × (hi - chi)

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

LitterI = ∑i cci × cai × (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:

a. Domestic animal grazing condition
b. Grazing intensity
c. Average grass height
d. Average herb height
e. % cover animal manure/dung

f. % cover animal traces/footprints
g. % cover animal tracks
h. % browsing damage on woody plants for each species
i. % 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 de-trending 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 3.1. The number of vascular plant species within macro plots was calculated as: (a) the sum of species recorded within the five 1-m^2 plots in each 10x10 macro plot, (b) the total number of species recorded in each 10x10 m macro plot included the species in the 1 m^2 plots, and (c) the total number of species in each 30x30 m extended macro plot included the species recorded in the 1-m^2 plots (c), Tab. 3.1. The ratio a/b and a/c was calculated for each macro plot.

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	23	26	32	0.88	0.72
2	16	18	21	0.89	0.76
3	31	35	38	0.89	0.82
4	18	24	29	0.75	0.62
5	28	29	32	0.97	0.88
6	20	23	27	0.87	0.74
7	21	21	22	1.00	0.95
8	26	30	35	0.87	0.74
9	22	26	27	0.85	0.81
10	23	23	35	1.00	0.66
Total number	**67**	**69**	**71**	**0.97**	**0.94**

The maximum number of species recorded in any 1-m^2 plot was 23, while the minimum number was 6. The average number of species recorded in the 1-m^2 plots was 12.3.The total number of species recorded within the 50 1-m^2 plots + ten 10x10m^2 plots was 69. The total number of species in the in the 50 1-m^2 plots + ten 30x30 m plots was 71. The maximum number of species recorded in any of the 10x10 m macro plots (the five 1-m^2 plots included) was 35 and the minimum number was 18. The average number of species in the 10x10 m macro plots (the five 1-m^2 plots included) was 25.5. The ratio a/b varied between 0.75 and 1.00 (Tab. 3.1). The ratio a/c varied between 0.62 and 0.95 in the macro plots.

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

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	Gramin -oids	Bryo-phytes	Lichens
1	0	0	20	0	3	4	2
2	0	0	13	0	3	2	0
3	0	2	25	0	4	4	1
4	0	2	12	1	3	4	0
5	0	3	21	0	4	4	2
6	0	2	15	0	3	2	2
7	1	2	16	0	2	2	0
8	1	1	21	0	3	4	2
9	1	1	16	1	3	4	1
10	1	1	17	1	3	2	0
Total number	**1**	**7**	**53**	**1**	**5**	**6**	**2**

DCA ordination of 50 plots is shown in Figs. 3.2 – 3.4. Gradient lengths (β-diversity) and eigenvalues for DCA 1-4 are given in Tab. 3.3.

3.2.2 MAIN GROUND VEGETATION GRADIENTS

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

	DCA 1	DCA 2	DCA 3	DCA 4
Eigenvalues	0.493	0.219	0.157	0.102
Gradient lengths	3.541	1.953	2.341	1.453

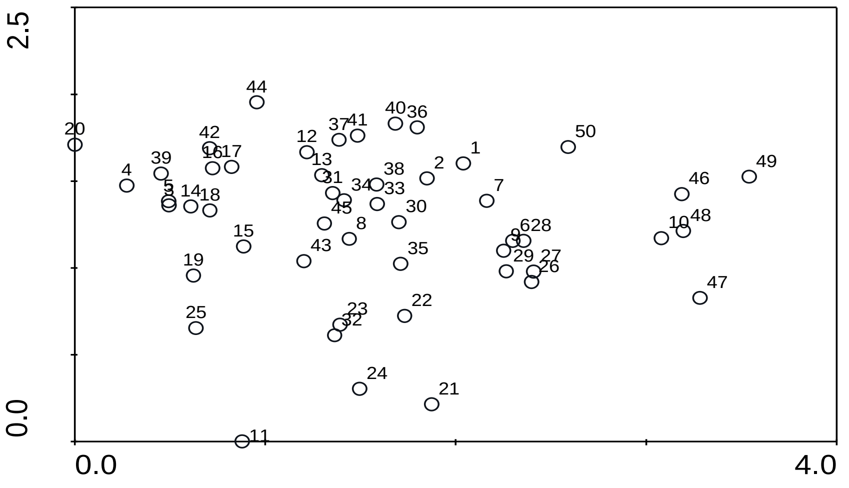

Fig. 3.3. DCA ordination of 50 1-m^2 plots, axes 1 (horizontal) and 3 (vertical). Plot numbers are plotted onto the sample plot positions. Scaling of axes in S.D. units.

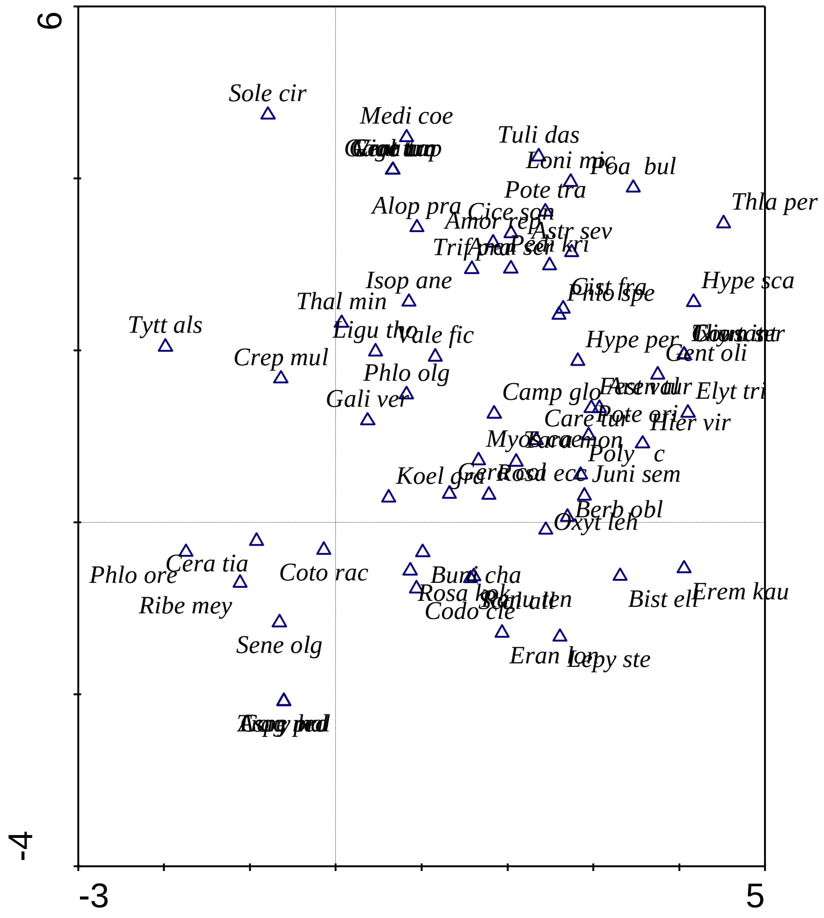

Fig. 3.4. DCA ordination of species in the 50 1-m² plots.

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.

	DCA 1	P	DCA 2	P	DCA 3	P	DCA 4	P
DCA 1	1.000	0.000	-0.122	0.213	-0.006	0.953	0.079	0.417
DCA 2	-0.122	0.213	1.000	0.000	-0.043	0.658	0.091	0.353
DCA 3	-0.006	0.953	-0.043	0.658	1.000	0.000	0.158	0.106
DCA 4	0.079	0.417	0.091	0.353	0.158	0.106	1.000	0.000
Inclination	0.134	0.177	0.019	0.847	0.037	0.706	0.144	0.147
Aspect	0.113	0.251	-0.032	0.744	0.121	0.218	-0.039	0.694
Aspectfav	-0.131	0.186	-0.083	0.402	0.208*	0.035	-0.056	0.569
Heatindex	-0.056	0.564	-0.074	0.447	**0.328****	**0.001**	0.012	0.900
Max. inclination	-0.042	0.669	-0.082	0.406	0.041	0.681	0.066	0.508
Sum conc. 1x1m	-0.128	0.210	-0.131	0.198	-0.054	0.600	-0.135	0.187
Var. conc. 1x1m	-0.222*	0.027	0.021	0.833	**-0.267****	**0.008**	-0.073	0.464
Abs.sum conc. 1x1m	-0.178	0.081	-0.008	0.939	**-0.299****	**0.003**	-0.125	0.221
Sum conc. 3x3m	-0.223*	0.030	-0.147	0.154	-0.026	0.799	-0.234*	0.023
Var. conc. 3x3m	**-0.320****	**0.002**	0.066	0.520	-0.093	0.361	-0.176	0.084
Abs.sum conc. 3x3m	**-0.383****	**0.000**	0.050	0.629	-0.097	0.346	-0.150	0.147
Relascope conifer trees	**-0.478****	**0.000**	0.040	0.687	**0.262****	**0.009**	0.003	0.973
Relascope total	**-0.478****	**0.000**	0.043	0.668	0.255*	0.011	-0.001	0.993
Crovn cover index	**-0.260****	**0.008**	0.112	0.252	0.061	0.530	0.050	0.610
Litter index	-0.246*	0.018	-0.099	0.341	0.176	0.090	0.075	0.470
Average grass height	-0.147	0.147	0.118	0.245	**-0.268****	**0.008**	**-0.295****	**0.004**
Average shrub height	-0.173	0.129	-0.190	0.095	-0.061	0.590	-0.016	0.890
Max. soil depth	-0.229*	0.020	-0.112	0.255	0.167	0.091	0.033	0.738
Min. soil depth	-0.093	0.348	-0.110	0.268	0.146	0.140	0.088	0.374
Med. soil depth	-0.111	0.259	-0.106	0.280	0.211*	0.031	0.103	0.295
Max. org. layer depth	**-0.415****	**0.000**	0.008	0.940	-0.004	0.967	-0.103	0.302
Min. org. layer depth	**-0.430****	**0.000**	0.056	0.574	0.018	0.860	-0.119	0.236
Med. org. layer depth	**-0.408****	**0.000**	0.023	0.815	-0.033	0.738	-0.107	0.276
Max. litter depth	-0.005	0.965	-0.077	0.462	0.024	0.815	0.200	0.056
Min. litter depth	0.024	0.821	0.006	0.958	-0.155	0.149	-0.071	0.509
Med. litter depth	-0.041	0.698	0.048	0.647	-0.065	0.540	0.110	0.296
Altitude	**0.308****	**0.002**	0.075	0.454	**0.308****	**0.002**	**0.276****	**0.006**
pH	0.160	0.169	-0.241*	0.039	0.111	0.342	0.033	0.776
H+	-0.160	0.169	0.241*	0.039	-0.111	0.342	-0.033	0.776
Dry matter	**-0.285****	**0.010**	-0.051	0.641	-0.226*	0.040	-0.264*	0.016
LOI	-0.177	0.108	-0.015	0.889	-0.221*	0.045	-0.064	0.560
Ctot	-0.203	0.066	-0.067	0.545	-0.149	0.177	-0.115	0.294
Ca	**-0.385****	**0.000**	-0.033	0.762	-0.192	0.081	-0.149	0.177
Mg	-0.077	0.484	0.005	0.963	-0.080	0.470	0.044	0.692
Na	0.028	0.806	0.012	0.916	-0.149	0.186	0.086	0.446
K	-0.126	0.253	0.101	0.363	-0.147	0.184	-0.067	0.544
CEC calc.	**-0.377****	**0.001**	-0.021	0.852	-0.215	0.050	-0.126	0.254
CEC	-0.030	0.795	-0.256*	0.025	-0.229*	0.045	-0.143	0.211

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

Total N	-0.054	0.625	-0.031	0.780	-0.251*	0.022	-0.064	0.560
PO4	-0.081	0.463	**0.334****	**0.003**	0.107	0.333	0.228*	0.039
SO4	-0.021	0.852	-0.003	0.981	-0.272*	0.014	-0.173	0.118
Ca, ppm	-0.226*	0.040	-0.187	0.089	-0.177	0.108	-0.195	0.077
Mg, ppm	**0.331****	**0.003**	-0.267*	0.015	0.149	0.177	0.187	0.089
Na, ppm	0.130	0.239	-0.178	0.105	-0.122	0.268	0.140	0.204
K, ppm	0.131	0.235	0.210	0.056	0.087	0.428	0.167	0.130
Al, ppm	0.272*	0.013	0.018	0.870	0.108	0.328	0.195	0.077
Fe, ppm	0.208	0.059	0.031	0.780	0.205	0.062	0.156	0.155
Mn, ppm	0.141	0.200	-0.123	0.263	0.138	0.208	0.028	0.798
Zn, pp	0.108	0.328	0.038	0.727	-0.085	0.442	0.123	0.263
Ca/LOI*100	**-0.444****	**0.000**	-0.067	0.545	-0.138	0.208	-0.238*	0.030
Mg/LOI*100	0.085	0.442	0.005	0.963	0.108	0.328	0.105	0.339
Na/LOI'100	0.074	0.505	-0.019	0.861	-0.074	0.505	0.082	0.462
K/LOI*100	-0.041	0.709	0.069	0.529	-0.074	0.499	-0.056	0.608
CECcalc/LOI'100	**-0.421****	**0.000**	-0.038	0.727	-0.131	0.235	-0.190	0.085
CEC/LOI*100	0.172	0.118	-0.251*	0.022	0.051	0.641	-0.095	0.389
Total N/LOI*100	0.133	0.226	-0.162	0.142	-0.203	0.066	-0.041	0.709
PO4/LOI*100	0.028	0.798	0.205	0.062	0.195	0.077	0.197	0.073
SO4, mkg/g/LOI*100	0.051	0.641	0.033	0.762	-0.208	0.059	-0.128	0.244
Ca, ppm/LOI*100	-0.200	0.069	-0.218*	0.048	-0.105	0.339	-0.128	0.244
Mg, ppm/LOI*100	0.246*	0.025	-0.110	0.316	0.249*	0.024	0.128	0.244
Na, ppm/LOI*100	0.179	0.103	-0.059	0.592	0.054	0.625	0.154	0.162
K, ppm/LOI*100	0.226*	0.040	0.044	0.692	0.156	0.155	0.128	0.244
Al, ppm/LOI*100	**0.297****	**0.007**	-0.008	0.944	0.208	0.059	0.149	0.177
Fe, ppm/LOI*100	0.256*	0.020	-0.003	0.981	0.223*	0.043	0.144	0.192
Mn, ppm/LOI*100	0.236*	0.032	-0.023	0.834	0.269*	0.014	0.169	0.124
P, ppm/LOI*100	0.003	0.981	-0.010	0.926	0.005	0.963	-0.054	0.625
Zn, ppm/LOI*100	0.159	0.149	0.054	0.625	0.044	0.692	0.097	0.376

3.3 Discussion

3.3.1 EVALUATION OF BIODIVERSITY

The plant species number recorded in the plots is relatively high compared to several of the other TEMP-CA monitoring sites. Several species are endemic for Central Asia. Most of the recorded species are herbs and as in most of the other TEMP-CA sites few bryophyte and lichen species were recorded. Herbaceous plants are represented by xeromorphic and thermophytic species.The shrubs layer includes *Berberis oblonga*, *Cotoneaster racemiflora*, *Lonicera microphylla*, *Ribes meyeri*, *Rosa kokanica* and *Rosa eccae*.

The field layer (graminoids and herbs) includes among others *Galium verticillatum, Hieracium virosum, Isopyrum anemonoides, Koeleria gracilis, Medicago coerulea, Oxytropis lehmanni, Pedicularis krilovii, Gentiana oliverii, Geranium transversale, Poa bulbosa, Phlomoides oreophila, Potentilla transcaspica* and *Bistorta elliptica.*

A high proportion of the species recorded in the macro plots are included in the species recorded in the fifty 1-m^2 plots, indicating that fifty plots is sufficient to include most of the forest plant species in the area.

3.3.2 INTERPRETATION OF GROUND VEGETATION GRADIENTS

The variable most strongly (negatively) correlated with DCA 1 was the variable *relascope sum of conifer trees* and *total relascope sum*, indicating that the tree density of juniper trees are important for the variation expressed along the main vegetation gradient. Variables expressing variation in micro-topography, depth of the organic soil layer and nutrient conditions (as e.g. *CEC* and content of *Ca* and *Mg* in soil), was also of the variables most strongly negatively correlated with DCA 1, while *altitude* was positively correlated along the same vegetation gradient. Thus the main complex-gradient corresponds to variation in vegetation (DCA 1) from sites with relatively low altitudes, high content of nutrients, dense juniper forest, deep organic soil layer and large variation in micro-topography (low DCA 1 scores), to vice versa.

Very few variables were significantly correlated with DCA 2; but content of phosphate in soil was positively correlated. Thus the variation in species composition along this gradient may partly be related to environmental variation not measured or expressed along the other DCA axes.

Heat index and *altitude* was the variables most strongly (positively) correlated with DCA 3, while average grass height, content of sulphate and nitrogen in soil were negatively correlated. Thus this gradient express partly variation in species composition is partly due to grazing and variation in topography.

The variation in species composition in ground vegetation in Zaamin is thus mainly due to influence by conifer trees affecting light and litter conditions as well as differences in altitude, topography, nutrient conditions and impact by domestic animals. This is more or less the same main complex gradients as in the juniper forest in the TEMP-monitoring reference area Kara-Koi in the Kyrgyz Republic.

3.4 Appendix

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

Scientific names of species:	**Uzbek names of species:**	**Russian names of species:**
Alopecurus pratensis	Мушук куйрук	Лисохвост луговой
Arenaria serpyllifolia	--	Песчанка тимьянолистная
Arenaria turkestanica	--	Песчанка туркестанская
Asperugo procumbens	--	Асперуга простертая
Astragalus severzovii	--	Астрагал Северцева
Berberis oblonga	Коракакнд	Барбарис продолговатый
Bistorta elliptica	Еркунок	Бисторта красивая
Bunium chaerophylloides	Хашаки зира	Буниум бутеневый
Campanulla glomerata	Кунгирок гул	Колокольчик скрученный
Carex turkestanica	Коракиек	Осока туркестанская
Cerastium tianschanicum	--	Ясколка тяньшанская
Cicer songaricum	Тог бурчок,нухат	Нут джунгарский
Codonopsis clematidea	Дугбай ут	Кодонопсис ломоносовидный
Corydalis ledebouriana	--	Хохлатка Ледебура
Cotoneaster racemiflora	Иргай	Кизильник кистецветный
Cousinia integrifolia	--	Кузиния цельнолистная
Crataegus turkestanica	Кизил дулана	Боярышник туркестанский
Crepis multicaulis	--	Скерда многостебельная
Cistopteris fragilis	--	Пузырник ломкий
Elytrigia trichophora	Тукли бугдойик	Пырей волосоносный
Eranthis longistipitata	Узунбандли эрантис	Весенник длинноножковый
Eremurus kaufmanii	Кауфман ширачи	Эремурус Кауфмана
Festuca valesiaca	Бетага	Типчак валезийский
Gagea capillifolia	Бойчечак	Гусиный лук
Galium verticillatum	Кумриут	Подмаренник мутовчатый
Gentiana oliverii	Газакут	Горечавка Оливьера
Geranium collinum	Анжабор	Герань холмовая
Geranium transversale	Анжабор	Герань поперечная
Hieracium virosum	--	Ястребинка ядовитая
Hypericum perforatum	Кизил пойча	Зверобой пронзенный
Hypericum scabrum	Дала чой	Зверобой шершавый
Ixiolirion tataricum	Чучмума	Иксиолирион татарский
Isopyrum anemonoides	Танга чуп	Равноплодник ветреницевидный
Juniperus semiglobosa	Саур арча	Можжевельник полушаровидный
Koeleria gracilis	Чиллак оек	Тонконог тонкий
Lepyrodiclis stellarioides	--	Пашенник костенечниковидный
Lonicera microphylla	Дук егоч	Жимолость мелколистная
Ligularia thomsonii	--	Бузульник Томпсона
Medicago coerulea	Беда	Люцерна голубая
Myosotis caespitosa	--	Незабудка дернистая
Oxytropis lehmanni	--	Остролодочник Леммана
Pedicularis krilovii	--	Мытник Крылова
Phlomis olgae	--	Зопник Ольги
Phlomoides oreophilla	--	Фломоидес горолюбивый
Phlomoides speciosa	Жадвар	Фломоидес красивый
Poa bulbosa	Кунгирбош	Мятлик луковичный
Polygala comosa	--	Истод гибридный
Potentilla transcaspica	--	Лапчатка закаспийская
Potentilla orientalis	Эшакгуль	Лапчатка восточная

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

Scientific names of species:	**Uzbek names of species:**	**Russian names of species:**
Ranunculus tenuilobus	Айиктовон	Лютик тонколопастной
Ribes meyeri	Коракат	Смородина Мейера
Rosa eccae	Наъматак	Роза Экке
Rosa kokanica	Кунгир наматак	Роза кокандская
Senecio olgae	--	Крестовник Ольги
Scaligeria allioides	Каргаоек	Скаллигерия луковичная
Solenanthus circinnatus	Оксеп	Трубкоцвет закрученный
Tytthostemma alsinoides	--	незначительнокоронник
Taraxacum montanum	Момакаймок	Одуванчик горный
Thalictrum minus	Санчикут	Василистник малый
Thymus seravschanicus	Какликут	Тимьян зеравшанский
Thlaspi perfoliatum	Тешикбарг тласпи	Ярутка пронзенная
Tragopogon malicus	Эчки сокол	Козлобородник маликский
Trifolium pratense	Утлок себарга	Клевер луговой
Trifolium repens	Туккиз тепа	Амориа ползучий
Tulipa dasystemon	Саргиш лола	Тюльпан волосистотычинковый
Valeriana ficariifolia	Асарун	Валериана чистяковолистная
Viola turkestanica	Туркистон бинафша	Виола туркестанская
Brachythecium albicans		
Brachythecium campestre		
Brachythecium velutinum		
Encalypta rhaptocarpa		
Hypnum lindbergii		
Tortula ruralis		
Cladonia sp.		
Peltigera sp.		

4 SOIL CLASSIFICATION AND SOIL DESCRIPTION

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2: The Public Foundation Relascope, Bishkek

4.1 Methods

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

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

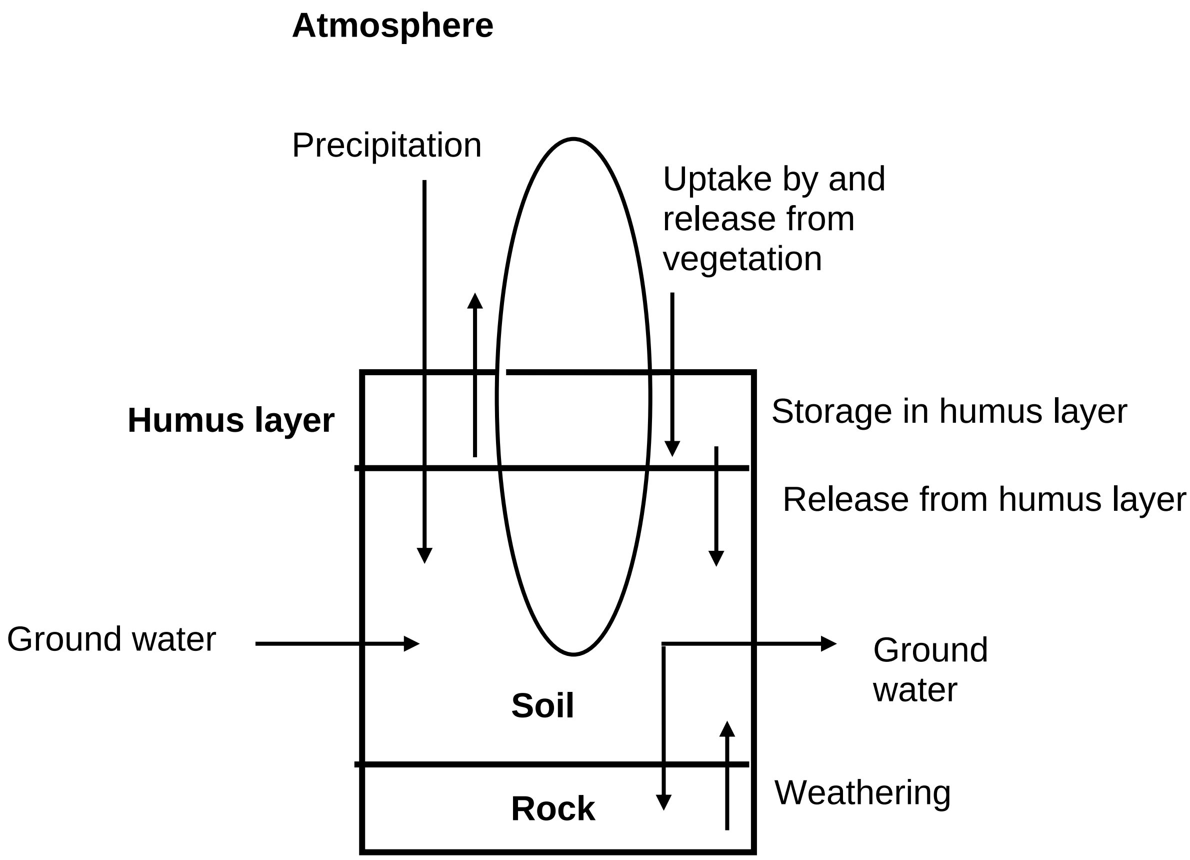

Fig. 4.1. Simplified model of biogeochemical cycling of elements.

The methodology for placing the macro plots and 1-m^2 vegetation plots is described in 3.1.1. During the 12th – 14th of May 2008 soil samples were taking from each 1-m^2 plot Weather conditions varied during the day. Generally in the morning it was dry, followed by thunderstorms later in the afternoon and evening. 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 gathered and put in a 0.5 litre sample box. After field work the boxes were stored at a cool and dry place.

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 and discussion

The parent material is in general limestone. The soils are weathered limestone or originating from slope processes, but only macro plot 10 is noted with limestone. The dominant soil type is an Umbrisol, but also Umbric Leptosols and Leptic Cambisols are recorded. In the dry stream beds umbric Leptosols are found. In general the A and B layer are decalcified. C layers were reacting with HCl. Under big trees the soil profile was less developed in comparison with more open vegetation. In these cases the C layer was closer to the surface.

The exposition is variable and two small streams are present in the area. Notes about the macro plots:

No. 2 is on a steep slope without an A-layer. Is on slate, and has a B-R profile.
No. 3 is in a dry stream bedding.
No. 4 is in a dry stream bedding.
No. 5 is open.
No. 6 is open.
No. 7 is in dense forest.
No. 8 is in dense forest.
No. 9 is on a very steep and moist slope.
No. 10 is open, on a very steep and dry slope without an A-layer, and has a B-R profile, with limestone.

Grazing is prohibited in the national park and no signs of erosion were found. Also the cutting of trees has been prohibited. Signs of wild pigs were present close to plot 10.

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 Edelmann 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 Gauyan were analyzed at the Central laboratory of the Ministry of natural resources of the Kyrgyz Republic in Bishkek (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. Extracting solution, Mehlich's :

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.

Extracting solution, Olsen's :

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. Molybdate-vanadate solution:

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. Standard phosphate solution:

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:

Mehlich's

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.

Olsen's

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:

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

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

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 second 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). Strong correlation (i.e. $r > 0.7$) was found between LOI and the carbon content (% Ctot; $r = 0.747$), despite a high content of calcareous minerals (see below chapt. 4.2). Furthermore, the LOI and % Ctot at this site were as commonly found correlated to the high total nitrogen content (tot N; $r = 0.816$ and 0.700, respectively) and phosphorous (P; $r = 0.735$ and 0.680, respectively). Adsorbed sulphate (Ads. $SO4^{2-}$) were generally high and decreased with depth along with the total N and adsorbed phosphate (Ads $PO4^{3-}$) content. In the C horizon more than 80% of the samples had Ads. $PO4^{3-}$ levels below the detection limit.

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	40	7.55	14	7.2	5073	94
		7.70 – 8.00	12 – 16	5.0 – 9.1	3873 – 6410	76 – 119
B	46	7.70	6.2	2.7	2352	81
		7.80 – 8.00	5.3 – 6.9	1.8 – 3.2	1917 – 2637	35 – 128
C	27	7.94	4.7	3.9	1555	2.1
		7.95 – 8.10	4.3 – 5.3	3.4 – 4.5	1057 – 1594	<1 – <1

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 in the A and B horizons are relatively high and increases further into the C horizon. The base cations constitute 44, 43 and 69% of the oxide composition in the A, B and C horizons, respectively. 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 = 0.799) and both Fe and Al are correlated to potassium (K) (r = 0.773 and 0.810, respectively).

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 = 0.880), and both elements are negatively correlated to % Ctot (r = -0.523 and -0.554), and as usual positively correlated to Al (r = 0.769 and 0.845) and Fe (0.568 and 0.763), in addition to the trace element Yttrium (Y) (r = 0.820 and 0.917). Total phosphorous (P) was correlated to LOI (r = 0.735) and tot N (0.715). Mn was not correlated to Fe and Al, or to base cations, nor any trace elements. Ba was found to be strongly correlated to Al (r = 0.775) and the trace elements beryllium (Be), chromium (Cr), zinc (Zn) and vanadium (V).

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.

Table 5.3. Average and quartile range of soil content of less abundant oxide elements in 40 A, 46 B and 27 C horizon samples from Zaamin.

Horizon	P	Mn	Ti	Ba
	mg/kg			
A	842	771	2898	520
	767 – 907	703 – 831	2501 – 3220	427 – 601
B	645	737	3288	764
	604 – 677	708 – 790	3013 – 3534	631 – 873
C	504	551	2409	620
	466 – 545	446 – 565	2037 – 2502	460 – 711

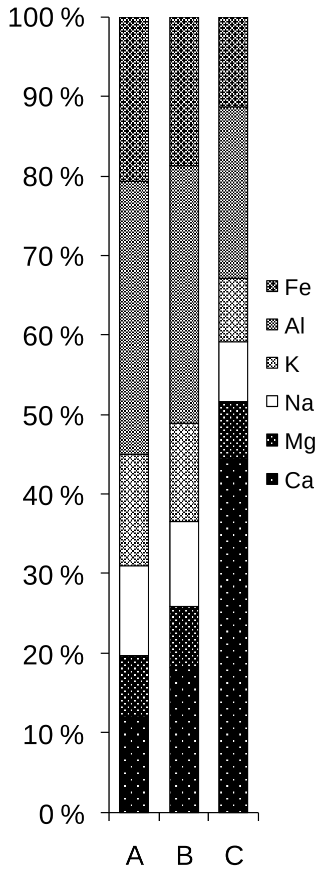

Fig. 5.1. Main (avg. value > 3.5 mg/g) oxide composition of the mineral soils.

The bedrocks in the studied sites are generally secondary sedimentary minerals. The contents of hard (type A) trace elements (i.e. Sr, Cr, V, Sc and Y) 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). The value for Cr lies slightly above the allowable limit. At Zaamin the content of most trace elements (Cr, Ni, V, Mo, Sc, Y and Zr) are the highest of the studied TEMP sites. The main exception is Pb, which is as usual found within the normal range. The levels of V and Zr are especially high.

The Al and Fe content are strongly correlated to only 4 and 5, respectively, 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. Molybdenum (Mo) gave no significant correlations due to a vast majority of samples below detection limit.

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

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						
Zaamin	A	12	520	211	12	1.1	38	93	123	46	17	115	11	17	104	2.2	<5
	B	14	620	193	12	1.4	48	101	144	53	20	161	13	19	132	2.6	14
	C	14	506	293	8.6	1.3	39	81	115	43	16	116	10	17	100	2.0	6.9

[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 (Allaway1968)

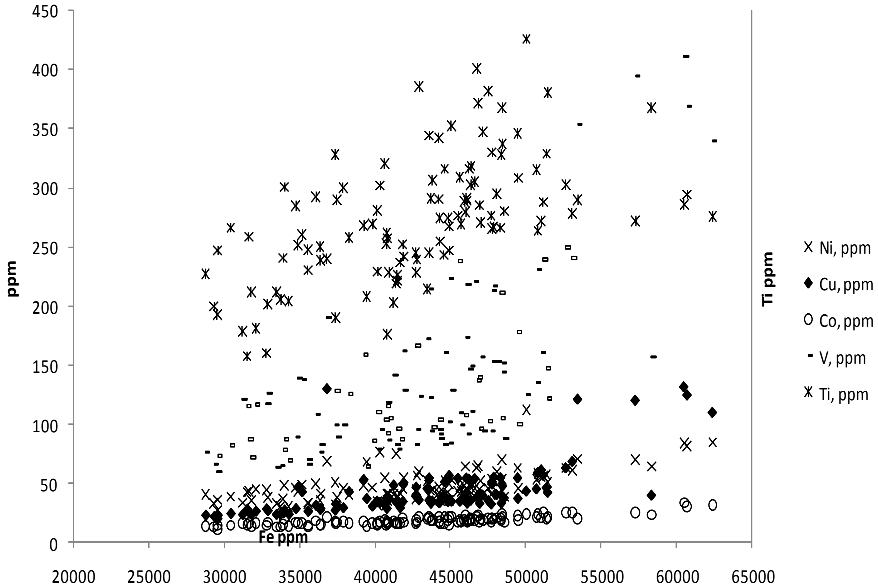

Fig. 5.2. Correlation between soil content of Iron (Fe) and typical borderline trace elements nickel (Ni), copper (Cu), cobolt (Co) vanadium (V) and titanium (Ti).

Tab. 5.5. The strongest sets of correlations (i.e. r > 0.7) found for each of the measured 18 trace elements in 40 A-, 46 B horizon and 27 C horizon samples from Zaamin. 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 (r > 0,7) correlations.

Elements	# of corr.	Vs.	r
Pb	0	-	-
Mo	-	-	-
Cd	2	Zn	0.724
As	0	-	-
Cu	4	V	0.892
Co	8	Be	0.893
Ni	2	Cr	0.768
Zn	6	Cu	0.874
V	5	Cu	0.892
Ti	2	La	0.880
Cr	7	La	0.787
Sc	5	Be	0.874
Y	5	La	0.917
La	6	Y	0.917
Zr	2	Sr	0.713
Ba	3	V	0.763
Sr	1	Zr	0.713
Be	7	Co	0.893

A large number (32) of strong correlations were found between the 18 measured trace elements (Tab. 5.5). As usual the typical borderline elements Co, Zn, Vanadium (V), chromium (Cr) and lanthanum (La) showed the largest number of strong correlations (Tab. 5.5). The more typical soft (or type B) elements (Pb, Mo, Cd and As) and the hard (or type A) elements (Ba, Sr) were the poorest correlated to the other trace elements. The exception is that few strong (r > 0.7) correlations were found for Ni. The amount of Zn was the highest among the studied sites, though the levels are not especially high.

5.3 Discussion

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) (Minitab®). In the A horizon the PCA 1 and PCA 2 axes explains 48.1% and 18.1% of the variation in the data set, respectively. In the B horizon the PCA 1 and PCA 2 axes explains 47.7% and 16.0% 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 most trace elements (Fig. 5.3). Negatively loaded to this cluster along the PCA 1 axis we find a cluster of Ca and P, 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 at these sites 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 A and B horizons the PCA 2 axis is therefore correlated to the Covalent index with an r = 0.542 and 0.482, respectively.

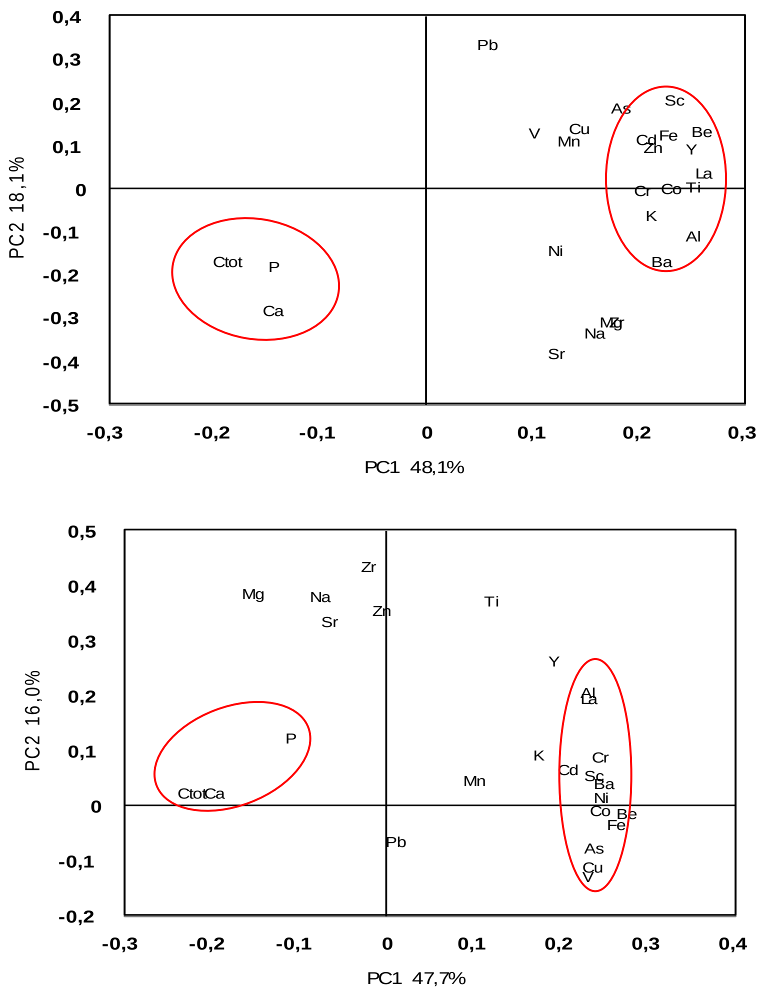

Fig. 5.3. Parameter loading along the two first principal components in a PCA analysis of soil data from the A horizon (top graph) and B horizon (bottom graph), explaining 62.4% and 71.8% of the variation in soil elemental composition, respectively.

6 REFERENCES

Allaway W.H. 1968. Agronomic controls over the environmental cycling of trace elements. Advan. Agronomy 29: 235-74.

Buttoud G., & Yunusova I. 2001. Modern aspects for multifunctional stable use of juniper forests in southern Kyrgyzstan. Materials of International symposium “Problems of juniper forests: retrieval of solution, ways and methods”. Bishkek, pp. 13-22.

Eilertsen O., Økland R.H., Økland T. & Pedersen O. 1990. Data manipulation and gradient length estimation in DCA ordination. J. Veg. Sci. 1: 261-270.

Heikkinen R.K. 1991. Multivariate analysis of esker vegetation in southern Häme, S Finland. Ann. Bot. Fenn. 28: 201-224.

Hill M.O. 1979. DECORANA - A FORTRAN program for detrended correspondence analysis and reciprocal averaging. - Cornell University, Ithaca, New York, USA.

Hill M.O. & Gauch H.G.Jr. 1980. Detrended correspondence analysis: an improved ordination technique. Vegetatio 42: 47-58.

ICP Forests 2006. II. Crown condition assessments. Manual on methods and criteria for harmonised sampling, assessments, monitoring and analysis of the effect of air pollution on forests. Part II. Visual assessment of crown condition. http://www.icp-forests.org/N8f/Chapt2_compl06.N8f.

ISO10390 1994. Soil quality - Determination of pH. International standard. 5pp.

ISO10694 1995. Soil quality - Determination of organic and total carbon after dry combustion (elementary analysis). International standard. 7pp.

ISO11048 1995. Soil quality - Determination of water-soluble and acid-soluble sulphate. International standard. 18pp.

ISO11261 1995. Soil quality - Soil quality - Determination of total nitrogen - Modified Kjeldahl method. International standard. 4pp.

ISO11465 1993. Soil quality - Determination of dry matter and water content on a mass basis - Gravimetric method. International standard. 3pp.

ISO13536 1995. Soil quality - Determination of the potential cation exchange capacity and exchangeable cations using barium chloride solution buffered at pH = 8.1. International standard. 7pp.

Kamelin R.V. 2002. Short essay about vegetation of Kyrgyzstan. In: Pimenov M.G.& Kluikov E.V. (eds) Umbelliferae of Kyrgyzstan. Moscow, pp. 5-18.

Kornet J.-G. & Rajapbaev M. 2004. Criteria and indicators of stable management of juniper forests in Southern Kyrgyzstan. Bishkek.

Krogstad T. 1992. Methods for soil analysis (In Norwegian). NLH report no. 6. Institutt for Jordfag, Ås-NLH, ISSN 0803-1304. 32pp.

Lacatusu R. 1998. Appraising levels of soil contamination and pollution with heavy metals. In: Heineke H.J., Eckelmann W., Thomasson A.J., Jones R.J.A., Montanarella L. & Buckley B. (Eds). ESB Research Report no. 4: Land Information Systems Developments for planning the sustainable use of land resources- EUR 17729 EN. 546pp. Office for Official Publications of the European Communities, Luxembourg. Pp. 393-402.

Lawesson J., Eilertsen O., Diekmann M., Reinikainen A., Gunnlaugsdóttir E., Fosaa A.M.

Carøe, I. Skov, F. Groom G., Økland T., Økland R.H., Andersen P.N. & Bakkestuen V. 2000. A concept for vegetation studies and monitoring in the Nordic countries. In: Tema Nord 517: 1-125.

Liu H.Y., Økland T., Halvorsen R., Gao J.X., Liu Q.R., Eilertsen O. & Bratli H. 2008. Gradient analyses of forests ground vegetation and its relationships to environmental variables in five subtropical forest areas, S and SW China. Sommerfeltia 32: 1-196.

Naturvårdsverket 1997. Bakgrundshalter i mark. Rapport 4640. Stockholm.

Økland R.H. & Eilertsen O. 1993. Vegetation-environment relationships of boreal coniferous forests in the Solhomfjell area, Gjerstad, S Norway. Sommerfeltia 16: 1-254.

Økland, R.H. & Eilertsen, O. 1996. Dynamics of understory vegetation in an old-growth boreal coniferous forest, 1988-1993. J. Veg. Sci. 7: 747-762.

Økland T. 1990. Vegetational and ecological monitoring of boreal forests in Norway. I. Rausjømarka in Akershus county, SE Norway. Sommerfeltia 10: 1-52.

Økland T. 1996. Vegetation-environment relationships of boreal spruce forest in ten monitoring reference areas in Norway. Sommerfeltia 22: 1-349.

Oksanen J., & Minchin P.R. 1997. Instability of ordination results under changes in input data order: explanations and remedies. J. Veg. Sci. 8: 447-454.

Olsen S.R. 1953. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U. S. Department of Agriculture. Circular 939.

Olsen S.R. & Sommers L.E. 1982. Phosphorus. In: Page A. L., Miller R. H. & Keeney D. R. (Eds.). Methods of Soil analysis, Part 2. Chemical and microbiological properties. Agronomy Monograph no. 9 (2nd edition) ASA-SSSA, S. Segoe., Madison, WI 53711, USA, pp. 403-430.

Parker K.C. 1988. Environmental relationships and vegetation associates of columnar cacti in the northern Sonoran Desert. Vegetatio 78: 125-140.

Ryazantseva Z.A. 1965. The Climate of the Kyrgyz SSR. - The Geography department of the Academy of Sciences of the Kyrgyz Republic. Frunze, Ilim, 291 pp.

Tabatabai M. A. 1982. Sulfur. In: Page, A. L., Miller, R. H. & Keeney. D. R. (Eds.). Methods of Soil Analysis, Part 2, Chemical and microbiological properties. Agronomy Monograph no. 9 (2nd edition) ASA-SSSA, S. Segoe., Madison, WI 53711, USA., pp. 501-538.

Tabatabai M. A. & Dick W. A. 1979. Ion chromatographic analysis of sulfate and nitrate in soils. In: Mulik J.D. & Sawicki E. (Eds). Ion Chromatographic Analysis of Environmental Pollutants, Vol. 2. Ann Arbor Science Publishers, Ann Arbor, Mich., pp. 361-370.

Taylor St.R. & McLennan S.M. 1985. The Continental Crust: its Composition and Evolution. Blackwell Scientific Publications (Oxford). Geoscience texts. 312 pp.

ter Braak C.J.F. & Šmilauer P. 1998. CANOCO reference manual and user's guide to Canoco for Windows: software for canonical community ordination (version 4). Microcomputer Power, Ithaca, N.Y.

Vogt R.D. & Wibetoe G. 2009. Assessment of Chemical analytical laboratories in Bishkek, Kyrgyzstan. Internal report to the TEMP-CA project. Norsk Institutt for Skog og Landskap. 18pp. Available at: http://www.folk.uio.no/rvogt/CV/Report/Lab_assessmentTEMP-CA.pdf

Zinkova Z.A & Pushkareva M.I. 1987. The Atlas of the Kyrgyz SSR. - Nature conditions and Resources Main department of Geodesy and mapping under Ministry SSSR. Geography department of the Institution of the Geology by Adishev M.M. under Academy of the Sciences of the Kyrgyz Republic. Moscow, p.157.