Save the Alpine Rivers




Scientific foundations for identifying ecologically sensitive river stretches in the Alpine Arc

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CONTENTS

LIST OF ABBREVIATIONS

General terms

Abbreviation	Full name
AWB	Artificial water bodies
HMWB	Heavily modified water bodies
RBD	River basin district
WFD	European Water Framework Directive
AT	Austria
DE	Germany
CH	Switzerland
IT	Italy
AO	River Basin District Alpi Orientali
PO	River Basin District PO
TAA	Region Trentino- Alto Adice
LIG	Region Liguria
FRI	Region Friuli
FR	France
SI	Slovenia

Institutions

Abbreviation	Full name
ADBPO	Autorità di bacino del fiume Po, Italy
ADBVE	Autorità di bacino dei fiumi Isonzo, Tagliamento, Livenza, Piave, Brenta-Bacchiglione, Italy
ARSO	Agencija RS za okolje / Slovenian Environment Agency
BAFU	Bundesamt für Umwelt, Switzerland
BfN	Bundesamt für Naturschutz, Germany
BKG	Dienstleistungszentrums des Bundesamt für Kartographie und Geodäsie, Germany
CIRF	Italian Centre für River Restoration, Italy
CSCF	Centre Suisse de Cartographie de la Faune
EAWAG	Swiss Federal Institute of Aquatic Science and Technology
EC	European Commission
EEA	European Environment Agency
GURS	Ministry of Infrastructure and Spatial Planning, Slovenia
IGB	Leibniz-Institut für Gewässerökologie und Binnenfischerei Berlin, Germany
BMLFUW / Lebensministerium	Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Austria
LFU	Bayerisches Staatsministerium für Umwelt und Gesundheit, Germany
UBA	Umweltbundesamt, Austria

1 INTRODUCTION

1.1 Background of the study

The Alps, characterized as 'water towers of Europe', are of central importance not only for the Alps themselves, but also for surrounding areas and for large parts of Europe in general (EEA, 2009). The river network of the Alps provides manifold ecosystem functions for about 180 million people of the catchment areas of rivers Rhone, Rhine, Po and Danube and shelters a unique diversity of fauna and flora.

For centuries, various human activities resulted in pressures on the aquatic environment affecting the physico-chemical conditions of running waters and strongly influencing and impacting morphological character, hydrological regime and as a consequence, aquatic biota (Muhar et al., 2000; Bourdin, 2004; Schmutz et al., 2010; Muhar et al., 2011; Schmutz et al., 2011; Schinegger et al., 2012; Trautwein et al., 2013). According to Tockner et al. (2009), almost all European river basins are heavily affected by human activities, that is, the degradation of European rivers and streams is widespread.

In the Alpine region, hydromorphological alterations due to hydropower production and flood protection measures can be addressed as the key pressures (Schinegger et al., 2012). Hydropower plays an important role throughout the Alpine space, both on a small and large scale. The types and characteristics of hydropower usage are diverse, ranging from the channeling of small torrents to big barrages, dams and large reservoirs (EEA, 2009). The remaining hydro-electrical potential depends on the still unutilized river stretches, which often are close to a natural state and which have - at the same time - become increasingly rare (Alpine Convention, 2011). Due to the high hydroelectric potential on the one hand and the important value of aquatic ecosystems on the other hand, the generation of hydropower in the Alpine area results in a conflict of interests between the use of renewable energy and the protection of the aquatic ecosystems and landscapes (Alpine Convention, 2010).

These divergent interests are reflected in several EU directives, e.g. the WFD, European Water Framework Directive 2000/60/EC (European Commission, 2000), aiming a good ecological status of water bodies, and the RES-e, European Renewable Energy Directive 2009/28/EC (European Commission, 2009a) with the key objective to increase share of energy from renewable sources with target figures for 2020. Additionally, the Habitats Directive (European Commission, 1992) and Birds Directive (European Commission, 2009b), together with the Convention on Biological Diversity (CBD, European Commission, 2011) define the legal framework for diversity conservation and sustainable use of biological resources.

Based on this legislation, there are huge efforts to improve the ecological status of running waters across all of Europe. However, most protection and restoration attempts are carried out on smaller spatial scales (i.e. case studies) and mainly focus on sectoral goals that address only one aspect of the river system (morphology, hydrology, species protection, etc.). Moreover, a huge deficit on the pan-Alpine scale is sparse and fragmented data availability paired with knowledge and information gaps. To detect changes in habitats and their biotic communities across the Alps and to develop adequate protection and restoration strategies, spatially explicit information about significant stressors as well as the ecological status of the river systems of the Alps is required. Only with this background, clear priorities for future restoration can be identified and adequate protection measures can be developed. These processes of assessment and prioritization are essential for decisions regarding the future use and development of rivers in the Alps, especially in the context of further development of hydropower.

Given the rarity of remaining unexploited rivers, strategic reflection is of the utmost importance in order to avoid irreversible impacts (Alpine Convention, 2011). Therefore, the legal framework of the Alpine Convention encompasses a series of issue-specific protocols (e.g. spatial planning and sustainable development, natural hazards, energy etc.) in order to support a sustainable development in the Alpine Arc.

In the past, a few studies were already focusing on the ecological value of Alpine rivers. A study conducted by the "International Commission for the Protection of the Alps" (Martinet & Dubost, 1992) gave a first overview of the pan-Alpine situation, stating that only about 10% of all Alpine rivers are (at least partly) in a natural or near-natural condition and that completely untouched rivers in the Alpine Arc do not exist anymore. Almost 20 years later, a study on existing pan-Alpine projects and relevant databases was conducted by Muhar et al. (2011), aiming to provide integrative basics for assigning protection and restoration priorities in river management. Within this preliminary study, existing data on geomorphologic, hydrologic, biological and socio-economic parameters of the large river systems in the Alps were collected and documented in a meta-database. The outcome was that the database seemed to be inconsistent and fragmented, as many data were lacking at a national level. Moreover the "WWF-Alpenflussstudie" (Rast & Tranter, 2011) delivered relevant and detailed results, but only for 15 selected rivers of the Alpine Arc.

In the last years, there were also some EU and Alpine space projects that dealt with aspects of water management, renewable energy production and ecosystem protection. The Alpine Space Programme (ASP) project ECONNECT (http://www.econnectproject.eu/) strove towards the establishment of an ecological continuum across the Alps. Moreover, another ASP project, SHARE (http://www.share-Alpinerivers.eu) aimed to develop, test and promote a decision support system to merge both, river ecosystems' and hydropower requirements. Finally, the EU-FP7 project RESTORE was a partnership for sharing knowledge and promoting best practice on river restoration in Europe (http://www.restorerivers.eu/). These projects derived important sectoral results (on the basis of case-studies). However, neither studies on the overall remaining hydropower potential, nor on how to balance this potential with the last preserved healthy river landscapes, exist so far on an Alpine scale. This is also the case on the national level of the Alpine Convention member states. However, the "Eco-Masterplan" (WWF Austria, 2009) presented a first general concept to identify rivers of high protection value and restoration measures for Austria.

Moreover, the MAVA Foundation defined the "Ecoregion Alps" and its related river systems as a focus region in their multi-annual program 2010-2014. In a first workshop (August 8, 2009, Zurich) the main problems and research needs were identified, and szenarios for the future of the Alps were developed. Concluding, the need of a pan-Alpine overview of the status of Alpine rivers and streams as an essential basis for a pan-Alpine protection strategy as well as further research on this topic has been addressed by representatives of MAVA and WWF. As a result, the Institute of Hydrobiology and Aquatic Ecosystem Management (IHG) at the University of Natural Resources and Life Sciences (BOKU) was commissioned by MAVA/WWF to conduct this study for the "Identification of ecologically sensitive river stretches in the Alpine Arc" as a basis for the campaign "Save The Alpine Rivers".

1.2 Aims & objectives

The goal of this study is to provide a comprehensive pan-Alpine foundation for setting nature protection and restoration priorities for Alpine rivers. Its specific objectives are (1) the designation of river stretches with very high/high protection priority (“no-go/priority areas”) and river stretches with high restoration potential, (2) the identification and documentation of the main impacts/pressures and (3) the compilation of a consistent pan-Alpine database on information related to running waters and their ecosystems.

The objectives of this study are clearly directed at a *pan-Alpine perspective, and its* outcomes are environmental status reports of the Alpine rivers. The compiled and reported criteria for all rivers with catchment area larger than 10 km² are: “ecological status of the aquatic biota”, “hydromorphological status” and “pressures”, “nature protection areas” and “floodplains/wetlands” along the rivers.

To visualize the outcomes of this study, maps, figures and tables on the status of Alpine rivers were produced. In this report the results are grouped my country and by catchment size.

This database serves to address the urgent need of protecting the last remaining ecologically sensitive river stretches, and to indicate protection priorities with regard to the vulnerability of the rivers.

In the frame of this study, it was agreed that data collection and analyses should focus on EU-, Alpine Space- and nationwide data collection and analyses; it was not intended by the funding institutions to extend the scope to the regional/local level except for the case study Soca (see separate report “Contribution to protection strategy Soča.

1.3 Project structure and timeframe

The organizational structure of the project was developed by WWF in cooperation with the project lead at BOKU IHG. In the course of the project WWF Freshwater Officers of six Alpine countries (Austria, Germany, France, Italy, Slovenia and Switzerland) together with the director of EALP programme formed an advisory team. It was agreed that central topics, methodological issues and interim results are discussed and jointly decided upon in close dialogue with the WWF team.

Additionally it was agreed that the WWF team assists in establishing contacts to official institutions as well as in data requesting whenever possible or necessary.

Time schedule: The project duration was defined from 1st January – 31st December 2013.

In the course of the project, three meetings were planned and took place in Innsbruck/Austria.

- Kick off meeting am 30.11.2012
- Workshop May 2013: presentation of first results, discussion with the FEOFs team
- Workshop November 2013: presentation of the final results, discussion with the FEWOs team

In addition to these meetings, upcoming questions concerning data status and availability as well as the project progression in general have been jointly addressed in regular Skype meetings.

2 METHODS

2.1 Investigation area

The area of investigation principally covers the whole Alpine Arc according to the Alpine Convention perimeter. The borders of the Alpine Convention were defined through geological criteria, vegetation zones, an altitude mainly above 700 meters, but also administrative borders (Reppe et al., 2004). Its member countries are Austria, Liechtenstein, Germany, Slovenia, France, Monaco, Switzerland and Italy. The rivers of Liechtenstein and Monaco are not included in our analyses, due to the negligible contribution to the Alpine river network (i.e. river Rhine is included in the Swiss dataset, Monaco has no rivers). Therefore, this study covers the Alpine parts of Austria, Germany, France, Italy, Slovenia and Switzerland (Figure 1).

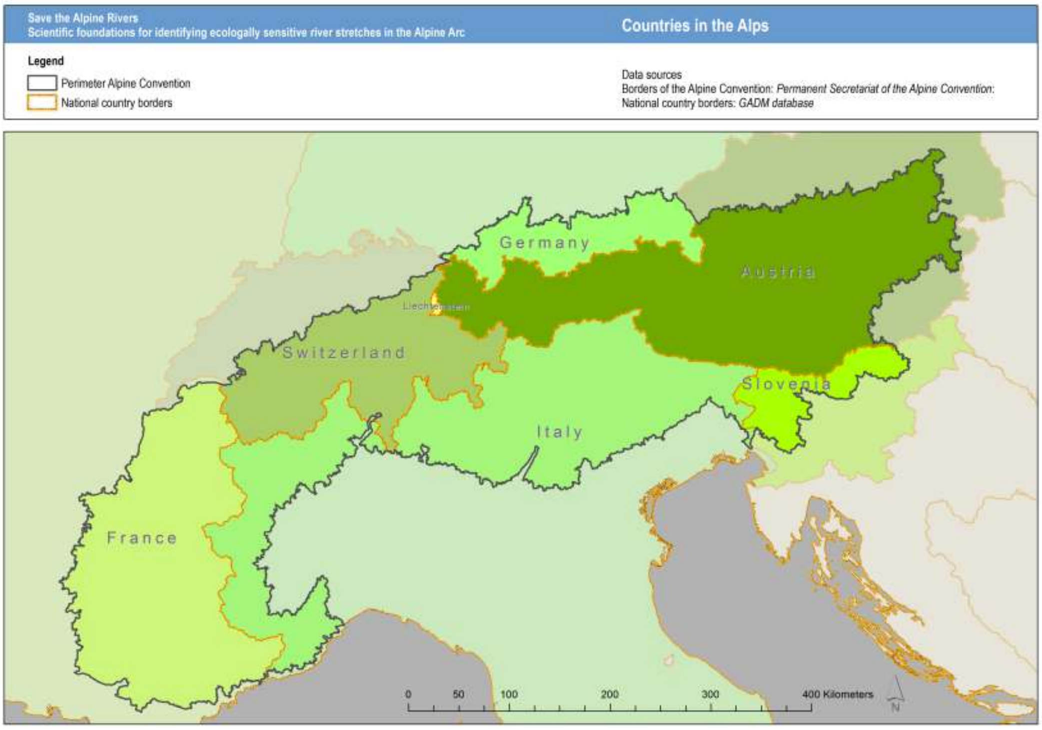


Figure 1 Overview of countries in the Alpine Arc

2.2 General methodological framework /evaluation scheme "protection priority"

The main aim of this study was to develop a consistent scheme for evaluating the protection priority of rivers in the Alpine Arc. This scheme is based on the Austrian Ecomasterplan II study (WWF Österreich, 2010), which we simplified due to data restrictions and consistency issues. All relevant decisions were discussed & decided with WWF freshwater officers in related Alpine countries. The final scheme is presented in Figure 2.

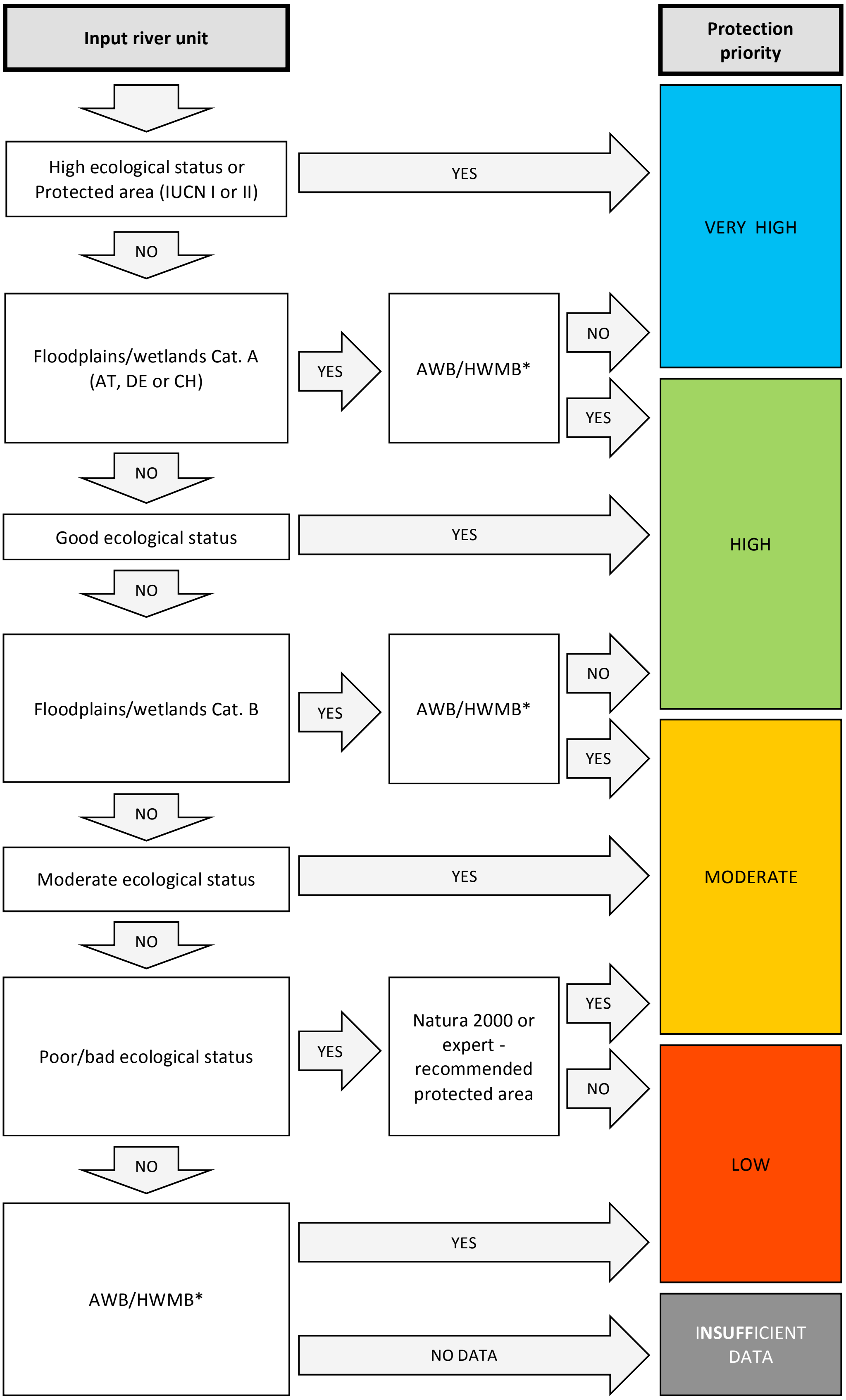


Figure 2 Protection priority rating scheme; *Artificial / Heavily Modified Water Body

The “protection priority rating” can be described as follows:

- **VERY HIGH PROTECTION PRIORITY:**
  All river units with a high ecological status or high ecological value (=surrogate for ecological status in Switzerland, see section 2.4.5.1.1), or units that fall within an IUCN Cat. Ia, Ib, or II area. Natural river units (= not AWB/HWMB) associated with Cat. A floodplains/wetlands (see section 2.4.5.4) are also rated “very high”.
- **HIGH PROTECTION PRIORITY:**
  All river units with a good ecological status, and all natural river units associated with Cat. B floodplains/wetlands fall into this category. AWB/HMWB river units associated with Cat. A floodplains/wetlands are also rated “high”.
- **MODERATE PROTECTION PRIORITY:**
  All river units with a moderate ecological status/value. If the ecological status is worse than moderate, or a river unit is AWB/HWMB, it can still have a moderate protection priority if it is associated with a Natura 2000 or expert-recommended protected area. AWBs/HMWBs associated with floodplains/wetlands are also rated “moderate”.
- **LOW PROTECTION PRIORITY:**
  All river units with a poor or bad ecological status, as well as AWBs/HMWBs not associated with floodplains/wetlands or protected areas.
- **INSUFFICIENT DATA:**
  All remaining stretches – those with no ecological status information, no floodplain, and no association with IUCN Cat. Ia, Ib or II protected areas, are classified as insufficient data. Please note that river units that fall within Natura 2000 or expert recommended protected areas are still “unrated” if they neither are associated with floodplains/wetlands nor have ecological status information present.

In Switzerland, no AWB/HMWB designation exists. Concerning the “floodplains/wetlands” criterion, river units with an ecomorphology class of 4 or 5, as well as river units affected by hydrological pressures, were treated like AWB/HMWBs in Switzerland.

2.3 Data research

2.3.1 Requested data

We requested the following GIS data required for the designation of the protection priority (see section 2.2):

- Ecological status
- Hydromorphological status
- Protected areas
- Floodplains/wetlands

Additionally we requested pressure data, i.e. information on hydropower plants and other barriers, stretches affected by water abstraction, hydropeaking or impoundment as well as data on restoration projects. Moreover, data to classify rivers/river stretches e.g. according to fish regions (i.e. salmonid and cyprinid regions), stream order, and catchment size were collected (summarized in Table 1).

Table 1 Overview of requested GIS data

General characteristics	Classification data	Protection priority criteria	Pressure data	Additional data
Country **Political unit** **Land use**	Catchment area Discharge Fish region Stream order	Ecological status Hydromorphological status Protected area Floodplains/wetlands	Hydropower plants Impoundment Water abstraction Hydropeaking Barriers (weirs, transversal structures)	Restoration projects

2.3.2 Contacted institutions

Data collection started in February 2013 and ended in late November 2013. Figure 3 shows the distribution of number of contacts for different data categories.

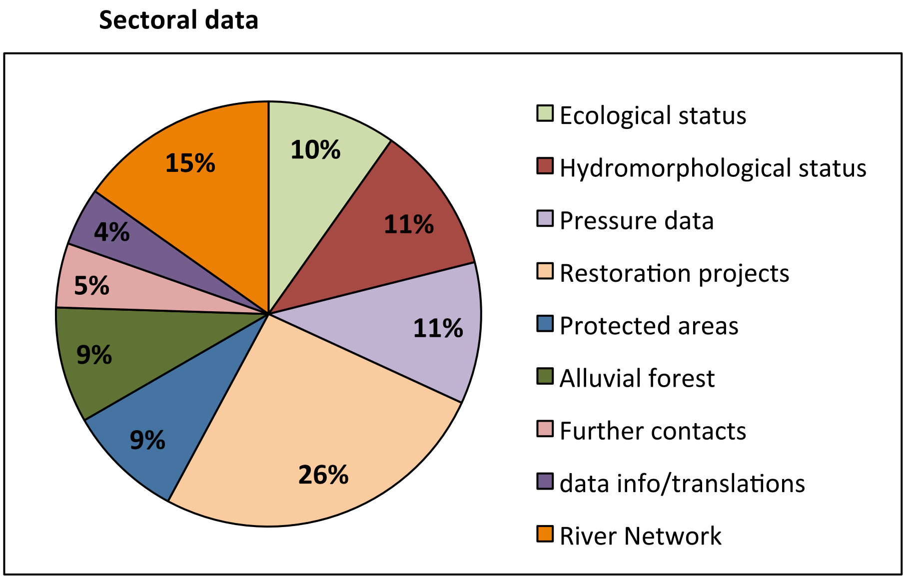


Figure 3 Share of persons contacted for data requests (total number of contacts: 125)

Data requests were conducted on EU-, on national- and on regional level, as presented in Figure 4. More than half of the received data were available by contacting people via email. The rest was acquired through governmental websites/web GIS. Data availability on EU-level but also on national level was limited, which is why data also had to be requested on a regional basis. The regional level includes federal states and river basin authorities (especially in Italy). As a further result, we created a database with contact data and contact reason available in the data appendix.

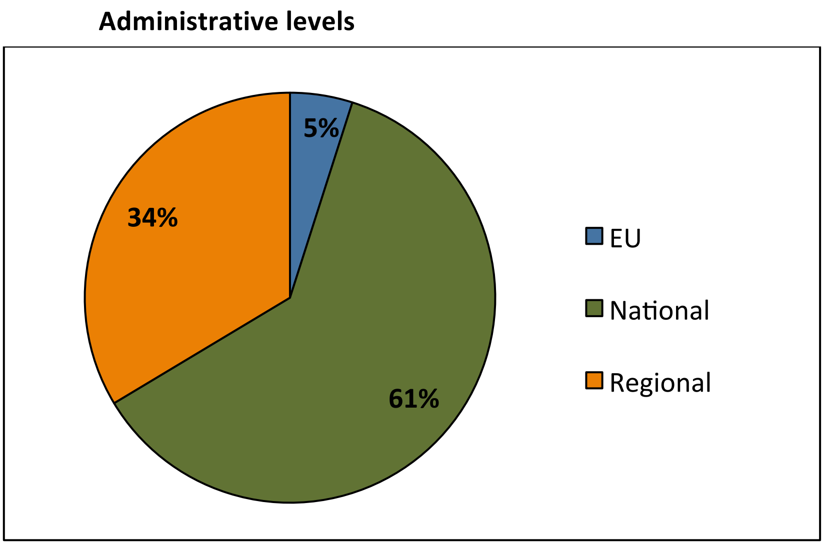


Figure 4 Share of contacted persons on different administrative levels (total number of contacts: 125)

The number of contacted persons for different data categories was quite balanced. Figure 5 presents the number of contacts per country. In Italy and Austria, many persons were contacted on regional level.

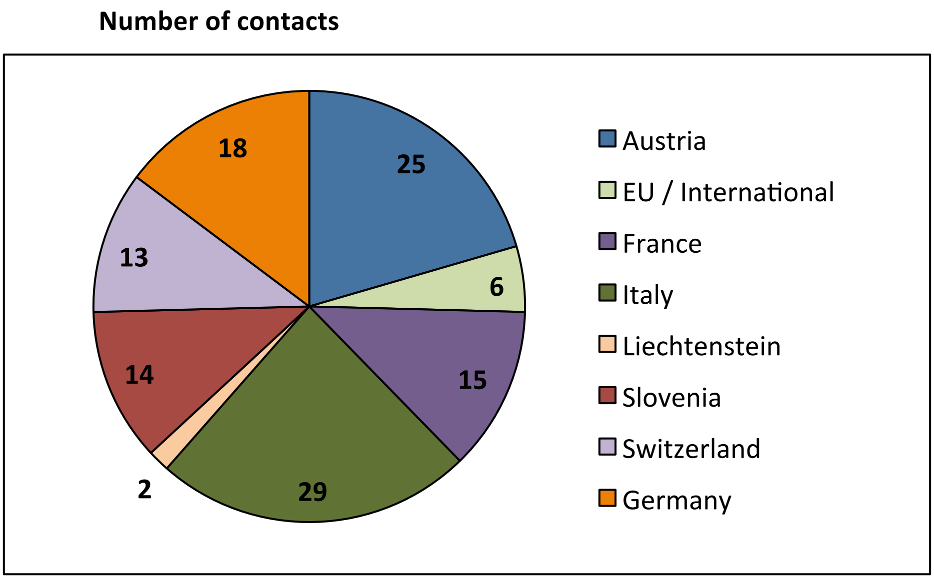


Figure 5 Number of persons contacted for data request per country

In total, 125 persons from 71 governmental and non-governmental organizations (Table 2 -8) were contacted via email. Moreover, a database was created with all persons, institutions, contact data and purpose of contact. The complete database is available from the data appendix of this report.

Table 2 Institutions contacted for data collection in Austria

Contacted institutions in Austria
Lebensministerium
Umweltbundesamt
Magistrat Wien
Land Salzburg, Referat Naturschutzgrundlagen
Amt der Tiroler Landesregierung, Abteilung Umweltschutz
Amt der NÖ Landesregierung, Abteilung Naturschutz
Landesverwaltung Kärnten, Umwelt - Natur- und Umweltschutz
Verwaltung Land Steiermark, Referat Fachstelle Naturschutz
Amt der Oberösterreichischen Landesregierung
Amt der Burgenländischen Landesregierung
eb&p Umweltbüro GmbH
WWF Austria

Table 3 Institutions contacted for data collection in Germany

Contacted institutions in Germany
Universität Münster
Bundesamt für Naturschutz
Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit
Leibniz-Institut für Gewässerökologie und Binnenfischerei (IGB) Berlin
Dienstleistungszentrums des Bundesamt für Kartographie und Geodäsie (BKG)
Ministerium für Ländlichen Raum und Verbraucherschutz
Bayerisches Staatsministerium für Umwelt und Gesundheit
Bayerisches Landesamt für Vermessung und Geoinformation
Landesamt für Vermessung und Geoinformation
Bayrische Wasserbaubehörde
WWF Germany

Table 4 Institutions contacted for data collection in France

Contacted institutions in France
Eau France
IRSTEA
Ministère de l'Ecologie, du Développement Durable, des Transports et du Logement
ONEMA
Agence de l'eau Rhône-Méditerranée et Corse
WWF France

Table 5 Institutions contacted for data collection in Italy

Contacted institutions in Italy
Ministero dell'Ambiente e della Tutela del Territorio e del Mare
CIRF Italian Centre für River Restoration
Direzione Geologia e Georisorse
Direzione centrale ambiente, energia e politiche per la montagna
Bacino Adige
Area Tecnico Scientifica, Servizio Osservatorio Acque Interne
Autorità di bacino del fiume Po
Autorità di bacino del fiume Adige
Autorità di bacino dei fiumi dell'Alto Adriatico
Autorità di Bacino dei fiumi Isonzo, Tagliamento, Livenza, Piave, Brenta-Bacchiglione
Regione Lombardia
Regione del Veneto
Regione Autonoma Friuli Venezia Giulia
Agencia Regionale per la Prevenzione e Protezione Ambientale del Veneto
Regione Liguria
Autonome Provinz Bozen, Südtirol
Provincia Trento
Aquaprogram
WWF Italy

Table 6 Institutions contacted for data collection in Slovenia

Contacted institutions in Slovenia
Institute for Water of the Republic of Slovenia
Ministry of Agriculture and Environment
Agencija RS za okolje / Slovenian Environment Agency
Ministrstvo za okolje in prostor
University of Ljubljana
Triglav National Park
ARNES
WWF Slovenia

Table 7 Institutions contacted for data collection in Switzerland

Contacted institutions in Switzerland
Bundesamt für Umwelt BAFU
EAWAG
Centre Suisse de Cartographie de la Faune (CSCF)
WWF Switzerland

Table 8 European/international institutions contacted for data collection

EU / International
European Commission
RESTORE / Cranfield University
European Environment Agency
UK Environment Agency
Permanent Secretariat of the Alpine Convention

2.3.3 Response to requested data

Figure 6 shows the amount of different responses to data requests per country.

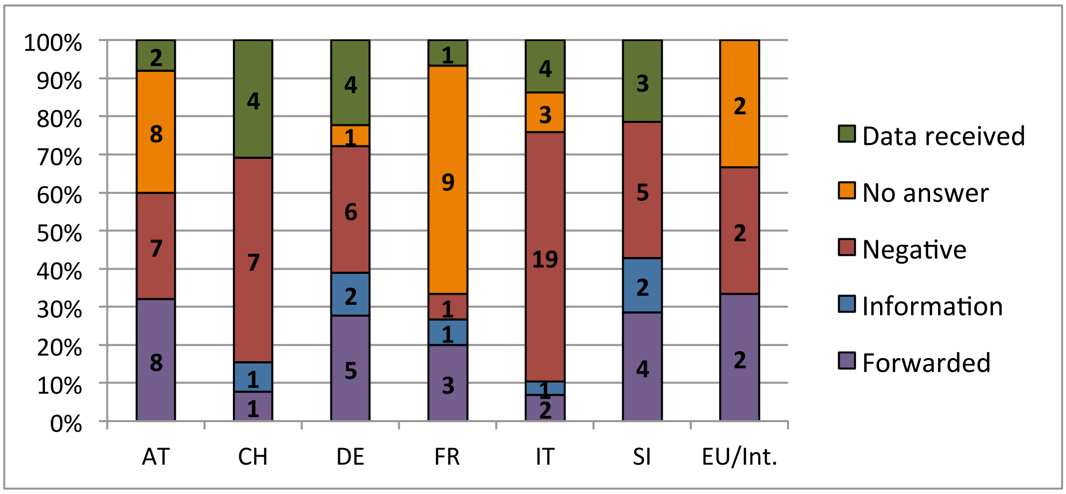


Figure 6 Number (bars) and percentage (y-axis) of different responses/outcomes to data requests per country

Generally, data availability was very diverse among countries and often, requested data were not available, especially on human pressures. Therefore, a large part of requests was unsuccessful (38%). Often the contact person forwarded us to further institutions and contacts (21%) or there was no response at all (19%). If contacted persons did not reply, a reminder was sent after approximately two weeks or the person was contacted by phone. In the end, 22% of the contacted persons sent us useful data or information necessary for data processing.

2.4 Database and data processing

2.4.1 River network

One essential basic requirement for this study was a complete GIS dataset containing all rivers in the Alpine Arc with a catchment area larger than 10 km². At first it seemed that the pan-European ECRINS (European catchments and RIvers network System, EEA 2012a) dataset that is freely available from the EEA homepage (EEA 2012a) could be used as the basic river network for this study. However, upon closer investigation it became clear that accuracy and scale differ too much from national datasets. This makes transfer of national river-network related data hard and inaccurate, especially for smaller rivers. In addition, the differences in river network geometry would make it impossible to transfer administrative codes - like water body IDs or river IDs. Such codes are required for joining additional national datasets, and upgrading to new versions in the future.

Consequently, the next option was merging the existing official national river networks of the Alpine countries provided by responsible national authorities. The advantage of this procedure is that the geometries of the national river networks are maintained.

Only a minimal loss of accuracy was introduced through re-projecting the national datasets to a common coordinate reference system (ETRS LAEA 1989).

For the combined pan-Alpine network, rivers were classified into different size classes, based on the total cumulative catchment size of the whole river. This parameter is analoguous to other classifications, i.e. ECRINS maindran classes (EEA 2012a) and Austrian GRKAT500 (owk_fg_tab.xls).

Lakes are handled very differently among countries: In Germany, Switzerland, "lake axes" were present as part of the river network, and designated as such. In Austria, France, and Slovenia lake axes were also present as part of the river network, but not designated as such. Finally, in Italy, lake axes were missing from the national river network. For the analyses in this study, lakes were not considered as part of the river network where possible.

2.4.2 River units

To associate the final rating of protection priority to certain river stretches, the next step was to define valuation units. Originally, WFD water bodies should have been these units, however, this was not possible for two reasons: First, they were not available for all countries (e.g. Switzerland). Second, the definition of water bodies varied strongly among countries; e.g. water bodies in Germany (average length 28 km) and France (average length 15 km) are much longer than the ones in Austria (average 4 km).

Therefore, we defined "river units" as the smallest valuation entity within the whole pan-Alpine river network (catchment area equal to or larger than 10 km²). A river unit was defined as the stretch of river between two tributaries. To each river unit, a unique ID code is assigned (referred to as "ID_MD10" in this document).

2.4.3 Data availability and methodological challenges during compilation of the pan-Alpine river network

During the compilation of the pan-Alpine river network, some methodological challenges came up: Some rivers were represented in river networks of two different countries, and rules had to be defined how to deal with such cases. Rather than to use political boundaries, which were only available on differing levels of accuracy, priority was given to rivers from countries with more complete/detailed information.

National river networks were given priority in the following sequence: **Austria > Germany > Italy > Slovenia > France > Switzerland**

This means, if a river was present in the French as well as in the Swiss dataset, only the French river course - including all related information - was kept.

Finally, it had to be ensured that rivers that cross borders are connected. This was done manually and led to some additional minor alterations of the river network geometry.

National data availability

- For Austria, all required data, except upstream catchment area, were available from the Environment Agency Austria (Umweltbundesamt, UBA) trough the dataset compiled for the 1st river basin management plan (*owk_fg.shp*; NGP 2009, BMLFUW 2010).

- For Germany, catchment size classification was not available from official sources. A dataset for Bavaria included topological information (i.e. Pfafstetter code, which describes hierarchical relationships among drainage areas), but it was not possible to combine it with the river network, as the geometry did not match and no usable ID codes were available to link rivers and catchments. To facilitate analyses by catchment size, ECRINS catchment information was manually transferred to the German river network (*by_fwk_2009.shp*).
- A Swiss-wide catchment shapefile that can be linked to the Swiss oficial river network (*gwn_25_l.shp*) was available from BAFU (*basisgeometrie.shp*). It was used to calculate upstream catchment area for each river section. Catchment sizes of whole rivers were then derived using the "Gewässerlaufnummer" (field "GWLNR").
- For France, upstream catchment area information was transferred from "*Troncons_SYRAH_04_04_12_Lambert93.shp* dataset", available from IRSTEA, to the WFD ecological status dataset "*etatmdoriv.shp*" from Eau France.
- For Italy we received separate WFD river network shapefiles for the River Basin Districts (RBD) "Alpi Orientali" and "Po", and for the region Liguria which is part of the RBD "Northern Apennines". Combined, these river networks cover the whole study area. To facilitate analyses by catchment size, ECRINS catchment size information was manually transferred to the Italian river networks, as catchment sizes were not available in the national shapefiles.
- The Slovenian river network for this study was compiled from various sources: 1) The official Slovenian river network supplied by GURS (*GBK25*), 2) two shapefiles of rivers larger 10 km² and larger 100 km² catchment size supplied by ARSO (*catchment size_above_10km2.shp*, cat*chment size_above_100km2.shp),* and 3) catchment size data from ECRINS for rivers larger 500 and 1000 km² catchment area. The catchment size data was transferred by manually comparing the data sets against each other, using the field "VOD_MID" of the *GBK25* dataset as identifier to trace consecutive rivers from source to mouth.

2.4.4 Compiling the final pan-Alpine river network dataset

The final pan-Alpine river network dataset keeps the most important information from source datasets, while still maintaining a manageable number of data fields. The following information was retained from national datasets (where available):

- **River ID:** ID that traces a stream from its source to its mouth.
- **Unique Feature Identifier:** OBJECTID, FID or similar of the original source datasets. This field corresponds to the smallest subdivision that is present in the source dataset. In some countries this corresponds to the water body (where classification of water bodies is available).
- **Water body code**
- **River name:** as in the original national datasets.

In addition, the following new fields were calculated:

- **River unit:** Unique code for each river unit, as described above.
- **Catchment size:** Size of catchment area of the whole river, as described above.
- **Reformatted river name:** Manually reformatted river name for mapping and other display purposes; only available for rivers with a catchment size > 100 km².

For a detailed description of the resulting dataset refer to *Metadata.xlsx* in the data annex.

2.4.5 Data description and data status

To gain an overview about the availability of different data types in the countries of the Alpine Arc, four different "data availability categories" were defined (Table 9). We classified data availability in all countries and regions according to these categories and mapped them for each data type.

Class 1 (data are available) means that data were provided by national authorities or we retrieved data from official websites (i.e. mapping of restoration projects). This, however, does not imply that data exist all over the country in a consistent way, i.e. that they were available for the entire country/region or in the same resolution. Class 2 was assigned if responsible authorities communicated, that relevant data are in preparation and will be available in the future. Class 3 means that data do not exist officially, and as far as we received information are not in preparation. Regions or countries are classified as class 4 if we could neither obtain data nor get the information on their existence.

Table 9 Data status categories

Class	Definition
1	Data officially exist (are published online, or are available via request) and we received them.
2	Data are in preparation/update process and are therefore not available yet.
3	Data do not exist officially (communicated via authorities) and are therefore not available.
4	We do not know if data exist.

In the following section, data sources, data categories and harmonization of datasets as well as methodological challenges are described. Moreover, data status categories as described above are displayed across the Alpine Arc for each criterion and pressure.

2.4.5.1 Ecological status

Data on the ecological status of rivers were available for all EU countries (see Figure 7), therefore, no further harmonization was necessary. For Slovenia, data on the ecological status were provided only for rivers with catchment sizes > 100 km². According to national authorities, a more detailed dataset is in process and will be available in near future.

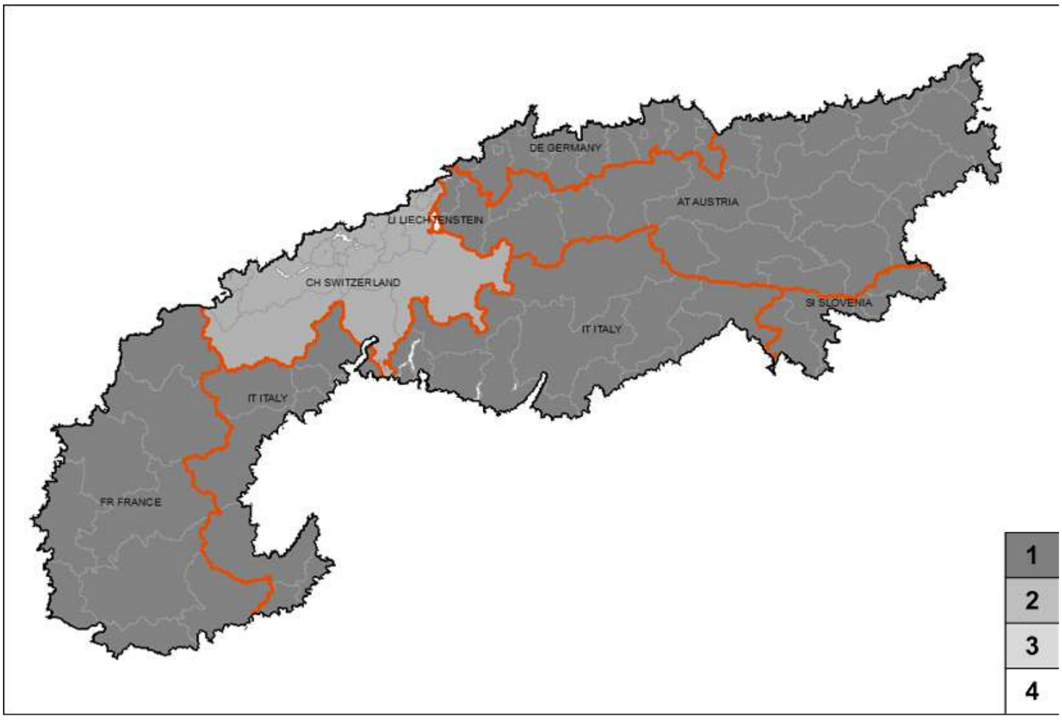


Figure 7 Data status: Ecological status classification; Class 1 – Data officially exist (are published online, or are available via request) and we received them; Class 2 - Data are in preparation/update process and are, therefore, not available yet; Class 3 - Data do not exist officially (communicated via authorities) and are, therefore, not available; Class 4 - We do not know if data exist

Table 10 Final/original classification, spatial scale and source of ecological status datasets summarizes the ecological status classes for different countries in national languages and their English translations.

Table 10 Final/original classification, spatial scale and source of ecological status datasets

	Ecological status	AT	DE	FR	IT PO	IT AO	IT LIG	SI
Classes	High	1	Sehr gut	État trés bien	Elevato	Elevato	Elevato	Zelo dobro
	Good	2	Gut	État bien	Buono	Buono	Buono	Dobro
	Moderate	3	Mäßig	État moyen	Moderato	Suficiente	Moderato	Zmerno
	Poor	4	Unbefriedigend	État médiocre	Scadente	Scarso	Scadente	Slabo
	Bad	5	Schlecht	État mauvais	Pessimo	Cattivio	Pessimo	Zelo slabo
Source		UBA	LFU	Eau France	ADBPO	ADBVE	Regione Liguria	ARSO

2.4.5.1.1 Methodological challenges / Surrogate Method CH

As Switzerland is not an EU member and, therefore, is not applying the WFD, no comparable methodology is available. To compensate this lack of data, we developed a surrogate method based on available biological-, hydromorphological- and pressure data from numerous sources. To avoid confusion with the ecological status classification required by the WFD, we developed a Swiss surrogate parameter called “ecological value”. This parameter is limited by data coverage, quality and inhomogeneity. It does not constitute a direct replacement for the ecological status, but rather an intermediate step to compare the situation in Switzerland with the other Alpine countries. Parameters included in the Swiss ecological value classification are presented in Table 11.

Table 11 Parameters included in the Swiss ecological value classification

Parameter	Categories	Geometry	Supplied by	Data type
Nase spawning areas / Grayling core areas / Grayling spawn areas / Grayling distribution areas	yes/no	Point / Line	BAFU	Biological (Fish)
Biological deficit analysis Canton Valais	1-4	Line	WWF CH	Biological (Fish)
Swiss Fish Index	1-5	Point	WWF CH	Biological (Fish)
European Fish Index (EFI+)	1-5	Point	EAWAG, cantons	Biological (Fish)
IBCH Index	1-5	Point	WWF CH	Biological (Macroinvertebrates)
Makroindex	1-5	Point	WWF CH	Biological (Macroinvertebrates)
Saprobien Index	1-5	Point	WWF CH	Biological (Macroinvertebrates)
Ecomorphology class	1-5	Line	BAFU, WWF CH	Hydromorphology
Hydropeaking	yes/no	Line	WWF CH	Pressure
Water abstraction	yes/no	Line	EAWAG	Pressure

Below, the most important methodological aspects for ecological value classification are summed up (see also the Swiss ecological value rating scheme, Figure 8):

- Generally, the ecological value class was derived by biological data in combination with pressure data. If no biological data were available for certain river units, hydromorphological data in combination with pressure data were considered as a substitute.
- If data were only available at sampling points, they were transferred to the closest river unit (i.e local point sampling based biological data were transferred to the entire river unit).
- If several sites of the same biological index were available on one river unit, the mean value was calculated.
- If several different biological indices were available on a river unit, a prioritization hierarchy, i.e. fish indices > macroinvertebrate indices > morphological data, was applied.
- For biological indices with a 5-tiered-scale, values 4/5 were merged to category 4.
- Nase spawning areas / Grayling core areas / Grayling spawning areas were assumed to equal a fish index rating of 1, while Grayling distribution areas were assumed to equal a fish index rating of at least 2.

- River units affected by hydropeaking or water abstraction were downgraded one class, if the rating was based on macroinvertebrate indices or ecomorphology, as they are known to reflect this pressure situation badly.

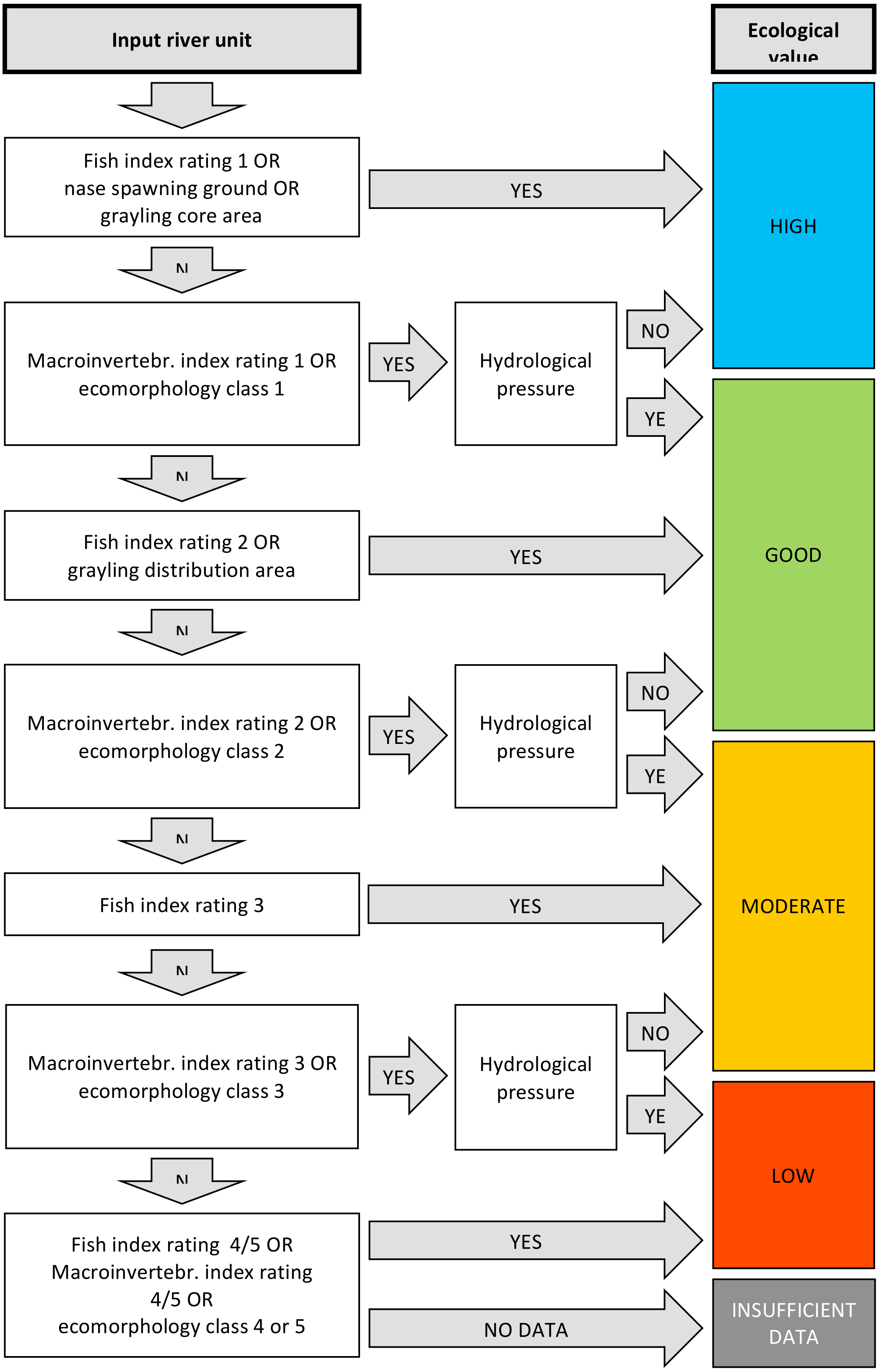


Figure 8 Overview of Swiss ecological value rating scheme

2.4.5.2 Hydromorphological status/ecomorphology class

The hydromorphological status as demanded in the WFD was available only for Austria, Slovenia and a few larger tributaries of the Po River in Italy (Figure 9). For Germany, Switzerland, France and Trentino-Alto Adige this data could be converted to a 5-tiered scale to make it comparable to the hydromorphological status as required by the WFD.

For France, hydromorphological status data were only available on a very rough basis through a few classified sampling points and only in two classes: “Très bon état” (corresponds to high hydromorphological status class) and “others”. In addition, hydromorphological pressure classifications can be found in the same dataset with the classes: “No pressure or low pressure”, “medium pressure” and “high pressure”. Combining this information we derived four classes and mapped each sampling point to the nearest river unit.

The German hydromorphological status is 7-tiered. Transformation into five EU-WFD compliant classes was carried out according to a proposal from local experts (LAWA). In Trentino-Alto Adige, 20 different hydromorphological classes were transformed into five classes according to the proposal of the Federal Environmental Agency, who provided the data.

In Switzerland, a similar approach to the hydromorphological status, the “ecomorphology” dataset (Ökomorphologie, BAFU, 2009), was available on a countrywide scale with varying completeness of coverage between cantons. This rating is also divided into five classes, which were considered as analogues to the 5 classes of the hydromorphological status.

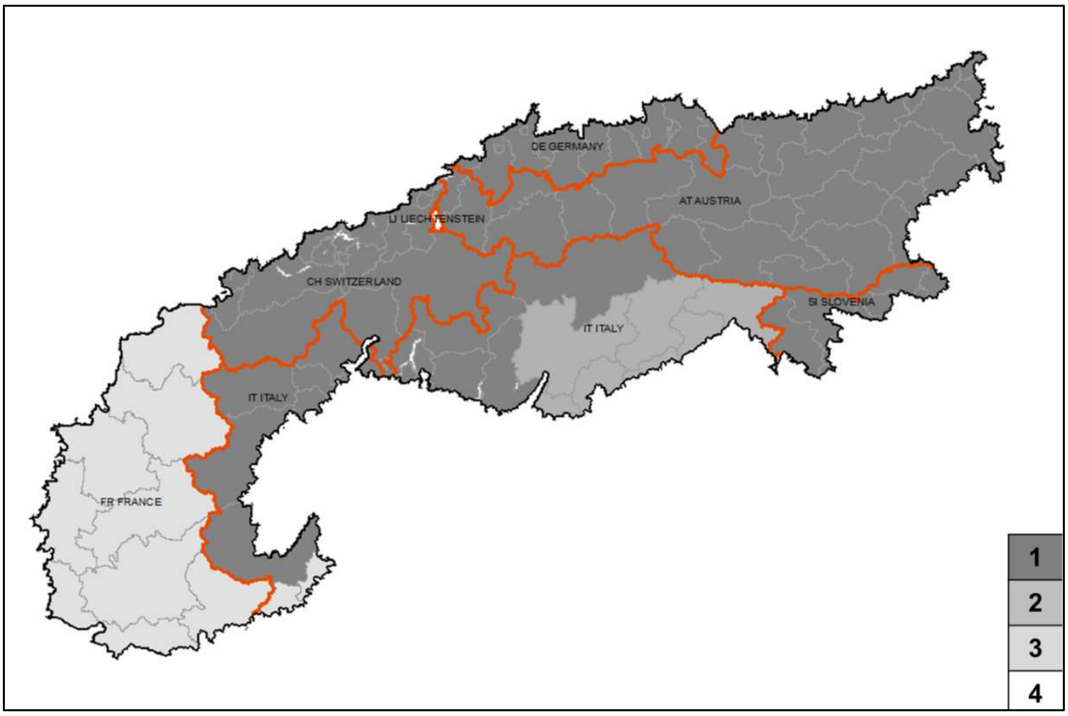


Figure 9 Data status: Hydromorphological status/ecomorphology class classification; Class 1 – Data officially exist (are published online, or are available via request) and we received them; Class 2 - Data are in preparation/update process and are therefore not available yet; Class 3 - Data do not exist officially (communicated via authorities) and are therefore not available; Class 4 - We do not know if data exist

Table 12 gives an overview of available data on the hydromorphological status/ecomorphology class.

Table 12 Final/original classification and source of hydromorphological status datasets

	Final name	AT	DE	CH	FR	IT Po	IT TAA	SI
Classes	High	1	1 & 2	1	Trés bien	Elevato	20	Naravni vodotok
	Good	2	3	2	Faible	Buono	17 – 20	Zmerno spremenjen vodotok
	Moderate	3	4	3	Moyen	Moderato	13 – 16	Obèutno spremenjen vodotok
	Poor	4	5	4		Scadente	9 – 12	Moèno spremenjen vodotok
	Bad	5	6 & 7	5	Fort	Pessimo	5 – 8	Zelo moèno spremenjen vodotok
Source		UBA	LFU	BAFU	Eau France	ADBPO	APPO Bozen	ARSO

2.4.5.2.1 Methodological challenges for processing and harmonizing hydromorphological status data

In Italy and Germany, hydromorphology data were supplied separately from the national river network. To account for positional differences between the national river networks and the hydromorphology datasets, buffer distances of 100 meters were used. In addition, manual corrections were necessary to account for larger differences.

2.4.5.3 Protected areas

Many different classifications of protected areas exist within the EU territory based on global, European and national approches. Most datasets on protected areas are easily accessible for all countries within the Alpine Arc (Figure 10 Data status: Protected areas;).

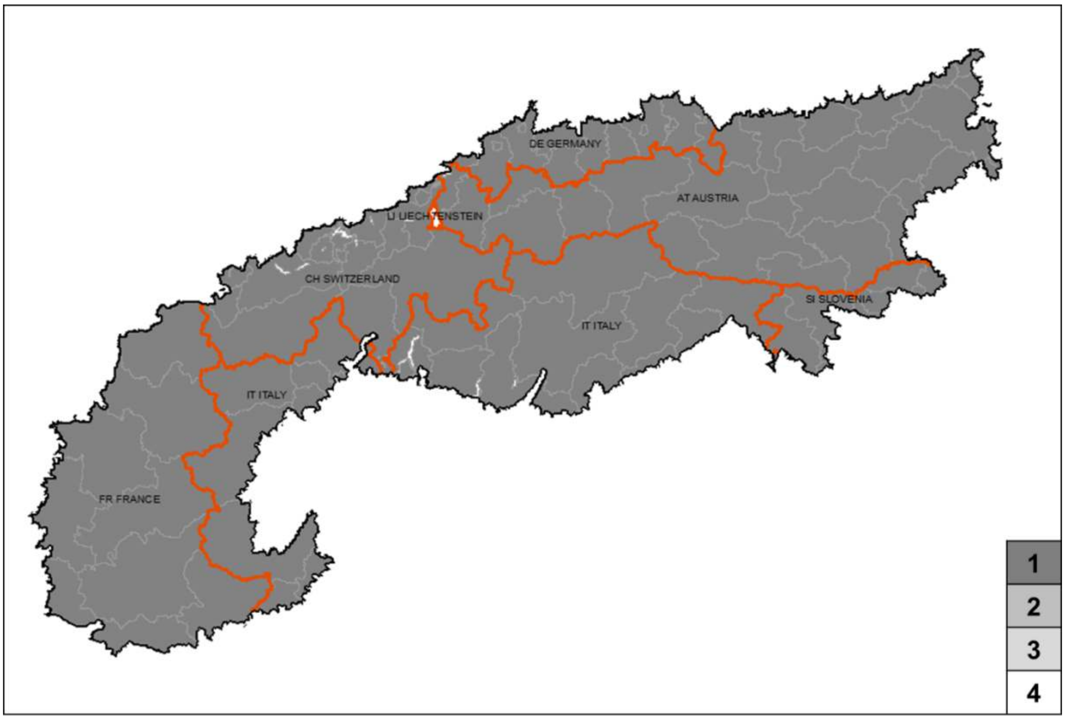


Figure 10 Data status: Protected areas; Class 1 – Data officially exist (are published online, or are available via request) and we received them; Class 2 - Data are in preparation/update process and are therefore not available yet; Class 3 - Data do not exist officially (communicated via authorities) and are therefore not available; Class 4 - We do not know if data exist

The two most important datasets are the "National Designated Areas (CDDA)" and the "Natura 2000" shapefiles, which are freely available from the EEA (2012b) website. While extensive information about Natura 2000 sites is available, little information is supplied for other sites. Alternative sources, e.g. RAMSAR wetlands and UNESCO World Natural Heritage sites, are available, though, this information is already included in the aformentioned EEA datasets. In many cases also national datasets of protected areas could be obtained. In Switzerland national datasets were used instead of EEA data to avoid loss of positional accuracy due to reprojecting the data. In Slovenia the "Valuable Natural Features" dataset was used to complement the EEA datasets. In the other countries national data on protected areas was redundant with the EEA datasets, and were therefore discarded.

The protected areas were classified into 2 categories:

- **Protected areas classified as Ia, Ib, or II** (Strict Nature Reserve, Wilderness Area, National Park) after the IUCN classification system.
- **Protected areas recommended by national experts** (only available for Slovenia, Switzerland, and Austria, see Table 13), and Natura 2000 areas.

Protected areas recommended by national experts are shown in tables 13 – 19, including the name of expert. The remaining classes were considered of low importance and, therefore, were not considered for this study.

Table 13 Types of protected areas inside the area of the Alpine Convention (international)

Protected area designation	IUCN rating	Expert recommended
International		
UNESCO World Natural Heritage		
Biosphere Reserve	VI	
RAMSAR Wetland		
EU/EC		
Natura 2000		

Table 14 Types of protected areas considered for Austria;
Expert: Maria Tiefenbach, head of the section biodiversity and nature protection of UBA

Protected area designation	IUCN rating	Expert recommended
Austria		
National Park	II	x
Nature Reserve	Ia, IV	x
Landscape Protection Area	V	
Nature Park	V	
Protected Landscape Section	III,IV,V	
Rest Area	IV	
Flora Protection Area	IV	
Special Conservation Areas	IV	
Townscape Protection Areas		

Table 15 Types of protected areas considered for Switzerland
Expert: WWF Switzerland

Protected area designation	IUCN rating	Expert recommended
Switzerland		
Moor Landscapes of National Importance	V	x
Floodplains of National Importance	IV	x
Reserves for Waterbirds and Migrants of International and National Importance	IV	x
Amphibian Spawning Grounds		x
Dry Grasslands	IV	
Swiss National Park	Ia	x
Federal Hunting Reserves	IV	
Fenlands of National Importance	IV	x
Emerald sites*	IV	x
RAMSAR Sites	IV	x
Landscapes and Natural Monuments of National Importance*	III,V	x
Sites for compensation of losses during use of hydropower	IV	
UNESCO World Natural Heritage	V	x

** consideration according to relevant species and ecosystems (emerald) or protection goal (landscapes)*

Table 16 Types of protected areas considered for Germany

Protected area designation	IUCN rating	Expert recommended
Germany		
Nature Reserve	IV	
National Park	II	
Landscape Protection Area	V	

Table 17 Types of protected areas considered for France

Protected area designation	IUCN rating	Expert recommended
France		
National Park - Buffer zone/Area of adhesion	V	
National Park - Core Area	II	
Nature Reserve		
Regional Nature Park	V	
Marine Nature Park	V	
Forest Biological Reserve	Ia, IV, 0	
National Nature Reserve	III, IV	
Regional Nature Reserve	IV	
National Hunting and Wildlife Reserve	IV	
Biotope Protection Order	IV	
Land acquired by Conservatoire du Littoral (national seaside and lakeside conservancy)	IV	

Table 18 Types of protected areas considered for Italy

Protected area designation	IUCN rating	Expert recommended
Italy		
Regional/Provincial Nature Reserve	Ia, IV, V	
National Parks	II	
Regional/Provincial Nature Park	IV, V	
Regional/Interregional Nature Parks		
State Nature Reserve	Ia, IV, V	
Nature Reserves		
Wetlands of International Importance		
Other Protected Natural Areas		
Land and Marine Potential Park Areas		
Other Protected Natural Regional Areas	III,IV,V	
Plant Protection Area		
Forest Reserve/Protected Forest	Ib/IV	
Protected Area	V	

Table 19 Types of protected areas considered for Slovenia
Expert: Andrej Arih, Triglav National Park

Protected area designation	IUCN rating	Expert recommended
Slovenia		
National Park	II	x
Regional Park	III,V	x
Landscape Park	III, V	x
Nature Reserve	Ia, Ib,III,V	x
Natural Monuments	III	x
Ecological Important Area		
Horticultural Monument		
Specially Protected Area		x
Valuable Natural Features (of national importance)		x
Valuable Natural Features (others)		

2.4.5.3.1 Methodological challenges for processing and harmonizing protected area data

The protected area datasets could be used without any major adaptations.

2.4.5.4 Floodplains/wetlands

Official floodplain and wetland inventories were obtained for Switzerland (BAFU, 2006), Germany (Brunotte et al., 2009), Austria (UBA, 2011), France (*ZH.shp*) and Slovenia (*MOKRISCA.shp*) as shown in Figure 11.

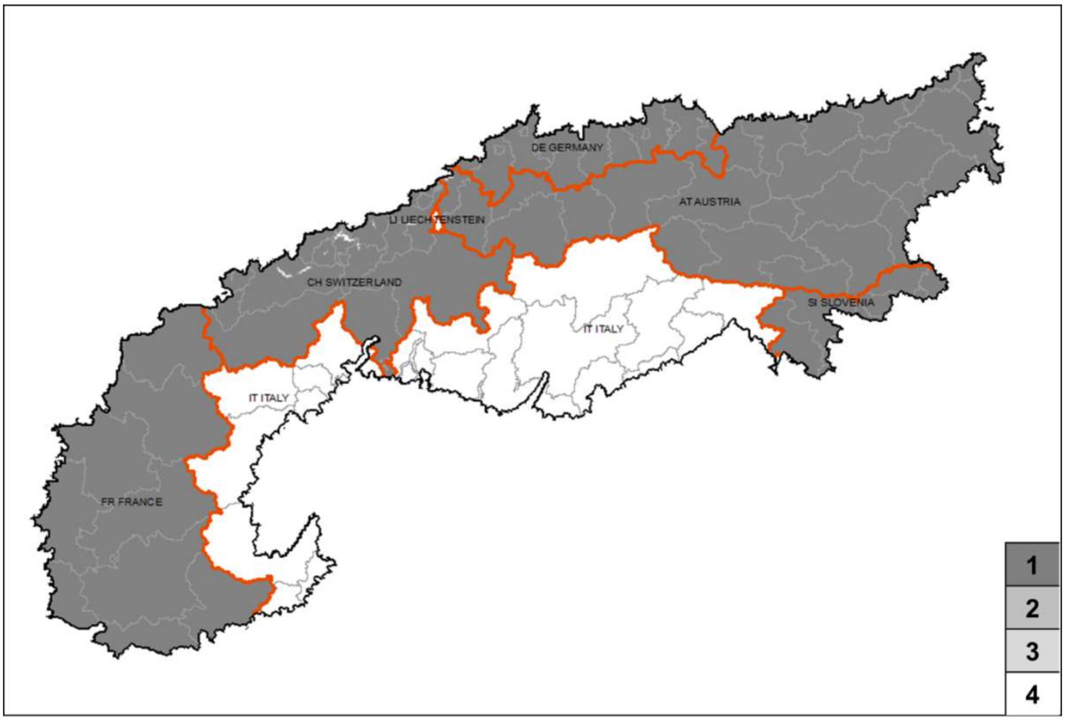


Figure 11 Data status: Floodplains/wetlands; Class 1 – Data officially exist (are published online, or are available via request) and we received them; Class 2 - Data are in preparation/update process and are therefore not available yet; Class 3 - Data do not exist officially (communicated via authorities) and are therefore not available; Class 4 - We do not know if data exist

German, Austrian and Swiss datasets were included into the pan-Alpine overview and in final analyses in its original format. In Germany and Austria, a classification of a nature protection value of floodplains exists.

For Austria, data on floodplains/wetlands was available, which allowed differentiating the protection priority in further analyses. Floodplains/wetlands of the highest ratings were classified as “Cat. A”, all others were classified as “Cat. B”. In Switzerland, we differentiated between the general floodplain inventory and floodplains of national importance. Floodplains of national importance were designated as “Cat. A”. The other Swiss floodplains and floodplains/wetlands of the other countries, which were not rated according to their protection value were classified as “Cat. B”.

The Slovenian wetland inventory is based on Ramsar habitat types (Ramsar, 2012). Only selected inland wetlands (Permanent freshwater marshes/pools, seasonal/intermittent freshwater marshes/pools on inorganic soils, non-forested peatlands, freshwater, tree-dominated wetlands; codes: Tp, Ts, U, Xf) were used for the pan-Alpine overview of floodplains/wetlands and for the final analyses. Other wetlands, like artificial wetlands, permanent freshwater lakes (code: O) or marine wetlands were not included, in order to maintain comparability to the inventories of the other countries.

In France, floodplain inventories were received through the French Water Agency. The classification was based on a national methodology. We selected relevant wetland types (marshes and heaths, floodplains, and local floodplains) and excluded others (e.g. artificial wetlands) to maintain comparability to other datasets. However, information about wetland types was only included in the dataset for Provence-Alps and not for Rhône-Alps. In order to avoid artificial and other non-relevant floodplain/wetland categories in our dataset, we used a dataset of Natura 2000 biotopes for the Rhône area instead. These data include CORINE biotope classifications (Bissardon, et al. n.d.). All floodplain forest biotopes (Code 44) were included into our pan-Alpine overview.

For Italy, no data on floodplains/wetlands were available. As a surrogate, we used Natura 2000 protected areas, including floodplain/wetland habitats (codes: 3140, 3150, 3220, 3230, 3240, 3250, 3260, 3270, 3280, 3290, 6410, 6420, 6430, 6440, 91E0, 91F0, 92A0, 92B0, 92C0, 92D0). In contrast to the Natura 2000 dataset, which was used in Rhône-Alps, only the complete protected area could be integrated into further processing. Biotopes/habitats could not be filtered and mapped separately within one Natura 2000 area. For this reason Natura 2000 areas only were included, when the selected habitats sum up to an area of > 2 ha and when more than 15% of the whole Natura 2000 area was associated with the selected floodplain/wetland habitat types.

Impounded river stretches were excluded from all floodplain/wetland datasets. All wetland types included into the pan-Alpine overview of floodplains/wetlands and into the designation of river stretches with high protection priority are listed in annex 9.1. Table 20 represents a summary of available floodplain/wetland datasets.

Table 20 Overview of floodplain/wetland datasets and data sources, additionally including a description if all floodplain/wetland types were used for further processing or if data was filtered; detailed information about included floodplain types is presented in annex 9.1.

Country	Dataset	Sources
AT	National floodplain inventory (all types included)	UBA
DE	National floodplain inventory (all types included)	LFU
CH	(1.) National floodplain vegetation inventory (2.) Floodplain forests of national importance (all types included)	BAFU
FR - *Provence-Alps*	National wetland inventory (selected freshwater floodplains/wetlands)	Eau France
FR - *Rhône-Alps*	CORINE biotopes (all floodplain forests)	Eau France
IT	Natura 2000 areas (selected floodplain/wetland types)	EEA
SI	RAMSAR classification (selected freshwater floodplains/wetlands)	ARSO

2.4.5.4.1 Methodological challenges

In the geo-datasets rivers are represented by the centreline of the river, while floodplains/wetlands are represented by polygons delineating the exact boundaries of the floodplain/wetland area. This has the effect that the broader a river is the farther away the GIS-representation of the floodplain is from the GIS-representation of the river. To mitigate this issue, and account for positional inaccuracies between the data sets, a buffer distance of 150 meters around floodplains/wetlands was chosen for associating them with the relevant river.

2.4.5.5 Pressures

2.4.5.5.1 Impoundment

GIS data on impounded stretches were received for Austria, Germany, France and the RBD Alpi Orientali, whereas in the rest of Italy and Slovenia this pressure type was not assessed. Intensity of the impairment was not taken into account for mapping and analysis. Figure 12 gives an overview of data available on impounded river stretches.

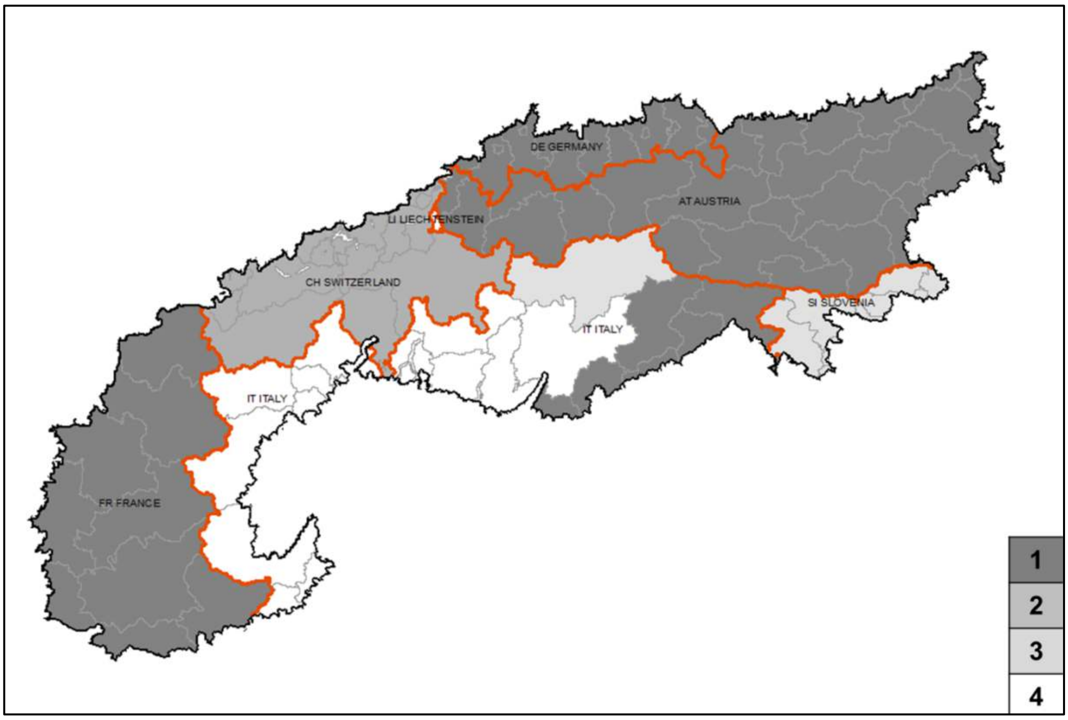


Figure 12 Data status: Impoundment; Class 1 – Data officially exist (are published online, or are available via request) and we received them; Class 2 - Data are in preparation/update process and are therefore not available yet; Class 3 - Data do not exist officially (communicated via authorities) and are therefore not available; Class 4 - We do not know if data exist

Institutions that provided these data are presented in Table 21.

Table 21 Sources for impoundment data

Country	AT	DE	FR	IT - AO
Source	UBA	LFU	IRSTEA	ADBVE

2.4.5.5.2 Methodological challenges for processing and harmonizing impoundment data

Austrian, Italian and French impoundment data were supplied directly on the respective national networks and no correction measures had to be implemented. In Austria and France, impounded stretches were supplied directly as geographic datasets (Austria: *belast_fg_stau.shp*, France: part of the ESRI personal geodatabase *Atlas_large_échelle_SYRAH_CE_diffusion_large.mdb*). In Italy impoundment data were supplied as a Microsoft Excel workbook (*pressure_impact_river.xls*) that can be linked to the Italian river network via the water body code.

Relevant data for Bavarian were provided by two different sources: The “Strukturgütekartierung” (Field: AUBFLUSSREG) and a more recent WFD related dataset that contains additional stretches (*by_rueckstau_ba2004.shp*). While the “Strukturgütekartierung” dataset is only available for larger rivers, the WFD dataset covers all rivers > 10 km² catchment size. The positional accuracy of both datasets differs from the Bavarian river network shape file. These differences were eliminated by combining manual and automated correction measures.

2.4.5.5.3 Water abstraction

Data were available for France, Switzerland, Germany, Austria and the RBD Alpi Orientali. In France and Alpi Orientali, the information was available in the ecological status dataset, in those cases where water abstraction was the reason for not achieving the good status. For France the information was available only sporadically and most likely is incomplete. In the Po basin, as well as in Slovenia these data are in process. The amount of abstracted water is not recorded and, therefore, was not taken into account and no further classification was developed. The data status is summarized in Figure 13.

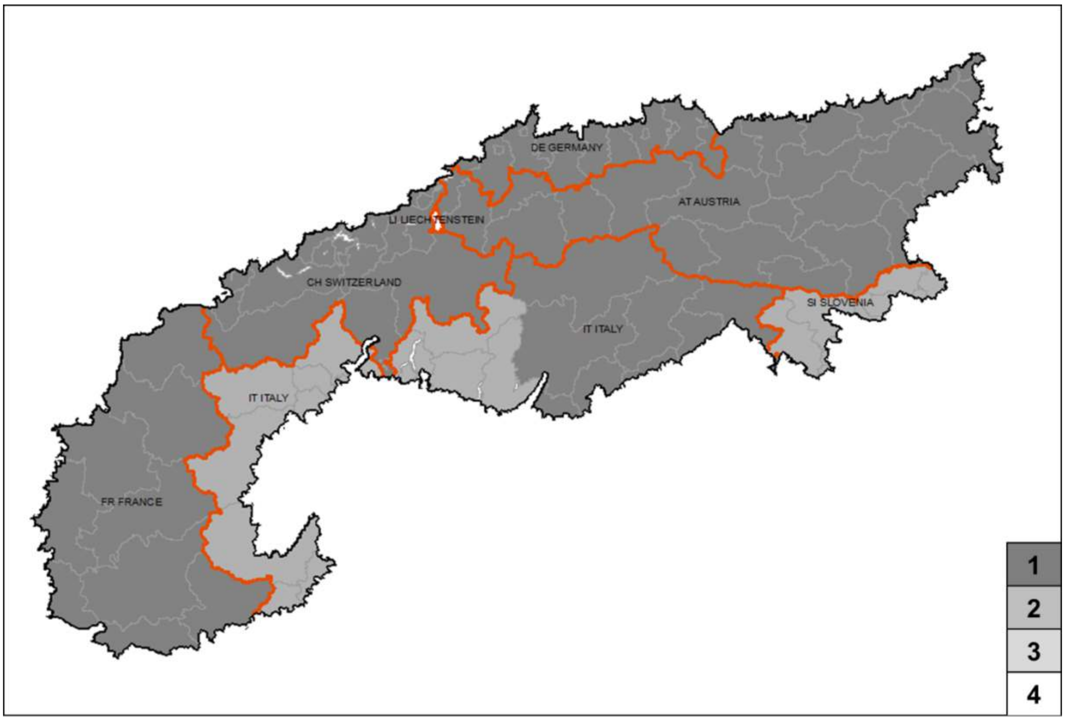


Figure 13 Data status: Water abstraction; Class 1 – Data officially exist (are published online, or are available via request) and we received them; Class 2 - Data are in preparation/update process and are therefore not available yet; Class 3 - Data do not exist officially (communicated via authorities) and are therefore not available; Class 4 - We do not know if data exist

Institutions that provided these data are presented in table 22.

Table 22 Sources for data on water abstraction

Country	AT	DE	CH	FR	IT- AO	IT- TAA
Source	UBA	LFU	EAWAG	Eau France	ADBVE	APPA Bozen

2.4.5.5.4 Methodological challenges for processing and harmonizing water abstraction data

In Austria and France, water abstraction stretches were supplied directly as GIS datasets (Austria: *belast_fg_restw.shp*, France: from the personal geodatabase *Atlas_large_échelle_SYRAH_CE_diffusion_large.mdb*). In Italy water abstraction data were supplied in the same Microsoft Excel workbook as impoundment data (*pressure_impact_river.xls*). Additional water abstraction data for Trentino-Alto Adige region was available in the form of the shapefiles *Tratti_derivati_10_2005.shp* and *tratti_derivati_06_2009*.

For Bavaria, data on water abstraction were available from the “Strukturgütekartierung” dataset (again from the field “ABFLUSSREG”). Water abstraction data for Switzerland (*Restwasserstrecken.shp*) showed some positional differences to the VECTOR25 river network dataset (*gwn_25l.shp*). Therefore they were manually corrected.

2.4.5.5.5 Hydropeaking

Data on river stretches affected by hydropeaking were not available across the whole Alpine Arc. Nationwide data were only provided for Austria. For Italy we received data of some stretches in the RBD Alpi Orientali by national authorities and additionally, a separate dataset for Trentino-Alto Adige with more detailed information. For Switzerland, we received a dataset on hydropeaking stretches compiled by WWF Switzerland. In the Po basin and in Slovenia this type of data is not available. Again, no distinction of pressure intensity was made for mapping and analysis. Figure 14 shows the data status for the pressure hydropeaking.

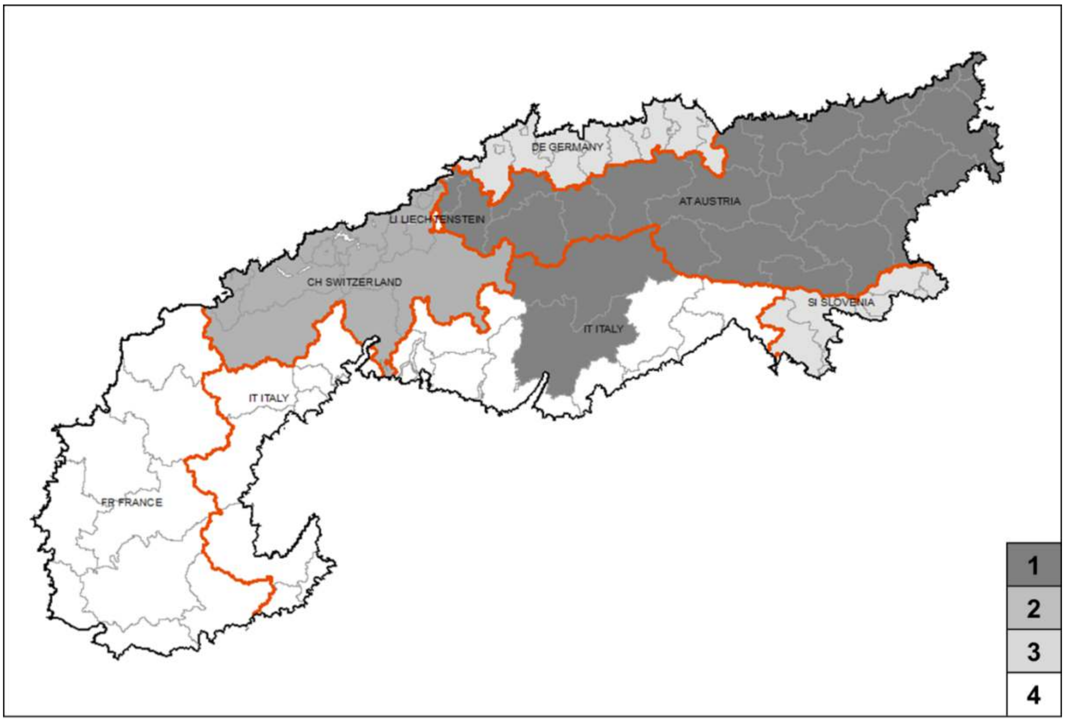


Figure 14 Data status: Hydropeaking; Class 1 – Data officially exist (are published online, or are available via request) and we received them; Class 2 - Data are in preparation/update process and are therefore not available yet; Class 3 - Data do not exist officially (communicated via authorities) and are therefore not available; Class 4 - We do not know if data exist

The hydropeaking data sources are presented in Table 23.

Table 23 Sources of received hydropeaking data

Country	AT	CH	IT- TAA	IT- AO
Source	UBA	WWF	APPA Bozen	ADBVE

2.4.5.5.6 Methodological challenges for processing and harmonizing hydropeaking data

For available hydropeaking data, methodological challenges during data transfer to national river networks were negligible. In Austria, like other hydrological pressures, it was directly supplied as shapefile (*belast_fg_schwall.shp*). In the RBD Alpi Orientali, hydropeaking data was available from the same Microsoft Excel workbook as other pressure data (*pressure_impact_river.xls*). Additional hydropeaking data for Trentino-Alto Adige province was available in the form of the shapefiles *Schwallbetrieb_2006.shp*.

2.4.5.5.7 Hydropower plants and other barriers

Datasets on hydropower plants were obtained for the whole study area; however, they are very heterogeneous in terms of completeness and classifications of hydropower plants. In many cases, several conflicting datasets with overlapping content were available per country: Five each for Italy and France, three for Austria and two for Slovenia. In Bavaria hydropower plants were mapped from the “Energieatlas Bayern” (Medien, Energie und Technologie, www.energieatlas.bayern.de/). Additionally, a EU-wide dataset of large hydropower plants is freely available from the European

Environment Agency (EEA, 2012a). Figure 15 shows the data status for hydropower plants.

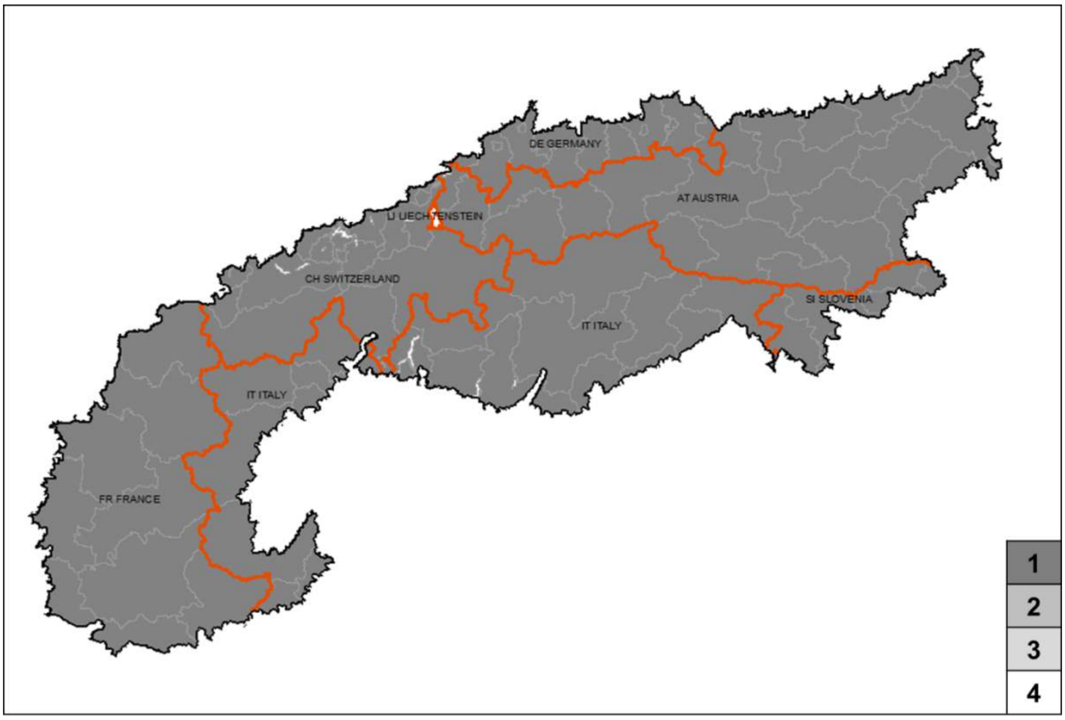


Figure 15 Data status: Hydropower plants; Class 1 – Data officially exist (are published online, or are available via request) and we received them; Class 2 - Data are in preparation/update process and are therefore not available yet; Class 3 - Data do not exist officially (communicated via authorities) and are therefore not available; Class 4 - We do not know if data exist

Information about the size and capacity of hydropower plants was not available for all countries/regions, therefore, these parameters were not considered for further processing. However, an overview of hydropower plants and other barriers is presented in a map in the data annex ('Hydropower plants and other barriers').

GIS datasets on other barriers than hydropower plants were also quite heterogeneous. The barrier types included in the datasets differ as well as the data completeness of assessed barriers. E.g. height information was not available in German barrier dataset. Institutions that provided these data are presented in table 24.

Table 24 Sources of received data on hydropower plants

	AT	DE	FR	IT - PO	IT - AO	IT - LiIG	SI
Sources	UBA Mader BMLFUW	LFU	Eau France	ADBPO	ADBVE	Regione Liguria	ARSO

As shown in Figure 16, we obtained data on other barriers (besides hydropower) for Switzerland, Austria, Germany, France and the Italian provinces Trentino-Alto Adige and Friuli. In the rest of Italy and in Slovenia these data were officially not available. Received barrier datasets of the different countries are very heterogeneous regarding types of barriers and number of recorded barriers. For Germany for example we received three datasets of barriers, culverts and ramps. In Switzerland one dataset included ramps and other “constructions”. Weirs, dams, levees, constructions, groynes and mobile barriers were given in the French dataset. In Austria the types flood protection constructions, barriers and “others” were included in the barrier data. In Trentino-Alto Adige it was differentiated between weirs and barriers. The height of barriers was only given in datasets from Austria, Switzerland, France and Trentino-Alto Adige. Due to the above described inhomogeneity, barriers were not included into protection priority rating but are instead visualized in the map ‘Hydropower plants and other barriers’ (see data annex). An overview of different data categories is presented in annex 9.2.

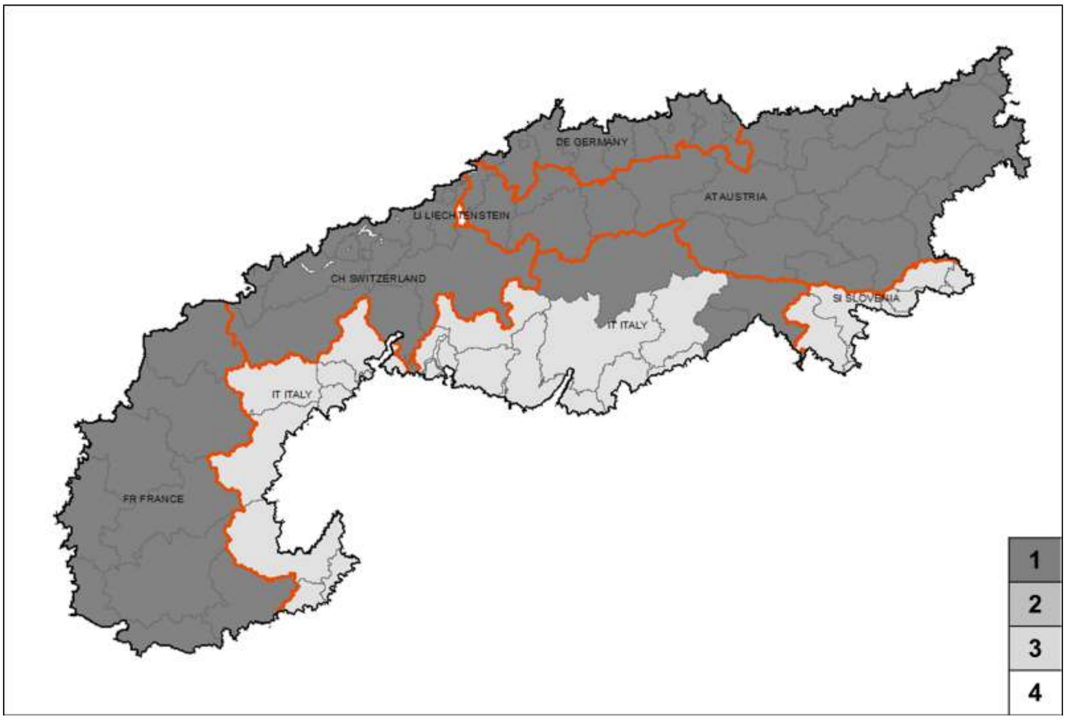


Figure 16 Data status: Barriers (excluding hydropower plants); Class 1 – Data officially exist (are published online, or are available via request) and we received them; Class 2 - Data are in preparation/update process and are therefore not available yet; Class 3 - Data do not exist officially (communicated via authorities) and are therefore not available; Class 4 - We do not know if data exist

Institutions that provided these data are presented in table 25.

Table 25 Sources of received data on barriers (excluding hydropower)

	AT	DE	CH	FR	IT - TAA	IT FRI
Source	UBA	LFU	BAFU	Eau France	APPA Bozen	WWF

2.4.5.5.8 Methodological challenges for processing and harmonizing hydropower plants & other barrier data

For our final analysis we discarded the hydropower dataset received from the Alpine Convention (*hydropower_HAO_AT.shp*, *HydropowerStation.shp*., *wasta_point*.shp), as in each case more comprehensive datasets were available. To avoid duplicate hydropower plants in the remaining datasets, those located in a distance of less than

50 m from each other were assumed to be the same facility. Hydropower plants located in a distance between 50 and 500 m from each other were checked manually in Google Earth. Duplicate power plants were deleted.

For other barriers, there were no conflicting datasets per country. In Italy, Germany, and Switzerland several datasets were available that complemented each other.

In Austria, Switzerland and Trentino-Alto Adige region, the barrier inventory was conducted in a much more detailed way than in other countries, and the datasets had to be filtered to be more comparable with other countries. In Austria, barriers marked as fish-passable were discarded from the dataset. For Switzerland two datasets existed: "Bauwerke" (structures) and "Abstürze" (drops). Structures were differentiated into several types, however, only weirs, dams, locks, and sediment restraint catches were retained (field "BAUWTYP", values 0, 3, 4, 5, 6, 8, 9) if they were higher than 30 cm. The drops dataset was classified in natural and artificial drops. Only artificial drops above a height of 30 cm were retained. In Trentino-Alto Adige region, fish-passable barriers were filtered and left out like for the Austrian dataset. Since a large fraction of barriers was not classified in terms of passability, similar filtering criteria like in Switzerland were applied to the rest: consolidation catches, restraint catches, and filter catches higher than 30 cm were retained (field "TYPE" values, 200, 201, 202, 203, 204, 205, 206, 207, 208, 220, 221, 222, 223, 224, 225, 226, 227, 230, 231, 232, 233, 234, 235, 236, 237).

The remaining barriers and hydropower plants were snapped to the closest rivers, with maximum snapping tolerance varying between countries depending on the accuracy of the original dataset:

- Austria, Switzerland, Trentino-Alto Adige region: Barrier datasets fit perfectly to the river network. To account for small digitization inaccuracies, barriers were snapped to the closest rivers, but with a maximum snapping distance of only 5 m.
- Hydropower plant position from Austrian datasets ("*Mader KW Potential-Studie"* and "*Hydrologischer Atlas") was* less accurate. The power plants were snapped up to a maximum distance of 300 m.
- In Germany and France, barriers had a displacement of up to several hundred meters from the river network in some cases; therefore, a maximum snapping distance of 500 m had to be used. For both countries, an ID code was present in the barriers dataset that linked the barriers with the associated water body. Therefore, it was possible to ensure that barriers were snapped to the right water body, though the location along the water body might be slightly inaccurate.
- In Italy and Slovenia, maximum snapping distances of 300 m were chosen.

2.4.5.5.9 Morphological pressures

River units with a hydromorphological status/ecomorphology class of moderate or worse (i.e. status classes 3-5) were defined as being affected by morphological pressures. For detailed information see section 2.4.5.2.

2.4.5.5.10 Heavily modified & artificial water bodies

Information on heavily modified water bodies (HMWB) and artificial water bodies (AWB) is included in all national datasets related to ecological status, except

Switzerland. For the German dataset, there was no distinction between artificial and heavily modified water bodies. For Switzerland, all rivers with an ecomorphological status of 4 (artificial) and 5 (culverted) were treated as category HMWB/AWB.

2.4.5.6 Restoration projects

Even though we gained data on restoration projects in each country of the Alpine Arc (figure 17), GIS data on LIFE restoration projects and others were generally not available from public authorities.

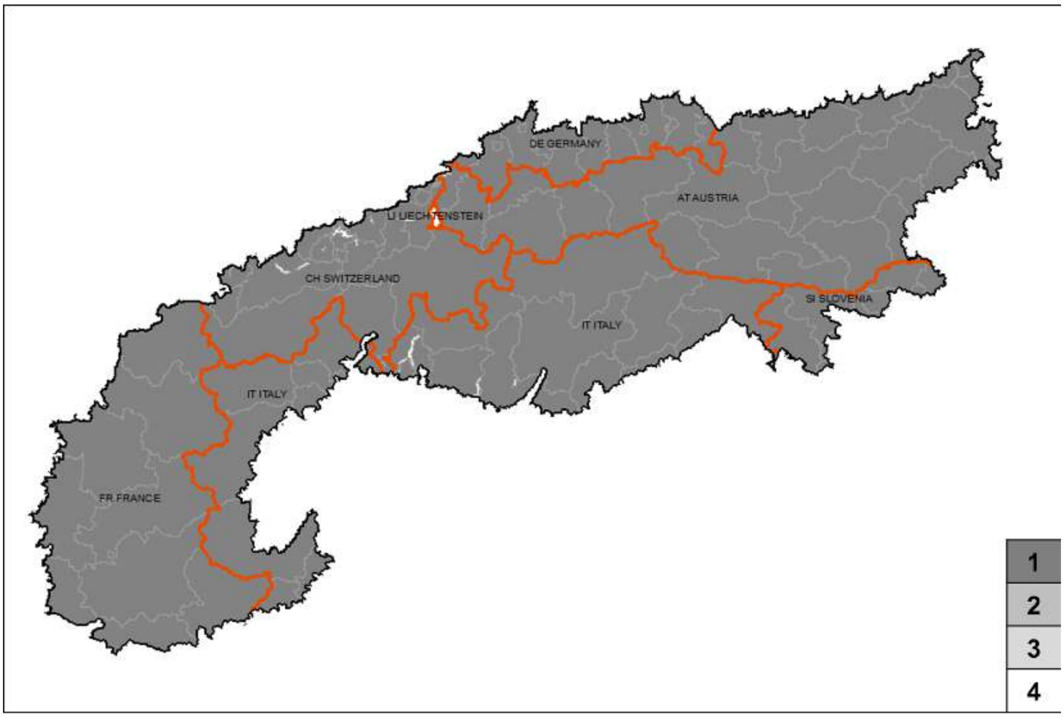


Figure 17 Data status: Restoration projects; Class 1 – Data officially exist (are published online, or are available via request) and we received them; Class 2 - Data are in preparation/update process and are therefore not available yet; Class 3 - Data do not exist officially (communicated via authorities) and are therefore not available; Class 4 - We do not know if data exist

A low and incomplete number of restoration projects data could be obtained through the EU funded project REFORM (reformrivers.eu). Besides these data, individual project data from online-sources and regional authorities might be available, but were not an issue for this study. For this reason we mapped EU LIFE river restoration projects accessible via the LIFE project database (http://ec.europa.eu/environment/life/).

We also added single projects found on the project website of the EU funded project RESTORE (restorerivers.eu). For Switzerland we mapped all projects presented on the Swiss website rivermanagement.ch (Eawag, et al. 2005), as well as restoration projects described by Hostmann & Knutti (2009). Moreover, works on a new restoration projects data set is in progress for Switzerland. We received the newest version; however, it only added a few more projects to our already mapped and collected ones. Data sources presented above are summarized in Table 26 Sources of received/mapped restoration data.

Table 26 Sources of received/mapped restoration data

	AT	DE	CH	FR	IT	SI
Sources	REFORM LIFE database	REFORM LIFE database RESTORE	REFORM Hostmann & Knutti 2009; EAWAG, et al. 2005	REFORM LIFE database RESTORE	REFORM LIFE database RESTORE	LIFE database

2.4.6 Data aggregation on river units

For mapping on the Alpine scale and rating of protection priority, all parameters described in section 2.2 were aggregated to the associated river units. Different methods had to be developed to aggregate different kinds of input parameters (see Table 27).

Table 27 Aggregation parameters

Parameter	Levels	Method
Ecological status/value	1-5, no data	Relative share over 50% (described below)
Hydromorphological status/ ecomorphology class	1-5, no data	Relative share over 50% (described below)
Protection status	1-3	Share over 20%
Floodplains/wetlands	1-2	Share over 20%
Water abstraction	yes/no	Share over 20%
Hydropeaking	yes/no	Share over 20%
Impoundment	yes/no	Share over 20%
AMWB/HWMB	1/0	Share over 50%

The rating for the whole river unit based on line data (ecomorphology class and biological deficit analysis in the canton Valais), is derived in the following way:

- 1 (Highest rating): More than 50% of the river unit are rated "1",
- 2: More than 50% of the river unit are rated either "1" or "2",
- 3: More than 50% of the river unit are either rated "1", "2", or "3",
- 4 (worst rating): More than 50% of the river unit are rated “4” or “5”,
- For determining classes 1-4, unrated sections of the river unit are ignored.

A river unit was designated as containing a protected area if at least 20% of its length can be associated with a protected area. Depending on the type of protected area the river unit assaigned a value of etiher: 1 (IUCN cat. Ia, Ib or II), 2 (expert recommended protected area) or 3 (Nautra 2000). This 3-tier system is only used internally, since for all anaylsis in this study expert recommended and Natura 2000 areas are treated equally.

Floodplains/wetlands were aggregated in a similar way: If at least 20% of a river unit is associated with a Cat. A floodplain/wetland, it is rated 1, if at least 20% of a river unit is associated with a Cat. B floodplain/wetland, it is rated 2 (see 0).

For hydrological pressures (water abstraction, hydropeaking, impoundment) it is only evaluated if more than 20% of the river unit is affected by one of these pressures. Information about severity of pressure was not available for distinguished rating.

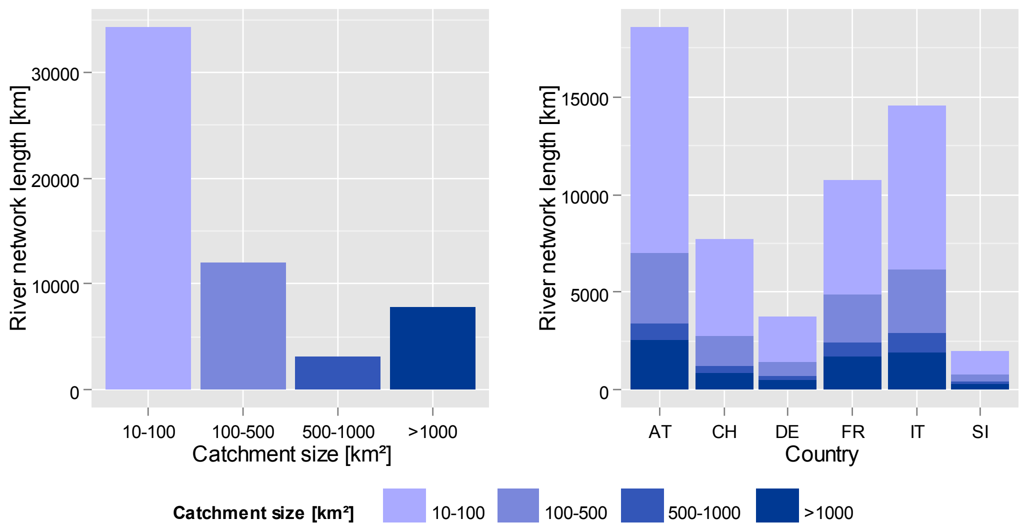
Finally, it is evaluated if a river unit has a share of HMWB/AWB. If a water body designated as HMWB/AMB covers more than 50% of a river unit, the whole river unit is designated as HMWB/AWB.

3 RESULTS

3.1 Sectoral results

3.1.1 River network

The pan-Alpine river network consists of 10 549 river units, totalling roughly 57 000 km in length. The average length of a river unit is 5.4 km. More than 50% of the total river length has a catchment size between 10 – 100 km². About 25% of the pan-Alpine network length comprises rivers with a catchment size of 100 – 500 km², and the remaining ones are larger rivers that drain more than 500 km². The country with the longest share of rivers kilometres in the Alpine Arc is Austria (32%), followed by Italy (25%) and France (19%). Figures 18 a,b show the pan-Alpine river network length per catchment size class and country.



Figures 18 a,b River network length (57 290 km in total) by catchment size (a) and country (b)

Table 28 shows the pan-Alpine river network length per catchment size class and country. Two maps showing the ‘Pan-Alpine _river network’ in the data annex give a spatial overview on the pan-Alpine river network for catchment sizes > 10km² and > 100 km².

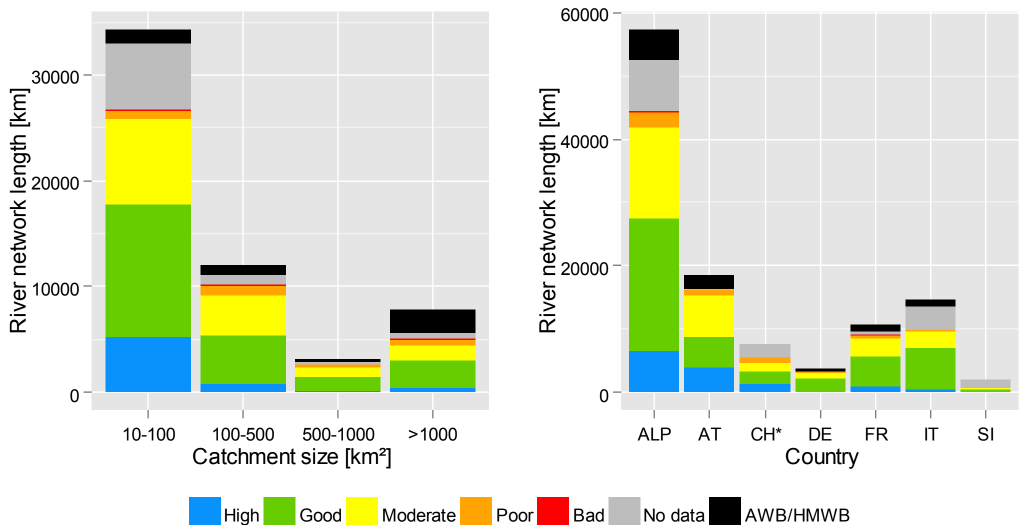
Table 28 River network length per catchment size class & country

Country	River network length in km and percent per catchment size class				
	Total	**10-100 km²**	**100-500 km²**	**500-1000 km²**	**>1000 km²**
AT	18 572.3 32%	11 577.8 20%	3 617.2 6%	813.3 1%	2 564 4%
CH	7 729.8 13%	4 957.5 9%	1 587.5 3%	309.1 1%	875.6 2%
DE	3 737.4 7%	2 309.2 4%	741.2 1%	160.0 0%	526.9 1%
FR	10 709.2 19%	5 859.3 10%	2 463.9 4%	683.8 1%	1 702.2 3%
IT	14 550.2 25%	8 367 15%	3 257 6%	999.5 2%	1 926.6 3%
SI	1 991.8 3%	1 195.3 2%	353.4 1%	171.0 0%	272.0 0%
Alps	57 290,7 100%	34 266,1 60%	12 020,2 21%	3 136,7 5%	7 867,3 13%

3.1.2 Ecological status/value

Half of the Alpine rivers with catchment sizes between 10 and 100 km² show a good or high ecological status/value (51%). About 30% of the rivers fail to attain the good status and for another 18% the ecological status was not assessed or is not available. For rivers with catchments sizes > 10 km², only a small proportion of the river units is classified as heavily modified or artificial (4%). About 30% of rivers with catchments > 1000 km² are classified as HMWB/AWB. Only a small proportion shows a high ecological status/value (4%); however, still quite a large proportion is in a good status (34 %).

Austria shows the highest amount of rivers in a high ecological status (21%), compared to the other countries. For Italy and Slovenia (as well as Switzerland) relatively large data gaps are documented (section 2.4.5.1), compared to other countries. Figures 19 a,b provide the ecological status/value data per catchment size class and country. Two maps in the data annex with the title ‘Ecological status/ ecological value – Alpine Arc’ give a spatial overview on the pan-Alpine river network for catchment sizes > 10 km² and > 100 km².



Figures 19 a,b Ecological status/value per catchment size class (a) and country (b); *For Switzerland the 4-tiered surrogate parameter "ecological value" is displayed

Table 29 shows the length of ecological status/value classes per country in absolute and percentage values.

Table 29 Ecological status/value class per country; * For Switzerland, the 4-tiered surrogate paramter "ecological value" is displayed

Ecological status/ value class	River network length in km and percent per country						
	Alps	**AT**	**CH***	**DE**	**FR**	**IT**	**SI**
High	6 479.5 11%	3 900.4 21%	1 236.4 16%	26.9 1%	794.1 7%	409.3 3%	112.3 6%
Good	20 990.2 37%	4 884.3 26%	2 087.7 27%	2 087.2 56%	4 930.8 46%	6 619.8 45%	380.5 19%
Moderate	14 307.8 25%	6 590.7 35%	1 274.9 16%	931.3 25%	2 754.4 26%	2 674.9 18%	81.5 4%
Poor	2 438.6 4%	660.5 4%	819.3 11%	241.3 6%	559.4 5%	126.4 1%	31.8 2%
Bad	314.1 1%	114.3 1%	not defined	0 0%	169.6 2%	30.2 0%	0 0%
No Data	8 025.0 14%	221.6 1%	2 311.4 30%	87.9 2%	371.7 3%	3 646.7 25%	1 276.8 64%
AWB/HMWB	4 735.4 8%	2 200.5 12%	not defined	362.8 10%	1 129.2 11%	1 042.9 7%	108.8 5%

Table 30 shows the length of ecological status/value classes per catchment size in absolute and relative values.

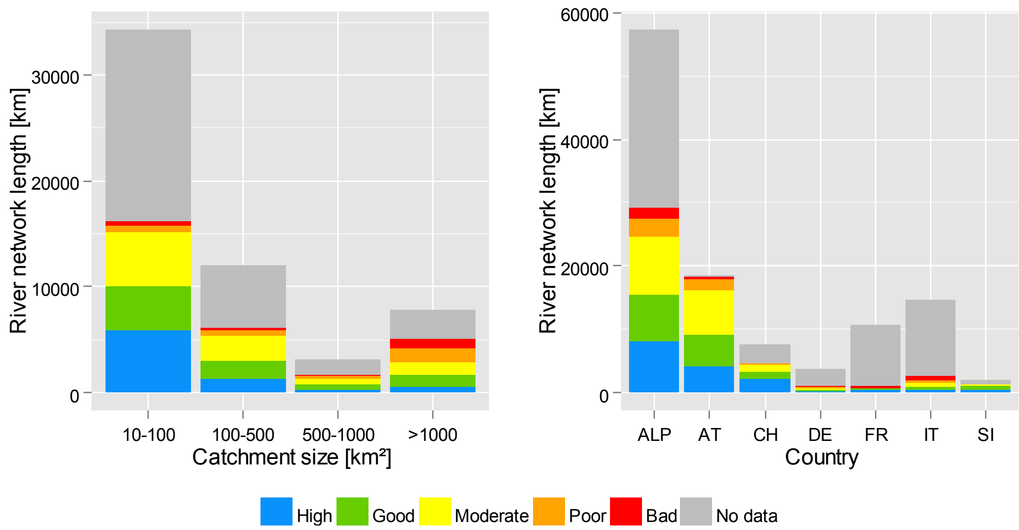
Table 30 Ecological status/value class per catchment size class; * For Switzerland, the 4-tier surrogate paramter "ecological value" is considered

Ecological status/ value class	River network length in km and percent per catchment size class			
	10-100 km²	**100-500 km²**	**500-1000 km²**	**>1000 km²**
High	5 201.2 15%	789.9 7%	150.2 5%	338.3 4%
Good	12 500.2 36%	4 525.8 38%	1 322 42%	2 642.2 34%
Moderate	8 151.9 24%	3 843.4 32%	846.7 27%	1 465.7 19%
Poor	773.2 2%	854 7%	272.7 9%	538.3 7%
Bad	59.9 0%	101.7 1%	61.6 2%	90.9 1%
No Data	6 250.8 18%	1 012.7 8%	183.6 6%	471.3 6%
AWB/HMWB	1 332.0 4%	892.7 7%	326.1 10%	2 291.2 29%

3.1.3 Hydromorphological status/ecomorphology class

As stated in section 2.4.5.2, the hydromorphological status was not completely assessed in most Alpine countries. Italy, France and Switzerland show especially large data gaps.

About 29 % of Alpine rivers with a catchment class between 10-100 km² are in a high or good hydromorphological status. The proportion of status classes “moderate” to “bad” is quite large with 18%, whereas the moderate class makes up the largest part. The share of rivers failing the good status is even bigger for larger rivers (catchment size >100 km²). For the largest rivers (catchment size > 1000 km²), 42 % of the cumulative length of river units is classified as moderate to bad, the relative frequencies of the three classes being equally distributed. To some extent, this corresponds to the pattern of ecological status classes. Again, in Austria, as well as in Switzerland, large parts of the rivers are still in a high hydromorphological status (especially in rivers with smaller catchment size). The classification of rivers as classes “poor” and “bad” is rare, except for larger rivers. Figures 20 a,b present the length of river units assigned to different ecological status/value classes. Two maps in the data annex with the title ‘Hydromorphological status – Alpine Arc’ give a spatial overview on the pan-Alpine river network for catchment sizes > 10 km² and > 100 km².



Figures 20 a,b Hydromorphological status/ecomorphology class per catchment size class (a) and country (b). * For Switzerland the ecomorphological status is displayed

Table 31 shows the length of hydromorphological status/ecomorphology class per country in absolute and relative values.

Table 31 Hydromorphological status per country; *For Switzerland, the ecomorphology class is displayed

Hydromorphological status class	River network length in km and percent per country						
	Alps	**AT**	**CH***	**DE**	**FR**	**IT**	**SI**
High	8 051.3 14%	4 206.1 23%	2 249.1 29%	334.5 9%	342.3 3%	401.5 3%	517.9 26%
Good	7 484.3 13%	4 898.9 26%	1 124.7 15%	90.2 2%	235.4 2%	485.8 3%	649.3 33%
Moderate	9 147.0 16%	7 080.0 38%	912.5 12%	272.1 7%	55.2 1%	682.3 5%	144.9 7%
Poor	2 708.6 5%	1 685.3 9%	348.1 5%	206.6 6%	0.0 0%	462.5 3%	6.1 0%
Bad	1 807.4 3%	470.0 3%	1.0 0%	122.1 3%	563.3 5%	651.0 4%	0 0%
No Data	28 092.0 49%	232.0 1%	3 094.4 40%	2 712.0 73%	9 513.1 89%	11 867.0 82%	673.6 34%

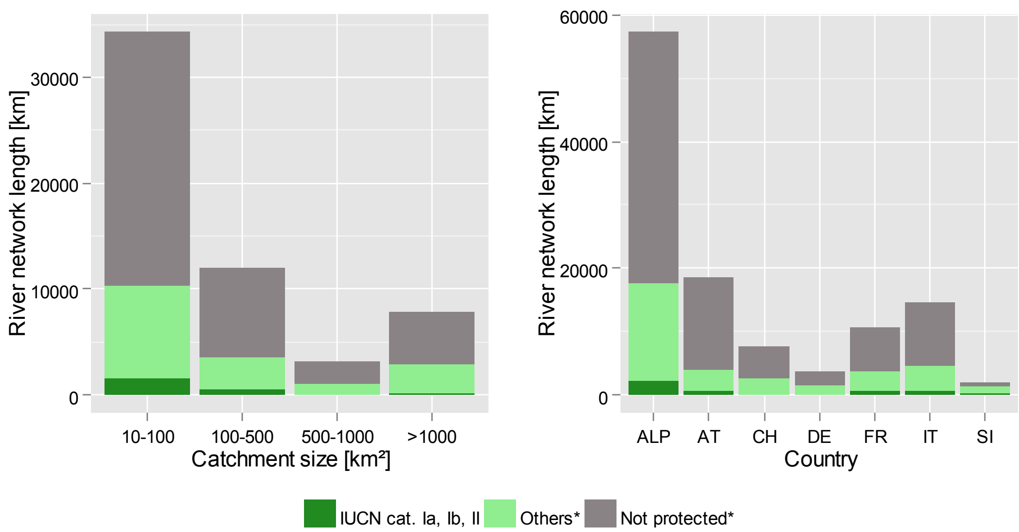
Table 32 shows the length of hydromorphological status/ecomorphology class per catchment size in absolute and percentage values.

Table 32 Hydromorphological status per catchment size class; *For Switzerland, the ecomorphology class is displayed

Hydromorphological status	River network length in km and percent per catchment size class			
	10-100 km²	100-500 km²	500-1000 km²	>1000 km²
High	5 888,4 17%	1 304,4 11%	306,6 10%	552,0 7%
Good	4 127,2 12%	1 693,4 14%	479,2 15%	1 184,5 15%
Moderate	5 057,3 15%	2 337,5 19%	554,6 18%	1 197,5 15%
Poor	648,5 2%	576,4 5%	180,1 6%	1 303,7 17%
Bad	468,9 1%	285,3 2%	239,8 8%	813,5 10%
No Data	18 078,8 53%	5 823,3 48%	1 402,7 44%	2 787,1 36%

3.1.4 Protected areas

Not all classes of protected areas were considered for this study, since some have very low legal value or no relevance for rivers (see section 2.4.5.3). Even after filtering out those protected areas deemed irrelevant, 31% of the Alpine river network is under some form of protection. Figures 21 a,b present the length of river units assigned to protection status by catchment size class & country. Two maps in the data annex with the title ‘Protected areas – Alpine Arc’ give a spatial overview on the pan-Alpine river network for catchment sizes > 10 km² and > 100 km².



Figures 21 a,b Protection status per catchment size class (a) and country (b). *Only Natura 2000, and protected areas recommended by national experts were considered

Table 33 shows the length of river units associated with protection status per country in absolute and relative values.

Table 33 Protection status per country. * Only Natura 2000, and protected areas recommended by national experts were considered

Protection status	River network length in km and percent per country						
	Alps	AT	CH	DE	FR	IT	SI
IUCN Cat. Ia, Ib, II	2 222.6 4%	609.5 3%	53.1 1%	30.7 1%	686.8 6%	645.0 4%	197.5 10%
Others*	15 498.5 27%	3 225.8 17%	2 636.9 34%	1 612.5 43%	3 037.7 28%	3 907.0 27%	1 078.5 54%
Not protected*	39 569.6 69%	14 737.0 79%	5 039.7 65%	2 094.1 56%	6 984.7 65%	9 998.2 69%	715.8 36%

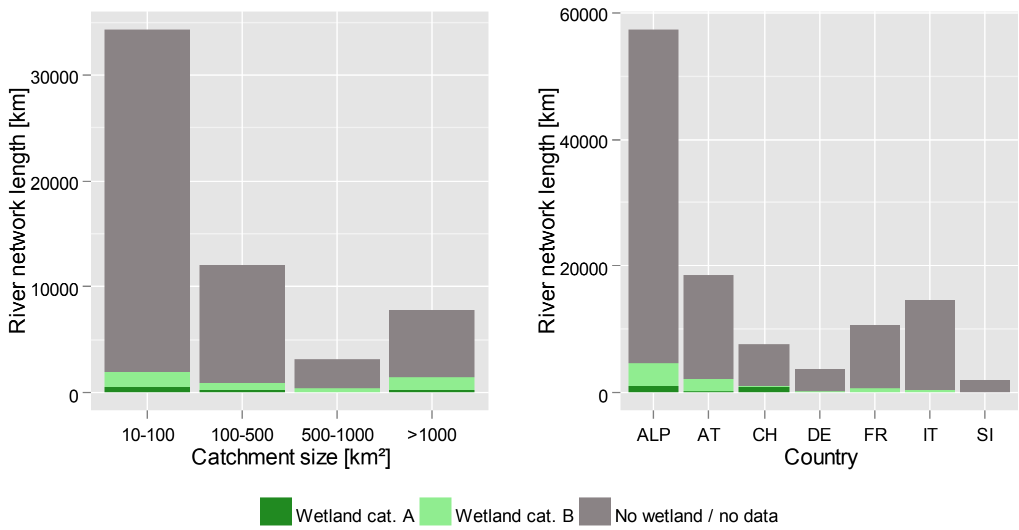
Table 34 shows the length of river units associated with protection status per catchment size in absolute and relative values.

Table 34 Protection status per catchment size class; *Only Natura 2000, and protected areas recommended by national experts were considered

Protection status	River network length in km and percent per catchment size class			
	10-100 km²	100-500 km²	500-1000 km²	>1000 km²
IUCN Cat. Ia, Ib, II	1 539,4 4%	479,7 4%	72,0 2%	131,4 2%
Others*	8 816,8 26%	3 028,7 25%	965,2 31%	2 687,8 34%
Not protected*	23 912,9 70%	8 511,8 71%	2 125,7 67%	5 019,2 64%

3.1.5 Floodplains/wetlands

Data on floodplains/wetlands were insufficient for some parts of the Alps, especially for Italy and the Rhône-Alps region in France or most likely were not assessed in a complete way. Available data show that only very few stretches of Alpine rivers are still associated with floodplains/wetlands (Figures 22 a,b). On the one hand this is due to the morphological characteristics of Alpine river lacking large floodplains in higher altitudes. On the other hand, most former floodplains/wetlands have been eliminated due to river channelization. Two maps in the data annex with the title ‘Floodplains/wetlands – Alpine Arc’ give a spatial overview on the pan-Alpine river network for catchment sizes > 10 km² and > 100 km².



Figures 22 a,b Length of river units associated with floodplains/wetlands per catchment size class (a) and country (b). *Floodplains/wetlands Cat. A: wetlands of high protection value defined by national authorities/experts; Floodplains/wetlands Cat. B: all other floodplains/wetlands included in the analyses

Table 35 shows the length of river units associated with floodplains/wetlands per country size in absolute and relative values.

Table 35 Floodplains/wetlands per country

Floodplain/wetland category	River network length in km and percent per country						
	Alps	AT	CH	DE	FR	IT	SI
Floodplain/wetland Cat. A	1 157,0 2%	198,2 1%	929,8 12%	29,0 1%	not defined		
Floodplain/wetland Cat. B	3 511,7 6%	1 965,9 11%	202,8 3%	247,1 7%	675,3 6%	394,4 3%	26,2 1%
No floodplain/wetland / no data	52 622,0 92%	16 408,3 88%	6 597,1 85%	3 461,3 93%	10 033,9 94%	14 155,7 97%	1 965,6 99%

Table 36 shows the length of river units associated with floodplains/wetlands per catchment size in absolute and relative values.

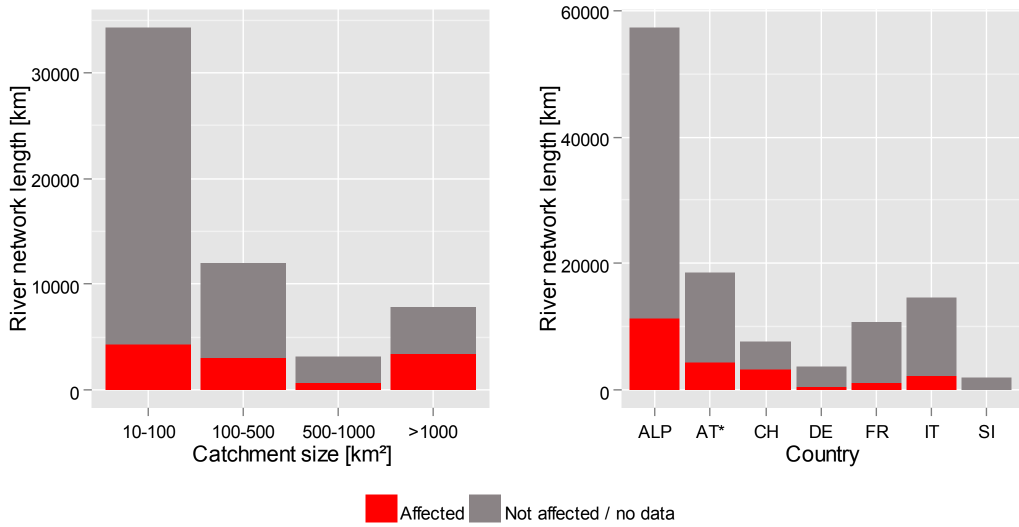
Table 36 Floodplains/wetlands per catchment size class

Floodplain/wetland category	River network length in km and percent per catchment size class			
	10-100 km²	100-500 km²	500-1000 km²	>1000 km²
Floodplain/wetland Cat. A	492,0 1%	303,2 3%	61,8 2%	299,9 4%
Floodplain/wetland Cat. B	1 513,2 4%	592,4 5%	303,6 10%	1 102,4 14%
No floodplain/wetland/ no data	32 263,9 94%	11 124,6 93%	2 797,5 88%	6 436,0 82%

3.1.6 Pressures

3.1.6.1 Hydrological pressures

Hydrological pressures belong to the dominating pressures in the Alpine Arc. Figures 23 a,b express the length of river units affected by hydrological pressures, including water abstraction, hydropeaking and impoundment. For many river units the presence of hydrological pressures is unknown (No data). The only country with a complete classification of hydrological pressures is Austria. Two maps in the data annex with the title 'Hydrological pressures – Alpine Arc' give a spatial overview of the pan-Alpine river network for catchment sizes > 10 km² and > 100 km².



Figures 23 a,b Hydrological pressures (water abstraction, hydropeaking, and impoundment) per catchment size class (a) and country (b)

Table 37 shows the length of river units affected by hydrological pressures per country and per catchment size in absolute and relative values.

Table 37 Hydrological pressures per country

Hydrological pressures	River network length in km and percent per country						
	Alps	AT	CH	DE	FR	IT	SI
Affected	11 363,2	4 406,2	3 371,8	378,4	1 042,4	2 164,4	0
	20%	24%	44%	10%	10%	15%	0%
Not affected / No data	45 927,4	14 166,1	4 358,0	3 359,0	9 666,8	12 385,7	1 991,8
	80%	76%	56%	90%	90%	85%	100%

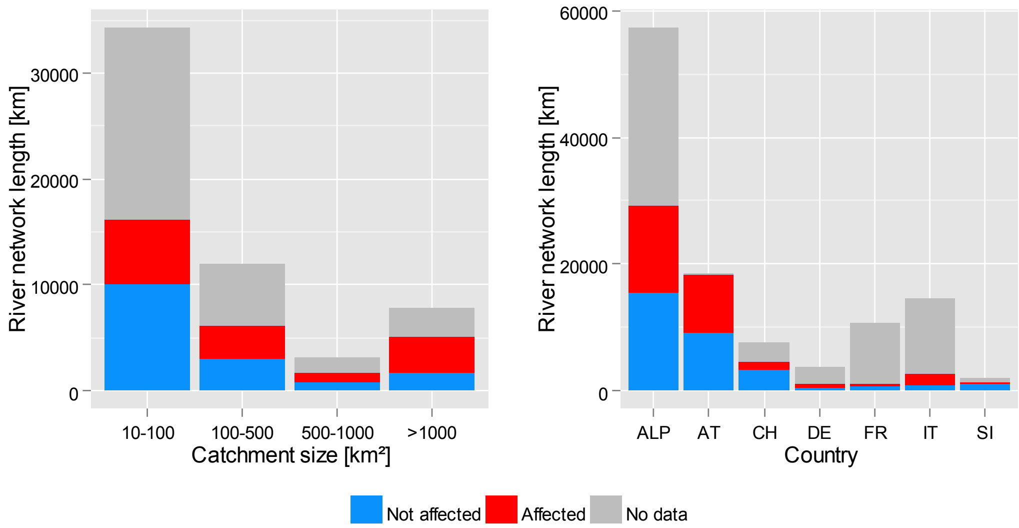
Table 38 shows the length of river units affected by hydrological pressures per catchment size in absolute and relative values.

Table 38 Hydrological pressures per catchment size class

Hydrological pressures	River network length in km and percent per catchment size class			
	10-100 km²	100-500 km²	500-1000 km²	>1000 km²
Affected	4 255,1 12%	3 040,3 25%	635,1 20%	3 432,8 44%
Not affected / No data	30 014,1 88%	8 980,0 75%	2 527,9 80%	4 405,6 56%

3.1.6.2 Morphological pressures

Accordding to data availability we could classify morphological pressures of all Alpine rivers in two categories, i.e. “affected” (classified as “moderate” to “bad”).In regions with comprehensive data cover we were able to designate river stretches which are “not affected” by morphological pressures (river units in “high” or “good” hydromorphological status). The ratio of affected to not affected river units increases from small to large rivers. Figures 24 a,b provide an overview of river units affected by morphological pressures. Two maps in the data annex with the title ‘Morphological Pressures – Alpine Arc’ give a spatial overview on the pan-Alpine river network for catchment sizes > 10 km² and > 100 km².



Figures 24 a,b Morphological pressures per catchment size class (a) and country (b); River units with a morphological status worse than "good" were designated as "affected"

Table 39 shows the length of river units affected by morphological pressures per country size in absolute and relative values.

Table 39 Morphological pressures per country

Morphological pressures	River network length in km and percent per country						
	Alps	AT	CH	DE	FR	IT	SI
Not affected	15 535,6 27%	9 105,1 49%	3 373,8 44%	424,7 11%	577,7 5%	887,3 6%	1 167,2 59%
Affected	13 663,1 24%	9 235,3 50%	1 261,6 16%	600,8 16%	618,5 6%	1 795,8 12%	151,1 8%
No Data	28 092,0 49%	232,0 1%	3 094,4 40%	2 712,0 73%	9 513,1 89%	11 867,0 82%	673,6 34%

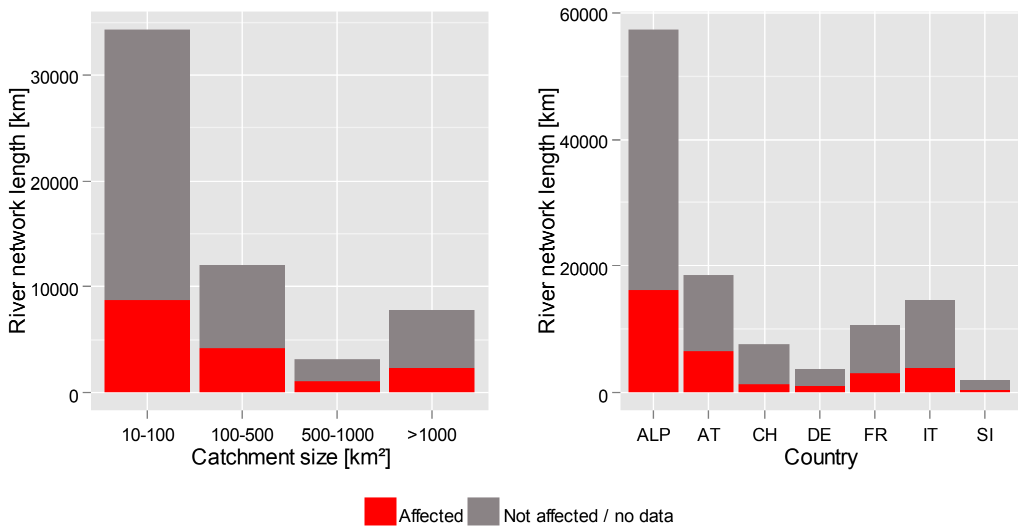
Table 40 shows the length of river units affected by morphological pressures per catchment size in absolute and relative values.

Table 40 Morphological pressures per catchment size class

Morphological pressures	River network length in km and percent per catchment size class			
	10-100 km²	100-500 km²	500-1000 km²	>1000 km²
Not affected	10 015,6 29%	2 997,8 25%	785,7 25%	1 736,5 22%
Affected	6 174,7 18%	3 199,2 27%	974,5 31%	3 314,7 42%
No Data	18 078,8 53%	5 823,3 48%	1 402,7 44%	2 787,1 36%

3.1.6.3 Hydropower plants and other barriers

Across the Alpine Arc, 2331 river units are affected by hydropower plants (as far as data is available). The relative abundance of affected river stretches varies only slightly between catchment size classes. It is difficult to compare the distribution between countries since scope and quality of the datasets vary widely (as discussed in section 2.4.5.5.7). As barrier data is too inhomogeneous to be comparable on an Alpine scale, no balancing was conducted for barriers (Figures 25 a,b Hydropower plants per catchment size class (a) and country (b); River units with one or more hydropower plants were designated as affected. The available barriers are visualized in the map 'Hydro-Power Plants and other Barriers' (see data annex).



Figures 25 a,b Hydropower plants per catchment size class (a) and country (b); River units with one or more hydropower plants were designated as affected

Tables 41 and Table 42 show the length of river units affected by hydropower plants per country and per catchment size in absolute and relative values.

Table 41 Affected by hydropower plant per country

Affected by hydropower plant	River network length in km and percent per country						
	Alps	AT	CH	DE	FR	IT	SI
Affected	16 245,8 28%	6 575,1 35%	1 260,2 16%	1 117,4 30%	2 988,3 28%	3 962,7 27%	342,1 17%
Not affected / no data	41 044,9 72%	11 997,3 65%	6 469,6 84%	2 620 70%	7 720,9 72%	10 587,4 73%	1 649,7 83%

Table 42 Affected by hydropower plant per catchment size class

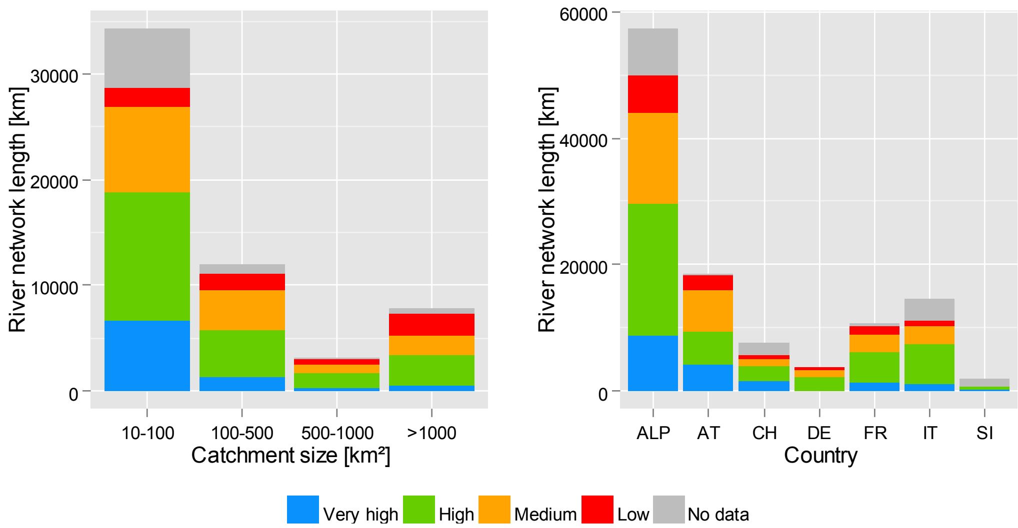
Affected by hydropower plant	River network length in km and percent per catchment size class			
	10-100 km²	100-500 km²	500-1000 km²	>1000 km²
Affected	8 766,9 26%	4 128,7 34%	1 036,3 33%	2 313,9 29%
Not affected / no data	25 499,3 74%	7 891,5 66%	2 100,7 67%	5 553,5 71%

3.2 Aggregated results / protection priority

About 15% (8 674 km) of Alpine rivers are of very high protection priority. Another 37% (21 010 km) are classified as rivers with high protection priority.

Small rivers with catchment sizes between 10 and 100 km² include a large part (19%) of rivers with very high protection priority. This class is also frequent in rivers with catchment sizes between 100 and 500 km². Only 5% of the smallest rivers have low protection priority. In contrast, 27% of rivers with a catchment size > 1 000 km² are classified as being of low protection priority, whereas only 7% (554 km) are of high protection priority.

A large part of river units with high protection priority is located in Austria and Switzerland. Contrarily, in Germany only 2% of the river units are of very high protection priority. In Italy, Slovenia and Switzerland large parts of the river network could not be classified due to data insufficiency. In Slovenia the ecological status is not available for the rivers of catchment sizes bellow 100 km², which explains the large data gaps. For a large part of the Swiss river network the ecological value could not be determined due to missing data. In Italy data availability was generally low. Figures 26 a,b present the length of river units with different protection priority categories.



Figures 26 a,b Length of river units with different protection priority categories per catchment size (a) and country (b)

Two maps in the data annex with the title ‘Protection Priority – Alpine Arc’ give a spatial overview on the pan-Alpine river network for catchment sizes > 10 km² and > 100 km². Sepparate maps for each country are also availbe in the data annex.

Tables 43 and 44 show the length of river units associated with protection priority categories per country and per catchment size in absolute and relative values.

Table 43: Length of protection priority categories per country

Protection priority category	River network length in km and percent of pan-Alpine river network						
	Alps	**AT**	**CH**	**DE**	**FR**	**IT**	**SI**
Very high	8 673,8 15%	4 261,8 23%	1 563,8 20%	86,0 2%	1 398,2 13%	1 054,3 7%	309,8 16%
High	21 010,3 37%	5 205,3 28%	2 287,1 30%	2 106,6 56%	4 700,4 44%	6 333,9 44%	373.0 19%
Moderate	14 356,1 25%	6 532,5 35%	1 199,4 16%	1 033,8 28%	2 753,8 26%	2 780,9 19%	59.7 3%
Low	5 944,3 10%	2 352,9 13%	601,7 8%	420,8 11%	1 512,6 14%	1 024,6 7%	136.7 7%
No data	7 306,2 13%	219,8 1%	2 077,8 27%	90,2 2%	344,2 3%	3 356,5 23%	1 112.7 56%

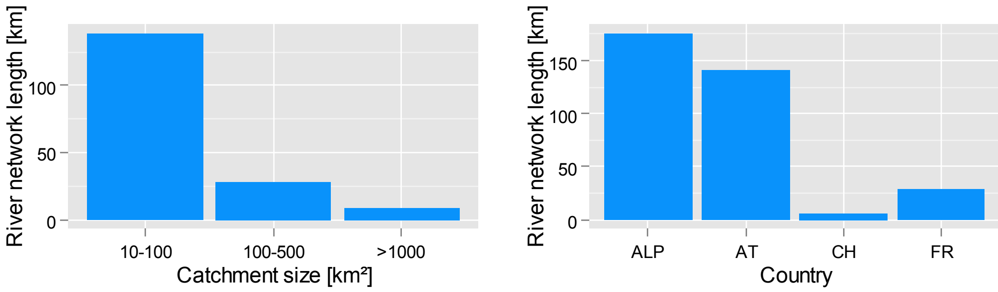
Table 44: Length of protection priority categories per catchment size class

Protection priority category	River network length in km and percent per catchment size class			
	10-100 km²	**100-500 km²**	**500-1000 km²**	**>1000 km²**
Very high	6 598,5 19%	1 293,6 11%	227,5 7%	554,1 7%
High	12 235,6 36%	4 461,1 37%	1 427,2 45%	2 882.4 37%
Moderate	8 069,7 24%	3 750,6 31%	778,1 25%	1 761.6 22%
Low	1 737,0 5%	1 554,0 13%	547,2 17%	2 208.7 28%
No data	5 625,3 16%	960,8 8%	157,0 5%	460.4 6%

Priority protection rivers (i.e. very high/ high protection priority) were separately visualized in three maps (title: ‘Priority Protection Rivers – Alpine Arc’, see data annex).

3.3 “Hot spots” for protection & protection need

As a further result, the “hots spots” for protection & the protection needs of Alpine rivers are highlighted. River units with a high/good ecological status, with an associated protected area (IUCN I & II) and an associated floodplain/wetland (Cat. A or B) were defined as “hot spots for protection” (see Figures 27 a,b).



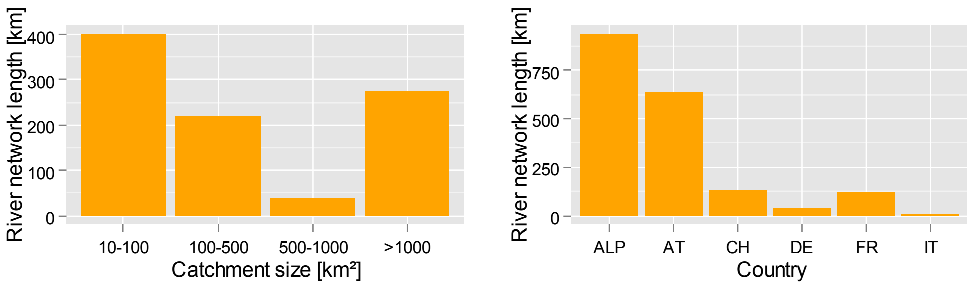
Figures 27 a,b Length of river units designated as "Hot spots for protection" per catchment size (a) and country (b); only the river units classified as beeing in "hot spots for protection" are shown. Data are not comparable between countries because of large differences in data availability

Table 45 shows the length of river network that are classified as “hot spots for protection” (176 km). Especially rivers with a catchment size between 10-100 km² are „hot spots for protection “, they are mainly located in Austria. Hot spots in larger rivers are very rare and, therefore, need special attention. The results are visualized in a map with the title ‘Hot spots for protection – Alpine Arc’ (see data annex).

Table 45: Length of river network associated with “hot spots” for protection

	River network length in kilometers per catchment size class & country				
	10-100 km²	**100-500 km²**	**500-1000 km²**	**>1000 km²**	**Total**
AT	103,8	28,2	0,0	8,7	140,7
CH	6,1	0,0	0,0	0,0	6,1
FR	29,1	0,0	0,0	0,0	29,1
Total	139,0	28,2	0,0	8,7	175,9

A need for protection is assigned to river units with a high/good ecological status and associated floodplains/wetlands, lacking any protection status (see Figures 28 a,b).



Figures 28 a,b Length of river units with different protection need per catchment size (a) and country (b); only river units classified as beeing in need of protection are shown. Data are not comparable between countries because of large differences in data availabilty

Table 46 shows the length of river network with a protection need. In total, this is about 937 km in the Alps, across all catchment sizes and countries.

Table 46: Length of river network with protection need

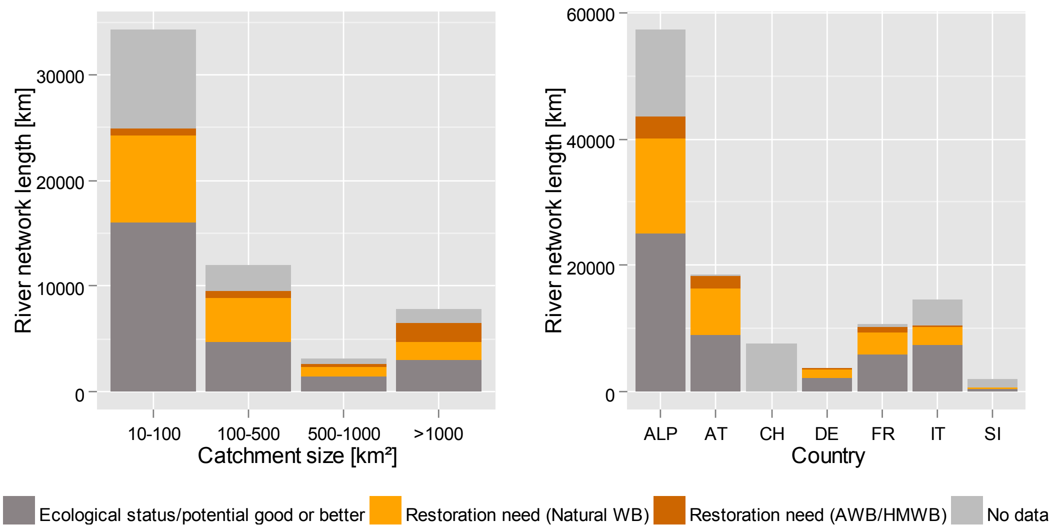
	River network length in kilometers per catchment size class & country				
	10-100 km²	100-500 km²	500-1000 km²	>1000 km²	Total
AT	226,4	138,6	39,4	234,9	639,2
CH	46,3	64,4	0,0	20,7	131,4
DE	29,2	4,7	0,0	5,2	39,2
FR	99,1	12,6	0,0	4,3	116,0
IT	0,0	0,0	0,0	11,0	11,0
Total	401,1	220,3	39,4	276,1	936,9

3.4 Restoration need

Finally, also the restoration need of the Alpine rivers is evaluated.

The results described refer to the methodology of the WFD. According to this directive, for all surface water bodies of the member countries an ecological status of „good“ or better has to be achieved by 2015, with possible extensions up to 2021 or 2027. Artificial and heavily modified water bodies are exempted from this obligation, but have to achieve at least a “good ecological potential”. Switzerland was excluded from this analysis as it is not an EU member country.

We defined river units with an ecological status or an ecological potential of “moderate” or worse as having a “restoration need”. About 24% of rivers with catchment size between 10 and 100 km² were found to be natural rivers in need of restoration. Only 2% of the small rivers are designated as artificial or heavily modified water bodies and are in need of restoration. In contrast, 46% of rivers of a catchment size larger than 1 000 km² are in restoration need, and half of those are artificial or heavily modified water bodies. The countries with the largest fraction of rivers in restoration need are Austria (51%) and France (42%). It is hard to make accurate statements on the rivers in Italy and Slovenia as large parts of their river networks are missing ecological status/potential informations. Figures 29 a,b present the length of river units with different restoration need categories.



Figures 29 a,b Length of river units with different restoration need categories per catchment size (a) and country (b)

Table 47 shows the length of river network with restoration need. In total, this is about 13 663 km in the Alps (24% of the total pan-Alpine river network). Especially 9 235 km in Austrian rivers (50% of the Austrian Alpine river network) need restoration.

Table 47 Restoration need per country

Restoration need	River network length in km and percent per country						
	Alps	AT	CH	DE	FR	IT	SI
Ecol. status/potential good or better	25 131,1 44%	8 954,7 48%		2 244,0 60%	5 931,5 55%	7 508,1 52%	492,8 25%
Restoration need (natural water body)	14 966,2 26%	7 365,5 40%		1 172,5 31%	3 483,4 33%	2 831,5 19%	113,3 6%
Restoration need (AWB/HWMB)	3 467,6 6%	2 030,5 11%		217,7 6%	922,6 9%	187,9 1%	108,8 5%
No data	13 725,7 24%	221,6 1%	7 729,8 100%	103,1 3%	371,7 3%	4 022,7 28%	1 276,8 64%

Table 48 shows the length of river network with restoration need per catchment size class. Here, especially rivers with a catchment size > 500 km² and > 1000 km² have a restoration need considering the lower share of larger rivers in the Alpine river network.

Table 48 Restoration need per catchment size class

Restoration need	River network length in km and percent per country			
	10-100 km²	100-500 km²	500-1000 km²	>1000 km²
Ecol. status/potential good or better	16 092,6 47%	4 690,8 39%	1 400,1 45%	2 947,7 37%
Restoration need (natural water body)	8 111,5 24%	4 190,6 35%	971,2 31%	1 693,0 22%
Restoration need (AWB/HWMB)	684,6 2%	663,6 6%	268,3 9%	1 851,0 24%
No data	9 377,4 27%	2 475,2 21%	497,4 16%	1 375,6 17%

4 SUMMARY & CONCLUSIONS

4.1 Status quo of the pan-Alpine river network

The results show that a high amount of Alpine rivers are affected by severe human pressures. Rivers with intact aquatic bioconeoses - expressed by their high ecological status - are restricted to 11% of the Alpine river network. While 15% of the smaller rivers and streams (catchment size 10-100 km²) are still in a high ecological status, only 4% (91km) of the large rivers (catchment size > 1000 km²) remain in a high ecological status (see data annex).

About 28% of the large rivers, like the rivers Inn, Drau, Isère or Piave, have been designated as HMWB/AWB, indicating the huge amount of human pressures on those river systems. In more detail this situation is exemplified by the share of hydrologically affected river units, which is increasing with catchment size. Moreover, 44 % of the large rivers (e.g. rivers Rhône, Rhine, Piave) show altered hydrological regimes due to water abstraction, hydropeaking and/or impoundments. In contrast, based on collected data only 12% of the smaller rivers were classified as being affected, however, data insufficiency should be taken into consideration.

Similarly, 42% of the large rivers fail to achieve good morphological status (e.g. rivers Rhône, Inn, Traun, Isar); about 8% are in poor or bad status. However, these numbers include relatively high uncertainties due to the large amount of missing data (see also chapter 4.3.).

We extended our analyses to the floodplain areas with the objective to additionally give an overview of the river-floodplain systems of the Alps. Although detailed information on the functional and nature conservation value of floodplains is missing from most of the national floodplain inventories, a rough overview of floodplains in the Alps can be provided by our study. Only 8% (4 669 km) of the Alpine rivers still have floodplains or wetlands. Historically, most large Alpine rivers (catchment size > 1 000 km²) were associated with floodplains; however, nowadays only 18% retained some fragments of their former floodplain habitats (e.g. upper regions of the Rhine river, Gail and Calavon). The situation in mid-sized rivers (catchment sizes 500 – 1 000 km²) shows similar trends (12 % of still existing floodplain or wetland areas). Additionally, remaining floodplain areas are impaired and dynamic processes have been strongly limited.

Based on the database developed in this project, we were able to identify rivers of protection priority due to the (1) high ecological status, (2) protection status as Strict Nature Reserve, Wilderness Area or National Park and/or (3) floodplains/wetlands of high or national importance. Rivers of “very high protection priority” comprise 15% of the total Alpine river network. Interestingly, a significant proportion of rivers with very high protection priority (937 km) is still not protected (e.g. Gail river, Roanne river). According to our evaluation scheme, another 37% are designated as rivers of high, 25% of moderate and 10% low protection priority.

Finally, a few rivers in the Alpine Arc can be designated as “protection hot spots”. These are rivers with high ecological status, existing floodplains/wetlands *and* protection (see chapter 4). Rivers classified as “protection hotspots” are located mainly in headwaters and small streams, like for example some tributaries of the river Salzach in the “Hohe Tauern National Park” in Austria, the Séveraissette stream in the “Ecrins National Park” in France and the Ova da Varusch, a tributary to the river Inn, located in the “Swiss National Park”.

4.2 Data gaps and uncertainties

During the course of this study, it became clear that huge gaps exist for certain types of data. Especially regarding hydromorphological status and other pressure data detailed information was missing. Due to this fact, it was not possible to include the hydromorphological status in the final protection priority scheme and to provide a complete overview of the pan-Alpine pressure situation. Moreover, the map on existing hydropower plants and other barriers shows an incomplete picture (see map “Hydro-power plants and other barriers” in the data annex), which leads to the fact that connectivity of rivers (i.e. the length of free-flowing river sections) could not be considered in a pan-Alpine protection priority scheme. In this context, the information given in maps of chapter 2.4.5 provides unique and valuable information for future WWF campaigns that also should encourage regional and national administrations to fill these data gaps.

Especially for Italy and France, information on the indicated data does not exist for certain regions or was not provided by national/regional authorities (see chapter 2). This corresponds to statements in the “Report from the Commission on the implementation of the Water Framework Directive and River Basin Management Plan” (European Commission, 2012). This document sums up the reported 1st RBMPs and states that e.g. for Italy, the ecological status of about 50% of water bodies in the River Basin District Alpi Orientali is unknown. However, these and other data (e.g. hydromorphological status, information on barriers etc.) need to be prepared or are under preparation and can be expected in the 2nd RBMP, to be submitted in early 2015 providing a more complete data set for further studies.

Another relevant issue is that some Swiss data are hardly comparable to EU WFD data (i.e. ecomorphology class) or do not exist at all (i.e. ecological status data). The surrogate method developed for characterising the “ecological value” (chapter 2) enabled a rough comparison with other countries; however, attempts by the Swiss national administration are required in the near future to make datasets comparable across the Alps.

Due to those data gaps, it is difficult to develop an integrated freshwater policy for the whole Alpine Arc. Nevertheless, on a regional scale, detailed information is available. Regional models/analyses could be developed in the future by using these data in combination with a regional classification, e.g. the “Freshwater Ecoregions of the World” (FEOWs), developed by Abell et al. (2008). Four FEOWs are of main importance in the Alpine Convention perimeter: “Upper Danube”, “Central & Western Europe”, “Gulf of Venice Drainages” and “Cantabric Coast – Languedoc” (see map “Freshwater Ecoregions” in the annex). These regional models/analyses for certain catchments in the relevant FEOWs could then be used to exemplify protection-planning efforts (e.g. Trentino-Alto Adige, Graubünden, Mur catchment, Soča catchment etc.).

4.3 Contributions of the study outcomes to river protection and management at different spatial/organisational scales

The main and overall intention of this study was to provide basic information for *developing a long-term vision for the future of Alpine rivers.* Based on these outcomes further strategies should be developed to “halt the loss of biodiversity by a *pan-Alpine policy*” (WWF European Alpine Programme, 2005). In particular this “pan-Alpine perspective” was emphasized in our study because most existing conservation activities rarely extend beyond national borders.

A fundamental basis for such strategic considerations is the *assessment of the pan-Alpine status of rivers* differentiated by country and river type. These results reflect (1) the “last remaining” ecologically sensitive river stretches and (2) the pressure status and provide an indication of the vulnerability of the Alpine river systems, referring also to the MAVA strategic priority of “conserving biodiversity and ecosystem functions”. This is also in line with the MAVA strategic priority 2 “promotion of sustainable management and use of natural resources”. The outputs of this study will increase the public awareness on the importance of an enhanced river protection in the Alps.

The outcomes assist to *establish a prioritisation framework with a river protection strategy*. A classification *of four protection priority categories* - from very high, high and moderate to low priority - is used for the pan-Alpine river network. By designating *hot spots for protection,* a special focus is dedicated to rivers of the Alpine Arc, which are characterized by high ecological status and which are at the same time associated with floodplains or wetlands and are part of a protected area.

These outcomes can leave its mark on key *legal obligations for water and nature protection policy* formulated by the particular EU Directives. Recently, first *efforts at national and river basin level* have been realized to address the issues of sustainable use of freshwater resources by suitable planning tools and management decisions. The *Strategic planning scheme* of the International Commission for the Protection of the Danube (ICPDR) for new hydropower development in the Danube catchment may exemplify these efforts. According to the “Guiding Principles” of the ICPDR (ICPDR, 2013), the key challenge is to identify those river stretches which should be kept free from hydropower development and those potentially appropriate for new hydropower plants to keep possible impacts on environment at a minimum. In this document a *strategic planning approach* (linked to the Renewable Energy Action Plan and the River Basin Management Plan) is recommended for the development of new hydropower plants *at large and regional/local scale.* This strategy of explicitly addressing “exclusion zones” at a supranational scale corresponds with the strategy of the WWF European Alpine Programme (EALP) / the *project “Save the Alpine Rivers”*.

Additionally, several initiatives at administrative level (e.g. in Switzerland, Austria and Slovenia) are on-going to develop national methods for the identification and designation of “no go areas” or “exclusion zones” or areas of high protective value (e.g. Wasserkatalog, BMLFUW, 2012). These efforts are in line with the general recommendations expressed by the CIS policy paper (2007) and the Statement of the EU Water Directors on Hydropower Development under the Water Framework Directive (EU Water Directors, 2010).

The outcomes of this pan-Alpine investigations, in particular the data and visualised results, will assist stakeholders in river management and nature conservation (decision-makers, administrations, NGOs) to deal with future programs and projects in the wider context of the Alpine Arc in a more efficient way. This is crucial for a sustainable implementation of protection and restoration and, hence, helps to avoid short term, single-case decisions without knowledge of the Alpine-wide context.

Several years ago the “*Biodiversity Vision”* (WWF, 2005) with a *pan-Alpine perspective* was developed by WWF in cooperation with CIPRA (International Commission for the Protection of the Alps), ISCAR (International Scientific Committee for Alpine Research) and ALPARC (Alpine Network of Protected Areas). Similar to this Alpine-wide vision also the present study might provide an important *contribution to strengthen the further implementation of the Alpine Convention*.

4.4 Conclusions

Based on the aforementioned aspects, the following conclusions can be drawn:

- Protection strategies for the whole Alpine Arc should be developed with focus on rivers with “very high” and “high” protection priority and the identified “hot spots for protections”. To promote the implementation of the current outcomes the key administrative bodies/policy and planning instruments should be addressed (see below). Particular attention should be given to those rare river stretches, which are, on the one hand characterised by high/good ecological status and associated floodplains/wetlands, and on the other hand are not protected.

- Further data compilation & homogenization needs to be conducted by national administrations, as significant data gaps on a pan-Alpine scale were identified. The results can guide research and administration in generating and collecting the most useful and relevant data.

- The impact of human pressures was not included in the final protection priority scheme due to the limitations of available data. Hence, characterization and quantification of these impacts is needed, so that these issues can be more completely addressed in future work. Quantitative information on existing hydropower plants and other barriers will be a necessity to assess the connectivity status of Alpine river stretches.

- An update of the developed protection priority scheme should be conducted with the new data expected for the 2nd RBMPs in early 2015.

- It will also be essential to address specific questions and needs on a regional scale, e.g. for certain river types (rare river types, large floodplain rivers).

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