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

Establishment of monitoring reference area in Umalak Teppa, Tashkent region, the Republic of Uzbekistan, 2009. TEMP-CA monitoring site No.10.

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

1: "Kara-Koi" in the Osch oblast, the Kyrgyz Republic.
2: "Sogot in the Jalal-Abad oblast, the Kyrgyz Republic.
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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 plot (macro plot) five plots of 1-m^2 were randomly placed. All trees within the ten 30x30 m plots were marked on a sketch map and a number of tree growth and tree vitality measurements were recorded. The trees at the Umalak site consisted mainly of *Juniperus seravschanica* (99,2%). The two smallest size classes (DBH < 25 cm) represented 51.9% of the trees, indicating adequate regeneration. The size distribution was also characterized by a high proportion of trees in the intermediate size class (DBH 25-35 cm). Defoliation was 34.9%, which is a notable level according to the ICP Forests classification. Discoloration was almost insignificant. Juniper trees in the area are probably attacked by *Gymnosporangium*, since leaves of two secondary hosts (*Cotoneaster pseudomultiflora* and *Crataegus turkestanica*) were infected and juniper trees in the nearby Yangonkli-San site (the Ahangaran Forest Damage Project) was infected by the fungus. Frequent cutting of branches for firewood in combination with climatic stress may have increased the fungal attacks in the area and thus the vitality of the juniper trees.

Two abundance measures were recorded for all species in each of the fifty 1-m^2 plots: frequency in subplots (presence/absence of all species in sixteen subplots in the 1-m^2 plots) and percentage cover. A total of 79 species of vascular plants were recorded in the 50 1-m^2 plots, along with 7 bryophytes. 64 of the vascular plants were herbs. The total number of vascular plant species in the in the 50 1-m^2 plots + ten 30x30m^2 plots was 88. Of the recorded vascular plant, 11 are endemic to Central Asia: *Carex turkestanica, Allium barsczewskii, Arum korolkovii, Asrtagalus turkestanus, A. siversianus, Euphorbia jaxartica, Galium pamiroalaicum, Iris sogdiana, Pedicularis krylovii, Rosa kokanica*, and *Veronica bucharica.* Detrended Correspondence Analysis (DCA ordination) of the subplot frequency data for the fifty 1-m^2 plots was performed in order to reveal the most important vegetation gradients. The ordination axes, i.e. expressing the vegetation gradients, were interpreted by means of Kendall's non-parametric correlation coefficient. Differences in topography, soil moisture, soil depths, depths of organic layer and litter layer, tree density, influence of *grazing* and some nutrients are important environmental factors influencing the species composition in this monitoring are. Probably most of this variation is related do the difference between northern and southern exposed sites, as plots in the southern sites was more strongly influenced by grazing and soil erosion which may explain also the lower depths of the organic layer and litter layer etc. The difference between sites on different aspects was much more pronounced in Umalak Teppa than in most other TEMP-CA monitoring areas.

The environmental conditions in the Umalak Teppa monitoring area are diverse and this also influence the soil types: (i) slopes facing north and south, (ii) macro plots grazed (4 – 10) and ungrazed (1 – 3), (iii) north slope with loess and south faced slope with weathered gneiss and rhomb porphyry, (iv) loess soils with a calcareous C horizon (sometimes also the A horizon) while the weathered soils are degraded and sometimes are heavy clayey with rocky outcrops, and (v) sparse and small juniper trees on south faced slope, big and well developed on north faced slope. The soils on the north slope (macroplots 1 – 4 and 8 – 10) were Luvisols with soil texture varying from silty loam to loamy clay. The non-fenced part (macroplots 8 – 10) showed clear signs of overgrazing. Erosion features were common and in some places buried A horizons were found. Generally the south faced slope (macroplots 5 – 7) is steep and consists of weathered gneiss/rhomb porphyry rocky outcrops. The weathered material varies in texture from sandy silt to a loam to very heavy clay. The soil was not calcareous. The south slope is severely overgrazed and large parts are dominated by a species of the genus Erumurus. Soil types found are Regosol and Leptosol.

A pH around 7.5 prevail at all the sampling plots and soil horizons. The pH does not decrease from the A to the C horizon as commonly found, though the organic content decreases along with total Carbon content. Studying all samples (across horizons) we find that strong correlations (i.e. r > 0.7) between soil chemical characteristics were only found between % C_{tot} and loss on ignition (LOI) (r = 0.869) and Total N (r = 0.925) content. The soil content of adsorbed phosphate (Ads. PO_4^{3-}) is the lowest among the TEMP-CA sites. In addition to SiO_2 (not measured) the main (avg. value > 3.5 mg/g) oxide composition of the mineral soils is made up by iron (Fe) and aluminium (Al), followed by calcium (Ca) and potassium (K). Base cations (Ca+Mg+Na+K) in the A and B horizons account for about 40% of the oxide composition. The C horizon is richer in base cations, likely due to that the weathering has not been as active as in the A and B horizons. The content of lead (Pb) and cadmium (Cd) were generally high with values between the normal maximum levels and the various maximum allowable limits. The content of Fe and Al are strongly correlated (r = 0.808), as found in all TEMP-CA sites (except Navobod). Both Al and Fe are correlated to manganese (Mn) (r = 0.844 and 0.783, respectively). The Al content is also as commonly found co-vary with K (r = 0.856), in addition to sodium (Na) (r = 0.753) as there is a strong correlation between Na and K (r = 0. 914). A Principal Component Analysis (PCA) of the metal content and chemical characteristics of the A and B horizons gave a main principal component (PCA 1), explaining only 49% of the variation in the dataset in the A horizon, and 57% in the C horizon. The PCA 1 was mainly explained by the Al and Fe content relative to Ca and LOI in the A horizon and the total C content in the C horizon, reflecting variations in the calcium carbonate content of the soil.

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

Adm.dir./Avdelingsdirektør

Oppdragsrapport fra Skog og landskap 14/2011

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Cover Photo: Umalak Teppa, Photo: Adilet Usupbaev

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ABSTRACT

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

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

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

The Umalak monitoring site in Tashkent region, the Republic of Uzbekistan, was the tenth of ten monitoring sites established in forests 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.

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.

Aitkul M. Burhanov, Nicholas Clarke, Zukhriddin Fazylov, Muratbai Sh. Ganiev, Abdushukur A. Khanazarov, Zikrullaeva Khusniya, Antonina I. Knyaz'kova, Ramazan K. Kuziev, Bakyt A. Mamytova, Karine Mirumyan, Oleg R. Mujdabaev, Gayrat Aminovich Mukhammedov, Saltanat R. Narynbaeva, Svetlana G. Nesterova, Lyutsian Nikolya, Tokhir Nurulloev, Hamro S. Sabirov and Abdudjabbar Sharohmatov.

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, January 24. 2011

Tonje Økland

Project leader

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INTRODUCTION

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

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

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

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

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

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

The project mandate was:

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

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

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

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

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

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

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

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

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

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

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

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

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

1 DESCRIPTION OF THE UMALAK REFERENCE MONITORING AREA

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1.1 Geographical position of the reference monitoring area

The Umalak monitoring site is located on the northern macro-slope of the Kurama mountain range in the Tien-Shan mountain system (Figs 1.1, 1.2). The study area belongs to the Tashkent province in the Republic of Uzbekistan. The total area of the forestry enterprise, according to the data of the last forest inventory, is 183,466 hectares and consists of five separate sites, one of which is located on southern slopes of Chatkal range (Kendjagal) and the others are located on northern slopes of Kurama range (Almalyk, Gushsai, Akcha and Parkent forest units).

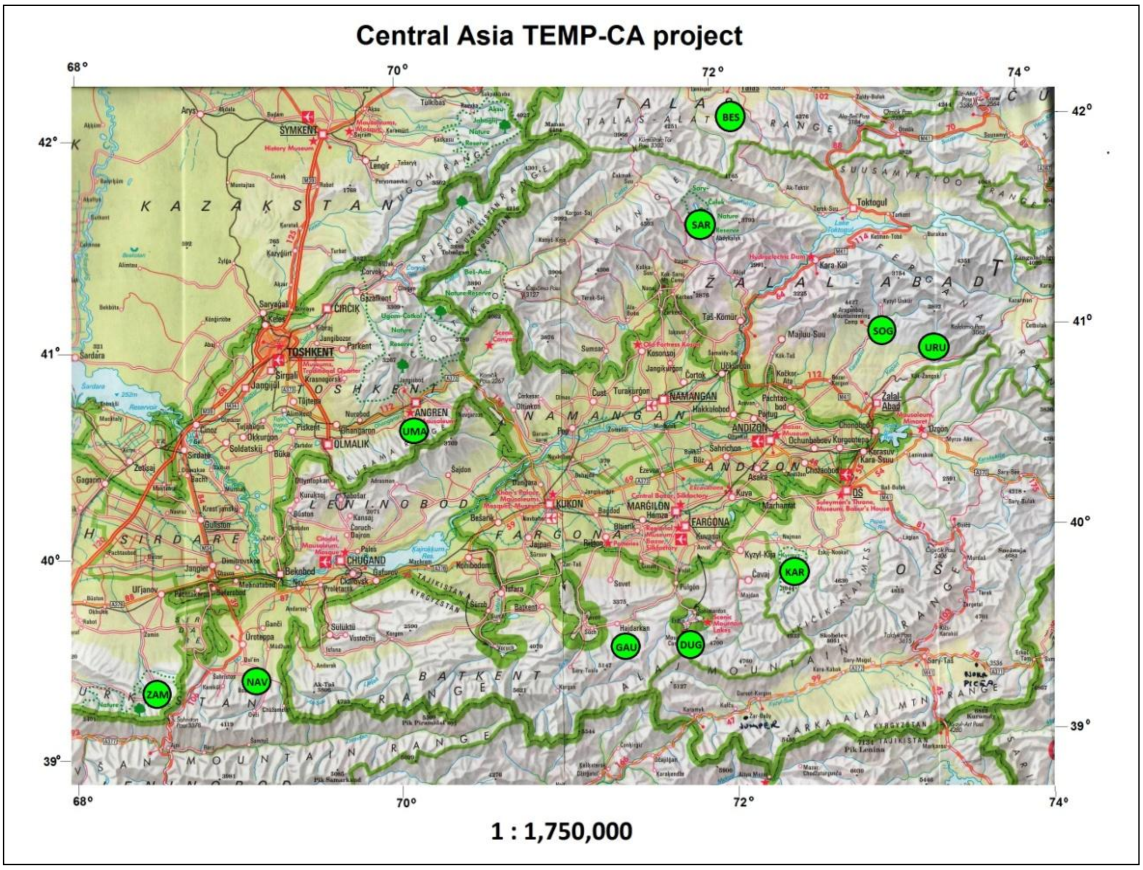

Fig. 1.1. Map of the Umalak (UMA) and the nine other TEMP-CA monitoring reference areas.

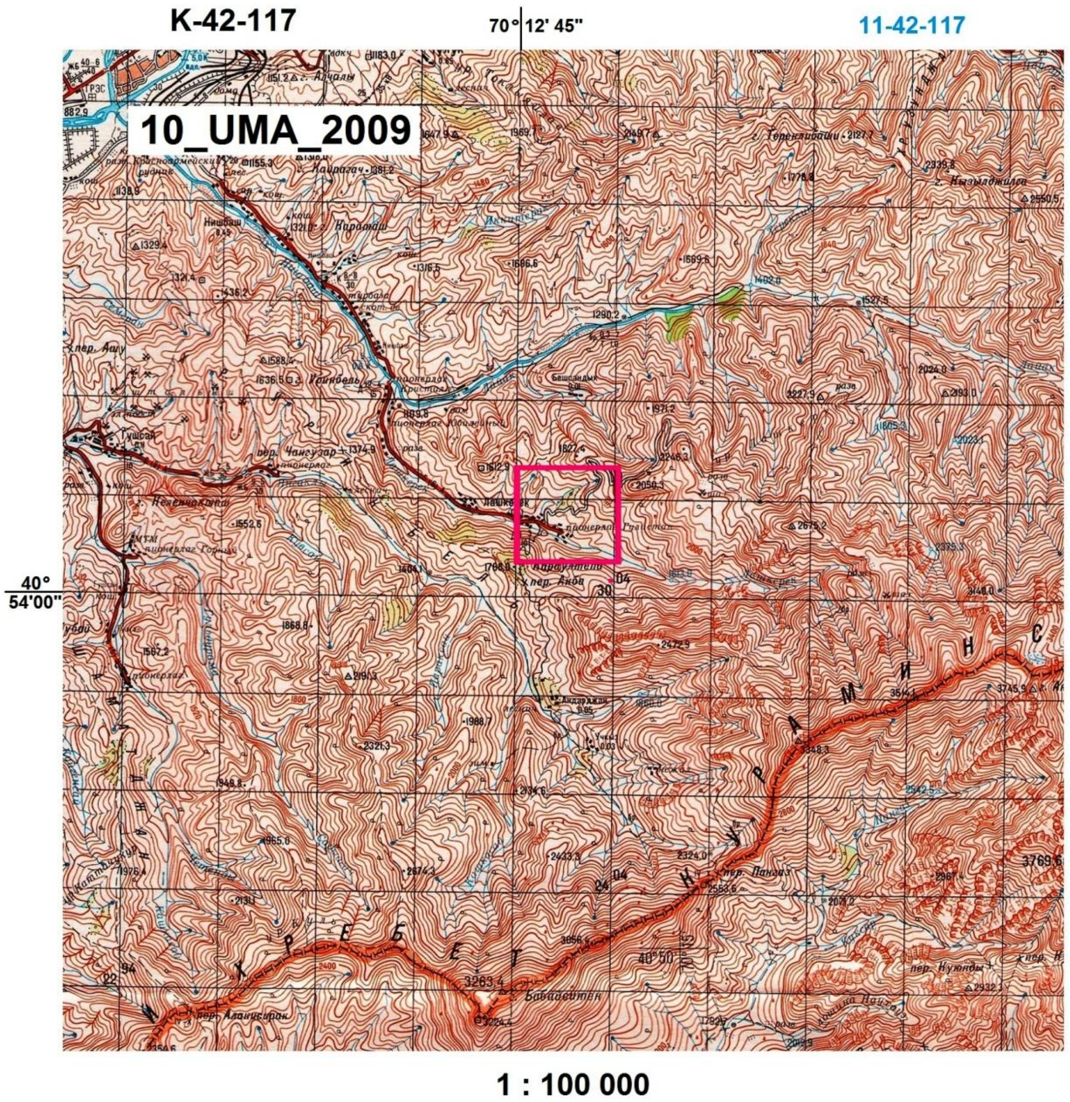

Fig. 1.2. Geographical position of the Umalak (UMA) monitoring reference area.

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

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

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

1.2 Forest type, ownership and conservation status

The Umalak Teppa reference site is located on the territory of the Ahangaran forestry enterprise which is included in the organization structure for Ugam-Chatkal State National Park, in turn subordinated to the Tashkent Regional Khokimiyat.

The Ahangaran forestry enterprise is a part of the Ugam-Chatkal State National Park organization, and is responsible for forest management. The main purpose for the establishment of this forestry entity was to provide protection of forests and forest biodiversity, to increase forest-covered areas through natural regeneration and forest plantations, to increase forest productivity, and to ensure effective use of non-wood forest products.

The forests in this area are dominated by two species of juniper; *Juniperus seravschanica* and *J. semiglobosa.* A third juniper species, *J. turkestanica,* is rather rare and is found only in the upper mountain zones.

According to the forest classification system of Uzbekistan, the juniper forests belongs to Category 1, which means that they play an important role in water-protection, water-regulation and soil-protection role.

1.3 Geology, topography, and quaternary deposits

Based on surface characteristics, sedimentology and the general direction of the mountain ridge, a part of Western Tien Shan is treated as an independent natural complex and geographical district named Middle-Syrdarya.

The topographical structure of this area is closely connected to the history of the development of Western Tien-Shan. At the end of Paleocene most part of this region was covered by sea which in the beginning of the Superior Oligocene was completely receded. The land was leveled and covered by deposits. During this period the tectonic movements that mark the beginning of the Alpine folding and the occurrence of the basic folded structures, anticlinal raisings and synclinal valleys, begun to develop. From the end of Oligocene and during all Neocene and Quaternary periods, clastic material drifted from surrounding anticlinal raisings and accumulated in intermountain depressions and on bottom-mountain plains. The most recent tectonic movements resulted in mountain forming processes with the accumulation of eroded material in the lower parts.

One major factor in the formation of landscape structure is the mountain drainage. The differentiation of landscapes is also influenced by drifting and accumulation of clastic material.

1.4 Climate

The climate in the area is strongly continental, and the climatic conditions are related to the latitude, remoteness from oceans, and the complex orography. During winter the climate is influenced by dry and cold air coming from the north. The climate is also influenced by relatively warm and damp air coming from the Mediterranean, Black and Caspian seas and the summer climate is characterized by intensive radiation and low precipitation.

The growth period is moderately hot dry in the foothills belt and low mountains. In the middle elevation mountain zones, the growth period is moderately hot damp (hydrothermal factor 0.5-0.75).

During winter the temperature normally reaches values from -20 to -25 ^{0}C, but with increasing altitude the temperature can fall to -40 ^{0}C.

Tab. 1.2. Description of climatic conditions (data from the meteorological station “Ablyk”)

Indicators	Unit	Value	Date
Average annual temperature	°C	12,6	
Absolute maximum temperature	°C	42	
Absolute minimum temperature	°C	-32	
Mean date of first frost	Days		29.10
Mean date of last frost	Days		31.03
Duration of frost-free period	Days	210	
Annual precipitations	Mm	408	
Maximum relative humidity	Mm	67	January
Minimum relative humidity	Mm	28	July
Quantity of days with relative humidity ≤ 30%	Days	90	September
Snow cover, min.	Cm	15-20	November, December
Snow cover, max.	Cm	150 and more	November, December
Mean date of first snow cover	Days		20.11
Mean date of snow cover melting	Days		12.03

The prevailing winds in the area come from North. Wind velocities are insignificant – 1.2-1.7 m/sec and the number of days with strong winds (more than 15 m/sec) averages to 3 days per year.

1.5 Vegetation zones

In the lower part of the mountainous zone (1500-1800 m a.s.l.), juniper woodlands covered by wheatgrass predominate. Besides the dominating grass species, *Agropyron trichophorum,* meadow-forest graminoids occur on the northern exposure slopes such as *Bromus inermis, Dactylis glomerata, Poa nemoralis,* herbs such as *Astragalus angrenii, Dicthamnus angustifolia, Galium pamiroalaicum, Hypericum scabrum, Hypericum perfoliatum* and *Inula grandis.*

Typical for the medium-altitude region of the Kuramin range (1800-2200 m a.s.l.) are juniper communities with predominance of large grasses in the lower layer like *Dactylis glomerata, Eremurus sogdianus, E. turkestanica, Ferula tenuisecta* and *Prangos pabularia*.

1.6 Forest history, forest structure, and external influence

The forests located on the territory of Ahangaran forestry enterprise were first invented in 1897 by the forest warden Navrotsky, who gave the first general description of the forest areas of the forestry enterprise. As a result of this work the forest sites were mapped. It was the first cartographical material of the forestry enterprise.

The subsequent work on forest stands in the area was carried out in 1924 - 1926. This work aimed basically at separating and bordering the State Forest Fund lands from public lands, and thereafter carrying out the forest inventory. The field inventory was carried out using simple tools and thus big blunders (discrepancies) were done. The forest inventory was carried out visually and no pilot plots were established.

The subsequent forest inventories were carried out in 1931, 1950, 1977 and 1987 according to revised versions of forest inventory protocols.

The area of the forestry enterprise defined during the forest inventory in 1987 made up 141,200 ha. Moreover, the area of the forestry enterprise defined by the recent forest inventory made up 183,466 ha, i.e. it has increased by 42266 ha.

The investigated area is under the influence of air pollution from several factories in the Angren corridor (petro-chemical, electricity production and metallurgic industry). Around 5 years ago the first signs of reduced vitality and damages on trees were observed. Close to Umalak Teppa is the Yangonkli-San site, established as a site in the Ahangaran Forest Damage Project in 2009. Umalak–Teppa is considered to have the lowest degree of damage on trees of the two sites.

The Umalak Teppa monitoring area is obviously also strongly influenced by other human activities; overgrazing followed by soil erosion, trampling by humans and domestic animals, cutting of branches of trees for fire wood and even planting of fruit trees was obvious when we revisited the area in September 2010.

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 were done in accordance with the ICP-Forest manual (ICP Forests 2006), revised for Central Asian 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 wais defined, in which more intensive assessments were done, such as measurement of tree heights, crown projections, and crown heights.

2.1.2 TREE PARAMETERS

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

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

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

2.2 Results

2.2.1 TREE COMPOSITION

The forest of the Umalak monitoring site was dominated mainly by one species, *Juniperus seravschanica* (99,2%) (Fig.2.1). In addition, there were a few trees of *Prunus sogdiana* and *Malus siversii.*

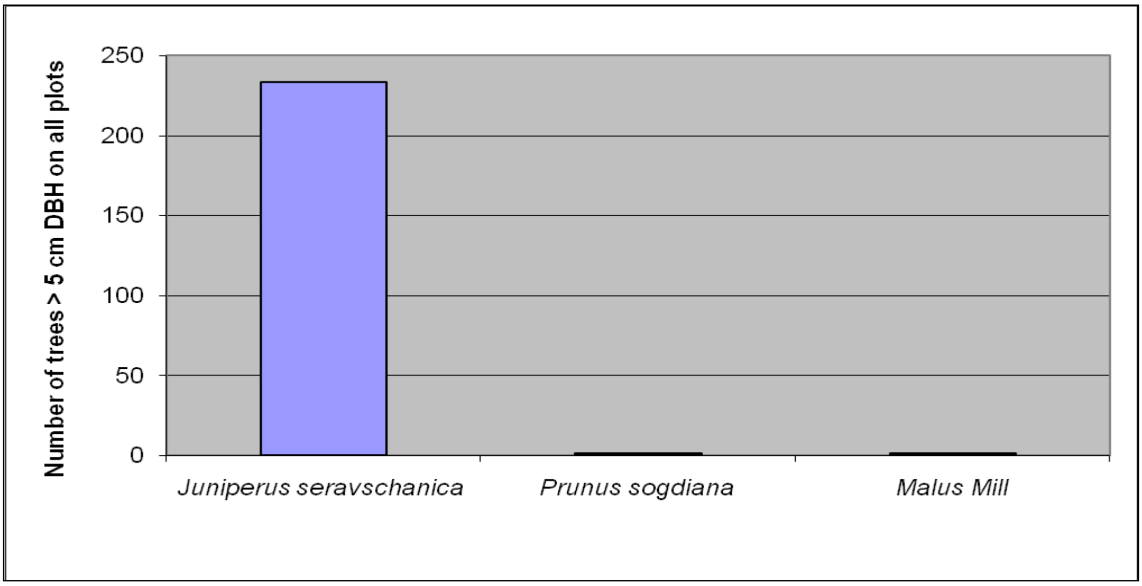

Fig. 2.1. Total number of trees of the different species > 5 cm DBH in all plots.

2.2.2 TREE CONDITION

Defoliation for *Juniperus seravschanica* was 34.9% (Fig. 3.2), which is a notable level according to the ICP Forests classification. The proportion of discolorated trees, on the other hand, was only 1.3%.

2.2.3. DEMOGRAPHY AND REGENERATION OF MAIN SPECIES

A high proportion of the *Juniperus seravschanica* trees belonged to the two smallest size classes, while the number of individuals decreased with increasing DBH > 35 cm (Fig. 2.2). The two smallest size classes (DBH < 25 cm) represented 51.9% of the trees, but the size distribution was also characterized by the high proportion of trees in the intermediate size class (DBH 25-35 cm). No saplings of *J. seravschanica* were recorded in the 1-m^2 ground vegetation monitoring plots.

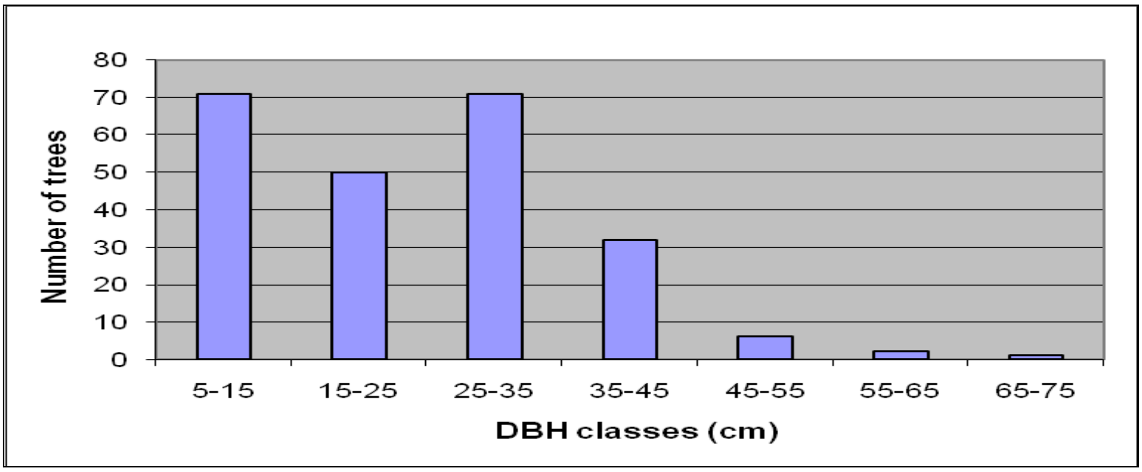

Fig 2.2. Size distribution (DBH) for *Juglans regia* across all plots.

2.3 Discussion

The forest condition was assessed using defoliation and discoloration of needles and leaves as the main indicators. Natural environmental factors such as climate and soil condition are known to be important for the forest condition. In addition, grazing and cutting of firewood may affect both regeneration and susceptibility to diseases. Thus, forest condition is determined by a number of natural and often anthropogenic factors, which implies that it could be difficult to single out the possible effect of pollutants for tree vitality at a given site. Nonetheless, the repeated assessments - which are the basic idea of monitoring, will always provide crucial information about temporal development in forest condition.

The average defoliation of *Juniperus seravschanica* was 34%, which is in the moderately damaged range. At the same time the frequency of discolorated trees was very low. One reason for the discrepancy between the level of defoliation and discoloration may be that discoloration preceded defoliation, and that the discolorated needles already were shed at the time of the assessment.

The juniper trees in the area are probably attacked by *Gymnosporangium* rusts causing dieback. *Gymnosporangium* sp. was sampled from twigs and branches of juniper trees in the plots in the Yangonkli-San site (very close to Umalak Teppa) that was investigated in the Anhagaran Forest Damage Project. However, *Gymnospoangium* sp. was also sampled on the bushes *Cotoneaster pseudomultiflora* and *Crataegus turkestanica* both secondary hosts for two different species of *Gymnosporangium*, in Umalak Teppa. Thus the vitality of juniper trees in this area is probably at least partly due to attack by *Gymnosporangium* (Halvor Solheim, pers. comm.). The frequent cutting of branches for firewood in the area may represent entries for rot fungi. It could be possible to compare trees which have been subject to branch cutting with untouched trees. Accordingly, branch cutting should be recorded as a separate parameter during the next assessment to see whether tree vitality may refer to human interference. Similarly, samples of needles, branches and wood should be collected in a more systematically way for pathological and entomological investigations. The climate or other stress factors may influence on i.e. *Gymnosporangium* infections on branches and stems.

Sufficient regeneration is fundamental for sustainable forests. According to the size distribution of *Juniperus seravschanica* a high proportion of the trees was found among the two smallest size classes (< 25 cm DBH), which is commonly the case. An astonishing deviation from the normal reversed J-shaped distribution curve, however, is the large intermediate size class (DBH 25-35 cm). This could be related to forest history, with one possibility that regeneration was greatly constrained in the past, but has more recently been allowed to grow up. Alternatively, the size distribution reflects that the present regeneration is hindered and deficient. Despite the total dominance of *J. seravschanica* in the tree layer, no saplings (< 5 cm DBH) were recorded in the ground vegetation monitoring plots. An obvious conclusion from this uncertainty is that the sapling stage (< 5 cm DBH) should be monitored specifically in the future.

3 BIODIVERSITY AND GROUND VEGETATION

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3.1 Methods

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

The key principles are summarised below:

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

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

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

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

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

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

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

3.1.1 SAMPLING DESIGN

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

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

3.1.2 VEGETATION PARAMETERS

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

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

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

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

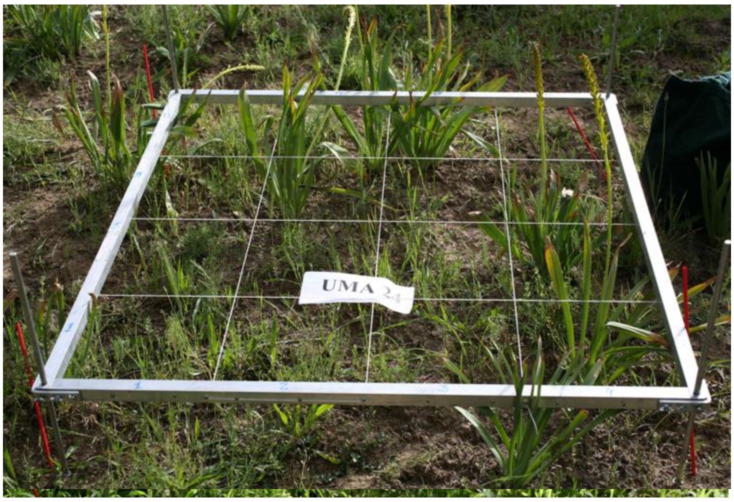

Fig. 3.1. A typical 1-m^2 plot with the field layer dominated by herbs and graminoids.

3.1.3 EXPLANATORY VARIABLES

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

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

(1) Topographical variables include:

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

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

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

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

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

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

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

(2) Tree influence variables include:

- Crown cover index
- Litter index
- Basal area

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

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

$CC = \sum_i \mathbf{cai} \cdot \mathbf{cci} /25$

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:

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

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

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

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

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

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

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

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

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

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

3.1.4 ORDINATION METHODS

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

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

3.1.5 INTERPRETATION OF GROUND VEGETATION GRADIENTS

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

3.2 Results

3.2.1 GROUND VEGETATION BIODIVERSITY

The number of species, α-diversity, are reported in this chapter, while β-diversity (variation in species composition along gradients) will be reported in chapter 3.2.2. The total species list is given in Appendix 3.4. The number of species within macro plot was calculated as the sum of species in the five 1-m^2 plots in each 10x10 m macro plot (a), as the total number of species in each 10x10 m macro plot included the species in the 1-m^2 plots (b), and as the total number of species in each 30x30 m extended macro plot included the species in the 1-m^2 plots (c, Tab. 3.1). The ratio a/b and a/c was calculated for each macro plot. All together 79 species was recorded in the 50 1-m^2 plots. Of these species 11 are endemic to Central Asia: *Carex turkestanica, Allium barsczewskii, Arum korolkovii, Asrtagalus turkestanus, A. siversianus, Euphorbia jaxartica, Galium pamiroalaicum, Iris sogdiana, Pedicularis krylovii, Rosa kokanica* and *Veronica bucharica.*

The maximum number of species recorded in any 1-m^2 plot (bryophytes included) was 22 while the minimum number was 4 and the average number was 11. The total number of vascular plant species recorded within the 50 1-m^2 plots + ten 10x10m^2 plots was 83. The total number of vascular plant species in the in the 50 1-m^2 plots + ten 30x30m^2 plots was 88. The maximum number of species recorded in any of the 10x10 m macro plots (the five 1-m^2 plots included) was 38 and the minimum number was 22. The average number of species in the 10x10 m macro plots (the five 1-m^2 plots included) was 27. The ratio a/b varied between 0.64 and 0.95 (Tab. 3.1). The ratio a/c varied between 0.54 and 0.90 in the macro plots.

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

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	34	38	42	0.89	0.81
2	24	30	37	0.80	0.65
3	14	22	26	0.64	0.54
4	21	24	28	0.88	0.75
5	22	26	29	0.85	0.76
6	26	28	31	0.93	0.84
7	25	30	34	0.83	0.74
8	18	22	26	0.82	0.69
9	26	30	34	0.87	0.76
10	25	28	30	0.89	0.83
Total number	79	83	88	0.95	0.90

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

Plot number	Tree species	Shrubs	Herbs	Ferns	Graminoids	Bryophytes	Lichens
1	1	3	26	0	4	5	0
2	1	0	20	0	3	5	0
3	1	0	9	0	4	0	0
4	0	3	16	0	2	4	0
5	0	1	17	0	4	0	0
6	0	1	22	0	4	1	0
7	0	1	20	0	4	0	0
8	0	2	14	0	2	4	0
9	0	2	22	0	2	5	0
10	0	1	20	0	4	2	0
Total number	**1**	**4**	**64**	**0**	**10**	**7**	**0**

3.2.2 MAIN GROUND VEGETATION GRADIENTS

DCA ordination of 50 plots is shown in Figs. 3.2-3.6. Gradient lengths; β-diversity, and eigenvalues for DCA axes 1-4 are given in Tab. 3.3.

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

	DCA 1	DCA 2	DCA 3	DCA 4
Eigenvalues	0.694	0.479	0.239	0.162
Gradient lengths	4.409	4.260	3.268	3.105

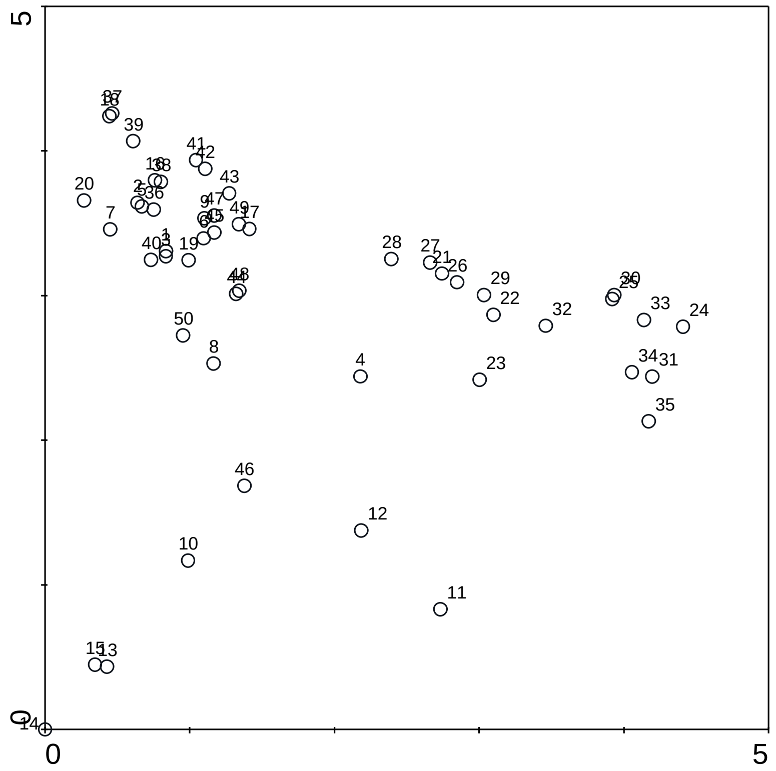

Fig. 3.2. DCA ordination of 50 1-m² plots, axes 1 (horizontal) and 2 (vertical). Plot numbers for the 50 1-m² plots are plotted onto the sample plot positions. Scaling of axes in S.D. units.

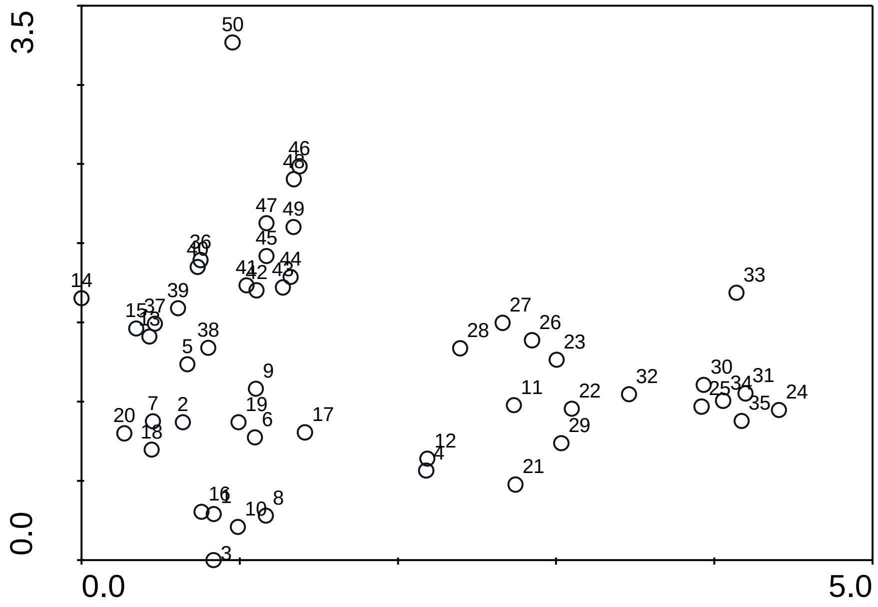

Fig. 3.3. DCA ordination of 50 1-m^2 plots, axes 1 (horizontal) and 3 (vertical). Plot numbers for the 50 1-m^2 plots are plotted onto the sample plot positions. Scaling of axes in S.D. units.

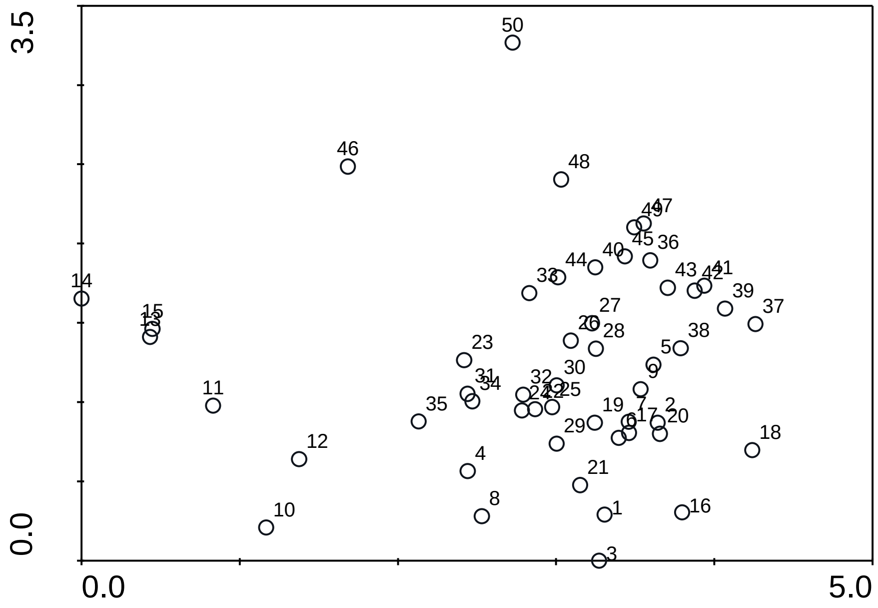

Fig. 3.4. DCA ordination of 50 1-m^2 plots, axes 2 (horizontal) and 3 (vertical). Plot numbers for the 50 1-m^2 plots are plotted onto the sample plot positions. Scaling of axes in S.D. units.

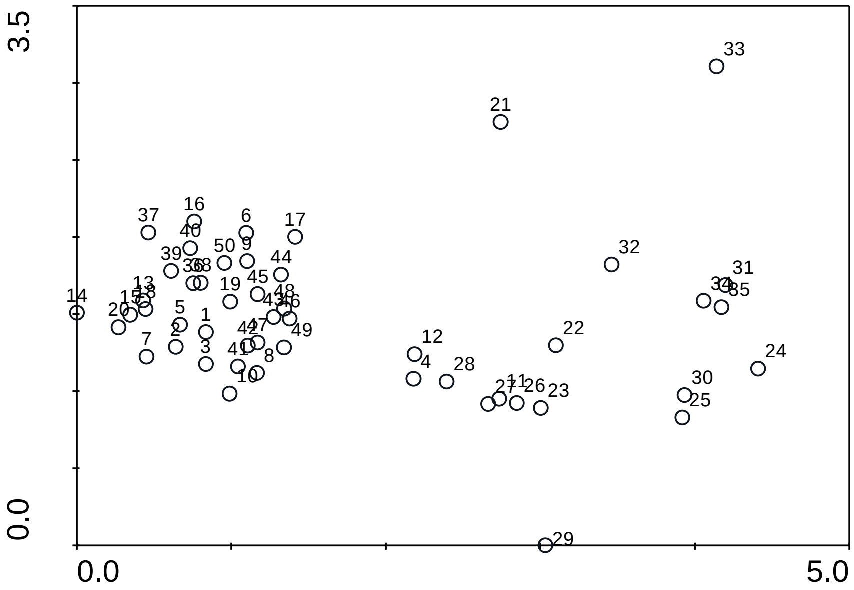

Fig. 3.5. DCA ordination of species in the 50 1-m^2 plots.

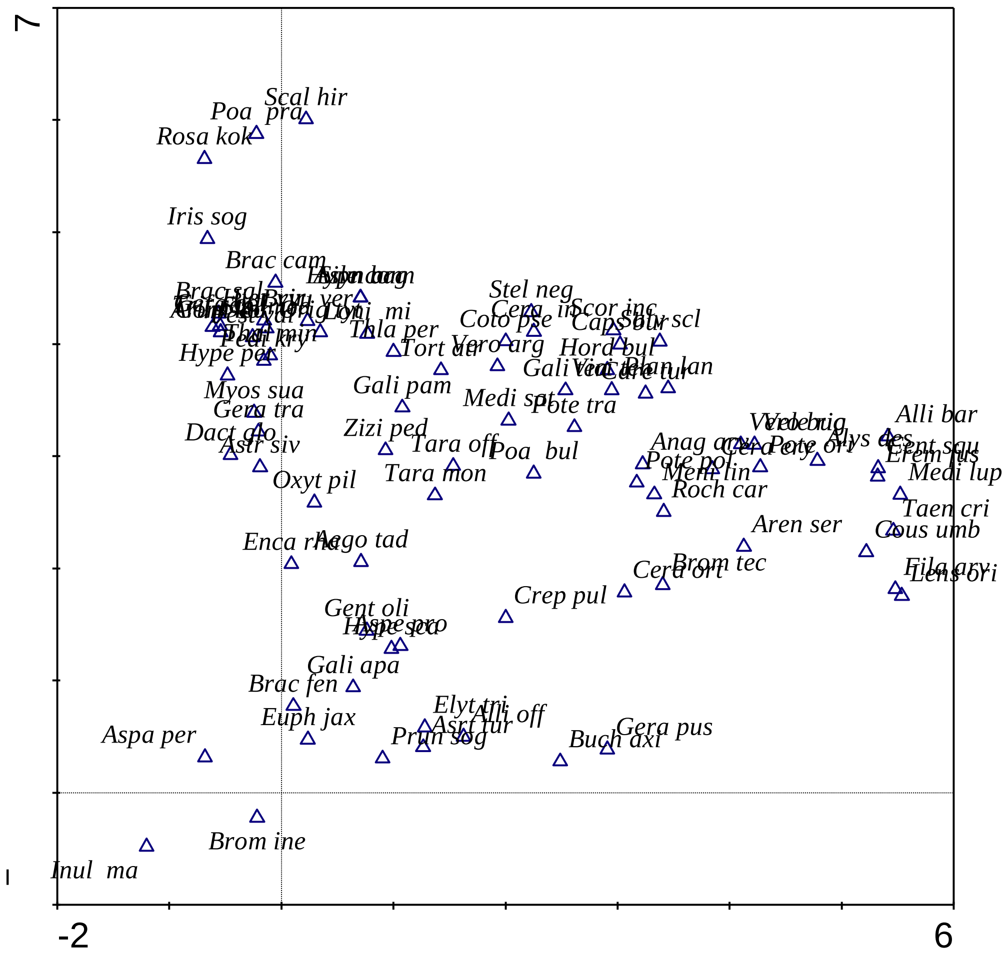

Fig. 3.6. DCA ordination of species in the 50 1-m^2 plots.

3.2.3 CORRELATION ANALYSIS BETWEEN EXPLANATORY VARIABLES AND DCA ORDINATION AXES

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

Variable	DCA 1	P	DCA 2	P	DCA 3	P	DCA 4	P
DCA 1	* * *	* * *	**-0.342****	**0.000**	-0.025	0.795	-0.187	0.055
DCA 2	**-0.342****	**0.000**	* * *	* * *	0.053	0.587	0.176	0.072
DCA 3	-0.025	0.795	0.053	0.587	* * *	* * *	0.127	0.195
DCA 4	-0.187	0.055	0.176	0.072	0.127	0.195	* * *	* * *
Soil moisture	**-0.465****	**0.000**	**0.402****	**0.000**	0.038	0.700	0.136	0.165
Inclination	-0.219*	0.028	**0.413****	**0.000**	0.142	0.154	0.195*	0.050
Aspect	**-0.506****	**0.000**	0.200*	0.043	-0.180	0.068	-0.010	0.920
Aspect fav	**0.478****	**0.000**	-0.152	0.123	0.192	0.052	-0.035	0.725
Heat index	**0.526****	**0.000**	**-0.256****	**0.009**	0.139	0.155	-0.144	0.141
Max. incl.	**-0.327****	**0.001**	**0.292****	**0.003**	-0.058	0.557	0.223*	0.025
Sum conc .1x1 m	-0.014	0.891	0.172	0.097	0.076	0.461	0.198	0.055
Var. conc. 1x1 m	-0.068	0.502	0.172	0.091	-0.195	0.056	0.198	0.052
Abs. sum conc. 1x1 m	-0.084	0.415	0.185	0.072	-0.154	0.135	0.183	0.074
Sum conc. 3x3 m	-0.042	0.683	0.037	0.721	-0.169	0.103	**0.277****	**0.008**
Var. conc. 3x3 m	-0.123	0.228	-0.018	0.859	-0.104	0.308	**0.356****	**0.000**
Abs. sum conc. 3x3 m	-0.112	0.277	0.054	0.599	-0.197	0.057	**0.293****	**0.005**
Relascope conif. trees	**-0.417****	**0.000**	0.190	0.061	0.208*	0.040	**0.294****	**0.004**
Crown cover index	-0.160	0.103	-0.138	0.157	-0.009	0.927	-0.207*	0.034
Grazing intensity	0.267*	0.018	0.151	0.181	0.267*	0.018	0.134	0.235
Average grass height	**-0.450****	**0.000**	0.062	0.546	0.025	0.805	0.029	0.779
Average shrub height	-0.217*	0.041	0.021	0.842	-0.140	0.187	0.042	0.691
% cover animal manure/dung	-0.003	0.980	0.113	0.334	-0.235*	0.045	0.264*	0.024
% cover animal traces/footpr.	0.236*	0.027	0.010	0.929	-0.027	0.803	0.057	0.592
% cover animal tracks	-0.138	0.232	0.179	0.121	-0.037	0.747	0.254*	0.028
Max soil depth	**-0.366****	**0.000**	**0.396****	**0.000**	0.137	0.164	0.114	0.248
Min soil depth	**-0.364****	**0.000**	**0.441****	**0.000**	0.053	0.591	0.148	0.135
Med soil depth	**-0.381****	**0.000**	**0.461****	**0.000**	0.156	0.112	0.138	0.160
Max. org. layer depth	**-0.365****	**0.000**	**0.302****	**0.003**	0.083	0.413	0.037	0.717
Min. org. layer depth	**-0.334****	**0.001**	**0.307****	**0.002**	0.228*	0.024	0.114	0.256
Med. org. layer depth	**-0.358****	**0.000**	**0.312****	**0.002**	0.147	0.138	0.096	0.335
Max. litter depths	**-0.487****	**0.000**	0.176	0.092	0.026	0.804	-0.037	0.725
Min. litter depths	**-0.342****	**0.001**	0.055	0.600	0.222*	0.035	-0.083	0.434
Med. litter depths	**-0.444****	**0.000**	0.144	0.171	0.003	0.979	0.008	0.938
Altitude	0.173	0.088	-0.049	0.632	**0.572****	**0.000**	0.055	0.584
pH	0.127	0.286	-0.029	0.806	-0.075	0.529	-0.189	0.113

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

H+	-0.127	0.286	0.029	0.806	0.075	0.529	0.189	0.113
LOI	0.010	0.935	-0.022	0.849	0.124	0.288	-0.099	0.398
Ctotal%	0.057	0.624	-0.022	0.849	0.175	0.134	-0.159	0.173
Ca	-0.040	0.733	-0.040	0.733	0.085	0.469	0.176	0.137
Mg	0.084	0.477	-0.078	0.512	-0.094	0.428	-0.074	0.530
Na	-0.251*	0.035	-0.179	0.132	0.036	0.763	-0.205	0.085
K	0.019	0.879	-0.111	0.368	0.118	0.339	-0.077	0.533
CEC calc.	0.051	0.663	-0.098	0.398	0.048	0.683	0.070	0.549
Total N, mkg/g	0.080	0.496	-0.038	0.744	0.057	0.624	-0.166	0.156
PO4 mg/kg	-0.164	0.167	-0.158	0.185	-0.184	0.122	-0.086	0.469
Ca, ppm	**-0.328****	0.005	0.029	0.806	0.203	0.086	0.267*	0.024
Mg, ppm	**-0.383****	**0.002**	**0.411****	**0.001**	0.056	0.647	**0.376****	**0.002**
Na, ppm	-0.026	0.827	0.248*	0.037	0.023	0.848	0.016	0.891
K, ppm	0.015	0.901	0.226	0.063	0.015	0.901	0.035	0.772
Al, ppm	-0.164	0.168	0.332**	0.005	0.008	0.946	0.248*	0.037
Fe, ppm	-0.191	0.112	0.342**	0.004	-0.066	0.583	0.165	0.170
Mn, ppm	-0.223	0.060	0.301*	0.011	-0.142	0.230	0.139	0.240
P, ppm	**-0.505****	0.000	0.226	0.054	-0.040	0.733	0.313**	0.008
Zn, ppm	-0.222	0.070	0.056	0.648	0.171	0.162	0.141	0.250
Ca/LOI*100	0.044	0.703	-0.016	0.892	-0.143	0.220	0.108	0.354
Mg/LOI*100	0.105	0.369	-0.070	0.549	-0.165	0.157	0.086	0.462
Na/LOI*100	-0.286*	0.014	-0.162	0.165	-0.168	0.149	-0.102	0.383
K/LOI*100	0.006	0.957	-0.016	0.892	-0.041	0.723	-0.102	0.383
CEC calc/LOI*100	0.067	0.567	-0.057	0.624	-0.152	0.191	0.105	0.369
Total N, mkg/g/LOI*100	0.010	0.935	0.006	0.957	0.051	0.663	-0.060	0.605
SO_4 water soluble	0.277*	0.023	-0.099	0.417	-0,096	0.433	-0.290*	0.017
SO_4¤-acid solunble	-0.238*	0.045	-0.034	0.774	**-0.368****	**0.002**	0.089	0.452
PO_4 mg/kg/LOI*100	-0.094	0.422	-0.300*	0.010	-0.246*	0.035	-0.052	0.653
Ca, ppm/LOI*100	**-0.365****	0.002	0.089	0.446	0.108	0.354	**0.352****	**0.002**
Mg, ppm/LOI*100	-0.221	0.058	0.230*	0.048	-0.046	0.693	0.278*	0.017
Na, ppm/LOI*100	-0.024	0.838	0.103	0.376	-0.033	0.775	0.106	0.361
K, ppm/LOI*100	0.003	0.978	0.070	0.549	-0.051	0.663	0.124	0.288
Al, ppm/LOI*100	-0.044	0.703	0.117	0.313	-0.060	0.605	0.178	0.127
Fe, ppm/LOI*100	-0.035	0.764	0.076	0.513	-0.102	0.383	0.143	0.220
Mn, ppm/LOI*100	-0.092	0.430	0.076	0.513	-0.114	0.327	0.162	0.165
P, ppm/LOI*100	-0.267*	0.022	0.130	0.264	-0.143	0.220	0.298*	0.010
Zn, ppm/LOI*100	-0.124	0.288	0.057	0.624	-0.051	0.663	0.175	0.134

3.3 Discussion

3.3.1 GENERAL DESCRIPTION OF VEGETATION AND GROUND VEGETATION BIODIVERSITY

The main dominating tree species of the juniper forests of the monitoring site Umalak Teppa is *Juniperus seravshanic.*. The juniper (archa) forests typically have a mosaic distribution of grass-stands, where shade-requiring plants grow under crowns and steppe plants with a considerable number of ephemers inhabit the inter-crown spaces.

Shrub species in the area includes among others *Cerasus erythrocarpa, Cotoneaster pseudomultiflora, Lonicera nummularifolia, Rosa canina, Rosa kokanica* and *Sorbus persica.*

The grass and herb layer is dominated by *Poa bulbosa* and *Bromus inermis,* with the less dominant species *Stellaria neglect* and *Buchingera axillaris.* Other species typical for the area are *Adonis parviflora Arenaria serpillifolia, Asperula arvensis, Cousinia umbrosa, Eremurus fuscus, Eremurus regeli,. Euphorbia jaxartica, Galium aparine, Alliaria petiolata, Alyssum desertorum, Buchingera axillaris* and *Ceratocephalus orthoceras.* Many species endemic for Central Asia occur in the area.

Herbaceous plants are represented by xeromorphic and thermophytic species. The area has many steppe species and also many bryophyte species. Most of the vascular plants are herbs, and out of 79 species recorded in the 50 1-m^2 plots 63 were herbs.

3.3.2 INTERPRETATION OF GROUND VEGETATION GRADIENTS

This site is strongly influenced by human impact; overgrazing by domestic animals, grass mowing and even planting of fruit trees. Some of the macro plots were in the area protected by a fence and was thus not so influenced by grazing, in other plots soil erosion due to overgrazing and trampling was more severe than in most other TEMP-CA plots. Also local pollution may influence the trees and ground vegetation in this area.

Most of the topographical variables were relatively strongly and significantly correlated with DCA 1; *aspect* and *maximum inclina*tion was negatively correlated while *aspect favorability* and the *heat index* was positively correlated. *Soil moisture*, *relascope sum for conifer trees*, *average grass height*, *maximum*, *minimum* and *median soil depths*, *maximum*, *minimum* and *median depth of the organic layer*, *maximum*, *minimum* and *median depth of litter layer* and total concentrations of *Ca*, *Mg*, and *P* in soil were all negatively correlated with DCA 1. These results indicate variation in species composition from sites with mainly northern *aspects*, relatively high *density of juniper trees*, and relatively high *soil moisture*, *soil depths*, *depth of the organic soil layer*, *litter depths, grass heights* and total concentration of nutrients in soil to sites with more or less southern *aspects,* lower *density of juniper trees*, lower *soil moisture*, lower *soil depths*, *litter depths* and *depths of the organic soil layer* and lower contents of some nutrients.

Many of the variables correlated with DCA 1 were also more or less strongly correlated with DCA 2, but with opposite signs. That was the fact for *soil moisture heat index*, *maximum inclination, maximum, minimum and median depths of the organic layer* and the total concentrations of *Mg*.

Altitude was the variable most strongly correlated with DCA 3 and this variable was not significantly correlated with any other DCA axes. Some variables were also correlated with DCA 4, but most of them were more strongly correlated with other DCA axes. However, two variables expressing variation in micro-topography had significant correlations only with this axes.

Apparently the main variation in vegetation in this monitoring area are due to variation in topography, *soil moisture*, *soil depths*, *depths of organic layer* and *litter layer*, *tree density*, influence of *grazing* followed by variation in some nutrients. Probably most of this is related do the difference between northern sites and southern exposed sites. The latter was more strongly influenced by grazing and soil erosion which may explain also the lower *depths of the organic layer* and *litter* *layer* etc. The difference between sites on different *aspects* was much more pronounced in Umalak Teppa than in most other TEMP-CA monitoring areas.

3.4 Appendix

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

Latin names of species:	Uzbek names of species:	Russian names of species:
Aegopodium tadshikorum	--	Сыть таджикская
Alliaria petiolata	--	Чесночник лекарственный
Allium barsczewskii	--	Лук Барщевского
Alyssum desertorum	Шидан	Бурачек пустынный
Anagallis arvensis	Совун ут	Очный цвет
Anisantha tectorum	Ялтир бош	Анизанта кровельная
Arenaria serpillifolia	--	Песчанка тимьянолистная
Arum korolkovii	Кучала	Аронник Королькова
Asparagus persicus	Сарсабил	Спаржа персидская
Asperugo procumbens	--	Асперуга простертая
Astragalus siversianus	Пахтак	Астрагал Сиверса
Astragalus turkestanus	--	Астраг ал туркестанский
Asyneuma argutum	Санжалит	Азинеума острая
Bromus inermis	Сув бугдойик	Костер безостый
Buchingera axillaris	--	Бухингера пазушная
Capsella bursa pastoris	Жаг -жаг	Пастушья сумка
Carex turkestanica	Кора киек	Осока туркестанская
Centaurea squarrosa	Тошкакра	Василек растопыренный
Cerastium inflatum	--	Ясколка вздутая
Cerasus erythrocarpa	Тошчия	Вишня красноплодная
Ceratocephalus orthoceras	Учма	Рогоглавник пряморогий
Corydalis ledebouriana	--	Хохлатка ледебура
Cotoneaster pseudomultiflora	Иргай	Кизилник ложнокистевидный
Cousinia umbrosa	Окбош тикон	Кузиния теневая
Dactylis glomerata	Оксухта	Ежа сборная
Elytrigia trichophora	Тукли бугдойик	Пырей волосоносный
Eremurus fuscus	Жингак ширач	Эремурус загорелый
Euphorbia jaxartica	Сутлама	Молочай сырдарьинский
Festuca valesiaca	Бетага	Типчак валезийский
Filago arvensis	Дала филагоси	Жабник полевой
Galium aparine	Чакамуг	Подмаренник цепкий
Galium pamiroalaicum	Чакамуг	Подмаренник памироалайский
Galium tenuissimum	--	Подмаренник тончайший
Gentiana olivierii	Газакут	Горечавка Оливьера
Geranium collinum	Анжабор	Герань холмовая
Geranium pusillum	Пакана анжабор	Герань низкая
Geranium transversale	Анжабор	Герань поперечная
Hieracium virosum	--	Ястребинка ядовитая

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

Latin names of species:	**Uzbek names of species:**	**Russian names of species:**
Hordeum bulbosum	Тактак	Ячмень луковичный
Hypericum perforatum	Кизилпойча	Зверобой пронзенный
Hypericum scabrum	Далачой	Зверобой шершавый
Inula macrophylla	Сариандиз	Девясил крупнолистный
Iris sogdiana	Гулисавсар	Ирис согдийский
Lens orientalis	Ясмик	Чечевица восточная
Lonicera microphilla	Дукегоч	Жимолость мелколистная
Medicago lupulina	--	Люцерна хмелевидная
Medicago sativa	Беда,енгучка	Люцерна посевная
Meniocus linifolius	--	Плоскоплодник льнолистный
Myosotis caespitosa	--	Незабудка дернистая
Origanum tythanthum	Тог райхон	Душица мелкоцветная
Oxytropis pilosissima	--	Остолодочник густоволосистый
Pedicularis krylovii	--	Мытник Крылова
Phaecasium pulhrum	--	Фекaзиум красивый
Plantago lanceolata	Баргизуб	Подорожник ланцетный
Poa bulbosa	Кунгирбош	Мятлик луковичный
Poa pratensis	Майсазор кунгирбош	Мятлик луговой
Potentilla orientalis	Эшак гул	Лапчатка восточная
Potentilla transcaspia	--	Лапчатка закаспийская
Poterium polygamum	Кукут,харгизагие	Черноголовник многобрачный
Prunus sogdiana	Тог олча	Слива восточная
Rochelia cardiosepala	Кенгбарг рохелия	Рохелия сердцевидно чашелистиковая
Rosa kokanica	Кунгир нематак	Роза кокандская
Salvia sclarea	Маврак	Шалфей мускатный
Scalligeria hirtula	Каргаоек	Скалигерия волосистая
Scorzonera inconspicua	--	Козелец незаметный
Silene conica	Зурча	Смолевка коническая
Stellaria media	Уртача юлдуз ут	Звездчатка средняя
Stellaria neglecta	Унитилган юлдузут	Звездчатка пренебреженная
Taeniaterum crinitum	Килтик	Лентоостник длинноволосый
Taraxacum montanum	Момакаймок	Одуванчик горный
Taraxacum officinale	Коки	Одуванчик обыкновенный
Thalictrum minus	Кичик санчикут	Василистник малый
Thlaspi perfoliatum	Тешикбарг тласпи	Ярутка пронзенная
Trifolium repens	Туккиз тепа	Амория ползучая
Velezia rigida	--	Велесия жесткая
Veronica arguteserrata	--	Вероника тонкопильчатая
Veronica bucharica	--	Вероника бухарская
Vicia tenuifolia	Юпкабарг бокла	Вика тонколистная
Ziziphora pedicellata	Кийик ут	Зизифора цветоножечная

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

Latin names of species:	**Uzbek names of species:**	**Russian names of species:**
Brachythecium campestre *Brachythecium fendleri* *Brachythecium salebrosum* *Bryum vernum* *Encalypta rhaptocarpa* *Hypnum bamberggeri* *Tortulla atrovirens*		

4 SOIL CLASSIFICATION AND SOIL DESCRIPTION

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4.1 Methods

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

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

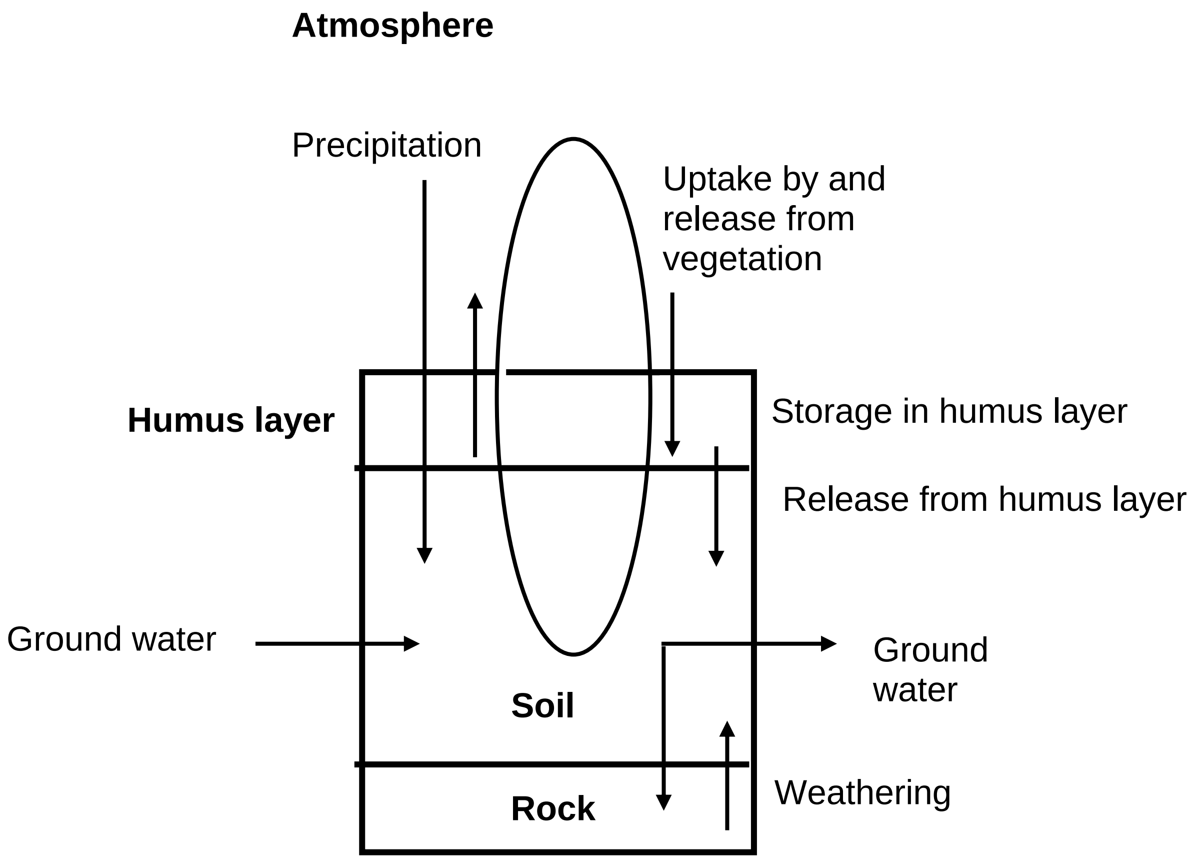

Fig. 4.1. Simplified model of biogeochemical cycling of elements.

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

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

4.2. Results

Umalak Teppa is ecologically very diverse: (i) slopes facing north and south, (ii) macro plots grazed (4 – 10) and ungrazed (1 – 3), (iii) north slope with loess and south faced slope with weathered gneiss and rhomb porphyry, (iv) loess soils with a calcareous C horizon (sometimes also the A horizon) while the weathered soils were degraded and sometimes were heavy clayey with rocky outcrops, and (v) big and well developed *Juniperus* trees on north faced slope, sparse and small on south faced slope. A part of the area was protected against grazing by fencing 15 years ago. Macroplots 1 – 3 were established within the fences.

The soils on the north slope (macroplots 1 – 4 and 8 – 10) were Luvisols. It was not possible to determine a clear B horizon by means of the soil auger, so all involved macro plots were classified with an AC profile (this in comparison with the Yangonkli-San site where clear ABC profiles could be distinguished!). These soils were calcareous and some had secondary chalk noodles. Soil texture varied from a silty loam to a loamy clay.

The non-fenced part (macroplots 8 – 10) showed clear signs of overgrazing. Erosion features were common and in some places buried A horizons were found. In the fenced part a long fissure in the surface was present indicating active slope processes (undermining of the slope by the stream?).

The soils on the south slope were totally different (macroplots 5 – 7). Generally the slope was steep and consisted of weathered gneiss/rhomb porphyry rocky outcrops. The weathered material varied in texture from sandy silt to a loam to very heavy clay. The soil was not calcareous.

The south slope was severely overgrazed and large parts of the vegetation were dominated by species of the genus *Eremurus*. Due to soil degradation (overgrazing) the soil profile was a B or BC profile. Soil types found were Regosol and Leptosol. Around macro plot 5 several small springs were emerging from the slope.

4.3. Discussion

The large ecological diversity makes Umalak Teppa a very interesting site. Over time the influence of fencing will become even more visible. The difference in geological deposit has a clear influence on the potentials for forest development.

The soil in Umalak Teppa is less developed than in the nearby Yangonkli-San site. The reason for this is not known. It could be the age of the site and/or the difference in climate/micro climate (precipitation).

5 SOIL CHEMISTRY

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5.1 Methods

5.1.1 SAMPLING DESIGN

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

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

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

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

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

5.1.2 SOIL CHEMISTRY PARAMETERS

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

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

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

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

5.1.3 SOIL CHEMISTRY ANALYSES

Samples from Umalak were analyzed at Central laboratory of the State Committee of Geology of the Republic of Uzbekistan, Tashkent and in The Research institute of soil science.

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:

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

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 <u>100 ppm of P</u> (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:

<u>Calcium phosphate monohydrate solution [$Ca(H_2PO_4)_2 \cdot H_2O$], 100 ppm of P:</u>
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.

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

Procedure:

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

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

Detection:

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

Calculation:

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

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

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

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

5.1.3.9. ICP-AES metal scan

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

5.1.3.10 Extractable sulphate

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

5.2 Results

5.2.1. SOIL CHEMISTRY DATA
Average soil chemical data for each horizon are presented in Tab. 5.2. A pH around 7.5 prevailed at all the sampling plots and soil horizons. The pH did therefore not decrease from the A to the C horizon as commonly found, though the organic content (measured as loss on ignition (LOI) decreased along with total Carbon content (% C_{tot}). Studying all samples (across horizons) we found strong correlations (i.e. r > 0.7) between soil chemical characteristics only between % C_{tot} and LOI (r = 0.869) and Total N (r = 0.925) content. The soil content of adsorbed phosphate (Ads. PO_4^{3-}) was the lowest among the TEMP-CA sites.

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

Horizon	Samples	pH_{H2O}	LOI	C total	Total N	Ads. PO_4^{3-}
	#		w/w %		µg/g	
A	36	7.48	13	7,5	4269	16
		7.4-7.5	11-15	6-9	3513-4810	10-17
B	14	7.48	4,5	2,2	1368	6,2
		7.5-7.5	4-5	2-3	913-1685	5-8
C	35	7.40	7,0	1,7	252	8,1
		7.5-7.5	6-8	1-2	200-280	5-8

In addition to SiO_2 (not measured) the main (avg. value > 3.5 mg/g) oxide composition of the mineral soils (Fig. 5.1) was made up by iron (Fe) and aluminium (Al), followed by calcium (Ca) and potassium (K). Base cations (Ca+Mg+Na+K) in the A and B horizons accounted for ca 40% of the oxide composition. The C horizon was richer in base cations, maybe because the weathering has not been as active as in the A and B horizons.

The content of Fe and Al were strongly correlated (r = 0.808), as found in all TEMP-CA sites (except Navobod). Both Al and Fe were correlated to manganese (Mn) (r = 0.844 and 0.783, respectively). The Al content was also as commonly found co-vary with K (r = 0.856), in addition to sodium (Na) (r = 0.753) as there was a strong correlation between Na and K (r = 0. 914). As found at all the TEMP-CA sites the Al content was also strongly correlated to beryllium (Be) (r = 0.854), in addition to zirconium (Zr) (r = 0.754). Fe was al always found to be strongly correlated to cobolt (Co) (r = 0.860) and scandium (Sc) (r = 0.713), and as usual with titanium (Ti) (r = 0.919) and vanadium (V) (r = 0.877).

The major oxide elements presented in Fig. 5.1 are followed in abundance by titanium, (Ti), total phosphorous (P), manganese (Mn) and barium (Ba) (Tab. 5.3). Barium content in these soils were high, especially in the B horizon. The amount of Ti was also relatively high compared to e.g. Na. In addition to Fe (se above) the Ti was correlated with Mg (r = 0.844) and the heavy metal Co (r = 0.931) and V (r = 0.875). The spatial variation in lanthanum (La) was as commonly found correlated with the trace elements scandium (Sc) and yttrium (Y). Total P appears to be strongly governed by the organic content (LOI; r = 0.428). In addition to Fe and Al (see above) the Mn was correlated to K (r = 0. 0.796) and Be (r = 0.758). In addition to Al, the Na was also correlated to Be (r = 0.807).

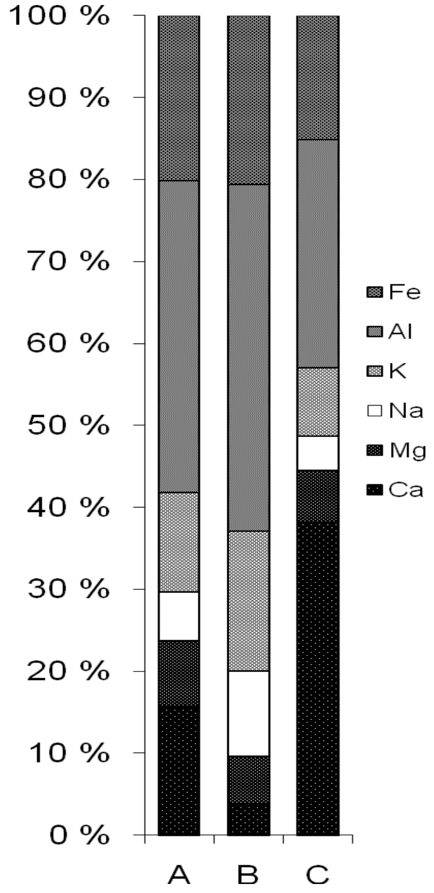

Fig. 5.1. Main (avg. value > 3.5 mg/g) oxide composition of the mineral soils.

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

Horizon	P	Mn	Ti	Ba	La
	mg/kg				
A	791	758	3319	581	22
	718 -863	710 - 833	3100 – 3800	505 - 610	21 – 24
B	676	859	3236	1239	20
	415 –995	773 -938	2600 – 3925	935 – 1625	18 – 22
C	620	636	3343	526	22
	550 -700	560 - 700	3100 – 3700	455 – 600	19 – 25

Soil composition of measured trace elements along with the composition of continental crust (Taylor and McLennan, 1985) and selected heavy metal contamination norms (Lacatusu 1998) are presented in Tab. 5.4. The bedrocks in the studied sites were generally secondary minerals (sandstone, clay and limestone) that were apparently partly transformed to shale and marble by metamorphosis. The contents of trace elements were therefore generally depleted compared to continental crust, except for soft (type B) element lead (Pb) which had average concentrations above maximum allowable limits in all three soil horizons. In a soil sample from a C horizon 1,3 g/kg Pb was detected. Generally the heavy metal contents were 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).

Tab.5.4. Soil content of measured trace elements in 36 A, 14 B and 35 C horizon samples along with some reference values.

Site	Hor	As	Sr	Pb	Cd	Cu	Cr	Zn	Ni	Co	V	Sc	Y	Zr	Be	Mo
		mg/kg														
Earth crust[1]		1.0	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						
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						
Umalak Teppa	A	3.5	211	141	0.3	43	80	106	52	13	80	13	18	75	1.6	2.2
	B	3.0	259	114	0.1	34	33	81	24	12	83	10	15	97	2.3	1.3
	C	3.6	273	126	0.2	35	70	68	56	13	80	13	18	73	1.5	1.6

[1] Taylor & McLennan (1985).
[2] Maximum allowable limits. See: 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)

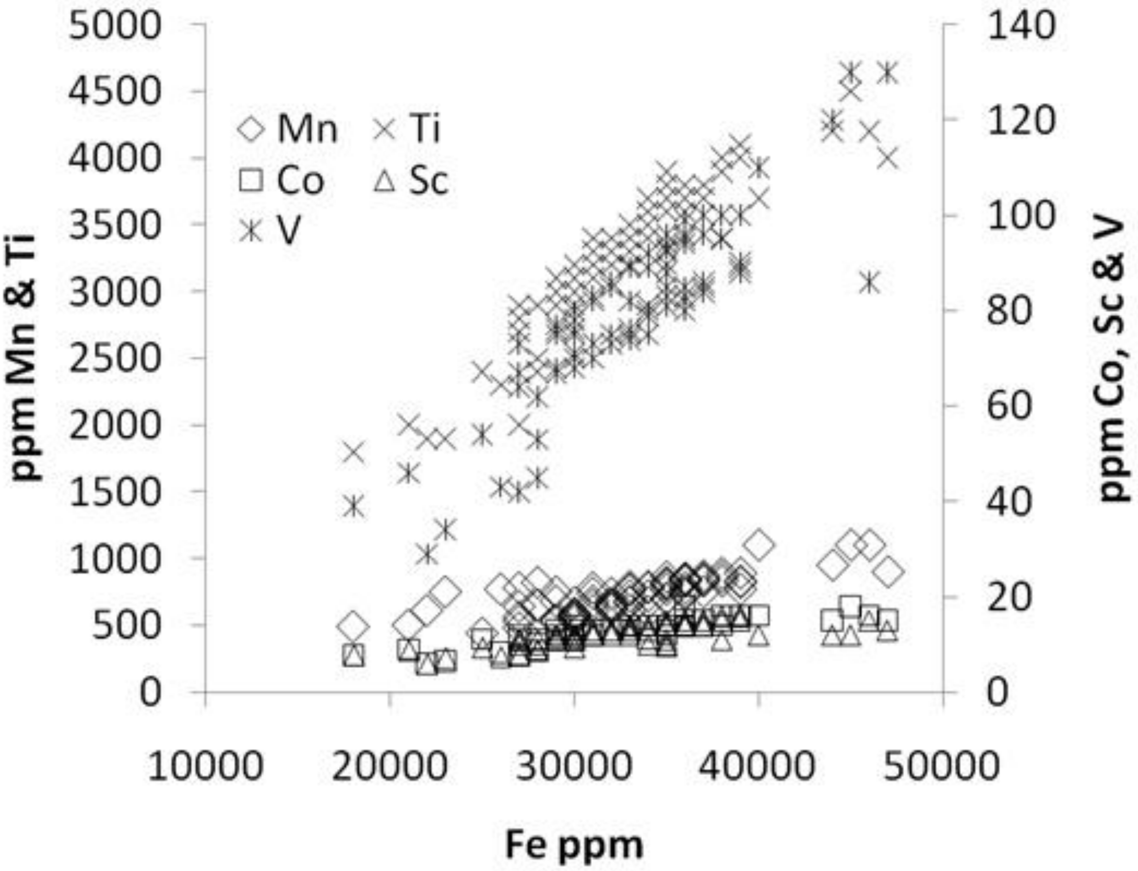

Fig. 5.2. Correlation between soil content of iron (Fe) and the elements manganese (Mn), titanium (Ti), cobalt (Co), scandium (Sc) and vanadium (V).

As described above the Al and Fe content was strongly correlated to a set of the 33 measured trace elements in the 85 soil samples (for Fe see Fig. 5.2) from 3 soil horizons in 50 soil plots in 10 macroplots at the site. Important exceptions were the soft (or type B) metals mercury (Hg), silver (Ag), lead (Pb), molybdenum (Mo) and cadmium (Cd), and some of the hard (type A), elements such as barium (Ba) and strontium (Sr). Soft metals (high covalent index) were instead generally found to be correlated only to each other (Tab. 5.5) and negatively correlated to hard (Type A) metals (e.g. Ca, Mg, Ba and Sr). Variation in Sr content followed closely the Ca levels ($r = 0.944$) and Ba was weakly correlated to Mn ($r = 0.520$). The chemical composition of the 14 B horizons, only found in macroplots 5 to 7, showed a very untypical relationship to its Fe content. This caused the relatively poorer correlation between Fe and trace elements. Omitting these B horizon samples from the correlation calculations improved the correlation between Fe and Co, Sc and Ti, and gave strong correlations also to yttrium (Y) ($r = 0.904$), lanthanum (La) ($r = 0.0.854$) and nickel (Ni) ($r = 0.728$).

The amounts of most trace elements co-varied in the soils across all soil plots and soil horizons; 33 strong correlations were found between the 33 measured trace elements (Tab. 5.5). As usual the borderline elements Ni, vanadium (V), Ti, scandium (Sc) and Y showed the largest number of strong correlations (Tab. 5). The type B elements (Ag, Te, Hg, Cd & As) and the type A elements (U, Sr, Cs, La and Ce) were among the poorest correlated to the other trace elements.

Tab. 5.5. The strongest sets of correlations (i.e. r > 0.700) found for each of the measured 33 trace elements in 36 A, 14 B and 35 C horizon samples from Umalak Teppa. The elements are sorted in the order of their covalent index with type B elements on the top and type A elements in the bottom. - Indicates no strong (r > 0.7) correlations.

	# of corr.	Vs.	r
Pb	1	Cu	0.709
Ag	0	-	-
Te	0	-	-
Bi	1	Zn	0.763
Hg	0	-	-
Tl	0	-	-
W	0	-	-
Se	0	-	-
Sb	0	-	-
Mo	0	-	-
Cd	0	-	-
As	0	-	-
Sn	0	-	-
Cu	0	-	-
Co	0	-	-
Ni	3	Sc	0.735
Zn	1	Bi	0.763
Nb	0	-	-
Th	0	-	-
V	3	Co	0.877
Ti	4	Co	0.931
Cr	1	Ni	0.725
Sc	6	Y	0.896
Y	5	Sc	0.896
Ce	0	-	-
La	0	-	-
Zr	2	Rb	0.771
Ba	2	Rb	0.834
Cs	0	-	-
Rb	2	Zr	0.771
Sr	0	-	-
U	0	-	-
Be	2	Ba	0.735

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®). More or less the same pattern is found in all the studied sites. In the plane of the first two principal components (PCA 1 and PCA 2) in both the A- and C 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 Sr along with organic content measured as LOI. The PCA 1 axis, explaining 30.4% and 44.2% of the variation in the A and C horizon, respectively, is therefore mainly explained by the Al and Fe relative to Ca content. The PCA 2 axis at most of the TEMP-CA sites is mainly explained by the Covalent index ($CI = X^2r$) of the elements, but this does not appear to be the case at Umalak Teppa. This may to some extent be due to that this is partly explaining the variation in the PCA 1, with typically hard trace elements having negative or low loadings and soft elements having high positive loadings.

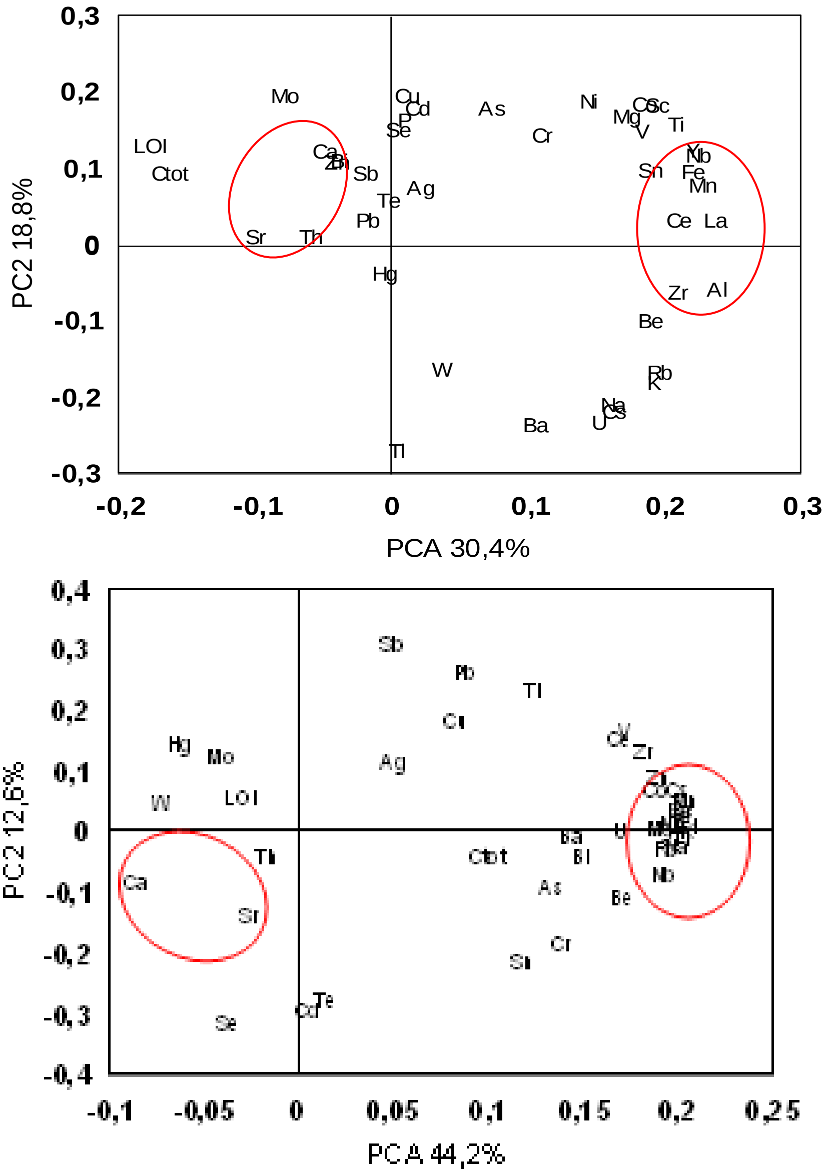

Figure 5.3. Parameter loading along the two first principal components in a PCA analysis of soil data from the A horizon (top graph) and C horizon (bottom graph), explaining 49.2 and 56,8 % of the variation in soil elemental composition, respectively.

6 REFERENCES

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

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

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

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.

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 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.

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.

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. & 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.

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

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, 291pp.

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.

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.

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

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.

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.