Working Report 2011-61

Results of Forest Monitoring on Olkiluoto Island in 2010

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November 2011

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ABSTRACT

Forest investigations carried out on Olkiluoto aim to monitor the state of the forest ecosystems, quantify Olkiluoto-specific processes taking place in the forests producing input data for the safety assessment of spent nuclear fuel disposal, and follow possible changes in the forest condition resulting from the intensive construction activities currently being carried out in the area. The forest investigations form a part of the monitoring programme being carried out on Olkiluoto Island under the management of Posiva Oy. This report focuses on activities performed on bulk deposition and forest intensive monitoring plots (MRK and FIP plots) in 2010. In general, the deposition levels in 2010 in the open area and in stand throughfall were quite comparable to those in earlier years, although sulphur and calcium depositions were somewhat higher in the open area than in earlier years (2004-2008). The soil solution quality in 2010 was also quite comparable to that in earlier years. The NH_4-N and NO_3-N concentrations were low at all depths in the mineral soil of the FIP plots 4, 10 and 11. Instead, nitrate concentrations were high in the soil solution on FIP14. There appeared to be a clear overall increase in sulphate concentrations with increasing depth on FIP4 and FIP10. Chloride concentrations in the soil solution were extremely high at all depths on all FIP plots throughout the monitoring period; it is clear that there is a considerable input of NaCl in the deposition derived from the sea. The concentrations of heavy metals (Cd, Cr, Ni, Pb) in the soil solution at all depths at Olkiluoto during 2004-2010 continued in many cases to be close to or below the limit of quantification. In 2010 the monthly level of transpiration in the Scots pine dominated stand was smaller in May and bigger in July than during previous years (2007-2009). Monthly transpiration in the Norway spruce dominated stand was clearly lower in 2010 than in 2007-2009, and there is a decreasing trend in the stand level transpiration of the spruce stand. Annual total litterfall production was smaller in coniferous plots in 2009 than during the previous collection period 2007-2008. The most notable differences between the plots were detected in Al and N concentrations. The Al concentration was higher in living pine needles than in spruce needles. High Al and Fe concentrations were found in remaining litter, and were most likely due to soil dust. The average defoliation level of the pines was 4.4 % and of the spruces 26.8 %; the pines were classified as non-defoliated and the spruces as moderately defoliated. The minirhizotron images filmed in 2010 in the FIP stands showed that within the three growing seasons the roots observed as new in 2008 had died by autumn 2010. Five new FET plots were established for the soil profile, ground vegetation surveys and analysis of nutrient concentrations in different compartments of the forests in the Ulkopäänniemi area during 2008-2010. According to the vegetation survey, the new FET plots represented very fertile site types.

Keywords: Bulk deposition, defoliation, fine root elongation and longevity, forest ecosystems, litterfall production, soil solution chemistry, stand throughfall, tree stand transpiration.

Olkiluodon metsien tilan seuranta 2010

TIIVISTELMÄ

Olkiluodon metsäntutkimusten tavoitteena on seurata metsien tilaa ja mitata metsissä tapahtuvia prosesseja. Tuloksia tarvitaan käytetyn ydinpolttoaineen loppusijoituksen turvallisuusarvioinnissa. Lisäksi tutkimuksilla seurataan alueen voimakkaan rakennustoiminnan mahdollisesti aiheuttamia muutoksia metsissä. Metsäntutkimukset ovat osa Posivan toteuttamaa ympäristön seurantaohjelmaa Olkiluodossa. Tässä raportissa esitetään keskeiset tulokset laskeuma-alojen ja metsien intensiiviseurannan alojen (MRK- ja FIP-alat) seurannasta vuonna 2010. Laskeuman analyysitulokset olivat suunnilleen samalla tasolla kuin aikaisempina vuosina lukuun ottamatta avoimien alojen rikki- ja kalsiumlaskeumia, jotka olivat hieman nousseet vuosiin 2004-2008 verrattuna. Maaveden ominaisuuksissakaan ei ollut pääsääntöisesti havaittavissa muutoksia aikaisempiin vuosiin verrattuna. NH_4-N ja NO_3-N pitoisuudet olivat poikkeuksellisen alhaiset kaikissa tutkituissa maakerroksissa FIP-aloilla 4, 10 ja 11. Sen sijaan uudella FIP14:llä maaveden nitraattipitoisuudet olivat suuret. Muutaman vuoden seurannan aikana on todettu maaveden sulfaattipitoisuuksien nousevan maanpinnasta syvempiin maakerroksiin siirryttäessä FIP-aloilla 4 ja 10. Maaveden kloridipitoisuudet olivat korkeat, mikä on luonnollinen seuraus meren läheisyydestä. Raskasmetallien (Cd, Cr, Ni, Pb) pitoisuudet maavedessä olivat lähellä tai alle määritysrajojen 2004-2010. Männikön (FIP4) kuukausihaihdunta oli pienempi toukokuussa ja suurempi heinäkuussa kuin aikaisempina vuosina (2007-2009). Kuusikon puuston haihdunta oli selvästi pienempi kuin aikaisempina vuosina (2007-2009). Vuotuinen kariketuotanto oli vuonna 2009 pienempi kuin 2007-2008. Merkittävimmät erot FIP-alojen välillä havaittiin karikefraktioiden Al- ja N-pitoisuuksissa: Al-pitoisuudet olivat selvästi korkeammat elävissä männyn kuin kuusen neulasissa. Muussa karikkeessa mitattiin korkeat Al- ja Fe-pitoisuudet, mikä selittynee maapölyllä. Männyissä ei havaittu harsuuntumista (harsuuntumisaste 4,4 %). Sen sijaan kuuset olivat harsuuntuneet kohtalaisesti (26,8 %). Vuoden 2010 miniritsotronikuvat osoittivat, että vuoden 2008 aikana syntyneet hienojuuret olivat kuolleet syksyyn 2010 mennessä. Ulkopäänniemen alueelle perustettiin viisi uutta FET-alaa vuosina 2008-2010, jolloin aloille tehtiin maannos- ja kasvipeitekuvaukset sekä analysoitiin maan ja kasvillisuuden ravinnepitoisuuksia. Kasvipeitekuvauksien perusteella uudet alat luokiteltiin hyvin viljaviksi kasvupaikoiksi, joista neljä edusti rannikolle tyypillisiä lehtotyyppejä.

Avainsanat: Harsuuntuminen, hienojuurten uusiutumisnopeus, karikesato, laskeuma, maavesi, metsikkösadanta, metsäekosysteemit, puuston haihdunta.

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1 INTRODUCTION

Forest investigations carried out on Olkiluoto aim to monitor the state of the forest ecosystems, quantify Olkiluoto-specific processes taking place in the forests producing input data for the safety assessment (Hjerpe et al. 2010, Posiva 2010) of spent nuclear fuel disposal, and follow possible changes in the forest condition resulting from the intensive construction activities currently being carried out in the area, as well as the future construction of the spent nuclear fuel repository. In addition, the forest investigations provide data for a range of modelling purposes either in terms of input data or validation data.

The forest investigations form a part of the monitoring programme being carried out on Olkiluoto Island under the management of Posiva Oy (Posiva 2003). Currently Posiva is updating the monitoring programme. In respect of monitoring possible environmental impacts of constructing a repository for spent nuclear fuel, and later on the continuation of the monitoring related to the operational safety of the repository, two potential pathways for loads going into forests should be considered. First, the network for monitoring atmospheric deposition should be positioned with consideration to the prevailing wind direction, i.e. north-west, north or north-east of the repository. Currently some MRK and FET sampling plots are located in that area, and their usability for monitoring purposes should be assured in the future. Secondly, in the case of the repository, the Liiklansuo watershed may be the most important area to monitor possible environmental impacts which occur via soil water or surface runoff. Forest intensive monitoring plots, FIP, have been established in that area.

This report focuses especially on activities performed on MRK and FIP plots in 2010.

2 MONITORING SYSTEM

2.1 Description of the forest monitoring network

The monitoring system consists of several overlapping levels (Figure 1). The first level is used for following changes in land use by interpreting aerial images. The second level is vegetation-type mapping, the purpose of which was to classify the vegetation and its distribution for use as a basis for the monitoring of primary plant succession caused by the post-glacial land uplift (about 6 mm/year, e.g. Haapanen et al. 2009) at the plant community level and the possible anthropogenic environmental impact (Haapanen 2009). Forest resources have also been mapped from the same vegetation polygons. The third monitoring level (FET, Forest ExTensive monitoring plots, Figure 2) is a grid of systematically located plots which are used to describe biomass distribution of forests and to monitor growth and other changes in tree stands. A part of the FET plots has been selected for further studies (FET sub-set). In these plots the vegetation is inventoried and the soil, needles and vegetation are sampled at intervals of 5 to 10 years in order to identify soil properties, vegetation composition and nutrient concentrations of plants and trees (for more details, see Tamminen et al. 2007, Haapanen 2009). The last two levels (MRK and FIP, Figures 1 and 2) comprise plots where observations are made daily or even hourly (see Ch. 2.2). The intensity of the sampling efforts increases towards the sixth monitoring level (Figure 1).

Due to continues changes in land use on Olkiluoto Island, it is not always possible to record the up-to-date extent of each monitoring network.

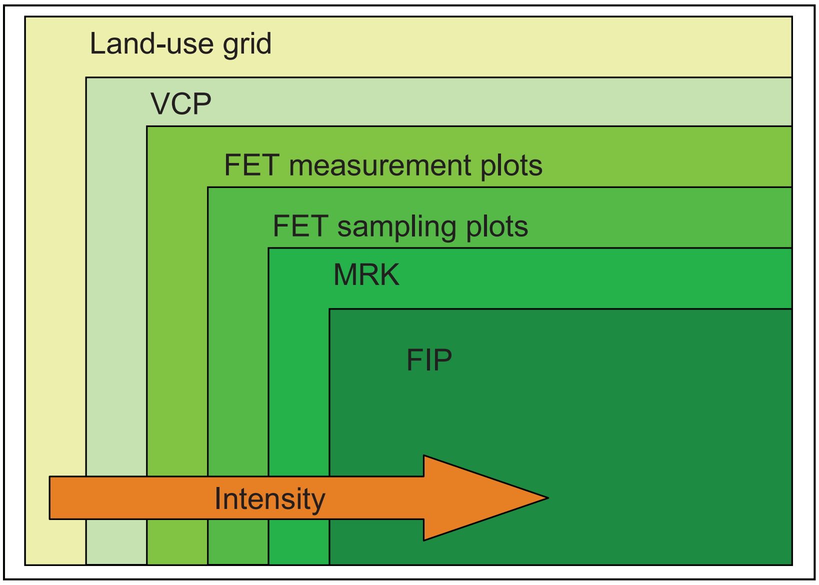


Figure 1. *Forest monitoring levels. The outermost land-use grid consists of plots at 50 m intervals. These have been visually interpreted for land-use. VCP contains the vegetation polygons, from which the forest resources have also been inventoried. The numbers of currently monitored plots are 485 (FET), 94 (FET sampling plots), 6 (MRK) of which 4 belong to the FIP grid as well. Grids have been modified (plots added/removed) according to increased knowledge of data needs and land-use changes on the island.*

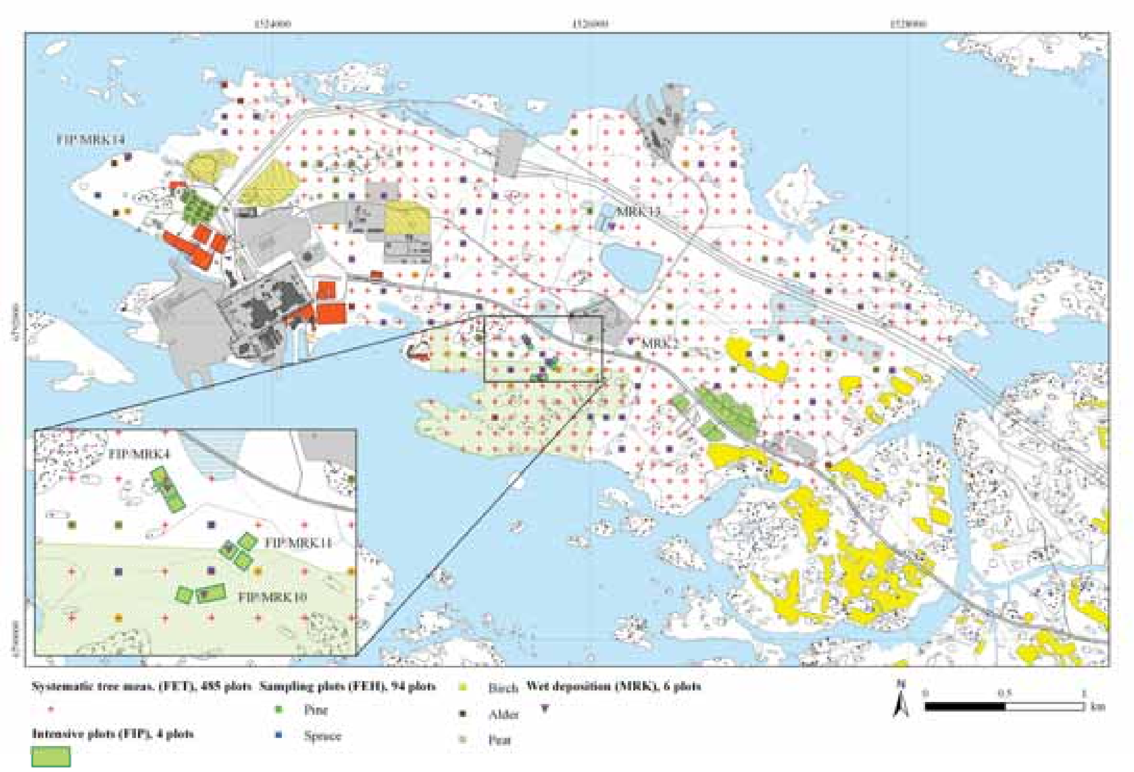


Figure 2. *Forest monitoring locations in 2010. Map layout by Jani Helin/Posiva Oy.*

2.2 Description of the MRK and FIP networks

2.2.1 Bulk deposition and stand throughfall plots (MRK)

The construction activities and rock crushing (i.e. an underground rock characterisation facility and an access to the spent fuel repository) on the Olkiluoto Island are producing a potentially negative impact on forests, primarily in the form of stone dust. To monitor the effects on the forests, a bulk deposition and stand throughfall monitoring network with rainwater and snow collectors (Figure 3) was established in 2003. The annual precipitation and interception of the tree canopies are also recorded on these plots. Currently four of the monitoring plots are within FIP plots and two in open areas (Figure 3). Rainwater is collected every two weeks and snow every four weeks, and from these samples the deposition is analysed for the mean pH and the amounts of a range of anions, cations and other elements.

Spruce and pine needles were also collected annually from all the seven forested sample plots of the bulk deposition and stand throughfall monitoring network between 2003 and 2007 to follow the foliar element concentrations (Rautio et al. 2009). Special attention was paid to the assessment of the effects of particulate matter originating from the construction activities on the foliar concentrations by means of different washing procedures. Since 2007 the sampling has been carried out biennially (year means a moment when current year needles have born). Needles born in 2009 were collected during March 2010.

Figure 3. *Examples of monitoring plots in an open area (MRK13, left) and in a spruce forest (MRK8, right). (Photos: A. Ryynänen/Metla and J. Ilomäki/Metla).*

2.2.2 Forest intensive monitoring plots (FIP)

In order to gain a better understanding of the effects of different stress factors on the forests, as well as understanding and quantifying the different processes typical of forest ecosystems on Olkiluoto Island, an intensive monitoring system similar to the Level II ICP Forests programme in Finland (e.g. Raitio et al. 2001) was established on Olkiluoto Island. The aim of the intensive monitoring activities is to continuously follow changes taking place in the nutrient budgets and fluxes in the soil, tree stands and vegetation at both the stand and the catchment level to cover the seasonal, annual and long-term variation (Table 1).

Each FIP plot (excluding FIP14) consists of three square sub-plots (30 m x 30 m, total area 900 m^2) coded as OA1, OA2 and OA3. The corners of the sub-plots, as well as their centre points, have been marked in the field using numbered poles. An approximately 5 to10 m wide strip has been left between and around the sub-plots for possible future use in special studies, and for additional sampling. This area constitutes the fourth sub-plot (OA4). OA1 is reserved for tree growth measurements, and OA3 for vegetation studies. Sampling methods that may have a detrimental long-term effect on the soil or stand, e.g. litter sampling, deposition and soil water collection, are concentrated on sub-plot OA2.

FIP14 consists only of one square sub-plot (OA2, total area 900 m^2) where litter sampling, deposition, soil water collection and micro-meteorological measurements are concentrated on. Plot FET930231 (total area 300 m^2) which is used for tree growth measurements and vegetation studies (see Figure 2) is located beside the OA2 sub-plot.

Table 1. *Performed monitoring activities and their frequency on the FIP plots.*

	Performed activities FIP4	FIP10	FIP11	FIP14	Normal Frequency
Establishment, start of equipment installations	2003	2003	2007	2009	
Location and measurement of trees	2004	2005	2008	2009	
Vegetation inventory (OA3)	2003, 2004, 2005, 2008	2003, 2004, 2005, 2008	2008	2010	Every 3 yrs
Soil condition	2007	2007	2007	2008	Every 10 yrs
Stand throughfall and precipitation measurements (MRK, OA2)	2003	2005	2007	2009	Continuous
Sap flow measurements	2007	2007	no	no	Continuous
Soil water sampling (OA2)	2003	2005	2007	2010	Continuous
Litterfall sampling (OA2)	2004	2005	2007	2009	Continuous
Foliage sampling (OA2)	2003, 2004, 2005, 2006, 2007, 2009	2004, 2005, 2006, 2007, 2009	no	2009	Every 2 yrs
Micrometeorology (OA2)	2004	2005	2007	2009	Continuous
Stem diameter growth (OA2)	2004	2005	no	no	Continuous
Tree growth (OA1)	2009	2009			Every 5 yrs
Crown condition survey	2006	2006	no	no	Annual
Soil microbial community structure and activity	2006	2006			

The first intensive monitoring plots were established in the small Liiklansuo catchment area, which represents the most important types of forest vegetation found on Olkiluoto Island. FIP4 was marked out in a 37-year-old Scots pine (*Pinus sylvestris*) stand (compartment no. 401.1, Rautio et al. 2004) and FIP10 in a 91-year-old Norway spruce (*Picea abies*) stand (compartment 366.1, Rautio et al. 2004) in August, 2003. The soil type on both plots was fine-textured till according to the compartment-wise inventory (Rautio et al. 2004). Both the Scots pine plot and the Norway spruce plot represent herb-rich heath forests (i.e. *Oxalis-Myrtillus* forest type, Salemaa & Korpela 2008, Figure 4). The third intensive monitoring plot (FIP11) was established in a young birch dominated stand in the Liiklansuo catchment area during 2006–2007 (Figure 4). This birch dominated plot (FIP11) is located on a rocky site and the vegetation represented partly mesic heath forests vegetation (i.e. *Myrtillus* type) and partly herb-rich heath vegetation (i.e. *Oxalis-Myrtillus* type, Salemaa & Korpela 2008). The fourth FIP plot (FIP14, Figure 4) was established in an alder stand of herb-rich type in 2009. The instrumentation of the FIP plots is presented in Table 2.

Figure 4. *A view on the intensive monitoring plots FIP4 (top left), FIP10 (top right), FIP11 (bottom left) and FIP14 (bottom right). Photos: L. Aro/ Metla.*

Table 2. *The instrumentation of the FIP plots with main installation information (i.e. the installation site in relation to ground level and the date of installation).*

Description	FIP plot	Instrument	Quantity	Installation site	Date
Air temperature	4	FW-5k	3	2, 9 & 24 m	1.9.2004
	10	FW-5k	1	2 m	23.5.2005
	11	FW-5k	1	2 m	19.6.2007
	14	Vishay-10k	1	2 m	3.11.2009
Radiation	4	LI-190/200SZ	2	24 m	1.9.2004
Air pressure	4	PTB210	1	2 m	26.4.2005
Wind	4	Adcon	1	24 m	1.9.2004
Relative humidity	4	HMP45D	2	2 & 9 m	1.9.2004
	10	HMP45D	1	2 m	23.5.2005
	11	HMP45D	1	2 m	19.6.2007
	14	HMP45D	1	2 m	3.11.2009
Precipitation	4	RMY-52203	1	1 m	1.9.2004
	10	RMY-52203	1	1 m	23.5.2005
	11	RMY-52203	1	1 m	19.6.2007

Soil temperature	4	FW-5k	13	-10 … -90 cm	1.9.2004
	10	FW-5k	13	-10 … -90 cm	23.5.2005
	11	FW-5k	13	-10 … -90 cm	19.6.2007
	14	Vishay-10k	13	-10 … -90 cm	3.11.2009
Soil moisture	4	Theta Probe	2	-20 cm	1.9.2004
	10	Theta Probe	2	-20 cm	23.5.2005
	11	Theta Probe	2	-20 cm	19.6.2007
	14	Theta Probe	2	-20 cm	3.11.2009
Soil solution	4	Plate lysimeter	8	-5 cm	Sept. 2003
		Suction cup	12	-10, -20, -30 cm	Sept. 2003
	10	Plate lysimeter	12	-5 cm	May 2005
		Suction cup	24	-20 & -30 cm	May 2005
	11	Plate lysimeter	8	-5 cm	13.12.2006
		Suction cup	12	-10, -20, -30 cm	13.12.2006
	14	Plate lysimeter	4	-5 cm	29.10.2009
Litterfall	4	Funnel type sampler	12	150 cm	June 2004
		Branch type	12	0 cm	7.5.2008
	10	Funnel type sampler	12	150 cm	12.5.2005
		Branch type	12	0 cm	7.5.2008
	11	Funnel type sampler	12	150 cm	25.4.2007
	14	Funnel type sampler	12	150 cm	15.5.2009
		Branch type	12	0 cm	30.6.2010
Stand throughfall	4	Snow sampler	5	180 cm	2.6.2003
		Rainwater collector	20	40–60 cm	2.6.2003
	10	Snow sampler	5	180 cm	23.5.2005
		Rainwater collector	20	40–60 cm	23.5.2005
	11	Snow sampler	5	180 cm	16.11.2007
		Rainwater collector	20	40–60 cm	May 2007
	14	Snow sampler	5	180 cm	17.9.2009
		Rainwater collector	20	40–60 cm	15.5.2009
Tree growth	4	Girth band	2	130 cm	1.9.2004
	10	Girth band	2	130 cm	23.5.2005

Soil profile descriptions and soil sampling were carried out on the FIP plots 4, 10 and 11 in 2007, and in the vicinity of FIP14 (i.e. FET930231) in October 2008. The soil on the plot FIP4 was podzolized to some extent, and all three soil profiles were classified as Haplic Arenosols, resembling Haplic Podzols. Two profiles on plot FIP10 were also classified as Haplic Arenosols and one profile as Haplic Gleysols. On the plot FIP11 two profiles were classified as Haplic Gleysols and one as Histic Gleysols (Tamminen & Aro 2008). The soil profile on FET930231 was classified as Haplic Arenosol.

The trees growing on the Scots pine plot (FIP4) were measured in 2004. According to the results, the mean age of the stand was 38 years, mean height 17 m, basal area 32 m^2 and mean volume 268 m^3/ha (Aro et al. 2010). Four years later (i.e. in Spring 2009) the corresponding figures for Scots pine on sub-plot OA2 were 42 years, 18 m, 34 m^2 and 303 m^3/ha, respectively.

The trees growing on the Norway spruce plot (FIP10) were measured in 2005. The spruce stand was silviculturally relatively over-aged (on average 93 years), and there was a lot of dead wood lying on the forest floor. Deciduous trees were also growing among the spruces. According to the results of the stand measurement, the mean height of the spruces was 19 m, basal area 34 m^2 and mean volume 386 m^3/ha (for the birches, 23 m, 7 m^2 and 74 m^3/ha, respectively) (Aro et al. 2010). Three years later the corresponding figures for the trees (Norway spruce and birch) on sub-plot OA2 were 20 m, 42 m^2 and 473 m^3/ha, respectively.

The trees growing on the plot with the young mixed stand (FIP11) were measured in June 2008. 42 743 young trees were growing on sub-plot OA2. Downy birch (*Betula pubescens*), with a stem number of 34 779/ha, was the dominant tree species. The mean height of the trees was 2.3 m, basal area 5 m^2/ha, and mean volume 16.8 m^3/ha (Aro et al. 2010). The trees growing on the black alder dominated plot (FIP14) were measured in November 2009. The mean height of the trees was 10.2 m, total basal area 24.4 m^2/ha, and total volume 147.1 m^3/ha (Aro et al. 2010).

Tree stand characteristics for five growing seasons after previous measurements on sub-plot OA1 of FIP4 and FIP10, as well as for the first measurement on sub-plot OA1 of FIP11 and FIP14 are presented in Table 3. The Scots pine dominated sub-plot was measured on 26.3.2009 and the Norway spruce dominated sub-plot on 29.9.2009.

An increase in the crown limit from 8.95 m to 10.86 m during 2004-2009 and the high basal area (32.82 m^2) in the pine dominated FIP4 showed clearly that thinning will be necessary in the near future (Table 3). There were signs of infection by *Peridermium* stem rust in several pine trees and therefore thinning should be targeted at infected trees. The birches have reached their mature age on the plot FIP10. Plant competition-caused self-thinning is a normal age-related phenomenon in natural stands and will probably continue during the following monitoring period.

Table 3. *The basic stand characteristics of Scots pine (FIP4),Norway spruce (FIP10), birch (FIP11) and black alder (FET930231) dominated plots during 2004-2009.*

Month/Year	Plot no.	Sub-plot no.	Tree species	Stem number	Basal area with bark m^2/ha	Mean diameter weighted with basal area, cm	Mean height, (arithmetical), m	Lower limit of crown, m	Dominant height (100/ha), m	Stem volume with bark, m^3/ha
6/2004	04	1	Scots pine	878	28.65	21.09	16.85	8.95	17.86	237.50
3/2009	04	1	Scots pine	867	32.82	22.69	18.18	10.86	19.13	290.36
6/2005	10	1	Norway spruce	722	30.03	29.82	18.34	8.25	27.58	341.47
9/2009	10	1	Norway spruce	667	30.59	31.44	18.50	8.17	27.31	340.50
6/2005	10	1	Birch	189	7.42	25.22	23.68	15.44	25.02	83.19
9/2009	10	1	Birch	133	5.63	25.76	23.77	13.97	24.29	63.80
6/2008	11	1	Silver birch	4779	2.74	4.03	3.78	1.26	6.28	8.63
	11	1	Downy birch	11239	4.12	3.50	3.19	1.14	6.03	12.88
	11	1	Norway spruce	1150	1.92	5.89	3.63	0.35	5.75	5.84
11/2009	14	2	Black alder	1200	23.51	19.64	10.31	5.21	17.08	142.76
	14	2	Deciduous	44	0.59	14.31	8.00	2.08	8.00	2.50
	14	2	Norway spruce	11	0.33	19.55	12.00	1.30	12.00	1.88

3 MATERIAL AND METHODS

3.1 Bulk deposition and stand throughfall on MRK plots

Deposition loads on the forest and forest floor were monitored using a deposition monitoring network (MRK plots, Table 4). The monitoring was performed during 2010 on 6 plots, of which two were located in open area (MRK2 and MRK13), one in the Scots pine stand (MRK4), one in the Norway spruce stand (MRK10), one in a young mixed stand (MRK11), and one plot in the alder dominated stand (MRK14).

The results for bulk deposition and stand throughfall during the period 2.2.2010-17.1.2011 are presented in this report (Ch. 4.1), and the deposition for this period is denoted in the following as the deposition for the year 2010. The results for 2010 are compared to the deposition load during the period 2004-2009 on Olkiluoto, as well as to the deposition load on two intensively monitored plots (one pine and one spruce) in Juupajoki and two plots (one pine and one spruce) in Tammela, southern Finland (EU Forest Focus, UN/ECE ICP Forests monitoring plots).

The samples were collected at predetermined intervals (at 2-week intervals during the snow free period, and at 4-week intervals during the winter) on Olkiluoto and mailed to Rovaniemi by the staff of Posiva Oy. This procedure was used in order to minimise contamination of the samples (while still in the collectors) through microbial growth during the warmer parts of the year. All the samples were stored in a cold room prior to making bulked samples in the laboratory. The chemical analyses (Table 5) were carried out by the laboratory staff of the Rovaniemi and Vantaa Units, Metla.

Table 4. *Basic characteristics of the establishment and deposition monitoring of the MRK plots. Type: TF=stand throughfall, BD=bulk deposition.*

MRK plot	Established	Type	Tree species	Monitoring period
1	6/2003	TF	Scots pine	6/2003 – 3/2008
2	6/2003	BD	open area	6/2003 – 12/2007, 4/2008 –
3	6/2003	TF	Scots pine	6/2003 – 3/2008
4	6/2003	TF	Scots pine	6/2003 –
5	6/2003	TF	Norway spruce	8/2003 – 3/2008
6	6/2003	TF	Norway spruce	8/2003 – 3/2008
7	6/2003	BD	open area	6/2003 – 3/2008
8	6/2003	TF	Norway spruce	6/2003 – 3/2008
9	4/2004	BD	open area	4/2004 – 3/2008
10	5/2005	TF	Norway spruce	5/2005 –
11	5/2007	TF	birch	5/2007 –
12	10/2007	BD	open area	1/2008 – 3/2008
13	5/2009	BD	open area	5/2009 –
14	5/2009	TF	Black alder	7/2009 –

The major problem in collecting deposition is the avoidance of contamination caused by bird droppings in the rainfall collection equipment. Bird droppings contain appreciable amounts of P which result in elevated phosphate concentrations in samples. The field workers had strict instructions to exclude samples from individual collectors where there is evidence of bird droppings.

There were no problems, in general, in the field work, transport of the samples to the laboratory or during the chemical analyses that can be considered to have had a significant effect on the results for 2010.

Table 5. *Performed analyses and their limits of quantification (LOQ) for water samples of bulk deposition and stand throughfall.*

Variable	Unit	LOQ
pH		
Alkalinity	mmol/l	
H+	mg/l	
Conductivity	µS/cm/25 °C	8
DOC	mg/l	0.6
Tot-N	mg/l	0.05
NH_4-N	mg/l	0.03
NO_3-N	mg/l	0.04
Ca	mg/l	0.0004
Mg	mg/l	0.001
K	mg/l	0.06
Na	mg/l	0.01
PO_4-P	mg/l	0.13
SO_4-S	mg/l	0.05
Cl	mg/l	0.1
Al	mg/l	0.03
Fe	mg/l	0.002
Mn	mg/l	0.001
Cu	mg/l	0.004
Zn	mg/l	0.002
Si	mg/l	0.006

3.2 Soil solution on FIP plots

3.2.1 Method of sampling soil solution

The chemical composition of soil solution is being monitored continuously during the snow-free period on FIP plots at Olkiluoto as a part of a comprehensive study on the functioning of forest ecosystems on the island. Changes in the chemical composition of rainfall (bulk precipitation) are being followed as the water first passes down through the tree canopy (stand throughfall), and then down the soil profile in the form of soil solution (Figure 5). Soil solution is sampled at different depths down the soil profile, thus providing information about soil formation processes. In addition to determining the concentrations of individual ions, the amount of water passing down through the soil is also being measured and modelled in order to be able to determine ion fluxes between the individual soil horizons in tree stands.

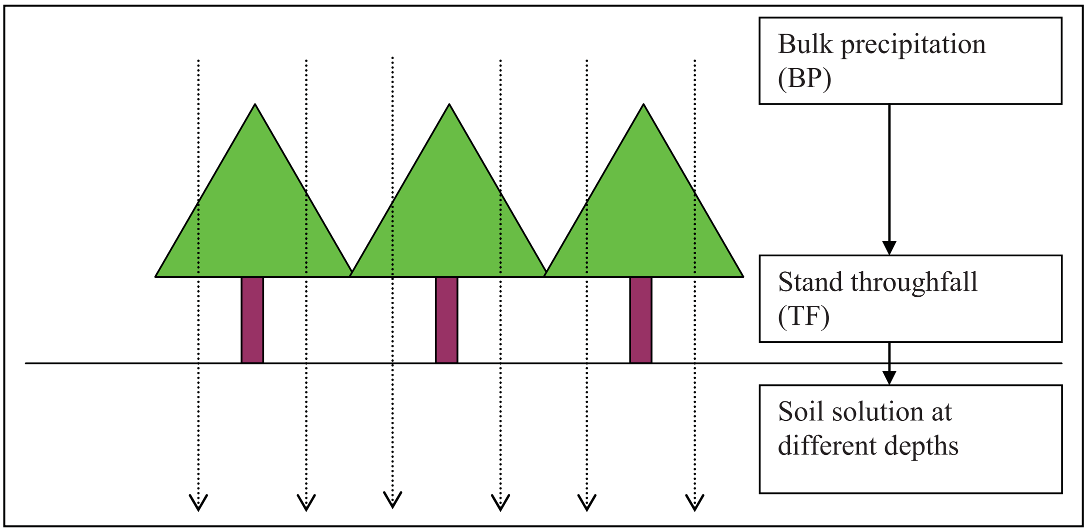


Figure 5. *A schematic presentation showing the path of water down through forest ecosystems, and the different components taken for chemical analysis (Derome 2007).*

Two sampling techniques are being used for sampling soil solution in the stands:

- Tension lysimetry (suction-cup lysimeters) installed at different depths, primarily in the mineral soil
- Zero-tension lysimetry (plate lysimeters) installed immediately below the organic layer

The two procedures differ considerably with respect to the soil solution fraction sampled, the effects of sampling on the site, as well as the extent to which they provide information about temporal and spatial variation in the properties of soil solution. Of the two methods, zero-tension lysimetry is the only one which samples a clearly definable fraction of the soil water, i.e. free-flowing water that percolates down through the soil when the field capacity is exceeded. Even so, there are drawbacks to this method because zero-tension lysimeters, for technical reasons, do not necessarily collect all of the free-flowing water at the sampling point, and the volume of water collected/surface area of the collector is therefore not always equal to the water flux at the sampling point. Tension lysimetry samples a relatively broad fraction of the soil water. However, soil water samples are obtained by this technique only when the magnitude of the negative pressure (vacuum) applied exceeds that of the hydraulic forces holding the water in the soil. Tension lysimetry obviously also samples free-flowing water when it is present.

The sampling of soil solution started on FIP4 (Scots pine stand) on 18.5.2004, on FIP10 (Norway spruce stand) on 19.7.2005, on FIP11 (young mixed stand) on 1.6.2007, and on FIP14 (alder stand) on 16.6.2010.

The layout (location, depths and replications) of the lysimeters on the three plots is comparable to that used in establishing the intensive monitoring plots of the ICP Forests (UN/ECE)/Forest Focus (EU) programmes. Furthermore, the sampling procedure and the pre-treatment and analysis of the soil solution samples are carried out in accordance with the ICP Forests Sub-manual on Soil Solution Collection and Analysis.

The soil solution samples were collected at predetermined intervals on Olkiluoto and sent to Rovaniemi by the staff of Posiva Oy. The chemical analyses were carried out by the laboratory staff of the Rovaniemi Unit and the Vantaa Unit, Metla.

3.2.2 Amounts of percolation water

Percolation water was collected during the snow-free periods in 2004-2010 on plot FIP4, in 2005-2010 on plot FIP10, in 2007-2010 on plot FIP11, and in 2010 on FIP14 using plate lysimeters with a surface area of 0.1 m^2 (40 cm x 25 cm), located at a depth of 5 cm, i.e. immediately below the organic layer. On plot FIP4 there was a total of 8 plate lysimeters at 4 sampling points (2 replications/point). On plot FIP10 there was a total of 12 plate lysimeters, and on plot FIP11 a total of 8 plate lysimeters, located systematically over the plot. On plot FIP14 there was a total of 4 plate lysimeters at one sampling point. The collection period of the percolation water starts in the spring after snowmelt when the ground is no longer frozen.

The amount of water percolating down to different depths in the soil is determined by a number of factors:

1) The amount of water falling on the forest floor as rain or snow. In a tree stand, this is the amount of stand throughfall (Figure 5).
2) Some of the water in stand throughfall is lost from the snow cover during the winter through evaporation directly from the snow surface. This can be especially high during spring when, even though the air temperature is below freezing point, solar radiation causes the sublimation of ice directly into water vapour that is released into the atmosphere.
3) Some of the water (as snow) falling on the forest floor is lost during snowmelt in the form of horizontal runoff out of the stand. This can be considerable if the ground immediately below the melting snow cover is still frozen, thus preventing the water from passing down into the soil
4) During the period extending from spring to autumn, a variable proportion of the water falling onto the forest floor is recycled back into the atmosphere though the uptake of water by the tree stand and ground vegetation (as evapo-transpiration). The plate lysimeters are located below the organic layer, which is the layer in the soil that contains the highest proportion of plant roots.
5) Some of the water (as rain) that collects on the surface of the ground vegetation during the snowfree period may evaporate directly into the atmosphere, especially during warm periods.
6) During the summer especially, the intensity (amount) of stand throughfall strongly affects the amount of percolation water: high precipitation events result in more percolation water owing to the proportionally smaller amount of water lost through evapo-transpiration.

In addition to the above natural factors, there are also technical problems during the snowmelt period: the capacity (volume) of the bottles used to collect the water samples may not always be sufficient to hold all the water running out of the plate lysimeters.

Under such conditions, the amount of percolation water will be underestimated. On plot FIP10 there are also problems in the spring with an excessively high water table and inundation by high sea water; the plot is located only a few meters above sea level and water may pass into the collection bottles that is not derived from precipitation.

3.2.3 Chemical composition of the soil solution on FIP plots

Soil solution was collected in the Scots pine stand using 8 plate lysimeters at a depth of 5 cm, and suction cup lysimeters at depths of 10, 20 and 30 cm, in four observation clusters on the plot during the snow-free period. Soil solution was collected in the Norway spruce stand using 12 plate lysimeters systematically located at a depth of 5 cm on the plot during the snow-free period. The 24 suction cup lysimeters were located at depths of 20 and 30 cm (12 for each depth). In the young mixed stand soil solution was collected using 8 plate lysimeters located at a depth of 5 cm, and 12 suction cup lysimeters at depths of 10, 20 and 30 cm (4 each for depth), systematically located on the plot during the snow-free period. Only 4 plate lysimeters were used to collect soil solution in alder stand. The samples from each plate lysimeter were analysed separately, and the samples obtained with the suction cup lysimeters were bulked to give one sample per depth per monitoring plot per sampling occasion.

Table 6. *Performed analyses and their limits of quantification (LOQ) for soil solution.*

Variable	Unit	LOQ
pH		
Alkalinity	mmol/l	
Conductivity	µS/cm/25 °C	8
DOC	mg/l	0.6
Tot-N	mg/l	0.05
NH_4-N	mg/l	0.03
NO_3-N	mg/l	0.04
Na	mg/l	0.01
PO_4-P	mg/l	0.13
SO_4-S	mg/l	0.05
Cl	mg/l	0.1
Al	mg/l	0.03
B	mg/l	0.004
Ca	mg/l	0.0004
Cd	mg/l	0.001
Cr	mg/l	0.001
Cu	mg/l	0.004
Fe	mg/l	0.002
K	mg/l	0.06
Mg	mg/l	0.001
Mn	mg/l	0.001
Na	mg/l	> 1
Ni	mg/l	0.01
P	mg/l	0.06
Pb	mg/l	0.015
S	mg/l	0.07
Si	mg/l	0.006
Zn	mg/l	0.002

3.3 Tree stand transpiration on the plots FIP4 and FIP10

The tree stand transpiration measurements on Olkiluoto Island were initiated on FIP4 and FIP10 in early May and early June 2007, respectively. Measurement system was enlarged with three new trees on both the plots in April 2010. The aim was to measure tree-level transpiration as a basis for calculating stand transpiration rate and variability in the FIP areas. A measurement system by UP GmbH, based on the constant heat method, was installed. Water movement is measured with a pair of needle sensors (30-40 mm long, 2 mm in diameter), which are radially inserted into the sapwood of a tree at a ca. 1.5 m height with a vertical spacing of 10 to 15 cm (Granier 1985, Köstner et al. 1996). Both sensors have a thermocouple for recording temperature. The upper sensor is heated constantly with 0.2W direct power and the temperature difference between the needles is monitored. Temperature differences between the sensors have been related to the mass flow of water based on empirical calibration (Granier 1985) with several tree species. The maximum temperature difference is during the night, when sap flow is assumed to be 0. In the daytime high flow lowers the difference because water flux transports the heat away from the upper needle. The measured flow density is extrapolated for the whole tree by multiplying by the tree sapwood area (Granier 1985). Since weather conditions (humidity, wind, radiation) determine the rate of transpiration, the meteorological data collected in the FIP4 weather station can be used in studying the variability of transpiration in relation to variations in local weather. The establishment of the system, calculation of sapwood area and results for 2007 and 2008 were presented earlier in memos by Hökkä (2008a, b).

Some problems occurred in sap flow measurements especially during the winter season in 2009 and 2010. Especially some measuring observations were missing which resulted in unreal peaks in calculated transpiration. Therefore calculated values for tree transpiration can be considered reliable only for the period from the end of March to the beginning of December, and consequently reliable for the period from April to November on month basis.

Table 7. *Maximum acceptable values of transpiration at single tree and tree stand levels.*

Level	Time unit	Max value	Unit
Tree stand	per hour	0.25 (min=0)	mm
	per day	2.5 (min=0)	mm
	per mounth	50 (min=0)	mm
Single tree	per hour	5	dm^3
	per day	45	dm^3

3.4 Litterfall production and element return to the forest floor on FIP plots

Litterfall was collected using 12 traps (UN/ECE 2004a) located systematically on FIP4 (pine), FIP10 (spruce), FIP11 (in deciduous forest) and FIP14 (black alder) plots in 2009. The litterfall collectors were funnel-shaped traps with a collection area of 0.5 m^2 placed about 1.5 m above ground level (see Figure 4a). Litterfall collection was started on the plots (FIP4, FIP10, FIP11) 14.-15.5.2009 and on FIP14 4.8.2009. Since the last collection date in 2008 was in beginning of December, the mass of first collection in 2009 represents the litterfall of the whole previous winter.

In 2009 the collected litter was divided into eight different fractions:

1= dead pine needles (brown needles)
2= living pine needles (green needles)
3= spruce needles
4= leaves
5= remaining litter
6= small branches
7= branches
12= remaining litter in branch traps

Fractions 1-6 were collected using the funnel type litterfall traps used in the ICP Forests programme (UN/ECE 2004a). Branches (fraction 6) collected by this trap are rather small. To collect the whole spectrum of branch litter we used a new type of traps that are positioned on the ground (Figure 4a). These new "branch traps", which consist of a nylon fabric stretched on a frame of approximately two centimeters height, were developed in the Finnish Forest Research Institute specifically to collect branch litter that is missed by the funnel type litterfall traps used in the ICP Forests programme (UN/ECE 2004a) mainly to collect foliage litter. These branch traps are similar to the funnel traps in size (0.5 m^2). 12 branch traps were positioned close to each funnel trap. Branch traps were used on plots FIP4 and FIP10, and new traps were positioned on FIP14 30.6.2010.

Litterfall production (dry mass in grams/m^2; 105°C) is reported for each of these fractions separately for each collection occasion. Element concentrations (aluminium, boron, calcium, chromium, copper, iron, potassium, magnesium, manganese, nickel, phosphorus, sulphur, zinc, carbon and nitrogen) were determined if there was enough material in a given litter fraction to allow homogenization (grinding) and microwave digestion in acid (HNO_3/H_2O_2) preceding chemical analysis. Concentrations of cadmium, molybdenum and lead were in most cases below the limit of quantification, and hence are not reported here.

3.5 Defoliation of trees on the plots FIP4 and FIP10

Visual assessment of the crown condition on intensive monitoring plots at Olkiluoto was carried out according to the guidelines of the UN/ECE crown condition sub-manual (UN/ECE 2004b).

3.6 Fine root elongation and longevity on FIP plots

The study was carried out on the intensive monitoring plots FIP4, FIP10 and FIP11. Fine root elongation and longevity were monitored using the minirhizotron (MR) method (Majdi et al. 2005). In June 2007 three clear plexiglass MR tubes were installed vertically in the soil, and three tubes horizontally within the organic layer of each stand (Helmisaari et al. 2009). There was a one-year conditioning period without taking any images, and filming was started in June 2008. Images were taken four times during the 2008 growing season (26.6., 15.8, 11.9 and 15.10), five times during the 2009 growing season (26.5., 1.7., 4.8., 3.9. and 6.10.), and five times during the 2010 growing season (18.5., 22.6., 27.7., 1.9. and 5.10.).

Images were taken continuously on two sides (A and B) of each tube, the two holes in each tube allowing positioning of the MR camera (Bartz Technology Inc., CA). Images were taken in the vertical tubes as a continuous image column from the soil surface down to depths in the mineral soil without any fine roots. The total number of images in the column in a vertical tube was 19 on FIP4, 15-16 on FIP10 and 12-16 on FIP11. As the size of each image was 1.4 x 1.8 cm, the total length of the image column was therefore 17-27 cm. In the horizontal tubes, images were taken throughout the whole length of the tube, resulting in 31-34 images on FIP4 and 50-53 on FIP10 and FIP11. Thus, in 2008 altogether a total of 3392 images were taken during the whole growing season, and 848 images at each filming session: 212, 376 and 260 images in FIP4, FIP10 and FIP11, respectively. As there was one more filming session in 2009 and 2010, altogether a total of 4206 images were taken in both years during the whole growing season, 836-844 images at each filming session: 206-208, 372-376 and 258-260 images on FIP4, FIP10 and FIP11, respectively.

The length and mean diameter of the fine roots were analyzed by manual tracing on the digital images with a computer mouse using the image analysis WinRHIZO Tron MF (Regent, Quebec, Canada) software. Captured images in the windows of the tubes were viewed as a time sequence. The date for when a root was first observed and the date of its death or disappearance were recorded. The data files produced by WinRhizo Tron were in ASCII text format, which is well-suited for manipulation into spreadsheet-style programs such as Excel. All the data files (ASCII text format) were converted into Excel format, each column having a defined format.

All new roots were followed when they were not yet suberized, i.e. white, turgid, and growing. The same roots were monitored and classified at each filming session as living, dead or disappeared. Roots were recorded as dead when they were black, no longer turgid, and were losing their outer suberized layer. The diameter, length and surface area of each root and EcM tip were recorded, and each root was classified as a tree, dwarf shrub or grass/herb root. Data and all figures have been stored in POTTI (Posiva's research result database).

3.7 Establishment of new FET sampling plots

Five new FET plots were established for the soil profile, ground vegetation surveys and analysis of nutrient concentrations in different compartments of the forests (Figure 6 and Table 8, see also Tamminen et al. 2007). Plots were positioned in Ulkopäänniemi at Olkiluoto because it is probable that the area will remain outside of construction activities.

Trees were measured in accordance with the field manual of the National Forest Inventory (see Saramäki & Korhonen 2005) during November 2008. Soil samples were collected during October 2008. The soil survey was carried out on systematically located sub-plots in a circle (r= 7 m) inside each FET plot (Figure 6). Leaf samples were collected from trees in August 2009 for chemical analysis, and needle samples in November 2009. Individual samples were taken from the dominant tree species on each plot (Figure 6). A vegetation survey was carried out during August 2010 in a similar way to the method presented by Huhta & Korpela (2006). When possible, shoot samples of the most abundant or frequent evergreen and deciduous dwarf shrub, herb, grass, bryophyte and lichen species were collected from each plot for chemical analysis in August 2010 (see details in Huhta & Korpela 2006 and Tamminen et al. 2007).

Soil and plant material was prepared and analysed as presented in Tamminen et al. (2007). The total C and N concentrations of the samples were analysed in a CHN analyser. The total element concentrations (P, K, S, Ca, Mg, B, Cu, Zn, Mn, Na, Fe, Al, Cd, Cr, Ni, Pb and Mo) were determined by wet digestion (HNO_3/H_2O_2) and analysed by ICP-AES. The results were expressed as concentration per weight of dry matter (drying at +105 °C). Concentrations of exchangeable cations, pH and exchangeable acidity were also determined, and cation exchange capacity and base saturation were calculated from the soil samples. The data have been stored in the POTTI database.

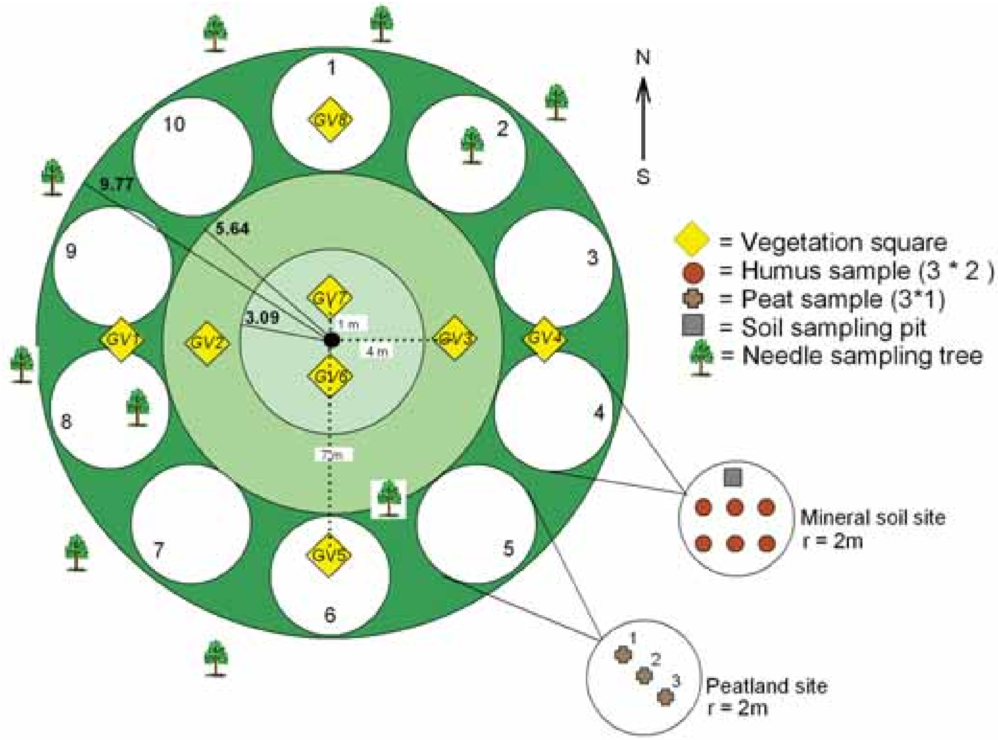


Figure 6. *Sampling design on the 300 m^2 circular plot.*

Table 8. *Basic characteristics of the new FET plots in the Ulkopäänniemi area. Coordinates in KKJ1 system.*

Plot	N coord.	E coord.	Tree species	Soil profile	Site type[1]
927230	6792689.40	1523015.53	Black alder	Haplic regosol	Grove
927231	6792699.74	1523090.35	Silver birch	Haplic regosol	Grove
928229	6792803.07	1522901.85	Norway spruce	Haplic regosol	Grovelike
930230	6793004.89	1523005.01	Black alder	Haplic regosol	Grove
930231	6793039.24	1523088.52	Black alder	Haplic regosol	Grove

[1] see Ch. 4.7

3.8 Temperature sum in the area

The length of the growing season and corresponding effective temperature sum (threshold +5^{o}C, measuring height 2 m) on FIP plots (code for Olkiluoto weather stations, WOM) for 2010 were as follows:

FIP4 (WOM2)	10.5. – 20.10.2010	1395.5 GDD
FIP10 (WOM3)	11.5. – 20.10.2010	1352.5 GDD
FIP11 (WOM4)	11.5. – 20.10.2010	1302.7 GDD

3.9 Data in POTTI

Data from measurements and analyses have been stored in POTTI (Posiva’s research result database). Definitions for data in POTTI are presented in Appendix 1.

4 RESULTS AND DISCUSSION

4.1 Bulk deposition and stand throughfall

The amount of precipitation in 2010 in open areas (bulk deposition, BD) and stand throughfall (TF) was higher than in 2009, but at a similar level to that in 2008. There were no clear increasing or decreasing trends in pH of BD and TF during the period 2004-2010, although the mean pH in BD was slightly lower in 2010 than during 2009 when it was rather high (>pH 5.5). The pH values were at a level slightly above the values measured at the ICP-Forests monitoring plots (reference plots) located at Juupajoki and Tammela in central and southern Finland.

There was variation in the deposition of total nitrogen in BD and TF during 2004-2010, but the values were comparable with those on the reference plots at Juupajoki and Tammela. There was also a variation in NH_4-N (Figure 7) and NO_3-N (Figure 8) deposition in BD and TF between the years, but the values were in general comparable to those measured at Juupajoki and Tammela. The NH_4-N deposition was higher in 2010 than in earlier years on all the BD and TF plots. The highest annual N_{tot} and NH_4-N deposition in TF during 2004-2010 was measured on the new black alder plot in 2010. The deposition of nitrogen compounds in TF was generally lower than that in BD due to nitrogen uptake by the tree canopies (absorption into the needles, utilization by the mosses, lichens and microflora on the needle surfaces). This is a well-documented phenomenon in coniferous stands in Finland, indicating that the deposition of nitrogen compounds is relatively low.

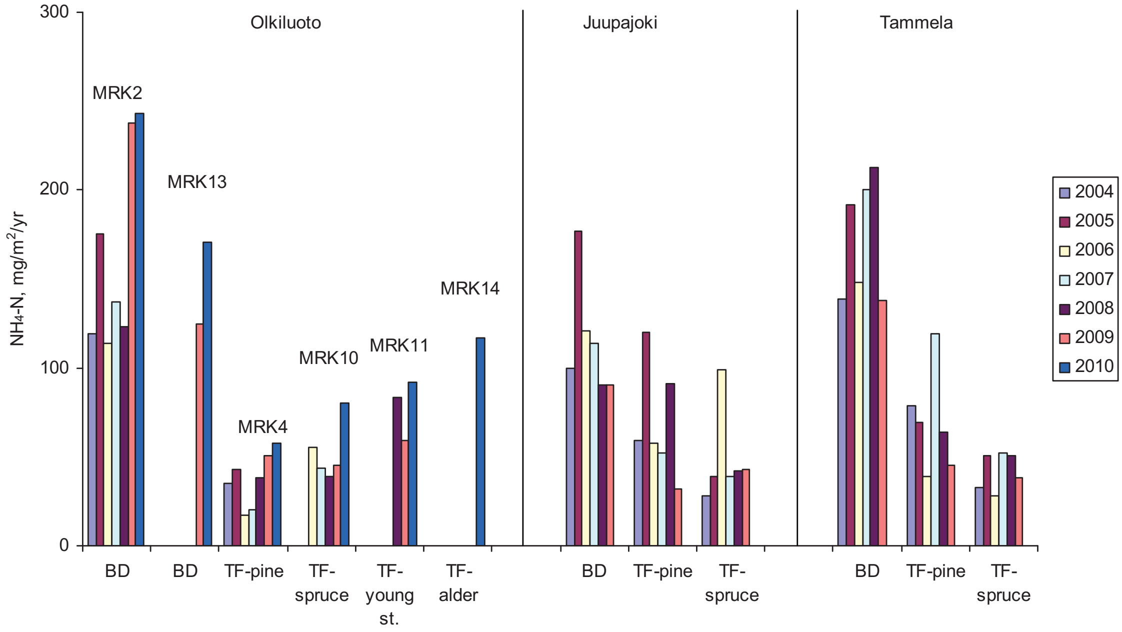


***Figure** 7. The NH_4-N deposition in bulk deposition (BD, open area) and stand throughfall (TF, inside the stand) on Olkiluoto in 2004-2010. The sample plots and tree species are indicated in the Figure (young st. = young mixed stand). Reference values for ICP Forests plots at Juupajoki and Tammela are given for comparison.*

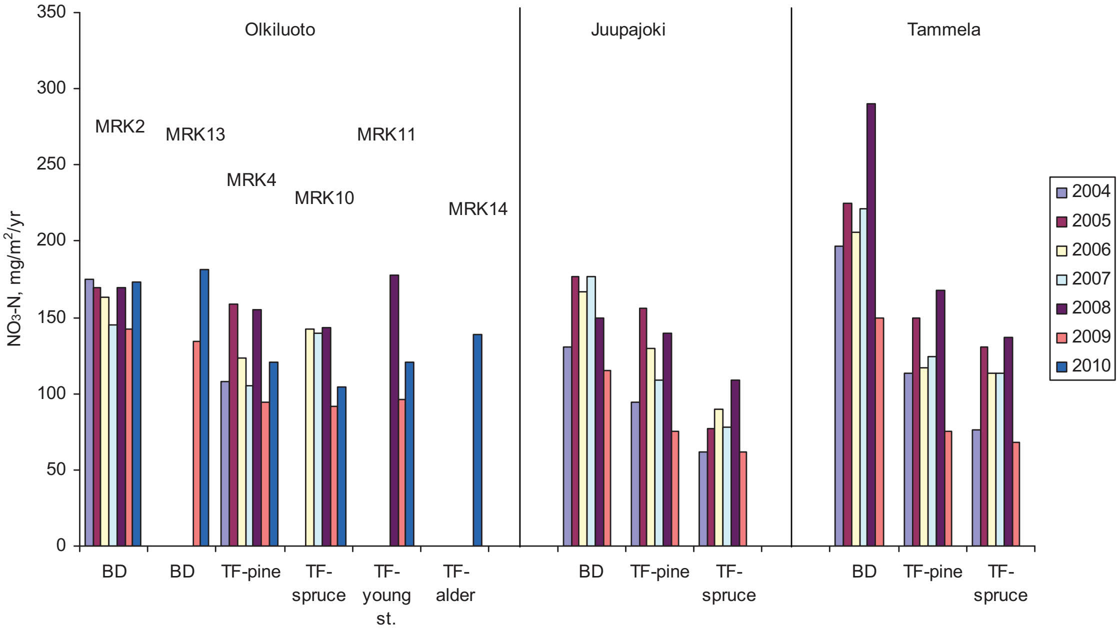


Figure 8. *The NO_3-N deposition in bulk deposition (BD, open area) and stand throughfall (TF, inside the stand) on Olkiluoto in 2004-2010. The sample plots and tree species are indicated in the Figure (young st. = young mixed stand). Reference values for ICP Forests plots at Juupajoki and Tammela are given for comparison.*

In 2010, the sulphur (SO_4-S) deposition in BD on plot MRK2 was lower than in 2009, but the values during these two years were higher than during 2004-2008. On plot MRK13 (BD, open area) the sulphur deposition in 2010 was comparable to that on plot MRK2, and the deposition in an open area on Olkiluoto has been slightly higher during the last two years than on the reference plots at Tammela (Figure 9). The TF deposition at the Tammela spruce plot was clearly higher than in Olkiluoto or Juupajoki.

The deposition of base cations (Ca, Mg, K) in BD on plot MRK2 was somewhat higher or at a similar level compared to the situation on the reference plots at Tammela and Juupajoki. The Ca deposition was the highest on plot MRK2 in 2009, and also higher in 2010 compared to 2004-2008. The relatively high deposition of Cl (with associated Na) at Olkiluoto is due to the proximity of the sea. This was especially the case on the new black alder plot MRK14 in 2010. The dissolved organic carbon (DOC) amounts in BD and TF were comparable to the values on the reference plots, indicating leaching of DOC from the tree canopies. The deposition of Al, Fe, Mn, Si, Cu, Zn and PO_4-P in BD and TF were relatively similar in 2010 compared to the values in earlier years.

In general, the deposition levels in 2010 in the open area and in stand throughfall were quite comparable to those in the earlier years, although during 2009/2010 the sulphur and calcium depositions were somewhat higher in the open area than in earlier years.

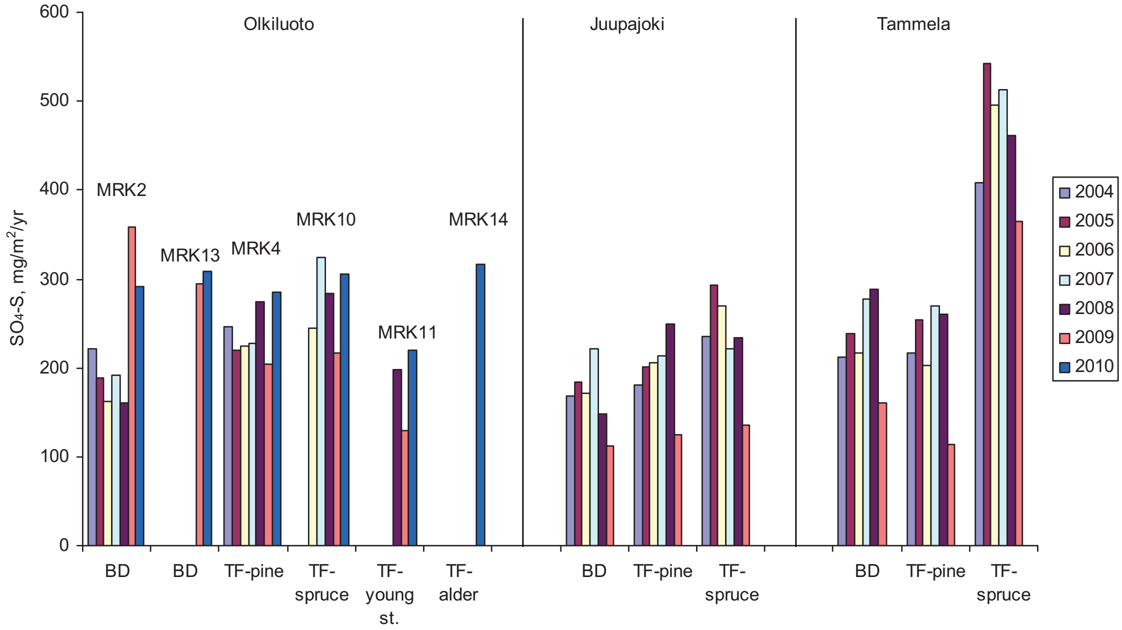


Figure 9. *The SO_4-S deposition in bulk deposition (BD, open area) and stand throughfall (TF, inside the stand) on Olkiluoto in 2004-2010. The sample plots and tree species are indicated in the Figure (young st. = young mixed stand). Reference values for ICP Forests plots at Juupajoki and Tammela are given for comparison.*

4.2 Soil solution

The proportion of percolation water passing down to a depth of 5 cm on plot FIP4 varied between 16 to 23 % of the input to the forest floor (stand throughfall) during the growing season for the period 2004-2010. In 2010, the value was 22 %. Corresponding values on the plots FIP10 (during 2005-2010) and FIP11 (during 2007-2010) were 1-28 % (19 % in 2010) and 1-17 % (15 % in 2010), respectively. The lowest values for the proportion of percolation water on FIP10 during 2005-2006 were explained by problems with the lysimeters which, however, are now functioning correctly. The proportion of percolation water passing down to a depth of 5 cm on plot FIP14 (black alder) was 22 % of the input to the forest floor (stand throughfall) during 2010, i.e. comparable to the other plots.

Overall, the pH of the soil solution clearly increased with increasing depth on FIP4. The pH of the soil solution at depths of 5-30 cm remained relatively constant throughout the 7-year monitoring period, without any increasing or decreasing trends (Figure 10, depth 5 cm). In contrast, there was large variation at a 10 cm depth in 2006 and 2007. Otherwise the pH values at all depths were fully comparable to a site of similar fertility at Tammela. There has been a slightly decreasing trend in the DOC concentration at a depth of 5 cm during the monitoring period 2004-2010 (Figure 10). Overall, the DOC concentration of the soil solution clearly decreased with increasing depth. The DOC concentrations in all seven years were considerably higher at a 5 cm depth than at the reference site, but not excessively high for forest soils rich in organic matter under a coniferous tree stand. At depths of 10, 20 and 30 cm the DOC concentrations decreased relatively strongly in 2005. The installation of the suction cup lysimeters in 2003 undoubtedly caused a short-term flush of DOC.

The pH of the soil solution at depths of 5, 20 and 30 cm on FIP10 during 2010 was comparable to a general level measured on this plot during the earlier years (2005-2009) (Figure 10, depth 5 cm). The DOC concentrations at all three depths were considerably higher than the reference site, but not excessively high for forest soils rich in organic matter under a coniferous tree stand. There has been a slightly decreasing general trend in the DOC concentration at a depth of 5 cm during the monitoring period 2004-2010, although the value in 2010 was somewhat higher than in 2009 (Figure 10).

The pH of the soil solution is relatively high at all sampling depths on FIP11 (Figure 10). The DOC concentrations were relatively high at depths of 10-30 cm, but at a depth of 5 cm, the values have been lower compared to the situation on the plots FIP4 and 10 (Figure 10).

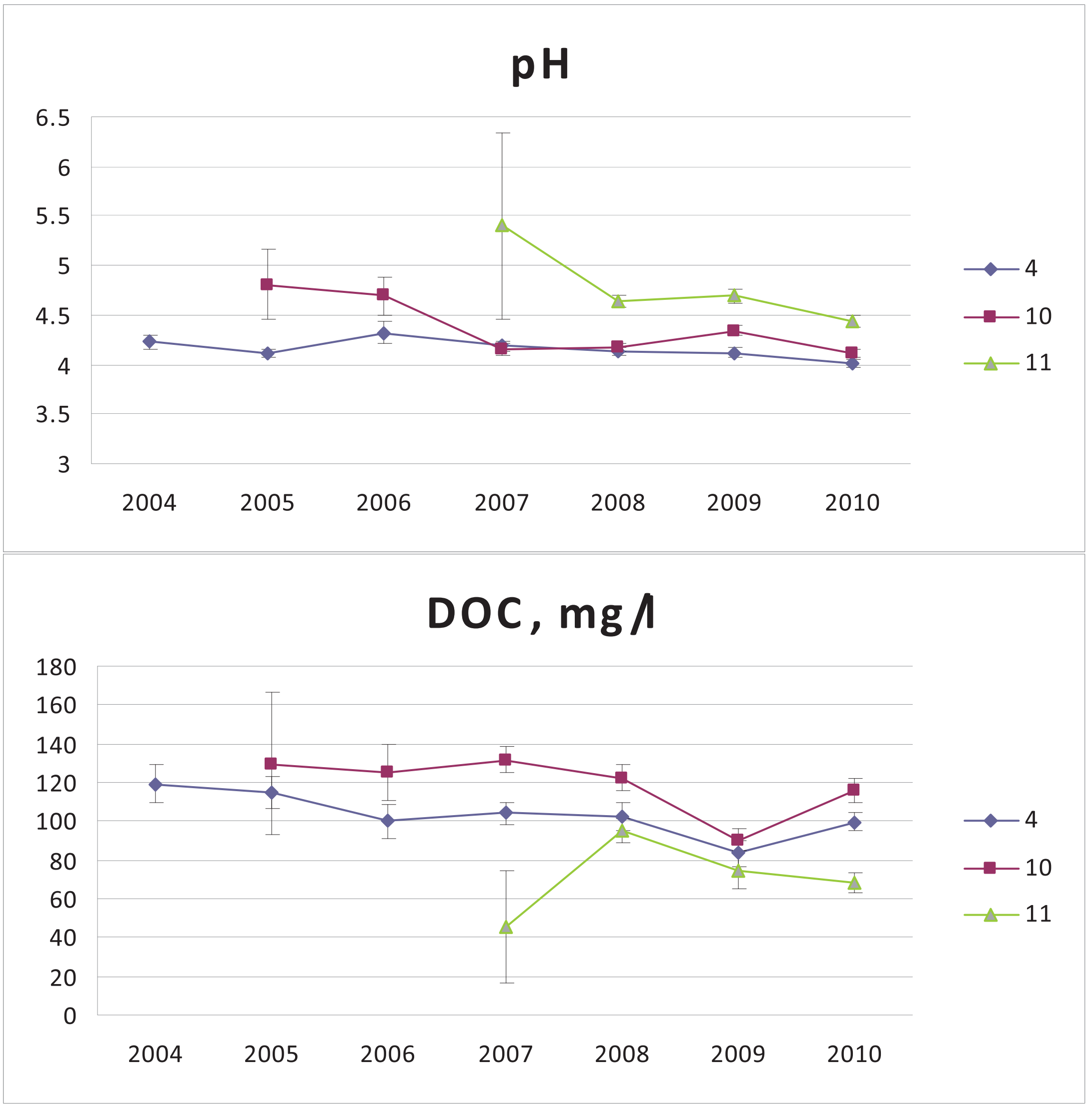


Figure 10. *Annual mean pH (a) and dissolved organic carbon (DOC) (b) concentration at a depth of 5 cm on plots FIP4 (pine stand), 10 (spruce stand) and 11 (mixed stand) at Olkiluoto during the snowfree period in 2004 – 2010. The bars denote the standard error of the mean.*

Total nitrogen which, in addition to ammonium and nitrate, also includes organic dissolved nitrogen, obviously closely followed the pattern for the DOC concentrations on plots FIP4, 10 and 11. At all depths, ammonium and nitrate accounted for only about 10 % of the total amount of nitrogen dissolved in the soil solution, i.e. most of the nitrogen in the soil solution is so-called dissolved organic nitrogen (DON). The NH_4-N, and especially the NO_3-N concentrations (Figure 11), were extremely low at all depths in the mineral soil of the FIP plots throughout the monitoring period. The low concentrations are primarily due to the fact that nitrogen is the main factor limiting tree growth in coniferous stands in Finland; the available nitrogen (NH_4 and NO_3) mineralized from the organic layer is rapidly taken up by the roots of the trees and ground vegetation. The low NO_3-N concentrations in soil solution mean low nitrate leaching from the forest soils indicating that the soils are far from the so-called nitrogen saturation point. High nitrate leaching could weaken the ground water quality. The nitrogen situation was totally different on the new black alder plot, FIP14, where nitrate concentrations were high in soil solution in 2010.

Sulphate concentrations at a 5 cm depth on FIP4 were considerably lower in all seven years than those at the reference site, but at other depths were relatively similar. Instead, sulphate concentrations were approximately the same on FIP10 as those for the corresponding reference site at a 5 cm depth, although the value in 2010 was slightly higher. There was a clear overall increase in sulphate concentrations with increasing depth on FIP4 and 10. Similar trends in sulphate concentration have been reported at all the ICP Forests Level II plots in Finland (Derome et al. 2007). No clear trends have been found in the SO4-S concentrations during 2004-2010 on the FIP plots 4, 10 and 11 at a depth of 5 cm (Figure 11).

Chloride concentrations were extremely high at all depths on all FIP plots throughout the monitoring period; it is clear that there is a considerable input of NaCl in deposition derived from the sea. Phosphate concentrations were in general very low. Phosphate concentrations are very low in the soil solution at most forested sites in Finland (Derome et al. 2007).

The concentrations of the three important plant nutrients (Ca, Mg, K) on FIP4, 10 and 11 were comparable in 2010 to the values measured in earlier years at all depths. The soil on the plots at Olkiluoto is very young, and weathering processes in the mineral soil will be relatively strong and release abundant amounts of these three nutrients. The high concentrations of Na at all depths are due to both the input from the sea and the weathering of minerals.

On the all the plots, the concentrations of total Al at all depths were relatively similar in 2010 than in earlier years. The concentrations of Al^{3+} were lower than the widely accepted toxicity level of 2 mg/l on all the plots. The Fe, Mn and Si concentrations at all depths were comparable in 2010 to the values measured in earlier years.

The concentrations of heavy metals (Cd, Cr, Ni, Pb) at all depths at Olkiluoto during 2004-2010 continued in many cases to be close or below the limit of quantification (LOQ for Cd = 0.001 mg/l, for Cr = 0.001 mg/l, for Ni = 0.010 mg/l, for Pb = 0.015 mg/l).

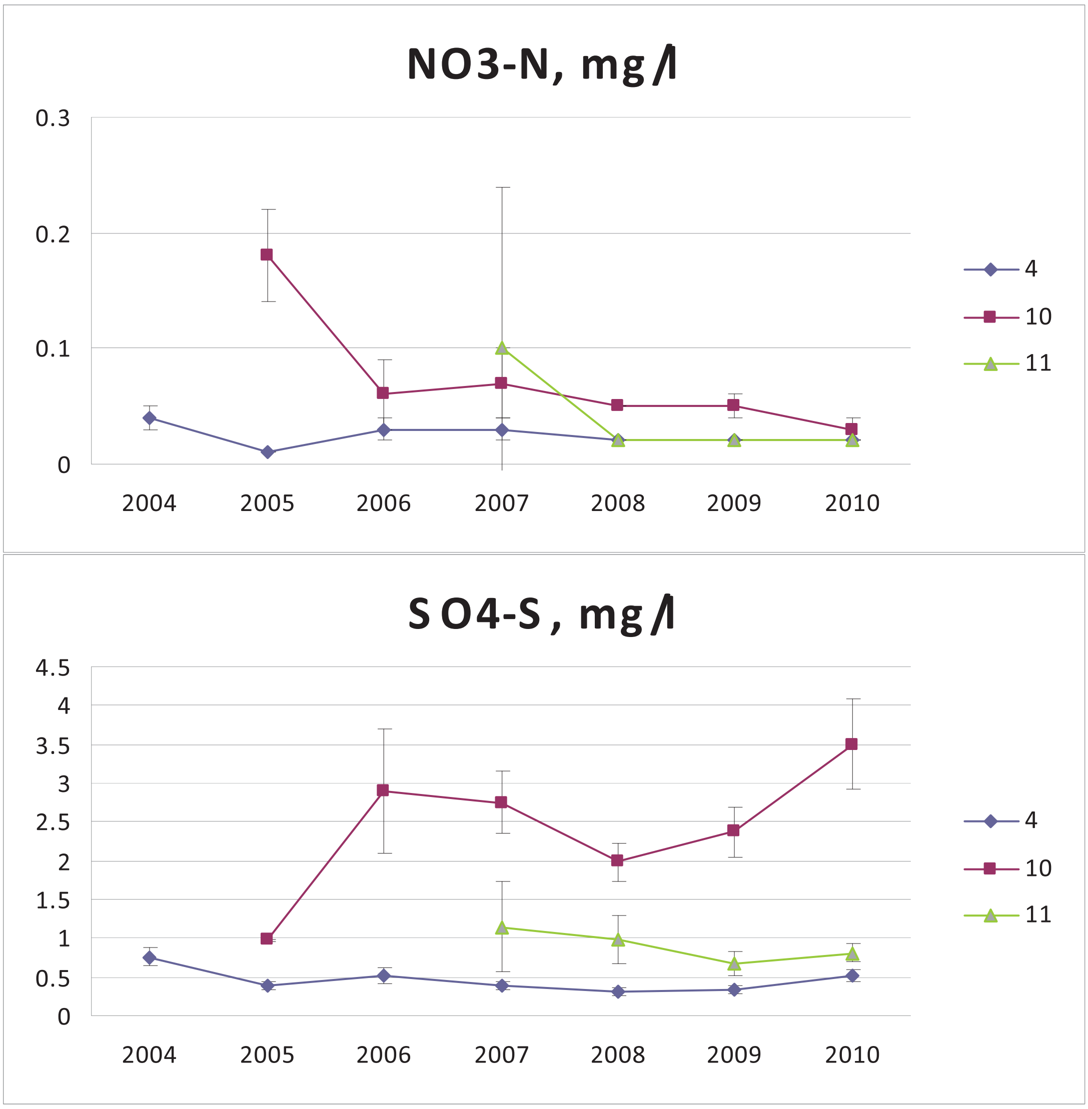


Figure 11. *Annual mean nitrate (NO_3-N) (a) and sulphate (SO_4-S) (b) concentrations at a depth of 5 cm on plots FIP4 (pine stand), 10 (spruce stand) and 11 (mixed stand) at Olkiluoto during the snowfree period in 2004 – 2010. The bars denote the standard error of the mean.*

4.3 Tree stand transpiration

The monthly stand level transpiration of Scots pine (FIP4) and Norway spruce (FIP10) dominated stands is presented in Figure 12. Stand transpiration was higher in the pine stand than in the spruce stand during the growing season. In 2010 the monthly level of transpiration on the plot FIP4 was not totally comparable to previous years (2007-2009); transpiration was lower in May and higher in July 2010 (Figure 13). Instead, monthly transpiration in the Norway spruce dominated stand was clearly lower in 2010 than in 2007-2009, and there is a decreasing trend in the stand level transpiration of the spruce stand. High values in winter months are due to errors in data and thus not reliable.

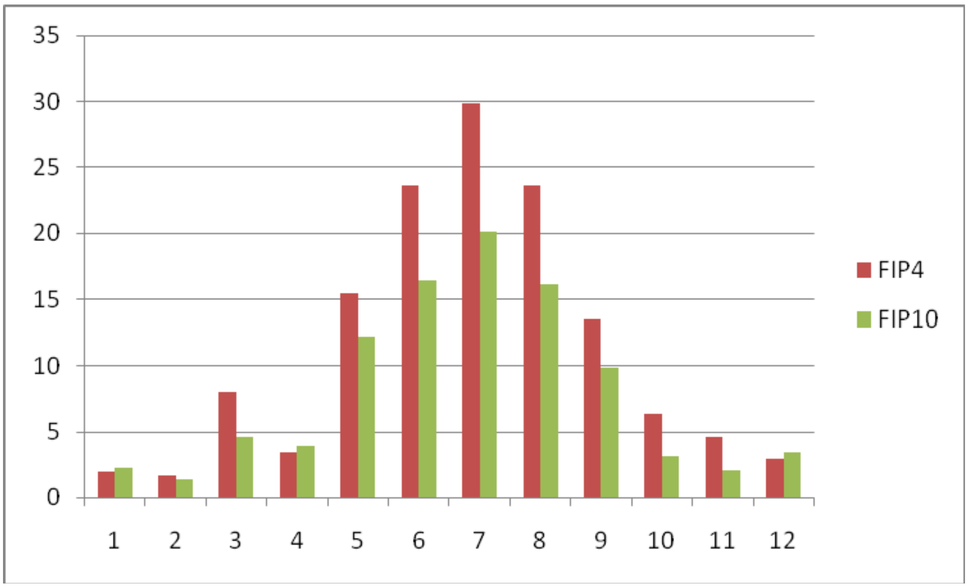


Figure 12. *Monthly stand level transpiration (mm) on the FIP4 and FIP10 sample plots in 2010. Results are only reliable for the period of April-November.*

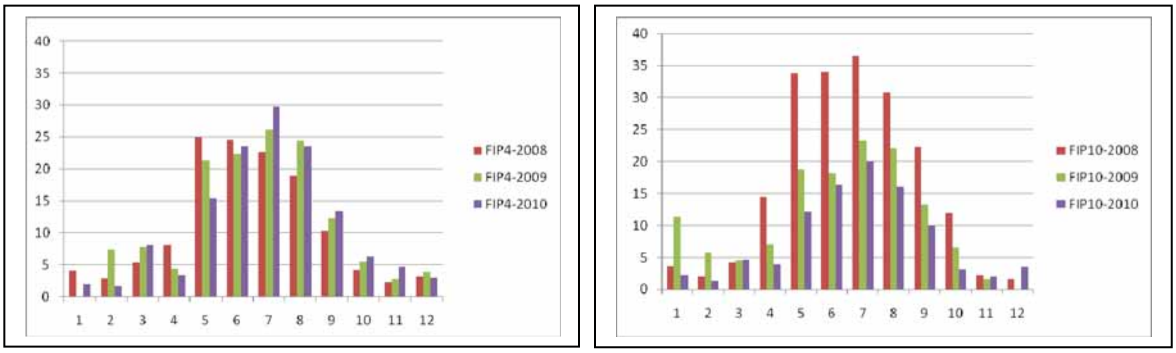
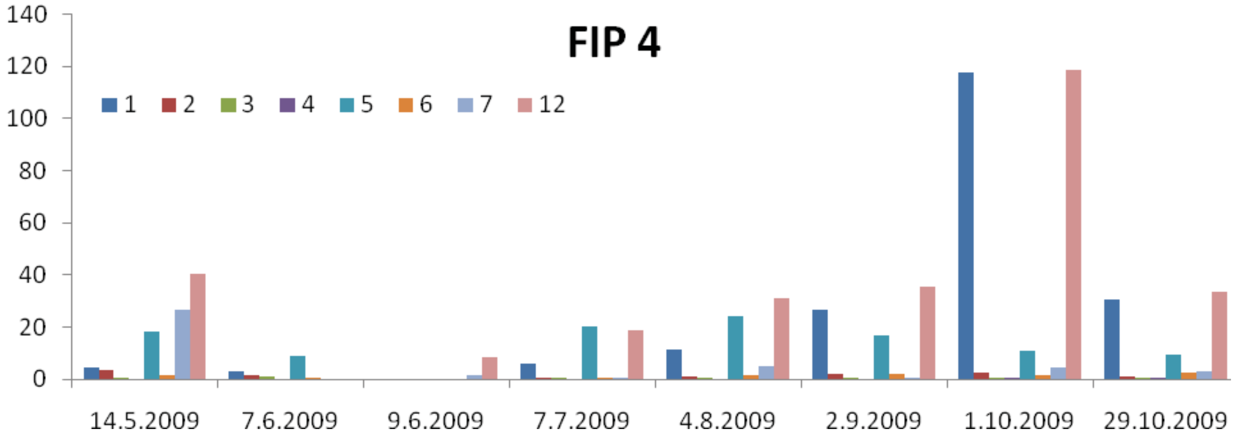


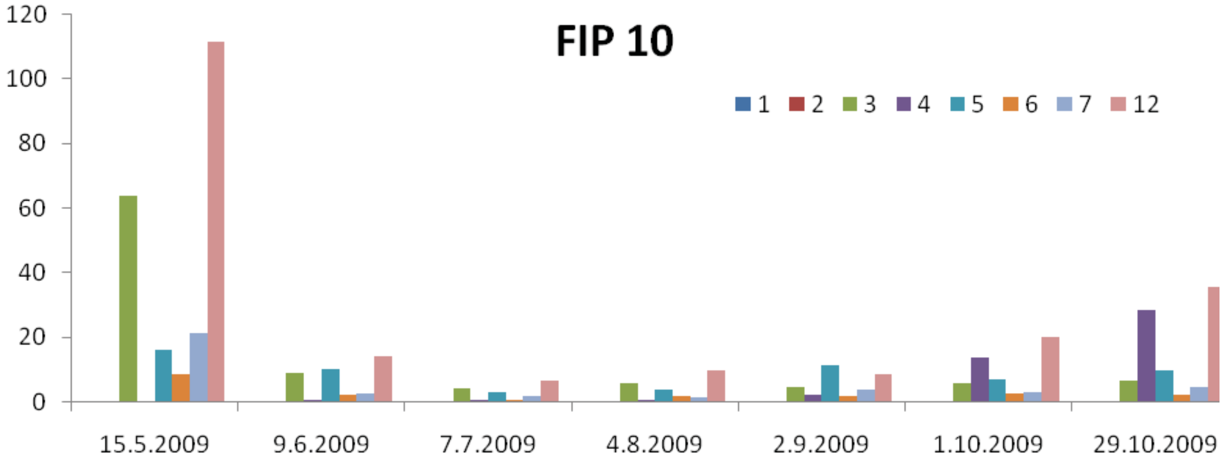
Figure 13. *Monthly stand level transpiration (mm) on the FIP4 (left) and FIP10 (right) sample plots during 2008-2010. Results are only reliable for the period of April-November.*

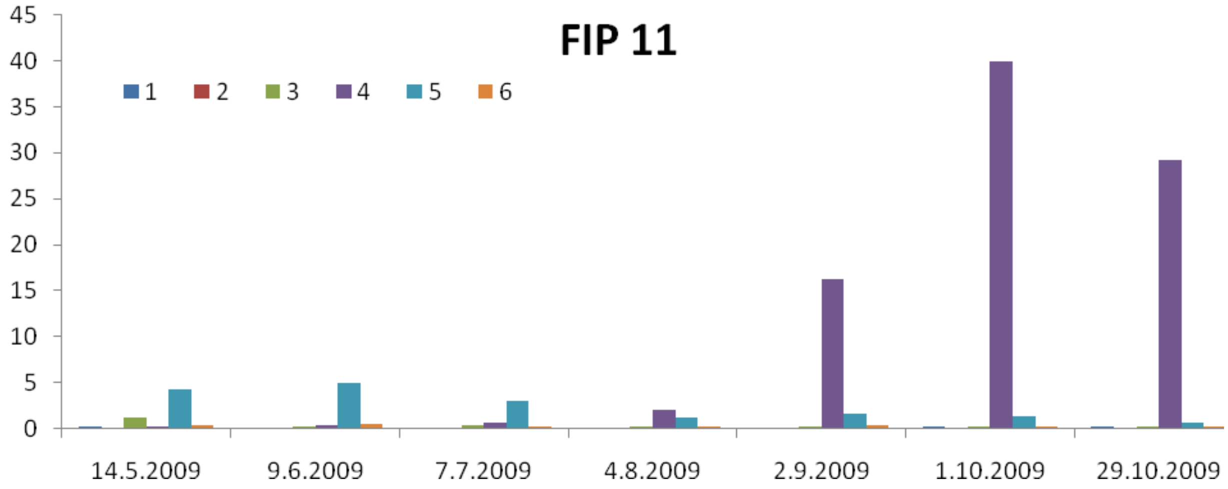
4.4 Litterfall production and element return to the forest floor

Annual total litterfall production was somewhat smaller in coniferous plots (FIP4 and 10) in 2009 (Figure 14) than during the previous collection period (2008, Aro et al. 2010). This was the case for all fractions except for fraction 7 (branches from “branch traps”), but since the collection of this fraction was in 2008 introduced not until the autumn, these two collection periods are not directly comparable. On the birch dominated plot (FIP11) annual total litterfall was somewhat larger during the present collection period than in 2008. However, this difference between years is natural annual variation caused by e.g. weather factors. The alder plot (FIP14) was established in 2009, so there is no reference to the earlier collection period. As a reference Ukonmaanaho et al. (2008) reported litterfall production (without large branches, i.e. fraction 7 here) of 226 g/m^2 for Scots pine and 350 g/ m^2 for Norway spruce in 13 Finnish ICP Forests plots (mainly in southern Finland) during 1996-2003.

The most notable differences between the plots are those of Al and N concentrations (Tables 9 and 10). Al is commonly higher in living pine needles than in spruce needles and this can also be seen in the Al concentration (Table 9) in litterfall on the pine plot (FIP4) vs. on the spruce plot (FIP10). High Al (Table 9) and Fe (Table 11) concentrations in fraction 5 (remaining litter) are most likely due to soil dust. The highest N concentrations were generally detected in fraction 4 (leaves) or 5 (remaining litter). The remaining litter can include e.g. seeds and flowers (i.e. living biological material) or insect faeces that is naturally high in N. Hence the remaining litter can in some cases have higher N concentration than alder leaves (Table 10, FIP14) which are known to have high N concentration even after senescence. On birch dominated plot (FIP11) the highest N concentrations in leaves occurred during summer (i.e. non-senescent leaves) but also senescent leaves contained nearly as much N than green pine needles (Table 10). C concentrations varied between 48.6 and 57.1 m-% in different litter fractions of the FIP plots.







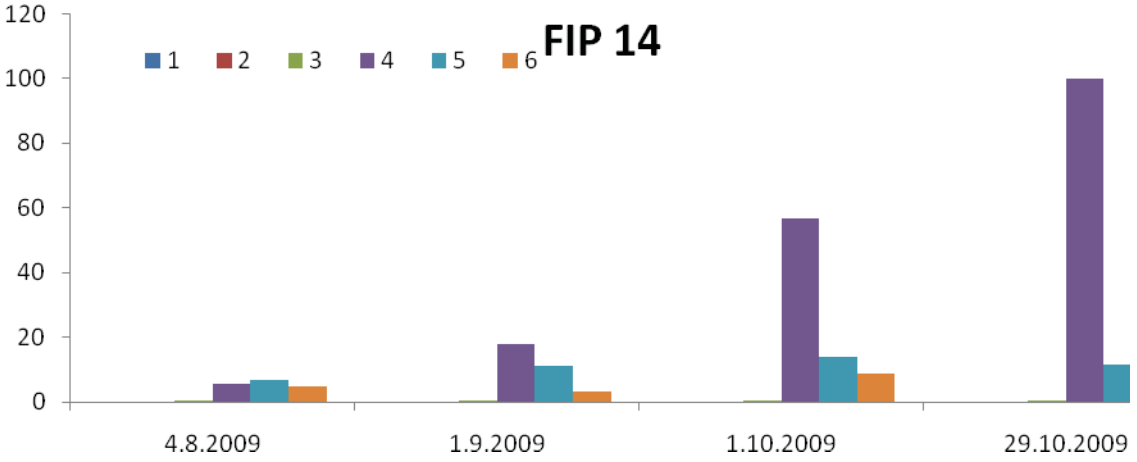


Figure 14. *Mass (g_{dw}/m^2) of different fractions of litterfall on different collection dates during 2009 on plots FIP4, FIP10, FIP11 and FIP14. Fraction legends refer to: 1= dead pine needles, 2= living pine needles, 3= spruce needles, 4= leaves, 5= remaining litter, 6= small branches, 7= branches from branch traps and 12= remaining litter in branch traps. FIP11 and FIP14 did not have branch traps.*

Table 9. *Aluminium concentrations (mg/kg_{dw}) in the seven fractions of litterfall on the FIP plots during 2009.*

		Litter fraction[1]						
Plot	Date	1	2	3	4	5	6	7
4	14.5.	869	517			1650	572	436
	7.6.	368	339	111		751	431	
	9.6.							422
	7.7.	337	282			427	518	547
	4.8.	343	224			565	428	302
	2.9.	328	255			593	448	490
	1.10.	328	272			635	395	351
	29.10.	350	245			742	465	369
10	15.5.			104	427	946	366	248
	9.6.			53	89	246	164	190
	7.7.			55	130	772	223	155
	4.8.			59	256	1240	234	180
	2.9.			51	164	473	192	170
	1.10.			48	52	372	221	188
	29.10.			50	62	277	229	205
11	14.5.			181		1150		
	9.6.				56	296		
	7.7.				55	379		
	4.8.				105	975		
	2.9.				70	414		
	1.10.				55	399		
	29.10.				49	545		
14	4.8.				207	296	97	
	1.9.				118	173	29	
	1.10.				55	247	25	
	29.10.				37	79	29	

[1)] Litter fractions: 1= pine brown needles, 2= pine green needles, 3= spruce needles, 4= leaves, 5= remaining litter, 6= small branches, 7= branches from "branch traps"

Table 10. *Nitrogen concentrations (%) in the seven fractions of litterfall on the FIP plots during 2009.*

		Litter fraction						
Plot	Date	1	2	3	4	5	6	7
4	14.5.	0.93	1.42	0.84		0.61	0.95	0.56
	7.6.	1.24	1.36	1.09		1.08	0.85	
	9.6.							0.75
	7.7.	0.89	1.25			1.00	0.92	0.85
	4.8.	0.91	1.58			0.99	0.66	0.47
	2.9.	0.65	1.25			0.82	1.10	0.95
	1.10.	0.53	1.27			0.91	0.63	0.52
	29.10.	0.46	1.24			0.81	0.77	0.59
10	15.5.			0.81	2.30	1.17	0.87	0.87
	9.6.			0.93	3.51	1.19	0.89	0.97
	7.7.			0.86	2.54	2.07	1.09	0.86
	4.8.			0.94	2.26	2.07	0.95	1.01
	2.9.			0.90	1.29	1.05	0.94	0.73
	1.10.			0.78	0.94	1.21	0.87	0.90
	29.10.			0.68	0.89	0.65	0.91	0.69
11	14.5.			0.76		1.01		
	9.6.				3.67	1.14		
	7.7.				2.03	1.44		
	4.8.				1.54	2.67		
	2.9.				1.14	2.19		
	1.10.				1.17	2.37		
	29.10.				1.16	2.14		
14	4.8.				2.70	3.10	1.47	
	1.9.				2.65	2.96	1.79	
	1.10.				2.02	2.30	1.68	
	29.10.				2.43	2.47	1.39	

[1] Litter fractions: 1= pine brown needles, 2= pine green needles, 3= spruce needles, 4= leaves, 5= remaining litter, 6= small branches, 7= branches from "branch traps"

Table 11. *Iron concentrations (mg/kg$_{dw}$) in the seven fractions of litterfall on the FIP plots during 2009.*

		Litter fraction						
Plot	Date	1	2	3	4	5	6	7
4	14.5.	1080	445			2630	611	406
	7.6.	230	132	91		1060	328	
	9.6.							333
	7.7.	197	96			435	477	485
	4.8.	173	79			611	423	310
	2.9.	160	94			584	419	394
	1.10.	119	78			678	385	265
	29.10.	147	70			784	412	357
10	15.5.			154	932	1590	586	386
	9.6.			98	228	402	252	302
	7.7.			84	400	1260	360	204
	4.8.			95	573	2030	358	276
	2.9.			88	506	716	297	264
	1.10.			65	228	572	347	301
	29.10.			63	302	439	363	312
11	14.5.			276		2180		
	9.6.				171	543		
	7.7.				180	662		
	4.8.				351	1640		
	2.9.				190	610		
	1.10.				157	619		
	29.10.				161	870		
14	4.8.				425	512	168	
	1.9.				288	292	83	
	1.10.				152	399	76	
	29.10.				111	160	79	

[1] Litter fractions: 1= pine brown needles, 2= pine green needles, 3= spruce needles, 4= leaves, 5= remaining litter, 6= small branches, 7= branches from "branch traps"

4.5 Defoliation

The degree of defoliation of Scots pine and Norway spruce was determined on the FIP plots during 16.–17.9.2010. The average defoliation level of the pines was 4.4 % (±0.8, sd) and of the spruces 26.8 % (±2.1). The pines were classified as non-defoliated indicating good crown condition of the trees. Instead, the spruces were classified as moderately defoliated (defoliation degree >25 %, Table 12). Previously (2006-2009) the spruces were classified as slightly defoliated. The defoliation degree levels were in good agreement with the results for the ICP Level II plots in Tammela (Lindgren et al. 2007).

The increase in defoliation of the pine in 2007 was due to severe infection by Peridermium stem rust on one pine on FIP4-OA2 (tree nr. 344; the degree of defoliation increased from 15 % to 85 % during 2006 – 2007). In 2008, tree 344 was already dead and it was replaced with tree nr. 334.

Table 12. *Number of assessed trees (Nr.) and defoliation degree (%) of the trees on the FIP plots by sub-plot during 2006-2010.*

Plot	Sub-plot	Species	Nr.	Defoliation 2006	2007	2008	2009	2010
4	1	Scots pine	20	3.2	3.4	5.2	4.5	3.5
	2	Scots pine	20	3.2	7.7	4.9	5.7	4.9
	3	Scots pine	20	4.2	2.9	3.7	3.3	4.0
	4	Scots pine	20	4.5	3.3	3.8	4.9	5.2
	Mean			3.7	4.3	4.4	4.6	4.4
	SD			0.7	2.2	0.8	1.0	0.8
10	1	Norway spruce	20	15.8	19.8	17.5	21.0	23.8
	2	Norway spruce	20	18.8	18.8	19.3	26.0	27.5
	3	Norway spruce	20	15.5	20.8	18.5	23.3	27.3
	4	Norway spruce	20	21.3	17.8	18.3	26.3	28.8
	Mean			17.8	19.3	18.4	24.1	26.8
	SD			2.7	1.3	0.7	2.5	2.1

4.6 Fine root elongation and longevity

Elongation and longevity are not reported here because the whole data set will be analysed after the last filming session in May 2011. Roots born in the first study year 2008 had enough time to live and die during the three-year long study period, making the estimation of root longevity reliable. Most of them were still alive in 2009 but by the end of 2010 they had died. Also a part of the roots born in 2009 died in 2010 and some more are expected to die by early summer 2011, also enabling their inclusion in the analysis of median root longevity. The three-year long measurement period from early summer 2008 to 2011 enables not only root longevity determination but also the analysis of the seasonality of root birth, growth, disappearance (mainly after grazing by soil animals) and death. This is completely new information, never before reported from sites of different tree species in the European boreal region measured this intensively and for such a long period. An example of the study material is presented in Figure 15.

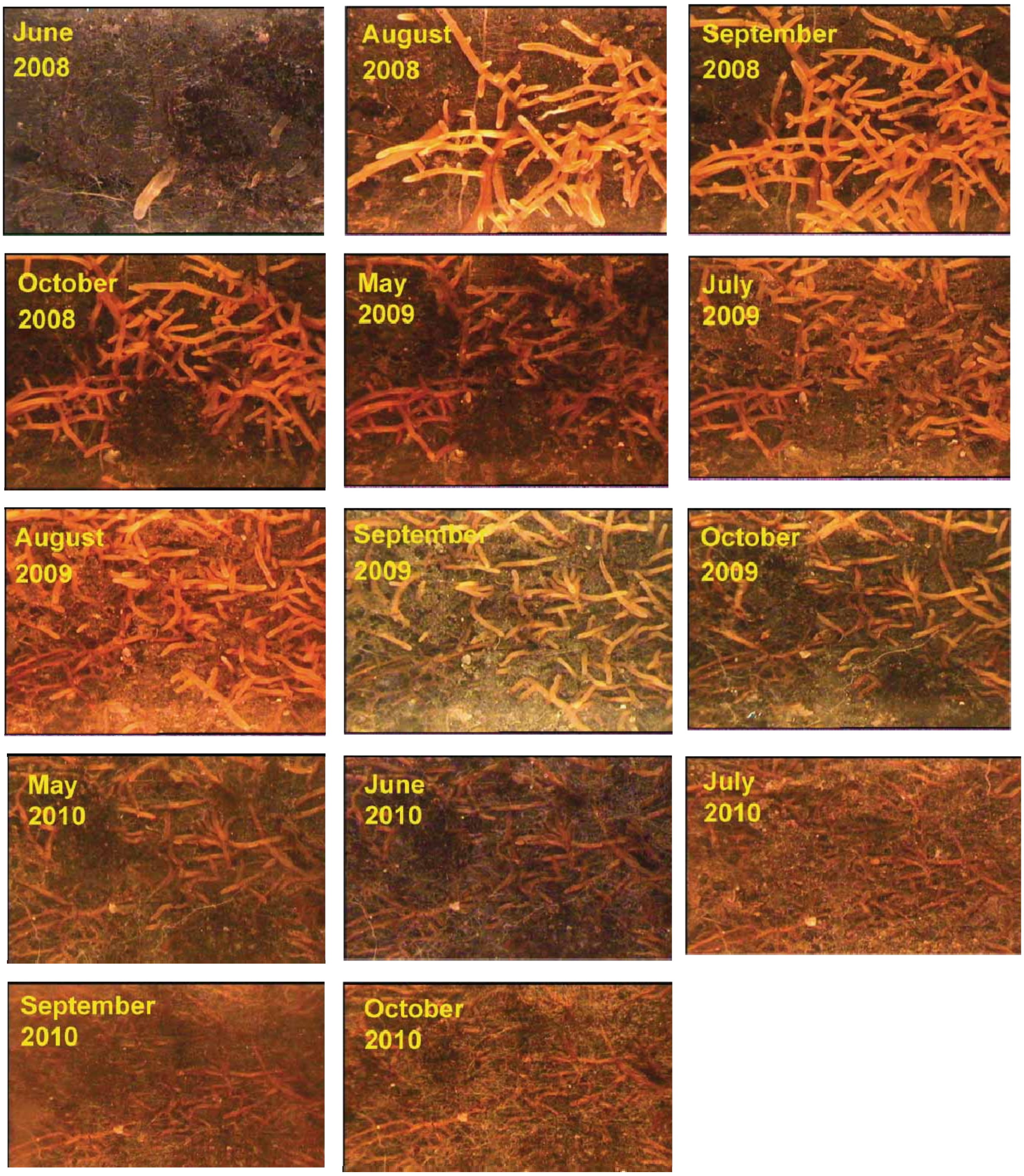


Figure 15. *Minirhizotron images of ectomycorrhizal fine roots from the birch stand FIP11. Images are from the horizontal tube no 6, filmed in the growing seasons 2008, 2009 and 2010. Grazing by a soil animal, probably an earthworm, is visible in the image from October 2008, causing fine root death and replacement by new root growth during the growing season 2009. In 2010 all the roots are dead and decomposing.*

4.7 Vegetation survey on the new FET sampling plots

4.7.1 Moist black alder seashore grove (FET927230)

Moist black alder seashore groves represent the youngest stage of seashore forest succession, and are found on the mainland as well as on forested islands. It occurs in its most widespread form along flat seashores and by small seashore ponds (Mäkinen et al. 2008). The plot 927230 is situated south-west of cape Ulkopäänniemi. The western-most quadrat GV1 is bordered by a narrow seashore meadow. However, no true seashore meadow species were found inside the plot. The absolute dominant species of the field layer is wood-sorrel (*Oxalis acetosella*). Wood stitchwort (*Stellaria nemorum*) and wood millet (*Milium effusum*) also occur abundantly. Other quite abundant species are May lily (*Maianthemum bifolium*) and red campion (*Silene dioica*). Alpine buckler fern (*Dryopteris expansa*), which was dominant in the mesic black alder seashore groves (930230 & 930231), was a little scarcer here. Compared to the classification of Keränen (1973) the plot represents types of meadowsweet (*Filipendula ulmaria*) characterized by wood stitchwort (StT), even though the main types character species is quite scarce. The total number of species is quite high (22, Table 13), and few nutrient-demanding grove-character species occur: wall lettuce (*Mycelis muralis*), common dog-violet (*Viola riviniana*) and wild strawberry (*Fragaria vesca*). Inside the plot only three supplementary species were found, which were not found inside the quadrats: red currant (*Ribes spicatum*), mugwort (*Artemisia vulgaris*) and herb-paris (*Paris quadrifolia*). The bottom layer cover was scarce. Species that occurred within more than one quadrat were *brachythecium* mosses: (*Brachythecium starkei, B. oedipodium* & *B. reflexum*) and cypress-leaved plait-moss (*Hypnum cupressiforme*).Litter accumulation is abundant, and there are clear marks of sea-cast, litter-welts and cast away waste in the area. The amount of decaying wood is also moderate. The terrain is easily eroding. Due to the vicinity of the seashore and the forest measurement group, the level of exposed mineral soil is almost 90 %, although the average cover remains low. The moist black alder seashore grove is regarded as close to being a threatened type of habitat in Finland (Mäkinen et al. 2008).

4.7.2 Mesic black alder seashore groves (FET930230 and 930231)

The vegetation in the plot 930230 corresponds to “wood millet – red campion” type (SilMiT) described by Keränen (1973). The dominant species along with their reciprocal arrangement is almost identical to plot 930231; the most abundant and covering species is alpine buckler fern. Wood stitchwort covers on average two percent, thus the plot 930230 represents more correctly mesic black alder seashore groves. However, the field species number (11, Table 13) is moderately low for its type, which is due to high cover values of the tall dominants, alpine buckler fern and raspberry (*Rubus idaeus*). This not an artefact, because no outside supplementary species were found (outside the quadrat, inside the plot). Also the bottom species compilation was almost identical to plot 930231. Litter consisted merely of deciduous tree leaves. Mesic black alder seashore groves are considered close to being a threatened (NT) type of habitat in Finland (Mäkinen et al. 2008).

The plot 930231 is a species-rich variant of the preceding plot 930230. The vegetation in the plot corresponds to the mesic black alder seashore groves´ wood millet red campion subtype (SilMiT) (Keränen 1973). Also here the most abundant species are alpine buckler fern and wood stitchwort, and thus the type converges to a wood stitchwort variant (StT) of the meadowsweet type (Keränen 1973). The high abundance of raspberry is noteworthy. Other common species in the plot are, e.g. wood sorrel, May lily and chickweed wintergreen. Tree saplings, only spruce, rowan and maple (*Acer platanoides*) occurred on quadrats sparingly, but the abundance of the latter outside the quadrats was seemingly high. Brachythecium mosses dominated in the bottom layer. Additionally broom forkmoss and cypress-leaved plait-moss occurred inside three quadrats. The bottom layer consisted of ten different species in total. The number of field layer species (17, Table 13) was quite typical for the type. Leaf litter formation was quite profuse within the plot. Mäkinen et al. (2008) consider the mesic black alder seashore groves close to being a threatened type of habitat (NT) in Finland.

Table 13. *The total number of tree shrub, dwarf shrub, herb, grass and bottom layer species, as well as the total number of all species in the new FET plots. Average cover % is presented for field and bottom layers.*

	927230	927231	928229	930230	930231
Tree shrubs	2	5	1	2	4
Dwarf shrubs	1	3	2	1	1
Herbs and grasses	19	24	8	8	12
Bottom layer species	9	10	12	9	10
Total of all species	31	42	23	20	27
Average cover, field layer	45.9	47.9	20.6	50.9	53.7
Average cover, bottom layer	8.9	38.9	33.9	4.9	8.4

4.7.3 Silver birch seashore grove (FET927231)

Birch seashore groves occur below the shoreline groves by the seaside and on islands, and represent slightly infertile and later succession stages, before true heath forests. The dominating trees are birches (*Betula* spp.). Plenty of rowan (*Sorbus aucuparia*), and some conifers may occur (Mäkinen et al. 2008). The quadrats are situated in two distinct areas of the plot 927231: the western-most quadrats lie under a thick stand of Norway spruce (*Picea abies*), and thus are scarce in species. For example the field layer is totally lacking from the quadrat GV3, while the North-South situated quadrats are grass-dominated and contain many species. Unlike black alder seashore groves, there are no clear dominant species. Grasses and herbs are found in equal amounts. Now dwarf scrubs, especially lingonberry (*Vaccinium vitis-idaea*) also occur quite abundantly. The most abundant herb is oak fern (*Gymnocarpium dryopteris*), accompanied by common dog-violet, chickweed wintergreen (*Trientalis europaea*) and May lily. Wood sorrel, a characteristic of the mesic heath forests, occurs in 50 % of the quadrats. The grass covering the most area is brown bent (*Agrostis capillaris*). Tufted hair-grass (*Deschampsia flexuosa*) and hairy wood-rush (*Luzula pilosa*) also occur commonly but scarcely. Two nutrient demanding sedges, pill and fingered sedge (*Carex pilulifera*, *C. digitata*) were also found. The shrub layer is well-developed, although only few scrubs and tree saplings happened to occur inside the quadrats. The bottom layer is well developed, reaching high cover values (on average 38.9 %, Table 13), which is due to the presence of red-stemmed feather-moss and glittering wood-moss (*Pleurozium shcreberi*, *Hylocomium splendens*). The dominating litter type is leaf, but the value for needle litter is also quite high, due to the placement of the western-side quadrats under the spruce thickets. For the same reason the cover value for overshadowing trees is high although the abundance is low. The birch dominated seashore grove is regarded as a vulnerable (VU) habitat type in Finland (Mäkinen et al. 2008).

4.7.4 Seashore spruce forest (FET928229)

The spruce dominated forests follow alder dominated groves in the succession development of the seashore forests on fine-grained moraine. Coniferous trees cannot withstand occasional high tide floods, and occupy the area from the decayed alder groves only after the land uplift has reached one meter above the mean water level (Mäkinen et al. 2008). The plot 920229 represents seashore grove-like spruce forests. The absolute dominant tree is Norway spruce. The shrub layer is scarce, consisting merely of rowans, stunted in their growth. The most abundant species in the species-low and scarce field layer is wood sorrel, having on average a 10 % cover in each of the study quadrats. Other species which occur sparingly are, e.g. May lily, alpine buckler fern (much stunted in growth when compared to alder groves), chickweed wintergreen and small cow-wheat (*Melampyrum sylvaticum*). The number of field species is seemingly low: only ten species. However, the bottom species number is high compared to alder groves, including typical species for mesic heath forests such as red-stemmed feather-moss and glittering wood-moss, although even they occur much more scarcely compared to true spruce dominated heath forests. Other abundantly occurring mosses include the above-mentioned brachythecium mosses, broom fork-moss (*Dicranum scoparium*) and smooth-stalk feather moss (*Brachythecium salebrosum*). Within the plot, but outside the quadrats only downy birch (*Betula pubescens*) was found. The cover values for both, needle and leaf litter is almost equal. Seashore spruce forest is regarded as an endangered (EN) habitat type in Finland (Mäkinen et al. 2008).

5 CONCLUDING REMARKS

The forest investigations form a part of the monitoring programme being carried out on Olkiluoto Island under the management of Posiva Oy. This report focused on activities performed on bulk deposition and forest intensive monitoring plots (MRK and FIP plots) in 2010, excluding litterfall production, results of which cover the previous year, 2009. All the data have been stored in POTTI (Posiva research result database) and only the main findings are presented in this report.

There were no essential changes in monitoring networks during 2010. The survey of the new FET sampling plots was finished in Ulkopäänniemi in August 2010.

In general, the deposition levels in 2010 in the open area and in stand throughfall were quite comparable to those in earlier years, although sulphur and calcium depositions were somewhat higher in the open area than in earlier years (2004-2008). The soil solution quality in 2010 was also quite comparable to that in earlier years. In 2010 the monthly level of transpiration in the Scots pine dominated stand was lower in May and higher in July than during previous years (2007-2009). Monthly transpiration in the Norway spruce dominated stand was clearly lower in 2010 than in 2007-2009, and there is a decreasing trend in the stand level transpiration of the spruce stand. Annual total litterfall production was smaller in coniferous plots in 2009 than during the previous collection period 2007-2008. The most notable differences between the plots were detected in Al and N concentrations. The Al concentration was higher in living pine needles than in spruce needles. High Al and Fe concentrations were found in remaining litter, and were most likely due to soil dust. The average defoliation level of the pines was 4.4 % and of the spruces 26.8 %. The pines were classified as non-defoliated indicating good crown condition of the trees. The spruces were classified as moderately defoliated differing from the previous (2006-2009) crown assessments where the spruces were classified as slightly defoliated. The minirhizotron images filmed in 2010 in the FIP stands showed that within the three growing seasons roots observed as new in 2008 had died by the autumn of 2010. According to the vegetation survey, the new FET sampling plots represented very fertile site types.

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Appendix 1. Data definition in POTTI.

DATA. Weather observations in a forest stand

WOM 2

Science	ENVI
Method Categories	Vegetation inventories
Method	WOM2,Weather Observation Mast 2
Description	Posiva Oy Memo POS-003125, Posiva WR 2009-45
Target type	Weather mast
Target	WOM2
Processing stage	MEAS
Subtext files	
Method variables	Date Channel1 Soil temperature -30 cm °C Channel2 Soil temperature -40 cm °C Channel3 Soil temperature -50 cm °C Channel4 Soil temperature -60 cm °C Channel5 Soil temperature -70 cm °C Channel6 Soil temperature -80 cm °C Channel7 Soil temperature -90 cm °C Channel8 Battery voltageV Channel9 Soil temperature -10 cm 1 °C Channel10 Soil temperature -10 cm 2 °C Channel11 Soil temperature -10 cm 3 °C Channel12 Soil temperature -20 cm 1 °C Channel13 Soil temperature -20 cm 2 °C Channel14 Soil temperature -20 cm 3 °C Channel15 Temperature (inside crown), 9 m (mean) °C Channel16 Temperature (top of mast), 24 m (mean) °C Channel17 Girth Band 1, tree No. 395 mm Channel18 Girth Band 2, tree No. 93 mm Channel19 Temperature, 2 m°C Channel20 Proportional humidity, 2 m % Channel21 Air pressure, 2m hPa Channel25 PAR-radiation, 24 m (mean) µmol s^{-1} m^{-2} Channel26 Total radiation, 24 m (mean) W m^{-2} Channel27 Proportional humidity, 9 m (mean) % Channel28 Wind direction, 24 m (mean) ° Channel29 Wind speed, 24 m (mean) m/s Channel30 Soil moisture –20 cm 1, % Channel31 Soil moisture –20 cm 2, % Channel32 Rain mm

	Channel33 Temperature (inside crown), 9 m (min) °C Channel34 Temperature (inside crown), 9 m (max) °C Channel35 Temperature (top of mast), 24 m (min) °C Channel36 Temperature (top of mast), 24 m (max) °C Channel37 PAR-radiation, 24 m (min) µmol s^{-1} m^{-2} Channel38 PAR-radiation, 24 m (max) µmol s^{-1} m^{-2} Channel39 Total radiation, 24 m (min) W m^{-2} Channel40 Total radiation, 24 m (max) W m^{-2} Channel41 Proportional humidity, 9 m (min) % Channel42 Proportional humidity, 9 m (max) % Channel43 Wind direction, 24 m (min) ° Channel44 Wind direction, 24 m (max) ° Channel45 Wind speed, 24 m (min) m/s Channel46 Wind speed, 24 m (max) m/s
Method parametes	Document reference

WOM 3

Science	ENVI
Method Categories	Vegetation inventories
Method	WOM3, Weather Observation Mast 3
Description	Posiva WR 2009-45
Target type	Weather mast
Target	WOM3
Processing stage	MEAS
Subtext files	
Method variables	Date Channel1 Soil temperature -30 cm (°C) Channel2 Soil temperature -40 cm (°C) Channel3 Soil temperature -50 cm (°C) Channel4 Soil temperature -60 cm (°C) Channel5 Soil temperature -70 cm (°C) Channel6 Soil temperature -80 cm (°C) Channel7 Soil temperature -90 cm (°C) Channel8 Battery voltage (V) Channel9 Soil temperature -10 cm 1 (°C) Channel10 Soil temperature -10 cm 2 (°C) Channel11 Soil temperature -10 cm 3 (°C) Channel12 Soil temperature -20 cm 1 (°C) Channel13 Soil temperature -20 cm 2 (°C) Channel14 Soil temperature -20 cm 3 (°C) Channel17 Girth Band 1, tree No. 29 (mm)

	Channel18 Girth Band 2, tree No. 119 (mm) Channel19 Temperature, 2 m (°C) Channel20 Proportional humidity, 2 m (%) Channel30 Soil moisture –20 cm 1(%) Channel31 Soil moisture –20 cm 2(%) Channel32 Rain (mm)
Method parametes	Document reference

WOM4

Science	ENVI
Method Categories	Vegetation inventories
Method	WOM4, Weather Observation Mast 4
Description	Posiva WR 2009-45
Target type	Weather mast
Target	WOM4
Processing stage	MEAS
Subtext files	
Method variables	Date Channel1 Soil temperature -30 cm (°C) Channel2 Soil temperature -40 cm (°C) Channel3 Soil temperature -50 cm (°C) Channel4 Soil temperature -60 cm (°C) Channel5 Soil temperature -70 cm (°C) Channel6 Soil temperature -80 cm (°C) Channel7 Soil temperature -90 cm (°C) Channel8 Battery voltage (V) Channel1B Soil temperature -10 cm 1 (°C) Channel2B Soil temperature -10 cm 2 (°C) Channel3B Soil temperature -10 cm 3 (°C) Channel4B Soil temperature -20 cm 1 (°C) Channel5B Soil temperature -20 cm 2 (°C) Channel6B Soil temperature -20 cm 3 (°C) Channel7B Soil temperature –20 cm 1 (%) Channel8B Soil temperature –20 cm 2 (%) Channel1C Temperature, 2 m (°C) Channel6C Channel7C Proportional humidity, 2 m (%) Channel8C Rain (mm)
Method parametes	Document reference

WOM5

Science	ENVI
Method Categories	Vegetation inventories
Method	WOM5, Weather Observation Mast 5
Description	Posiva WR 2009-45
Target type	Weather mast
Target	WOM5
Processing stage	MEAS
Subtext files	
Method variables	Date Channel1 Soil temperature -30 cm (°C) Channel2 Soil temperature -40 cm (°C) Channel3 Soil temperature -50 cm (°C) Channel4 Soil temperature -60 cm (°C) Channel5 Soil temperature -70 cm (°C) Channel6 Soil temperature -80 cm (°C) Channel7 Soil temperature -90 cm (°C) Channel8 Battery voltage (V) Channel1B Soil temperature -10 cm 1 (°C) Channel2B Soil temperature -10 cm 2 (°C) Channel3B Soil temperature -10 cm 3 (°C) Channel4B Soil temperature -20 cm 1 (°C) Channel5B Soil temperature -20 cm 2 (°C) Channel6B Soil temperature -20 cm 3 (°C) Channel7B Soil temperature -20 cm 1 (%) Channel8B Soil temperature -20 cm 2 (%) Channel1C Temperature, 2 m(°C) Channel7C Proportional humidity, 2 m (%)
Method parametes	Document reference

DATA. Wet deposition analysis

Science	ENVI
Method Categories	Continuous forest monitoring
Method	Wet deposition analysis
Description	Posiva WR 2009-45
Target type	Wet deposition monitoring plot
Target	MRKgroup
Processing stage	MEAS

Subtext files	
Method variables	Lab ID Plot Type Sampling date Amount (l/m2 = mm) pH Alkalinity (mmol/l) H+ (mg/l) Conductivity (µS/cm) Conductivity_ctrl DOC (mg/l) DOC_ctrl TOT-N (mg/l) TOT-N_ctrl NH4-N (mg/l) NH4-N_ctrl NO3-N (mg/l) NO3-N_ctrl Ca (mg/l) Ca_ctrl Mg (mg/l) Mg_ctrl K (mg/l) K_ctrl Na (mg/l) Na_ctrl PO4-P (mg/l) PO4-P_ctrl SO4-S (mg/l) SO4-S_ctrl Cl (mg/l) Cl_ctrl Al (mg/l) Al_ctrl Fe (mg/l) Fe_ctrl Mn (mg/l) Mn_ctrl Cu (mg/l) Cu_ctrl Zn (mg/l) Zn_ctrl Si (mg/l) Si_ctrl Notes
Method parametes	

DATA. Forest inventory: tree measurements

Science	ENVI	
Method Categories	Vegetation inventories	
Method	Forest inventory: tree measurements (FET)	
Description	FET: Posiva WR 2005-39, p. 7-9	
Target type	Forest extensive monitoring plot	
Target	FETgroup	
Processing stage	MEAS	
Subtext files	VMI9.pdf	
Method variables	FET/ FIP ID	
	Tree ID	TR-1
	Subplot	OA-1 (compartment number)
	Zone ID	MZ-1 (radius of tree measurement plot, m)
	New center distance	m
	New center direction	0-360 Degrees
	Tree distance	cm (from new center)
	Tree direction	0-360 Degrees (from new center)
	Tree Northing	N & m (-) & - & 6780000 & 6799000
	Tree Easting	N & m (-) & - & 15200000 & 15300000
	Tree species (class: 1=Scots pine, 2=Norway spruce, 3=silver birch, 4=downy birch, 5=aspen, 6=grey alder, 7=black alder, 8=rowan, 9=goat willow …… etc)	
	Diameter at a height of 1.3m (mm)	
	Tree class (class)	
	Tree class extension (class)	
	Crown layer (class)	
	Age (for sample trees, y)	
	Age_ctrl	
	Mode of regeneration (for sample trees)	
	Upper diameter (at 6.0m, cm of trees over 8m in height (for sample trees))	
	Upper diameter_ctrl	
	Dead branch limit (for sample trees) (dm)	
	Dead branch limit_ctrl	
	Lower limit of living crown (for sample trees) (dm)	
	Lower limit of living crown_ctrl	
	Height (dm, for sample trees)	
	Height_ctrl	
	Length of broken stem (for sample trees) (dm)	
	Damage symptoms (for sample trees)	
	Damage symptoms_ctrl	
	Time of damage occurrence (for sample trees) (y)	
	Time of damage occurrence_ctrl	
	Cause of damage (for sample trees)	
	Degree of damage (for sample trees)	

	Surveyor Date of inventory
Method parametes	Classification system Document reference Measured by Time

Science	ENVI
Method Categories	Vegetation inventories
Method	Forest inventory: tree measurements (FIP/MRK)
Description	MRK: Lindroos et al. 2008 (Kronodoc POS-003852); FIP: Aro 2006 (Kronodoc POS-003125)
Target type	Forest intensive monitoring plot, Wet deposition monitoring plot
Target	FIP MRK
Processing stage	MEAS
Subtext files	VMI9.pdf
Method variables	FIP/MRK ID Tree ID TR-1 Subplot OA-1 (compartment number) Zone ID MZ-1 (radius of tree measurement plot, m) Tree distance cm (from center) Tree direction 0-360 Degrees (from center) (Tree Northing N & m (-) & - & 6780000 & 6799000 Tree Easting N & m (-) & - & 15200000 & 15300000 Tree species (class: 1=Scots pine, 2=Norway spruce, 3=silver birch, 4=downy birch, 5=aspen, 6=grey alder, 7=black alder, 8…. as agreed) Crown layer (class) Tree group (class) D_1.3_1 D_1.3_2 Technical quality (class) Lower limit of living crown (dm) Height (dm) Damage symptoms (class) Time of damage occurrence Cause of damage (class) Degree of damage (class) Surveyor Date of inventory Sample tree
Method	Classification system

parametes	Document reference Measured by Time

Science	ENVI
Method Categories	Vegetation inventories
Method	Forest inventory: tree measurements (WOM1)
Description	WOMpuustoinv_ohje2011.doc / 16.3.2011 / L. Aro
Target type	Weather mast
Target	WOM1
Processing stage	MEAS
Subtext files	VMI9.pdf, MT257
Method variables	OBS ID Measurement line Line direction (from WOM1, /360°) Plot Tree species Tree species in Finnish Height (dm) Plot mean height (dm) Surveyor Date of inventory Comments Photo
Method parametes	Classification system

DATA. Forest inventory by plots: plot characteristics

Science	ENVI
Method Categories	Vegetation inventories
Method	Forest inventory by plots: plot characteristics
Description	
Target type	Forest extensive monitoring plot
Target	FETgroup
Processing stage	MEAS
Subtext files	
Method variables	FET ID Subplot Sample trees Limitations in wood prod.

	Limitations in wood prod. sg Estim prop of sp in rp_9.77 Estim prop of sp in rp_5.64 Estim prop of sp in rp_3.09 Land class Land sub-class Main site type Mixed site type Site type Site type extension State of drainage Drainage carried out Time of drainage Ditch spacing Condition of ditches Position of storey Number of tree storeys Development class Development class_2 Proportion of v_a_r_s Dominant tree species Prop of domin.tree species 1st sub-tree species Prop of 1st sub-tree species 2nd sub-tree species Proportion of conifers 1 Proportion of conifers 2 Stem number Total number of seedlings Age at breast height Damage symptom Time of occurrence of damage Cause of damage Degree of damage Beard lichens Foliose lichens Crustose lichens Quality of tree stand Cause of decrease in quality Fellings carried out Time of fellings Site preparation Time of site preparation S-cultural meas carried out Time of s-cultural measures Data link to field form 1 Data link to field form 2

Method parametes	Classification system Document reference Surveyor

DATA. Vegetation nutrition analysis

Science	ENVI
Method Categories	Vegetation inventories
Method	Vegetation nutrition analysis
Description	
Target type	Forest extensive monitoring plot, (Forest intensive monitoring plot)
Target	FET, (FIP)
Processing stage	MEAS
Subtext files	
Method variables	FET/FIP ID Sample ID Plant species Plant part: whole, all aboveground, stem, branches, shoots, leaves, buds, roots, rhizome, berries/fruits, flowers, inflorescences, light-coloured (for lichens), not known etc. Age class (c, c+1 ...c+n, young shoots, living shoots) Sampling date (dd.mm.yy) Analysing date Partition ID Lab ID Al (mg/kg_{dw}) Al_ctrl B (mg/kg_{dw}) B_ctrl Ca (g/kg_{dw}) Ca_ctrl Cd (mg/kg_{dw}) Cd_ctrl Cr (mg/kg_{dw}) Cr_ctrl Cu (mg/kg_{dw}) Cu_ctrl Fe (mg/kg_{dw}) Fe_ctrl K (g/kg_{dw}) K_ctrl Mg (g/kg_{dw}) Mg_ctrl

	Mn (mg/kg_{dw}) Mn_ctrl Mo (mg/kg_{dw}) Mo_ctrl Na (mg/kg_{dw}) Na_ctrl Ni (mg/kg_{dw}) Ni_ctrl P (g/kg_{dw}) P_ctrl Pb (mg/kg_{dw}) Pb_ctrl S (mg/kg_{dw}) S_ctrl Zn (mg/kg_{dw}) Zn_ctrl C (m-%, dw) C_ctrl H (m-%, dw) H_ctrl N (m-%, dw) N_ctrl
Method parametes	Sampling round

DATA. Soil chemical analysis

Science	ENVI
Method Categories	Soil inventories
Method	Soil chemical analysis (METLA)
Description	Posiva WR 2007-78
Target type	Forest intensive monitoring plot, Forest extensive monitoring plot
Target	FIP FET
Processing stage	MEAS
Subtext files	
Method variables	FET/FIP ID Sampling point ID (e.g. repeat HS1-HS3, MS1-MS2, PS1-PS3 etc.) Sample type (mineral soil, humus, peat, litter) Top of sampling interval (only mineral soil and peat, from mineral and peat soil surface, cm) Bottom of sampling interval (only mineral soil and peat, from mineral and peat soil surface, cm) Sampling date

	Analysing date Partition ID (e.g. parallel or control analyses) Lab ID Moisture (%) Ash content (%) Organic matter (%) Al (mg/kgdw) B (mg/kgdw) Ca (mg/kgdw) Cd (mg/kgdw) Cr (mg/kgdw) Cu (mg/kgdw) Fe (mg/kgdw) K (mg/kgdw) Mg (mg/kgdw) Mn (mg/kgdw) Mo (mg/kgdw) Na (mg/kgdw) Ni (mg/kgdw) P (mg/kgdw) Pb (mg/kgdw) S (mg/kgdw) Zn (mg/kgdw) C (m-%, dw) H (m-%, dw) N (m-%, dw) pH-H2O pH-CaCl2 Exchangeable acidity (Hmmol) (mg/kgdw) Al_BaCl2 (mg/kgdw) Ca_BaCl2 (mg/kgdw) Fe_BaCl2 (mg/kgdw) K_BaCl2 (mg/kgdw) Mg_BaCl2 (mg/kgdw) Mn_BaCl2 (mg/kgdw) Na_BaCl2 (mg/kgdw) P_BaCl2 (mg/kgdw)
Method parametes	Sampling round Document reference

Science	ENVI
Method Categories	Soil inventories
Method	Soil chemical analysis (METLA)
Description	Posiva WR 2007-78
Target type	(Forest intensive monitoring plot), Forest extensive monitoring plot

Target	(FIP) FET
Processing stage	PROC
Subtext files	
Method variables	FET/ FIP ID Sampling point ID (e.g. repeat HS1-HS3, MS1-MS2 etc.) Sample type (mineral soil, humus, peat, litter) Top of sampling interval (only mineral soil and peat, from mineral and peat soil surface, cm) Bottom of sampling interval (only mineral soil and peat, from mineral and peat soil surface, cm) Sampling date Analysing date Partition ID (e.g. parallel or control analyses) Lab ID OM_kgha (kg/ha dw) amount of organic matter (in dw) C_kgha (kg/ha dw) total carbon amount, Leco CHN-2000 or Leco CHN-1000 analyser, dw N_kgha (kg/ha dw) total nitrogen amount, Leco CHN-2000 or Leco CHN-1000 analyser, dw Ca_exc_kgha (kg/ha dw) amount of exchangeable base cation, dw, BaCl2 extraction K_exc_kgha (kg/ha dw) amount of exchangeable base cation, dw, BaCl2 extraction Mg_exc_kgha (kg/ha dw) amount of exchangeable base cation, dw, BaCl2 extraction Na_exc_kgha (kg/ha dw) amount of exchangeable base cation, dw, BaCl2 extraction Al_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw B_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw Ca_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw Cd_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw Cr_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw Cu_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw Fe_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw K_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw Mg_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw Mn_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw Mo_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw Na_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw Ni_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw P_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw Pb_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw S_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw Zn_kgha (kg/ha dw) total element amount, wet digestion+ICP/AES, dw BC_sum (mmol/kg) sum of base cation concentrations (mmol/kg): Cammol+Kmmol+Mgmmol+Nammol

	CEC (mmol(+)/kg) BS (%)	cation exchange capacity (BC sum+exchangeable acidity) Base saturation = 100*BC/CEC
Method parametes	Sampling round Document reference	

DATA. Foliage chemical analysis

Science	ENVI
Method Categories	Vegetation inventories
Method	Foliage chemical analysis
Description	
Target type	Forest extensive monitoring plot, (Forest intensive monitoring plot)
Target	FET (FIP)
Processing stage	MEAS
Subtext files	
Method variables	FET/FIP ID Sampling point ID (e.g. repeat 1…., TRxx etc.; composite sample) Number of sample trees Tree species Sample type (needle, leaf) Age class (c, c+1, …. c+n) Sampling date Analysing date (mostly date of approval) Partition ID (e.g. parallel or control analyses) Lab ID Al (mg/kgdw) B (mg/kgdw) Ca (g/kgdw) Cd (mg/kgdw) Cr (mg/kgdw) Cu (mg/kgdw) Fe (mg/kgdw) K (g/kgdw) Mg (g/kgdw) Mn (mg/kgdw) Mo (mg/kgdw) Na (mg/kgdw) Ni (mg/kgdw) P (g/kgdw) Pb (mg/kgdw) S (mg/kgdw) Zn (mg/kgdw)

	C (m-%, dw) H (m-%, dw) N (m-%, dw) Dry weight (g) *(of 100 needles/leaves)*
Method parametes	Document reference Sample taken by Sampling round

DATA. Sampler and sensor locations

FIP

Science	ENVI
Method Categories	Continuous forest monitoring
Method	Sampler and sensor locations
Description	
Target type	Forest intensive monitoring plot
Target	FIP
Processing stage	MEAS
Subtext files	
Method variables	FIP ID Easting Northing Sampler type in Finnish Sampler type Sampler ID Sampler/sensor depth/height cm (in relation to soil surface: + upwards, - depth in soil) Notes
Method parametes	Survey type Surveyed by

MRK

Science	ENVI
Method Categories	Continuous forest monitoring
Method	Sampler and sensor locations
Description	
Target type	Wet deposition monitoring plot
Target	MRK
Processing stage	MEAS

Subtext files	
Method variables	MRK ID Sampler type in Finnish Sampler type Number Northing Easting
Method parametes	Survey type Surveyed by

DATA. Forest soil water analysis

Science	ENVI
Method Categories	Vegetation inventories
Method	Forest soil water analysis
Description	
Target type	Test pit, Investigation trench, Infiltration test area
Target	KK TK TMA10
Processing stage	MEAS
Subtext files	
Method variables	Lab ID Evacuation day Sampling day Analysing date Analysed by Plate lysimeter Sample Depth (m) Sample type Conductivity (µS/cm / 25°C) pH Alkalinity (mmol/l) Cl (mg/l) PO4-P (mg/l) NO3-N (mg/l) SO4-S (mg/l) NH4-N (mg/l) TOT-N (mg/l) DOC (mg/l) Al (mg/l) B (mg/l) Ca (mg/l)

	Ca_2 (mg/l) Cd (mg/l) Cr (mg/l) Cu (mg/l) Fe (mg/l) K (mg/l) K_2 (mg/l) Mg (mg/l) Mn (mg/l) Na (mg/l) Na_2 (mg/l) Ni (mg/l) P (mg/l) Pb (mg/l) S (mg/l) Si (mg/l) Zn (mg/l) Remarks
Method parametes	

DATA. Sap flow measurement

Science	ENVI
Method Categories	Continuous forest monitoring
Method	Sap flow measurement
Description	Hökkä 2008 (Kronodoc POS-003795), Prosalog Manual version 1.1 (2005), UP Sap Flow-System User Manual Version 2.6
Target type	Forest intensive monitoring plot
Target	FIP
Processing stage	MEAS
Subtext files	
Method variables	FIP ID Date (dd.mm.yyyy hh:mm:ss) Sap flow signal_tree 1 (mV) Sap flow signal_tree 2 (mV) Sap flow signal_tree 3 (mV) Sap flow signal_tree 4 (mV)
Method parametes	Document reference

DATA. Sap flow measurement: tree stand transpiration.

Science	ENVI
Method Categories	Continuous forest monitoring
Method	Sap flow measurement: tree stand transpiration
Description	Hökkä 2008 (Kronodoc POS-003795), Prosalog Manual version 1.1 (2005), UP Sap Flow-System User Manual Version 2.6
Target type	Forest intensive monitoring plot
Target	FIP
Processing stage	PROC
Subtext files	
Method variables	Date (dd.mm.yyyy hh:mm:ss) Stand transpiration (mm)
Method parametes	Calibration method Document reference Processed by

DATA. Spring and ditch water chemical analysis

Science	ENVI
Method Categories	
Method	Spring and ditch water chemical analysis
Description	
Target type	Spring, Ditch
Target	TMAspring DI10
Processing stage	MEAS
Subtext files	
Method variables	Subplot Analysing date Analysed by Sample type Conductivity (µS/cm / 25°C) pH Alkalinity (mmol/l) DOC (mg/l) TOT-N (mg/l) Cl (mg/l) PO4-P (mg/l) NO3-N (mg/l) SO4-S (mg/l) NH4-N (mg/l)

	Al (mg/l) B (mg/l) Ca (mg/l) Ca_2 (mg/l) Cd (mg/l) Cr (mg/l) Cu (mg/l) Fe (mg/l) K (mg/l) K_2 (mg/l) Mg (mg/l) Mn (mg/l) Na (mg/l) Na_2 (mg/l) Ni (mg/l) P (mg/l) Pb (mg/l) S (mg/l) Si (mg/l) Zn (mg/l)
Method parametes	

DATA. Nutrient analysis of litter fractions

Science	ENVI
Method Categories	Continuous forest monitoring
Method	Nutrient analysis of litter fractions
Description	Aro 2006 (Kronodoc POS-003125); Rautio, P. & Aro, L. 2009 (Kronodoc POS-005671)
Target type	Forest intensive monitoring plot
Target	FIP
Processing stage	MEAS
Subtext files	
Method variables	FIP ID Sampling date Analysing date Partition ID Lab ID Litter fraction Moisture (%) Ash content (%) Al (mg/kgdw) B (mg/kgdw)

	Ca (g/kgdw) Cd (mg/kgdw) Cr (mg/kgdw) Cu (mg/kgdw) Fe (mg/kgdw) K (g/kgdw) Mg (g/kgdw) Mn (mg/kgdw) Mo (mg/kgdw) Na (mg/kgdw) Ni (mg/kgdw) P (g/kgdw) Pb (mg/kgdw) S (mg/kgdw) Zn (mg/kgdw) C (m-%, dw) N (m-%, dw) H (m-%, dw) Remarks
Method parametes	