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ENVIRONMENTAL PROTECTION

Environmental monitoring in Finland 2009-2012

Jorma Niemi (editor)

Finnish Environment Institute

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- Geological Survey of Finland *Hannu Idman*
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Jorma Niemi
Editor

1 Introduction

Jorma Niemi

Background. Global environmental questions such as climate change have increased general concern for environmental quality. Adequate environmental data, e.g. that produced by environmental monitoring, forms a basis for addressing these problems. Recently the importance of environmental data has increased, which is reflected e.g. in the policy of the European Union, particularly in the implementation of environmental directives such as the EU Water Framework Directive.

Milestones of environmental monitoring in Finland. Environmental monitoring has a long tradition in Finland. Weather phenomena have been monitored since 1839, water levels since 1849 and discharges in all important river systems since 1910, when the publication of the Hydrological Yearbook began. The first forest inventory covering the whole country was carried out in 1921-24. The field work for the eighth successive forest inventory was carried out in 1986-94 and the ninth inventory was started in summer 1996. Monitoring of birds was started early: Bird Ringing (1913), Nest Record Card Study (1954) and Winter Bird Census (1955). Wastewater inventories were started in the 1950s and those of drinking water in the 1960s. National water quality monitoring of rivers started in 1962 and that of lakes in 1965. After the implementation of the Water Act in 1962 the local pollution control monitoring network based on the polluter pays- principle was created and has been in operation since then. This network, typical of the Finnish monitoring strategy, currently includes some 5000 sampling sites. More recent monitoring programs are those of chemicals started from the 1960s, groundwater (1975), air quality (1983) and wastes in the 1980s. The most topical of the current water quality monitoring programs are those required by the EU Water Framework Directive.

Monitoring data produced. In recent decades the total amount of data produced by monitoring programs has rapidly increased. For example in spring 2008 the cumulative database of the Finnish Environment Institute contained water quality data of about 64 000 sampling sites (23.6 million results), phytoplankton data of about 2 500 sampling sites (some 14 000 results) and hydrological data of more than 2 500 sites (23 million results). This data and other monitoring data is published in scientific articles, reports and for the general public. Special attention is paid to quality control of the produced data e.g. by using certified personnel for sampling and standardized chemical analytical methods.

Data utilization. At the Finnish Environment Institute as in other institutes, the amount of monitoring data increases rapidly. Environmental problems are increasing and require expertise from many fields of science. The monitoring data gathered should be used effectively in assessing environmental questions. Simultaneous use of all monitoring data should therefore be encouraged in addressing environmental problems. This approach has been emphasized e.g. in the Environmental Monitoring Strategy published by the Finnish Ministry of the Environment.

National monitoring programmes presented. This report summarises the environmental monitoring programs to be carried out in Finland in 2009-2012 by the national organizations. It is based on the more detailed report "Ympäristön seuranta Suomessa 2009-2012" published by the Finnish Environment Institute. The monitoring activities of the following governmental institutes are presented:

- Geological Survey of Finland, (www.gsf.fi)
- Finnish Meteorological Institute, (www.fmi.fi)
- National Institute for Health and Welfare, (www.thl.fi)
- Evira - Finnish Food Safety Authority, (www.evira.fi)
- Finnish Museum of Natural History, (www.fmnh.helsinki.fi)
- MTT Agrifood Research Finland, (www.mtt.fi)
- Finnish Forest Research Institute, (http://www.metla.fi/)
- Metsähallitus – National Board of Forestry, (www.metsa.fi)
- Information Centre of the Ministry of Agriculture and Forestry, (www.mmmtike.fi)
- Finnish Game and Fisheries Research Institute, (www.rktl.fi)
- Radiation and Nuclear Safety Authority, (www.stuk.fi
- Ministry of Social Affairs and Health
- Statistics Finland, (www.stat.fi)
- Finnish Environment Institute (SYKE), (www.ymparisto.fi)
- Regional Environment Centres (REC), (www.ymparisto.fi)

Detailed information about the institutes, their field of expertise and the monitoring programs is available on the internet pages or from the contact persons given in the text.

2 Natural resources

2.1

Water

2.1.1

Hydrological observations

Johanna Korhonen

Hydrological observations comprise three basic programs, namely hydrometeorological monitoring, hydrometric (surface water) monitoring and hydrogeological monitoring. Hydrologeological monitoring is introduced separately in the Section 2.1.2.

Hydrometeorological monitoring can be further divided into three programs: areal precipitation, snow water equivalent, and potential evaporation. The values of areal precipitation are based on 250 precipitation gauges, operated by the Finnish Meteorological Institute. The areal values of snow water equivalent are calculated by using monthly measurements at 160 field stations, together with meteorological and geographical data. Both the areal values of precipitation and snow water equivalent are calculated daily by operational grid models. Potential evaporation is measured at 17 stations by using a standardised Class A pan. The number of evaporation stations will be diminished during 2009-2012.

Hydrometric monitoring is focused on inland surface waters. There are four hydrometric programs: water level, river discharge, ice cover and water temperature. The water level network has 400 stations, and the number of stations in the river discharge network is some 300. About 50 % of water level stations are automatic, with daily transmission of data. Ice thickness is measured at 65 points, whereas the dates of freezing and ice break-up are reported to the database from about 70 stations. Surface water temperature is measured at 40 stations, and temperature profiles are observed at 10 lakes. Most of the surface water and ice thickness data are available almost in real-time.

The main objectives of hydrological monitoring are operational service and the production of long-term records of Finnish water resources. Operational service includes real-time or almost real-time data services for water resources management and flood forecasting, data supply for other users and updating of the databases in real-time. Hydrological monitoring data are also used in the study of hydrological processes, as a contribution to the EU Water Framework Directive, and for other hydrological support related to water resources management, restoration and protection. In addition, hydrological data are essential in temporal and spatial water resource studies, as well as in the estimation of climate change effects and adaptation. As a major part of the data are collected in almost real-time, continuously updated web pages have become a very important channel of information. Hydrological data are also published in the Hydrological Yearbooks at 5-year intervals. Hydrological

reviews and bulletins are also made monthly, and when needed, for distribution in other media.

The Environmental Administration owns and maintains a total of some 850 hydrological observation sites. That is about 60% of the overall volume of the programs described above. The rest of the data (mainly water level and discharge) are obtained from other operators or received on the basis of legal obligations.

The division of labour between the Finnish Environment Institute (SYKE) and the Regional Environment Centres is as follows: SYKE is responsible for network design, standards, data processing, data systems and data services at the national level, whereas the Regional Environment Centres take care of the field operations and the hiring and training of observers. The standards and instructions related to hydrological monitoring are given in the hydrological quality system that is available on the Intranet of the Environmental Administration.

Contact person: Johanna Korhonen, Finnish Environment Institute, Tel. + 358 400 148 541, Email: firstname.lastname@ymparisto.fi.

2.1.2

Hydrogeological monitoring program

Mirjam Orvomaa

The hydrogeological monitoring program consists of the groundwater and groundfrost monitoring networks. The monitoring networks consist of observation stations which are located in unpolluted areas representing variable hydrogeological and climatic conditions. These observation stations provide basic hydrological information and data on the natural background concentrations of Finnish groundwater. Groundwater sampling for chemical analyses are conducted 2-4 times per year and hydraulic head is observed every two weeks. Groundfrost is monitored during the winter months three times per month by observing level changes in methylene blue tubes installed at the stations. The observations are more frequent when groundfrost is melting. The national hydrogeological monitoring network is maintained by the environmental administration.

The Regional Environment Centres have established monitoring programs according to the Water Framework Directive (WFD) for each river basin district for monitoring the chemical and quantitative status of groundwater. The programs consist of existing monitoring programs, license holders' mandatory surveillance programs and voluntary groundwater monitoring programs of the waterworks. In addition, the data from the monitoring of diffuse loading from agriculture and forestry as well as the Finnish Road Administration's road regions groundwater monitoring programs, aimed at monitoring the impacts of de-icing substances on groundwater, are also included in the WFD- monitoring programs.

All observation data gathered from the monitoring programs is stored in the national groundwater data system (POVET), which is managed by the environmental administration.

Contact persons: Risto Mäkinen, Mirjam Orvomaa and Juhani Gustafsson, Finnish Environment Institute, Tel. + 358 400 148 541, Email: firstname.lastname@ymparisto.fi, Risto Mäkinen, Email:firstname.p.lastname@ymparisto.fi,

2.1.3

Monitoring at small hydrological basins

Jukka Järvinen, Jarmo Linjama

Monitoring at small hydrological basins provides runoff data from 35 small drainage basins (0.07-122 km^2) without lakes. The basins are equipped with measuring weirs, rain gauges and snow measurements including frost measurement. In addition, physiographic factors are surveyed in the field. In 14 basins water quality is measured for calculating non-point loading or natural leaching. The measured data from basins are used as a reference for areas with no direct measurements, for modelling, for land use studies and for various process studies. Changes in long-term runoff time series can be used to detect trends, with special reference to climate change. There are 26 original basins that are still in operational use. These basins provide runoff observations from a period of more than 45 years.

Contact persons: Jarmo Linjama and Kirsti Granlund, Finnish Environment Institute, Tel. + 358 400 148 541, Email: firstname.lastname@ymparisto.fi

2.1.4

Hydrological models

Bertel Vehviläinen

In Finland the Watershed Simulation and Forecasting System (WSFS) is widely used for real- time simulation of hydrological cycles and for watershed forecasting and simulation of climate change effects on water resources. The system is based on a catchment rainfall-runoff model with the same basic structure as the HBV-model widely used in Scandinavia. The new version of the WSFS covers 390 000 km^2, comprising the total land area of Finland and some cross-boundary watersheds. The sub-basin division of the model is the third level watershed division (60-100 km^2) or the 1x1 km^2 grid used in research models.

The input values of the model are daily precipitation, temperature and water level data. The simulated variables are areal precipitation, evapotranspiration, snow storage, soil moisture, lake evaporation, surface, sub-surface and groundwater storage, runoff, discharges and water levels of the main rivers and lakes. An elevation model is used to calculate the height and gradient effects on areal precipitation, temperature and snow melt. In an ongoing project the catchment model is improved by using land-use, vegetation and soil type data to increase the measurement accuracy of the spatial variation of the simulated components (snow, soil moisture, soil frost, evapotranspiration).

The remote sensing data used in the model are satellite data from snow-covered areas and precipitation data from weather radar. In the Envisnow EU-project, methods of using ENVISAT snow data within WSFS were developed. An important part of the WSFS in forecasting is the automatic model updating system developed in the Finnish Environment Institute (SYKE). Model updating is made using water level, discharge and snow line observations. The updating procedure corrects the model simulation by changing the areal values of temperature, precipitation and potential evaporation so that the observed and simulated discharges, water levels and water equivalent of snow are equal.

The inputs of the WSFS are: precipitation from 200 stations, temperature from 40 stations, precipitation from weather radar covering almost the whole of Finland and Class A pan evaporation from 22 stations. During the updating procedure the mod-

els in WSFS are corrected against: water level observations from 450 stations (160 in real time), discharge observations from 320 stations (130 in real time), snow water equivalence observations from 180 stations and real-time data of the snow-covered area in Finland from satellite images.

The main operating part of WSFS is a distributed watershed model, which simulates the hydrological cycle using standard meteorological data for the whole of Finland. Other systems to which the WSFS is connected are the hydrological data register, operative watershed management systems, the automatic real-time water level and discharge observation station network, synoptic weather stations reporting through the Finnish Meteorological Institute (FMI), and weather forecasts from the European Centre of Medium-Range Weather Forecasts (ECMWF) via the FMI. Connection to a diffuse load simulation system (VEPS) has also been achieved.

The WSFS collects watershed data from the registers, runs forecasts and distributes the results to the Internet and registers for different users. The different stages in watershed forecasting are: weather data transfer in real time from the FMI, automatic collection of watershed data from registers, watershed model updating according to the real-time data obtained, forecast runs by watershed models and distribution of forecasts through the Internet: www.environment.fi/waterforecast

Contact person: Bertel Vehviläinen, Finnish Environment Institute, Tel. + 358 20 610 123, Email: firstname.lastname@ymparisto.fi

2.2

Atmosphere

Juho-Pekka Kaukoranta

2.2.1

Weather stations

The Finnish Meteorological Institute was started in 1838 when a magnetic observatory was founded at the University of Helsinki. One of the tasks of the observatory was to establish a weather observation network in Finland. The first review on Finland's climate was published as early as in the 1840s.

The Finnish Meteorological Institute regularly produces several kinds of meteorological observations from 188 ordinary weather stations and in addition rainfall and snow depth measurements from 153 precipitation stations. Until the 1980s the weather observations were made in the same manner: an observer read the values measured by instruments and made all the other observations at fixed times. As automated data processing and communication networks developed, automatic weather observations became feasible. Nowadays, more than 95 % of observations are automatic.

In addition to the Finnish Meteorological Institute, there are also other institutes and authorities (such as the Civil Aviation Administration, Finnish Road Administration, Finnish Forest Research Institute, municipalities) making weather and air quality observations.

2.2.2

Weather observations

Basic meteorological observations include air temperature and relative humidity: all 188 weather stations measure these parameters. In addition 157 stations also measure

wind speed and direction, 140 stations measure atmospheric pressure, 69 stations measure visibility and 63 stations measure cloudiness. At automatic weather stations observations are made and transmitted generally at 10 minute intervals. The network of precipitation stations is still mainly manual; therefore precipitation and snow depth are observed mainly once a day, at 06 UTC. However, 70 automatic weather stations measure precipitation (incl. rain intensity) continuously. In all, more than 200 station measure precipitation. Additionally, at some stations sunshine duration, global, diffuse and ultraviolet radiation and soil temperature are also observed.

At Jokioinen observatory, Sodankylä Arctic Research Centre and Jyväskylä Tikkakoski sounding station, meteorological parameters are also measured in the upper atmosphere up to a height of 20 – 30 kilometres. This is performed twice a day by launching a meteorological balloon carrying instruments and a radio transmitter.

Mast stations are used for observation of the vertical profiles of several meteorological parameters up to 200-300 m. These are being used e.g. in exploring temperature inversions, low clouds and wind shear.

In addition to the meteorological observations described above, the Finnish Meteorological Institute produces observations on air quality and the Earth's magnetic field.

Contact person: Juho-Pekka Kaukoranta, Finnish Meteorological Institute, www.fmi.fi, Tel. +358 9 1929 5748, Email: firstname.lastname@fmi.fi

2.3

Forests

2.3.1

The Finnish National Forest Inventory

Kari T. Korhonen, Erkki Tomppo

The National Forest Inventory (NFI) is a monitoring system producing reliable, nationwide information on forests and forest resources – volume, growth and quality of the growing stock, forms of land use, needs for silvicultural measures in the forests, forest condition and forest biodiversity. The NFI is also a key information source in the UNFCCC LULUCF greenhouse gas reporting for forests. The first sample-based NFI was carried out already during the 1920s. Since then, NFIs have been repeated at approximately 10 year intervals. The most recent, 10th NFI was in 2004 – 2008.

The Finnish NFI, is based on statistical sampling. Sample plots measured in the field form the sampling units. In the 9th NFI, more than 70 000 sample plots were measured. More than 150 variables were recorded for each sample point and approximately 0.5 million trees were measured.

The applied sampling design has varied over the decades. The first NFIs were based on line surveys and measuring sample plots placed on the survey lines. Since the 1960s the sample plots have been placed in clusters and the field work has been done region by region. In the 10th NFI sampling design was changed so that now field plots are measured in the whole country each year. The advantage of the new design is that the field data represent the same years in each part of the country. In the 10th NFI the cycle of the field work was intensified to 5 years from the 8 – 10 years of the previous NFIs.

Traditionally, temporary plots have been used in the NFI. In the 9th NFI some of the field plots were established as permanent plots. These plots were remeasured

in the 10th NFI. The permanent plots will produce more reliable information on the changes in forests.

Multi-source NFI. The results of the NFI are reliable for large areas, i.e. for areas with high enough numbers of measured field plots. A multi-source inventory was introduced in the end of the 1980s and has been used in an operative way since 1990. It employs satellite images (e.g. Landsat TM and ETM+) and digital map data, e.g. base map data including a digital elevation model, in addition to field sample plots. It produces statistics for small areas, e.g. for municipalities, as well as thematic maps of forest resources. In order to improve the accuracy, the estimation method is under continuous development.

Publication of NFI results. The main results are published in the journals of Metla and the Statistical Yearbook of Forestry as well via the Metla's Metinfor www-service. Articles on selected themes are also published in other scientific journals. The first results based on the 10th NFI were published for southern and northern Finland in 2006 and for the forestry centers in 2007. The methods have been and will be published in international journals.

Contact persons: Kari T. Korhonen, Finnish Forest Research Institute, P.O.Box 68, 80110 Joensuu, Tel. +358 10 211 3030 Email: firstname.lastname@metla.fi

Inventory methods and multi-source inventory, Erkki Tomppo, Finnish Forest Research Institute, Jokiniemenkuja 1, 01370 Vantaa, Finland, Tel. +358 10 211 2170, Email: firstname.lastname@metla.fi

2.3.2

Forest damage diagnostic service

Antti Pouttu

The forest damage advisory service is responsible for answering enquiries and for providing diagnoses about forest damage and diseases. Forest damage is monitored and prognoses are made when necessary. Information is gathered annually from forest authorities and forest owners. Reports of the forest damage situation are presented to the Ministry of Agriculture and Forestry and published on the Internet every year.

The Internet Forest Health service "Metinfo Metsien terveys" (in Finnish) is updated according to the research results. The Internet service is intended as a practical tool in pest and disease management, training and education. In the Internet service there are over 150 descriptions of damaging agents with over 800 photos. It also includes interactive diagnosis, prognosis leaflets, a list of forest damage experts and legislation information on forest protection.

Contact person: Antti Pouttu, Finnish Forest Research Institute, Vantaa, Tel, 010 211 2576, Email: firstname.lastname@metla.fi

Further information: http://www.metla.fi/hanke/3047/index-en.htm http://www.metla.fi/metinfo/metsienterveys/index.htm

2.3.3

Specimen bank of the Finnish Forest Research Institute

Eero Kubin, Jarmo Poikolainen, Juha Piispanen

The Environmental Specimen Bank (ESB) of the Finnish Forest Research Institute (Metla) situated in Paljakka was established in 1994 and extended in 1999. Its total floor area of 770 m^2 has a specimen storage space of 296 m^2 divided into nine fireproof storage rooms (19 m^2 – 62 m^2). The total storage shelf length is 3 960 m. Sample pretreatment and office rooms as well as an auditorium, exhibition room and accommodation services are available.

Only pre-treated and dried plant samples are currently stored. The ESB contains all Metla´s dried plant samples that require long-term storage. The most important samples of the ESB are the moss samples collected in the national heavy metal monitoring surveys, the needle samples of trees collected in the ICP Forests -program and the forest litter material from tree seed crop studies. In addition, separate sample series from the universities of Helsinki and Oulu and reference moss material for a European survey of atmospheric heavy metal deposition (UN/ECE ICP Vegetation) are stored. The total number of samples exceeds 200 000.

The Ministry of Education initiated a project entitled "Environmental specimen banking and cooperation" as a part of the Biodiversity and Monitoring Program in Finland (MOSSE, 2003-2006). The project focused on long-term storage of environmental samples and cooperation between the national institutes active in specimen banking in Finland. The main target of the project was to develop procedures in environmental banking and to improve and unify the storage and use of environmental samples collected in Finnish monitoring programs. One of the objectives was to promote the use of existing specimen material in research and education. The results of the project were published in the Finnish Environment 56/2006.

Contact persons: Eero Kubin, Tel. +358 10 211 3710, Jarmo Poikolainen, Tel. +358 50 391 3753 and Juha Piispanen, Tel. +358 10 211 3720 (reference material), Finnish Forest Research Institute (Metla), Muhos Research Unit, Kirkkosaarentie 7, 91500 Muhos, Email: firstname.lastname@metla.fi

2.4

Animals, plants, mushrooms and berries

2.4.1

Fish

2.4.1.1

Fish resources

Jari Raitaniemi

The Finnish Game and Fisheries Research Institute (FGFRI) produces monitoring data of the fisheries and of the biology of the most important fish stocks. The monitoring is carried out for national needs and for fulfilling various international agreements concerning the protection and use of the fish resources.

The most important results concerning the state and trends of the fish populations are parameters such as spawning stock biomass, total biomass, year class strength, and fishing mortality.

Baltic herring, sprat, cod, and salmon fisheries are internationally regulated. Because of mainly national needs, the Baltic Sea fish stocks of e.g. populations of whitefish, sea trout, vendace, pike-perch, perch, pike, flounder and inland vendace are monitored. The salmonid populations of rivers are monitored with electric fishing in over 250 sample areas every year. The populations of noble crayfish and signal crayfish are monitored by test fishing and on the basis of bookkeeping by the fishermen.

The commonly used fish stock models require information on the total catch, CPUE (catch per unit effort), composition of the catch, growth, and reproduction success.

Catch samples are usually taken from the catches of professional fisheries or occasionally from recreational fishing or from test fishings e.g. in connection with echo sounding. In addition, information on fish populations is acquired by e.g. markings and genetic studies of fish. The stocking statistics are needed especially for the salmonids. The catch information is obtained from the national catch statistics of the FGFRI or sometimes from separate enquiries.

Monitoring data of the most important fish species and populations are available for the past 20–30 years. The monitoring results have been reported in species or stock specific publications and in1997–2005 in a publication by Statistics Finland. Since then, information of fish resources has been given in the web pages and publications of the FGFRI. Data of the occurrence of fish species in different river systems have been collected in a fish stock register.

Contact person: Jari Raitaniemi, Finnish Game and Fisheries Research Institute, Turku Game and Fisheries Research, Itäinen Pitkäkatu 3 (entry from Kaivokatu 16, yard), FIN-20520 Turku, Finland, Tel. + 358 0205751685, Email: firstname.lastname@rktl.fi
Finnish Game and Fisheries Research Institute, Main Office in Helsinki, P.O. Box 2, Viikinkaari 4, 00791 Helsinki, Tel. + 358 02057511

2.4.1.2

Environmental fish monitoring

Martti Rask

Coastal fish communities in the Baltic Sea are monitored in three areas as a part of cooperation between the Baltic states. The areas are located close to Helsinki, close to the Tvärminne Zoological Station in the western Gulf of Finland, and in Brunskär in the Archipelago Sea. The fish communities are sampled by means of multi mesh gillnets at sites not exceeding 10 m in depth. The method is suitable for the monitoring of percid and cyprinid fish species and some marine species like Baltic herring, but cold water species and small littoral fishes are mainly excluded. In the case of perch, which is in the focus of the monitoring, growth and population structure are monitored by annual sampling for age and growth determination. In the course of monitoring that has lasted over 20 years in the Brunskär area, the most striking trend has been the eutrophication-induced increase of roach in the test fishing catches. The results of the monitoring are also reported through HELCOM.

Fish community monitoring in rivers and lakes according to the EU Water Framework Directive was started in 2007. This is because fishes are one of the biological quality elements to be used in the assessment of the ecological status of rivers and lakes. For rivers, monitoring of fish by electro fishing has been a common practice over the last 30 years, especially in the northern salmon rivers such as the rivers Tornionjoki and Tenojoki. Regular monitoring of fish communities in lakes by gillnet sampling was started as an assignment from the WFD. The monitoring programme and practices are to be developed in the years to come in close cooperation with the

environmental administration. The monitoring network in the near future will consist of ca. 200 river and 200 lake sites.

Reproduction disturbance of the Baltic salmon (M74) appears as increased mortality among the yolk sac fry of salmon. M74 is monitored annually from fishes during their spawning migration to the rivers Simojoki, Tornionjoki, Kemijoki, and Kymijoki. Fertilized eggs of salmon from those rivers are reared and monitored in the biological laboratory of the Finnish Game and Fisheries Research Insitute, Helsinki. The results are given as two measures for each river:

- the percentage of female salmon whose yolk sac fry suffered at least partially from M74 syndrome
- the percentage of female salmon whose complete yolk sac fry died as a consequence of M74
- the average yolk sac fry mortality of salmon from each river

Typically, the M74 mortality varies from year to year between levels of < 10% to more than 80% at the worst.

Contact person: Martti Rask, RKTL/Evo Game and Fisheries Reserach, Rahtijärventie 291, 16970 Lammi, p. +358 205751422, +358 40 5238311, Email: martti.rask@rktl.fi
Finnish Game and Fisheries Research Institute, Main office in Helsinki, P.O.Box 2, Viikinkaari 4, FI-00791 Helsinki, p. +358 2057511

2.4.2 Livestock

Sanna Vuorisalo

Tike, the Information Centre of the Ministry of Agriculture and Forestry (http://www.mmmtike.fi), is the authority responsible for the statistics on the number and production figures of livestock. Statistics on the numbers of livestock are compiled from administrative registers and from farmers. Since 1999, data on the number of bovine animals has been obtained from the bovine register. Figures on other animals pertaining to the situation on the first of May are obtained from the integrated administration and control system (IACS). Farmers are also asked to report the number of animals on their farms during farm surveys conducted on the first of June and on the first of December each year. The farm surveys are conducted on 10,000 farms selected using a sampling method.

Contact person: Sanna Vuorisalo, Tike, Information Centre of the Ministry of Agriculture and Forestry, tel. +358 20 77 21324, Email: firstname.lastname@mmmtike.fi.

2.4.3 Horticultural statistics

Anna-Kaisa Jaakkonen

Tike, the Information Centre of the Ministry of Agriculture and Forestry, (http://www.mmmtike.fi), maintains a register of horticultural enterprises that is used for compiling statistics on commercially cultivated horticultural products. The statistics cover the cultivation of vegetables, berries, fruit, decorative plants and mushrooms, as well as nurseries, greenhouses, storage facilities and certain other factors related to this field. Information in the register goes back to 1984. Prior to that year, horticultural statistics were compiled in conjunction with the agricultural census from 1940, and

through sample studies from 1952 to 1983. Statistics on the amounts of wild berries and mushrooms, as well as cultivated berries supplied to retailers, have been compiled since 1974. These statistics cover the price of domestic berries and mushrooms and their retail value, as well as the income generated by collection and cultivation.

Contact person: Anna-Kaisa Jaakkonen, Tike, Information Centre of the Ministry of Agriculture and Forestry, tel. +358 20 77 21374, Email: firstname.lastname@mmmtike.fi.

2.4.4

Plant phenology

Eero Kubin, Jarmo Poikolainen

The Finnish Forest Research Institute (Metla) started phenology monitoring of most common forest trees and dwarf shrubs on the national level in 1996. The aim of the monitoring is to obtain information concerning biological cycles of forest trees and other forest vegetation and to investigate factors affecting these phenomena.

Observations are made in about 40 monitoring sites throughout Finland in co-operation with Metsähallitus (National Board of Forestry), universities and other research and education organizations. The number of monitoring sites will decrease starting from 2009 and the observations will be concentrated to the sites with measurements of climate conditions. Nine different tree species are monitored, pubescent birch (*Betula pubescens*), silver birch (*B. pendula*), aspen (*Populus tremula*), rowen (*Sorbus aucuparia*), bird cherry (*Prunus padus*), grey alder (*Alnus incana*), Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), juniper (*Juniperus communis*) and two dwarf shrubs, bilberry (*Vaccinium myrtillus*), and lingonberry (*V. vitis-idaea*). Emergence, yellowing and shedding of leaves and flowering are monitored in broadleaves, flowering and height growth in conifers, and flowering and ripening of berries in dwarf shrubs. Observations are made twice a week during the growing season from the same trees and same stands of dwarf shrubs. Results can be viewed almost in real time on Metla´s web pages (www.metla.fi/metinfo/fenologia/).

Contact persons: Eero Kubin, Tel. +358 10 211 3710, Jarmo Poikolainen, Tel. +358 50 391 3753, Finnish Forest Research Institute (Metla), Muhos Research Unit, Kirkkosaarentie 7, 91500 Muhos, Email: firstname.lastname@metla.fi

2.4.5

Annual forecast and inventory system of bilberry, cowberry and commercial mushrooms

Kauko Salo

In 1997 the Finnish Forest Research Institute (Metla) launched a national forecasting system of wild berries and commercial mushrooms. There are 200 forest and peatland sites under survey annually in different parts of Finland. The survey encompasses economically the most important berry species (cowberry, bilberry and cloudberry) and 31 commercial mushrooms (e.g. ceps, russulae and milk caps).

Five 1.0 m^2 survey squares have been established in each forest site or peat land under study. In these survey squares the numbers of flowers, unripe berries and ripe berries are counted during the growing season. The abundance of commercial mushrooms is counted on the whole forest site.

The data is delivered to Metla at Joensuu Research Unit, where the yield data is processed in the MASI -database. For each berry species, the ArcInfo -software

is used to draw theme maps considering for example the schedules of flowering and ripening in different parts of Finland. The notifications and theme maps issued during the growing season can be accessed in the internet (www.metla.fi/metinfo/monikaytto/marjasieni/).

In the form of communications and theme maps shown on television and in newspapers, and broadcast on the radio, Finnish berry pickers are informed about the timing of flowering and the development of unripe and ripe berries, factors affecting yields (e.g. frost, pollination and drought), the sites where the biggest yields occur and the yield levels of wild berries (very abundant, abundant, average, poor and very poor).

Contact person: Kauko Salo, Finnish Forest Research Institute, Joensuu, Yliopistokatu 7, Box 68, FIN-80101 Joensuu Finland, Tel. + 358 10 211 3034, Email: firstname.lastname@metla.fi.

2.5

Cultivated soils

2.5.1

Monitoring of chemical properties of arable soils

Visa Nuutinen, Martti Esala

MTT Agrifood Research Finland monitors the chemical quality of arable soils in Finland at approximately ten year intervals. The study was started in 1974 and has been repeated in 1987 and 1998. The fourth study is being conducted in 2008 and 2009. Sampling is done in collaboration with the Geological Survey of Finland.

The purpose of the study is to yield extensive information on the changes of chemical soil properties for the follow-up of arable soil quality and for the management of environmental risks in agriculture. The 700 monitoring sites are situated in farmers' fields covering the whole cultivated area of Finland. Samples are taken from the plough layer as composite samples from an area of 10 m x 10 m. Samples are analysed for easily soluble nutrients, trace elements and heavy metals (P, K, Ca, S, Mg, Al, B, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Se and Zn). In addition, soil organic matter content, pH, electrical conductivity, bulk density and soil texture are determined. Samples have been stored in MTT's soil bank for later reference and research.

The results are used to assess the trends of field soil quality nationally, regionally and in different soil types. Selected soil properties (soil organic matter, pH, P and Cd) are included in the agri-environmental indicators of the Ministry of Agriculture and Forestry. The study is part of the research project MYTVAS3 (Monitoring the Impacts of the Finnish Agri-Environmental Support Scheme Programme) co-ordinated by MTT.

The soil bank data resulting from the study will allow later exploitation of the samples for different study purposes and novel analyses as the study methods develop. The samples have hitherto been utilized in the study of selenium trends in arable soils and heavy metal flows in Finnish agriculture.

Contact persons: Visa Nuutinen and Martti Esala, MTT Agrifood Research Finland, FI-31600 Jokioinen, Email: firstname.lastname@mtt.fi, Tel : +358 3 41881; web pages: www.mtt.fi

2.5.2

Arable land and crop production

Anneli Partala

Tike, the Information Centre of the Ministry of Agriculture and Forestry (http://www.mmmtike.fi), is the authority responsible for compiling statistics on arable land in crop production and on harvests. Statistics on the use of arable land are compiled in early summer as preliminary statistics based on administrative registers and a sample survey. The final statistics are compiled on the basis of data from all farms. Nationwide data on the use of arable land dates back to 1920. Regional data extends back several decades. Municipal data is available from the beginning of 1910. It is derived from the results of agricultural surveys performed at ten year intervals. Since 1995, municipal information has been compiled annually.

Contact person: Anneli Partala, Tike, Information Centre of the Ministry of Agriculture and Forestry, tel. +358 20 77 21376, Email: firstname.lastname@mmmtike.fi.

3 Environmental pressures

3.1

Water abstraction and water use

Ritva Britschgi, Maria-Leena Hämäläinen

On average the abstraction of total renewable freshwater resources in Europe is about 15%, and in Finland about 2 %. This shows that Finnish water resources are relatively abundant in comparison to their use. According to the present classification there are about 3770 groundwater areas suitable for drinking water purposes. There are also 2470 groundwater areas belonging to class III, which means that evaluating their degree of usability requires further study of their feasibility for water supply. However, the daily use of groundwater and artificial groundwater is presently 0.7 million cubic metres or 60 % of the water distributed by waterworks. It is estimated that by 2010 this percentage will increase to 70 %. It has been estimated that theoretically a volume of about 5 million cubic metres per day could be abstracted from the Finnish groundwater areas.

Contact person: Ritva Britschgi, Finnish Environment Institute, Tel. + 358 20 610 123, Email: firstname.lastname@ymparisto.fi

Data on water abstraction by communities and municipalities is stored in the national VELVET data base.

Contact person: Lauri Etelämäki, Finnish Environment Institute, Tel. +358 20 610123, E-mail: firstname.lastname@ymparisto.fi

Data on water abstraction by industry is stored in the national VAHTI data base. The data extends back to 1998. The data is regularly reported to e.g. Statistics Finland, OECD and EEA.

Contact person: Maria-Leena Hämäläinen, Finnish Environment Institute, Tel. + 358 20 610 123 , maria-leena.hamalainen@ymparisto.fi

3.2

Regulation of lakes

Mika Marttunen

Regulation of lakes has an important role in the management of water resources. About 15 000 km^2 or 45 % of the lake area is regulated. The main purposes of regulation are hydro power production and flood protection, but water transport, water

supply and recreational use are also important. In addition regulation is often used as a means for restoration of small lakes.

Contact person: Mika Marttunen, Finnish Environment Institute, Tel. + 358 20 610 123
Email: firstname.lastname@ymparisto.fi

3.3

Wastewater loading

3.3.1

Industrial wastewaters

Timo Jouttijärvi, Maria-Leena Hämäläinen

Forest industry wastewaters. In the 1980s and particularly since 1985 when the first biological wastewater treatment plants were constructed, the wastewater load of the forest industry started to decrease. Since then, the positive development in pulp and paper processes as well as in treatment technology has led to drastic decrease in terms of organic matter and suspended solids released to the recipient. The replacement of elementary chlorine (Cl_2) with chlorine dioxide (ClO_2) in bleaching processes in the early 1990s dramatically decreased the total load of organic chlorine compounds measured as AOX and practically prevented the formation of the most harmful polychlorinated compounds in the process. Effluents from pulp and paper mills also contain nitrogen (N) and phosphorus (P) in various forms, some of which are available to aquatic biota and thus have a eutrophying impact on receiving waters. Thanks to the efficient biological purification of wastewaters, the contribution of the forest industry to the total anthropogenic nutrient load on Finnish surface waters has fallen drastically, being 4.4 % for phosphorus and 3.6 % for nitrogen in 2007. However, pulp and paper mills still contribute to local eutrophication.

In 2007 the total annual load from the pulp and paper industry was: total suspended solids 15 097 tonnes, biological oxygen demand (BOD_7) 11 891 tonnes, chemical oxygen demand (COD_{Cr}) 180 612 tonnes, organic chloride compounds (AOX) 0.16 kg per ton of bleached pulp produced, phosphorus 177 tonnes and nitrogen 2 697 tonnes.
Contact person: Timo Jouttijärvi, Finnish Environment Institute, Tel. + 358 20 610 123,
Email: firstname.lastname@ymparisto.fi.

Discharges from industry. Data on discharges from industrial sources is stored in the national VAHTI data base. Complete data sets are available since the 1980s. The VAHTI emission data is used for national and international reporting e.g. for the needs of EU, EEA, HELCOM, OSPAR and OECD.

Contact person: Maria-Leena Hämäläinen, Finnish Environment Institute, Tel. + 358 20 610 123, Email: maria-leena.hamalainen@ymparisto.fi

3.3.2

Municipal wastewaters

Lauri Etelämäki

Since 1970 the environmental protection policies concerning water pollution from urban areas have developed favourably. The municipal discharges of organic mat-

ter and phosphorus decreased sharply during the 1970s and this decrease has since continued. In 2006, municipal wastewater treatment served about 83 % of the population. Effective wastewater treatment dramatically decreases the input of nutrients discharged to waters by municipal wastewater. Information stored in the data banks of the Finnish Environment Institute show that in the early1970s (1971-1974) the BOD_7 load from municipalities after treatment varied between 41 000 and 46 000 tonnes per year, whereas in 2006 it was only 4 200 tonnes per year. In the early 1970s (1971-1975) the phosphorus load from municipalities after treatment was about 2000 tonnes per year and in 2006 only 200 tonnes per year. In 2005 the reduction of BOD_7 load was 97%, phosphorus 95% and nitrogen 54%.

Contact person: Lauri Etelämäki, Finnish Environment Institute, Tel. + 358 20 610123, Email: firstname.lastname@ymparisto.fi

More information:
http://www.vyh.fi/tila/vesi/kuormit/yhdyskun/orgkuot.htm) and
http://www.vyh.fi/tila/vesi/kuormit/yhdyskun/foskuot.htm

3.3.3

Agriculture

Kirsti Granlund

Agriculture involves manipulation of soil, water and other natural resources and has significant effects on the environment. In Finland, the percentage of agricultural land is 9 % of the total land area. In many comparatively large river basins, however, it can exceed 30 %. In these areas, particularly in south-western Finland, agriculture is a major source of nutrient loading. Eutrophication of surface waters is a severe environmental problem caused by agriculture. Much attention has therefore been paid to policies aiming at reducing loading from non-point sources e.g. by introducing the Finnish Agri-Environmental Support Scheme.

The overall effects of diffuse loading (agriculture, forestry and scattered settlement) can be estimated by monitoring water flow and quality in small representative study catchments and river basins representing different land uses. The effects of hydrological, soil and management conditions on diffuse loading are studied in 14 small research catchments (See Section 2.1.3). Intensive automatic water sampling provides accurate estimates of nutrient loads during high flow periods. The results from these catchments have been widely used e.g. for model testing and estimation of total nutrient load to surface waters.

Contact person: Kirsti Granlund, Finnish Environment Institute, Tel. + 358 20 610123, Email: firstname.lastname@ymparisto.fi

3.3.4

Fish farming

Erkki Kaukoranta

In 2005 Finnish fish farms produced annually some 12 000 tonnes of rainbow trout for human consumption. About two thirds of the fish farms are net cage installations located mainly in coastal waters of the Baltic Sea. Only a minor proportion of fish farms are land basin installations located in inland waters. Fish-farming damages locally the water quality of coastal waters, particularly in the south-western part of the

country, and locally may also cause quality deterioration in inland waters. In recent years the intensity of fish farming has declined, and simultaneously the loading has decreased.

Contact person: Erkki Kaukoranta, Regional Environment Centre of Southwest Finland, Turku, Finland, http://www.vyh.fi/eng/rec.htm, Tel. + 359 2 5253500, Email:firstname.lastname@ymparisto.fi

3.4

Air emissions

3.4.1

The Finnish Environment Institute

Kristina Saarinen

The Finnish Environment Institute (SYKE) produces information on air pollutant emissions and greenhouse gases to comply with the reporting obligations of international conventions for use in environmental planning and policy making, research and for public use. The emission inventories are used in reporting to the UN Framework Convention of Climate Change, the UNECE Convention on Long Range Transboundary Air Pollution (CLRTAP) and to various EU Directives. These data are also supplied to the regional conventions of HELCOM and OSPAR. SYKE is the national responsible unit when reporting to the UNECE CLRTAP and under the obligations of EU Directives concerning air pollutants. A special task for SYKE is to maintain national information on emission estimation methods and emission factors in cooperation with the expert institutes and industry. To enable this task, the air emission team actively participates in international, Nordic and national expert work in developing release estimation techniques.

The Air Emissions Data System is part of the Environmental Information System based on the Environmental Protection Act and produces emission data at the level of individual processes and on local and national scales. The emission data is available both through the user interface of the environmental administration (Hertta) and on the website: http://www.ymparisto.fi/default.asp?node=13255&lan=en

Contact person; Kristina Saarinen, Finnish Environment Institute, Tel. +358 20 610123, Email: firstname.lastname@ymparisto.fi.

3.4.2

Statistics Finland

Kari Grönfors

Statistics Finland has been designated as the national authority with overall responsibility for the greenhouse gas inventory in Finland. In addition Statistics Finland is responsible for calculation of Energy and Industrial Processes Sectors, excluding F-gases and NMVOC emissions.

Statistics Finland uses the ILMARI calculation system to produce comprehensive data on greenhouse gas emissions and some other emission components from energy production and consumption as well as from industrial processes in Finland. The system is currently used to calculate emissions of sulphur, carbon monoxide,

carbon dioxide, hydrocarbons, methane, nitrogen oxides and particulates classified by industry, type of combustion process, fuel type and area. Data are available from 1990, excluding 1991.

ILMARI serves as a part of the Finnish National System for greenhouse gas inventories, producing some essential information for reporting to the United Nations Framework Convention on Climate Change and to the Kyoto Protocol. The data are also published in Statistics Finland's annual Environment Statistics and Energy Statistics publications. Data by branch of industry produced with ILMARI also constitute a basic element of environmental accounting.

Contact persons at Statistics Finland: Kari Grönfors and Teemu Oinonen, Tel.: +358 9 17341 (switchboard), kasvihuonekaasut@stat.fi
Further information at: http://www.stat.fi/greenhousegases

3.4.3

Contribution of MTT Agrifood Research Finland

Kristiina Regina

MTT produces the greenhouse gas inventory for agriculture submitted to the secretary of the UN Framework Convention on Climate Change and the commission of the EU each year. These emissions consist of methane emissions from the enteric fermentation of ruminants, methane and nitrous oxide emissions from manure management and nitrous oxide and carbon dioxide emissions from soils. The activity data is collected mainly from the statistics of the Information Centre of the Ministry of Agriculture and Forestry in Finland. The calculation methods are based on the methodological guidance of the IPCC.

Contact persons: Martti Esala, Tel. 03 41882411, Kristiina Regina, Tel. 03 41882426 and Sanna Pitkänen, Tel. 03 41882412,Email: firstname.lastname@mtt.fi

3.5

Wastes

3.5.1

Finnish Environment Institute

Kirsi Merilehto

SYKE is responsible for collecting national emission and effluent data, and for the related international reporting. In accordance with Finnish waste legislation, SYKE's tasks are to conduct research on waste and waste management, arrange training, provide information and advice, make announcements, compile statistics, engage in monitoring and maintain a master register of waste data registers. According to a bilateral contract between SYKE and Statistics Finland, the last-mentioned is in charge of compiling national waste statistics. SYKE's role is to provide information on wastes and waste management for several EU reports as well as to take part in preparing the reports in cooperation with the Ministry of the Environment. SYKE is also responsible for data production for the European Environment Agency as well as for the secretariat of the Basel convention and the EU Commission concerning transfrontier shipments of wastes.

The monitoring system for wastes forms a basis for today's follow-up activities. The monitoring system is a complex system maintained by various parties (Fig. 1).

The system relies to a great extent on the environmental protection database which is maintained by the Environmental Administration. Information provided for the system is obtained from enterprises/operators on the basis of obligations given in the Environmental Legislation. Waste producers that possess an environmental permit for their operation, must provide annually information for the authorities regarding the generation of wastes as well as their recovery and disposal operations as specified in the permit. Regional Environmental Centres together with environmental permit authorities and municipal environment protection authorities provide regional data for the Compliance monitoring system VAHTI. They also have a duty to monitor the state of the environment. Environmental Protection Act sets a duty for SYKE to maintain a national environmental protection database, which contains data on permits and notifications based on the Act. Data provided for VAHTI forms a major data source for the environmental protection database. Another part of the environmental protection database (Basel register) concerns notifications of transboundary waste shipments and of the relevant decisions, and is maintained by SYKE.

According to the environmental legislation, the Regional Environmental Centres must also maintain registers containing information on waste collection and transport on a professional basis with the potential to operate as a seller or dealer in waste if the waste is intended for recovery or disposal outside Finnish territory. In addition, Pirkanmaa Regional Environment Centre is obliged to maintain a nationwide database on wastes covered by producer responsibility. The database includes data on notifications made to them in accordance with the Waste Act, and of the decisions made thereupon. Producer responsibility applies to end-of-life vehicles, recycled paper, packaging and packaging waste, wastes of electronic and electric equipment (WEEE), used tyres, and batteries and accumulators.

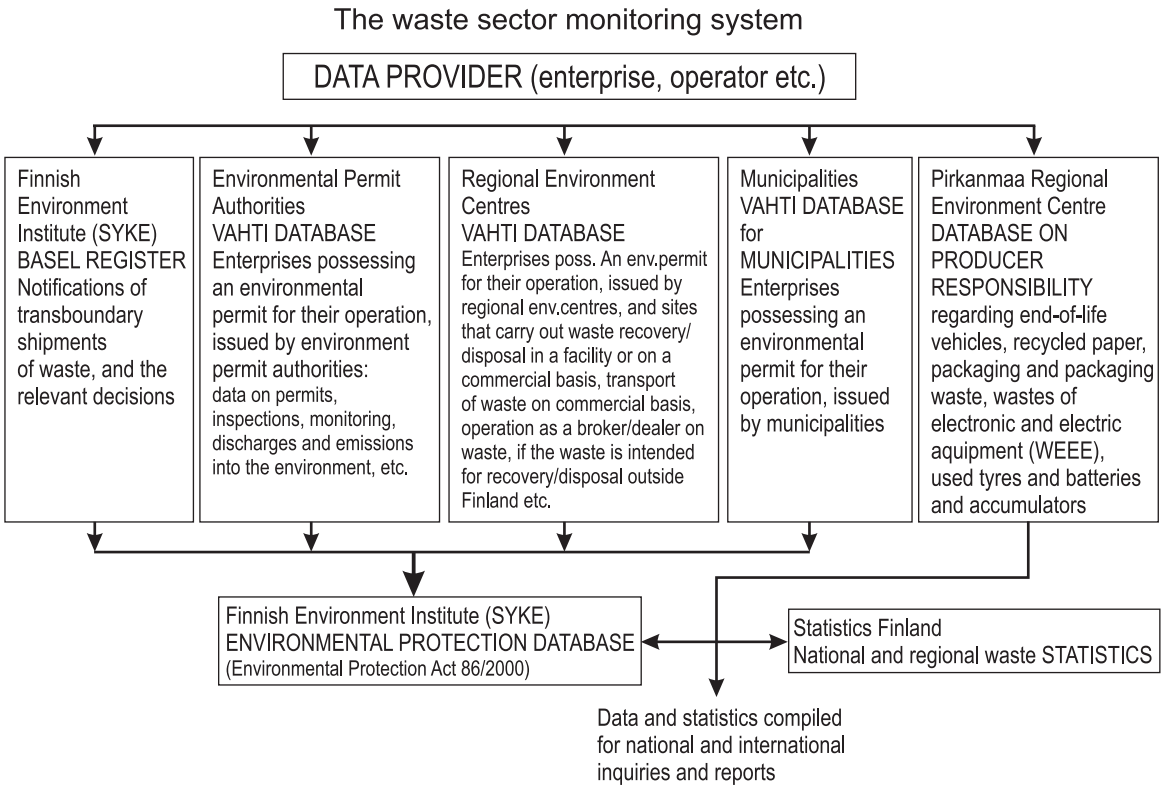

Fig. 1 The waste sector monitoring system

According to the waste legislation, the Ministry of the Environment is in charge of preparing a nationwide strategic waste plan, which includes principles and objectives of waste management and waste prevention. SYKE´s task is to take part in preparing this plan. The recently governmentally approved national waste plan sets certain follow-up tasks for both authorities; a particular follow-up program for the plan will be set up, including developing of proper indicators for assessing the impacts and targets set by the waste plan, gathering data based on it and preparing follow-up reports.

A systematic waste monitoring system requires on-going maintenance and development work. For improving the quality of waste data provided for the system, the Finnish Environmental Administration and Statistics Finland have been working jointly since the late 1990s.

Contact persons: Kirsi Merilehto, and Eevaleena Häkkinen, Finnish Environment Institute Tel. +358 20 610123, and Tarja-Riitta Blauberg, Ministry of the Environment, Tel. +358 400 143 917, Email: firstname.surname@ymparisto.fi
Links: http://www.ymparisto.fi/default.asp?node=6044&lan=en
http://www.ymparisto.fi/default.asp?node=6029&lan=en

3.5.2

Statistics Finland

Jukka Muukkonen

Statistics Finland compiles national waste statistics, which are reported to Eurostat, the Statistical Office of the European Communities, and to the OECD, among others. Waste statistics are today produced according the waste classification (EWC-Stat) and the industrial classification (NACE) within the European Union.

The Finnish Environmental Administration and Statistics Finland have been working jointly on the outlines for waste classification. The first Finnish guide to waste classification was published by Statistics Finland in 1997 and a guide revised according to the 2002 hazardous and non-hazardous waste catalogue was published in 2005.

The first Regulation of the European Parliament and Council on Waste Statistics (EC N:o 2150/2002) was adopted in autumn 2002. The Regulation requires statistical data to be compiled on the production and recovery of waste in all economic activities. The reporting is to be performed following the waste classification that has been aggregated from the European Waste Catalogue and is annexed to the Regulation.

Contact persons: Simo Vahvelainen and Jukka Muukkonen, Statistics Finland, Tel. +358 917341 (switchboard), ymparisto.energia@stat.fi
Further information at: www.tilastokeskus.fi/ymparisto

3.6

Land use

Jukka Muukkonen

Statistics Finland has published a national Land Use Classification, compiled using international land use classifications and the SLICES project of the National Land Survey of Finland as the starting points. Introduction of the Classification supports harmonization of the definitions and concepts used in land use statistics, thereby improving their comparability. The Classification is a binding standard for official

statistics but it is also recommended for other information systems describing the use of land. Statistics Finland has published land use statistics that are derived from the results of the SLICES project.

Contact persons: Riitta Poukka, Statistics Finland, Classification Services, and Jukka Muukkonen, Statistics Finland, Environment and Energy, Tel. +358 917341 (switchboard), ymparisto.energia@stat.fi.

3.7

Extraction of gravel and rock aggregates

Jari Rintala

The extraction of gravel and rock aggregates causes landscape deterioration and increases the risk of groundwater pollution. In a project coordinated by the Finnish Environment Institute (SYKE), crucial information on the geological formations and groundwater areas is collected for mediation of groundwater protection and aggregate production. The information on the extracted aggregate volumes is collected by municipalities, which are also responsible for granting the permits, and recorded in a database by the inspecting authorities (Regional Environment Centres). An accounting system on the extraction volumes is being developed by SYKE and the Geological Survey of Finland, and reports on volumes of permitted and extracted aggregates are published annually. The restoration measures needed will be estimated after mapping all the extraction areas.
Contact persons: Jari Rintala and Ritva Britschgi, Finnish Environment Institute, Tel. +358 20 610123, Email: firstname.lastname@ymparisto.fi
Hannu Idman, Geological Survey of Finland, Tel. +358 20 550 2294,
Email: firstname.lastname@gsf.fi.

3.8

The use of chemicals

Susan Londesborough

The use of chemicals in Finland is monitored jointly by the Health and Environmental authorities. The Finnish Environmental Institute (SYKE) is responsible for the environmental aspects of monitoring of harmful substances. At present, data on concentrations of harmful substances in discharges and in the Finnish environment are limited. Therefore, diffuse and point source pollution is assessed mainly by modeling techniques. Industrial discharges to waters of metals, oils and AOX are estimated from measured concentration data. An advance approval procedure is applied for biocides and plant protection products in order to prevent risk use of these substances. Information on sales volumes is available for plant protection products, slimicides and wood preservatives. In addition, import and production volumes of professionally used chemicals classified as dangerous to human health or the environment have been registered in the Finnish Register of Chemical Products since 2002.

Contact person: Susan Londesborough, Finnish Environment Institute,
Tel. +358 20 610123, Email: firstname.lastname@ymparisto.fi.

4 State of the environment

4.1

Water

4.1.1

Inland waters

4.1.1.1

Description of Finnish freshwaters

Jorma Niemi, Heidi Vuoristo, Sari Mitikka, Jaakko Mannio

Finland is a relatively flat northern country with a humid climate. It is situated between 60 and 70 degrees of latitude, being about 1100 km in length and having an area of 338 000 km^2. Due to its northern location, climatological variations are high and the freezing and break-up of ice on rivers and lakes varies considerably. As much as 30 - 40 % of water discharged annually into the sea (3400 m^3s^{-1}) takes place during the spring thaw. The average rainfall in the country in 1961-1990 was 660 mm a^{-1}, of which 341 mm a^{-1} evaporated resulting in a runoff of 318 mm a^{-1}. The country is divided into 74 main drainage basins.

Water resources are abundant in terms of surface area. Inland waters cover some 33 500 km^2 (about 10 % of the total area of the country). A survey showed that the number of lakes and ponds exceeding 500 m^2 (0.05 hectares) totalled 188 000. Of these about 56 000 have an area greater than 10 000 m^2 (0.01 km^2) and 4607 have an area greater than 0.5 km^2. A total of 46 lakes have an area greater than 100 km^2.

Finnish lakes are typically shallow, with an average depth of about 7 m and they often form lake chains. The lakes in such chains are interconnected by straits that can occasionally be rapidly flowing and may to a great extent resemble rivers. The majority of large lakes are in the central part of the country. The total volume of lakes, about 235 km^3, is relatively small in comparison to their large area. The detention time of lakes is relatively short, being on average about two years. The deepest lakes, with a maximum depth of 90-95 m, are Lakes Saimaa, Päijänne, Pääjärvi and Inari.

The number of rivers is comparatively small. It has been calculated that there are 647 rivers with a catchment area of over 100 km^2 and with at least 10 km of channel uninterrupted by lakes. The total length of these rivers is about 20 000 km. If rivers with smaller drainage basins were included in the calculation this number would be considerably larger. Discharges of rivers vary widely, being highest during the spring thaw. The majority of rivers are in the coastal areas, discharging into the Baltic Sea, either into the Gulf of Finland or the Gulf of Bothnia. Lakes are less abundant in the coastal areas than in other parts of the country and rivers in these areas are, therefore, more frequently used as raw water sources and are appreciated for recreational activities such as swimming, fishing and water sports.

Contact persons at the Finnish Environment Institute Sari Mitikka (water quality), Heidi Vuoristo (water quality), Jorma Niemi (water quality), Marko Järvinen (phytoplankton), Markku Puupponen (hydrology), Tel: + 358 20 610123,Email: firstname.lastname@ymparisto.fi.

4.1.1.2
Ecological classification
Sari Mitikka

In 2008 the Finnish water bodies were classified for the first time on the basis of their chemical and ecological state. The new classification system was necessary because the fundamental elements of the water quality classification were changed due to the EU Water Framework Directive (WFD) and accordingly by the Finnish legislation. The new classification system requires that the effects of human impacts on the aquatic biota must be estimated. The legislation demands further that all inland water should be in a good state by 2015 and that the quality of waters being presently in good or excellent state shall not be decreased. The classification is necessary for assessing the state of waters and forms a basis for taking measures to improve their quality.

The ecological state of about half of the classified Finnish water bodies is good or excellent Less than a third of the classified lakes, half of rivers and half of the coastal waters by area have been classified into lower than good classes, although their chemical state is typically good. Monitoring of harmful substances required by the WFD has been carried out in waters of populated and industrial areas and in agriculturally impacted rivers. A restricted number of harmful substances are analyzed. As well as in water, harmful substances will also be monitored in fish and sediments.

Ecological classification of waters
http://www.environment.fi/default.asp?contentid=285780&lan=en
Contact person: Sari Mitikka, Finnish Environment Institute,
Email: firstname.lastname@ymparisto.fi

4.1.1.3
Monitoring of inland waters
Sari Mitikka, Kari-Matti Vuori

This is an umbrella project that consists of the following nine monitoring projects, most of which have connections to the Water Framework Directive.

Monitoring of lakes and rivers in 2009-2012. The project was created in 2008 for monitoring of the physical and biological quality of lakes and rivers. It is a mutual project of the Environmental Authorities composed by re-designing and merging the earlier nationwide monitoring programs with the programs of the Regional Environment Centers. Moreover the program is a compilation of the local surveillance monitoring networks of the Water District Basins.

The program aims at a balanced sampling of natural water body types. The major part of the sites was selected to produce data for assessing the reference conditions. However, some of the sites are impacted by human activities. However, most of the data concerning impacted waters comes from other sub-programs such as local pollution control monitoring programs or from the monitoring project on diffuse loading from agriculture and forestry. The network includes several sites that have been monitored since the early 1960s and therefore have long-time series of water quality data. In addition, sites with only limited and scattered time-series are included. These are typically small lakes.

The lakes and rivers monitored are divided into two groups: (i) significant water bodies by water volume or area and (ii) other water bodies. The frequency of sampling varies. Some of the sites are sampled intensively two or three times a year. Some sites are sampled every three, six or 12 years. Reference water bodies include several sites that have relevance from the point of view of biodiversity. These waters are situated in Natura 2000 areas or in areas close to sites known to harbour endangered species.

The program produces information on water quality and biology of reference waters, long-term changes in water quality, eutrophication, pressures caused by regulation and hydromorphology and toxic substances in biota. Much of the data is required by several EU Directives, the most important of which are the Water Framework Directive (2000/60/EC), the Nitrates Directive (91/676/EEC 1991), and the Freshwater Fish Directive(78/659/EEC). All the data produced are stored in the common HERTTA- data bank of the Environmental Authority.

Material input to the Baltic Sea by Finnish rivers. Material input to the Baltic Sea by Finnish rivers is estimated with the network of some 35 river sites with a minimum frequency of 13 samples per year. The results are reported to HELCOM and to Statistics Finland. The material includes point loading (industry, municipalities and fish farming), diffuse loading (agriculture and forestry, small settlements outside the sewage system), deposition and background loading. The main objective is to monitor the long-term changes in runoff and loading in the river basins.

In addition the following projects presented in other sections of this report produce data that help to form the general image of the quality of Finnish inland waters.
Monitoring of diffuse loading from agriculture and forestry, Section 4.1.1.4
Monitoring of transboundary waters, See 4.1.1.5
Monitoring of small hydrological basins, Section 2.1.3
Integrated monitoring, Section 4.7
Harmful substances in fish and sediments, Section 4.6.2
Local pollution control monitoring programs, Section 4.1.1.6.

Contact person: Sari Mitikka Finnish Environment Institute, Helsinki Office, Tel. + 358 20 610123, Kari-Matti Vuori, Finnish Environment Institute, Oulu Office, Tel. +358 20 610111, Email: firstname.lastname@ymparisto.fi

4.1.1.4

Monitoring of diffuse loading from agriculture and forestry

Kari-Matti Vuori

Monitoring of diffuse loading from agriculture and forestry is part of the implication of the EU Water Framework Directive and national legislation. Its objective is to produce representative information concerning the effects of agriculture and forestry both on surface and ground waters.

The legislation requires the monitoring of diffuse loading and its impacts in sites where loading is considered to cause a significant risk of failing to achieve good ecological state in the receiving waters. Particularly the good ecological state of several smaller rivers, lakes and coastal sea areas impacted by agriculture is at risk, because of factors such as eutrophication, erosion and elevated concentrations of harmful substances caused by agriculture and forestry. Furthermore the good state of ground waters may also be at risk. The use of pesticides must be monitored to ensure that the limits set for these substances are adhered to.

The program for the monitoring of diffuse loading from agriculture and forestry started in 2007. It is funded by the Ministry of Agriculture and Forestry. Currently the network includes some 50 lake sites, 50 river sites and 39 sites in coastal sea areas. These sites are monitored for ecological and chemical state. During the first year of

the program pesticides were monitored monthly in 9 rivers. In the future some of the sites will be changed and the sampling will be focused on the summer season. The chemical state of ground waters will be monitored at 60 sites. In addition an automatic sampling site has been founded at one drainage basin dominated by cattle grazing, with the objective of investigating the effects of slurry on waters. In 2007 and 2008 all the elements used in the ecological classification of waters were measured in an intensive survey.

The project will be continued in 2009-2012, supported by funding from the Ministry of Agriculture and Forestry. The objective is to intensively monitor the ecological state of waters by using biological, physical and chemical variables

Contact person: Kari-Matti Vuori, Finnish Environment Institute, Tel. +358 20 610111, Email: firstname.lastname@ymparisto.fi.

4.1.1.5

Transboundary waters

Sari Mitikka

Finland has common transboundary waters with the Russian Federation, Sweden and Norway. During recent decades these waters have been regularly monitored.

Finland-Russia. The transboundary area between Russia and Finland has 20 watercourses including 448 lakes, rivers, ponds and streams. The largest river basins along the common border are those of the rivers Vuoksi and Paatsjoki. The monitoring was started in 1966 within the Joint Finnish-Russian Commission. The monitoring focuses on rivers under the impact of waste waters from communities and industry, and from agriculture. These rivers are the Vuoksi, Hiitolanjoki, Rakkolanjoki, Urpalanjoki and the Saimaa Canal. The Commission meets annually to discuss the monitoring results and actions to be taken.

Finland-Sweden. The transboundary River Commission between Finland and Sweden acts as a cooperation and permit authority. The Lapland Regional Environment Centre and the County administration of Norrbotten are responsible for monitoring of the Tornio river basin. This long- term cooperation is promoted by the EU WFD directive that requires the border states to manage the transboundary waters together.

Finland-Norway. The national border between Finland and Norway forms the northernmost 715 km long border of the European Union. It crosses extensive watersheds, the largest rivers the Tenojoki (Tana), the Näätämöjoki and the Paatsjoki (Pasvik) rivers. The Finnish-Norwegian Transboundary Water Commission, established in 1980, acts as a body for cooperation and strives to preserve the good ecological state of river Tenojoki. The commission meets at least once a year. Monitoring programs of the boundary rivers are carried out by Lapland Regional Environment Centre and the County governor of Finnmark. As with Sweden, the cooperation has been intensified due to the EU WFD directive.

Finnish Russian Transboundary Water Commision
http://www.rajavesikomissio.fi/index_eng.htm

Contact person: Sari Mitikka, Finnish Environment Institute, Tel. + 358 20 610123, Email: firstname.lastname@ymparisto.fi

Co-operation with Sweden, Norway and Russia on transboundary river basins
http://www.ymparisto.fi/default.asp?node=16163&lan=en
http://www.ctc.ee/riverdialogue/index.php?tree_id=48

Contact person: Pekka Räinä, Lapland Regional Environment Centre, Tel. +358 20 610 113, Email: firstname.lastname@ymparisto.fi

4.1.1.6
Local pollution control monitoring programs
Heidi Vuoristo

Local pollution control monitoring of waters is based on the Environmental legislation and is paid by polluters. On the basis of the legislation the impacts of municipal and industrial waste waters and those of fish farms, peat mining companies, landfills, water abstractions and hydraulic engineering operations are monitored regularly. Local pollution control monitoring plans are tailored individually for each polluter, taking into account the quality and quantity of waste waters and the conditions prevailing in the recipient water body. The plans are accepted by the environmental authorities. The authorities also promote local pollution control monitoring by preparing guidelines, drawing up summaries on the basis of gathered data, promoting quality assurance and by organizing workshops for training of the personnel.

The contents of the programs vary depending on the type of loading and receiving waters. Typically the programs include a list of sampling sites and water quality analyses to be made. The number of water quality sampling sites (rivers, lakes and coastal sea areas) is about 5000. Biological variables are included in the programs covering large water areas. Hygienic indicator bacteria are monitored in most programs. Monitoring of harmful substances is focused close to the sites that receive loading. The demands of the Water Framework Directive are taken into consideration in the programs e.g. by increasing the monitoring of biological elements and harmful substances. The monitoring results are reported annually to the Environmental Authorities.

Contact person: Heidi Vuoristo, Finnish Environment Institute, Tel. + 358 20 610 123, Email: firstname.lastname@ymparisto.fi

4.1.1.7
Monitoring of air pollution and climate change impacts in reference lakes
Jussi Vuorenmaa

The aim of the monitoring program is to assess the impacts of global environmental problems, such as air pollution and climate change, on aquatic ecosystems. The monitoring has been carried out by Finnish Environment Institute and Regional Environment Centres using the network of 30 forested catchments and lakes located in reference areas. The monitoring comprises the assessments of levels and long-term changes of acidifying compounds and harmful substances (heavy metals, persistent organic pollutants) in surface waters, studies on the recovery processes from acidification in headwater lakes under changing deposition loads, and assessments of potential eutrophication risk caused by nitrogen deposition.

The national monitoring program was launched in 1979, and at the beginning the main emphasis was monitoring of airborne lake acidification. During the recent years, the focus in research and monitoring has been extended from air pollutants to other global themes such as climate change, and one of the key concept is to study the interactions between different global environmental problems.

Several catchments and lakes of the monitoring program are also included in the international monitoring programmes under UNECE Convention on Long-Range Transboundary Air Pollution CLTRAP (UNECE ICP Waters, UNECE ICP Integrated

Monitoring IM). The monitoring results are reported mainly in the international scientific journals and ICP program reports.

Contact person: Jussi Vuorenmaa, Finnish Environment Institute, Tel. + 358 20 610 123, firstname.lastname@ymparisto.fi

4.1.2

The Baltic Sea

Mika Raateoja, Pirkko Kauppila

The Finnish sea areas, both the open sea and coastal waters, are monitored in accordance with the programme of the COMBINE Baltic Sea protection agreement. Monitoring of coastal waters is carried out according to the requirements of the Water Framework Directive (WFD) and the national water protection programmes.

Monitoring of the Open Baltic Sea is carried out using the research vessel Aranda. Its three annual voyages cover the whole Baltic Sea. Nutrients are monitored in January-February, bottom animals in May-June, and phytoplankton in August. Furthermore, three additional monitoring excursions are annually made to the Gulf of Finland with the objective of gathering information on the impacts of the waste waters of St Petersburg. Each year, Aranda visits an average of 80 stations within the context of COMBINE monitoring. In total approximately 150 sampling stations are sampled annually.

In the monitoring of coastal waters, the Baltic Sea COMBINE programme comprises 16 stations sampled 20 times a year. In addition, approximately 150 monitoring stations are sampled from 2 to 4 times a year. HELCOM's Baltic Sea monitoring programme will be modified during the next few years with the objective of developing it further to comply with the requirements of the EU Marine Strategy Directive and other environmental directives.

According to the WFD, ecological classification is carried out on the basis of biological variables. Therefore the amount of biological monitoring has been increased in the six coastal river basin districts. In the new programme, the monitoring of zoobenthos is carried out at approximately 50 stations, phytobenthos at approximately 30 transects, and the biomass and species composition of phytoplankton at about 30 stations.

The results of the Baltic Sea monitoring programme are delivered to the database of the International Council for Exploration of the Sea (ICES). Both the Baltic Marine Environment Protection Commission (HELCOM) and the European Environment Agency obtain information from this database.

4.1.2.1

Long-term monitoring of water quality and material flows

Pirkko Kauppila, Antti Räike, Mika Raateoja, Hannu Haahti

Monitoring of material inputs discharged by rivers to the Baltic Sea. Rivers carry the major part of the total loading discharged to the Baltic Sea. The monitoring of this loading is therefore important. The material inputs of rivers are composed e.g. of natural leaching, atmospheric deposition and both point source and diffuse loading. By allocating the total loading on the basis of its component sources, the protection measures can be directed to the most significant sources of pollution. The objective of the project is to monitor long-term changes in the leaching of nutrients and the internal loading of the river basins A total of 32 rivers are sampled at least 13 times a year. The numbers of chemical variables analysed is 37. The most important vari-

ables are nutrients, heavy metals, organic matter and suspended solids. In addition, several background variables, such as alkalinity, electrical conductivity and oxygen concentration are analysed. The results are reported annually to Statistics Finland and to HELCOM.

Contact person: Antti Räike, Finnish Environment Institute, Tel. + 358 20 610 123, Email: etunimi.sukunimi@ymparisto.fi

Monitoring of diffuse loading from agriculture and forestry. Monitoring of the impacts of diffuse loading on the water quality of coastal waters was initiated in 2007, with financing by the Ministry of Agriculture and Forestry. The focus is on monitoring of the eutrophication of coastal waters, where the most important variables are nutrients and chlorophyll *a*. Furthermore, at some sites the biomass and species composition of phytoplankton and zoobenthos are monitored. Monitoring is focused particularly on the estuaries of agriculturally impacted rivers. In coastal waters a total of 39 sites are monitored for diffuse loading. The vast majority of the sites are located in the Gulf of Finland or in the Archipelago Sea. The number of variables analysed is 21, of which nutrients are the most important group. Other important physico-chemical variables are oxygen, turbidity, suspended solids and total organic carbon (TOC). Of the biological variables, the biomass and species composition of phytoplankton and the zoobenthos are determined particularly in intensively sampled sites. Samples are taken five times a year from the surface layer of the water and from the water layer close to the bottom.

Contact person: Antti Räike, Finnish Environment Institute, Tel. 020 610 123, Email: firstname.lastname@ymparisto.fi

Long-term monitoring of the water quality of the Baltic Sea - HELCOM monitoring. In this project the nutrients, oxygen content and pH are monitored. Monitoring is carried out on COMBINE voyages with the research vessel Aranda, on excursions to the Gulf of Finland and in the operative monitoring of the Baltic Sea (Alg@line). Soluble nutrients (PO_4, NO_2, NO_3, NH_4, SiO_2) and total nutrients (tot N, tot P) are determined. Oxygen content is measured with both CTD equipment (temperature - salinity probe) and by measuring oxygen from water samples.

On Aranda's journeys, comprehensive physico-chemical and biological data are collected. The variables determined include CTD parameters, such as temperature, salinity, oxygen content and *a*-chlorophyll *in vivo* fluorescence. Specified variables analysed from separate water samples are oxygen content, pH, chlorophyll *a*, inorganic nutrients and particle nutrients. Secchi depth is also measured.

In addition, a separate water sample close to the bottom is taken. With the exception of Secchi depth, the sampling and analyses of all monitored variables are FINAS-accredited, and quality assurance complies with the SFS-EN ISO/IEC 17025 standard. Water quality monitoring will in the near future be supplemented by nutrient analyzers which enable higher measurement frequency, e.g. at Alg@line surface water measurement stations.

In 2008, eight indicator reports describing the state of Baltic Sea were produced on the basis of the monitoring results of COMBINE and Alg@line. The reports are being utilized e.g. in examining the implementation of HELCOM's Baltic Sea Action Plan.

The Finnish Meteorological Institute is responsible for the physical monitoring of the HELCOM programme for the Baltic Sea. The monitoring is mainly carried out from the research vessel Aranda using the CTD equipment. The Finnish Coast Guard

produces additional data with their vessels carrying CTD equipment for measuring oxygen and *in vivo* fluorescence.

The Finnish Meteorological Institute also carries out physical monitoring at fixed coastal stations, where the personnel measure temperature and salinity at ten-day intervals. This monitoring has generated long time series, e.g. the measurements in Utö, an island at the outer archipelago in the northern Baltic Sea, began in 1911. Other stations are located in the Krunnit archipelago in the Bay of Bothnia, on Valassaari Island in Merenkurkku, in Seili in the Archipelago Sea, and in Tvärminne in the western Gulf of Finland. There are plans to automate this monitoring in the near future.

Contact persons in Finnish Environmant Institute: Mika Raateoja and Hannu Haahti, Tel. +358 20 610 123, Email: firstname.lastnamei@ymparisto.fi

Contact person in Meteorological Institute: Pekka Alenius, Tel. +358 9 192 91, Email: firstname.lastname@fmi.fi

Monitoring the basin districts in coastal areas. There are 16 intensively monitored stations situated in the outer coastal waters beyond the direct land-derived loading. Intensive monitoring produces data on seasonal and annual fluctuations of hydrography and eutrophication as well as long-term trends of water quality. Intensive monitoring supplements the data obtained by remote sensing based on satellites.

The quality of coastal waters is monitored at 150 stations at least twice a year, in February and in July. The monitoring produces information on temporal and spatial fluctuations in the hydrography and eutrophication of the coastal waters. In addition, several shallow bays of the archipelago are monitored for oxygen content and eutrophication.

In the new monitoring programme, the numbers of sites, the sampling frequencies and the selection of analyses have been decreased at some stations in coastal waters. Furthermore, to save expenses, there has been an attempt to integrate sampling with the journeys of the research vessels Aranda and Muikku.

The new monitoring programme includes surveillance and operational monitoring, both of which generate information for the ecological classification according to the WFD. The observation stations of the environmental administration mainly belong to the surveillance and operational monitoring, whereas the impacted monitoring stations belong to operational monitoring. The monitoring of Finnish coastal water quality serves the monitoring required by the WFD, but also forms part of the international Baltic and European-wide monitoring of the seas.

Contact person: Pirkko Kauppila, Finnish Environment Institute, Tel. +358 20 610 123, Email: etunimi.sukunimi@ymparisto.fi

4.1.2.2

Biological long-term monitoring.

Mika Raateoja, Seija Hällfors, Pirkko Kauppila, Juha Flinkman, Maiju Lehtiniemi, Alf Norkko, Jouko Rissanen

Baltic Sea HELCOM programme for the monitoring of phytoplankton. This monitoring focuses on the structure and development of the phytoplankton community. The monitoring is mainly carried out during the excursions of research vessel Aranda's COMBINE - journeys to the Gulf of Finland and in the operative monitoring of the Baltic Sea (Alg@line). Phytoplankton biomass and species composition are determined at approximately 20 stations in the northern Baltic Sea during the Combine 3 - journey. Additional information is obtained from Alg@line's regular station located

in the northern Baltic Sea, which is sampled at one to two week intervals throughout the year, except in mid-winter.

Because Alg@line generates a large amount of information, a semi-quantitative phytoplankton analysis is mainly used. The large number of samples ensures the statistical reliability required. As a result, a comprehensive picture of the phytoplankton community of the Baltic Sea is obtained.

Phytoplankton data is used in reporting the occurrence of algae in the Baltic Sea. In addition, there is an attempt to summarise the information into an indicator report describing the development of the state of the Baltic. The report will serve in overseeing the implementation of HELCOM's Baltic Sea Action Plan.

Contact persons in Finnish Environment Institute: Mika Raateoja, Tel. +358 20 610 123 and Seija Hällfors, Tel. +357 9 613 941, Email addresses: firstname.lastname@ymparisto.fi

Phytoplankton monitoring in the coastal river basin districts. Phytoplankton monitoring is carried out in the Finnish coastal waters using both intensive and normal monitoring

Intensive monitoring is focused on the outer coastal waters. The biomass and species composition of phytoplankton are determined at a total of 16 stations during the entire growth period or during the summer period. The objective is to generate more information on seasonal and annual fluctuations of phytoplankton and their long-term trends.

Normal monitoring consists of a total of 17 stations where the biomass and species composition of the phytoplankton are determined at three-year intervals. During the observation years, samples are taken at least four times during the growth season. The monitoring complements the available information of phytoplankton, particularly from the inner and intermediate archipelago. The results serve the ecological classification of waters required by the WFD, implementation of the Nitrates Directive, assessment of the impacts of agriculture and forestry and general decision-making in water management.

Contact person: Pirkko Kauppila, Finnish Environment Institute, Tel. +358 20 610 123, Email: firstname.lastname@ymparisto.fi

Baltic Sea HELCOM programme for the monitoring of zooplankton. The monitoring is mainly carried out on the excursions of research vessel Aranda's COMBINE-journeys to the Gulf of Finland and in the operative monitoring of the Baltic Sea (Alg@ line). The biomass and species composition of zooplankton are determined at the approximately 20 stations in the northern Baltic Sea during the COMBINE 3 - journey. In operative monitoring, the Continuous Plankton Recorder (CPR) system, hauled at the stern of the ship, has been in use since 1998. It collects zooplankton samples from the sea as the ship sails.

Contact persons in Finnish Environment Institute: Juha Flinkman, Tel. +358 20 610 123 and Maiju Lehtiniemi, Tel. +358 9 613 941, Email addresses: firstname.lastname@ymparisto.fi

Baltic Sea HELCOM programme for the monitoring of zoobenthos. The structure and development of the Baltic Sea zoobenthos community and its development is monitored. The monitoring is mainly carried out on the excursions of research vessel Aranda's COMBINE 2- journey. The amount and species composition of the bottom fauna are determined at approximately 50 stations during the COMBINE 2- journey. In addition, the oxygen content close to the bottom sediment is determined.

Contact person: Alf Norkko, Finnsh Environment Institute, Tel. +358 09 613 941, Email: firstname.lastname@ymparisto.fi

Zoobenthos monitoring in the coastal river basin districts. Macrozoobenthos communities of coastal areas have been monitored since 1964 at two observation sites in Tvärminne located in the western part of the Gulf of Finland. Statutory monitoring of zoobenthos and regional monitoring carried out by the Southwest Finland Regional Environment Centre have contributed to the project. However, the current monitoring does not provide sufficient information for implementation of the ecological classification required by WFD.

In the new monitoring programme, the intensive annual monitoring of zoobenthos is expanded to comprise all coastal water types around Finland. Moreover, for the ecological classification, some of the water bodies will be monitored using rotation every each three or six years. Monitoring will be supplemented by a monitoring programme on the impacts of diffuse loading, financed by the Ministry of Agriculture and Forestry.

The occurrence of bottom fauna is strongly related to depth and salinity. From each of the water bodies monitored, sampling is carried out to represent various depth and salinity zones. Depending on the water body, this means 5-15 observation sites per water body. Altogether, samples of bottom animals will be taken on an annual basis from an average of 100-200 sites.

The monitoring produces a comprehensive picture of macroscopic bottom fauna in Finnish costal waters. Statutory monitoring, financed by polluters, produces supplementary information.

Contact person: Jouko Rissanen, Finnish Environment Institute, Tel. +358 20 610 123, Email: firstname.lastname@ymparisto.fi

Macrophyte monitoring in the coastal river basin districts. Species composition of macrophytes is monitored intensively based on the underwater transects In addition, the lower limit of the bladder wrack zone is monitored.

The impacts of eutrophication of coastal waters are visible particularly in shallow waters close to the shore. In order to monitor these waters, a Baltic shore zone monitoring programme was initiated in 1999 in HELCOM's member countries, in accordance with the programme prepared under Finland's leadership. The objective is to monitor the state of the macrophyte communities of vascular plants, moss and algae in the shore zones beyond direct loading, and to detect potential trends. Macrophyte monitoring will be a part of the monitoring of phytobenthos communities required by the Maritime Strategy Directive. Monitoring will be carried out by diving, using the quantitative method of underwater vegetation transects situated at a total of 23 sites in the Gulf of Finland, the Archipelago Sea, Bothnian Sea, Quark and Bothnia Bay. The results will be reported to HELCOM.

In WFD the lower depth limit of the uniform distribution of bladder wrack *(Fucus vesiculosus)* has been chosen to describe the ecological state of coastal waters. This method was developed in a pilot project in 2007-2008. Monitoring of the lower limit of bladder wrack can be carried out only in areas where the species is well established, it is not possible in the Gulf of Bothnia where bladder wrack does not occur. The growth of bladder wrack and changes in its uniform lower zone are slow and therefore their monitoring every three years is sufficient. Monitoring of the lower limit of the bladder wrack zone will be carried out in the Gulf of Finland, the Archipelago Sea, Bothnian Sea and Quark at approximately 60 sites.

Other indicator species resembling bladder wrack are *Rhodomela*, *Furcellaria* and *Phyllophora*. Their use as indicators of the ecological state will be studied in connection with macrophyte monitoring.

Contact person: Jouko Rissanen, Finnish Environment Institute, Tel. +358 20 610 123, Email address: firstname.lastname@ymparisto.fi

4.1.2.3

Operative monitoring of the state of the Baltic Sea

Seppo Kaitala, Vivi Fleming-Lehtinen

Alg@line monitoring. The Marine Centre of the Finnish Environment Institute is responsible for the operative monitoring of the HELCOM Baltic Sea programme (Alg@line).

The Alg@line monitoring, started in 1991, is based on near-surface measurements collected from commercial ships sailing the Baltic Sea. As the ship proceeds, it continuously samples water and automatically measures water temperature, salinity, turbidity, chlorophyll *a in vivo* fluorescence and blue-green alga pigment *in vivo* fluorescence. A tailor-made data collection programme records data from sensors every 20 seconds. The distance between successive measurements is approximately 200 m, depending on the speed of the ship. In addition, the equipment gathers water samples along the route (max 24), from which the soluble (PO_4, NO_2, NO_3, NH_4, SiO_2) and particle nutrients (tot P, tot N), chlorophyll *a* and species composition of phytoplankton are determined in the laboratory. The results are sent once an hour from the ship to the Marine Centre by satellite.

Since 2009, measurements from surface water samples have been measured in the following parts of the Baltic Sea: between Helsinki and Stockholm by the shipping company Tallink - Silja with the ship Silja Serenade, between Vyborg and Utö by the shipping company Kristina Cruises with the ship Kristina Brahe, between Göteborg and Kemi by the shipping company Transatlantic with the ship Transpaper, and between Helsinki and Travemünde by the shipping company Finnlines with the ship Finnmaid.

The Alg@line project is carried out in cooperation with the environmental administration. The Regional Environment Centres of Southeast Finland, Uusimaa and North Ostrobothnia and the City of Helsinki cooperate to ensure smooth running of this program.

Contact person: Seppo Kaitala, Finnish Environment Institute, Tel. +358 20 610 123, Email: firstname.lastname@ymparisto.fi

Remote sensing of the Baltic Sea. This project is presented in section 4.1.4.2.

Contact persons in the Finnish Environment Institute: Seppo Kaitala, Kari Kallio and Timo Pyhälahti, Tel. +358 20 610 123, Email addresses: firstname.lastname@ymparisto.fi

Operative algal monitoring. The Baltic Sea web-based algal information service has been in operation since 1995 (www.levatiedotus.fi). It is an essential part of the operative monitoring of the state of the Baltic (Alg@line). The algal information service generates weekly algal reports and other information describing the current state of the Baltic Sea (maps showing algal blooms, species reports, results of the measured water quality variables and their time series, results of remote sensing). The service

is produced in cooperation with the Finnish Coast Guard, the Sea Scouts and other civic organizations.

Contact person: Vivi Fleming-Lehtinen, Finnish Environment Institute, Tel. +35820 610 123, email: firsname.lastname@ymparisto.fi

4.1.2.4
Monitoring of harmful substances
Harri Kankaanpää, Mirja Leivuori

Heavy metals and organo-chlorine compounds in Baltic herring. The Marine Centre of the Finnish Environment Institute is responsible for the operative monitoring of heavy metals and organo-chlorine compounds in the HELCOM Baltic Sea programme. The contents of heavy metals and organo-chlorine compounds are monitored annually in two year old Baltic herring that have not yet spawned. Of the heavy metals lead, cadmium, copper and zinc are determined from the liver. Mercury, DDT and PCB compounds, organo-chlorine compounds and ⍺- and ⍺-HCH and HCB are determined from the muscle.

The Finnish Game and Fisheries Research Institute samples the sea areas outside Kalajoki, Pori, Hanko and Kotka and Åland. The future implementation of HELCOM's Baltic Sea Action Plan will probably require changes in the monitoring, which must be taken into account during the next few years.

Contact persons in the Finnish Environment Institute: Harri Kankaanpää and Mirja Leivuori, Tel. +358 20 610 123, Email addresses: firstname.lastname@ymparisto.fi

Hydrocarbon content in water. The Marine Centre of the Finnish Environment Institute is responsible for the monitoring of total oil content in surface water in accordance with the HELCOM Baltic Sea programme.

Data are produced with the fluorometric measurement method at the research stations, which have a long series of data from 1977-2008. Most of the monitoring data is produced in winter (Aranda's COMBINE 1- journey), when the concentrations of oil are highest. In addition, data are also gathered during Aranda's COMBINE 3- journey. The results are reported to HELCOM.

Contact person: Harri Kankaanpää, Finnish Environment Inastitute, Tel. +358 20 610 123, Email: firstname.lastnamei@ymparisto.fi

Harmful substances in fish and sediments. This monitoring programme is presented in Section 4.1.1.4.

Contact person : Jaakko Mannio, Finnish Environment Institute, Tel. +358 20 610 123, Email: firstname.lastname@ymparisto.fi

4.1.3
Use of Earth Observation in environmental monitoring at SYKE

4.1.3.1
Use of satellite images in water quality monitoring
Kari Kallio, Jenni Attila, Saku Anttila

The operational satellite-based water quality products of SYKE are surface water temperature and surface algal blooms for sea areas surrounding Finland. In addition, turbidity and chlorophyll a are reported seasonally. The usability of the products

in the implementation of the water framework directive is supported by creating additional products, such as bloom indexes and chlorophyll a time series. In lakes, surface water temperature is estimated operationally for 12 large lakes in Finland. The processors developed in the MERIS Lake water algorithms-project are tested in the estimation of total suspended solids and chlorophyll a, and their suitability for regular lake monitoring is evaluated.

The satellite images used for water quality estimation are NOAA/AVHRR and ENVISAT/MERIS. The operational products are available on SYKE's internet pages (www.environment.fi/syke/remotesensing).

Contact persons: Saku Anttila, Kari.Y.Kallio, and Jenni Attila ,Finnish Environment Institute, Tel. +358 20 610123, Email: firstname.lastname@ymparisto.fi

4.1.3.2

Use of satellite images in the monitoring of snow melt

Sari Metsämäki

Satellite images by optical sensors have been used in the monitoring of snow melt since 1999 in the Finnish Environment Institute (SYKE). Remote sensing of snow is related to SYKE's nationwide hydrological monitoring and forecasting; its major task is to provide information for hydrological forecasting in order to improve the forecasts. The remote sensing activity produces estimates on the regional fraction of Snow Covered Area (SCA) for 500m×500m grid cells as well as for all third order drainage basins of Finland. The basin-wide product enables the practical use of SCA-estimates in hydrological forecasting models. Currently, SCA-maps are poduced with a specific SCA-method developed at SYKE. The method uses optical data provided by Terra/MODIS (other sensors such as NOAA/AVHRR can also be used). MODIS-imagery covering the Baltic Sea drainage area is delivered daily to SYKE from the Finnish Meteorological Institute. At SYKE, an automatic processing system handles the data until it is ready for snow interpretation. The results are presented as thematic maps in SYKE's internet pages (www.environment.fi/snowcover). Besides the thematic maps, the numerical information is delivered to the hydrological model.

A handicap with optical imagery is that observations are often obscured due to cloudiness. This limits their use to clear sky condition only. This is not the case with microwave sensors, which provide usable data independently of the cloudiness. The method for SCA-estimation using microwave radar data has been developed at the Helsinki University of Technology. The method was adapted to operational use at SYKE in 2006, the Radarsat-imagery over northern Finland serving as major data source. The method has already proved its usefulness in hydrological forecasting. Due to the high cost of the data, the number of images is limited to 4-5 images per melting period, with emphasis on the end the season.

The snow water equivalent (SWE) can be mapped using 25km×25km satellite microwave radiometer data combined with the ground observations on snow depth. The AMSR-E radiometer data are well suited for SWE-mapping, with two daily overpasses over Finland which are freely downloadable from NASA's web-portal. An AMSR-E- based method is still under development, mainly related to its accuracy. However, the method should be providing reliable SWE data for use in in hydrolgical forecasts in the near future.

Contact person: Sari Metsämäki, Finnish Environment Institute, Tel. +358 20 610123, Email: firstname.lastname@ymparisto.fi

4.1.3.3
Land Cover monitoring at SYKE

Pekka Härmä

SYKE has participated in the production of land cover data since the late 1980s. The land use of Finland was recently mapped in a national cooperation project called SLICES, describing the situation in the year 2000. It will be updated in 2006. The data are based on information collected, updated and managed by different organizations. The National Survey of Finland is responsible for data production (see http://www.slices.nls.fi/). In the CORINE2000 program the land cover of Europe in the year 2000 (+/- 1 year) was mapped. SYKE produced the data covering Finland by combining satellite- and map information with field measurements.

The CORINE Land Cover databases are updated on a regular basis (every 5-10 years). Presently CLC2000 is updated to the reference year 2006 in Europe. In Finland the work will be completed in 2009 and a new land cover database including land cover changes between 2000 and 2006 will be produced at the Finnish Environment Institute. The update is based on national GIS data sets, environmental registers, in-situ measurements and IMAGE2006 satellite data (IRS P6 LISSIII and SPOT 4/5 XS). The Finnish Forest Research Institute produces the land cover information in forests using field measurements of the National Forest Inventory and IMAGE2006 data.

Information on land cover is used in various research and monitoring programs as background data, for example in monitoring of land use, assessment of nutrient loads, hydrological monitoring and modeling of biodiversity. Land use and land cover information are made available as regional statistics (drainage basins, municipalities, ground water areas) in the Hertta environmental information system and as GIS data in data servers. Additionally the CORINE2000 data for Finland are available on the Internet (www.ymparisto.fi/oiva).

Contact person: Pekka Härmä, Finnish Environment Institute, Tel +358 20 610123, Email: firstname.lastname@ymparisto.fi.

4.2
Air

4.2.1
Deposition and air quality in background areas

Jussi Vuorenmaa, Sirkka Leppänen

Monitoring of bulk deposition or contaminants in the air in background areas in Finland has been carried out by monitoring networks of the Finnish Meteorological Institute (FMI) and the Finnish Environment Institute (SYKE) since the early1970s. The monitoring networks were integrated in 2004, resulting in an extensive monitoring network of deposition including acidifying compounds (major ions), harmful substances (persistent organic pollutants, heavy metals) and nutrients (fractions of N and P) measured throughout the country. The network comprises 20 measuring stations, of which nine stations (maintained by FMI) belong to international programs: Arctic Monitoring and Assessment Program (AMAP), Cooperative program for monitoring and evaluation of the long-range transmission of air pollutants in Europe (EMEP), HELCOM network under the Helsinki Commission monitoring the airborne pollution load to the Baltic Sea, Global Atmosphere Watch program of the

World Meteorological Organization (WMO/GAW), and Integrated Monitoring (IM) investigating the whole ecosystem in small catchments.

FMI monitors major cations and anions in bulk deposition at nine stations, and heavy metals at seven stations (mercury at four stations). Moreover, persistent organic pollutants POPs (PAH) are monitored by FMI at three stations. More comprehensive measurements of POPs (PAH, PCB, OCP) in air and in bulk deposition, and heavy metals including gaseous and particulate mercury in air, are conducted at one station in the Pallas research area in northern Finland by the FMI in cooperation with the Swedish Environmental Research Institute IVL. The measurements of nutrients in bulk deposition are carried out at 14 stations by SYKE. Moreover, SYKE monitors the deposition of POPs (PAH, PCB, OCP, PCDD/F, kPCB) at two sites.

The monitoring of air quality is carried out by FMI. Sulphur and nitrogen in gaseous and particulate form are measured at five stations and ozone at nine stations. Sulphur dioxide, nitrogen oxides and particle mass are continuously measured at some stations. In addition, low molecular weight light hydrocarbons are measured at two stations. At the Pallas-Sodankylä GAW station a variety of different measurements are routinely made, including greenhouse gases, black carbon, UV radiation, column ozone, etc.

Contact persons: Sirkka Leppänen, Finnish Meteorological Institute, www.fmi.fi, Tel. +358 9 1929 5422, Email: firstname.lastname@fmi.fi
Jussi Vuorenmaa, Finnish Environment Institute, Tel. +358 20 610123,
Email: firstname.lastname@ymparisto.fi

4.2.2 Urban air quality monitoring

Pia Anttila

The present urban air quality monitoring network in Finland stems from the early 1980s and its development has largely been driven by the national air quality guidelines which were first given in 1984 and renewed in 1996. These guidelines are still in operative use by the environmental permit authorities. At present there are about one hundred fixed monitoring stations equipped with on-line ambient air quality monitors in about 50 municipalities in Finland. The set of new air quality directives in the beginning of 2000 has induced some mainly qualitative changes in the networks, whereas the number of stations has not changed dramatically.

In Finland the municipalities are responsible for air quality assessment and management in their territory; nowadays there are about 30 separate bodies running their own air quality networks. In a decentralized organization such as this the maintenance of high quality of the measurements is a challenging task. The Finnish Meteorological Institute functions as the national reference laboratory of air quality. Its tasks include verification of the comparability of urban air quality measurements within the European Union, arrangement of national intercomparison measurements and provision of training and transmission of information on air quality measurement issues between the EU and the municipalities.

The need for real-time public information on air quality is highly emphasized in the EU legislation of the 2000s. In order to provide this information a national Air Quality Portal (www.airquality.fi) has been constructed by the Finnish Meteorological Institute. It is a free and open Internet service providing among other things real-time information on air quality in the Finnish cities (from 76 stations in summer 2008).

Contact person: Pia Anttila, Finnish Meteorological Institute (www.fmi.fi), Tel. +358 50 368 6420, Email: firstname.lastname@fmi.fi

4.2.3

Measurements of the atmosphere

Rigel Kivi, Esko Kyrö

4.2.3.1

Ozone layer

Ozone column monitoring has been carried out at the Finnish Meteorological Institute, Arctic Research Centre (FMI-ARC), in Sodankylä (latitude 67 N) since 1988 and at the Jokioinen meteorological observatory (latitude 60 N) since 1994 using Brewer spectrophotometers. At Sodankylä ozone soundings are carried out regularly throughout the year, whereas in Jokioinen these measurements are conducted during winter and spring when chemical ozone depletion is expected. The wintertime ozone column has also been monitored at Sodankylä with an SAOZ spectrophotometer in cooperation with CNRS, Paris since 1990. SAOZ is capable of making measurements through the winter up to latitudes of 67° N. Multi-year ozone measurements from both stations have revealed wide inter-annual variations and significant ozone loss in several winters since the early 1990s (http://fmiarc.fmi.fi/ozonecolumn.html). FMI also has a strong participation in satellite-based observations that are targeted for monitoring ozone in the atmosphere, particularly a GOMOS instrument onboard the Envisat satellite, OSIRIS onboard Odin and OMI onboard EOS-Aura. In 2006 and 2007 FMI hosted at Sodankylä a NASA lead comparison/validation campaign aiming to achieve < 1% total ozone measurement accuracy in both ground-based and satellite- based platforms. Sub-percent accuracy is needed for reliable monitoring of the effects of Montreal protocol.

4.2.3.2

Polar stratospheric clouds

Polar stratospheric clouds (PSCs) play an essential role in chemical chlorine activation and subsequent ozone depletion in the polar stratosphere (WMO, 2007). PSCs are observed in cold regions of the lower polar stratosphere and are generally divided into two types based on their optical parameters. PSCs of type II are large particles of primarily water ice, type 1 are typically smaller particles of mostly nitric acid trihydrate (HNO3 3 H2O -NAT, type Ia) or supercooled ternary solution droplets (HNO3/H2SO4/H2O STS, type Ib). At FMI-ARC, Sodankylä, these stratospheric cloud particles have been observed during stratospheric campaigns since 1991/1992 by lidar and since 1994 by aerosol backscatter sondes. By these aerosol sonde measurements, it has also been possible to monitor the stratospheric background aerosol concentration, which was disturbed for five years by the eruption of Mt Pinatubo in 1991. Sodankylä has participated in all major European stratospheric ozone campaign.

World Meteorological Organisation (WMO) (2007), Scientific assessment of ozone depletion: 2006, Global Ozone Research and Monitoring Project, Geneva, Switzerland.

4.2.3.3

Stratospheric water vapour

Water vapour plays a central role in the radiation budget of the Earth's atmosphere, forming the most important "greenhouse gas" for the natural greenhouse effect. Observed increases in the lower stratospheric water vapour mixing ratio over the last few decades are likely to have caused a decrease in stratospheric temperatures by an

amount comparable to that produced by ozone decreases. These changes also have an impact on ozone chemistry and on radiative forcing of the atmosphere. Presently there are two types of light-weight balloon-borne instruments capable of measurements of lower stratospheric water vapour that can be used for long-term sytematic programs started in Sodankylä: NOAA CMDL frost point hygrometer and FLASH-B Lyman alpha hygrometer developed by CAO. In Sodankylä the frost point hygrometers were first flown in 1996 and the operation has continued since the winter of 2002/2003. Both process studies and investigation of long-term changes in the water vapour mixing ratio are expected to continue at Sodankylä during the coming years. Presently the accurate stratospheric and upper tropospheric water vapor observations at Sodankylä are to a extent part made by the cryogenic frost point hygrometers (CFH), which use a measurement principle similar to that used by the NOAA CMDL frost point hygrometers.

4.2.3.4

Ultraviolet radiation

FMI has measured spectral UV irradiance since 1990 in Sodankylä (Brewer Mark II instrument) and since 1995 in Jokioinen (Brewer Mark III). In Sodankylä, a NILU-UV multi channel filter radiometer has been used to measure UV radiation since 2002. A Bentham DM150 instrument was acquired for campaign use. Dark room UV calibration facilities exist both in Jokioinen and Sodankylä. FMI operates an SL501 broad band instrument network consisting of six sites: Sodankylä, Sotkamo, Tikkakoski, Jokioinen, Helsinki and Utö. These instruments provide on-line information on erythemal irradiance that is published in the internet along with the UV-Index forecast, which includes a contour map of the local solar noon maximum clear sky UV Index.

The studies of biological impacts of UV-B radiation at the Finnish UV-International Research Centre (FUVIRC) have been enhanced by UV- B -exposure fields (forest site and peatland site) built at Sodankylä. Enhanced exposure exceeds the ambient UV-B irradiance level by 46%, corresponding to 20% loss of stratospheric ozone. FUVIRC serves atmospheric chemistry, human health, and biological research initiatives by providing UV monitoring data, guidance (i.e. calibration of instruments, maintenance of field test sites), and research facilities (i.e. laboratories, instruments, equipment and accommodation for visiting researchers).

Contact persons: Finnish Meteorological Institute - Arctic Research Centre, Sodankylä, Finland, Tel. +358 16 619619, Esko Kyrö, Rigel Kivi, Email: firstname.lastname@fmi.fi.

4.3

Forests

Martti Lindgren, John Derome, Päivi Merilä

Forest condition monitoring under the UN/ECE and EC programmes. The International Co-operative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) was established in 1985 under the UN/ECE Convention on Long Range Transboundary Air Pollution (CLRTAP). At the moment the monitoring of forest condition is carried out in 40 participating countries. In 1986 the European Union adopted the Scheme on the Protection of Forests against Atmospheric Pollution, and the legal basis for co-financing of the assessments was provided through Council Regulation (EEC) No. 3528/86. During 2009–2010, the forest condition monitoring programme will receive funding through the FutMon Poject under the EU Life+ -programme). The monitoring activities pursue also the objectives of

resolution S1 of the Strasbourg, resolution H1 of the Helsinki, and resolution L2 of the Lisbon Ministerial Conference on the Protection of Forests in Europe.

Under the programme, large-scale extensive monitoring took place on a network of over 6,000 plots arranged on a systematic grid in 2008. This Level I network provides a relatively representative, annual picture of wide-scale trends in crown condition throughout Europe. It also offers the possibility to investigate large-scale relationships between stress factors and forest condition. Finland has been participating in this large-scale extensive monitoring of forest condition since 1985.

In order to gain a better understanding of the effects of air pollution and other stress factors on forests, a Pan-European Programme for Intensive and Continuous Monitoring of Forest Ecosystems (Level II) was implemented in 1995. Approximately 860 intensive monitoring plots have been established throughout the participating countries. On these plots, intensive investigations are carried out on site and stress factors, as well as on the biological and chemical condition of the ecosystems.

The Finnish Forest Research Institute (Metla) is responsible for forest condition monitoring under the UN/ECE and EC programmes in Finland. The Parkano unit is responsible for the task of the National Focal Centre, and John Derome is the National Coordinator.

Objectives of the ICP Forests program

- to provide a periodic overview of the spatial and temporal variation in forest condition in relation to anthropogenic (in particular air pollution), as well as natural stress factors on a European and national large-scale systematic network (Level I),
- to contribute to a better understanding of the relationships between the condition of forest ecosystems and anthropogenic (in particular air pollution), as well as natural biotic and abiotic stress factors through intensive monitoring on a number of selected permanent observation plots throughout Europe (Level II), and to study the development of important forest ecosystems in Europe,
- to provide a deeper insight into the interactions between the various components of forest ecosystems by compiling available information from related studies,
- to contribute, in close cooperation with ICP Modelling and Mapping, to the calculation of critical levels/loads and their exceedances in forests, and to improve collaboration with other environmental monitoring programs within and outside the CLRTAP,
- to contribute, by means of the monitoring activities, to other relevant aspects of forest policy at the national, pan-European and global levels, such as the effects of climate changes on forests, sustainable forest management and biodiversity in forests, and
- to provide policy-makers and the general public with relevant information.

The aims of the national ICP Forests monitoring programme are:

- to facilitate the implementation of international agreements ratified by Finland, e.g. on sustainable forest management, by providing relevant, up-to-date information,
- to follow temporal variations in the vitality and nutrient status of forest trees and the occurrence of damaging agents and fungal diseases,
- to follow the development of acidifying deposition in forested areas,
- to increase our knowledge of the processes involved in the flux of carbon and nutrients in forest ecosystems,

- to investigate the relationships between forest condition and different environmental factors,
- to develop parameters, and measurement, analysis and data interpretation techniques for assessing forest condition, and
- to maintain forest condition databases, and to ensure the long-term storage of sample material.

Extensive monitoring of forest condition – Level I

The Finnish Forest Research Institute annually inventories tree condition, using internationally standardised methods, at a representative sample of tree stands. During 1986-2008 the inventory was carried out on ca. 600 permanent sample plots selected from the permanent National Forest Inventory sample plots established in 1985 (8th NFI). From 2009 onwards, the extensive monitoring of forest condition will be continued on a corresponding number of permanent sample plots selected from the 9th NFI. A number of internationally agreed parameters will be measured on the trees.

Intensive and continuous monitoring of forest ecosystems – Level II

When Finland joined the European Union in 1995, some modifications were made to the national monitoring of forest condition (Level I) and, at the same time, the intensive monitoring of forest ecosystems (Level II) was also started.

Observation network

During 2009-2010, intensive forest monitoring activities will be carried out on 18 plots. Seven of the plots have stands comprising Scots pine, nine Norway spruce, and two Silver birch. All the plots, except the four Integrated Monitoring (ICP IM) plots, are located in commercially exploited forests. The ICP IM plots represent natural stands in catchment areas. A number of the plots are located close to background, air quality monitoring stations primarily run by the Finnish Meteorological Institute.

Monitoring activities at Level II plots

Survey	No of plots	Frequency of assessments
Crown Condition	18	Annual
Soil condition	18	Every 10 years
Needle chemistry	18	Every 2 years
Tree growth	18	Every 5 years
Deposition	18	Every 4 weeks, but every 2 weeks during summer
Soil solution snowfree	18	Every 2 weeks during the period
Litterfall	18	Every 2 weeks during the snow free period
Phenology	18	Three times a week during the growing season
Air quality (passive sampler) (O_3, SO_2, NO_x, NH_4)	18	Every 4 weeks during the snow free period
Meteorology	18	
- air temperature	11	Hourly
- relative humidity	11	Hourly
- soil temperature	11	Hourly
- soi moisture	11	Hourly
- wind speed	11	Hourly
- wind direction	11	Hourly
- PAR	11	Hourly
- solar radiation	11	Hourly
Under-storey vegetation	18	Every 5th year

Contact persons:
National Co-ordinator John Derome, Finnish Forest Research Institute, Parkano Research Unit, Kaironiementie 54, 39700 Parkano, Tel . +358 10 211 4452
Level I, Martti Lindgren, Finnish Forest Research Institute, Vantaa Research Unit, Jokiniemenkuja 1 01301 Vantaa, Tel. +358 10 211 2357
Level II Päivi Merilä, Finnish Forest Research Institute, Parkano Research Unit, Kaironiementie 54, 39700 Parkano, Tel . +358 10 211 4061
Email: firstname.lastname@metla.fi.

4.4

Biodiversity

4.4.1

Monitoring of biodiversity in Finland

Ulla-Maija Liukko

Currently about 60 national biodiversity monitoring schemes or other monitoring projects provide data concerning biodiversity in Finland. This monitoring work involves seven governmental research institutes: the Finnish Museum of Natural History of the University of Helsinki, MTT Agrifood Research Finland, Metsähallitus (National Board of Forestry), the Finnish Forest Research Institute, the Finnish Institute of Marine Research, the Finnish Game and Fisheries Research Institute and the Finnish Environment Institute. Other organizations participating in monitoring include the Regional Environment Centres, Expert groups for threatened species protection, the Forestry Development Centre Tapio, the Forestry Centres, the Geological Survey of Finland, Universities, the Provincial Museums of Natural History, the Hunters´ Central Organization, the Game Management Districts, the Employment and Economic Development Centres, BirdLife Finland (BL), WWF Finland, the Finnish Lepidopterists' Society, and the South Karelia Allergy and Environment Institute. Monitoring schemes may be carried out by a single organization alone or jointly. Observations submitted on a voluntary basis play a significant role in biodiversity monitoring in Finland.

Monitoring objectives are based mainly on the Convention on Biological Diversity (Rio 1992), the EU Habitats Directive, the EU Birds Directive and the Finnish Nature Conservation Act. Finland should also be able to monitor and evaluate progress towards the EU 2010 biodiversity target (halting the decline of biodiversity). Monitoring of the state of biodiversity and current trends includes the collection of information on changes taking place in ecosystems and habitats, species and species communities, and genes and genotypes. Such monitoring data is of irreplaceable value in the effective evaluation and planning of measures to conserve biodiversity. Monitoring databases are also necessary for obligatory reporting procedures related to EU legislation and international agreements.

4.4.2

Proposal for a national monitoring system of biodiversity

Ulla-Maija Liukko

The National Action Plan for Biodiversity in Finland 2006–2016 specified that an effective national system should be set up for the monitoring and evaluation of trends

in the state of biodiversity, also enabling monitoring of the pressures that affect biodiversity and the impacts of biodiversity policies, using indicators devised for these purposes. An effective system for monitoring the state of biodiversity and current trends should be set up by 2010.

According to the expert working group focusing on research, monitoring and information systems (TST working group) that worked under the monitoring group of the National Action Plan, about 60 ongoing Finnish monitoring schemes currently provide data related to biodiversity. These existing schemes provide a good basis for the future organisation of biodiversity monitoring, although if some of the schemes need to be improved and new schemes still need to be set up for insufficiently monitored aspects of biodiversity.

To improve biodiversity monitoring, co-operation between the different parties involved in monitoring must be promoted, and the various biodiversity monitoring schemes must be harmonised. This will serve to increase the usability of monitoring databases, encourage the common use of data, improve reporting on the state of biodiversity, and enhance monitoring work. Openly available databases should be compiled through networked cooperation covering monitoring schemes and the organizations that carry them out, as well as the resultant databases and reports.

The monitoring schemes are divided into two sections: general monitoring and specific monitoring. *General monitoring* will involve the collection of data on basic elements of the biodiversity of forests, peat lands, alpine fells, marine and coastal habitats, inland waters and agricultural habitats, covering changes in the state of biodiversity at the species, habitat and landscape levels. Implementation of the collection of biodiversity indicators will be one part of this activity. *Specific monitoring* will focus on nationally or internationally rare or endangered species and habitat types. Such monitoring data is required e.g. for the planning of conservation measures and the evaluation of protection schemes. Specific monitoring is also legally required by various laws and international agreements such as EU Directives and national legislation (threatened species).

4.4.3 Monitoring schemes of biodiversity in Finnish environmental administration

Ulla-Maija Liukko

The Finnish environmental administration is responsible for general planning and co-ordination of national biodiversity monitoring. There are also eight ongoing or developing iodiversity monitoring schemes:

- Butterfly monitoring in Finnish agricultural landscapes
- The Finnish Moth Monitoring Scheme
- Monitoring of threatened species
- Monitoring of habitat types of Annex I in the Habitats Directive
- Monitoring of the species of the Habitats Directive
- Monitoring of Bird Directive Species
- Monitoring of Expanding Insects
- Monitoring of heavily increased species (Great cormorant and Barnacle geese)

The main task for the next few years is to organize monitoring for the habitat types and species of EU´s Habitats Directive. The main objective of the monitoring is to ensure that the conservation status of the habitat types and species is maintained at a favourable level or that it is successfully improved with the measures taken. When establishing monitoring according to the Directive, the national monitoring needs,

i.e. starting of the monitoring of rare and threatened habitat types as well as the supplementing of threatened species monitoring, should also be taken into account and the monitoring should also be directed according to those needs. The objective is to utilise resources effectively and avoid overlapping work. This also implies integration of monitoring obligations with other EU Directives such as the Water Framework Directive and the Marine Strategy Directive.

The Finnish Environment Institute (SYKE) is hosting a data system for species observations. The scope of the species is firstly threatened species and secondly those species for which there is other legal obligation for monitoring. The field work and inputting is provided by a number of institutions: SYKE itself, the Regional Environment Centres and Metsähallitus.

Contact person: Ulla-Maija Liukko, Finnish Environment Institute, Tel. +358 20 610123, Email: firstname.lastname@ymparisto.fi

4.4.4

Monitoring programs of the Finnish Museum of Natural History

4.4.4.1

Biological monitoring programs

Juhani Lokki

The Finnish Museum of Natural History is responsible for 18 nationwide biological monitoring programs. Each program comprises continuous and regular quantitative research using standardized methods. Data are collected mostly by voluntary amateur biologists. Data can be used for ecological research and for other purposes, e.g. conservation of plants and animals.

The Finnish Natural History Museum consists of four departments. Monitoring projects are arranged by the Botanical Museum (Finnish plant atlas) and the Zoological Museum (vertebrates 13, invertebrates 4 monitoring programs). The Ringing Centre works within the Zoological Museum. It is responsible for the supervising of bird ringing in Finland, and for the collecting and studying of ring recoveries. In the renewed organization of the Museum, there is a team in the Zoological museum working with monitoring tasks.

Most monitoring projects were started in the 1980s. The oldest are Phenological Monitoring (started in 1846), Bird Ringing (1913), Nest Record Card Study (1954) and Winter Bird Census (1955). A total of 11 monitoring projects are included in the Finnish Bird monitoring program. This program covers the most important environment types and population ecology of various bird groups. In addition to birds there are three monitoring programs for insects, one for molluscs, one for amphibians and reptiles and one for plants. Phenological Monitoring includes certain animal and plant species which are common and widespread in Finland.

4.4.4.2

Bird ringing in Finland

Jari Valkama

Ringing of birds was initiated in Finland in 1913. In the beginning, the yearly ringing numbers increased only slowly. It was not until the 1930s that yearly totals of over 10,000 individuals were reached, and 100,000 ringings were achieved in 1939. During the war the number of ringings plunged, as ringers found themselves in a different position. Shortly after the war the enthusiasm for ringing grew at a rapid rate, with a total of one million ringed birds being exceeded in 1966, three million in 1978 and five

million in June 1988. During the last twenty years 180,000 - 260,000 birds per year have been ringed in Finland. Of these, nestlings represent some 40%. In all, approximately 9.5 million birds have been marked with an individual ring in Finland between 1913 and 2007. In the statistics for the entire period the most commonly ringed birds are: Great Tit, Pied Flycatcher, Willow Warbler, Goldcrest, Blue Tit, Robin, Black-headed Gull, Sedge Warbler, Redpoll and Barn Swallow.

In 2007, the Ringing Centre processed a total of 38,606 recovery and recapture reports of Finnish rings. The grand total of recoveries filed in the database for the years 1913-2007 was over 986,000 at the end of 2007. The majority of recoveries of birds ringed in Finland come from Finland. Some 20% of the recoveries defined as "interesting" are reported from abroad. However, only 11% of all recoveries included in the database are foreign.

Contact person: Jari Valkama, Ringing Centre, Finnish Museum of Natural History, Tel. + 358 9 191 28849, Email: firstname.lastname@helsinki.fi

4.4.4.3
Constant Effort Ringing in Finland

Jari Valkama

The Constant Effort Sites (CES) ringing program, aimed at net ringers, uses catches from standardized mist-netting to monitor our most common breeding songbirds. The CES provides a measure for the changes in population size of abundant CES species, and supplements the view given by line transects and point counts. It also provides valuable information about breeding success after the nestling stage. Other monitoring programs do not measure this. In addition, recaptures from adult birds can be used in estimating mortality. In practice, CES works as follows: the ringer erects a standard number of nets, in standard positions, all chosen personally, on twelve days evenly spread between early May and late August. Everyone can choose their own capture routines, which should however be followed from one year to the next.

The CES concept was brought in 1986 as such from Great Britain to Finland. The Constant Effort Sites were started in Great Britain in 1981, and today birds are ringed there at more than 130 catch sites within the program. In addition to the Finnish program, similar capture programs have been started in France, the Netherlands and Sweden. The corresponding North American MAPS monitoring study already includes more than 400 catch sites. It is the goal of EURING to expand CES so that it would cover all of Europe. In 2007, CES was running at 28 sites in Finland. The catch sites were situated in 24 different municipalities, and 46 ringers took part in this project.

Contact person: Jari Valkama, Ringing Centre, Finnish Museum of Natural History, Tel. + 358 9 191 28849, Email: firstname.lastname@helsinki.fi

4.4.4.4
Monitoring study on the Osprey

Pertti Saurola

In 1971, Finnish ringers made the Osprey a target for a special monitoring study, after which almost all Osprey nest sites reported to the Zoological Museum (an estimated 90 % of them) have been checked on a yearly basis. In 2007, 1,624 nest sites were checked, and 964 territories proved to be occupied. In addition to checking nest sites and ringing nestlings ringers have made observations on fishing grounds and prey

fish of the Ospreys. Ringers have also collected unhatched eggs and dead nestlings found in the nests for analyses of environmental contaminants.

Lack of nest trees - in addition to environmental contaminants and persecution – has been found to be a serious threat to the Osprey population in Finland. The only means of trying to ward off this threat factor brought on by intense forestry is to build artificial nests, a project to which Osprey ringers have devoted much time and money. Today, nearly half of the known Finnish Osprey pairs nest in artificial nests. Due to the effective building of artificial nesting sites, a decline in persecution during migration and lightening of the toxic load the recent development of the Finnish Osprey population has been favourable: the average breeding success has been good and the population has been stable during the last 15 years. Migration and wintering of Finnish Ospreys have been studied by using satellite tracking, in addition to ordinary ringing.

Contact person: Pertti Saurola, Ringing Centre, Finnish Museum of Natural History, Tel. + 358 9 191 28850, Email:firstname.lastname@helsinki.fi

4.4.4.5

Monitoring birds of prey

Pertti Saurola

The nationwide monitoring project on birds of prey, conducted in unison with the Ringing Centre and the Ministry of the Environment, started in 1982. Populations of birds of prey are studied in 10 km x 10 km raptor grid squares based on the National Grid and spread over the country. The aim is to find all nests - or at least all occupied territories of the birds of prey in the squares. From 1986, the monitoring was made more effective by gathering all information from the ringers on the nest sites checked and nests found outside the squares as well. One of the important aims of the project is to obtain information on nest sites, breeding performance and population trends needed for the protection of birds of prey. The species included in the program consist of all species of birds of prey except the Golden Eagle, the White-tailed Eagle, the Peregrine and the Osprey, all of which have their own monitoring programs. In 2007, 124 raptor grid squares were studied and altogether 41,442 birds of prey territories (44,272 in 2006) were checked in Finland.

A recent analysis (Ambio 37 (6):413—419) indicated that some species of forest-dwelling species of birds of prey have declined steeply during the last 15 years in Finland, most probably due to the direct and indirect effects of modern forest management. Birds of prey are important indicators of the state of the environment in many ways, because they are at the top of food chains. Many environmental changes, in addition to habitat destruction, are reflected in bird of prey populations. For this reason, ringers have collected unhatched eggs and dead nestlings found in the nests of all species of birds of prey for the future analyses of environmental contaminants.

Contact person: Pertti Saurola, F Ringing Centre, Finnish Museum of Natural History, Tel. + 358 9 191 28850, Email: firstname.lastname@helsinki.fi

4.4.4.6

Monitoring study of the White-tailed Sea Eagle *(Haliaeetus albicilla)*

Torsten Stjernberg

The White-tailed Sea Eagle has been monitored in Finland by a voluntary Sea Eagle working group within WWF Finland since 1973. Every known territory has been checked annually, and new territories and nests have been searched intensively by

regional working groups. In northern Finland, i.e. the county of Lapland and the former county of Oulu,the surveys are performed by Metsähallitus (National Board of Forestry).

Besides population size, data on breeding success, mortality factors, habitat selection and factors threatening the breeding sites are collected by the surveyors. Nestlings are ringed. The rings used are coloured, indicating the year and the region of hatching. Samples are taken from the nestlings, and addled eggs, eggshell fragments and moulted feathers are collected for further studies. In some regions prey remnants have also been collected.

The productivity of the population began to deteriorate in the 1950s, reaching its lowest level during the 1970s. Almost all pairs then nested on the Baltic fringe. The breeding population diminished, from approximately 55 pairs in 1960 to ca 40 pairs 1970, many of them incapable of reproducing As a result of active protection measures, breeding success improved and the population increased to about 50 pairs in 1980, 80 in 1990 and 200 pairs in 2000. The number of occupied territories (= at least one decorated nest known) increased from 37 in 1980 to 75 in 1990 and to 167 in 2000, also including 4, 14 and 21 fresh water territories in Lapland, respectively. In 2008, 302 occupied territories were found (37 in fresh-water habitats in northern Finland), producing at least 282 half-grown nestlings.

The data is stored at the Zoological Museum, Finnish Museum of Natural History. Since 2005 a process has been going on to store all the data since 1972, and even earlier data, in a special data base generated by the Department of computer science at the University of Helsinki.

Contact person: Torsten Stjernberg, Tel. 09-19128857,
Email: firstname.lastname@helsinki.fi

4.4.4.7

Monitoring study of the Caspian Tern *(Sterna caspia)*

Torsten Stjernberg

In Northern Europe the Caspian Tern breeds only in the Baltic (Finland, Sweden, Estonia and Russia). A few pairs originating from the Baltic also breed in Lake Ladoga (Russian Karelia) and Lake Vänern (Sweden).

In 1984 a monitoring project on the Baltic Caspian Tern was started in Finland when the numbers of ringed young had declined dramatically in Finland as well as in Sweden, and some colonies had disappeared. Monitoring performed that year in Finland, Sweden and Estonia showed a decline of 25 % of the Baltic population since 1971 when there were about 2500 breeding pairs, the highest number ever recorded in the Baltic. The Baltic population continued to decline after 1984, but since the 1990s the population has been rather stable, about 1500–1700 pairs.

The Zoological museum at the Finnish Museum of Natural History, together with the Finnish Game and Fisheries Research Institute coordinate the voluntary countrywide Caspian Tern project. In Finland as well as elsewhere, the Caspian Tern breeds in colonies but also in solitary pairs. About 10 % of the population breeds as solitary pairs. The preliminary figures for Finland in 2007 were 687 colonial pairs (in 12 colonies) and 107 solitary pairs, a total of 794 checked pairs. If breeding sites occupied in 2006 but which remained unchecked in 2007 are also included, the population size in Finland in 2007 was about 830 pairs.

In Finland, annually almost all of the slightly more than 200 treeless islets known as recent or former nesting sites for Caspian Terns are surveyed. Almost all of them are in the outermost part of the archipelagos off the coast. Around 150 volunteers have taken part in the surveys since the very start; every year about 30 persons are active.

The majority of these voluntary surveyors are bird ringers, who check the numbers of pairs, ring the nestlings and make notes about the type of the breeding habitat and possible threats to the species.

The data is stored at the Zoological Museum, Finnish Museum of Natural History. The work to store them in a database has not yet been completed.

Contact person: Torsten Stjernberg, Tel. 09-19128857, Email: firstname.lastname@helsinki.fi

4.4.4.8
Phenological monitoring of the Finnish wildlife

Juhani Terhivuo

The Zoological Museum in the Finnish Museum of Natural History collects dates for the onset of events related to different phenophases of the annual lifecycle in numerous animal and plant species of Finland. The project relies on voluntary observers interested in Finnish wildlife. The Zoological Museum compiles the observations and also prepares an annual summary report. The other collaborators of the project are the Finnish Forest Research Institute, the Department of Forest Ecology (University of Helsinki) and Nature League (Luonto-Liitto in Finnish). Observations are located in the 10x10 km squares of the Finnish Uniform Grid (grid 27° E) system and they are saved in an electronic database.

The first systematically organized phenological inquiry was undertaken by the Finnish Society of Sciences and Letters as early as 1846. Since those days the survey have been repeated annually. From the early 1960s onwards the Zoological Museum has carried out the inquiry in cooperation with the Finnish Society of Sciences and Letters. Today more than 100 volunteers make observations in the field every year and the number of their observations is about 5000.

Contact person: Juhani Terhivuo, Zoological Museum, Finnish Museum of Natural History, Tel. + 358 9 191 28844, Email: firstname.lastname@helsinki.fi

4.4.4.9
Atlas of amphibians and reptiles in Finland

Juhani Terhivuo

The distribution and status of populations of amphibian and reptile species in Finland are monitored by means of the data received through enquiries published in newspapers and nature magazines, through the Internet and in connection with the phenological monitoring of Finnish wildlife. Observations are located to the 10x10 km squares of the Finnish Uniform Grid (grid 27° E) system and they are saved into an electronic database. The greatest emphasis is on observations referring to the period from 1992 onwards. The annual contribution of observations is about 250.

The first inquiry was launched in the early 1970s. It was repeated during the 1980s and early 1990s and the results were published in 1993. More than 13 500 observers have contributed to the data set, which currently includes more than 35 000 observations.

The Finnish herpetological atlas is part of the atlas survey of the amphibians and reptiles of Europe.

Contact person: Juhani Terhivuo, Zoological Museum, Finnish Museum of Natural History, Tel. + 358 9 191 28844, Email: firstname.lastname@helsinki.fi

4.4.4.10

Atlas of the distribution of vascular plants in Finland

Raino Lampinen

The atlas is a periodically updated electronic publication based on the database KASTIKKA maintained by the Botanical Museum of the Finnish Museum of Natural History, available at www.luomus.fi/kasviatlas. The database, comprising c. 5 million records in autumn 2008, combines the floristic records from the specimens of several Finnish herbariums, botanical literature and unpublished field notes. The atlas shows the distribution in Finland of all native plants and established aliens, as well as the ranges of the most common casual aliens as 10-km grid square dot maps, as colour scaled maps indicating the regional frequency estimates, or as combinations of dot and frequency estimates. The frequency estimates are interpolated from the results of an intensive survey of 1 km grid squares continued since 1985. Hitherto over 6600 1 km squares from some 1500 different 10 km squares have been thoroughly studied.

Contact person: Raino Lampinen, Botanical Museum, Finnish Museum of Natural History, Tel. + 358 9 191 24429, Email: firstname.lastname@helsinki.fi

4.4.4.11

Developing of bat monitoring

Juhani Lokki

In the Finnish Museum of Natural History, Eeva-Maria Kyheröinen has conducted bat research since 2002, funded by the Ministry of the Environment. Tasks of this project include collating information on hibernation sites of bats, starting the ringing of bats in Finland and taking care of the reporting and other work related to the EUROBATS agreement. In connection with the reporting procedure of the Habitats Directive, all information available on bat species distribution in Finland was collected. The status of knowledge is not yet sufficient and thus starting of large scale bat surveys and monitoring of bat populations is crucial. The Finnish Chiropterological Society (FCS) has launched a project to educate bat workers. The bat project of the museum and FCS aim at starting surveys suitable for bat monitoring. These would be mainly carried out by voluntary bat workers. There are good experiences of such surveys e.g. in the United Kingdom. The FCS is coordinating a study on monitoring bat migration. The pilot phase of this study took place in 2008. The project has several partners.

Contact person: Eeva-Maria Kyheröinen, tel. (09) 191 28865, Email: eeva-maria.kyheroinen@helsinki.fi

4.4.4.12

Monitoring of the freshwater pearl mussel *(Margaritifera margaritifera)* in Finland

Ilmari Valovirta

The occurrence and distribution of the freshwater pearl mussel in Finland has been monitored since 1978 by the joint margaritifera working group of the University of Helsinki and WWF-Finland. The inventory work has produced special data for the species conservation, changes in the diversity and abundance of the freshwater pearl mussel and information on ecology and vulnerability. In addition to freshwater pearl mussel, other large mussels living in the inventory area, such as the thick-shelled river mussel (*Unio crassus*), have been monitored.

The inventories of the freshwater pearl mussel and *U. crassus* have been made by scuba divers. The number of individuals is counted from one meter wide diving lines which are usually 100 meters in length or from crosslines from bank to bank. The inventory frequency is dependent on the need for conservation and on funding, because the research done by the scuba divers is relatively expensive and time-consuming. The rivers will be monitored at six-year intervals, which is the same as that recommended in EU Habitats Directive. There are approximately one hundred parameters indicating the environment of the monitored mussels, of which 32 are more significant than the others.

Since 1978, over 3500 km of one meter wide diving line has been surveyed. The margaritifera working group has also done some inventory work in other countries, e.g. Russian Karelia, Norway, Estonia and Latvia. The working group has also provided know-how to neighboring countries and the inventory methods have been coordinated. The LIFE/Nature project (1997-2002) concentrating on the "Restoration of fluvial ecosystems containing pearl mussels" obtained very significant conservation results in this respect. Data has been saved in the Zoological museum`s FinnMarga database. It is not public due to conversation aspects. Information is obtainable primarily for conservation purposes.

Contact person: Ilmari Valovirta, Tel. + 358 40 5201909, Email: ilmari.valovirta@helsinki.fi

4.4.4.13

Monitoring *Hemiptera* and small insect orders

Anders Albrecht

The Zoological Museum participates in the nationwide monitoring of Hemiptera and small insect orders coordinated by the Finnish Expert group on Hemiptera. Target groups are Heteroptera, Auchenorrhyncha, Psylloidea, Aleyrodoidea, Coccoidea, Aphidoidea, Orthoptera, Blattodea, Dermaptera, Neuroptera, Mecoptera, Psocopteraand Thysanoptera. The aim of the monitoring is to clarify the distribution and distribution changes, phenology and host-plant relationships of the species concerned. Regularly updated checklists and atlases can be found on the home page of the expert group: (http://users.utu.fi/veirinne/tyoryhma/tyoryhma_eng.htm).

Conctact person: Anders Albrecht, Tel. +358 0 191 28837, Email: firstname.lastname@helsinki.fi

4.4.5

Crop protection surveys

4.4.5.1

Weed survey in spring cereal fields

Jukka Salonen

MTT Agrifood Research Finland has conducted extensive surveys of weeds in spring cereal fields since the early 1960s. The fourth survey is being carried out in 2007-2009. A total of 600-650 fields will be investigated, representing both conventional and organic cropping. Regular long-term survey data provide a basis for monitoring the response of weed flora to changes in agricultural practices and habitats. The survey is part of the research project MYTVAS3 (Monitoring the Impacts of Finnish Agri-Environmental Support Scheme Programme) coordinated by MTT.

Contact person: Jukka Salonen, MTT Agrifood Research Finland, Tel. +359 3 4188 2483 / + 358 400 784 464, Email: firstname.lastmname@mtt.fi,

4.4.5.2

Monitoring networks of pests in crop production

Irmeli Markkula

MTT Agrifood Research Finland runs a monitoring network in order to estimate the real-time pest and disease pressure in the most important agricultural areas in Finland. The information is stored in the pest database at MTT. Most of the monitoring information is on pests of vegetables and cereals. The aim of the activity is to design and implement a relational database for the information storage of pest monitoring. In time, it will be possible to make observations on changes in populations, the appearance of new species or on the new behaviour of old species. The information of the database has been exploited during the growing season by updating MTT's web pages, in newspaper articles and in telephone advisory services.

Contact person: Irmeli Markkula, MTT Agrifood Research Finland, Tel . +358 3 4188 2593 / + 358 40 551 7561, Email: firstname.lastname@mtt.fi.

4.5

Radioactive substances

Raimo Mustonen

4.5.1

Institutions involved

Surveillance of environmental radioactivity in Finland is one of the official obligations of the Radiation and Nuclear Safety Authority (STUK). The obligation is based on both national and EU legislation. The Finnish radiation protection legislation appoints STUK as the national authority responsible for surveillance of environmental radioactivity. The EURATOM treaty requires member countries to carry out continuous monitoring of radioactivity in the air, water and soil and to report annual monitoring results to the commission. The Finnish Meteorological Institute and the Defence Forces also monitor environmental radiation at their own stations. Results of the monitoring program are published annually in the publication series of STUK in Finnish, Swedish and English. The report is available at the home pages of STUK www.stuk.fi.

Contact person: Raimo Mustonen, radiation monitoring, Nuclear Safety Authority (STUK), Email: firstname.lastname@stuk.fi

4.5.2

Monitoring of external radiation and airborne and deposited radioactive substances

The first sign of a possible change in the radiation situation is obtained from the measurements of external radiation and/or of radionuclides in outdoor air. The automatic network monitoring external dose rate includes about 280 continuously measuring automatic stations. Sampling of outdoor air and wet plus dry deposition is carried out continuously at nine stations in Finland. Air samples are analysed twice a week

and deposition samples monthly. All the samples are analysed for gamma-emitting radionuclides, some also for radiostrontium. The Finnish Meteorological Institute monitors gross beta activity of ground-level air at eleven stations.

4.5.3

Monitoring of surface water, milk, daily meals and drinking water

Water samples from four large rivers discharging from Finland to the Baltic Sea are taken four times a year for monitoring purposes. Regional Environmental Centres take the samples for STUK. The samples are analysed for gamma-emitting radionuclides and radiostrontium.

Milk from dairies at five sites is sampled weekly. The samples are bulked monthly before analysing. Daily meals are taken from three sites twice a year. Drinking water is sampled simultaneously with the meal samples at the same sites. Samples of drinking water from two water supply plants using surface water as raw water are taken twice a year. The samples are analysed for gamma-emitters and ^{90}Sr, drinking water also for ^{3}H. Samples of commercial natural produce, such as fish and wild mushrooms, from three sites are analysed for gamma-emitting radionuclides.

4.5.4

Radioactivity in humans

People at three sites are monitored regularly for radionuclides once a year. Groups of people of various ages are chosen for the measurements. Activity concentrations of gamma-emitters are measured with equipment constructed specially for this purpose.

4.5.5

Radioactivity in the Baltic Sea

The Helsinki Commission (HELCOM) coordinates the international cooperation for monitoring of the Baltic Sea. All the Baltic Sea countries contribute to the monitoring with their own national programs. The Finnish contribution consists of about 120 annual samples from seawater, bottom sediments, fish and other biota, analysis of radioactive substances and reporting of the results to the HELCOM database. STUK is responsible for the Finnish part of the program.

4.6

Harmful substances

4.6.1

Role of the Finnish Environment Institute

Jaakko Mannio

The Finnish Environment Institute (SYKE) performs monitoring of harmful substances mainly in aquatic and terrestrial environments. A main objective of the monitoring is to determine and measure concentrations, enrichment and effects of anthropogenic, persistent organic pollutants and heavy metals in selected organisms of the food chain. Some organisms and tissues are stored in the environment specimen bank (ESB) for retrospective monitoring of unknown chemical properties. New compounds have been screened and will be included in the monitoring programs, according to the EU

Water Framework Directive, international conventions and national needs. A national working group with participants from research institutes has been established to develop the monitoring of harmful substances.

4.6.2 Monitoring of contaminants in fish and sediments

Tarja Nakari

The aim of the project is to quantify concentrations of bioaccumulating harmful compounds in fish on yearly basis from seven marine/coastal areas and seven inland sites to elucidate the effects of these compounds on the water ecosystem and human exposure. Sediments and sedimentation (2 stations) will be screened in the same locations. Substances of relevance include heavy metals (e.g. Hg, Cd, Pb, Cu, Zn), PCBs, DDTs, HCHs, HCB, chlordanes, dioxins and furans, brominated flame retardants and organotin compounds. The programme is co-operated with other institutions dealing with fisheries and food security.

Contact persons in the Finnish Environment Institute, Tel. +358 20 610123, Tarja Nakari and Jaakko Mannio, Email: firstname.lastname@ymparisto.fi

4.6.3 Monitoring of harmful substances using incubated mussels

Sirpa Herve

The aim of the project is to monitor the concentrations of organic compounds using incubated mussels. This method, based on the incubation of common mussels, has been used since 1984 in freshwater receiving water bodies of the pulp industry. Monitoring will be continued in 2009-2012, but only in seven recipients. This permanent monitoring will be completed by making yearly surveys in 2-4 water areas where some possibilities of pollution can be expected. The concentrations of chlorophenolics have decreased significantly from the high values of the 1980s to very low levels at present. However, a rather worrying observation is the continued detection of PCBs and DDTs in some industrial recipient water bodies. This monitoring provides useful information concerning the speed of recovery in the previously heavily polluted water bodies. The monitoring results can be used in assessing the chemical status of water bodies.

Contact person: Sirpa Herve, Finnish Environment Institute, Jyväskylä Office,
Tel. +358 40 5135 127, Email: firstname.lastname@ymparisto.fi

4.6.4 Terrestrial environment

Tarja Nakari

The Finnish Environment Institute (SYKE) collects data on concentrations and accumulation of harmful substances in the shrew (Sorex sp.), which is a key species in the boreal forest food chain. Monitoring is focused on background areas in Evo (southern Finland) and Pallas (northern Finland). These areas serve as international stations for monitoring of pollutants and are therefore subjected to versatile research (ICP IM, ICP FOREST, AMAP). The main sources of pollution in the areas are air-

borne contaminants such as organochlorine pesticides (OCPs), and polychlorinated biphenyls (PCBs) and trace metals (Cd, As, Pb, Hg, Pt, Pd), which are monitored in the food chains. Monitoring will be adjusted according to screening results of novel contaminants (priority substances). Monitoring data is stored in the LIMS-system of the environmental authorities.

Contact person: Tarja Nakari, Finnish Environment Institute, Tel. +358 20 610123,
Email: firstname.lastname@ymparisto.fi.

4.6.5

Environmental specimen bank

Tarja Nakari

The Finnish Environment Institute (SYKE) coordinates and participates in monitoring of harmful substances in aquatic and terrestrial environments. In connection with this monitoring work a selection of animal species and tissues are stored in the Environmental Specimen Bank for retrospective studies of unknown chemical properties in future. Furthermore, some small mammals and insects stored whole can be used for specific studies e.g. on morphological characters, abnormalities and fluctuating asymmetry in relation to levels of contaminants in a species itself or its living environment. Faunal species and their tissues are stored in different forms ,i.e. frozen at -196° C (fish muscle) or at -25 C (shrews) and freeze-dried. The specimens originate from fauna samples which are annually collected for national monitoring of harmful substances.

Contact person: Tarja Nakari, Finnish Environment Institute, Tel. +358 20 610123,
Email: firstname.lastname@ymparisto.fi

4.6.6

Monitoring of heavy metal and nitrogen deposition by means of mosses

Juha Piispanen, Jarmo Poikolainen, Eero Kubin

A national survey based on moss samples (*Hylocomium splendens*, *Pleurozium schreberi*) has been carried out in Finland five times (1985, 1990, 1995, 2000, 2005/2006). The surveys are part of the pan-European network coordinated by the UN/ECE ICP Vegetation Program. The objectives of the survey are to study heavy metal and nitrogen deposition patterns in Finland and to identify the major emission sources and changes in their emissions.

Concentrations of eight elements (Cd, Cr, Cu, Fe, Ni, Pb, V and Zn) have been determined in moss samples since 1985 and arsenic and mercury since 1995. Nitrogen concentration was determined for the first time in the pan-European surveys in 2005-2006. In Finland, moss samples have been analysed for nitrogen already since 1990. Moss samples were collected from the permanent plots of the Finnish National Forest Inventory. The laboratory of Muhos Research Unit (Metla), the Central Laboratory (Metla) and the Chemistry Department of the University of Oulu were responsible for the chemical analyses. After analysis, the remaining samples were stored at the Paljakka Environmental Specimen Bank (Metla) for future research purposes.

The next pan-European survey is to be carried out in 2010. In Finland, the moss samples will be collected from the plots of the Finnish National Forest Inventory. The nitrogen concentrations of mosses will be compared to the critical load of nitrogen (SYKE).

Contact persons: Juha Piispanen, Tel. +358 10 211 3720, Jarmo Poikolainen, Tel. +358 50 391 3753 and Eero Kubin, Tel. +358 10 211 3710, Finnish Forest Research Institute (Metla), Muhos Research Unit, Kirkkosaarentie 7, 91500 Muhos, Email: firstname.lastname@metla.fi.
More information: http://www.metla.fi/metinfo/metsienterveys/raskasmetalli/

4.7

Integrated environmental monitoring

Jussi Vuorenmaa

Integrated monitoring of ecosystems means physical, chemical and biological measurements over time of different ecosystem compartments simultaneously at the same location. The multi-disciplinary Integrated Monitoring program (ICP IM) is part of the effect-oriented activities under the 1979 Convention on Long-range Transboundary Air Pollution (LRTAP), which covers the region of the United Nations Economic Commission for Europe (UNECE). It belongs to a group of six specialist International Cooperative Programs (ICPs) which have been set up under the LRTAP Convention's Working Group on Effects to look at relevant receptors and environmental issues. The main aim of ICP IM is to provide a framework to observe and understand the complex changes occurring in natural/semi-natural ecosystems. At present 17 countries participate in the ICP IM program. The international Program Centre is located at the Finnish Environment Institute (SYKE). The Program Centre collects, stores, processes and analyses the data and is responsible for the cooperation with other related programs.

The ICP IM Program has been carried out in Finland since 1987 at four monitoring areas. It is one of the most intensive ecological cooperation programs ever conducted in Finland. Most of the Finnish research institutes and universities involved in environmental research and several regional authorities have participated in the ICP IM Program. At present the program is carried out in the Valkea-Kotinen, Hietajärvi and Pallas areas. Currently the research and monitoring work involves the following core members: Finnish Environment Institute, Finnish Meteorological Institute, Finnish Forest Research Institute, Finnish Game and Fisheries Research Institute, Universities of Helsinki and Joensuu and Regional Environment Centres of Häme, Pohjois-Karjala and Lappi. The Finnish ICP IM Program is coordinated by an expert group consisting of experts from the participating governmental research institutes.
Contact person: Jussi Vuorenmaa, Finnish Environment Institute, Tel. +358 20 610123, Email: firstname.lastname@ymparisto.fi,
Additional information: www.environment.fi/syke/im

4.8

Finnish Long-Term Socio-Ecological Research network FinLTSER

Martin Forsius, Lauri Arvola, Jouni Aspi, Eeva Furman, Juha Helenius Juha Karjalainen, Kimmo Kurunmäki, Kari Laine, Eero Nikinmaa, Jussi Paatero, Marko J. Reinikainen, Jussi Vuorenmaa

FinLTSER (Finnish Long-Term Socio-Ecological Research network) brings together the Finnish research sites and scientists that have conducted world-class research on long-term socio-ecological processes and problems into a coordinated Finnish research infrastructure, where the expertise and resources of both universities and major governmental research institutes are combined. These ecosystem research sites/

platforms support, enhance and promote the inter-disciplinary investigation of long-term biodiversity and ecosystem processes at varying spatial and temporal scales. The long-term perspective helps to determine the impacts of drivers and pressures of environmental change and to investigate ecosystem processes and their response to environmental pressures.

The FinLTSER network was established in 2006 and consists presently of nine highly instrumented sites/research platforms, representing the main ecosystems (marine, terrestrial, agricultural, lake, sub-arctic, urban) in Finland. The core infrastructure of the FinLTSER infrastructure is composed of research stations of the universities of Helsinki, Jyväskylä, Oulu and Turku; research sites, instrumentation and long-term monitoring programmes of main governmental research institutes (Finnish Environment Institute, Finnish Meteorological Institute, Finnish Forest Research Institute, Finnish Game and Fisheries Research Institute, MTT Agrifood Research Finland); and, information management structures and databases of the participating universities and research institutes.

FinLTSER is a formal member network of the European and global LTER-networks. FinLTSER is also accepted to the first Finnish Roadmap on research infrastructures (RI). The Finnish Environment Institute (SYKE) acts as coordination body of FinLTSER.

Research and monitoring themes within national and international LTER networks cover a wide spectrum of ecosystem studies:

- Research and monitoring related to the ILTER (International LTER) core areas (global water circulation, biogeochemical processes, changes in biodiversity) Other ecosystem processes and disturbances
- Ecosystem services (e.g. photosynthesis, regulation of climate, soil health and soil fertility, insect pest control, forest and agricultural production, carbon assimilation, water resources, regeneration of habitats, recreation)
- Societal and other socio-economic pressures on the functioning of the ecosystems (e.g. political decisions, land use)
- Effects on the local communities of nature conservation and resource exploitation
- Local environmental conflicts

Additional information: www.environment.fi/syke/lter

Contact persons: Finnish Environment Institute: Martin Forsius, Eeva, Furman, Jussi Vuorenmaa, Email: firstname.lastname@ymparisto.fi
University of Helsinki: Lauri Arvola, Juha Helenius, Kimmo Kurunmäki, Eero Nikinmaa, Marko J. Reinikainen, Email: firstname.lastname@helsinki.fi
University of Jyväskylä: Juha Karjalainen, Email: juhakar@bytl.jyu.fi
University of Oulu: Jouni Aspi, Kari Laine, Email: firstname.lastname@oulu.fi
Finnish Meteorological Institute: Jussi Paatero, Email: firstname.lastname@fmi.fi

5 Water and health

5.1

Drinking water

Outi Zacheus

Frequent monitoring of the quality of drinking water has been practiced by virtue of the Public Health Act since 1968. The Health Protection Act (763/1994) includes general rules and the Decree of the Ministry of Social Affairs and Health 461/2000 detailed regulations concerning the quality and monitoring of drinking water. This Decree is based on the Council Directive 98/83/EC on the quality of water intended for human consumption. The basic purpose of the Decree is the protection of human health and it is applied to drinking water that is supplied at least 10 m^3 a day or for the use of at least 50 people. Regulations concerning smaller production units are included in another Decree of the Ministry of Social Affairs and Health (401/2001).

Municipal health protection authorities are responsible for the frequent monitoring of drinking water. Monitoring results of large water suppliers distributing water at least 1 000 m^3 in a day or serving at least 5 000 consumers are submitted to the European Commission at three-year intervals. Municipal health protection authorities send the results to the Provincial State Office to be forwarded to the National Institute for Health and Welfare which draws up a report to the European Commission. The data is uploaded into the WISE information system. The annual number of monitoring results is around 85 000.

Contact person: Outi Zacheus, National Institute for Health and Welfare, Tel. +358 20 610 6374, Email: firstname.lastname@thl.fi.

5.2

Waterborne outbreaks caused by drinking water

Ilkka Miettinen

By virtue of the Health Protection Act 763/1994, municipal health protection authorities can issue instructions on the treatment and use of drinking water to prevent harmful health effects. Since 1997, municipal health protection authorities are obliged to report all suspected waterborne outbreaks to the National Institute for Health and Welfare which then gives expert help when needed in solving the outbreak. The final reports on waterborne outbreaks are sent to the Finnish Food Safety Authority, which annually publishes a national report on foodborne and waterborne outbreaks in Finland.

Contact person: Ilkka Miettinen, National Institute for Health and Welfare, Tel. + 358 20 610 6371, Email: firstname.lastname@thl.fi.

5.3

Bathing water

Outi Zacheus

In Finland, the quality of bathing water has been monitored since the 1970s. Nowadays, by virtue of the Health Protection Act 763/1994, municipal health protection authorities are responsible for the frequent monitoring of bathing water. Detailed regulations concerning large public bathing areas are included in the Decree of the Ministry of Social Affairs and Health 177/2008. The Decree is based on the Bathing Water Directive 2006/7/EC. The basic purpose of the Decree is the protection of human health by taking adequate management measures with a view to preventing exposure of bathers to pollution.

Today, there are nearly 350 large public bathing areas having at least 100 bathers in a day. Frequent monitoring of bathing water consists of analysis of *Escherichia coli* and intestinal enterococci and visual inspection of cyanobacteria. Bathing water will be classified as excellent, good, sufficient or poor according to the monitoring results of *Escherichia coli* and intestinal enterococci. Municipal health protection authorities send the monitoring results to the Provincial State Office to be forwarded to the National Institute for Health and Welfare which draws up a report to the European Commission at the end of each year. The National Institute for Health and Welfare sends the list of large public bathing areas to the European Commission before the start of each bathing season. All the information concerning bathing water is uploaded into the WISE information system.

In addition to these large public bathing areas there are around 2 000 small public bathing areas in Finland where the quality of water is frequently monitored by municipal health protection authorities. Detailed regulations concerning these small public bathing areas are included in the Decree of the Ministry of Social Affairs and Health 354/2008.

Contact person: Outi Zacheus, National Institute for Health and Welfare, Tel. +358 20 610 6374, Email: firstname.lastname@thl.fi

6 Monitoring land use

Antti Rehunen, Kaisu Harju, Kari Oinonen

Information about land use is required in land use planning, in the development and steering of planning and building as well as in carrying out National Land Use Guidelines and other environmental policy objectives. Land use information is also used in strategic planning, decision-making, monitoring and research. Main focuses in the use of land use information are the functionality of communities, the integration of community structure, good human living environment, the development of land use steering, climate change mitigation, taking into account of the cultural environment, and the provision of green areas and outdoor recreation areas. Requirements on more extensive land use information have increased since the new Department of the Built Environment was founded in the Ministry of Environment.

In order to obtain a good overall picture of the land use, comprehensive datasets, their combination and processing, and relevant information systems are required. The work related to land use information in Finland's environmental administration is done in close cooperation with data producers, users, and developers as well as other branches of administration. Most information needed is produced outside the environmental administration: in Statistics Finland, municipalities and regional councils, or it is received from national basic registers. The environmental administration aims to influence data availability, quality and standardisation, and to reduce the production of overlapping data.

The present land use planning legislation that came into force in 2000 includes regulations concerning land use monitoring (Land Use and Building Act, Section 205 and Land Use and Building Decree, Section 96), and provisions on the duties of the government administration and local authorities (Land Use and Building Decree, Section 2). The information systems and datasets that are entrusted to the Ministry of the Environment are maintained by the Finnish Environment Institute (SYKE). The Land Use Group in SYKE develops and manages land use information systems and datasets, uses them and promotes their use. Land use information work in SYKE does not include own data gathering.

Regional Environment Centres produce and maintain regional geographic datasets on land use planning, building and the cultural environment. The data is used in the Regional Environment Centre's operational work and decision-making through the geographic information system GISALU. The source data is received mainly from municipalities and stored in the GISALU system. The transmission of geographic data between municipalities and Regional Environment Centres could be made more efficient. For example, the forms for monitoring local detailed plans are already filled in on the web by municipalities and planning consultancies, and the Regional Environment Centres only take care of the coverage of completed forms. In the GISALU's further development project starting in the year 2009, the aim is to examine ways to improve data gathering, storing and use as well as cooperation with other organizations to eliminate overlapping data production. In the project, it is also necessary

to prioritize information gathering and processing work carried out in Regional Environment Centres.

The topics of land use information systems include land use planning, community structure and the human living environment. In environmental administration, the information systems are used through the web-based Finnish Environmental Information System Hertta. Land use GIS data is available in Hertta's Map Service and through the administration's own GIS user interfaces GEO and GISALU. Outside environmental administration, a part of Hertta's subsystems, the Map Service and a part of its data contents can be accessed through the Environment and GIS Data Service OIVA. The land use information systems and GIS datasets maintained in environmental administration are described in Table 1.

Table 1. The land use information systems and GIS datasets maintained in environmental administration

Information system/dataset	**Type of information**	**Data content**	**User interface**	
Plans and decisions			**GIS interface**	**Web-based interface**
Nationwide Regional Land Use Plan Geographical Database	GIS	Regional plans from regional councils in uniform vector format and as scanned raster images.	GEO	Hertta's Map Service (aimed to be a part of OIVA service)
Land Use GIS (GISALU)	GIS	Regional data on land use plans, deviation decisions, and the cultural environment produced by Regional Environment Centres.	GISALU	Hertta's Map Service, (aimed to be a part of OIVA service)
Forms for monitoring local detailed plans	statistics	Forms for monitoring local detailed plans, which municipalities complete, collect data on procedures of plans, areas, building rights and conservation, and shore plans.	–	Hertta
Information System for Monitoring Land Use Planning	statistics	Statistical data about land use planning produced in environmental administration on the basis of GISALU data, and the forms for monitoring local detailed plans.	–	Hertta, also in OIVA
Built environment				
Information System for Monitoring Spatial Structure (YKR)	GIS and statistics	Comparable information on population, jobs, commuting, services and green areas, their structure and relations in 250 m squares, territorial divisions and analyses in 1980–2005.	YKR	Hertta
Information System for Monitoring Living Environment (ELYSE)	statistics	Statistical and indicator data about popu-lation, buildings, housing, services, jobs, commuting and community structure in municipalities and in their densely populated and residential areas.	–	Hertta (soon becoming a part of OIVA service)
GIS data on outdoor recreation opportunities (VIRGIS)	GIS	Nationwide and uniform GIS data on recreation areas, trails and services.	GEO	Aimed to be a part of Hertta's Map Service and OIVA service.

More information:
Finnish Environment Institute (SYKE), Data and Information Centre, Geoinformatics and Land Use Division
Land use information systems user guidance: www.ymparisto.fi/aluneuvonta, alu_tuki@ymparisto.fi
Information systems of the environmental administration: www.environment.fi > Information services > Data systems

7 Monitoring of environmental policy and implemented measures

7.1

Environmental protection expenditure

Eila Salomaa

7.1.1

Public sector

Statistics on environmental protection expenditure in the public sector describe the annual amounts of money which central and local governments spend on environmental protection. Apart from the budget-funded organisations of public administration, the statistics also extend to commercial enterprises that account for substantial proportions of e.g. municipal waste management and water supply. The statistics are produced in compliance with the principles of national accounts, the European Union and the OECD relating to statistics concerning the monitoring of environmental expenditure. This facilitates both national and international evaluations and comparisons of the public sector's environmental protection activities.

Contact person: Leo Kolttola, Statistics Finland, Tel.: +358 9 17341 (switchboard), ymparisto.energia@stat.fi. Further information at: http://www.stat.fi/til/jsys/index.html

7.1.2

Industry

Statistics on the environmental protection expenditure of industry describe the costs which industry incurs from environmental protection. The statistics facilitate comparisons of such expenditure between different branches of industry and areas of environmental protection as well as internationally. Indirectly the statistics can be used to assess the demand for environmental protection and the scope of the environmental market created by industry. Compilation of the statistics follows the statistical principles developed jointly by Eurostat, the Statistical Office of the European Communities, and the Member States. Data for Finland are available from 1992 onwards.

The statistics cover industrial activities, i.e. mining and quarrying, manufacturing, energy supply, and collection, purification and distribution of water. The industries included in these categories are grouped according to the industrial classification confirmed by the European Commission's Regulation. The statistics do not extend to non-industrial activities, such as waste water and waste management, which come under environmental services. Environmental protection investments include both process integrated and end-of-pipe investments. Energy saving and occupational safety measures are not included in the statistics.

Contact person: Eila Salomaa, Statistics Finland, Tel. +358 9 17341 (switchboard), ymparisto.energia@stat.fi. Further information at: http://www.stat.fi/til/tymm/index.html.

7.1.3

Other sectors

As yet there is no established system for producing statistics concerning the environmental protection expenditure of households, organisations, service enterprises or agriculture and forestry. Their environmental protection expenditure can be estimated to some degree from statistics on the final consumption expenditure of households and the financial statement statistics of enterprises and organisations as well as indirectly from statistics concerning waste and waste water management.

7.2

Environmental taxation

Eila Salomaa

The statistics on environment-related taxes and charges describe the amounts of environment-related taxes and charges collected by the public sector and their share of the total tax revenue. The statistics extend to environment-related taxes and charges as well as to certain environment-related tolls. The statistics serve decision-making and planning in society, and the needs of international statistics. Environmental taxes and charges are a central element of administrative steering towards sustainable development.

Statistics on environmental taxation are compiled within an internationally consistent statistical framework, jointly defined by e.g. the OECD and the Statistical Office of the European Communities, Eurostat. Data collected in accordance with the current statistical methodology are available from 1980 onwards.

The starting point in the definition of environmental taxes is the basis of taxation, not the nature of taxes. An environmental tax must be levied on some measurable physical quantity that has a harmful effect on the environment. By definition, all energy and vehicle taxes, for example, are environmental taxes, which additionally also include taxes and charges on packaging and pesticides, as well as oil pollution and oil waste charges, water protection charges and waste tax. The statistics also cover municipal waste, water and waste water charges as separate items. According to international practice, the statistics are compiled on a payment basis, i.e. taxes and charges are recorded under the year in which they are actually paid.

Contact person: Leo Kolttola, Statistics Finland, Tel. +358 9 17341 (switchboard), Email: ymparisto.energia@stat.fi. Further information at: http://www.stat.fi/til/yev/index.html

8 The use of monitoring data

8.1

Data Systems of the Finnish Environmental Administration

8.1.1

Environmental information system (Hertta)

Kati Manni

The environmental administration has developed an environmental information system Hertta that consists of the following different subsystems:

- Hydrology, floods and water resources management
- Lake and river bed registers
- Water resources engineering
- State of surface waters - water quality, zoobenthos, monitoring programmes
- WFD water bodies
- Ground water - areas and observation sites
- Species - monitoring, references and statutes
- Air emission
- Emission estimations into surface waters
- Environmental properties of chemicals
- Living environment and monitoring of urban structure
- Planning indicators and land use plans
- Map service

Data collection and storage for all the subsystems is continuously performed by the Regional Environment Centres, the Finnish Environment Institute and some cooperation partners. For some of the subsystems, data has already been collected and maintained for over a century. The contents of Hertta evolve constantly as new subsystems are developed.

Most of the data produced by environmental monitoring can be retrieved using Hertta. Data produced by compliance monitoring is also included in subsystems of Hertta, and various GIS data are put to use via Map Service in the Hertta system. The main goal of developing the Hertta system has been to rationalize the use of environmental data and to help users to combine data from different sources. Hertta is implemented as a web-based user interface to ensure easy access for users. Hertta can be used by all the employees of the environmental administration.

Since may 2008, major parts of the Environmental information system (Hertta) have also been published on the internet for the general public as well as municipalities, provinces and partners working in cooperation with our administration. The

internet version of Hertta is part of the Oiva service that is free of charge but requires registration.
More information: http://www.environment.fi/datasystems.

Contact persons: Jorma Sipilä, Finnish Environment Institute, Tel: + 358 20 610123 and Väinö Malin, Ministry of Environment, Tel . + 358 20 6107936, Email: firstname.lastname@ymparisto.fi.

8.1.2

The VAHTI compliance monitoring data system

Markku Nurmio

The VAHTI compliance data system is a tool for the 13 Regional Environment Centres in their work on processing and monitoring environmental permits. The data system contains information on the environmental permits of clients and on their wastes generated, discharges into water, and emissions to air. In the future, the system will also include information on noise emissions. This baseline data is used by the Regional Environment Centres and by other interested parties. Additionally, case management has been incorporated into the system.

VAHTI also contains information on how installations comply with environmental regulations. At the beginning of 2005, a new application was added which contains data on how the Regional Environment Centres carry out their compliance monitoring.

Currently, there are 800 active users of the system and it has a sound reputation as an effective tool in the everyday work of the environmental administration. Moreover, the data system provides reports for the diverse needs of the administration and for other interested parties needing information. In 2008 the system included the data of some 34 000 clients.

The user interface makes it possible to add new customers, change or add customer data, retrieve reports from the database and write inspection reports. Additionally, the system has other helpful functions, such as mapping functions and a calendar to remind an inspector of time limits.

VAHTI is a customer information system (operators must have an environmental permit from the authorities) containing, for example, the following information

- identification,
- contact persons,
- respective authorities,
- licence conditions,
- environment insurance,
- loading points such as stacks and sewers,
- emission control equipment,
- treatment plans,
- boilers and fuels used,
- landfills,
- emissions to air, discharges to water and wastes
- energy production,
- raw materials,
- production,
- water consumption,
- fish farming,
- peat production,
- animal shelters and
- analyses.

Contact person: Markku Nurmio, Email: firstname.lastname@ymparisto.fi.
West Finland Regional Environment Centre
Koulukatu 19, FIN-65100 Vaasa Tel. +358 400-161538

8.2

Environmental accounting

Jukka Muukkonen

Environmental accounting systems describe interaction between the environment and the national economy. The UN's System for integrated Environmental and Economic Accounts (SEEA) is a general framework, which combines the statistical systems for producing environmental and economic data. The first version of the SEEA was published in 1993 and a revised version in 2003. The Statistical Office of the European Communities, Eurostat, has developed its environmental accounting system mainly on National Accounting Matrix including Environmental Accounts (NAMEA), on Environmental Protection Expenditure Accounts (EPEA), on Material Flow Accounting (MFA) and on Integrated and Economic Accounting for Forest (IEEAF).

Contact persons: Leo Kolttola and Jukka Muukkonen, Statistics Finland, Tel.: +358 9 17341 (switchboard), ymparisto.energia@stat.fi.

Emission accounting (as part of National Accounting Matrix including Environmental Accounts, NAMEA) shows the monetary and physical flows within the national economy and their effects on the economy and on the environment. Emission accounting combines conventional monetary supply and consumption tables of national accounts with accounts that describe the burden on the environment and the use of natural resources in physical measurement units. The burden is expressed as environmental theme-specific indices with weights based on chemical or physical properties, such as climate change and acidification effect.

Contact person: Marianne Kaplas, Statistics Finland, Tel.: +358 9 17341(switchboard), ymparisto.energia@stat.fi.

Environmental protection expenditure accounting examines environmental protection economy as part of the national economy. It compiles accounts on transactions that are also covered by conventional national accounts but are not presented separately in them. The most important elements of this accounting are environmental protection expenditure, environmental business activity and environmental taxation.

Contact person: Eila Salomaa, Statistics Finland, Tel.: +358 9 17341 (switchboard, ymparisto.energia@stat.fi.

Forest accounting mainly describes changes in the timber resources and in the flows of wood material, as well as in associated economic values in the national economy. In addition to wood, the statistics extend to other forest-based benefits, of which the quantities or monetary values are known, and to area data related to the forests.

Forest accounting includes forestry, the forest industries, other industries and final consumption analysed in accordance with the standard industrial classification used in national accounting. Forest accounts data on the use of wood and forests are linked to national accounts data on the economy and employment, input-output

tables, and energy and emissions data at the industry and partially also at the commodity level.

Contact person: Jukka Muukkonen, Statistics Finland, Tel.: +358 9 17341 (switchboard), ymparisto.energia@stat.fi.

Material flow accounting describes flows of matter from the environment to the economy, inside the economy, between the economy and foreign economies, and from the economy back to the environment. In physical input-output tables (PIOT) the flows of matter are described by branches of industry. Economy-wide material flow accounts describe material groups, the total material use of the economy (TMR, Total Material Requirement), including both direct material use and unused extraction of domestic materials, as well as hidden flows included in imported raw materials and products. The perspective of environmental accounting will also receive more emphasis in the further development of waste statistics. Material flow accounts have mainly been compiled by the Thule Institute of the University of Oulu, in cooperation with e.g. the environmental administration and Statistics Finland.

Contact person: Jukka Muukkonen, Statistics Finland, Tel.: +358 9 17341 (switchboard), ymparisto.energia@stat.fi.

8.3

Sustainable Development Indicators

Ulla Rosenström, Jarmo Muurman

Environmental monitoring programs produce a great deal of information. Indicators play an important role in facilitating the use of this information, as the aim of indicators is to condense extensive amounts of information into a concise format. Indicators are particularly useful and important when directing certain information to decision-makers and the public.

Key criteria for choosing indicators are that they should be reliable and useful. Indicators are often based on data produced by environmental monitoring programs precisely because the data is reliable, covers long time-periods and is internationally comparable. It is therefore recommended that scientists developing indicators cooperate with those responsible for monitoring programs.

Indicators are developed on multiple scales, from international to national, to local scales. Currently some of the most prominent sustainable development indicator sets are those produced by the OECD, the European Environment Agency (EEA) and Eurostat. International indicator sets often consist of indicators using data from a number of countries. Indicators developed for use at the national and local levels, are often more detailed and sophisticated.

Finland has it own national sustainable development indicators, first published in 2000, to monitor the national sustainable development strategy. Since then the indicators have been regularly updated and maintained on the internet. Over the years the policy relevance of the indicators has been given more significance and the latest set of 34 indicators was published together with the national strategy for sustainable development in 2006. The indicators are also available in the internet.

The indicators have been used to evaluate the implementation of the national strategy in 2007 and the next evaluation will take place in 2009. The environmental administration also maintains a supplementary set of about 40 indicators and produces thematic indicator leaflets to support the meetings of the National Commission for Sustainable Development that meets four times a year.

Contact persons: Ulla Rosenström and Aino Inkinen, Finnish Environment Institute,
Tel. +358 20 610123, Email: firstname.lastname@ymparisto.f
Jarmo Muurman, Ministry of the Environment, Tel. +358 20 690160, Email: firstname.
lastname@ymparisto.fi
The national sustainable development indicators can be found on the internet at:
http://www.environment.fi/indicators

Appendix: Abbreviations used

Abbreviation	Explanation
AMAP	Arctic Monitoring and Assessment Program
AOX	Organic Cloride Compound
BL	Bird Life, WWF Finland
BOD7	Biological Oxygen Demand
CES	Constant Effort Sites (bird ringing)
CLRTAP	UNECE Convention on Long Range Transboundary Air Pollution
CNRS	Centre Nationale de la Recherche Scientifique
CODCr	Chemical Oxygen Demand
CORINE2000	Land Cover Program for Europe
ECMWF	European Centre of Medium Range Weather Forecasts
EEA	European Environment Agency
ELYSE	Information System for Monitoring the Living Environment
EMEP	Long-Range Transmission for Air Pollutants in Europe
ENVISAT/MERIS	Satellite images used for water quality estimations in SYKE
EPEA	Environmental Protection Expenditure Accounts
ESB	Environmental Specimen Bank (Finnish Forest Institute/ Finnish Environ-mental Institute)
EURATOM	European Atomic Energy Community
EUROSTAT	The Statistical Office of the European Communities
EWC	European Waste Catalogue
FGFRI	Finnish Game and Fisheries Institute
FLASH-B	Lyman alpha hygrometer
FMI	Finnish Meteorological Institute
FMI-ARC	Finnish Meteorological Institute - Arctic Research Centre
FUVIRC	Finnish UV-International Rresearch Centre
GISALU	Land Use GIS - Geographical Infirmation System
GOMOS	Instrument for measuring ozone onboard ENVISAT- satellite
HELCOM	Helsinki Commision
Hertta	Information System of SYKE
IACS	Integrated Administration and Control System of Tike
ICES	International Council for the Exploration of Sea
ICP Forests	International Cooperative Program on the Assessment and Monitoring of Air Pollution Effects on Forests
ICP IM	The International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems
IPC Waters	The International Cooperative Programme on Assessment and Monitoring of Rivers and Lakes
IEEAF	Forest Accounts
ILMARI	Calculation System for Producing Data on Greenhouse Gas Emissions (Statistics Finland)
IM	Integrated Monitoring
IVL	Swedish Environmental Research Institute
KASTIKKA	Database of vascular plants in Finland maintained by the Botanical Museum of the Finnish Museum of Natural History
LIMS	Laboratory Information Management Systems
LRTAP	Long-Range Transboundary Air Pollution
Metla	Finnish Forest Research Institute
MFA	Material Flow Accounts

MOSSE	Biodiversity and Monitoring Program in Finland 2003-2006
MTT	MTT Agrifood Research Finland
MYTVAS	Monitoring the Impacts of Finnish Agri-Environmental Support Scheme Programme
NACE	Industrial Classification in EU
NAMEA	National Accounting Matrix including Environmental Accounts
NFI	The National Forest Inventory
NMVOC	non Methane Volatile Organic Compounds
NOAA CMD	Frostpoint hygrometer
NOAA/AVHRR	Satellite imges used for water quality estimations in SYKE
OCPs	Organochlorine pestisides
OECD	Organization for Economic Cooperation and Development
OSIRIS	Instrument for measuring ozone onboard ODIN- satellite
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PIOT	Physical input-output tables (in Material Flow Accounting)
POVET	Groundwater register of SYKE
PSP	Polar Stratospheric Clouds
SAOZ	Instrument for measuring ozone
SEEA	UN System for Integrated Environmental and Economic Accounts
SLICES	Land Use classification of the National Survey of Finland
STUK	Radiation and Nuclear Safery Authority
SYKE	Finnish Environment Institute
TERRA/MODIS	Satellite imges used for water quality estimations in SYKE
Tike	Information Centre of the Ministry of Agriculture and Forestry
TMR	Total Material Requirement (in Material flow Accounting)
UNECE	United Nations Economic Commission for Europe
UNFCCC LULUCF	Greenhouse Gas Reporting for Forests.
VAHTI	Waste Data Register of SYKE
VEPS	Diffuse Load Simulation System (SYKE)
WMO/GAW	Global Atmosphere Watch Program of the World Meteorological Organization
WWF	World Wide Fund for Nature
YKR	Urban Structure Monitoring System

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Environmental monitoring has a long tradition in Finland as illustrated by the following examples. Monitoring of weather was started in 1839, that of water levels in 1849, and river discharges in 1910. The first forest inventory covering the whole country was carried out in 1921-24. Monitoring of birds began early: Bird Ringing (1913), Nest Record Card Study (1954) and Winter Bird Census (1955). Wastewater inventories were begun in the 1950s and those of drinking water in the 1960s. National monitoring of rivers was started in 1962 and that of lakes in 1965. After the implementation of the Water Act in 1962 the local pollution control monitoring network based on the polluter pays-principle was created and has been in operation since then.

This publication presents the environmental monitoring to be carried out in Finland by the following national organizations in 2009-2012.

- Geological Survey of Finland
- Finnish Meteorological Institute
- National Institute for Health and Welfare
- Finnish Food Safety Authority
- Finnish Museum of Natural History
- Agrifood Research Finland
- Finnish Forest Research Institute
- Metsähallitus (National Board of Forestry)
- Information Centre of the Ministry of Agriculture and Forestry
- Finnish Game and Fisheries Research Institute
- Radiation and Nuclear Safety Authority
- Ministry of Social Affairs and Health
- Statistics Finland
- Finnish Environment Institute
- Regional Environment Centres

The monitoring programs described focus on topics such as air, water, forests, land, animals and plants, biodiversity, radioactivity, harmful substances, water and health, land use and environmental policy.

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