CATALOG OF COMMON METHODOLOGIES

Catalog of used methodologies and recommendations for common transboundary monitoring methodologies.

Monitoring of forests

Monitoring of mires

Monitoring of lakes

Monitoring of streams

Monitoring of hydrochemistry

Monitoring of deicing salt

Long-term monitoring in the Große Ohe catchment

More detailed descriptions of current monitoring projects and used methodologies were published in a special issue of the Silva Gabreta journal vol. 21(1).

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Monitoring	**Monitoring of forests: Biodiversity monitoring - the BIOKLIM Project**
Methods	In 2006 a total of 288 plots along four straight transects following the altitudinal gradient were set up. Five additional plots were installed beside the main transects to compensate for the lack of old growth forest samples at higher altitude. Four main transects with 100 m between plots ensures that a minimum of 23 replications for each altitudinal range exists; sufficient to overcome simultaneous environmental effects. In 2008 a number of 38 lowland plots down to the Danube were added to extend the altitudinal gradient. On each plot a plethora of environmental variables were measured, recorded or modeled. They include for example basic topographic information (e.g., altitude, exposition), forest structural variables (e.g. dead wood, tree species composition at different strata), soil chemical physical and chemical properties, and a set of biological meaningful climate variables (see BÄSSLER et al. 2008 and references therein). All taxonomic groups, methods and number of sampled plots (replications) are presented in BÄSSLER et al. (2008). Altogether we collected data on 25 higher taxa. The number of plots to be sampled depended on the nature of the scientific enquiry and on the target group. For this reason we stratified 331 sample plots, selecting pre-stratified sub-samples with respect to the two main gradients (altitude and forest structure) for some groups (BÄSSLER et al. 2008). For a new project in season 2016: in the Bavarian Forest National Park the record of 150 study sites (110 in the national park and 40 in the surrounding area) is planned. For the Šumava NP the record of 150 study sites is planned too (120 in forests and 30 in naturally tree less areas, i.e. mires, peat meadows, heathlands). In both national parks recording of vegetation (flowering plants, ferns, mosses and lichens), fungi, birds, snails, beetles, bugs, spiders and other insects is planned. These taxonomic groups will be mapped, collected, and/or recorded by insect traps. Further, different environmental parameters (climate variables, stand structure) will be recorded and soil samples will be taken and analyzed. Moreover, a common Laser-Scanning for recording vegetation structure is planned.
Garant	Claus Bässler, Bavarian Forest National Park, Freyunger Str. 2, D-94481 Grafenau, Germany.
References	BÄSSLER C., FÖRSTER B., MONING C. & MÜLLER J., 2008: The BIOKLIM-Project: Biodiversity Research between Climate Change and Wilding in a temperate montane forest – The conceptual framework. *Forest Ecology, Landscape Research and Nature Conservation*, 7: 21–33. BÄSSLER C., SEIFERT L. & MÜLLER J., 2015: The BIOKLIM Project in the National Park Bavarian Forest: Lessons from a biodiversity survey. *Silva Gabreta*, 21: 5–27.

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Monitoring	**Forest monitoring: Terrestrial monitoring of forest structure in non-intervention areas**
Methods	A network of randomised points separated by 353.55 meters, formerly established as a network for the Forest Inventory in the Czech Republic (ÚHÚL 2007) and the Large-Scale Inventory of the Šumava NP Forests, was used to place the centers of permanent plots. Similar network is also used for the project Operational Forest Inventory, some of the plots overlap and can be used in both projects. Field-Map technology (ČERNÝ 2010) was used to mark the plots in the field and collect the data. Permanent plots are circles with the size of 500 m2 (12.62 m in diameter). Each plot is fixed by three independent ways for the next investigation. The plot centre is fixed by a merestone, GPS coordinates are recorded and one or two trees close to the research plots are marked by reflex spray. Coordinates of these trees are also recorded. Each plot is divided into two concentric circles, 7 m and 12.62 m in diameter. Positions of trees with diameter breast height (DBH) >30 cm are measured in a whole plot. More detail investigation, including all trees with DBH>7 cm, is conducted in a small inner plot having 7 m in diameter. Natural regeneration (individuals with DBH<69 mm) is recorded in a whole plot and a more detail investigation is conducted in a small regeneration plot, a circle 3 m in diameter. A centre of this circle is located 7 m north from the centre of the research plot (Fig. 2). The methodology of the Biomonitoring was agreed in 2009 (NPŠ 2009), data on each plot are clustered in seven sections: (1) plot characteristics; (2) living trees (DBH>30 cm, or >7 cm); (3) dead trees; (4) snags and stumps; (5) lying dead wood; (6) tree regeneration (seedlings >10 cm high, DBH<7 cm); (7) phytocoenological relevé and proportion of microsites important for tree species regeneration (Table). Also soil characteristics are recorded. 120 plots from the Biomonitoring project in the Šumava NP will be used for monitoring biodiversity following the design BIOKLIM project. Data from Biomonitoring project will be used as explanatory variables and help to describe forest structure in study sites.
Garant	Jitka Zenáhlíková, Šumava National Park, Sušická 339, CZ-34192 Kašperské Hory, Czech Republic
References	ČÍŽKOVÁ, P., SVOBODA, M., KŘENOVÁ, Z., 2011: Natural regeneration of acidophilous spruce mountain forests in non-intervention management areas of the Šumava National Park – the first results of the Biomonitoring project. *Silva Gabreta*, 17: 19–35. ZENÁHLÍKOVÁ J., ČERVENKA J., ČÍŽKOVÁ P., BEČKA P., STARÝ M., MAREK P., KŘENOVÁ Z. & SVOBODA M., 2015: The Biomonitoring project – monitoring of forest ecosystems in non-intervention areas of the Šumava National Park. *Silva Gabreta*, 21: 95–104.

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Monitoring	**Monitoring of mires**
Methods	The numerous mires in the natural region (Sumava/ Bavarian National Park) differ in their altitude and the impact of the adjacent forest structure. The specific species communities of the mires are influenced by the microclimate, mainly water balance. Changes in natural or close-to-nature mires could give hints about climatic impacts, while revitalized mires could documents the effects of restoration activities. Monitoring design Mire sites with different level of drainage (without drainage, moderately disturbed and highly disturbed) are monitored (in Sumava NP - 6 sites that were monitored since 2005, 3 sites since 2015 and 3 more will have to be included to complain design). Both ombrotrophic mires - raised bogs - and minerotrophic mires - spruce mires, fens are represented. The monitoring of the permanent plots provides data on microtopography, and vegetation and drainage patterns of the different mire sites. The following environmental variables are monitored: - groundwater table - runoff from restored sites - water chemistry of both groundwater and surface water - peat chemistry - precipitation - microclimate condition (air, soil moisture and temperature) - vegetation Water table levels are measured manually approximately in two-week intervals from April to November. Automatic gauging (at 1 h intervals) by piezometers is used in a selected boreholes. Water samples from selected boreholes, ditches and runoff profiles from both drained and control sites are taken monthly for a detailed hydrochemical analysis, including the content of main cations and anions (SO_4, NO_3, NH_4, PO_4, Ca, Mg, K, Al, Fe, Cl, total P, total N), pH, conductivity and DOC. Runoff from drained sites as well as the amount of precipitation are measured continually using UV sensors in the standard Thompson profiles for runoff data. Vegetation is sampled in 1 x 1 m permanent plots in 3 replicates around each borehole. The percentage cover values for all vascular plants and bryophytes present on the permanent plots is estimated visually. In the Bavarian Forest National Park, where monitoring of mires has not been implemented till now, the record of 8 mire sites (6 in the national park and 2 in the surrounding area) is planned with consistent methods like in Sumava.
Garant	Ivana Bufková, Šumava National Park, Sušická 339, CZ-34192 Kašperské Hory, Czech Republic.
References	BUFKOVÁ I., STÍBAL F. & MIKULÁŠKOVÁ E., 2010: Restoration of drained mires in the Šumava National Park, Czech Republic. – In: Eiseltová M. (ed.), Restoration of lakes, streams, floodplains, and bogs in Europe: principles and case studies, 331–354, Springer Verlag.

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Monitoring	**Monitoring of lakes**
Methods	Eight small glacial lakes are located on forested slopes of the central summit of the Bohemian Forest. On Czech side there are Černe, Čertovo, Plešné, Prasilske and Laka Lake. On Bavarian side there are Rachelsee, Großer and Kleiner Arbersee. There is an integrated catchment–lake approach, especially in the Čertovo Lake and Plešné Lake catchments, and long-term limnological research of all eight lakes to study key processes and responses of different systems to the decreasing atmospheric pollution and the increasing air temperature. Besides regular monitoring of atmospheric deposition, water chemistry of the lakes and their tributaries, ongoing chemical and biological recovery of both aquatic and forest ecosystems from acid stress, including soil chemistry, microbial activity, vegetation, and forest disturbances in the lake catchments are studied. Common hydrochemical and hydrobiological monitoring: Every 4 years all eight lakes are sampled in spring and late summer. Assemblages of macroinvertebrates are sampled by semi-quantitative kick-sampling method (Frost et al. 1971) using a hand net (0.5mm mesh size). Sampling is time limited to 5 min sampling. In late summer also water and plankton samples are taken at the deepest point of the lake at different depths. Additionally, water chemistry and runoff off lake inlets and outlets are measured. Methodology is described in detail in Soldán et al. 2012.
Garant	Hydrochemistry: Jaroslav Vrba & Jiří Kopáček, Department of Ecosystem Biology, University of South Bohemia, Na Sádkách 7, České Budějovice CZ-370 05, Czech Republic. Hydrobiology: Jindřiška Bojková, Department of Botany and Zoology, Faculty of Science, Masaryk University, Kotlářská 2, CZ-61137 Brno, Czech Republic.
References	SOLDAN, T., BOJKOVA, J.,VRBA, J., BITUSIK, P., CHVOJKA P., PAPACEK, M., PELTANOVA, J., SYCHRA J. & TATOSOVA J., 2012: Aquatic insects of the Bohemian Forest glacial lakes: Diversity, long-term changes, and influence of acidification. *Silva Gabreta*, 18: 123–283.

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Monitoring	**Monitoring of streams**
Methods	The Bohemian forest is characterized by comprehensive stream networks covering a great topographical diversity from smooth sloping streams at Czech high-level plateaus to steep-sloping streams in Bavaria. Such a broad monitoring will documents ecological changes after restoration and can provide answers to many research questions. Due to different history of usage monitoring will focus on different questions but it will implemented with comparable methods. Monitoring of restored streams on Czech side will focus on re-colonization of macroinvertebrates and monitoring of sloping streams on Bavarian side will focus on macroinvertebrate diversity at elevational and structural gradients. Locations on Czech side are Hučina, Žlebský Potok and Jedlový Potok. Locations on Bavarian side are Große, Deffernik, Kolbersbach, Kleiner Regen, Große Ohe, Kleine Ohe, Sagwasser, Reschbach The restored streams Hučina, Žlebský Potok and Jedlový Potok are sampled using a meso-habiatat approach to detect changes during stream development. Macroinvertebrates are sampled semiquantitatively using a hand net with 0.5 mm mesh size. At each mesohabitat, altogether five approx. 25×25 cm plots are sampled and merged into one sample characterising one mesohabitat. Macroinvertebrates are collected also quantitatively by metal strainer with about 0.8 mm mesh size to find all species inhabiting the sampling sections. Adults of Ephemeroptera, Plecoptera and Trichoptera are collected by sweeping of riparian vegetation. Prior to sampling of each plot, water depth and velocity are measured using a Flo-Mate flow metre (Model 2000; Marsch-McBirney, Frederick, MD, USA). The following parameters are analysed: alkalinity, Dissolved Organic Carbon, total P, NH4+, NO3−, SO42−, Cl−, Ca2+, Mg2+, Na+, K+, Al and Fe forms. Water temperature, discharge, conductivity and pH are continuously measured in the Hučina stream near the road bridge. The Bavarian streams are sampled using the multi-habiat sampling method taking 20 samples of macroinvertebrates in respect to the proportion of the available substrate habitats. A 25×25 cm net is used. Each transect represents a 50m long stream section and will be equipped with 2 temperature data loggers measuring in 2-hours-intervalls. Influences on temperature balance by canopy are estimated by arial photos concerning 300m stream sections. Study sites are located at the main branches in 100m steps of elevation starting at a height of about 1100m and ending at the lowest height within the Park. Plots planned in this way are characterized by changing stream orders. To ensure also a set of the same stream order at different elevation levels additional 3rd order side-stream were added. In summary, we selected transects along the main branches with replicates of the 3rd order at side branches (in total 48 transects).
Garant	Czech specialist: Jindřiška Bojková, Department of Botany and Zoology, Faculty of Science, Masaryk University, Kotlářská 2, CZ-61137 Brno, Czech Republic. German specialist: Peter Haase, Fließgewässerökologie, Forschungsinstitut Senckenberg Clamecystr. 12, 63571 Gelnhausen.
References	BOJKOVÁ J., ČÍŽKOVÁ H., KUČEROVÁ A., RÁDKOVÁ V., SOLDÁN T., SVIDENSKÝ T. & VRBA J., 2015: Monitoring of the restored streams in the Vltavský Luh (Šumava National Park). *Silva Gabreta*, 21: 73–79.

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Monitoring	**Stream water chemistry**
Methods	Within these periods 1984–1990, 2003–2004, 2010, 2015 stream water samples were collected in the territory of the Šumava National Park and its close vicinity and NP Bavarian Forest (only 2015), GPS coordinates are available. In each sampling period samples were collected at identical locations. In the periods 1984–1990 and 2003–2004 samples were not filtered, during the 2010 and 2015 campaigns they were filtered (0.45 µm). Chemical analysis: Samples were analyzed for the following: anions – Cl, F, NO3, SO4; cations – Ca, Fe, Mg, Al, Mn, K, Na and Si; trace elements – Pb, Cd, As, Be, Li, Sr, Zn, Cu; total dissolved phosphorus (TDP, 2010 only); pH; conductivity and absorbance at 254 nm (ABS254, 2010 & 2015 only). The conductivity and pH were measured on the day of the collection using a portable conductometer (Cond 315i WTW GmbH, Weilheim, Gemany) and a portable pH meter with a combination glass electrode (Radiometer pH meter PHM201 with temperature correction). All laboratory analyses were performed in the laboratory of the Czech Geological Survey (ISO 9001). The Cl, NO3, SO4 concentrations were determined by high pressure liquid chromatography with conductivity detection; F concentrations were determined with an ion-selective electrode (ISE); Na, K, Ca, Mg, SiO2, Al, Fe, Mn, Sr, Zn, and Li were determined by flame atomic absorption spectrometry (FAAS); and As, Be, Cd, Cu, and Pb were determined by graphite furnace atomic absorption spectrometry (AAS). All the samples for the cation analyses were acidified with HNO3 (10 ml.l–1) after filtration in the field. The dissolved organic carbon (DOC) concentrations of 20% of the samples were determined using platinum-catalysed high temperature oxidation by exploiting the non-purgeable organic carbon method (Apollo 9000 Tekmar-Dohrmann). The total dissolved phosphorus (TDP) was determined spectrophotometrically after perchloric acid digestion (KOPÁČEK & HEJZLAR 1993). The analytical quality was controlled by intercomparison between laboratories as per Youden, which was organized by ICP Waters (DAHL & HAGEBØO 2011). Sampling scheme All samples were collected during the vegetation growing season (April 15–October 15). The seasonal and hydrological sample variabilities were minimized through sampling during stable hydrological conditions, i.e., when discharge at the nearest hydrological station of the Czech Hydrometeorological Institute (www.chmi.cz) was between 50% and 200% of the long-term average discharge, following the same methodology as VESELÝ et al. (1998). Data analysis Solute concentrations distribution was log-normal, thus non-parametric statistics was applied for statistical data treatment. Logarithm of concentration was used for the map creation. Maps of individual solutes were created using SURFER (Golden Software Inc. Data). Solute concentrations were re-calculated into regular grid (500×500 m) using kriging. We used a kriging method within 10 km radius divided onto 4 search sectors when interpolating grid nodes. Within each search sector maximum of four sampling points was used for interpolation, with total number of 10 nearest sampling points from all sectors. In case there was no sampling point within the search radius, the value was not interpolated for that particular grid node. Then isolines were generated and contour maps produced.
Garant	Jakub Hruška, Czech Geological Survey, Klárov 3, CZ-11821 Prague 1, Czech Republic.
References	HRUŠKA J. & MAJER V., 2015: Stream water chemistry between 1984–1990 and 2010 reflects declining acidic deposition and bark beetle induced ecosystem changes. *Silva Gabreta*, 21: 29–41.

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Monitoring	**Effects of applying deicing salt to roads in protected areas**
Methods	Permanent sites for monitoring were established, GPS coordinates are available <u>Soil, snow, and water sampling and analyses</u> Soil structure and horizons were recorded at all the study sites at distances of 5 and 10 meters from the road edge. Samples of soil are collected from the upper (0 m to −0.1 m) and lower soil layers (> −0.1 m) at four sample points and then samples from each soil horizon mixed for each site. The mixed soil samples for each site are analysed by the certified laboratory in Klatovy (The Health Institute Pilsen, Laboratory Klatovy). The following parameters are measured: pHH2O, Na+, Cl−, SO42−, conductivity (after water extraction); pHKCl (after KCl extraction); and Ca2+, Mg2+, K+, Na+ (after Mehlich 2 extraction). If possible also snow samples are collected with a standard snow tube, 10 cm in diameter in distances 5 m and 10 m from the road edge. Also snow depth is measured in all sampled sites. The snow samples are melted and pH, Eh, and conductivity are measured. Later the samples are sent for chemical analyses, which are done again by the certified laboratory in Klatovy (The Health Institute Pilsen, Laboratory Klatovy). The following parameters are measured: Na+, Ca2+, Mg2+, K+, Cl−, NO3−, conductivity, and pHH2O. Twenty new dataloggers were installed in summer 2015 to improve monitoring of impact of deicing salt on water environment. The dataloggers were installed in streams crossed by the roads maintained by the salt and they can continuously measure water level, temperature and conductivity. <u>Vegetation</u> Five-meters long transects were laid out at each site in order to identify the plants occurring there. These transects ran parallel with the road. The first one is located just at the edge of the asphalt road surface and the second one meter from the road edge. In addition, if necessary, another transect has been established to record the vegetation at a distance five meters from the road edge. The standard method, based on five levels of abundance for each species (BRAUN-BLANQUET 1951), is used for the transects. Also percentage cover of mosses, herbaceous plants, shrubs and trees are recorded along all transects. Floristic terminology follows KUBÁT et al. 2002. The species occurrences and their salt-tolerance are studied. Three categories of species are distinguished (ELLENBERG et al. 1992): halophytes – species that tolerate and thrive on substrates with a high salinity; sub-halophytes – species that can tolerate moderate salinity but not a high salinity; and glycophytes – species that are easily damaged by saline conditions. Transects are characterized by the percentages of halophytes, sub-halophytes and glycophytes. Necrosis, leaf senescence and other forms of damage are recorded too.
Garant	Vladimír Zýval, GeoVision s.ro., Částkova 1977/73, CZ-32600 Plzeň 2 – Slovany, Czech Republic.
References	KŘENOVÁ Z., CHOCHOLOUŠKOVÁ Z. & ZÝVAL V., 2012: Effects of applying deicing salt to roads in protected areas: a preliminary study in the Bavarian Forest National Park. European Journal of Environmental Sciences, 2: 50–55. ZÝVAL V, KŘENOVÁ Z., CHOCHOLOUŠKOVÁ Z., ZÝVAL V. JUN. & ZÝVALOVÁ J., 2015: Effects of applying deicing salt to roads in protected areas of the Bohemian Forest region. *Silva Gabreta*, 21: 43–52 .

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Monitoring	**Long-term monitoring in the Große Ohe catchment**
Methods	The monitoring program in the Große Ohe catchment comprises precipitation measurements to derive catchment precipitation, snow depth and snow water equivalent courses to estimate snow cover and above surface water storage and discharge measurements to complete the data base for calculating catchment balances. Information on groundwater level and quality come from IHM and UN ECE-IM stations. Precipitation: There are different bucket types in the field which are designed to catch precipitation over different intervals for different purposes. From 1979 to 1989, daily precipitation was measured using 53 Hellman type buckets at 2 m height covering the whole catchment in order to describe the spatial distribution of precipitation yields and to test different approaches to estimate mean catchment precipitation. Catchment precipitation is calculated according to KLÖCKING et al. (2005) using precipitation records of six out of eight monthly totalising samplers. Beginning in the early 2000s, weighing type precipitation recorders have been successively installed at those locations where monthly totalising samplers are operated. This design enables to study the rainfall intensity and allows for comparison and cross-validation of the equipment, at least during snow-free periods. Snow depth and snow water equivalents: In 1978, a snow course has been established consisting of graduated (10 cm resolution) and calibrated snow stakes fixed on permanent open sites representing the topographic characteristics of the catchment with respect to elevation and aspect. In 1994, the snow course has been reduced from 53 to 33 stakes. The locations fulfill the WMO (2008) requirements for precipitation sites. Measurement of snow depth (5 cm accuracy of the estimate), accounting for the effects of snow melting or accumulation immediately surrounding the stake, is repeated in regular intervals of two weeks. In 1978, the second snow course has also been established consisting of 12 forests stands (7 plots Norway spruce, 5 plots European beech) to investigate species specific differences in snow dynamics. The stands follow the altitudinal gradient pairwise from 802 to 1323 m a.s.l. in the centre of the catchment. The snow sampling equipment consists of a Teflon coated aluminium tube (cross-sectional area 25 cm²) and a spring balance. Height and weight records of 10 snow samples are averaged to compute mean height, snow water equivalent, and density of snow for each date and location. Discharge and runoff water chemistry: In 1977, continuous water level measurements in the Große Ohe stream have launched at the Taferlruck stream gauging station using a pressure sensor. The artificial and geometrically defined flume is split into a small part enabling low flow and a large cross section for high flow measurements (Fig. 2). Up to now, instantaneous flow varied between 0.09 and 24 m3.s−1. Independent discharge measurements with a current meter are conducted to check the rating curve. Temperature, pH, oxygen content and electric conductivity are measured continuously and registered every minute. Samples for chemical analysis are taken manually every two weeks and analysed for major and some minor components according to DIN/EN/ISO methods in the laboratories of LFU. Groundwater level and chemistry: Since 1987, groundwater level has been measured in three observation boreholes. Two of them are located in the middle slope of the catchment (970 and 980 m a.s.l.) representing the deep, slow flowing aquifer. The third is located in the lower slopes (810 m a.s.l.) representing the fast flowing aquifer in solifluction layers and in situ weathered

	regolith. Beginning in the early 2000s, manual measuring of stage height has been replaced by pressure sensors with hourly registration. Physical and chemical data are taken from the Forellenbach (UN ECE-IM) and Markungsgraben (IHM) monitoring programs. Climate During the 1980s, a climate station was established near the Taferlruck gauging station. It is used as a reference for valley locations, which are characterised by frequent late frosts in spring and early frosts in autumn. Meteorological instruments are mounted on a 10 m mast at standardized heights according to WMO (2008) requirements. Sensors for wind speed and wind direction are fixed at the top; insolation, air temperature, and humidity sensors are clamped on arms at 2 m. Soil temperature is measured in several depths down to 100 cm. Sensor readings are stored every 10 minutes. Further climate data are taken from the NPBW station Waldhäuser (945 m a.s.l., 48°55'45.89'' N, 13°27'53.28'' E) and from climate models (KLÖCKING et al. 2005). Establishing of a long-term monitoring site in the Roklansky potok stream catchment is currently under discussion in the Šumava NP. First monitoring activities are going to be start soon.
Garant	Germany: Burkhard Beudert, Bavarian Forest National Park, Freyunger Str. 2, D-94481 Grafenau, Germany.
References	BEUDERT B. & GIETL G., 2015: Long-term monitoring in the Große Ohe catchment, Bavarian Forest National Park. *Silva Gabreta*, 21: 5–27.