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Report on models, tools, and indices integrated to the BioFresh portal

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BIOFRESH

Biodiversity of Freshwater Ecosystems: Status, Trends, Pressures, and Conservation Priorities

Project no. 226874

Large scale collaborative project

Report on models, tools, and indices integrated to the BioFresh portal

Deliverable number	D4.2; D5.2 and D6.2
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RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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In case the report consists of the delivery of materials (guidelines, manuscripts, etc)

Delivery name	Delivery name	From Partner	To Partner

Introduction

This consolidated report covering D4.2, D5.2 and D6.2 is the first report of a total of 3 reports on the integration of the results of the science Work Packages 4-7 in the data portal. This report is primarily an inventory of the ongoing (modelling) work, an evaluation of the possibilities and relevance for integration in the portal and the future perspectives and planning for this integration.

While this report focuses primarily on the results from the science Work Packages, tools, models and indices from other WPs are included here in order to provide a consistent overview of the data portal developments.

Planned models, tools and indices (explicitly mentioned as such in the Description of Work)

- Task 1.4 Integration of existing visualisation tools and dedicated GIS layers in the portal
- Task 1.5 Installation of analytical tools and predictive models; AquaMaps, European Fish Index and Index of Biodiversity Vulnerability
- Task 4-6.2 Integration of results into the BioFresh portal

  From DoW: *"In close collaboration with WP 1 (see Task 1.5, D1.4), relevant predictive and descriptive models, analytic tools, and indices, developed or improved in WP4-6 will be integrated into the BioFresh portal (lead: RBINS; all partners of WP)."*

  As is evident from the task description above, there is a need to evaluate the relevance of the modelling work with regards to the integration in the data portal.

Overview of ongoing work on models, tools and indices and the planed integration in the portal

General visualization and GIS tools (T1.4)

As detailed in the deliverable report D1.2 *"Tools for visualisation of biodiversity data retrieved through the data portal, against dedicated GIS layers"*, the recently launched version of the portal (March 2011) includes this functionality. By relying on technologies such as GeoServer and OpenLayers, we can easily extend the mapping tools with relevant shapefile layers and GIS functionality.

Additional functionality will continuously be added as required for the general improvement of the portal and/or for the integration of any of the tools/models discussed below.

AquaMaps (T1.5)

Freshwater AquaMaps is an approach to generating model-based, large-scale predictions of freshwater species and is based on a methodology, which was originally developed for marine mammals. Models for the freshwater AquaMaps are constructed from estimates of the environmental tolerance of a given species with respect to elevation, temperature, soil pH, soil moisture, soil carbon, precipitation and the Compound Topographic Index (a wetness index) and occurrence data available through FishBase and GBIF. Maps show the colour-coded relative likelihood of a species to occur in a global grid of half-degree latitude/longitude cell dimensions, which corresponds to a side length of about 50 km near the equator. The possibility to use 15 min cells will be explored. Predictions are generated by matching habitat usage of species, termed environmental envelopes, against local environmental conditions to determine the relative suitability of specific geographic areas for a given species. Knowledge of species' distributions within FishBase, FAO areas or bounding boxes is also used to exclude potentially suitable habitats in which the species is not known to occur.

Integration in the portal. The first freshwater AquaMaps results (currently only for the Americas) are available along with their marine counterparts through the AquaMaps website at <http://www.aquamaps.org/>. Integration of AquaMaps in the data portal is planned for month 27 and will be achieved by either integrating the output data matrix or the map-layer (potentially using GeoServer).

European Fish Index (EFI+) (T1.5)

The EFI+-tool (Improvement and Spatial extension of the European Fish Index) allows assessing the ecological status of rivers in accordance with the EU Water Framework Directive. The tool is based on the European Fish Index (EFI) developed within the FAME and EFI+ project as a standardised fish-based assessment method applicable across a wide range of European rivers. The EFI employs a number of environmental descriptors (see http://efi-plus.boku.ac.at/software/insert_data_manual.php, data input matrix) to predict biological reference conditions and quantifies the deviation from reference conditions on a statistical basis.

Integration in the portal. The EFI+-tool is currently available as a web tool at <http://efi-plus.boku.ac.at/software/>. This tool will be integrated on a specific 'tools page' on the data portal, together with links to e.g. modelling/software packages used within BioFresh. This page will be created by July 2011. No other integration is planned for the moment and would not be feasible unless a whole EFI+-like dataset will be integrated in the portal.

Index of Biodiversity Vulnerability (T1.5)

See under Climate Vulnerability Index (CVI; T5.4)

Tools for taxonomic quality control (T2.2)

For taxonomic quality control, we need to compare received databases to agreed authoritative lists. In order to streamline this, we would need (a) taxon match tool(s) such as available for the World Register of Marine Species <http://www.marinespecies.org/> for those lists. At the 2nd BioFresh project meeting, we agreed to explore the possibility for integrating existing open source tools to do this using the BioFresh registry (which is primarily based on the Freshwater Animal Diversity Assessment (FADA) database). This evaluation will be mostly technical, i.e. how much work would it be to adapt the tools for the BioFresh dataset and code. We plan to have completed this evaluation by July 2011.

Review paper results (T4.3)

The BioFresh review paper aims to sketch an overview of the major hypotheses on the natural drivers and stressors affecting biodiversity in freshwater ecosystems. This work also focuses on identifying knowledge gaps in terms of the types of ecosystems, organism groups and spatial and temporal scales that should be tackled to aid science based freshwater conservation. The methodology consisted of keyword-based searches for papers on freshwater associated organism groups and ecosystems on Web of Science. A total of 4866 papers from the last decade (2000-2010) was further screened for their suitability for analysis. Detailed evaluation was based on 368 literature records and revealed, amongst others, a dominance of short-term (within one year) studies at ecoregion and catchment scale focusing on invertebrates, macrophytes and fish in Palaearctic and Nearctic regions.

Integration in the portal. Selected results are suitable for mapping data in a kind of atlas interface (as opposed to the current species-occurrence oriented mapping interface). This would include for instance a visualization of the number of studies of a specific organism group in each biogeographic region. Ideally this 'tool' should be launched close to the publication date of the review paper, which is planned for autumn 2011. In addition to visualizing the data included in the review paper itself, the team working on it is currently evaluating the usefulness to have taxa/occurrence lists included in these papers digitized and included in the portal.

Biodiversity matrix (T4.4)

A biodiversity matrix is constructed for identifying particularly vulnerable sub-catchments and will be used in different tasks including the global freshwater biodiversity model (next paragraph) and the CVI. See next paragraph for an evaluation of the possibilities for integration in the portal.

Comparative & predictive Freshwater Biodiversity Models (T4.5/5.5/6.5)

This title covers the major strand of modelling work within BioFresh. Because in practice the modelling work will not be divided into comparative vs. predictive work, but rather be organized at different scales, this task is further subdivided into global, European and catchment scale models below. In case of species distribution modelling, the focus will be on the following 3 types of scenarios: 1) current distribution, 2) habitats with similar environmental characteristics as the native distribution range and 3) future projections.

The modelling methodology across the different scales is similar, but the focus and environmental variables used may vary according to the scientific questions and the data that can be extracted at each of the scales. In general different statistical model approaches are tested using the Biomod package in R; http://r-forge.r-project.org/projects/biomod/ and Maxent.

Global models: The significance of large-scale determinants of global freshwater biodiversity as well as the correlations in species richness between taxa is not fully understood. The global freshwater biodiversity analysis aims at assessing the congruence in the patterns and processes driving freshwater diversity across several organism groups. To date, a biodiversity matrix covering the total species richness and the number of endemic species has been derived at the catchment grain for mammals, amphibians, reptiles, crayfish (from IUCN), birds (from BirdLife International) and fish data (from SPRICH database maintained by IRD and UPS). As soon as available, fish data from IUCN will be used.

The set of environmental and climatic data, extracted in parallel to the species data, allows us to test key ecological hypothesis for explaining freshwater biodiversity patterns: (1) the “Climate/Energy” hypothesis describing the influence of climate, acting either directly through physiological effects, or indirectly through resource productivity or biomass; (2) the “Area and habitat diversity” hypothesis suggesting that habitat heterogeneity and diversity of available trophic resources increase with catchment size, thus offering more available niches and consequently favouring the coexistence of a larger number of species; (3) the “Dispersal and historical” hypothesis suggesting that past climatic events (Last Glacial Maximum) associated with dispersal limitations of species partly explain current biodiversity patterns.

European models: The European scale modelling work consists of two approaches; 1) species-distribution modelling at catchment scale (CCM2) and 2) site specific community analysis. For (1) methodology will be similar to the catchment models. For (2), the modelling work will focus on site-specific community analysis, mainly using EFI+/fish data. This community analysis is based on community/abundance data and not on presence/absence.

Catchment models (incl. comparative biodiversity trend analysis): Species distribution models at catchment scale for the Danube, Ebro and Elbe under different climate scenarios are calculated for river segments (CCM river network) using a climate envelope model approach. Preliminary selected environmental variables include temperature, precipitation, elevation, slope, catchment size. Initially, the model will be run for selected fish species (e.g. *Salmo trutta*). In further steps, different approaches will be tested, e.g. modelling at genus level and for species from functional groups like cold vs. warm water fishes. Once suitable data become available, analyses will be extended to macroinvertebrate taxa.

Case studies: In further steps, impact of human stressors (land use scenarios, hydrological connectivity, impoundment, hydromorphological degradation,…) should be implemented. As the information on human stressors is not always consistent in the three catchments, these questions may be addressed in specific case studies focusing on smaller scale e.g. to study dispersal abilities/migration barriers.

Integration in the portal. In general, the data (incl. biodiversity matrix) and (raw) output of the models described above will consist of a matrix of values (distribution probability, richness, congruence data,…), which can be mapped by linking the data to existing shapefiles such as HydroSHEDS and CCM2 (sub)catchments / river network. The first modelling results (distribution of selected fish species at catchment scale) will be incorporated

starting in the summer of 2011 and release of the results would ideally coincide with the publication of the papers (e.g. for "*Salmo trutta in Mediterranean and temperate European river drainages: forecasting future distribution patterns*"). The integration of the global scale biodiversity matrix and congruence analysis for a subset of 1000 basins is scheduled for the end of 2011. The European scale models and projections at catchment grain will be available for integration in the portal early 2012. The site-specific community analysis at European scale will be integrated starting in spring 2012.

Given the high number of shapefile segments in most of these datasets (ca. 170'000 river segments for the 3 catchments and 100'000 HydroSHED sub basins) ensuring a good performance of the tools will be a major challenge for the development team at RBINS. We will therefore need to study the possibilities to exclude and/or join certain of the smallest segments for data-driven mapping (e.g. leaving out stream order 1 stretches for rivers) and by restricting mapping of certain data to a predefined region (e.g. Europe or catchment). Obviously, these shapefile layers could also be pre-generated where necessary.

If we are successful in mapping the data in a data-driven way, it will be relatively easy to provide simple on-the-fly arithmetic operations between different output scenarios (e.g. for visualizing the % of change/difference between two scenarios).

Theoretically, it should also be feasible to include some real dynamic modelling options on the portal (depending on the model type and length of the calibration data sample, a single model run takes from a few seconds to a couple of minutes). This would require the availability of suitable data (>100 unique occurrence – presence/absence points and integration of global climate and environmental data), simple models and sufficient calculating power. The development team will explore the feasibility of this scenario.

One exception to the above-described integration is the site-specific analyses on the European scale. Here, results will be linked to X/Y coordinates and could be shown for each of the sites included in the analysis.

Climate Vulnerability Index (CVI; T5.4)

The CVI aims to provide an indication of the vulnerability of biodiversity within sub-catchments to climate change. Viewing vulnerability as susceptibility to harm rather than a measure of harm itself provides a framework for a more holistic conceptualization of vulnerability. Within this framework, vulnerability is defined as a function of sensitivity and adaptive capacity to (a) given stressor(s). This allows vulnerability to climate change to be assessed using a trait-based approach without the need for complex and uncertain climate models. A composite index will be constructed resulting in a vulnerability overlay sub-catchment map(s). This would combine both the biophysical traits of sub-catchments that lead to sensitivity of biodiversity to climate change alongside the socio-economic and institutional traits of sub-catchments that afford adaptive capacity against climate change to biodiversity. As such, sub-catchments (~100km^2) developed from HydroSHEDs data form the study unit. Important to this study is the concept of scale, both spatially and temporally. Due to the hierarchical nature of sub-catchments, traits will be identified at multiple scales (e.g. basin, catchment, sub-catchment). It may also be possible to include intra-sub-catchment data from the 'Biodiversity Matrix' (Work Package 4) once it has been completed. This will allow for analysis of species-traits in addition to the sub-catchment traits that impact on species. Assessing vulnerability to climate change at multiple timescales will allow a 'rate of change' in vulnerability to be assessed. This will capture the temporal dynamism of vulnerability and is particularly useful for application in projects such as the KBAs (Work Package 7). Predicting future vulnerabilities will require the use of economic and biophysical models and scenarios such as future land-use change and predicted population densities etc. Climate and hydrological models could then be applied to the resulting vulnerability overlay to produce potential areas of impact of current and future climate change.

Integration in the portal. In terms of integration in the portal, the CVI could be seen as quite a flexible tool, designed to be transparent (traits shown when clicking subcatchment) and interactive (allowing the user to modify the weight they give to a certain trait). Calculation wise, this should be relatively easy to achieve (~20 traits to be weighted, summed up and divided by a factor for each subcatchment). As discussed for the freshwater biodiversity models above, the subcatchment shapefiles are however quite numerous and heavy, so the possibilities for attaining a reasonable performance would have to be explored by the development team at

RBINS (e.g. map per catchment/basin). Once the product is ready for prime time, it may also be released under a dedicated URL in order to give it more visibility and make it more easily discoverable.

As this will be a major task in terms of web developments, the RBINS team will have to take this into account in its planning. Currently the developments for the CVI are in a conceptual and data gathering phase. The first complete dataset and case study (for a subregion) will be completed by late summer 2011. At that stage, we would organize a joint meeting between the team working on the CVI and the portal development team to work out a detailed planning.

Global Freshwater Atlas (T5.5)

The Global Freshwater Atlas is actually not a model or tool in itself, but rather a product displaying the results of the models and analyses discussed in this report. This Atlas will be released as both a printed and on-line version. For the on-line version to be integrated in the portal, we plan to create different thematic views, each with a specific selection of shapefile-layers that can be interactively visualized and combined. Plans for the Atlas will be further worked out starting in autumn 2011 in close collaboration with the portal development team.

Early warning of invasive species spread - Ensemble forecasting methods for invasive species (T6.5)

The task on early warning of invasive species spread consists of 3 components: 1) Identifying determinants of richness of non-native vs. native species across spatial scales, 2) predictive models of potential current and future fish invasions in Europe and 3) studying congruence in invasion patterns across Europe for different organism groups (esp. fish and macroinvertebrates). The predictive modelling consists of two main strands of work; using Iterative Ensemble Forcasting for invasive species already present in Europe and classical Ensemble Forcasting for potentially invasive species not yet present in the EU.

Integration in the portal. Similarly to the freshwater biodiversity models, results from the species forecasting at EU scale could be integrated both in a data driven way and through a static shapefile/image layer, depending on what's most convenient. The first paper on this modelling work is currently in review and model integration will be started once the paper is accepted, so the first results should already be available on the portal in the course of 2011.

Key Biodiversity Areas (KBAs; T7.4)

The aim of the KBAs is to identify important sites for freshwater biodiversity, based on global thresholds and standard criteria, including criteria related to the vulnerability and irreplaceability of sites. The KBAs will provide a gap analysis of the coverage of protected areas, allow strategic expansion for the coverage of species and provide a focus for future conservation work and funding. The KBA methodology consists of the following 7 steps: 1) define geographic boundaries and 2) ecological context for defining KBAs, 3) map the distribution of inland water types, 4) assemble an inventory of the distribution and conservation status of priority aquatic taxa, 5) apply species based selection criteria, 6) ensure full representation of inland water habitats among the sites selected and 7) ensure the inclusion of keystone species. The final product will be a shapefile layer with the KBAs, which could obviously be overlaid with the spatial data that was used for its construction (e.g. http://www.iucnredlist.org/initiatives/freshwater/panafrica/geographic).

Integration in the portal. Given the nature of the resulting product, i.e. static shapefiles, integration in the portal will be a non-issue. The first results which detail KBAs across continental Africa have already been produced. Further areas, probably Europe and parts of Asia will be available by mid 2012 at the latest. outputs will then be integrated in the portal within the month after.

Future work on modelling, tools and indices for evaluation

A number of tasks that will result in models, tools or indices have not yet started at this time, therefore we have not yet fully explored the possibilities for the integration in the portal. To make sure they stay on our radar, we include them in the listing below, with a brief description of the expected work for the integration in the portal.

Impact of freshwater biodiversity change on ecosystem function – statistical models (T5.6)

Impacts of future freshwater biodiversity change on ecosystem functioning will be evaluated by developing models on species composition and trait distribution, which will be linked to information on ecosystem processes (i.e. rates of leaf litter breakdown, primary production and nutrient uptake) and food web interactions. Mapping of the results (e.g. for 5 European and 2 northern American lakes) is expected to be comparable to the integration of the freshwater biodiversity models.

Comparison of response signatures (T6.5)

The response signature analysis will use a site-based approach where taxalists and environmental variables will be used to determine the sensitivity of individual species to selected stressors. This will allow to forecast distribution on different 'stressor scenarios'. The work on the response signatures will cover the range of freshwater environments including rivers, lakes, wetlands and groundwater. A first meeting to discuss the response signature methodology is planned for July 2011. Integration in the portal is expected to be comparable to the integration for the review paper, although some modifications may be needed to display site-based information. Mapping (e.g. for lakes) could be done for both the occurrence of key species at the different sites and for spatial elements of the statistical modelling outputs (e.g. mapping the spatial distribution of the importance of different explanatory parameters, mapping certain metrics of biodiversity etc.).

Development of analytical protocols for the use of lake sediment records to identify changes in biodiversity (T4.6)

The protocols for comparing contemporary surveys of aquatic macrophytes, chironomids, cladocerans and diatoms with their representation in surface and older sediments (among sites exposed to different levels of anthropogenic stress), will be a valuable result that can be included in the 'tools page'. The sites included in the register of sites with paleolimnological records (LakeCores) could easily be visualized in an atlas interface and will be available late summer 2011. The usefulness of mapping the site based analysis results will be evaluated based on the extent of the data to which the methods can be applied.

National responsibility for species

National responsibility (NR) can be thought of as a measurement directly correlated with the effect of the loss of a population in the area of a political entity on the species global survival. Such a method allows conservation decisions to be based not only on the conservation status of a species (Red List) but also on the responsibility of a geographic or administrative entity for the survival of a species. Defining the NR consists of the following 3 steps: 1) define the taxonomic unit of interest, 2) classify distribution pattern into local endemic, regional or widespread and 3) identify the Distribution Probability in the countries of interest. This tool was started in the framework of the EuMon project and possibilities to further develop and integrate this tool within BioFresh WP7 will be explored during a workshop in autumn 2011. As this tool is specifically of interest to policy makers, it would be very valuable addition to the portal. Especially if we could work on a method to easily visualize this information for any European country. Integration in the portal could be done using a simple visualization tool/layer, but given their low complexity, calculations on the fly could be considered as well.

Overview table

Task	Name tool/model	Type of integration	Planning for integration in the portal
1.4	General visualization and GIS tools	General mapping interface	Available, will be continuously improved
1.5	AquaMaps	Maps on species pages + summary atlas map	Integration by Spring 2012
1.5	European Fish Index (EFI+)	Tools page	Integration in July 2011
2.2	Tools for taxonomic quality control	Tools page	Evaluation by July 2011
4.3	Review paper results	Atlas interface	Release during Autumn 2011
4.4	Biodiversity matrix	Atlas interface	Integration around end 2011
4-6.5	Comparative & predictive Models		
	• Global scale	Atlas interface	Integration of first results around end 2011
	• European scale - catchment grain	Maps on species pages	Start integration early 2012
	• European scale - site grain	Maps on species pages	Start integration spring 2012
	• Catchment scale	Maps on species pages	Integration of first results starting summer 2011
5.4	Climate Vulnerability Index (CVI)	Atlas interface	First case study available for testing by late summer 2011
5.5	Global Freshwater Atlas	Atlas interface	Planning to be worked out during summer 2011
6.5	Early warning of invasive species spread - Ensemble forecasting methods for invasive species	Maps on species pages	Integration in autumn 2011
7.4	Key Biodiversity Areas (KBAs)	Atlas interface	Integration around mid 2012
5.6	Impact of freshwater biodiversity change on ecosystem function – statistical models	Atlas interface	To be defined
6.5	Comparison of response signatures	Atlas interface	To be defined
4.6	Development of analytical protocols for the use of lake sediment records to identify changes in biodiversity	Tools page + Atlas interface	To be defined
	National responsibility for species	Atlas interface	To be defined