**European Sediment Research Network**

***Acronym: SedNet***

**EC contract No. EVK1-CT-2001-20002**

**Key action 1.4.1 Abatement of water pollution from contaminated land, landfills and sediments**

# SedNet recommendations for sediment research priorities related to the soil research clusters

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# 1. Introduction

### 1.1. SedNet

SedNet is the acronym for the demand driven, European Sediment Research Network. The SedNet objective is to form on a European scale inter-disciplinary links and trans-disciplinary bridges between scientist, engineers, sediment managers and those responsible for developing and implementing sediment related policy. The SedNet activities are financially supported for three years by the EC under the FP5 EESD programme and within area 1.4.1 on "Abatement of water pollution from contaminated land, landfills and sediments" (Thematic Network project, EC contract No. EVK1-CT-2001-20002, starting date: 1 January 2002). The main deliverable of the SedNet project will be a publication with guidance on sustainable sediment management (SSM).

### 1.2. Objective

The objective of this paper is to provide SedNet recommendations for short/medium/long-term sediment research priorities, related to the 5 main soil research clusters as proposed by the Soil Thematic Strategy Working Group Research [1].

### 1.3. SedNet perspective on sediment

The SedNet perspective, in brief, is that sediments are an integral part of river systems and are a natural resource of extreme value for a healthy river ecosystem [2]. Soil contamination and water pollution may lead to sediment contamination which may cause adverse effects on the ecological status of water bodies, wetlands, floodplains and estuaries. Therefore SedNet supports the initiative to address the issue of sediment in the EU Thematic Strategy for Soil Protection. However, by its nature sediment should also have a prominent place in the EU Water Framework Directive.

Within SedNet there is consensus on a common perception of the word <u>sediment</u>:

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| Sediments are suspended or deposited solids, acting as a main component of a matrix, which has been, or is susceptible to being transported by water. Solids comprise mineral as well as organic material [2]. |

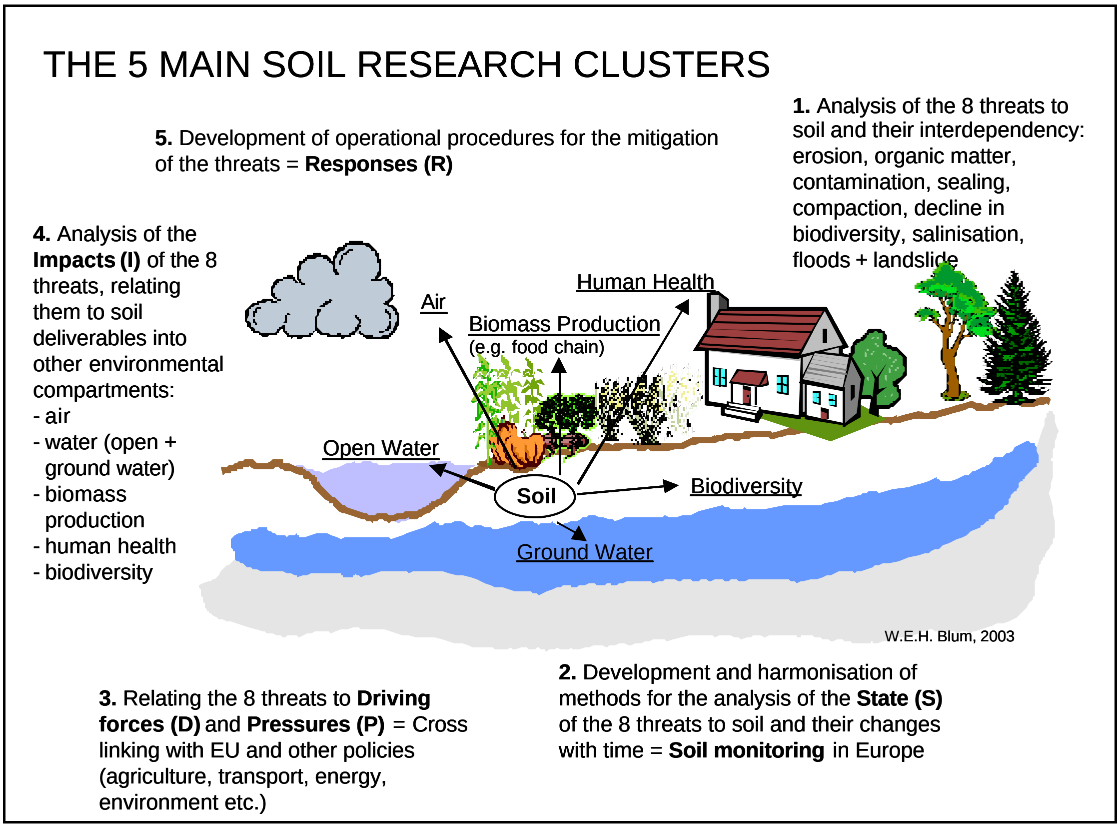
From this viewpoint it is clear that <u>sediment and soil are strongly interlinked</u> (see also section 2.1):

- Soil erosion leads to the formation of sediment and *vice versa* may turn into soil again after natural (at floodplains after a flooding) or controlled (dredged material) disposal on land
- Thus soil contamination may lead to sediment contamination and *vice versa*

However, there is also a big difference: (contaminated) soil is a site-specific issue, while the <u>mobility</u> of (contaminated) sediment makes it a river basin issue and thus in many cases a trans-boundary issue [2].

### 1.4. Soil research clusters

The Working Group Research [1] has defined clusters for targeted research which can be put into operation by national and European institutions, e.g. the Directorate-General for Research of the European Commission in order to promote research in the context of the EU Soil Thematic Strategy, e.g. in the actual 6th Framework Programme, as well as in future programmes. In order to reach this target, soil research proposals were grouped into five main research clusters as indicated in the Figure below (extracted from [1]):



## 2. Clustered sediment research recommendations

The SedNet research reccomendations in the sections of this chapter are extracted from [4] unless indicated otherwise.

### 2.1. Cluster 1: understanding the 8 soil threats

<u>Scope</u>*: Research for a better understanding of the basic processes behind the 8 threats to soil and their processural inter-dependencies. The goal for this research cluster is to link soil physics, soil chemistry, mineralogy and soil biology in order to contribute to a better understanding of:* ***erosion****, organic matter,* ***contamination****, sealing, compaction, decline in biodiversity, salinisation, and* ***floods*** *and landslides [1].*

<u>Soil erosion and floods</u>: It is very roughly estimated by SedNet that the total amount of sediment delivered from land to rivers in Europe is ca. **1800 x $10^6$ t $year^{-1}$** [3]. Furthermore, it is very roughly estimated that 100 units of sediment eroded in European catchments would be distributed downstream on an annual timescale in the following way [3]:

⇒ 30 units would be deposited on floodplains

⇒ 19 units would be deposited in reservoirs

⇒ 11 units would be extracted for aggregate

⇒ 40 units would reach the lowermost deposition zones and the coastal zone.

Estimations indicate orders of magnitude of each of the main sediment-related processes in rivers of Europe, and so considerable caution should be used with these values. Uncertainty is high due to the lack of extensive, reliable and homogeneous data on sediment production, transport and deposition for all European river catchments.

*Long-term research*: Because of the limitations associated with the values presented above, there exists a need for a comprehensive Europe-wide assessment of sediment production due to soil erosion and of sediment deposition at floodplains for all European river catchments.

<u>Contamination</u>: An important source for sediment contamination is eroded, contaminated soil and *vice versa* when contaminated sediment is deposited on land. In order to predict the quality of sediments more information, at the river basin scale, is needed on soil quality. This is not so much related to scientific research, but more an issue dealing with lack of information: data on soil quality in Europe. It should be mentioned however, that if information is available it has often a restricted availability, which hampers their inclusion in predictive modelling on sediment and floodplain soil quality.

*Short-term information need for research*: Database on soil and sediment quality in Europe and general availability of public data for research needs.

These information needs are not strictly research questions for the scientific community but belong to agencies like the EEA and its counterparts in Europe.

Basic information is available for current priority chemicals. However, there is a definite lack of information on emerging pollutants such as pharmaceuticals. Nor is their enough information on inputs in the aquatic system to set priorities for their study.

*Short-Medium term Research*: Identify and quantify those ‘emerging pollutants', originating from contaminated soils, which are relevant for the aquatic system (and sediments), determine their behaviour in the aquatic system and incorporate them in models at the river basin scale.

## 2.2. Cluster 2: development of soil monitoring methods (STATE)

Scope*: Development of new and harmonization of existing methods for the analysis of the STATE (S) of threats to soil in Europe and their changes with time = SOIL MONITORING [1].*

By state in the DPSIR framework in this context is meant: can we predict to date the quantity and quality of sediments in a water body and at its depositional areas (e.g. wetlands, river flood plains and coastal areas)?

Erosion: Research is needed on how eroded soil material actually gets to and enters the river system. We know that much soil is eroded from land and river banks (see section 2.1), but our understanding of its delivery to rivers and streams is poor. In fact in most cases an empirical value is introduced to link the erosion of soils (e.g. the infamous soil loss equation) to actual sediment delivery to the main water body. A better understanding is a prerequisite for devising and implementing management measures.

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| *Long-term research*: Quantitative (process oriented) description of the link between soil erosion and the actual sediment delivery to the water body. |

Erosion and floods: Once this is know it will be possible to determine how sediment budgets at the river basin scale vary throughout Europe, in its contrasting river basins, and how they change with changing land use which affects soil erosion and climate change which affects the hydrology. This will additionally require a stronger link, than exists at present, between the soil, the sediment and the climate scientific communities.

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| *Long-term research*: Integrated research to determine the sediment transport process (including erosion and sedimentation) at the river basins scale as a function of land and water use and hydrological (climate) change in Europe. |

Once this is know it will be possible to determine how changing sediment regimes will affect the depositional areas like wetlands and floodplains.

It should be understood that these “depositional” areas are not permanent but subject to both sedimentation and erosion. This is in particular the case for temporary storage in river floodplains. In this context more research is needed on the “stability” of depositional areas to global change.

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| *Long term research*: more research is needed on the ‘stability’ of depositional areas, such as floodplains, to global change |

Contamination (local and diffuse): Once the contaminants (direct or adhered to soil particles) have entered the water system, depending on water characteristics adsorption-desorption processes take place, which determine the concentrations in solution and the concentrations in the sediment (including suspended particulate matter). Although a lot is known on the adsorption characteristics of priority pollutants on sediments (and soils), very few models exist that describe the fate and transport at the river basin scale.

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| *Short-Medium term Research*: Assessment and further development of models describing the fate and transport of contaminants in rivers at the river basin scale. |

## 2.3. Cluster 3: relating the 8 threats to DRIVING FORCES and PRESSURES

Scope*: Relating the 8 threats to DRIVING FORCES (D) and PRESSURES (P) through cross-linking with EU and other policies, such as agriculture, regional planning, environment, transport, energy, development, single market (competition) and others [1].*

Several threats: Europe faces existing and upcoming regulations like the Water Framework Directive, Thematic Strategy for Soil Protection, Habitats and Birds Directive, Marine Strategy etc. (Figure 2). These regulations influence the best management practices in sediment management (e.g. sustainable relocation, wetland restoration, mudflat regeneration, etc.) and thus also in soil management.

The response factor and involving stakeholders, dealing with regulations and taking policy into account has been hotly debated within SedNet. Figure 2 is a simple presentation of the complex issues involved. On the one hand sediment quality and quantity is determined by human and natural processes/activities in rural, urban areas and by direct inputs. These activities are subject to (partly) by EU directives but are also heavily influenced by global change. Global change includes changes in the industrial landscape as well as demographic changes in Europe.

These responses (e.g. directive) as well-anticipated global-European change have determined sediment and soil quality and will determine future quality. On the other hand sediments (with their contaminants), after introduction in the river basin sys tem, become deposited in floodplains, harbours, wetlands and in the coastal area. These areas (output side) are subject to different directives, agreements and local and regional policy. To state it differently: the regulations and societal pressures on the input side are different from those on the output side. One of the functions of SedNet is to form a bridge between these conflicting or sometimes emerging joint interests.

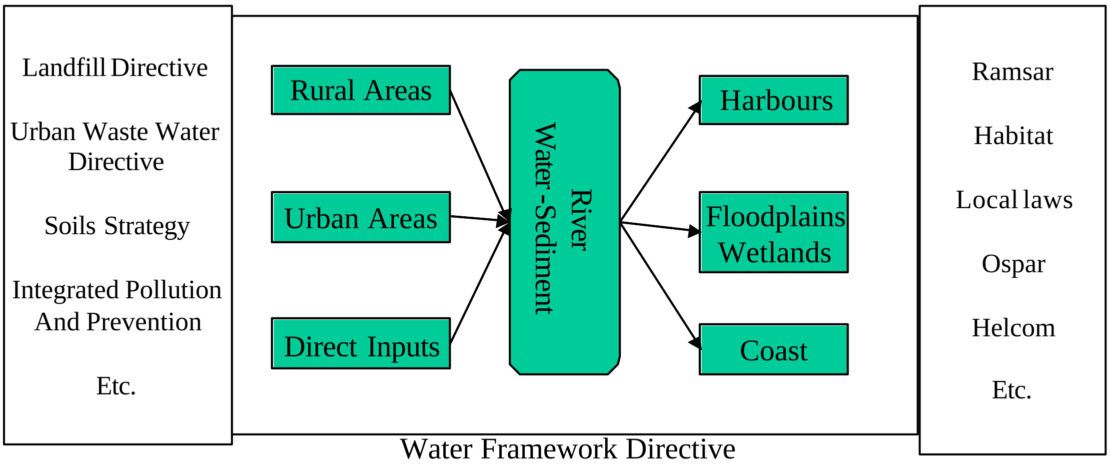


**Figure 2**. Policy, directives, agreements and biophysical parameters that have to be taken into account for an integrated view of the sediment/soil issue (including the EU marine strategies on the right).

This 'bridging function' contains several research questions, which have to deal with interaction between different policy domains, involvement of stakeholders (and different interests) in the policy process and the multilevel governance character of the policy process.

The interaction between different policy domains that have an effect on sediment and soil or are affected by sediments and soil, and the interaction with different interests (stakeholder involvement) asks for new policy processes. These processes should have an architecture that can deal with these interaction issues, acknowledges the different stakeholder perspectives and interests, applies new knowledge production and -use processes (more "expert-fed" than "expert-led") and leads to joint actions.

*Short-term research*: Research about new architectures for policy processes with respect to sediment and soil issues that enable interaction of several involved policy domains, interaction with stakeholders, new joint knowledge production processes and joint actions.

One of the big bottlenecks for the implementation of EU-policies is the multi-level character of it and the dividing line ('watershed') between strategy and actual implementation. The multi-cultural character of it poses extra problems. This asks for new approaches and probably new institutional arrangements that can facilitate the connection between the several involved policy levels (EU-national-local) as well as the connection between strategy and implementation with respect to sediment and soil policy. In such a new approach one might expect that support of the implementation and 'feedback and learning' play an important role.

*Short-term research*: Research about how the connection between the different involved policy levels and between strategy and implementation can best be established.

Furthermore, a research issue is how global change, European change and local change in industrial landscape, changing land use and demography affects sediment supply and its quality. This requires the downscaling of readily available scenarios (IPCC, OECD, country etc.) to the river basin scale and see how long term changes will effect sediments and soils and whether management actions are required. This might be in particular be important for NAS countries were socio-economic changes are to be expected.

*Short-term research*: Evaluation (social/economic/technical/environmental) of source control programs and a cost benefit analysis of risk reduction through source control, including the management of historic contamination.

*Long-term research*: Downscaling of global, European and country scale socio-economic scenarios to the river basin scale and their effect on sediment quantity and sediment and soil quality and research into the development of best management to comply with current and future EU regulations.

### 2.4. Cluster 4: analysis of the IMPACTS (I) of the 8 threats

*Scope: Analysis of the IMPACTS (I) of the 8 threats by relating them to soil deliverables into other ecological compartments, such as air, water (open water and ground water), biomass production, human health and biodiversity [1].*

Contamination (local and diffuse) including the influence of floods: The quality of sediments has a direct impact on the aquatic ecosystem and biodiversity or to the terrestrial ecosystem and biodiversity when deposited upland (natural or controlled). Floods affect the behaviour of contaminants.

Controlled disposal of dredged material have been either relocation in the river system, at sea, sub-aqueous disposal or **upland disposal**. Options like the separation of contaminants from the sediment or separation by grain size to separate the more contaminated fine sediment fraction can be costly. This also holds for options to minimise contaminants with thermal treatment or addition of absorbing agents. Treatment and reuse of dredged material can on the other hand sometimes be feasible.

Controlled upland disposal may also still be economical for the current and NAS countries in the European Union. Important issues in respect to upland disposal, treatment and reuse of dredged material include long-term effects, leaching, liability, lifecycle analysis etc. Controlled disposal and dredged material treatment have been studied intensively and the results are summarised in many state-of-the-art reports (e.g.: CEDA, PIANC, POSW, US Army Core of Engineers etc.).

With regard to natural upland disposal (due to/after flooding) there still exist in some countries a “legacy of the past” which refers the storage of what now is considered severely contaminated sediment. This also includes **floodplains**, which have been contaminated in the past. The change from an aqueous to a terrestrial environment for sediments means a drastic change in (geo)chemical conditions, which may effect the behaviour of contaminants. In particular cycles of wetting and drying (changing hydrological conditions) might affect this. In this respect more research is needed to address upland disposal as a “legacy of the past”.

*Short/medium-term research*: Better understanding and predicting the behaviour of non-treated or treated contaminated dredged material, especially in relation to climate change, during and after upland disposal, and better understanding of the impact on ground water, water and soil. This also includes research on ageing and natural recovery potential of contaminated sediments.

Contamination (local and diffuse): The SedNet Strategy Paper [2] as well the general literature on wetlands, floodplains etc. demonstrate the importance of sediments and its quality on the ecosystem and its bio-diversity. Many tests to determine sediment and soil quality have been devised of the past years. They start from simple chemical test on contaminant concentrations, to bio-assays/Triad tests or even field trials. Common across Europe and (partly) embedded in legislation are the chemical tests on concentrations. A number of countries have endeavoured in more (expensive) and complicated bio-assay methods (aquatic and terrestrial) due to the fact that chemical tests only detect a very limited No. of the potential available contaminants and hardly give an indication of the bio-availability of contaminants or their mixture toxicity. However, comparisons are lacking taking into account the diversity of European conditions as well as economic criteria on costs. The latter might be of particular importance for NAS countries.

*Short- to mid-term research*: Integrative assessment of currently available sediment and soil quality assessment tools taking into account their limitations and costs, aiming to harmonisation in Europe and making these tools applicable for (trend) monitoring/assessment at the basin scale.

Furthermore, more and more research results demonstrate that severely contaminated sediment and/or soil not always results in toxic effects in bioassays and/or a negative impact to ecology. Sometimes even the opposite happens: sediment and/or soil that appears to be chemically clean (toxicants overlooked?) gives negative effects in bioassays and/or a negative effect to ecology.

This demonstrates two things:

1) That it is useful to think of implementing effect monitoring complementary to chemical (compliance) monitoring;
2) That we need to improve our understanding of the relation between sediment contamination (hazard) and its actual risk to the ecosystem functioning (ecological quality/biodiversity).

For the latter we need multidisciplinary research, integrating already existing techniques. These are: physical/chemical techniques, effect monitoring techniques (e.g. bioassays, functional monitoring, etc.) and ecological monitoring/assessment (community surveys) techniques. To advance science in this field it also needs the complementary integration of 'bridging tools' like Toxicity Identification Evaluation (TIE), Model Ecosystems and modeling.

*Short/mid-term research*: Improve our understanding of the relation between sediment and/or soil contamination (hazard) and its actual risk to the ecosystem functioning (ecological quality)

### 2.5. Cluster 5: mitigation of the 8 threats to soil (RESPONSES).

Scope*: Development of operational procedures for the mitigation of the 8 threats to soil in relation to soil deliverables into other environmental compartments = RESPONSES (R)[1].*

*Based on the understanding of processes behind the 8 threats to soil and their processural interdependencies (research cluster 1), the analysis of their state (cluster 2) of their driving forces and pressures (cluster 3) and impacts (cluster 4), a 5$^{th}$ research cluster for the development of operational procedures for responses to the threats and impacts can be formulated.*

*Some research proposals have been developed by the Working Group, e.g. on the raising of awareness, education, capacity building, networking and co-operation. One further proposal aims at an integrated risk-based management approach to prevent or reduce the pollution of natural water and soil resources, caused by agricultural, urban and industrial activities.*

*Results of intensive research in- and outside Europe have to be taken into consideration, e.g. ongoing research programmes, steered by the International Council of Science (ICSU) and its 26 scientific Unions in co-operation with UN-bodies, such as the International Geosphere-*

*Biosphere Program (IGBP) and many others. Here, research proposals should be formulated, defining the role of Europe in research in this context [1].*

SedNet agrees with the text above and, for the moment, has no specific, complementary research recommendations.

## 3. Summary of clustered sediment research recommendations

A summary of the clustered sediment research recommendations is presented in the Table at the next page.

## 4. References

[1] Blum WEH, Büsing J, de l'Escaille T. 2003. European Union Soil Thematic Strategy Working Group Research. Interim report October 2003. Executive summary. http://forum.europa.eu.int/Public/irc/env/soil/home

[2] SedNet. 2003. The SedNet Strategy Paper. The opinion of SedNet on environmentally, socially and economically viable sediment management. June 2003. http://www.sednet.org/newsitem.asp?ni=57

[3] Owens P, Batalla R. 2003. A first attempt to approximate Europe's sediment budget. SedNet paper, 30 November 2003.

[4] Brils J, Salomons W, van Veen J. 2003. Preliminary SedNet recommendations for research priorities related to sediment. SedNet paper, 7 November 2003. http://www.sednet.org/newsitem.asp?ni=80

**Table:** summary of the clustered sediment research recommendations based on [4] (Priority: S = Short-, M = Medium- and L = Long-term)

| Cluster | Threat | Research recommendation | Priority S | Priority M | Priority L |
|---|---|---|---|---|---|
| 1. Understand threats | Erosion & floods | Comprehensive assessment of sediment production due to soil erosion and of sediment deposition at floodplains for all European river catchments | | | X |
| | Contamination | Information need: Database on soil and sediment quality in Europe and general availability of public data for research needs. | X | | |
| | | Identify and quantify 'emerging pollutants' in contaminated soils, which are relevant for the aquatic system (and sediments), determine their behaviour in the aquatic system and incorporate them in models at the river basin scale. | X | X | |
| 2. State | Erosion | Quantitative, process oriented description of the link between soil erosion and the actual sediment delivery to the water body. | | | X |
| | Erosion & floods | Integrated research to determine the sediment transport process (including erosion and sedimentation) at the river basins scale as a function of land and water use and hydrological (climate) change in Europe. | | | X |
| | | More research is needed on the 'stability' of depositional areas, such as floodplains, to global change | | | X |
| | Contamination | Assessment and further development of river basin scale, contaminant fate and transport models | X | X | |
| 3. Drivers & pressures | Several | Research about new architectures for policy processes with respect to sediment and soil issues that enable interaction of several involved policy domains, interaction with stakeholders, new joint knowledge production processes and joint actions. | X | | |
| | | Research about how the connection between the different involved policy levels and between strategy and implementation can best be established. | X | | |
| | | Downscaling of global, European and country scale socio-economic scenarios to the river basin scale and their effect on sediment quantity and sediment and soil quality and research into the development of best management to comply with current and future EU regulations | | | X |
| | Contamination | Evaluation (social/economic/technical/environmental) of source control programs and a cost benefit analysis of risk reduction through source control, including the management of historic contamination. | X | | |
| 4. Impacts | Contamination & floods | Better understanding and predicting the behaviour of non-treated or treated contaminated dredged material, especially in relation to climate change, during and after upland disposal, and better understanding of the impact on ground water, water and soil. This also includes research on ageing and natural recovery potential of contaminated sediments. | X | X | |
| | Contamination | Integrative assessment of currently available sediment and soil quality assessment tools taking into account their limitations and costs, aiming to harmonisation in Europe and making these tools applicable for (trend) monitoring/assessment at the basin scale. | X | X | |
| | | Improve our understanding of the relation between sediment and/or soil contamination (hazard) and its actual risk to the ecosystem functioning (ecological quality) | X | X | |
| 5. Responses | | SedNet agrees with what is already stated by the WG Research and, for the moment, has no complementary suggestions | | | |