International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests)

Further development and implementation of an EU-level Forest Monitorng System (FutMon)

Forest Condition in Europe

2011 Technical Report of ICP Forests and FutMon

Work Report of the:

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Institute for World Forestry

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Institute for World Forestry

Forest Condition in Europe

2011 Technical Report of ICP Forests and FutMon

Richard Fischer, Martin Lorenz (eds.)

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United Nations Economic Commission for Europe (UNECE)
Convention on Long-Range Transboundary Air Pollution CLRTAP
International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests)
www.icp-forests.org

Further development and implementation of an EU-level Forest Monitorng System (FutMon)
www.futmon.org

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Cover photos: Dan Aamlid (landscape, top), Richard Fischer (middle) Silvia Stofer (bottom)

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Preface

Forests provide a wealth of benefits to the society but are at the same time subject to numerous natural and anthropogenic impacts. For this reason several processes of international environmental and forest politics were established and the monitoring of forest condition is considered as indispensable by the countries of Europe. Forest condition in Europe has been monitored since 1986 by the International Co-operative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) in the framework of the Convention on Long-range Transboundary Air Pollution (CLRTAP) under the United Nations Economic Commission for Europe (UNECE). The number of countries participating in ICP Forests has meanwhile grown to 41 including Canada and the United States of America, rendering ICP Forests one of the largest biomonitoring networks of the world. ICP Forests has been chaired by Germany from the beginning on. The Institute for World Forestry of the Johann Heinrich von Thünen-Institute (vTI) hosts the Programme Coordinating Centre (PCC) of ICP Forests.

Aimed mainly at the assessment of effects of air pollution on forests, ICP Forests provides scientific information to CLRTAP as a basis of legally binding protocols on air pollution abatement policies. For this purpose ICP Forests developed a harmonised monitoring approach comprising a large-scale forest monitoring (Level I) as well as a forest ecosystem forest monitoring (Level II) approach laid down in the ICP Forests Manual. The participating countries have obliged themselves to submit their monitoring data to PCC for validation, storage, and analysis. The monitoring, the data management and the reporting of results used to be conducted in close cooperation with the European Commission (EC). EC co-financed the work of PCC and of the Expert Panels of ICP Forests as well as the monitoring by the EU-Member States until 2006.

While ICP Forests - in line with its obligations under CLRTAP - focuses on air pollution effects, it delivers information also to other processes of international environmental politics. This holds true in particular for the provision of information on several indicators for sustainable forest management laid down by Forest Europe (FE). The monitoring system offers itself for being further developed towards assessments of forest information related to carbon budgets, climate change, and biodiversity. This is accomplished by means of the project “Further Development and Implementation of an EU-level Forest Monitoring System” (FutMon). FutMon is carried out from January 2009 to June 2011 by a consortium of 38 partners in 23 EU-Member States, is also coordinated by the Institute for World Forestry of vTI, and is co-financed by EC under its Regulation “LIFE+”. FutMon revises the monitoring system in close cooperation with ICP Forests. It establishes links between large-scale forest monitoring and National Forest Inventories (NFIs). It increases the efficiency of forest ecosystem monitoring by reducing the number of plots for the benefit of a higher monitoring intensity per plot. This is reached by means of a higher number of surveys per plot and newly developed monitoring parameters adopted by ICP Forests for inclusion into its Manual. Moreover, data quality assurance and the database system are greatly improved.

Given the current cooperation between ICP Forests and FutMon, the present Technical Report is published as a joint report of both of them.

7. Epiphytic lichen diversity in relation to atmospheric deposition

Paolo Giordani [1], Vicent Calatayud [2], Silvia Stofer [3], Oliver Granke [4]

7.1. Introduction

Lichens have been considered to be among the most sensitive groups of organisms at the ecosystem level for several types of pollutants (Nimis et al., 2002). They have been recently used for revising the critical levels for NH_3 in sensitive ecosystems (e.g. Geiser et al., 2010) and they have also been used for defining critical loads (e.g. for forest habitats) under the Air Quality Directive and UNECE/CLRTAP. Besides their use for evaluating effects in sensitive ecosystems, they can be used in other ecosystems as early-warning indicators since they are most likely the first species group to react. In the present chapter, methodological aspects for assessing epiphytic lichen diversity and possible relations between this diversity and nitrogen deposition are studied in 83 Level II plots from Czech Republic, Denmark, Finland, France, Italy, Germany, Netherlands, Slovak Republic, Spain, Switzerland. In particular, the question of the minimum number of trees that should be used in lichen diversity surveys at a large scale in different types of forest is tackled, and the possible relations of lichen functional groups with different levels of nitrogen deposition are explored.

7.2 Methods

7.2.1. Data

The evaluations are mainly based on the existing ForestBIOTA database. The dataset includes information on the occurrence and frequency of epiphytic lichen species at 83 Level II plots of the EU and ICP Forests networks located in 10 countries, which had been monitored within the ForestBIOTA project (www.forestbiota.org). The data were collected in the years 2004-2006 according to the ForestBIOTA sampling protocol (Stofer et al. 2003), which largely follows the basic principles described in Asta et al. (2002). Information on the ecology of lichen species follows ITALIC – The information system on Italian Lichens (Nimis & Martellos 2008) and Wirth (1995).

The data on the throughfall deposition of atmospheric pollutants (mainly nitrogen compounds) have been collected by different institutions collaborating within the ICP Forests and the LIFE+ FutMon project ("Further Development and Implementation of an EU-level Forest Monitoring System" - www.futmon.org) and other previous European and national projects.

The statistical analyses applied within each evaluation step are described in the following paragraphs.

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[3] *Swiss Federal Research Insitute WSL, Biodiversity and Conservation Biology, Zürcherstrasse 111, CH-8903 Birmensdorf, Switzeland*
[4] *Johann Heinrich von Thünen-Institute (vTI), Federal Research Institute for Rural Areas, Forestry and Fisheries, Hamburg, Germany*

7.2.2. Lichen diversity

The minimum number of trees that have to be sampled in order to obtain reliable estimates of lichen diversity in terms of species number and species composition was evaluated using a Jackknife approach. Rarefaction curves were calculated to determine the increase in the number of species sampled when the number of studied trees per plot increased (i.e., subsamples of 1 to *n*-1 trees, species present in all the studied trees per plot = *n* trees).
The Jaccard distance was calculated to check the similarity of the species composition of the tree subsamples with regard to the overall species composition of the plot. Calculations were performed using the software packages PC-ORD (McCune and Mefford, 1999) and Statistica 8.0 (StatSoft inc., 2007).

7.2.2.1 Jacknife estimations

Palmer (1990, 1991, 1995) compared several ways of estimating species richness of an area subsampled with smaller sample units. In these comparisons two jackknife estimators were included which were nonparametric resampling procedures. The approach is based on the assumption that the number of observed species in a subsample will typically be smaller than the true number of species. These jackknife estimators produce more accurate and less biased estimates, at least when subsampling a restricted area. The first-order jackknife estimator was used (Heltshe and Forrester 1983; Palmer 1990), which is defined as:

$$\text{Jacknife} = S + r1(n-1)/n$$

where S = the observed number of species, r1 = the number of species occurring in one sample unit (tree in this case), and n = the number of sample units (trees).

7.2.2.2 Jaccard distance measures

Within Jaccard distance measures, the average distance is calculated for each possible size of subsamples (i.e. from 1 tree vs. all sampled trees in the plot to “n-1 trees” vs. all sampled trees in the plot). If the average distance between a subsample and the whole sample is small, then one can conclude that the subsample is nearly as effective for characterizing the community as it is the whole sample. Like the species area curve, this is most informative for determining whether the community has been oversampled, compared to the expected subsample size. Among the several indices of similarity, the Jaccard distance measure was used, which is defined as:

$$1-2W/(A+B-W)$$

where W is the sum of shared abundances and A and B are the sums of abundances in individual sample units (trees).

7.2.3 Nitrogen deposition and lichen functional groups

The possible effects of nitrogen deposition on lichens, based on functional groups, were studied in a subset of 70 plots for which nitrogen deposition data were available. For the correlation with lichen data, mean deposition values (years 1996-2007) were used. The methodology for the calculation of mean deposition follows Fischer et al. (2010). The functional group “Oligotrophic lichens” was selected based on species ecology in Italy and Germany (Nimis & Martellos, 2008; Wirth 2005). Each lichen taxon was classified as oligotrophic, mesotrophic or nitrophitic (Annex). When the expert evaluations of nitrogen tolerance were in disagreement, the more conservative one was selected (e.g., Species X, which is “mesotrophyc” according to Wirth’s and “nitrophytic” according to Nimis’ index, was considered as “nitrophytic”).

Oligotrophic species are associated to weak or even absent levels of eutrophication, mainly caused by nitrogen compounds and/or alkaline dust. Since the fall in SO_2 concentrations, there has been an increase in lichen diversity especially in areas of former lichen “deserts”, but this did not follow expected patterns. Former oligotrophic species did not return, instead an increase in species associated with high nitrogen was observed. This shift towards nitrogen tolerant species was observed in several countries in Europe, characterized by the intensification of livestock and other agriculture practices.

7.3 Results: method development

An evaluation of the adequate number of trees to be sampled for obtaining reliable estimations of lichen diversity was carried out, in order to provide suggestions for increasing the cost-effectiveness of future sampling efforts and the overall quality of the results.

7.3.1 Representativeness of sampled trees

Within the ForestBIOTA project, the assessment of a minimum number of 12 trees per plot was prescribed. On average of all 83 plots nearly 14 species were determined on 12 trees (Fig. 7-1, left). An increase in the number of trees resulted in a negligible increase in species number. The peak of 16 species found on average on 15 trees is probably associated to a shift to other epiphytic lichen communities mainly observed in conifer forests by sampling more than 14 trees. When considering the total number of species, relevant differences have been observed between forest groups (Fig. 7-1, right). As a general outcome, the higher the number of trees per plot, the higher the overall number of recorded species, but, given the same number of trees, plots with broadleaved evergreen forests showed more species than plots with broadleaved deciduous tree species and conifers.

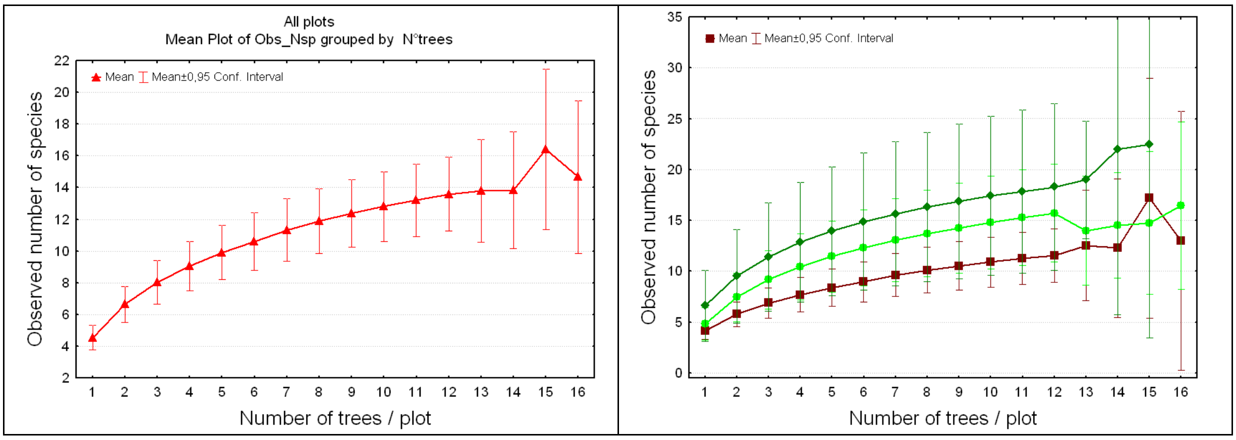

Figure 7-1: Rarefaction curves plotting the cumulated number of observed species vs. the number of sampled trees in the plot; left: all 83 plots; right: disaggregated analysis per forest type (light green: deciduous broadleaves forests; dark green: evergreen broadleaves; brown: conifers).

On the average, the Jacknife estimation suggests that by sampling 12 trees/plot 77% of the total number of species is found. This percentage did not increase significantly by adding more trees (Fig. 7-2, left). Some small differences have been observed between forest groups (Fig. 7-2, right) when considering the total number of observed species (conifers > broadleaves deciduous > broadleaves evergreen), but for 12 trees these differences were not statistically significant.

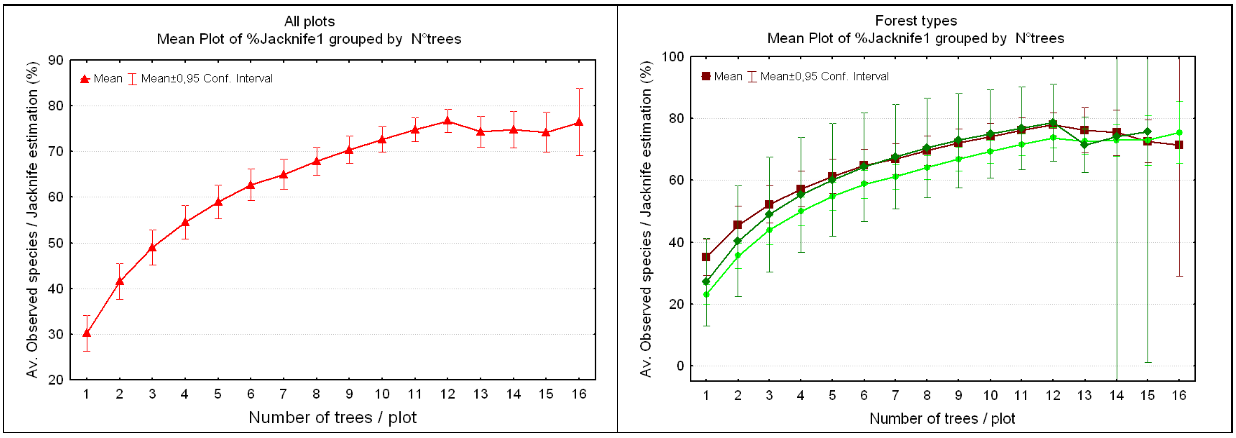

Figure 7-2: Trend of the observed/estimated species ratio, in relation with the number of the number of sampled trees in the plot; left: all 83 plots; right: disaggregated analysis per forest type (light green: deciduous broadleaves forests; dark green: evergreen broadleaves; brown: conifers).

Some minor differences also occur from country to country. With 12 trees, the percentage of lichen species found in the surveys was always > 70% of the total in all countries, with a minimum of 71% (Czech Republic) and a maximum of 89% (Spain).

With an increasing number of trees per plot, the Jaccard curve was continuously decreasing to 11 trees/plot (Fig. 7-3, left). As in many plots more than 12 trees were sampled, the results showed the improvement that can be expected with more than 12 sampled trees. On average, a reduced distance measure between subsample vs. total sample was not observed if there were less than 18 trees in the plot. This shows that, once 12 trees have been sampled, at least 18 trees have to be sampled in order to at least slightly increase the representativeness in species composition of the subsample.

Stratification of the data per forest type (Fig. 7-3, right), shows that, given the same number of trees, on plots with coniferous woodlands the lichen species composition on the trees was more similar than in broadleaves woodland. Nevertheless, for 11-12 sample trees these differences among forest groups were quite small.

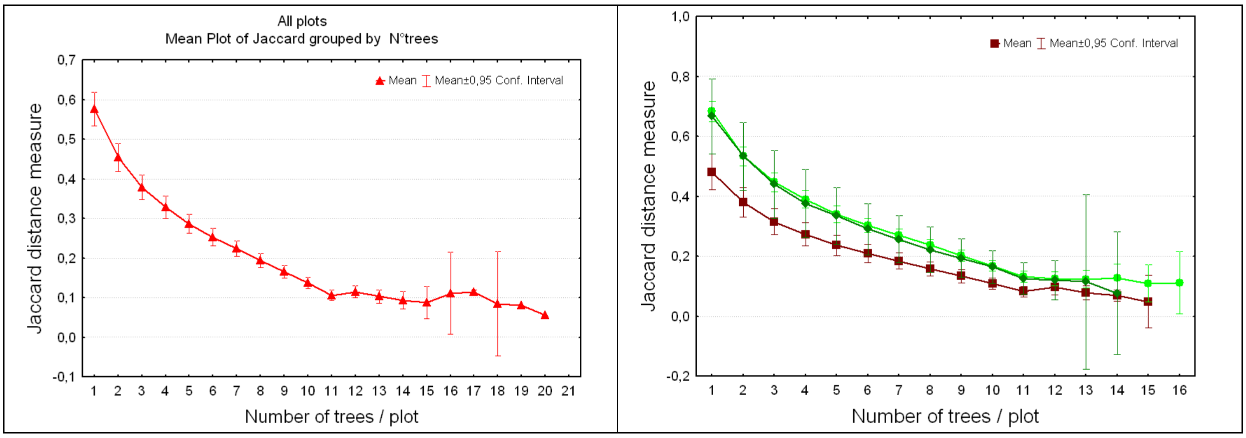

Figure 7-3: Jaccard distance measure in relation to the number of sampled trees per plot; left: All 83 plots; right: disaggregated analysis per forest type (light green: deciduous broadleaves forests; dark green: evergreen broadleaves; brown: conifers).

7.4 Results: effects of nitrogen deposition

A total of 292 epiphytic lichen species was determined on 1 155 trees of the ForestBIOTA plots. The total epiphytic lichen species richness on the observed plots was related to the average yearly total throughfall deposition, and significantly decreased for nitrogen deposition > 10 kg ha^{-1} yr^{-1} (Fig. 7-4).

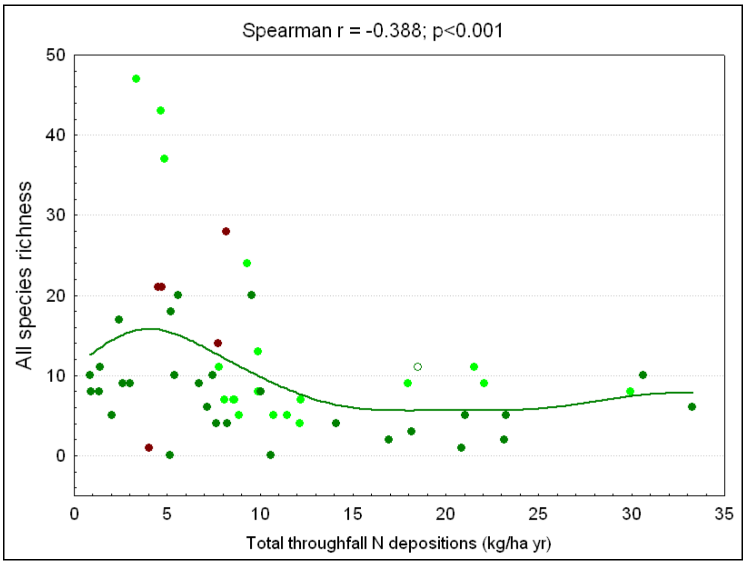

Figure 7-4: Biplot of the richness of all species as a function of the total throughfall nitrogen deposition at plot level. The fitting line is a distance weighted least square function with stiffness = 0.25. Plots (dots) are categorized according to the forest type: dark green: conifers; light green: deciduous broadleaves forests; brown: evergreen broadleaves forests; white: mixed forests.

7.4.1 Relation between nitrogen deposition and % oligotrophic macrolichen species

142 species corresponding to a share of 49% from all determined species were classified as oligotrophic. When focussing more specifically on aggregated descriptors of lichen communities (e.g. functional groups), closer links between lichen species composition and deposition could be determined. In particular, aggregated descriptors showed relations between nitrogen compounds (ammonium and nitrate) and the epiphytic lichen vegetation at plot level. A value of 40% of all lichens species on a plot being oligotrophs has been considered a critical threshold for nitrogen deposition (Geiser et al., 2010). When evaluating the percentage of oligotrophic macrolichens on the evaluated plots, a throughfall nitrogen deposition of ≈ 3.8 kg ha^{-1} yr^{-1} was related to the threshold of 40% oligotrophs (Fig. 7-5). The effects of NH_4^+ and NO_3^- on the percentage of oligotrophs seem to be quite similar (Figs. 7-6, 7-7).

As expected, the effects of nitrogen compounds were closely related to the amount of throughfall precipitation (Fig. 7-8). Although the correlation was always statistically significant, in drier plots a nitrogen deposition of > 9 kg ha^{-1} yr^{-1} led to a complete disappearance of oligotrophic species, whereas, given the same amount of nitrogen deposition, a modelled percentage of 20% oligotrophic species is still expected in plots with higher annual precipitation.

Moreover, significant differences between coniferous and broadleaved forests were observed. The effects of nitrogen deposition are by far less evident in the coniferous than in the latter forest types. The underlying ecological phenomena has still to be explored in more detail. A separate analysis of the results for different forest types might be appropriate. It might be hypothesized that a relevant synergistic interaction between nitrogen and light may more strongly limit the colonization by oligotrophs in deciduous broadleaved forests as compared to evergreen conifers. Forthcoming applications of this approach should consider differentiated interpretations, taking into account the amount of dry vs. wet deposition and the forest type.

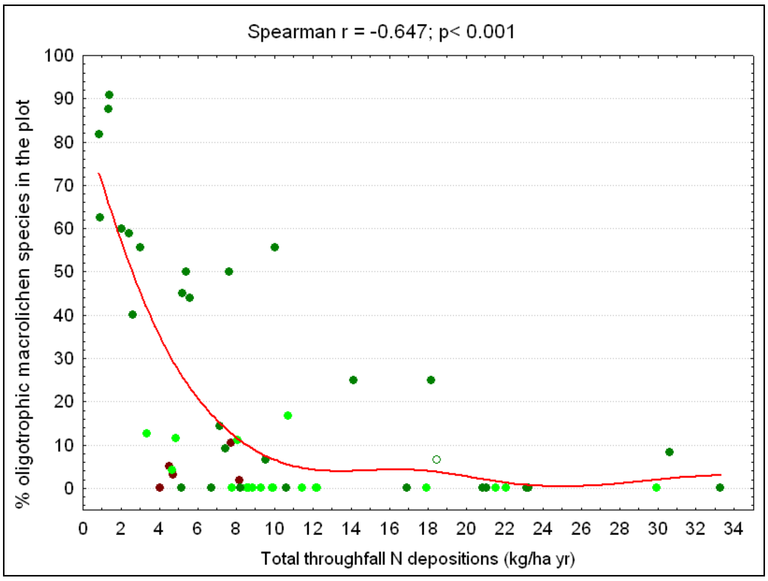

Figure 7-5: Biplot of the % oligotrophic macrolichens as a function of the total throughfall nitrogen deposition at plot level. The fitting line is a distance weighted least square function with stiffness = 0.25.

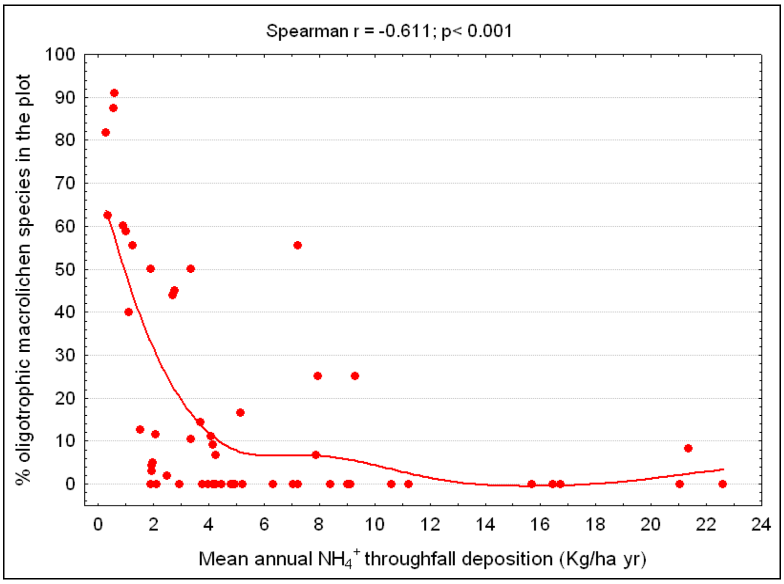

Figure 7-6: Biplot of the % oligotrophic macrolichens as a function of the mean annual NH_4^+ deposition at plot level. The fitting line is a distance weighted least square function with stiffness = 0.25.

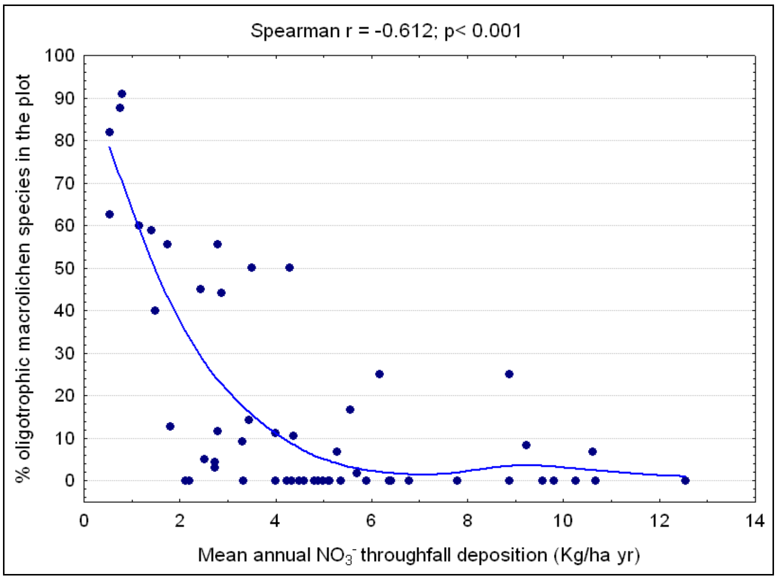

Figure 7-7: Biplot of the % oligotrophic macrolichens as a function of the mean annual NO_3^- deposition at plot level. The fitting line is a distance weighted least square function with stiffness = 0.25.

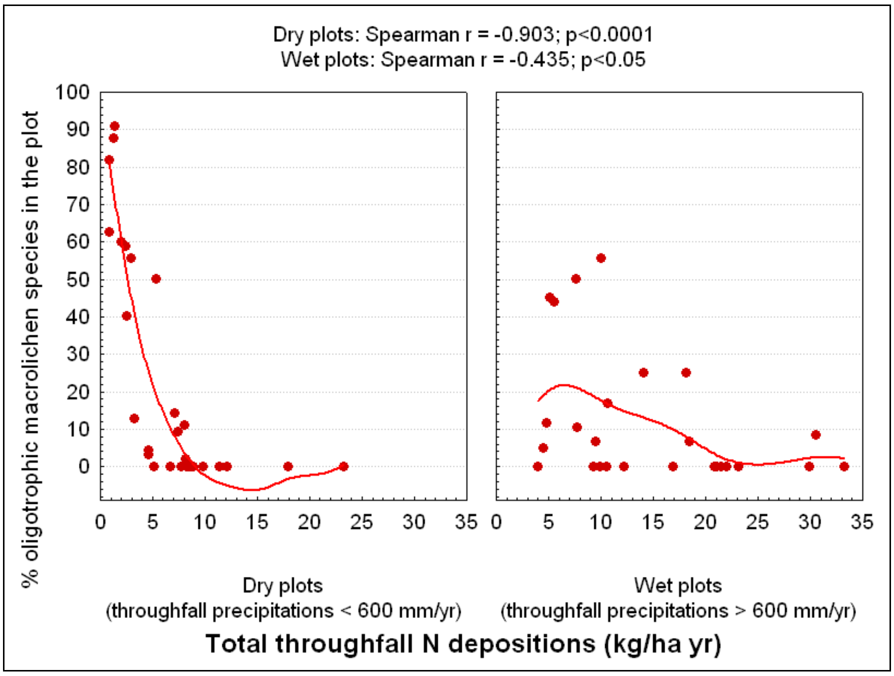

Figure 7-8: Percentage of oligotrophic macrolichens as a function of the total throughfall nitrogen deposition at plot level, I relation with the amount of precipitations. Left: dry plots; right: wet plots. The fitting line is a distance weighted least square function with stiffness = 0.25.

7.4.2 Mapping of the percentage of oligotrophic lichens

As far as the spatial pattern is concerned (Fig. 7-9), the higher values of % oligotrophs have been observed in Finland and in some Oromediterranean plots of Italy and Spain, whereas most of the plots in Central Europe (esp. Germany) were characterized by very low percentages of oligotrophic lichen species. Plots in Central Europe and the Netherlands are affected by relatively high nitrogen deposition values (Lorenz & Granke, 2009). Interestingly, in some plots of Italian Eastern Alps (IT8, IT17, IT27) and Spain (ES22, ES30) a mean annual N deposition over the critical value did not correspond to a decrease of oligotrophs under the 40% threshold.

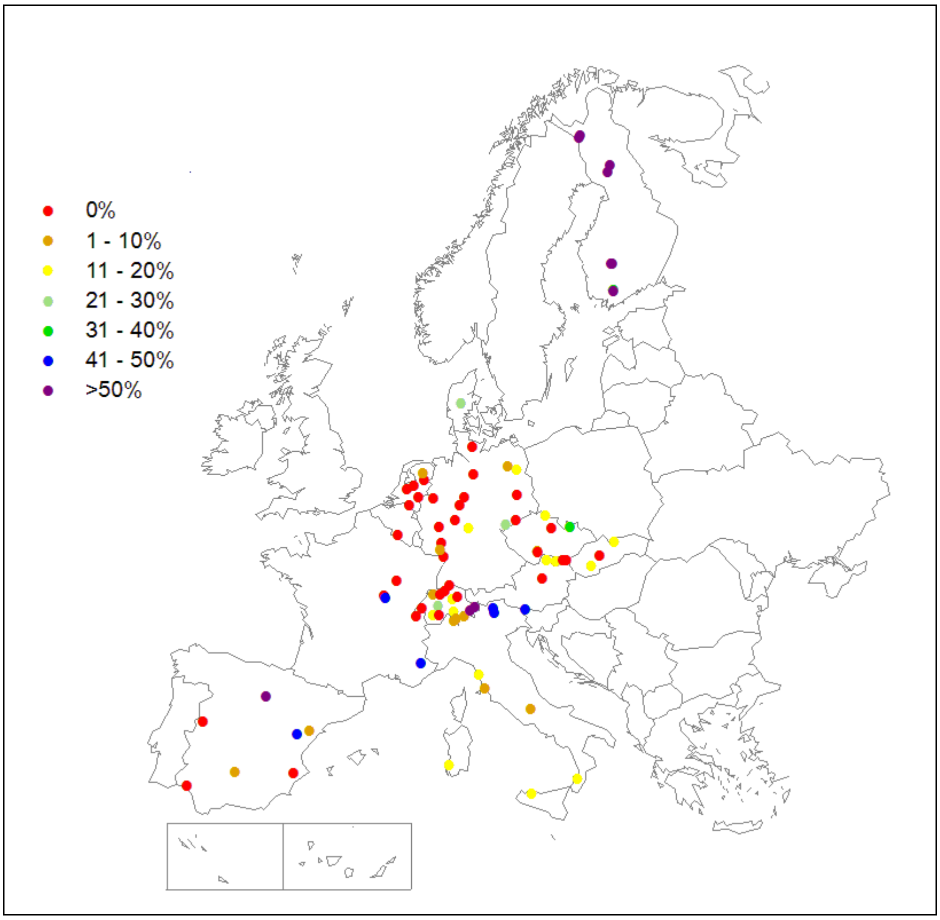

Figure 7-9: Percentage of oligotrophic macrolichens on the total number of species on selected ICP Forests Level II plots.

7.5 Discussion and conclusions

Based on the statistical analysis of the ForestBIOTA dataset, a number of conclusions for large-scale lichen biodiversity studies can be drawn as a basis for future lichen assessments on forest monitoring plots.

- Jacknife and Jaccard analyses showed that a sample of 12 trees per plot is enough for ensuring a sufficient sampling effort/species catching ratio in the considered forest types in Europe. On average, such a sample allowed to catch 77% of the total number of species estimated by Jacknife. This percentage did not increase significantly by adding more trees. Results of Jaccad analysis also suggest that with 12 trees the lichen species composition is also well characterized. Moreover the results were quite stable both considering conifer and broadleaved forests and no relevant differences have been observed between countries.

For the determination of critical thresholds of nitrogen deposition and for the further use of epiphytic lichens as bioindicators the following conclusions are relevant:

- The occurrence of oligotrophyc lichen species provided information on the actual impact of reduced nitrogen compounds (mainly ammonia). This functional group has been recently used to revise of the critical levels of NH_3 and of the nitrogen critical loads for forest habitats (Geiser et al., 2010). Based on the relative share of oligotrophic macrolichen species at plot level, it was shown that approx. 80% of the ForestBIOTA Level II plots are affected by an unsustainable throughfall nitrogen deposition, that can be suspected to cause a significant change of the expected composition of epiphytic lichen vegetation, together with a significant decrease in total lichen diversity, as well. About 58% of the plots, mainly located in Germany and other central European countries, showed a very low occurrence or even a complete lack of oligotrophic lichen species. Possible interactions between the effects of nitrogen on lichens and those caused by other pollutants and/or climatic factors have been mainly explored at local scale (e.g. Giordani 2006, 2007) and should be taken into account in forthcoming applications of this approach at European scale.

- Lichen functional groups for eutrophication and/or, more specifically, nitrogen tolerance have been extensively used to assess the critical level and critical load of nitrogen compounds in several forest ecosystems all over the world (Geiser et al., 2010, Fenn et al., 2008, Geiser and Neitlich, 2007, Pinho et al., 2008a, Pinho et al., 2008b, Pinho et al., 2009). According to Geiser et al. (2010), the percentage of oligotrophic macrolichen species within the plot was used as indicator of alteration caused by the deposition of nitrogen compounds. Following these authors the critical threshold indicating a significant response of lichen species composition to nitrogen has been set when more than 40% of all lichens species were oligotrophs. Geiser et al. (2010) found, for wet deposition, a critical load ranging from 0.7 to 4.4 kg ha^{-1} yr^{-1}, depending on the amount of precipitation in conifer forests of the Pacific North West of USA. The results for European ForestBiota Level II plots are in accordance with these findings. A percentage of 40% oligotrophs seemed to be related to throughfall nitrogen deposition of approx. 3.8 kg ha^{-1} yr^{-1}. The effects of NH_4^+ and NO_3^- deposition on the percentage of oligotrophs are supposed to be similar. Nevertheless, a contribution of other influencing factors (e.g. other pollutants or climate) can not yet be excluded and more studies are still needed at European level for a better understanding of the underlying cause-effect relationships.
- Based on these findings, the use of lichens as bioindicators is recommended for inclusion in the monitoring activities both on Level I and Level II plots, in order to quantify effects of nitrogen atmospheric deposition on sensitive forest ecosystems components even on plots without direct measurements of nitrogen deposition.

7.6 References

Asta, J., Erhardt, W., Ferretti, M., Fornasier, F., Kirschbaum, U., Nimis, P.L., Purvis, O.W., Pirintsos, S., Scheidegger, C., Van Haluwyn, C. & Wirth, V. (2002) Mapping lichen diversity as an indicator of environmental quality. Monitoring with Lichens - Monitoring Lichens (eds P. L. Nimis, C. Scheidegger & P. A. Wolseley), pp. 273-279.

Fenn, M.E., Jovan, S., Yuan, F., Geiser, L., Meixner, T. & Gimeno, B.S. (2008) Empirical and simulated critical loads for nitrogen deposition in California mixed conifer forests. Environmental Pollution, 155, 492-511.

Fischer, R., Lorenz, M., Granke, O., Mues, V., Iost S., Van Dobben, H., Reinds, G.J., De Vries, W. (2010). Forest Condition in Europe, 2010 Technical Report of ICP Forests. Work Report of the Institute for World Forestry 2010/1. ICP Forests, Hamburg, 2010, 175pp.

Geiser, L.H., Jovan, S.E., Glavich, D.A. & Porter, M.K. (2010) Lichen-based critical loads for atmospheric nitrogen deposition in Western Oregon and Washington Forests, USA. Environmental Pollution, 158, 2412-2421.

Geiser, L.H. & Neitlich, P.N. (2007) Pollution and climate gradients in western Oregon and Washington indicated by epiphytic macrolichens. Environmental Pollution, 145, 203-218.

Giordani, P. (2006) Variables influencing the distribution of epiphytic lichens in heterogeneous areas: A case study for Liguria, NW Italy. Journal of Vegetation Science, 17: 195-206.

Giordani, P. (2007) Is the diversity of epiphytic lichens a reliable indicator of air pollution? A case study from Italy. Environmental Pollution, 146: 317-323.

Heltshe, J.F. & Forrester, N. E. (1983) Estimating species richness using the jackknife procedure. Biometrics 39, 1-12.

Lorenz M., Granke O.(2009) Deposition measurements and critical loads calculations: monitoring data, results and perspective. iForest, doi: 10.3832/ifor0478-002

McCune, B. & Mefford, M.J. (1999) Multivariate Analysis of Ecological Data. Version 4.25. - MjM Software, Gleneden Beach, Oregon, U.S.A.

Nimis, P.L., Scheidegger, C. & Wolseley, P.A. (2002). Monitoring with lichens : monitoring lichens. Kluwer Academic published in association with the NATO Scientific Affairs Division, Dordrecht ; London.

Nimis, P.L., Martellos, S. (2008) ITALIC - The Information System on Italian Lichens. Version 4.0. University of Trieste, Dept. of Biology, IN4.0/1. Available from: http://dbiodbs.univ.trieste.it/.

Palmer, M.W. (1990) The estimation of species richness by extrapolation. Ecology 71, 1195-1198.

Palmer, M.W. (1991) Estimating species richness: the second-order jackknife reconsidered. Ecology 72,1512-1513.

Palmer, M.W. (1995) How should one count species? Natural Areas Journal 15, 124-135.

Pinho, P., Augusto, S., Maguas, C., Pereira, M.J., Soares, A. & Branquinho, C. (2008a) Impact of neighbourhood land-cover in epiphytic lichen diversity: Analysis of multiple factors working at different spatial scales. Environmental Pollution, 151, 414-422.

Pinho, P., Augusto, S., Martins-Loucao, M.A., Pereira, M.J., Soares, A., Maguas, C. & Branquinho, C. (2008b) Causes of change in nitrophytic and oligotrophic lichen species in a Mediterranean climate: Impact of land cover and atmospheric pollutants. Environmental Pollution, 154, 380-389.

Pinho, P., Branquinho, C., Cruz, C., Tang, S., Dias, T.R., AP, Máguas, C., Martins-Loução, M., Sutton, M. (2009) Assessment of critical levels of atmospherically ammonia for lichen diversity in cork-oak woodland, Portugal. In: Sutton, M., Reis, S., Baker, S. (Eds.), Atmospheric Ammonia - Detecting emission changes and environmental impacts - Results of an Expert Workshop under the Convention on Long-range Transboundary Air Pollution. Springer, pp. 109-119.

StatSoft, Inc. (2007) STATISTICA (data analysis software system), version 8.0. www.statsoft.com.

Stofer S., Catalayud V., Ferretti M., Fischer R., Giordani P., Keller C., Stapper N. & Scheidegger C. (2003) Epiphytic Lichen Monitoring within the EU/ICP Forests Biodiversity Test-Phase on Level II plots. (http//www.forest-biota.org).

Wirth, V. (1995) Die Flechten Baden-Württembergs. Teil 1–2. Ulmer, Stuttgart.

7.7 Annex

Eco-functional traits for the lichen species observed during the ForestBIOTA test phase.

Eutrophycation indices: oligo = oligotrophic; meso = mesotrophic; nitro = nitrophytic.
Growth form. Microlichens: Lepr = leprose; Cr = crustose; cr.pl = crustose placodiomorph; sq = squamulose; Macrolichens: Fol.n = foliose with narrow lobes (*Physcia*-type); Fol.b = foliose with broad lobes (*Parmelia*-type); Frut = fruticose; Fut.f = fruticose filamentous.
Photobiont: Ch = chlorococcoid green algae; Tr = trentepohlioid algae; Cy.h = cyanobacteria, filamentous (e.g. *Nostoc*, *Scytonema*).
Reproductive strategy: S = mainly sexual; A.s = mainly asexual by soredia; A.i = mainly asexual by isidia; A.f = mainly asexual, by thallus fragmentation.

ID ForestBIOTA	Taxon (ForestBIOTA nomenclature)	Nimis' eutrophycation index (Nimis & Martellos 2008)	Wirth's eutrophycation index (Wirth 2005)	Growth form	Photo-biont	Reproduc-tive stategy
10	*Acrocordia cavata*	oligo		Cr	Tr	S
12	*Acrocordia gemmata*	oligo	meso	Cr	Tr	S
30	*Amandinea punctata*	nitro	meso	Cr	Ch	S
47	*Anaptychia ciliaris*	meso	meso	Frut	Ch	S
66	*Anisomeridium polypori*	oligo		Cr	Tr	S
102	*Arthonia cinnabarina*	oligo	oligo	Cr	Tr	S
109	*Arthonia didyma*	meso		Cr	Tr	S
140	*Arthonia leucopellaea*	oligo	oligo	Cr	Tr	S
144	*Arthonia mediella*	oligo		Cr	Tr	S
163	*Arthonia punctiformis*	oligo		Cr	Tr	S
164	*Arthonia radiata*	meso	oligo	Cr	Tr	S
168	*Arthonia spadicea*	oligo	oligo	Cr	Tr	S
170	*Arthonia stellaris*	oligo		Cr	Tr	S
178	*Arthonia vinosa*	oligo	oligo	Cr	Tr	S
183	*Arthonia sp.*	oligo		Cr	Tr	S
211	*Arthopyrenia persoonii*	oligo		Cr	Tr	S
227	*Arthopyrenia sp.*	oligo		Cr	Tr	S
236	*Arthothelium ruanum*	oligo	oligo	Cr	Tr	S
396	*Bacidia chloroticula*	oligo		Cr	Ch	S
402	*Bacidia fraxinea*	oligo		Cr	Ch	S
417	*Bacidia naegelii*	meso		Cr	Ch	S
419	*Bacidia neosquamulosa*	oligo		Cr	Ch	S
426	*Bacidia rosella*	meso		Cr	Ch	S
427	*Bacidia rubella*	meso	meso	Cr	Ch	S
437	*Bacidia subincompta*	oligo	oligo	Cr	Ch	S
447	*Bacidia sp.*	oligo		Cr	Ch	S
451	*Bacidina sp.*	oligo		Cr	Ch	S
453	*Bactrospora dryina*	oligo	oligo	Cr	Tr	S
536	*Bryoria capillaris*	oligo	oligo	Frut.f	Ch	A.s
539	*Bryoria furcellata*	oligo		Frut.f	Ch	A.s
540	*Bryoria fuscescens*	oligo	oligo	Frut.f	Ch	A.s
543	*Bryoria implexa*	oligo		Frut.f	Ch	A.s
559	*Bryoria sp.*	oligo		Frut.f	Ch	
568	*Buellia arborea*	oligo		Cr	Ch	S
581	*Buellia disciformis*	oligo	oligo	Cr	Ch	S
600	*Buellia griseovirens*	oligo	oligo	Cr	Ch	A.s
634	*Buellia schaereri*	oligo		Cr	Ch	S
675	*Calicium abietinum*	oligo		Cr	Ch	S

682	*Calicium glaucellum*	oligo	oligo	Cr	Ch	S
685	*Calicium montanum*	oligo		Cr	Ch	S
692	*Calicium trabinellum*	oligo	oligo	Cr	Ch	S
693	*Calicium viride*	oligo	oligo	Cr	Ch	S
694	*Calicium sp.*	oligo		Cr	Ch	S
730	*Caloplaca cerina*	nitro	meso	Cr	Ch	S
734	*Caloplaca cerinella*	nitro		Cr	Ch	S
743	*Caloplaca citrina*	nitro	nitro	Cr	Ch	S
766	*Caloplaca ferruginea*	meso		Cr	Ch	S
769	*Caloplaca flavorubescens*	meso		Cr	Ch	S
782	*Caloplaca herbidella*	nitro	oligo	Cr	Ch	A.i
808	*Caloplaca lobulata*	meso		Cr.pl	Ch	S
836	*Caloplaca pyracea*	nitro		Cr	Ch	S
891	*Candelaria concolor*	nitro	meso	Fol. n	Ch	A.s
906	*Candelariella reflexa*	nitro	meso	Cr	Ch	A.s
914	*Candelariella xanthostigma*	meso	meso	Cr	Ch	S
915	*Candelariella sp.*	nitro		Cr	Ch	
975	*Catillaria nigroclavata*	meso		Cr	Ch	S
979	*Catillaria pulverea*	oligo		Cr	Tr	A.s
1006	*Cetraria chlorophylla*	oligo	oligo	Fol.b	Ch	A.s
1019	*Cetraria laureri*	oligo		Fol.b	Ch	A.s
1026	*Cetraria sepincola*	oligo	oligo	Frut	Ch	S
1032	*Cetrelia olivetorum*	oligo		Fol.b	Ch	A.s
1037	*Chaenotheca chrysocephala*	oligo	oligo	Cr	Ch	S
1039	*Chaenotheca ferruginea*	oligo	oligo	Cr	Ch	S
1045	*Chaenotheca phaeocephala*	oligo	oligo	Cr	Ch	S
1049	*Chaenotheca trichialis*	oligo	oligo	Cr	Ch	S
1051	*Chaenotheca sp.*	oligo				
1064	*Chrysothrix candelaris*	oligo	oligo	Lepr	Ch	A.s
1085	*Cladonia caespiticia*	oligo	oligo	Frut/sq	Ch	
1094	*Cladonia chlorophylla s.l.*	oligo		Frut/sq	Ch	
1100	*Cladonia coniocraea*	meso	oligo	Frut/sq	Ch	A.s
1104	*Cladonia cornuta*	oligo		Frut/sq	Ch	
1117	*Cladonia digitata*	oligo	oligo	Frut/sq	Ch	A.s
1120	*Cladonia fimbriata*	meso	oligo	Frut/sq	Ch	A.s
1137	*Cladonia macilenta*	oligo	oligo	Frut/sq	Ch	S
1153	*Cladonia parasitica*	oligo	oligo	Frut/sq	Ch	S
1158	*Cladonia polydactyla*	oligo	oligo	Frut/sq	Ch	
1172	*Cladonia squamosa*	oligo	oligo	Frut/sq	Ch	
1196	*Cladonia sp.*	oligo		Frut/sq	Ch	
1256	*Collema furfuraceum*	meso		Fol.b	Cy.h	A.i
1278	*Collema subnigrescens*	meso		Fol.b	Cy.h	S
1390	*Dimerella pineti*	oligo	oligo	Cr	Tr	S
1394	*Diploicia canescens*	nitro	nitro	Cr.pl	Ch	A.s
1475	*Evernia divaricata*	oligo	oligo	Frut	Ch	A.f
1479	*Evernia prunastri*	meso	oligo	Frut	Ch	A.s
1497	*Fellhanera viridisorediata*	oligo		Cr	Ch	A.s
1523	*Fuscidea arboricola*	oligo		Cr	Ch	S
1531	*Fuscidea cyathoides s.l.*	oligo		Cr	Ch	S
1545	*Fuscidea pusilla*	oligo		Cr	Ch	S
1568	*Graphis scripta*	oligo	oligo	Cr	Tr	S
1572	*Gyalecta flotowii*	oligo		Cr	Tr	S
1584	*Gyalecta truncigena*	oligo		Cr	Tr	S
1602	*Gyalideopsis*	oligo		Cr	Ch	A.i

	anastomosans					
1614	*Haematomma ochroleucum*	oligo	oligo	Cr	Ch	A.s
1657	*Heterodermia obscurata*	meso		Fol.n	Ch	A.s
1673	*Hyperphyscia adglutinata*	nitro	meso	Fol.n	Ch	A.s
1677	*Hypocenomyce caradocensis*	oligo	oligo	Sq	Ch	S
1680	*Hypocenomyce friesii*	oligo		Sq	Ch	
1682	*Hypocenomyce praestabilis*	oligo		Sq	Ch	A.s
1683	*Hypocenomyce scalaris*	oligo	oligo	Sq	Ch	A.s
1684	*Hypocenomyce sorophora*	oligo		Sq	Ch	A.s
1685	*Hypocenomyce stoechadiana*	meso		Sq	Ch	S
1690	*Hypogymnia bitteri*	oligo		Fol.n	Ch	A.s
1691	*Hypogymnia farinacea*	oligo	oligo	Fol.n	Ch	A.s
1696	*Hypogymnia physodes*	oligo	oligo	Fol.n	Ch	A.s
1698	*Hypogymnia tubulosa*	oligo	oligo	Fol.n	Ch	A.s
1701	*Hypogymnia sp.*	oligo		Fol.n	Ch	
1707	*Hypotrachyna sp.*	oligo		Fol.b	Ch	
1711	*Imshaugia aleurites*	oligo	oligo	Fol.n	Ch	A.i
1740	*Koerberia biformis*	oligo		Fol.n	Cy.h	S
1770	*Lecanactis abietina*	oligo	oligo	Cr	Tr	S
1784	*Lecanactis patellarioides*	oligo		Cr	Tr	S
1847	*Lecanora albella*	oligo	oligo	Cr	Ch	S
1850	*Lecanora allophana*	meso	meso	Cr	Ch	A.s
1850	*Lecanora allophana*	meso	meso	Cr	Ch	S
1854	*Lecanora argentata*	oligo	oligo	Cr	Ch	S
1864	*Lecanora cadubriae*	oligo		Cr	Ch	S
1868	*Lecanora carpinea*	meso	oligo	Cr	Ch	S
1874	*Lecanora cf. phaeostigma*	oligo		Cr	Ch	
1875	*Lecanora chlarotera*	nitro	meso	Cr	Ch	S
1882	*Lecanora circumborealis*	oligo		Cr	Ch	S
1890	*Lecanora conizaeoides*	meso	meso	Cr	Ch	S
1911	*Lecanora expallens*	oligo	meso	Cr	Ch	A.s
1932	*Lecanora hagenii*	nitro	nitro	Cr	Ch	S
1936	*Lecanora horiza aggr.*	meso		Cr	Ch	S
1944	*Lecanora intumescens*	oligo	oligo	Cr	Ch	S
1988	*Lecanora phaeostigma*	oligo		Cr	Ch	
2002	*Lecanora pulicaris*	oligo	oligo	Cr	Ch	S
2021	*Lecanora saligna*	oligo	meso	Cr	Ch	S
2045	*Lecanora strobilina*	oligo		Cr	Ch	S
2050	*Lecanora subcarpinea*	oligo		Cr	Ch	S
2052	*Lecanora subintricata*	oligo		Cr	Ch	S
2057	*Lecanora subrugosa*	oligo		Cr	Ch	S
2065	*Lecanora symmicta aggr.*	oligo		Cr	Ch	S
2066	*Lecanora symmicta var. aitema*	oligo		Cr	Ch	S
2077	*Lecanora umbrina*	nitro		Cr	Ch	S

2082	*Lecanora varia*	oligo	oligo	Cr	Ch	S
2089	*Lecanora sp.*	oligo		Cr	Ch	S
2100	*Lecidea amaurospoda*	meso		Cr	Ch	S
2180	*Lecidea hypopta*	oligo		Cr	Ch	S
2231	*Lecidea nylanderi*	oligo		Cr	Ch	A.s
2328	*Lecidea sp.*	oligo		Cr	Ch	S
2346	*Lecidella elaeochroma*	nitro	meso	Cr	Ch	S
2346	*Lecidella elaeochroma*	meso	meso	Cr	Ch	A.s
2351	*Lecidella flavosorediata*	nitro		Cr	Ch	A.s
2362	*Lecidella sp.1*	nitro		Cr	Ch	S
2363	*Lecidella sp.2*	nitro		Cr	Ch	S
2364	*Lecidella sp.3*	nitro		Cr	Ch	S
2405	*Lepraria elobata*	oligo		Lepr	Ch	A.s
2408	*Lepraria incana*	oligo	oligo	Lepr	Ch	A.s
2409	*Lepraria jackii*	oligo		Lepr	Ch	A.s
2411	*Lepraria lobificans*	oligo	oligo	Lepr	Ch	A.s
2416	*Lepraria rigidula*	meso		Lepr	Ch	A.s
2417	*Lepraria sp.1*	oligo		Lepr	Ch	A.s
2420	*Lepraria sp.*	oligo		Lepr	Ch	A.s
2465	*Leptogium lichenoides*	meso	nitro	Sq	Cy.h	S
2489	*Leptogium sp.*	oligo		Fol.b	Cy.h	
2507	*Letharia vulpina*	oligo	oligo	Frut	Ch	A.s
2551	*Lobaria pulmonaria*	oligo	meso	Fol.b	Ch	A.s
2567	*Loxospora elatina*	oligo	oligo	Cr	Ch	A.s
2578	*Megalaria sp.*	oligo		Cr		
2619	*Melaspilea sp.*	oligo		Cr		
2622	*Menegazzia terebrata*	oligo	oligo	Fol.b	Ch	A.s
2635	*Micarea cinerea*	oligo		Cr	Ch	S
2652	*Micarea lignaria*	oligo	oligo	Cr	Ch	S
2658	*Micarea melaena*	oligo	oligo	Cr	Ch	S
2666	*Micarea nitschkeana*	oligo		Cr	Ch	S
2671	*Micarea peliocarpa*	oligo	oligo	Cr	Ch	S
2672	*Micarea prasina*	oligo	oligo	Cr	Ch	S
2689	*Micarea sp.*	oligo		Cr	Ch	S
2732	*Mycoblastus affinis*	oligo		Cr	Ch	S
2735	*Mycoblastus fucatus*	oligo		Cr	Ch	A.s
2736	*Mycoblastus sanguinarius*	oligo	oligo	Cr	Ch	S
2740	*Mycomicrothelia sp.*	oligo		Cr		S
2767	*Nephroma laevigatum*	oligo	meso	Fol.b	Cy.h	S
2775	*Normandina pulchella*	meso	meso	Sq	Ch	A.s
2782	*Ochrolechia alboflavescens*	oligo	oligo	Cr	Ch	A.s
2783	*Ochrolechia androgyna*	oligo	oligo	Cr	Ch	A.s
2784	*Ochrolechia arborea*	meso	meso	Cr	Ch	A.s
2796	*Ochrolechia microstictoides*	oligo	oligo	Cr	Ch	A.s
2798	*Ochrolechia pallescens*	oligo	oligo	Cr	Ch	S
2806	*Ochrolechia tartarea*	oligo		Cr	Ch	S
2808	*Ochrolechia turneri*	meso	meso	Cr	Ch	A.s
2823	*Opegrapha atra*	oligo	oligo	Cr	Tr	S
2830	*Opegrapha celtidicola*	oligo		Cr	Tr	S
2862	*Opegrapha rufescens*	oligo	oligo	Cr	Tr	S
2874	*Opegrapha varia*	oligo	oligo	Cr	Tr	S
2879	*Opegrapha viridis*	oligo	oligo	Cr	Tr	S

2880	*Opegrapha vulgata*	oligo		Cr	Tr	S
2883	*Opegrapha sp.*	oligo		Cr	Tr	S
2905	*Pannaria conoplea*	oligo	meso	Fol.n	Cy.h	S
2913	*Pannaria mediterranea*	oligo		Sq	Cy.h	A.s
2923	*Parmelia acetabulum*	meso	meso	Fol.b	Ch	S
2929	*Parmelia caperata*	meso	oligo	Fol.b	Ch	A.s
2938	*Parmelia elegantula*	meso	oligo	Fol.b	Ch	A.i
2941	*Parmelia exasperatula*	meso	meso	Fol.b	Ch	A.i
2944	*Parmelia glabra*	meso	meso	Fol.b	Ch	S
2947	*Parmelia glabratula ssp. fuliginosa*	meso		Fol.b	Ch	A.i
2955	*Parmelia laciniatula*	meso	meso	Fol.b	Ch	A.i
2956	*Parmelia laevigata*	oligo		Fol.b	Ch	A.s
2966	*Parmelia pastillifera*	meso	meso	Fol.b	Ch	A.i
2978	*Parmelia reticulata*	oligo		Fol.b	Ch	A.s
2982	*Parmelia saxatilis*	meso	oligo	Fol.b	Ch	A.i
2994	*Parmelia subaurifera*	meso		Fol.b	Ch	A.s
2995	*Parmelia submontana*	oligo	oligo	Fol.b	Ch	A.i
2996	*Parmelia subrudecta*	meso		Fol.b	Ch	A.s
2998	*Parmelia sulcata*	meso	meso	Fol.b	Ch	A.s
3000	*Parmelia tiliacea*	meso	meso	Fol.b	Ch	A.i
3003	*Parmelia sp.*	meso		Fol.b	Ch	
3010	*Parmeliopsis ambigua*	oligo	oligo	Fol.n	Ch	A.s
3011	*Parmeliopsis hyperopta*	oligo	oligo	Fol.n	Ch	A.s
3017	*Parmotrema chinense*	oligo	oligo	Fol.b	Ch	A.s
3019	*Parmotrema stuppeum*	oligo		Fol.b	Ch	A.s
3021	*Parmotrema sp.*	oligo		Fol.b	Ch	
3050	*Peltigera praetextata*	oligo	meso	Fol.b	Cy.h	A.i
3069	*Pertusaria albescens*	meso	meso	Cr	Ch	A.s
3071	*Pertusaria albescens var. corallina*	meso		Cr	Ch	A.s
3074	*Pertusaria amara*	meso	oligo	Cr	Ch	A.s
3086	*Pertusaria coccodes*	meso	oligo	Cr	Ch	A.i
3092	*Pertusaria coronata*	oligo	oligo	Cr	Ch	A.i
3103	*Pertusaria flavida*	oligo	oligo	Cr	Ch	A.s
3110	*Pertusaria hemisphaerica*	oligo	oligo	Cr	Ch	A.s
3112	*Pertusaria hymenea*	oligo	oligo	Cr	Ch	S
3122	*Pertusaria leioplaca*	oligo	oligo	Cr	Ch	S
3137	*Pertusaria pertusa*	oligo	oligo	Cr	Ch	S
3145	*Pertusaria pustulata*	oligo		Cr	Ch	S
3162	*Pertusaria sp.*	meso		Cr	Ch	
3179	*Phaeophyscia endophoenicea*	meso	meso	Fol.n	Ch	A.s
3180	*Phaeophyscia hirsuta*	nitro		Fol.n	Ch	A.s
3185	*Phaeophyscia orbicularis*	nitro	nitro	Fol.n	Ch	A.s
3194	*Phlyctis agelaea*	oligo	oligo	Cr	Ch	S
3195	*Phlyctis argena*	oligo	oligo	Cr	Ch	A.s
3203	*Physcia adscendens*	nitro	nitro	Fol.n	Ch	A.s
3204	*Physcia aipolia*	nitro	meso	Fol.n	Ch	S
3226	*Physcia semipinnata*	meso		Fol.n	Ch	S
3231	*Physcia tenella*	nitro		Fol.n	Ch	A.s
3239	*Physcia sp.*	meso		Fol.n	Ch	
3241	*Physconia distorta*	nitro	nitro	Fol.n	Ch	S
3242	*Physconia enteroxantha*	nitro	meso	Fol.n	Ch	A.s
3248	*Physconia perisidiosa*	meso	meso	Fol.n	Ch	A.s

3251	*Physconia venusta*	oligo		Fol.n	Ch	S
3291	*Placynthiella dasaea*	oligo		Cr		
3293	*Placynthiella icmalea*	oligo	oligo	Cr		
3317	*Platismatia glauca*	oligo	oligo	Fol.b	Ch	A.i
3442	*Porina aenea*	oligo	oligo	Cr	Tr	S
3463	*Porina leptalea*	oligo		Cr	Tr	S
3480	*Porina sp.*	oligo		Cr	Tr	S
3525	*Protoparmelia hypotremella*	oligo		Cr	Tr	S
3546	*Pseudevernia furfuracea*	oligo	oligo	Fol.b	Ch	A.i
3546	*Pseudevernia furfuracea*	oligo	oligo	Fol.b	Ch	A.i
3664	*Pyrenula nitida*	oligo	oligo	Cr	Tr	S
3665	*Pyrenula nitidella*	oligo	oligo	Cr	Tr	S
3673	*Pyrrhospora quernea*	meso		Cr	Ch	A.s
3691	*Ramalina arabum*	oligo		Frut	Ch	
3709	*Ramalina farinacea*	oligo	oligo	Frut	Ch	A.s
3715	*Ramalina fastigiata*	meso	meso	Frut	Ch	S
3717	*Ramalina fraxinea*	meso	meso	Frut	Ch	S
3726	*Ramalina obtusata*	oligo		Frut	Ch	A.s
3924	*Rinodina exigua*	meso	nitro	Cr	Ch	S
3980	*Rinodina pyrina*	meso	meso	Cr	Ch	S
4006	*Rinodina sp.*	nitro		Cr	Ch	
4022	*Ropalospora viridis*	oligo	oligo	Cr	Ch	A.s
4061	*Schismatomma decolorans*	meso		Cr	Tr	A.s
4066	*Schismatomma pericleum*	oligo	oligo	Cr	Tr	S
4079	*Scoliciosporum chlorococcum*	meso	meso	Cr	Ch	S
4085	*Scoliciosporum sarothamni*	oligo		Cr	Ch	A.s
4087	*Scoliciosporum umbrinum*	meso	meso	Cr	Ch	S
4088	*Scoliciosporum sp.*	meso		Cr	Ch	S
4242	*Sticta limbata*	oligo		Fol.b	Cy.h	A.s
4258	*Strigula affinis*	meso		Cr	Tr	S
4267	*Strigula stigmatella*	oligo		Cr	Tr	S
4271	*Strigula sp.*	oligo		Cr	Tr	S
4282	*Teloschistes chrysophthalmus*	meso		Frut	Ch	S
4290	*Tephromela atra*	oligo	meso	Cr	Ch	S
4432	*Thelopsis sp.*	oligo				
4435	*Thelotrema lepadinum*	oligo	oligo	Cr	Tr	S
4512	*Trapelia corticola*	oligo		Cr	Ch	A.s
4520	*Trapeliopsis flexuosa*	oligo		Cr	Ch	S
4523	*Trapeliopsis granulosa*	oligo	oligo	Cr	Ch	S
4599	*Usnea ceratina*	oligo		Frut.f	Ch	A.f
4605	*Usnea filipendula*	oligo	oligo	Frut.f	Ch	A.s
4615	*Usnea hirta*	oligo	oligo	Frut.f	Ch	A.s
4639	*Usnea sp.*	oligo		Frut.f	Ch	
4884	*Vulpicida pinastri*	oligo	oligo	Fol.b	Ch	A.s
4899	*Xanthoria parietina*	nitro	nitro	Fol.b	Ch	S
4913	*Zamenhofia coralloidea*	oligo		Cr	Tr	S
7116	*Bacidia adastra*	oligo		Cr	Ch	
7118	*Lecanora strobilina aggr.*	oligo		Cr	Ch	S
7119	*Caloplaca ferruginea aggr.*	meso		Cr	Ch	S
7120	*cf. Lecidea nylanderi*	meso		Cr	Ch	
4918	*indet. species*	N/A	N/A	N/A	N/A	N/A