FAME WP6/7 SPATIAL APPROACH

ALPS/ECOREGION 4

REFERENCE AND DEGRADED CONDITIONS

A. Melcher, S. Schmutz & G. Haidvogl

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Contents

1 Overview reference and degraded conditions (preclassification)

The results of the abiotic discriminat analysis figured out four main types. Er1, ER2, MR and HR dominate and 88% of the sites belong to these 4 types (Fig. Xx). The number of sites was for type ST and WA to low for further statistical analysis. Not only because of the low number of sites the types MR Hu and HR BW are not included in the next step. They are historical types, so they need a special procedure including historical data.

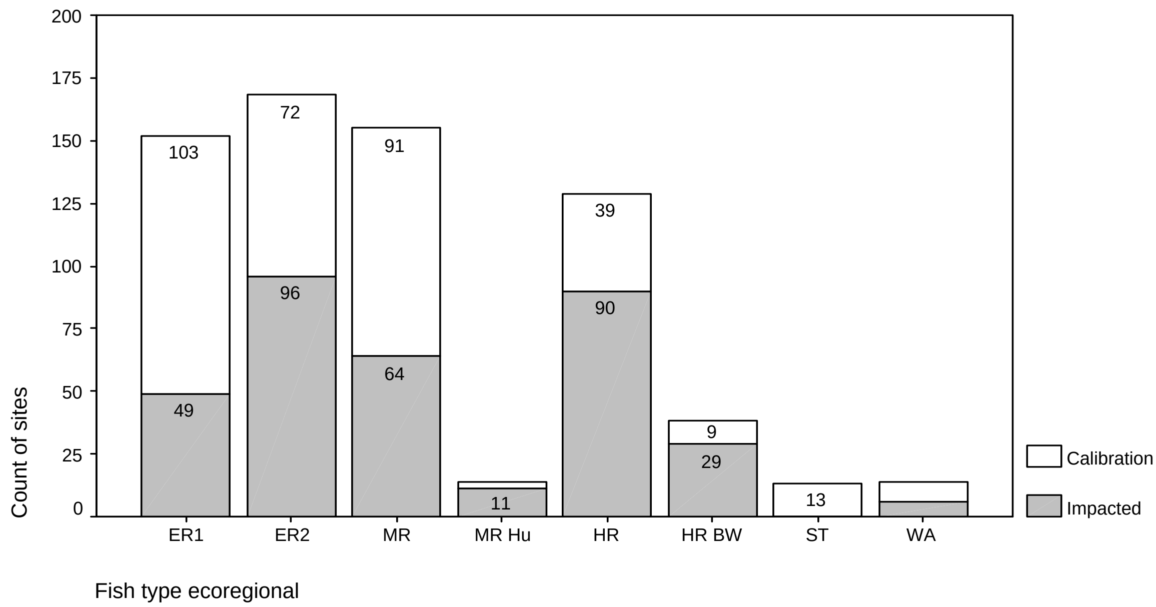


Figure xx: Numbers of impacted sites per fish type after discriminant analysis compared with numbers of calibration sites per fish type

Figure xx gives a general overview about the situation before going more into detail. Five major anthropogenic impact criteria (FIDES) with an impact score from 1-5 where chosen.

Calibration data (CD) means that none of the impact variables scores higher than 2. All others were indicated as impacted.

9 of the used 558 sites had no preclassification and were omitted, therefore the new total number of sites is 549 (Tab xx).

Scenario after Sesimbra

After many discussions about total impacts (see scenarios below), during the Sesimbra meeting a new decision was made:

Connectivity river was added and a so called "Multiscale Connectivity (MSC)" was created. MSC is the sum of Connectivity_river and Connectivity_segment. Whereas in Connectivity_river the impactclasses 2, 3 and 4 where encoded as 2 and 5 as 3; 1 remaines as class 1. Concerning Connectivity_segment the impactclasses 1, 2, 3 and 4 where changed into 0 and class 5 into 2 (Table xx, page 6).

The new total impact is a mean value of MSC, Hydrological_regime_site, Morphological_condition_site, Toxic acidification_site and Nutrients_organic_input_site (see below, Scenario 1 –Five main variables).

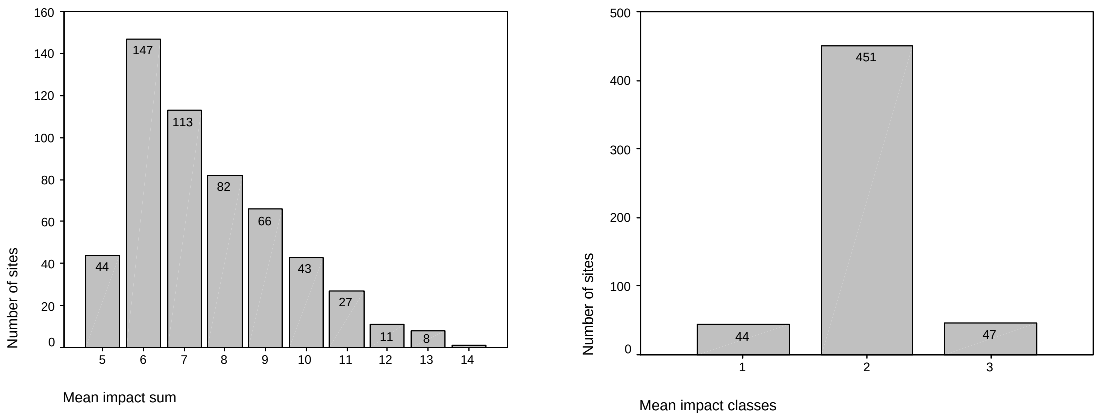


Figure xx: Numbers of impacted sites – scenario after Sesimbra

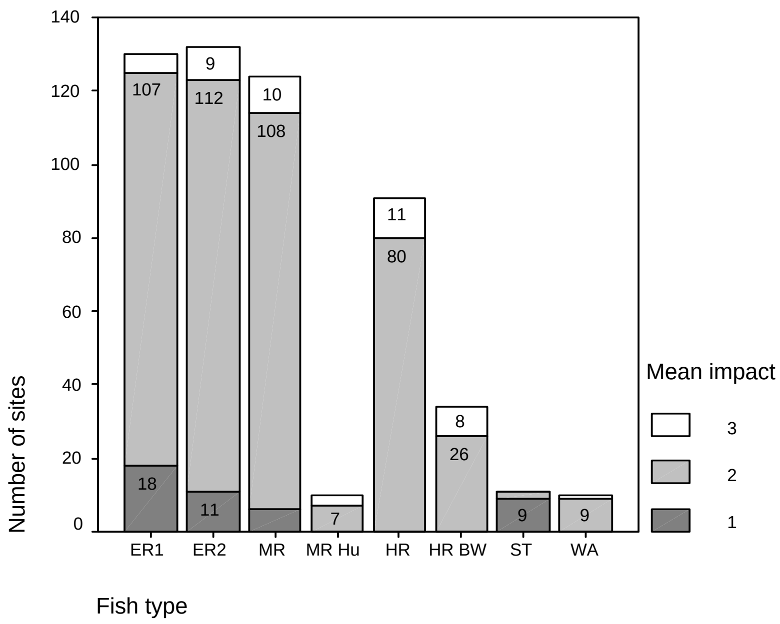


Figure xx: Numbers of impacted sites per fish type – scenario after Sesimbra

As Figure xx and xx show unmistakeable 83% data cumulate in total impact class 2. From this point of view it is not feasible to test several statistics. Looking at fish type distribution for further analysis to little impacted sites were present.

Scenario 1 –Five main variables

As mentioned before five main variables from FIDES (Connectivity_segment, Hydrological_regime_site, Morphological_condition_site, Toxic acidification_site and Nutrients_organic_input_site) were chosen to explain the level of human impactes on rivers. Each fishing occasion was classified from 1 (high) to 5 (bad).

The impacts are unevenly distributed. Toxic impact has only class 1 and 2, and also nutrients impact has no 4 and 5. Looking at chemical influences, more than 95% of the sites, are classified as a reference and 99% of the sites are calibration data.

Table xx: Numbers of sites per impact category and per fish type

		Fish type ecoregional								Total	Total %
	Class	**ER1**	**ER2**	**MR**	**MR Hu**	**HR**	**HR BW**	**ST**	**WA**		
Connectivity river	**1**	126	130	117	10	90	34	11	0	518	96%
after Sesimbra	**2**	3	0	4	0	0	0	0	10	17	3%
	3	1	2	3	0	1	0	0	0	7	1%
Connectivity segment	**0**	113	113	92	9	73	24	11	10	445	82%
after Sesimbra	**2**	17	19	32	1	18	10	0	0	97	18%
MSC	**1**	109	111	85	9	72	24	11	0	421	78%
Multiscale	**2**	3	0	4	0	0	0	0	10	17	3%
Connectivity	**3**	18	21	35	1	19	10	0	0	104	19%
	4	0	0	0	0	0	0	0	0	0	0%
	5	0	0	0	0	0	0	0	0	0	0%
Connectivity	**1**	56	89	59	9	58	24	11	0	306	56%
	2	30	13	15	0	3	0	0	9	70	13%
	3	16	9	13	0	11	0	0	0	49	9%
	4	11	2	5	0	1	0	0	1	20	4%
	5	17	19	32	1	23	12	0	0	104	19%
Hydrology	**1**	78	80	63	1	55	11	10	0	298	54%
	2	44	26	41	0	20	0	1	8	140	26%
	3	7	21	16	4	9	17	0	2	76	14%
	4	1	2	2	5	7	6	0	0	23	4%
	5	0	3	2	0	5	2	0	0	12	2%
Morphology	**1**	31	15	17	0	1	0	9	3	76	14%
	2	71	65	73	4	36	12	2	6	269	49%
	3	24	29	27	1	24	13	0	1	119	22%
	4	1	20	4	5	21	5	0	0	56	10%
	5	3	3	3	0	14	6	0	0	29	5%
Nutrients	**1**	114	128	120	10	96	36	11	3	518	94%
	2	14	4	2	0	0	0	0	6	26	5%
	3	2	0	2	0	0	0	0	1	5	1%
Toxic	**1**	129	132	123	10	96	36	11	9	546	99%
	2	1	0	1	0	0	0	0	1	3	1%
Total		130	132	124	10	96	36	11	10	549	100%

Really bad influence on classification has connectivity; 23% of the sites are classified less than 4, nevertheless 69% of the sites refer to the calibration dataset (cp. hydrology 80% and morphology 63%).

But it is not the aim of this WP to find a solution for each of this variable, because a total impact is postulated. The next scenarios will show the differences between various approaches to compute total impacts.

Scenario 2 – Total impact, worst case classification

One possibility to find a total impact is to classify each site in the way, that the worst impact class of one of the five variables gives the new value (e.g. all variables are classified as 1, but connectivity is 5, the total impact is 5).

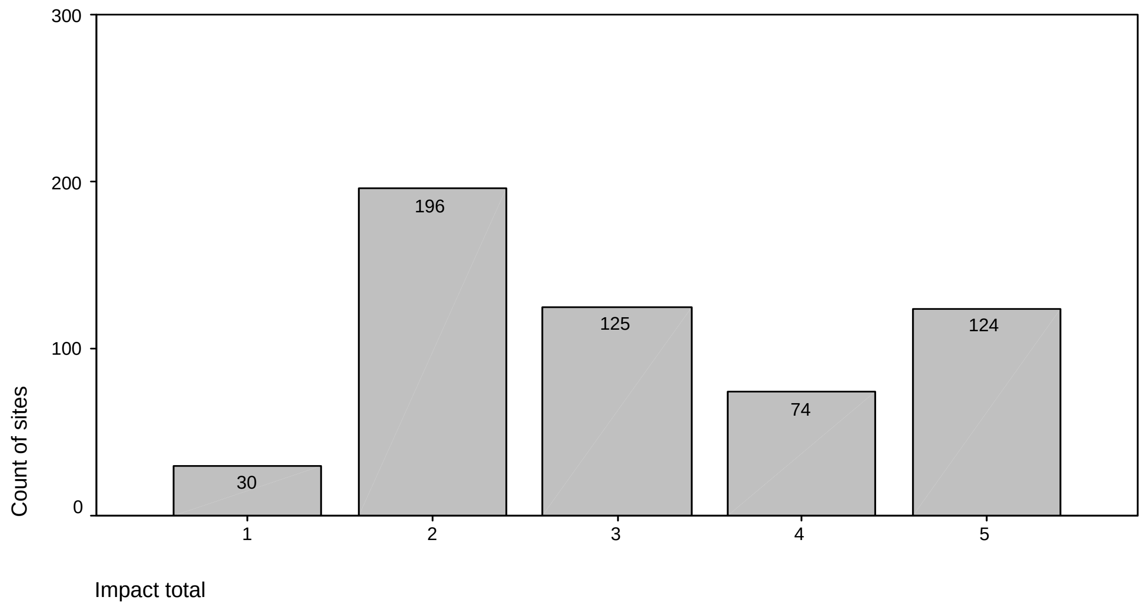


Figure xx: Numbers of impacted sites – worst-case scenario

Figure xx shows that there are only 30 sites from 549 having a reference status, whereas more than 20% are in a very bad condition. That means that 58% of the sites are more or less impacted and 42% are in a mainly good condition (Figure xx).

Scenario 3 – Total impact, mean values

Another possibility to identify total impact classes is to compute the mean value between all five variables and to group 5 classes afterwards.

The class limits were given from 1 to 5 [1.0, 1.8] [1.8, 2.6] [2.6, 3.4] [3.4, 4.2] [4.2, 5.0].

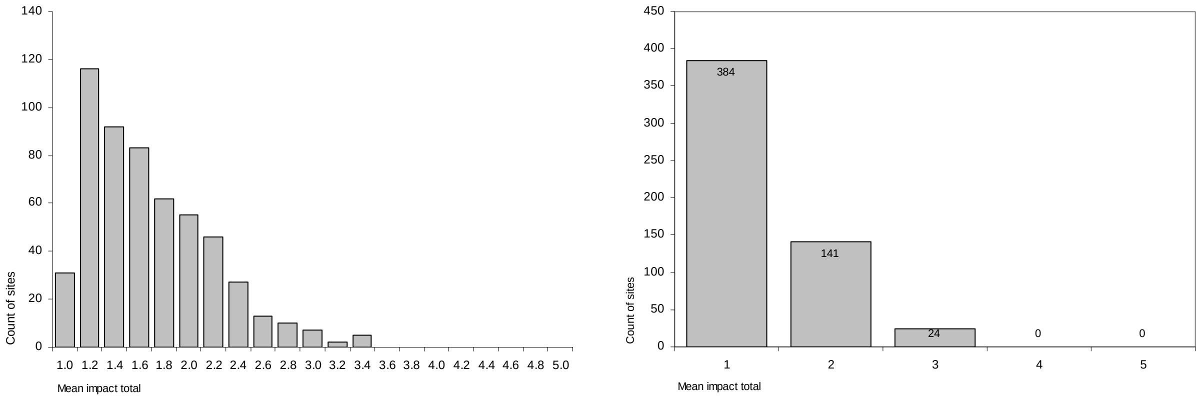


Figure xx: Numbers of impacted sites – mean values classification

As mentioned above in the Alps chemical parameters show nearly no bad influenced rivers and sites. This is the reason why in this scenario 95% of the data are classified better than 3. No impacted sites would mean that there is no need and also no precondition for further analysis (Figure xx).

Scenario 4 – Total impact, sum of scores

An often-used method is to sum up all scores and generate classes. In this case two variations (a) with five and (b) with three groups were generated. This method is the same as using mean values.

Additional thought has been given for class 1 and 2 (CD) that none of the five critical impact variables score higher than 2.

a. Sum of score with five impact classes

Using sum of score the minimum is five (five classes) and the maximum value is 25. Five class limits were generated for [5] [5, 10] [10, 15] [15, 20] [20, 25].

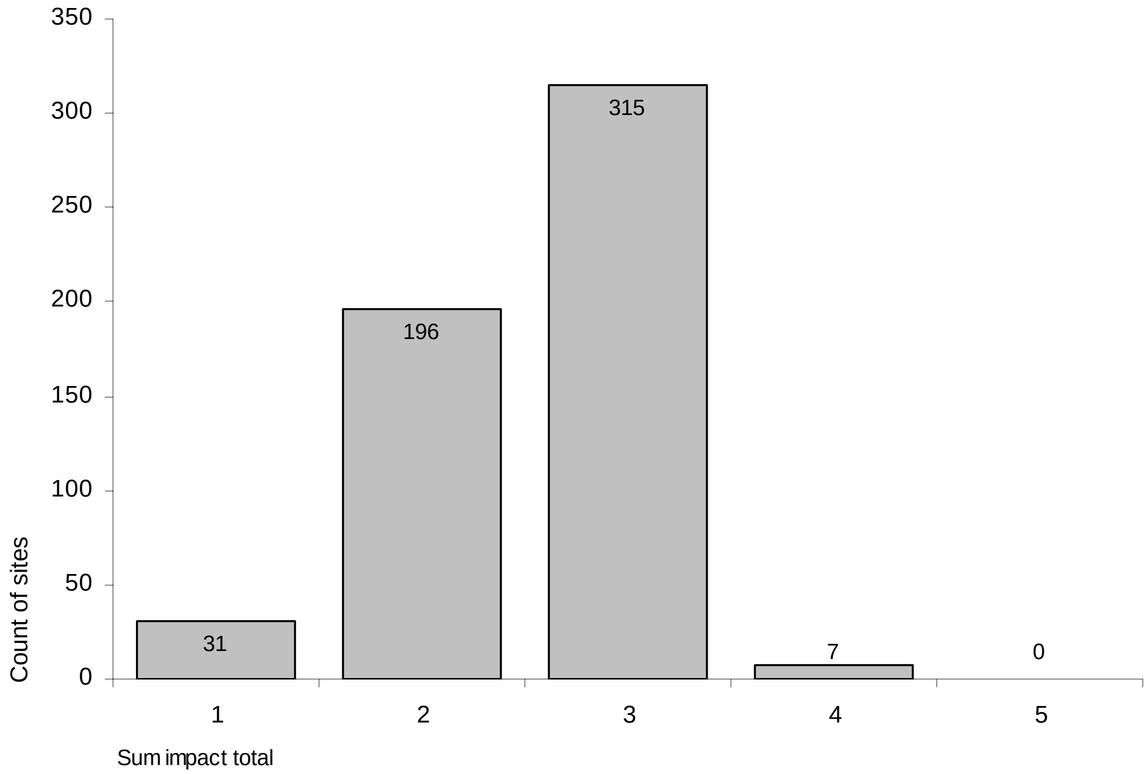


Figure xx: Numbers of impacted sites – sum values classification, 5classes

Class 2 and 3 are the largest classes, they together are 93% of the sites. There are no sites in class 5 and there are only 7 sites in class 4. On the other side there are only 31 sites belonging to class 1. In this data set there are no really bad sites and nearly no very good sites, and the majority of cases is in the middle (Figure xx).

b. Sum of score with three impact classes

As a result of the scenario above and in addition to the suggestion from the modelling group the final classification was made with three classes.

1 Calibration sites - sum of the five scores is lower or equal to ten [5, 10]
2 Impaired sites - weak human impact; sum of scores is between 11 and 15
3 Impaired sites - strong human impact; sum of the five scores is higher than 15

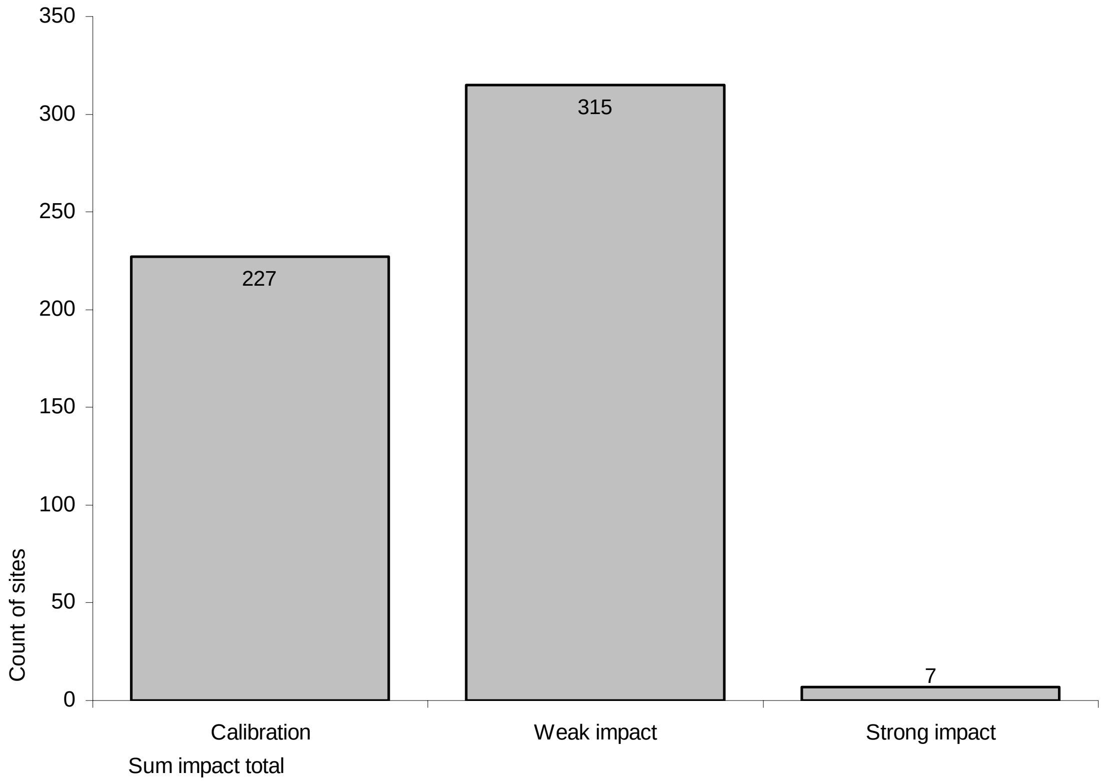


Figure xx: Numbers of impacted sites – sum values classification, 3 classes

Due to the lack of data, because of the uneven distribution of sites per impact class it is not possible to develop an algorithm for all types and all impact classes (Table xx). Further analyses include mainly classes 2 and 3 (Figure xx and xx). That means that the results should figure out important biotic differences between calibration data and weak impact for four fish types - ER1, ER2, MR, HR (Table xx).

Table xx: Level of disturbance (3 classes) per site and fish type

	Sum impact total			Total
	Calibration	Weak impact	Strong impact	

Fish type ecoregional	ER1	68	62	0	130
	ER2	50	82	0	132
	MR	56	68	0	124
	MR Hu	0	10	0	10
	HR	30	61	5	96
	HR BW	3	31	2	36
	ST	11	0	0	11
	WA	9	1	0	10
Total		227	315	7	549

2 Data cleaning/mining per fish type

As in the guideline for spatially-based approach version 2 (Böhmer J. & S. Schmutz, 2003) written only one randomly selected fishing occasion per site is used for the analyses.

In this case data mining is focusing on availability and distribution on (a) seasonal and (b) methodical aspects. Also relationships between them and biotic factors are tested.

A Seasonal aspects

Looking first at the distribution of sites per month it is obvious that most of the field sampling took place in the month from August to November (Figure xx). This circumstance causes that three seasonal groups were generated:

1 Spring - from April to July (n=101)

2 Autumn - from August to November (n=472)

3 Winter - from December to March (n=74)

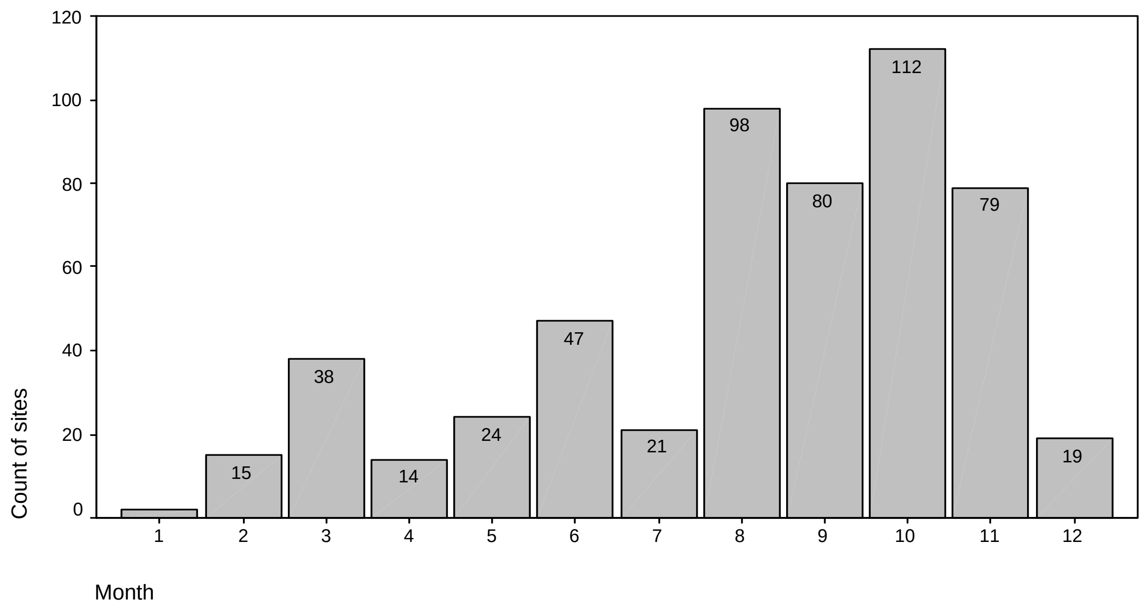


Figure xx: Frequency of sites per month

The hypothesis was that there are seasonal differences comparing the density of fish and impact classes (sum impact total – 3 classes).

Using one-way ANOVA for testing this hypothesis the depending variable was Ln transformed density [ind/ha] of all species.

Significant differences between density and season autumn for fish type ER1 (Sig. p=0.017), ER2 (Sig. p=0.028) and MR (Sig. p=0.049) were figured out. Data from spring and winter showed also no significances. There was also no significant difference between Fish type HR.

These results show that it is necessary to split data for further analyses into seasonal groups.

Only data from autumn were used for further analyses.

b Methodical aspects

The main method in the upper regions is wading. Nearly 50 % of the sites in the fish type HR are sampled by boat (Figure xx).

Also ANOVA shows effects on dividing method in the HR (Sig. P=0,008), but there are no significant distinctions in ER and MR. But because of data homogeneity and better understanding / plausibility all further analyses should be separated

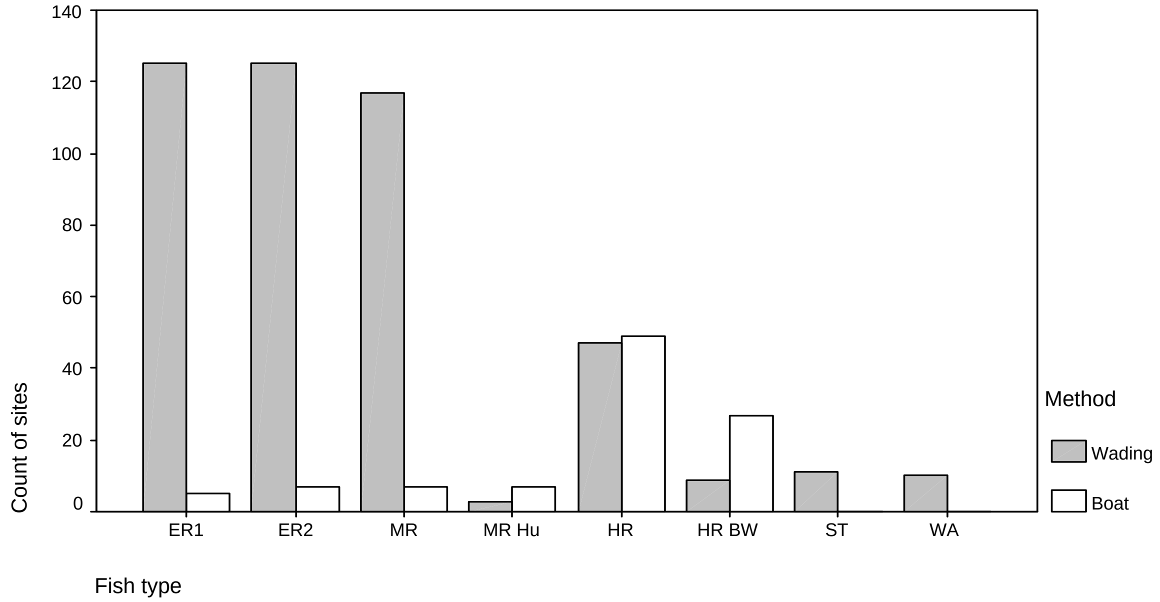


Figure xx: Frequency of sites per Fish type and sampling method

c Quality and quantity of metrics (general, density, biomass, ln transformation)

Some statistical analyses (Regression etc.) apply normal distribution of data. Often ln transformation is used to archieve this. An example what ln transformation causes is shown in figure xx.

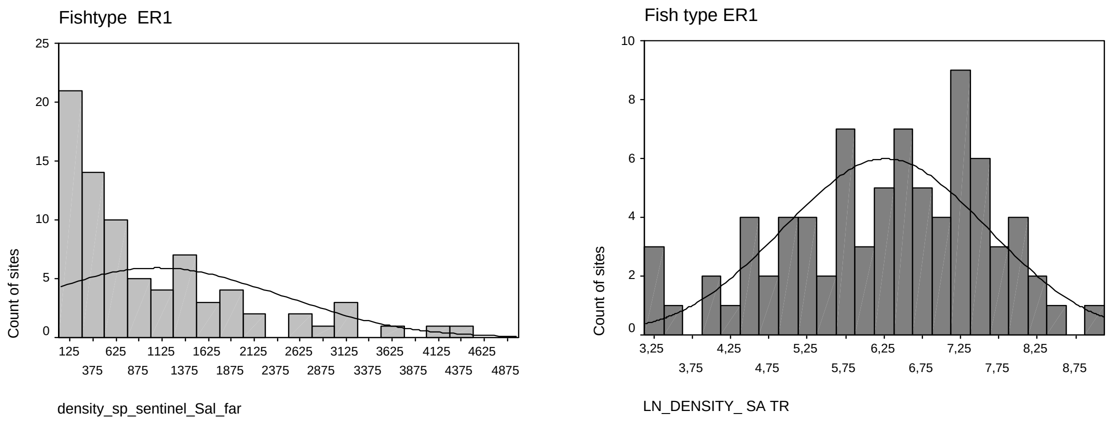


Figure xx: Distribution of density salmo trutta, before and after ln transformation (n=80).

Additionally to these considerations is to be aware of outliers. One possibility to detect them is to use the outlier test after Grubbs. Using or deleting outliers depends on what statistical procedure is used. All in all results should be resistant against them. Outliers were unaccounted for further process.

Finally the following decisions for data selections was made:

One fishing occasion per site,

Season = autumn,

Method =wading

Metric variables could be splitt into three big different groups. One is related to species composition [N species]; this is the group with the most number of sites (Table xx). The second group is formed by all metrics dealing with density of fish [ind/ha]. Some data get lost because no information about fished area. The biggest lack of data concerns biomass of fish [kg/ha]. This results in a data reduction of round about more than 50% from the original data.

Therefore it is very important to be aware of what quantity and quality of data was selected, because this might cause wrong interpretation of the results.

Table xx: Number of sites after different data screenings.

Statistics after selected site and method					
Fish type ecoregional			Density_sp_all	N species all	Biom_sp_all
ER1	N	Valid	112	125	71
		Missing	13	0	54
ER2	N	Valid	125	125	69
		Missing	0	0	56
MR	N	Valid	117	117	72
		Missing	0	0	45
HR	N	Valid	35	47	28
		Missing	12	0	19
Statistics after selected site, season and method					
ER1	N	Valid	81	80	61
		Missing	0	1	20
ER2	N	Valid	94	94	62
		Missing	0	0	32
MR	N	Valid	81	81	61
		Missing	0	0	20
HR	N	Valid	26	21	18
		Missing	0	5	8

Note. Because of ANOVA it is possible for fish type HR to select all seasons, but analysing both methods wading and boat.

Spss Syntax for data selection:

```
USE ALL. COMPUTE filter_$=(sel_type = 1 & sel_site = 1 & season = 2 & method = 0).
```

3 Metric screening and selection procedure

Number of fish species and guild classification (WP1) is basis for a metric calculation (annex). All in all more than 200 metrics were computed by acer and should be compared now.

Table xx (annex) shows all species occurring in the alpine data set and their guild classification. As mentioned in the draft of river typology alpine rivers are characterized by a very low number of fishspezies. This can cause a lot of redundancy between different metrics (e.g. ER1 mainly dominated by one species (brown trout) will give high correlations between number of species, number of intolerant species, number of insectivorous species etc.).

In this case a correlation matrix per fish type has to be done to select redundant metrics. After exhibiting high significant correlations the next step can follow. But it is also possible to act in the other direction.

a) Spearman rank correlation between total and separated impact scenarios

First the correlation between different impact scenarios should be compiled (Table xx). This table gives an idea, which of five main impact variables influences a lot. It was not possible to compute correlations with toxic acidification, because of two classes only. The other chemical variable nutrients input shows very weak and mainly non-significant results. Both will be excluded from the next analyses. They are not relevant for this ecoregion because they are mainly classified as 1 or 2.

Table xx: Over all correlation and different scenarios

Spearman's rho		Impact total 3 classes	Impact total 5 classes	Connectivity	Hydrologie	Morphologie	Nutrients	Toxic
Impact total 3 classes	Correlation Coefficient	1	,893(**)	,488(**)	,278(**)	,551(**)	-,153(*)	.
	Sig. (2-tailed)	.	0	0	0	0	0,01	.
Impact total 5 classes	Correlation Coefficient	,893(**)	1	,677(**)	,331(**)	,536(**)	-,176(**)	.
	Sig. (2-tailed)	0	.	0	0	0	0,003	.
Connectivity	Correlation Coefficient	,488(**)	,677(**)	1	,286(**)	-0,004	0,086	.
	Sig. (2-tailed)	0	0	.	0	0,941	0,151	.
Hydrology	Correlation Coefficient	,278(**)	,331(**)	,286(**)	1	,126(*)	,121(*)	.
	Sig. (2-tailed)	0	0	0	.	0,034	0,042	.
Morphology	Correlation Coefficient	,551(**)	,536(**)	-0,004	,126(*)	1	-,208(**)	.
	Sig. (2-tailed)	0	0	0,941	0,034	.	0	.
Nutrients	Correlation Coefficient	-,153(*)	-,176(**)	0,086	,121(*)	-,208(**)	1	.
	Sig. (2-tailed)	0,01	0,003	0,151	0,042	0	.	.
Toxic	Correlation Coefficient	.	.	.	.	.	.	.
	Sig. (2-tailed)	.	.	.	.	.	.	.

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

The next step explains correlation between impacts scenarios separated per fish type. Impact total 3 classes in type ER1 has high correlation to connectivity (0,664). Connectivity also has higher correlation in type MR and HR. Morphology has high correlation in type HR and MR. On the other hand hydrology shows lowest correlation to total impact.

So the impact total mainly results from bad classification of connectivity and morphology.

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table xx: Over all correlation per fish type and different scenarios

Fish type	Spearman's rho		Impact total 3 cat	Impact total 5 cat	Connectivity	Hydrologie	Morphologie
ER1	Impact total 3 cat	Correlation Coefficient	1	,928(**)	,664(**)	-0,112	,375(**)
		Sig. (2-tailed)	.	0	0	0,319	0,001
		N	81	81	81	81	81
	Impact total 5 cat	Correlation Coefficient	**,928(**)**	1	,767(**)	-0,067	,392(**)
		Sig. (2-tailed)	0	.	0	0,554	0
		N	81	81	81	81	81
	Connectivity	Correlation Coefficient	**,664(**)**	,767(**)	1	0,077	0,01
		Sig. (2-tailed)	0	0	.	0,497	0,928
		N	81	81	81	81	81
	Hydrologie	Correlation Coefficient	-0,112	-0,067	0,077	1	0,092
		Sig. (2-tailed)	0,319	0,554	0,497	.	0,416
		N	81	81	81	81	81
	Morphologie	Correlation Coefficient	,375(**)	,392(**)	0,01	0,092	1
		Sig. (2-tailed)	0,001	0	0,928	0,416	.
		N	81	81	81	81	81
ER2	Impact total 3 cat	Correlation Coefficient	1	,844(**)	,268(**)	,348(**)	,611(**)
		Sig. (2-tailed)	.	0	0,009	0,001	0
		N	94	94	94	94	94
	Impact total 5 cat	Correlation Coefficient	**,844(**)**	1	,477(**)	,432(**)	,609(**)
		Sig. (2-tailed)	0	.	0	0	0
		N	94	94	94	94	94
	Connectivity	Correlation Coefficient	,268(**)	,477(**)	1	,386(**)	-,221(*)
		Sig. (2-tailed)	0,009	0	.	0	0,032
		N	94	94	94	94	94
	Hydrologie	Correlation Coefficient	,348(**)	,432(**)	,386(**)	1	-0,006
		Sig. (2-tailed)	0,001	0	0	.	0,956
		N	94	94	94	94	94
	Morphologie	Correlation Coefficient	**,611(**)**	,609(**)	-,221(*)	-0,006	1
		Sig. (2-tailed)	0	0	0,032	0,956	.
		N	94	94	94	94	94
MR	Impact total 3 cat	Correlation Coefficient	1	,902(**)	,674(**)	,426(**)	,490(**)
		Sig. (2-tailed)	.	0	0	0	0
		N	81	81	81	81	81
	Impact total 5 cat	Correlation Coefficient	**,902(**)**	1	,856(**)	,450(**)	,440(**)
		Sig. (2-tailed)	0	.	0	0	0
		N	81	81	81	81	81
	Connectivity	Correlation Coefficient	**,674(**)**	,856(**)	1	,382(**)	0,152
		Sig. (2-tailed)	0	0	.	0	0,175
		N	81	81	81	81	81
	Hydrologie	Correlation Coefficient	,426(**)	,450(**)	,382(**)	1	0,085
		Sig. (2-tailed)	0	0	0	.	0,449
		N	81	81	81	81	81
	Morphologie	Correlation Coefficient	,490(**)	,440(**)	0,152	0,085	1
		Sig. (2-tailed)	0	0	0,175	0,449	.
		N	81	81	81	81	81
HR	Impact total 3 cat	Correlation Coefficient	1	,889(**)	,717(**)	,490(*)	,823(**)
		Sig. (2-tailed)	.	0	0	0,011	0
		N	26	26	26	26	26
	Impact total 5 cat	Correlation Coefficient	**,889(**)**	1	,914(**)	,410(*)	,748(**)
		Sig. (2-tailed)	0	.	0	0,038	0
		N	26	26	26	26	26
	Connectivity	Correlation Coefficient	**,717(**)**	,914(**)	1	0,332	,619(**)
		Sig. (2-tailed)	0	0	.	0,097	0,001
		N	26	26	26	26	26
	Hydrologie	Correlation Coefficient	,490(*)	,410(*)	0,332	1	,520(**)
		Sig. (2-tailed)	0,011	0,038	0,097	.	0,006
		N	26	26	26	26	26
	Morphologie	Correlation Coefficient	**,823(**)**	,748(**)	,619(**)	,520(**)	1
		Sig. (2-tailed)	0	0	0,001	0,006	.
		N	26	26	26	26	26

b Spearman rank correlation between density metrics and scenario to screen potential metrics

After using spearman rank correlation eight variables have low, but significant correlation to impact total 3 classes (Table xx). It does not astonish that density of all species and density of salmo trutta fario has the same value (-0.28), because brown trout dominates this type. A negative correlation concludes a decline of a selected metric. The next chapter will show redundancies between metrics itself.

Table xx: Spearman correlation per fish type ER 1 and different scenarios

	VAR_Spearman's rho	Impact total 3 classes	Impact total 5 classes	Connectivity	Hydrologie	Morphologie
1	Density_sp_all	**-,280(*)**	-,239(*)	-,263(*)	-0,111	0,196
2	density_sp_sentinel_Sal_far	**-,280(*)**	-,269(*)	-,254(*)	-0,001	0,146
3	n_ha_Hab_wc	**-,277(*)**	-,266(*)	-,250(*)	0,002	0,151
4	n_ha_Fe_insev	**-,268(*)**	-,253(*)	-,255(*)	-0,043	0,135
5	n_ha_Hab_rh	**-,267(*)**	-,253(*)	-,252(*)	-0,039	0,138
6	n_ha_Re_lith	**-,267(*)**	-,253(*)	-,252(*)	-0,039	0,138
7	n_ha_Intol	**-,266(*)**	-,252(*)	-,254(*)	-0,043	0,137
8	Density_sp_native	**-,264(*)**	-,248(*)	-,248(*)	-0,041	0,143
9	perc_sp_Hab_rh	-0,173	**-,267(*)**	-,259(*)	-0,032	-,259(*)
10	perc_sp_Re_lith	-0,173	**-,267(*)**	-,259(*)	-0,028	-,258(*)
11	n_sp_Re_phyt	0,174	**,267(*)**	,260(*)	0,03	,259(*)
12	n_sp_Fe_omni	0,174	**,267(*)**	,260(*)	0,03	,259(*)
13	n_sp_Lon_ll	0,174	**,267(*)**	,260(*)	0,03	,259(*)
14	n_sp_Hab_li	0,173	**,267(*)**	,259(*)	0,032	,259(*)
15	perc_sp_Hab_li	0,173	**,267(*)**	,259(*)	0,032	,259(*)
16	perc_sp_Re_phyt	0,173	**,267(*)**	,259(*)	0,028	,258(*)
17	perc_sp_Lon_ll	0,173	**,267(*)**	,259(*)	0,028	,258(*)
18	perc_sp_Fe_omni	0,173	**,267(*)**	,259(*)	0,028	,258(*)
19	Density_sp_alien	-0,096	-0,042	-0,146	**-,275(*)**	0,04
20	perc_sp_Fe_insev	-0,074	-0,124	-0,181	**-,226(*)**	-0,114
21	perc_sp_Hab_b	0,026	0,089	0,143	-0,119	**-,288(**)**
22	perc_sp_Hab_wc	-0,026	-0,089	-0,143	0,119	**,288(**)**
23	perc_sp_Lon_sl	0,03	0,077	0,109	-0,137	**-,285(*)**
24	n_sp_Lon_sl	0,023	0,071	0,109	-0,127	**-,281(*)**
25	n_sp_Hab_b	0,027	0,094	0,153	-0,114	**-,270(*)**
26	perc_nha_Lon_sl	0,035	0,083	0,107	-0,119	**-,224(*)**

Screening of metrics for type ER2 identified eleven metrics with high significance with impact criteria impact total 3 classes (Table xx). This type also shows that density of brown trout has very high correlation as it was in type ER1.

Table xx: Spearman correlation per fish type ER2 and different scenarios

	VAR_Spearman's rho	Impact total 3 classes	Impact total 5 classes	Connectivity	Hydrologie	Morphologie
1	n_sp_Mi_potad	**,293(**)**	,299(**)	-0,019	0,191	,207(*)
2	n_ha_Mi_potad	**,292(**)**	,294(**)	-0,022	0,196	0,2
3	perc_sp_Mi_potad	**,292(**)**	,302(**)	-0,026	0,195	,219(*)
4	perc_nha_Mi_potad	**,292(**)**	,297(**)	-0,023	0,182	,205(*)
5	n_ha_Fe_insev	**-,291(**)**	-0,177	0,069	-0,023	-0,188
6	n_ha_Intol	**-,290(**)**	-0,175	0,072	-0,023	-0,189
7	density_sp_sentinel_Sal_far	**-,288(**)**	-0,193	0,066	-0,064	-0,148
8	n_sp_Hab_wc	**,280(**)**	,277(**)	-0,001	0,147	0,17
9	n_ha_Re_lith	**-,272(**)**	-0,176	0,048	-0,043	-0,172
10	n_ha_Hab_rh	**-,269(**)**	-0,177	0,049	-0,052	-0,169
11	Density_sp_native	**-,268(**)**	-0,175	0,046	-0,044	-0,168
12	n_ha_Hab_wc	**-,263(*)**	-0,188	0,053	-0,081	-0,137
13	Density_sp_alien	**,263(*)**	,314(**)	0,096	,282(**)	,204(*)
14	N species all	**,245(*)**	,271(**)	0,17	,339(**)	0,053
15	Perc_sp_native	**-,244(*)**	-,319(**)	-,221(*)	-,214(*)	-,229(*)
16	perc_sp_Fe_insev	**-,228(*)**	-0,191	0,064	-0,188	-0,146
17	perc_nha_Fe_insev	**-,228(*)**	-0,192	0,058	-0,193	-0,138
18	Density_sp_all	**-,220(*)**	-0,137	0,021	-0,018	-0,128
19	perc_sp_Intol	**-,214(*)**	-0,148	0,114	-0,135	-0,176
20	perc_nha_Intol	**-,214(*)**	-0,147	0,115	-0,135	-0,173
21	density_sp_sentinel_Thy_thy	**,214(*)**	,266(**)	0,045	0,174	0,114
22	N_sp_native	0,104	0,106	0,078	**,250(*)**	-0,108
23	n_sp_Hab_b	0	0,009	0,114	**,246(*)**	-,221(*)
24	n_sp_Re_lith	0,084	0,078	0,08	**,232(*)**	-0,131
25	perc_nha_Hab_wc	-0,02	-0,043	-0,068	**-,225(*)**	0,176
26	perc_nha_Hab_b	0,02	0,043	0,068	**,225(*)**	-0,176
27	perc_sp_Hab_wc	0,068	0,058	-0,11	**-,222(*)**	,262(*)
28	perc_sp_Hab_b	-0,068	-0,058	0,11	**,222(*)**	-,262(*)
29	n_ha_Hab_b	-0,003	0,029	0,082	**,217(*)**	-0,177
30	n_sp_Hab_rh	0,084	0,078	0,08	**,212(*)**	-0,128
31	perc_sp_Lon_sl	-0,08	-0,093	0,097	0,126	**-,255(*)**
32	n_sp_Fe_insev	-0,014	0,014	0,131	0,2	**-,221(*)**
33	n_sp_Lon_sl	-0,03	-0,041	0,099	0,134	**-,211(*)**
34	n_sp_Intol	0,001	0,015	0,119	0,183	**-,208(*)**

In type MR seven metrics with high significance were identified (Table xx). None of the sentinel species metrics exhibited significant correlation with impact in this type.

Type HR has six significant metrics (Table xx). Of all screened metrics density of sentinel species grayling and 0+ of grayling exhibited the strongest correlation with impact.

Table xx: Spearman correlation per fish type MR and different scenarios

	VAR_Spearman's rho	Impact total 3 classes	Impact total 5 classes	Connectivity	Hydrologie	Morphologie
1	perc_sp_Hab_wc	**-,371(**)**	-,346(**)	-,257(*)	-,341(**)	-0,129
2	perc_sp_Hab_b	**,371(**)**	,346(**)	,257(*)	,341(**)	0,129
3	perc_sp_Lon_sl	**,363(**)**	,312(**)	0,143	,220(*)	,262(*)
4	perc_sp_Mi_potad	**-,311(**)**	-,312(**)	-,274(*)	-,342(**)	-0,014
5	n_sp_Hab_wc	**-,291(**)**	-,329(**)	-,324(**)	-,350(**)	-0,069
6	n_sp_Mi_potad	**-,291(**)**	-,329(**)	-,332(**)	-,351(**)	-0,029
7	n_ha_Mi_potad	**-,291(**)**	-,322(**)	-,314(**)	-,331(**)	0,014
8	perc_nha_Mi_potad	**-,282(*)**	-,306(**)	-,346(**)	-,266(*)	0,025
9	n_sp_Lon_sl	**,260(*)**	0,193	0,043	0,08	0,193
10	n_sp_Hab_b	**,258(*)**	0,215	0,141	0,206	0,063
11	perc_nha_Intol	**,222(*)**	0,186	0,125	0,15	,225(*)
12	density_sp_sentinel_Thy_thy	**-,219(*)**	-,235(*)	-,247(*)	-,308(**)	0,082
13	Density_sp_alien	-0,182	**-,278(*)**	-,323(**)	-0,209	0,128
14	Density_sp_all	-0,216	**-,263(*)**	-0,173	-,272(*)	-0,012
15	n_sp_Fe_omni	-0,192	-0,202	**-,228(*)**	-0,157	-0,035
16	perc_sp_Fe_omni	-0,192	-0,202	**-,228(*)**	-0,158	-0,034
17	perc_nha_Fe_omni	-0,192	-0,202	**-,228(*)**	-0,158	-0,034
18	n_ha_Fe_omni	-0,192	-0,202	**-,227(*)**	-0,156	-0,036
19	n_ha_Hab_rh	-0,157	-0,194	-0,094	**-,269(*)**	0,025
20	n_ha_Re_lith	-0,157	-0,194	-0,094	**-,269(*)**	0,025
21	n_ha_Hab_wc	-0,15	-0,186	-0,076	**-,261(*)**	0,019
22	Density_sp_native	-0,166	-0,204	-0,094	**-,254(*)**	0,006
23	n_ha_Intol	-0,169	-0,187	-0,057	**-,241(*)**	-0,006
24	n_ha_Fe_insev	-0,181	-0,189	-0,046	**-,228(*)**	-0,025
25	Perc_sp_native	-0,081	0,008	0,098	-0,083	**-,280(*)**
26	n_sp_Mi_long	-0,187	-0,162	-0,014	0,117	**-,270(*)**
27	n_ha_Mi_long	-0,187	-0,162	-0,014	0,117	**-,270(*)**
28	perc_sp_Mi_long	-0,187	-0,162	-0,014	0,117	**-,270(*)**
29	perc_nha_Mi_long	-0,187	-0,162	-0,014	0,117	**-,270(*)**
30	perc_nha_Fe_insev	0,199	0,183	0,117	0,13	**,227(*)**

Tabelle xx: Spearman correlation per fish type HR and different scenarios

	VAR_Spearman's rho	Impact total 3 classes	Impact total 5 classes	Connectivity	Hydrologie	Morphologie
1	density_sp_sentinel_Thy_thy	**-,521(*)**	-,499(*)	-0,41	-0,273	-,580(**)
2	density_0plus_Thy_thy	**-,512(*)**	-,444(*)	-,512(*)	-0,272	-,446(*)
3	perc_nha_ Fe_pisc	**-,483(*)**	-,597(**)	-,538(*)	-0,138	-0,233
4	n_ha_ Fe_pisc	**-,474(*)**	-,584(**)	-,532(*)	-0,126	-0,212
5	perc_sp_Lon_sl	**,438(*)**	,507(**)	,445(*)	0,17	0,277
6	perc_0plus_Thy_thy	**-,432(*)**	-0,37	-,407(*)	-0,243	-,415(*)
7	perc_sp_ Fe_pisc	-0,373	**-,537(**)**	-,491(*)	-0,242	-0,216
8	n_sp_ Fe_pisc	-0,256	**-,460(*)**	-,452(*)	-0,131	-0,053
9	perc_0plus_Sal_far	0,287	**,428(*)**	,422(*)	0,068	0,018
10	perc_sp_Mi_potad	-0,272	-0,342	-0,278	**-,580(**)**	-0,317
11	n ha tol	0,319	0,154	0,133	**,556(**)**	,574(**)
12	perc_nha_Tol	0,319	0,167	0,146	**,545(*)**	,561(**)
13	perc_nha_Hab_wc	-0,26	-0,254	-0,179	**-,439(*)**	-0,146
14	perc_nha_Hab_b	0,26	0,254	0,179	**,439(*)**	0,146
15	n species tol	0,336	0,163	0,031	0,352	**,539(**)**
16	perc_sp_Tol	0,336	0,171	0,044	0,354	**,534(**)**
17	n_ha_Intol	-0,211	-0,226	-0,264	-0,357	**-,491(*)**
18	n_ha_Fe_insev	-0,211	-0,226	-0,264	-0,357	**-,491(*)**
19	perc_sp_Re_lith	-0,383	-0,259	-0,149	-0,261	**-,414(*)**

c Spearman rank correlation to identify redundancy between metrics

The following tables explain the redundancy between all metrics for each fish type. A list of all potential metrics is located in the annex. It is not possible to print the whole correlation matrix because of big size. Metrics with high significant redundancy (correlation > 0.8) were selected.

Table xx: Spearman correlation (>0.8) for fish type ER1 beetween potential metrics

VAR_Spearman's rho	Density_sp_all	n_ha_Hab_rh	n_ha_Re_lith	Density_sp_native	n_ha_Intol	n_ha_Fe_insev	n_ha_Hab_wc	density_sp_sentinel_Sal_far
1Density_sp_all	1	,933(**)	,933(**)	,933(**)	,932(**)	,932(**)	,889(**)	,889(**)
2n_ha_Hab_rh	,933(**)	1	1,000(**)	1,000(**)	,999(**)	,999(**)	,966(**)	,966(**)
3n_ha_Re_lith	,933(**)	1,000(**)	1	1,000(**)	,999(**)	,999(**)	,966(**)	,966(**)
4Density_sp_native	,933(**)	1,000(**)	1,000(**)	1	,999(**)	,999(**)	,966(**)	,965(**)
5n_ha_Intol	,932(**)	,999(**)	,999(**)	,999(**)	1	1,000(**)	,965(**)	,965(**)
6n_ha_Fe_insev	,932(**)	,999(**)	,999(**)	,999(**)	1,000(**)	1	,964(**)	,965(**)
7n_ha_Hab_wc	,889(**)	,966(**)	,966(**)	,966(**)	,965(**)	,964(**)	1	,999(**)
8density_sp_sentinel_Sal_far	,889(**)	,966(**)	,966(**)	,965(**)	,965(**)	,965(**)	,999(**)	1

Tabelle xx: Spearman correlation (>0.8) for fish type ER2 between potential metrics

VAR_Spearman's rho	n_sp_Mi_potad	n_ha_Mi_potad	perc_sp_Mi_potad	perc_nha_Mi_potad	n_sp_Hab_wc
n_sp_Mi_potad	1	,997(**)	,997(**)	,996(**)	,957(**)
perc_sp_Mi_potad	,997(**)	,994(**)	1	,993(**)	,942(**)
n_ha_Mi_potad	,997(**)	1	,994(**)	,996(**)	,953(**)
perc_nha_Mi_potad	,996(**)	,996(**)	,993(**)	1	,956(**)
n_sp_Hab_wc	,957(**)	,953(**)	,942(**)	,956(**)	1

	n_ha_Fe_insev	n_ha_Intol	density_Sal_far	n_ha_Re_lith	n_ha_Hab_rh	Density_sp_native	Density_sp_all	n_ha_Hab_wc
n_ha_Fe_insev	1	1,000(**)	,943(**)	,958(**)	,950(**)	,949(**)	,926(**)	,906(**)
n_ha_Intol	1,000(**)	1	,942(**)	,963(**)	,956(**)	,954(**)	,933(**)	,911(**)
n_ha_Re_lith	,958(**)	,963(**)	,895(**)	1	,999(**)	,999(**)	,979(**)	,948(**)
n_ha_Hab_rh	,950(**)	,956(**)	,888(**)	,999(**)	1	,999(**)	,978(**)	,950(**)
Density_sp_native	,949(**)	,954(**)	,886(**)	,999(**)	,999(**)	1	,979(**)	,949(**)
density_sp_sentinel_Sal_far	,943(**)	,942(**)	1	,895(**)	,888(**)	,886(**)	,857(**)	,950(**)
Density_sp_all	,926(**)	,933(**)	,857(**)	,979(**)	,978(**)	,979(**)	1	,922(**)
n_ha_Hab_wc	,906(**)	,911(**)	,950(**)	,948(**)	,950(**)	,949(**)	,922(**)	1

	perc_nha_Fe_insev	perc_sp_Fe_insev	perc_sp_Intol	perc_nha_Intol	N species all
perc_nha_Fe_insev	1	,998(**)	,938(**)	,940(**)	,583(**)
perc_sp_Fe_insev	,998(**)	1	,948(**)	,946(**)	,573(**)
perc_nha_Intol	,940(**)	,946(**)	,998(**)	1	,581(**)
perc_sp_Intol	,938(**)	,948(**)	1	,998(**)	,579(**)
perc_nha_Fe_omni	-,813(**)	-,817(**)	-,861(**)	-,864(**)	,576(**)
n_sp_Fe_omni	-,813(**)	-,818(**)	-,862(**)	-,864(**)	,419(**)
n_ha_Fe_omni	-,812(**)	-,816(**)	-,860(**)	-,863(**)	-,233(*)
perc_sp_Fe_omni	-,812(**)	-,816(**)	-,861(**)	-,863(**)	-,227(*)
N_sp_native	-,486(**)	-,484(**)	-,442(**)	-,443(**)	,833(**)
n_sp_Hab_rh	-,394(**)	-,389(**)	-,339(**)	-,342(**)	,810(**)
n_sp_Re_lith	-,390(**)	-,388(**)	-,339(**)	-,340(**)	,809(**)

Tabelle xx: Spearman correlation (>0.8) for fish type MR between potential metrics

VAR_Spearman's rho	perc_sp_Hab_wc	perc_sp_Hab_b	n_sp_Hab_b	perc_sp_Mi_potad	perc_sp_Lon_sl	n_sp_Mi_potad	n_sp_Hab_wc	n_sp_Lon_sl
perc_sp_Hab_wc	1	-1,000(**)	-,797(**)	,778(**)	-,729(**)	,566(**)	,535(**)	-,532(**)
perc_sp_Hab_b	-1,000(**)	1	,797(**)	-,778(**)	,729(**)	-,566(**)	-,535(**)	,532(**)
n_sp_Hab_b	-,797(**)	,797(**)	1	-,555(**)	,558(**)	-0,109	-0,029	,745(**)
perc_sp_Mi_potad	,778(**)	-,778(**)	-,555(**)	1	-,677(**)	,799(**)	,576(**)	-,453(**)
perc_sp_Lon_sl	-,729(**)	,729(**)	,558(**)	-,677(**)	1	-,482(**)	-,324(**)	,801(**)
n_sp_Mi_potad	,566(**)	-,566(**)	-0,109	,799(**)	-,482(**)	1	,872(**)	-0,04
n_sp_Hab_wc	,535(**)	-,535(**)	-0,029	,576(**)	-,324(**)	,872(**)	1	0,164
n_sp_Lon_sl	-,532(**)	,532(**)	,745(**)	-,453(**)	,801(**)	-0,04	0,164	1

	n_ha_Mi_potad	perc_nha_Mi_potad	density_sp_Thy_thy	e
n_ha_Mi_potad	1	,896(**)	,859(**)	
perc_nha_Mi_potad	,896(**)	1	,817(**)	
density_sp_Thy_thy	,859(**)	,817(**)	1	

Tabelle xx: Spearman correlation (>0.8) for fish type HR between potential metrics

VAR_Spearman's rho	perc_0plus_Thy_thy	density_0plus_Thy_thy	perc_nha_ Fe_pisc	n_ha_ Fe_pisc
perc_0plus_Thy_thy	1	,998(**)	0,263	0,291
density_0plus_Thy_thy	,998(**)	1	0,278	0,312
presence_0plus_Thy_thy	,897(**)	,976(**)	0,299	0,309
perc_nha_ Fe_pisc	0,263	0,278	1	,984(**)
n_ha_ Fe_pisc	0,291	0,312	,984(**)	1
n_sp_ Fe_pisc	0,269	0,348	,976(**)	,976(**)
perc_sp_ Fe_pisc	0,341	0,38	,968(**)	,958(**)
perc_sp_Hab_eury	0,073	0,051	,863(**)	,789(**)
perc_nha_Hab_eury	-0,001	-0,001	,846(**)	,787(**)
perc_sp_Lon_ll	0,06	-0,016	,833(**)	,767(**)
n_sp_Hab_eury	0,054	0,025	,815(**)	,756(**)

d Spearman rank correlation to to screen potential biomass metrics

The same procedure as above was made with all metrics concerning biomass. The separation was because the lack of biomass data (see before).

Generally the metrics selected during the screening process did not exhibit strong correlation with the impact variables. Few of the biomass based metrics exhibit high significant correlations.

Only the biomass of brown trout in type ER2 and the biomass of grayling in type HR could be taken under consideration (Table xx and xx). All other metrics failed because of reduncy or no significant correlation.

Table xx: Spearman correlation per fish type ER1/ER2 and different scenarios

Type	Spearman's rho	Impact total 3 cat	Impact total 5 cat	Connectivity	Hydrologie	Morphologie
ER1	kg_ha_Fe_omni	,257(*)	,254(*)	0,205	0,006	,249(*)
ER1	kgha_run1_fe_omni	,257(*)	,254(*)	0,205	0,006	,249(*)
ER1	perc_kgha_Fe_omni	,256(*)	,256(*)	0,205	0,002	,250(*)
ER1	Biom_sp_alien	0,041	0,046	-0,077	-,402(**)	0,048
ER1	biom_run1_alien	0,039	0,043	-0,081	-,406(**)	0,048
type	Spearman's rho	Impact total 3 cat	Impact total 5 cat	Connectivity	Hydrologie	Morphologie
ER2	biom_sp_sentinel_Sal_far	-,318(**)	-,307(**)	0,06	0,018	-,427(**)
ER2	kg_ha_Intol	-,309(**)	-,307(**)	0,052	0,045	-,449(**)
ER2	kg_ha_Fe_insev	-,309(**)	-,307(**)	0,052	0,045	-,449(**)
ER2	kg_ha_Hab_rh	-,275(*)	-,302(*)	0,025	0,027	-,428(**)
ER2	kg_ha_Hab_wc	-,269(*)	-,304(**)	0,02	0,037	-,424(**)
ER2	kgha_run1_intol	-,262(*)	-,247(*)	0,054	0,062	-,376(**)
ER2	kgha_run1_fe_insev	-,262(*)	-,247(*)	0,054	0,062	-,376(**)
ER2	kg_ha_Re_lith	-,256(*)	-,282(*)	0,003	0,084	-,415(**)
ER2	Biom_sp_all	-,247(*)	-,276(*)	-0,062	0,064	-,377(**)
ER2	Biom_sp_native	-,246(*)	-,277(*)	0,001	0,08	-,407(**)
ER2	kgha_run1_hab_rh	-,239(*)	-,248(*)	0,032	0,04	-,360(**)
ER2	kg_ha_Mi_potad	,238(*)	0,157	-0,212	0,122	0,212
ER2	kgha_run1_mi_potad	,238(*)	0,159	-0,212	0,122	0,215
ER2	perc_kgha_Mi_potad	,238(*)	0,165	-0,212	0,11	0,222
ER2	kgha_run1_hab_wc	-0,227	-,250(*)	0,03	0,04	-,356(**)
ER2	biom_run1_native	-0,208	-0,221	0,006	0,093	-,335(**)
ER2	kg_ha_Lon_sl	-0,14	-0,098	0,046	0,092	-,267(*)
ER2	perc_kgha_Lon_sl	-0,16	-0,079	0,087	0,036	-,254(*)
ER2	biom_run1_all	-0,187	-0,208	-0,064	0,088	-,295(*)
ER2	kgha_run1_re_lith	-0,213	-0,223	0,011	0,094	-,341(**)

Tabelle xx: Spearman correlation per fish type MR/HR and different scenarios

type	Spearman's rho	Impact total 3 cat	Impact total 5 cat	Connectivity	Hydrologie	Morphologie
MR	perc_kgha_Mi_long	-0,201	-0,172	-0,013	0,1	-,289(*)
MR	perc_kgha_Re_phyt	0,14	0,114	0,017	0,046	,285(*)
MR	perc_kgha_Lon_ll	0,14	0,114	0,017	0,046	,285(*)
MR	biom_sp_sentinel_Thy_thy	0,026	-0,015	-0,071	-0,135	,281(*)
MR	kg_ha_Re_phyt	0,144	0,122	0,027	0,047	,278(*)
MR	kg_ha_Lon_ll	0,144	0,122	0,027	0,047	,278(*)
MR	kgha_run1_re_phyt	0,144	0,122	0,027	0,047	,278(*)
MR	kgha_run1_lon_ll	0,144	0,122	0,027	0,047	,278(*)
MR	kg_ha_Mi_long	-0,181	-0,153	0,011	0,1	-,273(*)
MR	kgha_run1_mi_long	-0,181	-0,153	0,011	0,1	-,273(*)
MR	kgha_run1_mi_potad	-0,007	-0,065	-0,111	-0,133	,238(*)
MR	perc_kgha_Fe_pisc	0,098	0,15	0,15	0,174	,232(*)
MR	kg_ha_Mi_potad	-0,025	-0,076	-0,12	-0,143	,230(*)
MR	biom_sp_sentinel_Eso_luc	0,101	0,149	0,15	0,168	,223(*)
MR	kg_ha_ Fe_pisc	0,101	0,149	0,15	0,168	,223(*)
MR	kgha_run1_fe_pisc	0,101	0,149	0,15	0,168	,223(*)
MR	perc_kgha_Mi_potad	-0,117	-0,172	-,242(*)	-0,2	0,206

MR	Biom_sp_alien	0,014	-0,066	-0,103	-,263(*)	0,154
MR	biom_run1_alien	0,013	-0,072	-0,105	-,265(*)	0,149

type	Spearman's rho	Impact total 3 cat	Impact total 5 cat	Connectivity	Hydrologie	Morphologie
HR	kg_ha_Mi_potad	-,279(*)	-,518(**)	0,018	-0,042	-,465(**)
HR	biom_sp_sentinel_Thy_thy	-,399(**)	-,503(**)	-0,147	-0,059	-,487(**)
HR	kgha_run1_mi_potad	-0,231	-,461(**)	0,074	-0,031	-,419(**)
HR	Biom_sp_native	-0,21	-,449(**)	0,148	0,018	-,478(**)
HR	Biom_sp_all	-0,228	-,448(**)	0,153	0,029	-,503(**)
HR	kg_ha_Re_lith	-0,202	-,432(**)	0,123	-0,006	-,451(**)
HR	kg_ha_Hab_wc	-0,203	-,427(**)	0,106	-0,041	-,469(**)
HR	kg_ha_Intol	-0,225	-,427(**)	0,082	-0,054	-,484(**)
HR	kg_ha_Fe_insev	-0,235	-,420(**)	0,063	-0,065	-,494(**)
HR	biom_run1_all	-0,191	-,408(**)	0,19	0,059	-,478(**)
HR	biom_run1_native	-0,173	-,405(**)	0,184	0,052	-,450(**)
HR	kgha_run1_hab_wc	-0,184	-,397(**)	0,13	-0,011	-,445(**)
HR	kgha_run1_re_lith	-0,173	-,396(**)	0,149	0,026	-,423(**)
HR	kgha_run1_intol	-0,204	-,396(**)	0,106	-0,022	-,460(**)
HR	kg_ha_Hab_rh	-0,166	-,388(**)	0,159	0,027	-,425(**)
HR	kgha_run1_fe_insev	-0,204	-,384(**)	0,098	-0,022	-,463(**)
HR	perc_kgha_Mi_potad	-0,233	-,373(**)	-,295(*)	-0,184	-0,105
HR	kgha_run1_hab_rh	-0,138	-,350(*)	0,184	0,051	-,400(**)
HR	biom_run1_alien	-0,054	-0,16	0,256	0,095	-,382(**)
HR	Biom_sp_alien	-0,053	-0,165	0,242	0,088	-,380(**)
HR	biom_sp_sentinel_Sal_far	-0,066	-0,216	0,253	0,026	-,378(**)
HR	kg_ha_Lon_sl	-0,16	-0,062	-0,024	-0,143	-,293(*)

e) Stepdisc procedure to screen poetential metrics

Doing spearman rank correlation was not satisfying, because it was not so easy to exhibit the most important variables for further predictions and assessment methods.

Given a classification variable (impact) and several quantitative variables (metrics), the stepdisc procedure performs a stepwise discriminant analysis to select a subset of quantitative variables for use in discriminating among the classes. This procedure might be a useful prelude to further analyses using discriminant analyses.

Summary for stepwise selection species composition and density based metrics:

ER1	Density_sp_all
ER2	perc_sp_Mi_potad, Perc_sp_native, n_ha_Fe_insev, density_0plus_Sal_far
MR	n_sp_Fe_pisc, n_sp_Mi_potad, presence_0plus_Sal_far, n_sp_Intol, n_ha_Lon_ll, perc_sp_Re_lith, n_ha_Mi_potad, density_0plus_Thy_thy, perc_nha_Lon_sl
HR	perc_sp_Mi_potad, Perc_sp_native, Density_sp_alien, density_sp_sentinel_Huc_huc, n_sp_Lon_ll, perc_sp_Hab_eury, n ha tol, perc_sp_Lon_sl

Summary for stepwise selection biomass based metrics:

ER1	Biom_sp_all
ER2	perc_kgha_Mi_potad
MR	perc_kgha_Hab_b, perc_kgha_Mi_potad, biom_sp_sentinel_Sal_far, kgha_run1_hab_rh, kgha_run1_re_lith
HR	biom_sp_sentinel_Thy_thy

f) The discriminant analysis

This method is useful in two ways. On the one hand it is possible screen potential metrics and on the other it is possible to produce prediction models for classifying ecological impacts (Status_ecoregional).

Two approaches were testet per fish type – A) with metrics based on species composition and density and B) metrics based on biomass

A) Species composition and density based procedure

As it is shown in table xx the over all average of correct classifed impact classes is 70%.

Table xx: Classification Results for model A)

Fish type			Total impact 3 classes	Predicted Group Membership		Total
				Calibration	Weak impact	
ER1	Original	Count	Calibration	31	13	44
			Weak impact	14	22	36
		%	Calibration	70,5	29,5	100,0
			Weak impact	38,9	61,1	100,0
ER2	Original	Count	Calibration	21	10	31
			Weak impact	18	45	63
		%	Calibration	67,7	32,3	100,0
			Weak impact	28,6	71,4	100,0
MR	Original	Count	Calibration	25	9	34
			Weak impact	14	33	47
		%	Calibration	73,5	26,5	100,0
			Weak impact	29,8	70,2	100,0
HR	Original	Count	Calibration	18	3	21
			Weak impact	23	34	57
		%	Calibration	85,7	14,3	100,0
			Weak impact	40,4	59,6	100,0

a For split file ER1, 66,3% of original grouped cases correctly classified.
b For split file ER2, 70,2% of original grouped cases correctly classified.
c For split file MR, 71,6% of original grouped cases correctly classified.
d For split file HR, 66,7% of original grouped cases correctly classified.

Variables in the analysis are perc_sp_Lon_sl, precence_0plus_Sal_far, density_sp_all, density_sp_sentinel_Thy_thy, n_ha_Fe_insev, n_ha_Mi_potad, perc_nha_Fe_omni, perc_nha_Mi_potad.

All significant Variables per each fish type are listed in table xx.

The description of selected metrics per fishtype and total impact after discriminant procedure shows the gradient of impairment (Figure xx).

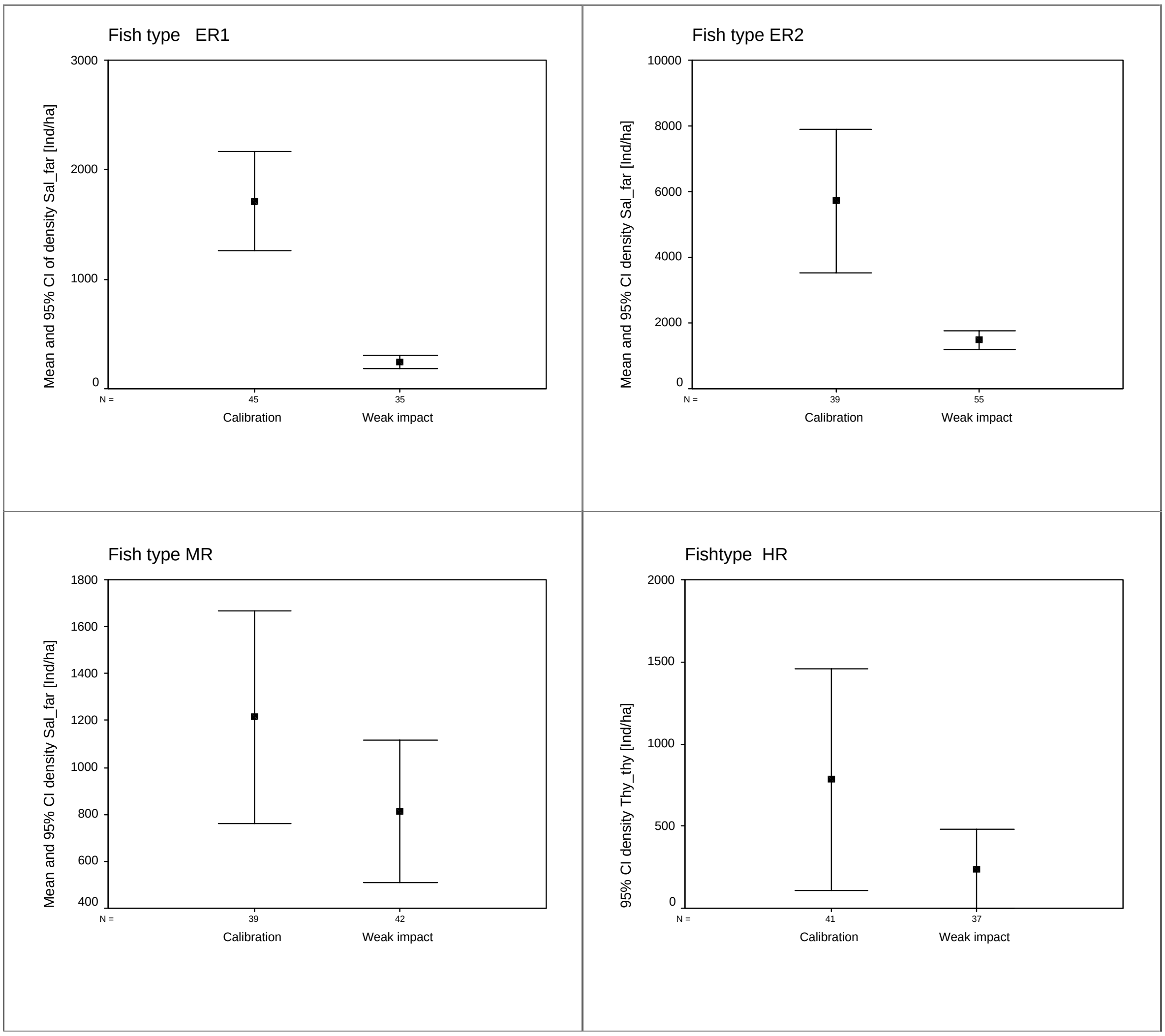


Figure xx: Mean and 95% CI of density for sentinel species

B) Biomass based procedure

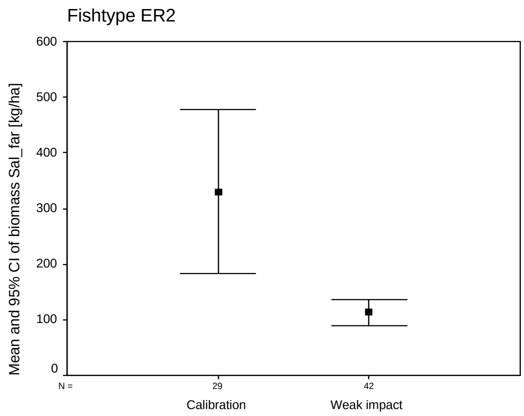
Biomass model does not fit for ER1, but for all other types it makes a significant improvement of impairment explanation (Table xx).

Table xx: Classification Results for model B)

Fishtype			Total impact 3 classes	Predicted Group Membership		Total
				Calibration	Weak impact	
ER1	Original	Count	Calibration	44	7	51
			Weak impact	13	9	22
		%	Calibration	86,3	13,7	100,0
			Weak impact	59,1	40,9	100,0
ER2	Original	Count	Calibration	14	8	22
			Weak impact	15	34	49
		%	Calibration	63,6	36,4	100,0
			Weak impact	30,6	69,4	100,0
MR	Original	Count	Calibration	17	13	30
			Weak impact	5	38	43
		%	Calibration	56,7	43,3	100,0
			Weak impact	11,6	88,4	100,0
HR	Original	Count	Calibration	16	1	17
			Weak impact	11	22	33
		%	Calibration	94,1	5,9	100,0
			Weak impact	33,3	66,7	100,0

a For split file T_ECO8=ER1, 72,6% of original grouped cases correctly classified.
b For split file T_ECO8=ER2, 67,6% of original grouped cases correctly classified.
c For split file T_ECO8=MR, 75,3% of original grouped cases correctly classified.
d For split file T_ECO8=HR, 76,0% of original grouped cases correctly classified.

Variables in the analysis: biom_sp_sentinel_Sal_far, biom_sp_sentinel_Thy_thy, kg_ha_Lon_sl, kg_ha_Lon_sl, kgha_run1_intol, perc_kgha_Mi_potad, perc_kgha_Hab_wc



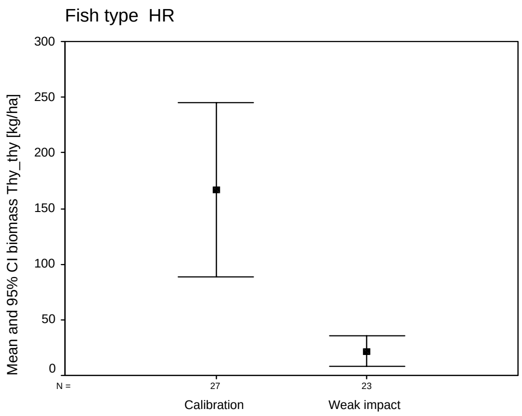


Figure xx: Mean and 95% CI of biomass for sentinel species

Screening of potential metrics

Table xx: N species based metrics with significant correlation corresponding to impact variable (impact total 3 classes).

VAR_Spearman's rho	ER1	ER2	MR	HR
N_species_all				
N_sp_native				
n_sp_ Fe_pisc				
n_sp_Fe_insev			y	
n_sp_Fe_omni				
n_sp_Hab_b				
n_sp_Hab_li				
n_sp_Hab_rh				
n_sp_Hab_wc		x	x	
n_sp_Intol			y	
n_sp_Tol				
n_sp_Lon_ll				y
n_sp_Lon_sl				
n_sp_Mi_long				
n_sp_Mi_potad		x	X + y	
n_sp_Re_lith				
n_sp_Re_phyt				
perc_sp_ Fe_pisc				
perc_sp_Fe_insev				
perc_sp_Fe_omni				z
perc_sp_Hab_b			x	
perc_sp_Hab_eury				y
perc_sp_Hab_li				
perc_sp_Hab_rh				
perc_sp_Hab_wc			x	
perc_sp_Intol				
perc_sp_Lon_ll				
perc_sp_Lon_sl			X + z	X + y
perc_sp_Mi_long				
perc_sp_Mi_potad		X + y	X	Y
Perc_sp_native		y		y
perc_sp_Re_lith			y	
perc_sp_Re_phyt				
perc_sp_Tol				
precence_0plus_Sal_far		y	z	

X….spearman correlation >0.26
y….stepdisc procedure
z…discriminant procedure

Table xx: Density based metrics with significant correlation corresponding to impact variable (impact total 3 classes).

VAR_Spearman's rho	ER1	ER2	MR	HR
density_sp_alien		Z		y
density_sp_all	X + y + z			
density_sp_native	X	X		
density_sp_sentinel_Huc_huc				
density_sp_sentinel_Sal_far	X	X		
density_sp_sentinel_Thy_thy			Y + z	x
density_0plus_Sal_far		y		
density_0plus_Thy_thy				X
n ha tol				y
n_ha_ Fe_pisc				x
n_ha_Fe_insev	X	X + y + z		
n_ha_Fe_omni				
n_ha_Hab_b				
n_ha_Hab_rh	X			
n_ha_Hab_wc	X			
n_ha_Intol	X	X		
n_ha_Lon_ll			y	
n_ha_Mi_long				
n_ha_Mi_potad		X	X + y + z	
n_ha_Re_lith	X	X		
perc_0plus_Sal_far				
perc_0plus_Thy_thy				x
perc_nha_ Fe_pisc				x
perc_nha_Fe_insev				
perc_nha_Fe_omni				z
perc_nha_Hab_b				
perc_nha_Hab_wc				
perc_nha_Intol				
perc_nha_Lon_sl			y	
perc_nha_Mi_long				
perc_nha_Mi_potad		x		z
perc_nha_Tol				

X….spearman correlation >0.26
y….stepdisc procedure
z…discriminant procedure

Table xx: Biomass based metrics with significant correlation corresponding to impact variable (impact total 3 classes).

#	Spearman's rho	ER1	ER2	MR	HR
1	biom_run1_alien				
2	**biom_run1_all**	y			
3	biom_run1_native				
4	Biom_sp_alien				
5	**Biom_sp_all**	y			
6	Biom_sp_native				
7	**biom_sp_sentinel_Sal_far**		x	y + Z	
8	**biom_sp_sentinel_Thy_thy**				x + y + z
9	kg_ha_Fe_insev				
10	**kg_ha_Fe_omni**	x			
11	kg_ha_Hab_rh		X	y	
12	**kg_ha_Hab_wc**	Y + Z	X		
13	**kg_ha_Intol**		X + Z		
14	kg_ha_Lon_ll				
15	**kg_ha_Lon_sl**				z
16	kg_ha_Mi_long				
17	**kg_ha_Mi_potad**				x
18	**kg_ha_Re_lith**			y	
19	kg_ha_Re_phyt				
20	kgha_run1_fe_insev				
21	**kgha_run1_fe_omni**	x			
22	kgha_run1_hab_rh				
23	**kgha_run1_hab_wc**	z			
24	**kgha_run1_intol**		X + Z	Z	
25	kgha_run1_lon_ll				
26	kgha_run1_mi_long				
27	kgha_run1_mi_potad				
28	kgha_run1_re_lith				
29	kgha_run1_re_phyt				
30	**perc_kgha_Fe_omni**	x			
31	perc_kgha_Fe_pisc				
32	perc_kgha_Lon_ll				
33	perc_kgha_Lon_sl				
34	perc_kgha_Mi_long				
35	**perc_kgha_Mi_potad**	z	y	y + Z	z
36	perc_kgha_Re_phyt				
37	**perc_kgha_Hab_wc**			z	
38	**perc_kgha_Hab_b**			y	

X….spearman correlation >0.26
y….stepdisc procedure
a…discriminant procedure

Regression analysis

Statististical requirements (normal distribution, continuity) are not really fullfiled. In consideration of this procedure is renounced.

5 Conclusions

Fish types ER1 and ER2:

Density based metrics fulfill our demands. This fish type is dominated by brown trout and therefore the density of this species would be the best metric. Biomass based metrics work, but do not advance the model in a significant way. It is also clear that all N species based metrics are not sensible.

Fish type MR:

This type between ER and HR is sensitive for metrics from both. Where as some N species based metrics start to explain. Biomass based metrics also do not advance the model.

Fish type HR:

Density and biomass of grayling the indicator species of this region are enough to explain degraded conditions in a significant way

6 Annex

Table xx: Alpine species and guild classification

#	Species	Tolerance	Habitat_feeding	Habitat_rheo	Reproduction	Feeding	Migration	Longevity
1	Abramis brama	TOLE	B	EURY		OMNI	POTAD	LL
2	Alburnoides bipunctatus	INTOL	WC	RH	LITH	INSV		SL
3	Alburnus alburnus	TOLE	WC	EURY		OMNI		SL
4	Anguilla anguilla	TOLE	B	EURY			LONG	
5	Barbatula barbatula		B	RH	LITH			
6	Barbus barbus		B	RH	LITH		POTAD	LL
7	Barbus meridionalis		B	RH	LITH	INSV	POTAD	
8	Carassius carassius	TOLE	B	LI	PHYT	OMNI		
9	Chondrostoma nasus		B	RH	LITH		POTAD	
10	Chondrostoma toxostoma	INTOL	B	RH	LITH	OMNI	POTAD	
11	Cobitis taenia		B	EURY	PHYT			SL
12	Coregonus sp.							
13	Cottus gobio	INTOL	B	RH	LITH	INSV		SL
14	Cyprinus carpio	TOLE	B	EURY	PHYT	OMNI		LL
15	Esox lucius		WC	EURY	PHYT	PISC		LL
16	Eudontomyaon mariae	INTOL	B	RH	LITH		POTAD	
17	Gasterosteus aculeatus	TOLE	WC	EURY		OMNI		SL
18	Gobio gobio		B	RH				SL
19	Gymnocephalus cernuus		B	EURY				
20	Hucho hucho	INTOL	WC	RH	LITH	PISC	POTAD	
21	Hybrid							
22	Lampetra planeri	INTOL	B	RH	LITH		POTAD	
23	Lepomis gibbosus	TOLE	WC	LI		INSV		SL
24	Leuciscus cephalus		WC	RH	LITH	OMNI	POTAD	LL
25	Leuciscus idus		WC	RH		OMNI	POTAD	
26	Leuciscus leuciscus		WC	RH	LITH	OMNI		LL
27	Leuciscus souffia	INTOL	WC	RH	LITH			
28	Lota lota		B	EURY	LITH	PISC	POTAD	LL
29	No fish							
30	Oncorhynchus mykiss		WC	RH	LITH		POTAD	
31	Perca fluviatilis	TOLE	WC	EURY				
32	Phoxinus phoxinus		WC	RH	LITH			SL
33	Pseudorasbora parva	TOLE	WC	LI		OMNI		SL
34	Pungitius pungitius	TOLE	WC	LI		OMNI		SL
35	Rhodeus sericeus	INTOL	WC	LI				SL
36	Rutilus frisii		WC	RH	LITH			
37	Rutilus rutilus	TOLE	WC	EURY		OMNI		
38	Salmo trutta fario	INTOL	WC	RH	LITH	INSV		
39	Salmo trutta lacustris	INTOL	WC	LI	LITH	INSV	POTAD	
40	Salvelinus alpinus	INTOL	WC	LI	LITH			LL
41	Salvelinus fontinalis	INTOL	WC	RH	LITH	INSV		
42	Sander lucioperca		WC	EURY		PISC		LL
43	Scardinius erythrophthalmus		WC	LI	PHYT	OMNI		
44	Silurus glanis		B	EURY	PHYT	PISC		LL
45	Thymallus thymallus	INTOL	WC	RH	LITH	INSV	POTAD	
46	Tinca tinca	TOLE	B	LI	PHYT	OMNI		LL
47	Aingel streber	INTOL	B	RH	LITH			

Table xx: Overview metrics and their codes

Guild	Selection	ID	Metric	Code in Metrics_temp
Overall Composition	All species	**1**	N all species	N_sp_all
	Native species	**2** **3**	N native species % native species	N_sp_native Perc_sp_native
Abundance	All species	**4** **5** **6**	Density (n/ha) Biomass (kg/ha) Biomass 1. run (kg/ha)	Density_sp_all Biom_sp_all Biom_run1_all
	Native species	**7** **8** **9**	Density (n/ha) Biomass (kg/ha) Biomass 1. run (kg/ha)	Density_sp_native Biom_sp_native Biom_run1_native
	Alien species	**10** **11** **12**	Density (n/ha) Biomass (kg/ha) Biomass 1. run (kg/ha)	Density_sp_alien Biom_sp_alien Biom_run1_alien
Native species (Alien species, All species)				
Tolerance	Intolerant	**13** **14** **15** **16** **17** **18** **19**	Species % species of N native Individuals (n/ha) % individuals of Density Biomass (kg/ha) % biomass of Biomass Biomass 1. run (kg/ha)	n_sp_Intol perc_sp_Intol n_ha_Intol perc_nha_Intol kg_ha_Intol perc_kgha_Intol kgha_run1_Intol
	Tolerant	**20** **21** **22** **23** **24** **25** **26**	Species % species of N native Individuals (n/ha) % individuals of Density Biomass (kg/ha) % biomass of Biomass Biomass 1. run (kg/ha)	n_sp_Tol perc_sp_Tol n_ha_Tol perc_nha_Tol kg_ha_Tol perc_kgha_Tol kgha_run1_Tol
Habitat	Water Column	**27** **28** **29** **30** **31** **32** **33**	Species % species of N native Individuals (n/ha) % individuals of Density Biomass (kg/ha) % biomass of Biomass Biomass 1. run (kg/ha)	n_sp_Hab_wc perc_sp_Hab_wc n_ha_Hab_wc perc_nha_Hab_wc kg_ha_Hab_wc perc_kgha_Hab_wc kgha_run1_Hab_wc
	Benthic	**34** **35** **36** **37** **38** **39** **40**	Species % species of N native Individuals (n/ha) % individuals of Density Biomass (kg/ha) % biomass of Biomass Biomass 1. run (kg/ha)	n_sp_Hab_b perc_sp_Hab_b n_ha_Hab_b perc_nha_Hab_b kg_ha_Hab_b perc_kgha_Hab_b kgha_run1_Hab_b
	Rheophilic	**41** **42** **43** **44** **45** **47** **48**	Species % species of N native Individuals (n/ha) % individuals of Density Biomass (kg/ha) % biomass of Biomass Biomass 1. run (kg/ha)	n_sp_Hab_rh perc_sp_Hab_rh n_ha_Hab_rh perc_nha_Hab_rh kg_ha_Hab_rh perc_kgha_Hab_rh kgha_run1_Hab_rh
	Limnophilic	**49** **50** **51** **52** **53** **54** **55**	Species % species of N native Individuals (n/ha) % individuals of Density Biomass (kg/ha) % biomass of Biomass Biomass 1. run (kg/ha)	n_sp_Hab_li perc_sp_Hab_li n_ha_Hab_li perc_nha_Hab_li kg_ha_Hab_li perc_kgha_Hab_li kgha_run1_Hab_li
	Eurytopic	**56** **57** **58** **59** **60** **61** **62**	Species % species of N native Individuals (n/ha) % individuals of Density Biomass (kg/ha) % biomass of Biomass Biomass 1. run (kg/ha)	n_sp_Hab_eury perc_sp_Hab_eury n_ha_Hab_eury perc_nha_Hab_eury kg_ha_Hab_eury perc_kgha_Hab_eury kgha_run1_Hab_eury

Repro-duction	Lithophilic	**63**	Species	n_sp_Re_lith
		64	% species of N native	perc_sp_Re_lith
		65	Individuals (n/ha)	n_ha_Re_lith
		66	% individuals of Density	perc_nha_Re_lith
		67	Biomass (kg/ha)	kg_ha_Re_lith
		68	% biomass of Biomass	perc_kgha_Re_lith
		69	Biomass 1. run (kg/ha)	kgha_run1_Re_lith
	Phytophilic	**70**	Species	n_sp_Re_phyt
		71	% species of N native	perc_sp_Re_phyt
		72	Individuals (n/ha)	n_ha_Re_phyt
		73	% individuals of Density	perc_nha_Re_phyt
		74	Biomass (kg/ha)	kg_ha_Re_phyt
		75	% biomass of Biomass	perc_kgha_Re_phyt
		76	Biomass 1. run (kg/ha)	kgha_run1__Re_phyt
Longevity	Long lived	**77**	Species	n_sp_Lon_ll
		78	% species of N native	perc_sp_Lon_ll
		79	Individuals (n/ha)	n_ha_Lon_ll
		80	% individuals of Density	perc_nha_Lon_ll
		81	Biomass (kg/ha)	kg_ha_Lon_ll
		82	% biomass of Biomass	perc_kgha_Lon_ll
		83	Biomass 1. run (kg/ha)	kgha_run1_Lon_ll
	Short lived	**84**	Species	n_sp_Lon_sl
		85	% species of N native	perc_sp_Lon_sl
		86	Individuals (n/ha)	n_ha_Lon_sl
		87	% individuals of Density	perc_nha_Lon_sl
		88	Biomass (kg/ha)	kg_ha_Lon_sl
		89	% biomass of Biomass	perc_kgha_Lon_sl
		90	Biomass 1. run (kg/ha)	kgha_run1_Lon_sl
Feeding	Piscivorous	**91**	Species	n_sp_ Fe_pisc
		92	% species of N native	perc_sp_ Fe_pisc
		93	Individuals (n/ha)	n_ha_ Fe_pisc
		94	% individuals of Density	perc_nha_ Fe_pisc
		95	Biomass (kg/ha)	kg_ha_ Fe_pisc
		96	% biomass of Biomass	perc_kgha_Fe_pisc
		97	Biomass 1. run (kg/ha)	kgha_run1_Fe_pisc
	Insectivorous/ Invertivorous	**98**	Species	n_sp_Fe_insev
		99	% species of N native	perc_sp_Fe_insev
		100	Individuals (n/ha)	n_ha_Fe_insev
		101	% individuals of Density	perc_nha_Fe_insev
		102	Biomass (kg/ha)	kg_ha_Fe_insev
		103	% biomass of Biomass	perc_kgha_Fe_insev
		104	Biomass 1. run (kg/ha)	kgha_run1_Fe_insev
	Omnivorous	**107**	Species	n_sp_Fe_omni
		108	% species of N native	perc_sp_Fe_omni
		109	Individuals (n/ha)	n_ha_Fe_omni
		110	% individuals of Density	perc_nha_Fe_omni
		111	Biomass (kg/ha)	kg_ha_Fe_omni
		112	% biomass of Biomass	perc_kgha_Fe_omni
		113	Biomass 1. run (kg/ha)	kgha_run1_Fe_omni
Migration	Long distance	**116**	Species	n_sp_Mi_long
		117	% species of N native	perc_sp_Mi_long
		118	Individuals (n/ha)	n_ha_Mi_long
		119	% individuals of Density	perc_nha_Mi_long
		120	Biomass (kg/ha)	kg_ha_Mi_long
		121	% biomass of Biomass	perc_kgha_Mi_long
		122	Biomass 1. run (kg/ha)	kgha_run1_Mi_long
	Potamodrom	**123**	Species	n_sp_Mi_potad
		124	% species of N native	perc_sp_Mi_potad
		125	Individuals (n/ha)	n_ha_Mi_potad
		126	% individuals of Density	perc_nha_Mi_potad
		127	Biomass (kg/ha)	kg_ha_Mi_potad
		128	% biomass of Biomass	perc_kgha_Mi_potad
		129	Biomass 1. run (kg/ha)	kgha_run1_Mi_potad
Historical metrics – Status scale class >0				
	Per F. occasion	**130**	N historical Species	N_sp_hist
		131	% native of historical Sp.	Perc_sp_hist
Tolerance	Intolerant	**132**	% historical species of N native species	Perc_histsp_Intol
	Tolerant	**133**		Perc_histsp_Tol

Habitat	Water Column Benthic Rheophilic Limnophilic Eurytopic	**134** **135** **136** **137** **138**		Perc_histsp_Hab_wc Perc_histsp_Hab_b Perc_histsp_Hab_rh Perc_histsp_Hab_li Perc_histsp_Hab_eury
Repro- duction	Lithophilic Phytophilic	**139** **140**		Perc_histsp_Re_lith Perc_histsp_Re_phyt
Longevity	Long lived Short lived	**141** **142**		Perc_histsp_Lon_ll Perc_histsp_Lon_sl
Feeding	Piscivorous Insectivorous Omnivorous	**143** **144** **145**		Perc_histsp_Fe_pisc Perc_histsp_Fe_insev Perc_histsp_Fe_omni
Migration	Long distance Potamodrom	**146** **147**		Perc_histsp_Mi_long Perc_histsp_Mi_potad
Historical metrics – Status scale class = 7				
	Per F. occasion	**148**	N historical Species.	N_sp_hist_7
45 Sentinel Species				
Abundance	Abramis brama	**149** **150**	Density Abr_bra (n/ha), Biomass Abr_bra (kg/ha)	Density_sp_sentinel_Abr_bra Biom_sp_sentinel_Abr_bra
Age-length structure	Abramis brama	**151** **152** **153**	presence 0+ (0,1) Density 0+ (n/ha) % of 0+	Presence_0plus_Abr_bra Density_0plus_Abr_bra Perc_0plus_Abr_bra
Abundance	Alburnoides bipunctatus	**154** **155**	Density Alb_bip (n/ha), Biomass Abr_bip (kg/ha)	**etc.**
Age-length structure	Alburnoides bipunctatus	**156** **157** **158**	presence 0+ (0,1) Density 0+ (n/ha) % of 0+	**etc.**
Abundance	Aspius aspius	**etc.**	**etc.**	
Age-length structure	Aspius aspius	**etc.**	**etc.**	

FAME WP6/7 SPATIAL APPROACH

ALPS/ECOREGION 4

RIVER AND FISH COMMUNITY TYPOLOGY

A. Melcher, S. Schmutz & G. Haidvogl

Typology report September 2003

1 Introduction

Austrian attempts to typify rivers go back more than a decade (Moog & Wimmer). Nation-wide classifications of Austrian rivers are available in terms of stream order (Wimmer & Moog 1994), flow regime (Mader et al. 1996), ecoregions (Moog et al. 2001, Schmidt-Kloiber et al. 2001) and landscape types (Fink et al. 2001).

In respect to the implementation of the WFD, the Austrian government decided to use System B of Annex II of the WFD as the basis for developing the Austrian river typology. The following procedure was set up:

· First step abiotic classification

· Second step biotic validation

· Third step Final definition of river types

The process of developing an Austrian river typology suitable for the WFD is still ongoing. For the first step, Wimmer et al. (2000) developed a pre-classification of Austrian rivers based on landscape types (Fink et al. 2001), altitude (class boundaries: 200, 500, 800, 1500 m), ecoregion (Illies 1978, adapted by Moog et al. 2001), as well as on geology and flow regime (Mader et al. 1996), yielding 17 “type-regions” and 9 additional special types (“large rivers”), for a total of 26 “basic types”.

Typologies for phytobenthos, benthic macroinvertebrates and fish are currently being developed.

2 The FIDES Database as Tool for the Analyses of River Types

Number and geographic distribution of sites and fishing occasions

The analyses of river types are based on the dataset from the Fish Database of European Streams (FIDES), a Europe-wide database of the FAME projekt. The whole database comprises sampling sites from 12 different countries and 18 ecoregions (according to the system of Illies, 1978; Tab 1).

Table 1: Countries and ecoregions participating in FIDES.

Eco_region_no	Ecoregion name	Participating country
1	Iberian Penisula	Portugal, Spain
2	Pyrenees	France, Spain
3	Italy	Italy
4	Alps	Austria, France, Germany
5	Dinaric Western Balkan	Austria
6	Helenic Western Balkan	Greece
8	Western Highlands	Germany, France, Belgium/Wallonia
9	Central Highlands	Germany, Austria, Poland
10	The Carpathians	Poland
11	Hungarian Lowlands	Austria
13	Western Plains	France, Belgium,/Flanders and Wallonia, The Netherlands
14	Central Plains	The Netherlands, Germany, Sweden, Poland
15	Baltic Province	Lithuania, Poland
16	Eastern Plains	Poland
18	Great Britain	United Kingdom
20	Borealic Uplands	Sweden
22	Fenno-Scandian Shield	Sweden

In a first step river types were established on a national scale. In a second step the analyses were carried out on an ecoregional level. This report focuses on ecoregion 4, Alps. Ecoregion 4 covers areas in France, Italy, Austria, Switzerland, Liechtenstein, Germany, and Slovenia. Important alpine countries, such as Italy and Switzerland, are not participating in the FAME project. Therefore the description of river types is based on data from Austria, France and Germany only (Tab. 2).

However, it has to be stressed that there is no even spatial distribution of sites and fishing occasions in these 3 countries (Fig. 1): Nearly 90% of the FIDES sites of ecoregion 4 are situated in Austria, the eastern part of the Alps.

The uneven distribution becomes also evident when looking at the distribution of Main River Regions: For ecoregion 4 FIDES contains data from 206 rivers in 4 main river regions (MRR). About 90% of the sites belong to the MRR of the Danube, which is the most eastern one (Tab. 2).

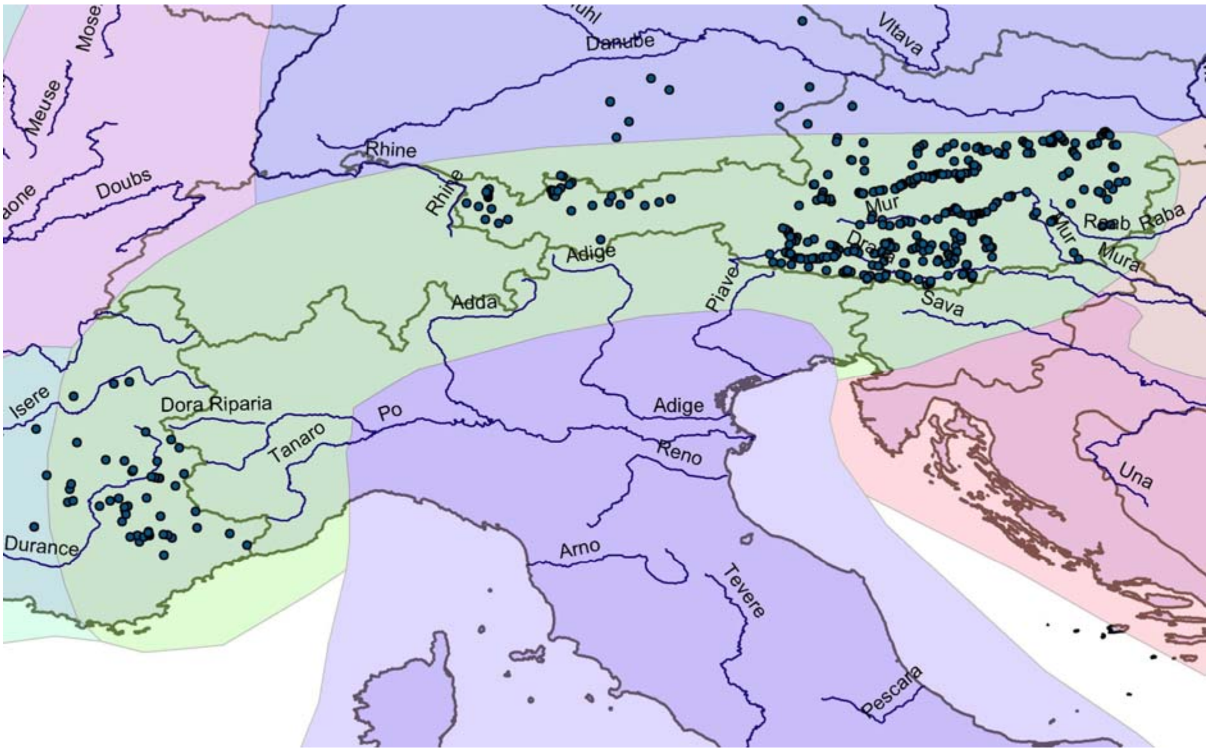


Figure 1: Sitemap – representativeness of data

Table 2: Frequency of sites and fishing occasions per country and main river region (MRR)

Country	Fishing occasions		Sites	
	Frequency	Percent	Frequency	Percent
Austria	598	86	496	89
France	84	12	52	9
Germany	10	1	10	2
Total	692	100	558	100
MRR				
Danube	576	83	490	88
Rhone	73	11	45	8
Rhine	32	5	16	3
Mediterranean Sea	11	2	7	1
Total	692	100	558	100

Only one randomly selected fishing occasion per site were used for further analyses.

Abiotic description of sites

Sites were included from all the five catchment classes as defined by the FIDES manual, but more than 80% have a catchment lower than 100 km². Catchments < 10 km² are represented by 81 sites, <100 km^2 by 204 sites, <1000 km^2 by 173 sites, < 10 000 km^2 by 98 sites and > 10 000 km^2 by 2 sites. Approximately 80% of the sites have been classified as water source type "nival" the rest is pluvial influenced. The geology was classified to be calcareous at about 75 % and siliceous at about 25% of the sites.

The mean altitude of the sites is 676 m (sd 258). The mean air temperature is normally distributed (mean 6.92 °C, sd 1.26) and significantly higher in the western part of the alps (Fig. 3).

Alpine rivers are also characterized by a high gradient of slope (Fig. 3a).

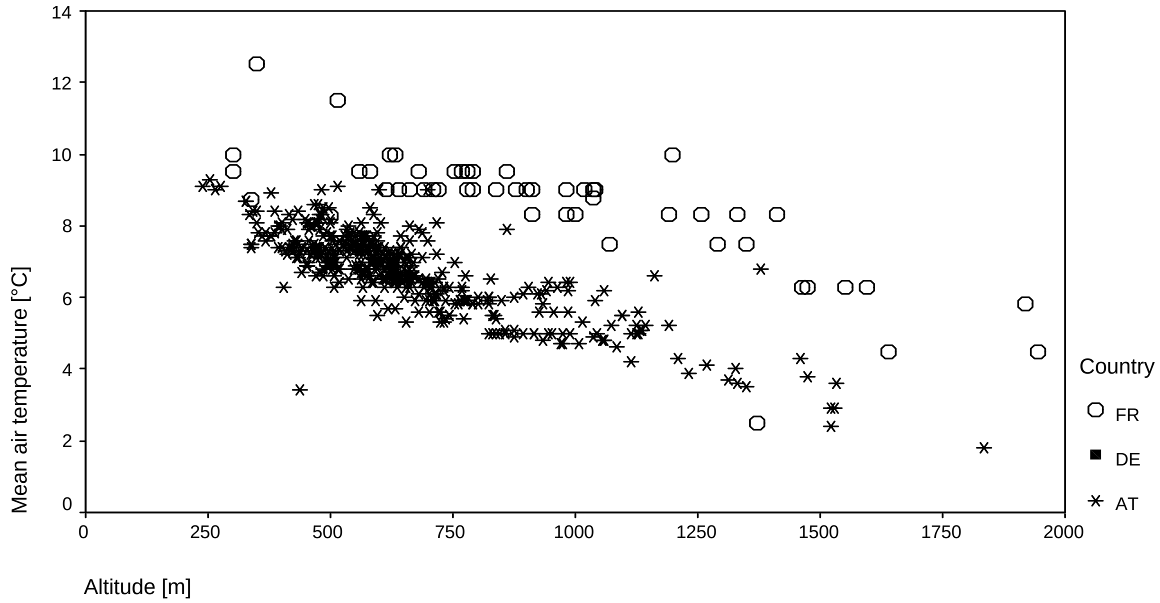


Figure 3: Scatter plot, altitude and mean air temperature (n=558 sites)

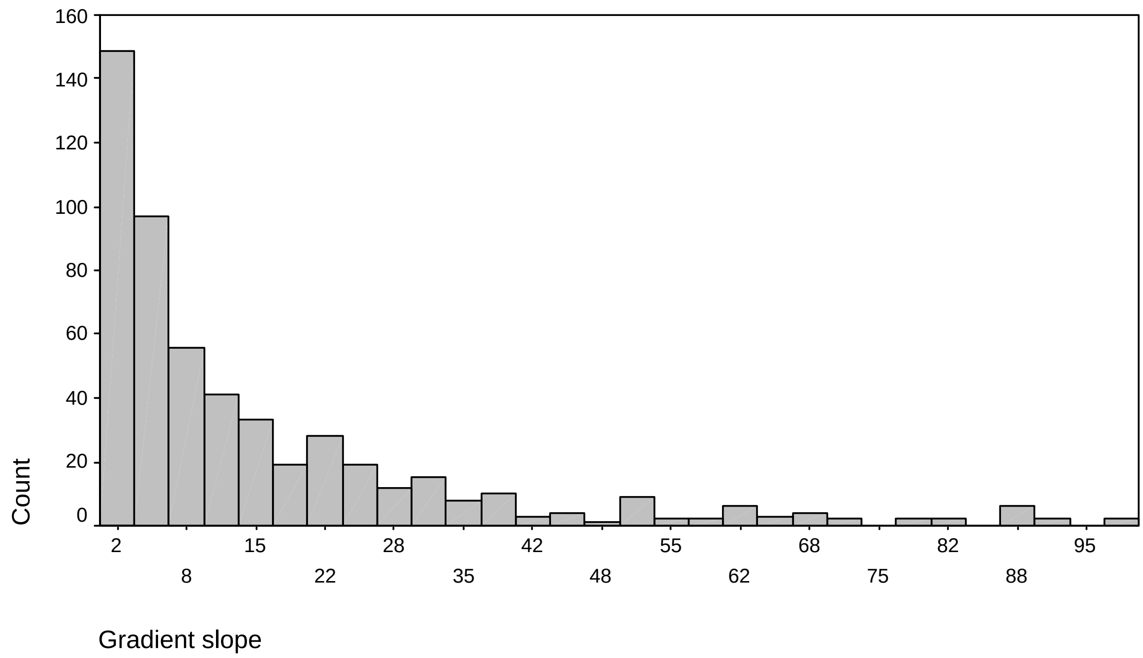


Figure 3a: Frequency of gradient slope (n=558 sites)

Seasonal and annual distribution of fishing occasions

FIDES includes currently fishing occasion data from the last 22 years. The oldest sampling is from 1980, but lot of sites were fished in the middle of the nineties.

More than 70% of the occasions were carried out in autumn (“Autumn” comprises data from August to November, “winter” from December to March and “spring” from April to July).

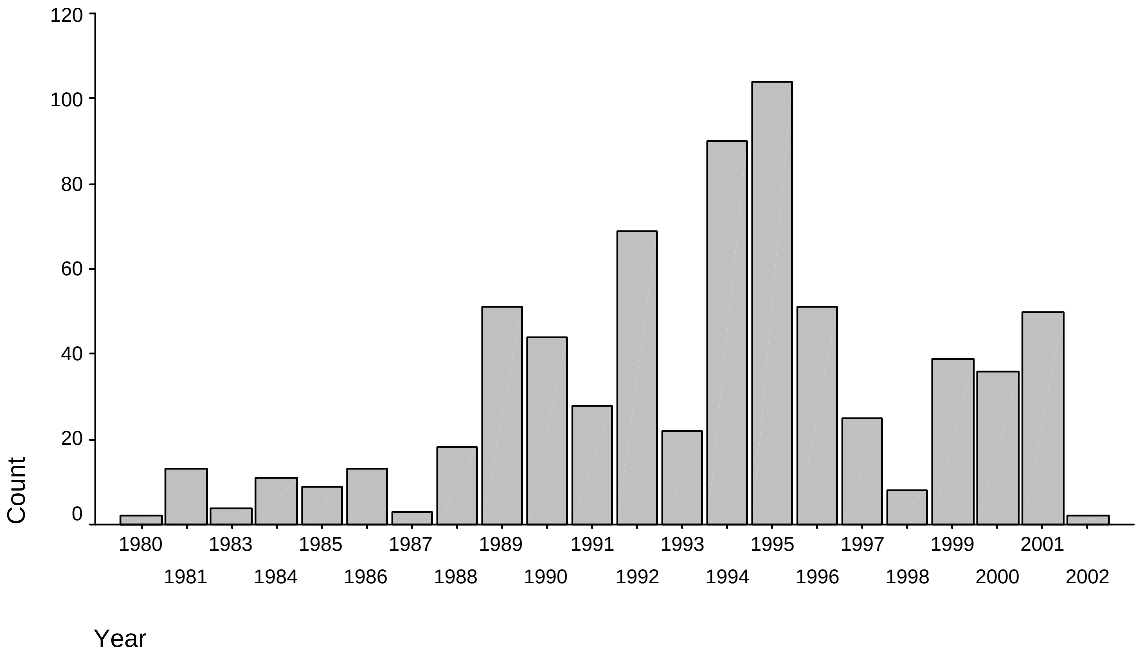


Figure 4: Annual distribution of fishing occasions (n=692)

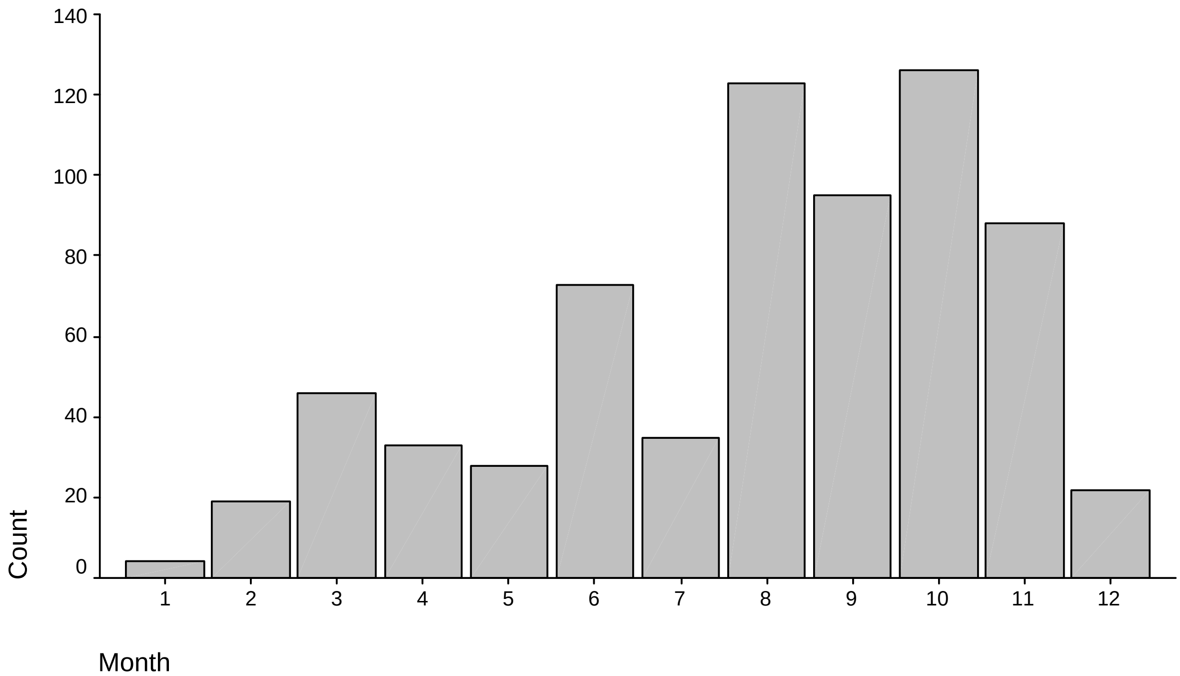


Figure 5: Monthly distribution of fishing occasions (n=692)

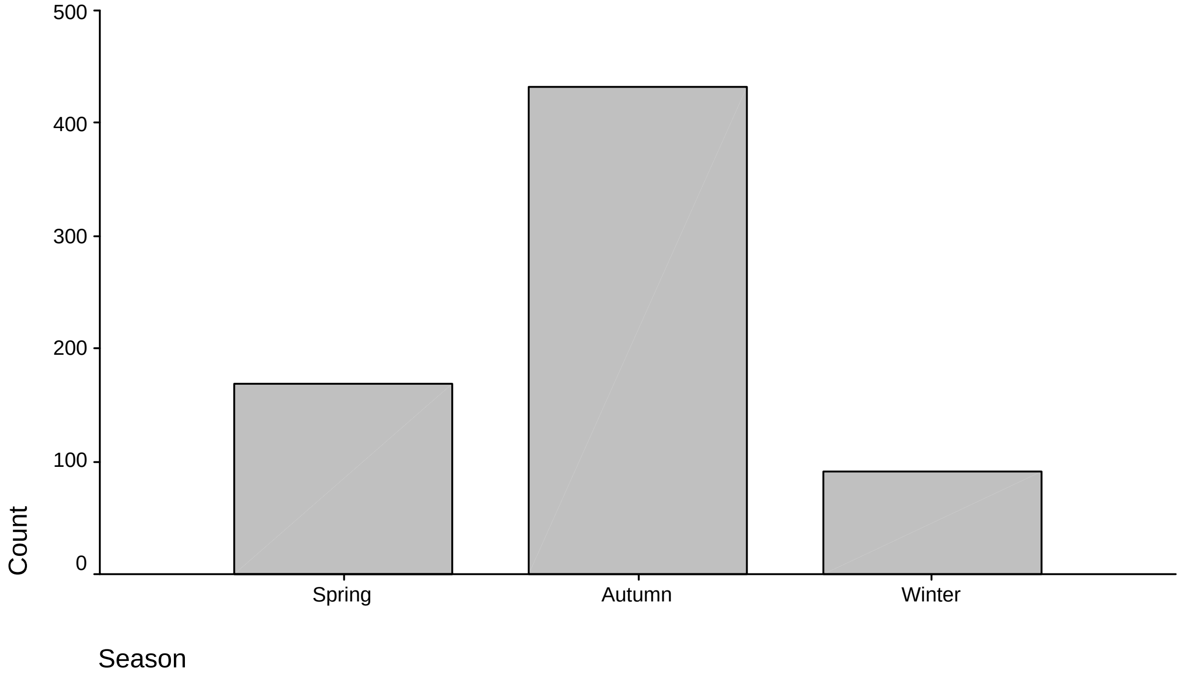


Figure 6: Seasonal distribution of fishing occasions (n=692)

Description of the fish fauna

All in all there are 45 alien and native fish species in the FIDES dataset for ER Alps. The classification of origin is for some species different: For example, grayling, a native species in the Danube MRR, is an alien in the MRR Mediterranean Sea (Tab. 3).

Table 3: Overview of alien and native species per MRR within the alps

	Species	Danube	Mediterranean Sea	Rhine	Rhone
1	Abramis brama	native	native	native	native
2	Alburnoides bipunctatus	native	alien	native	native
3	Alburnus alburnus	native	native	native	native
4	Anguilla anguilla	alien	native	native	native
5	Barbatula barbatula	native	native	native	native
6	Barbus barbus	native	alien	native	native
7	Barbus meridionalis		native		native
8	Carassius carassius	native	alien	native	alien
9	Chondrostoma nasus	native	alien	native	alien
10	Chondrostoma toxostoma		native		native
11	Cobitis taenia	native	native	native	native
12	Coregonus sp.				
13	Cottus gobio	native	native	native	native
14	Cyprinus carpio	native	alien	alien	alien
15	Esox lucius	native	alien	native	native
16	Eudontomyzon mariae	native			
17	Gasterosteus aculeatus	alien	native	native	native
18	Gobio gobio	native	native	native	native
19	Gymnocephalus cernuus	native	alien	native	alien
20	Hucho hucho	native			
21	Lampetra planeri	native	native	native	native
22	Lepomis gibbosus	alien	alien	alien	alien
23	Leuciscus cephalus	native	native	native	native
24	Leuciscus idus	native		native	
25	Leuciscus leuciscus	native	native	native	native
26	Leuciscus souffia	native	native	native	native
27	Lota lota	native	alien	native	native
28	Oncorhynchus mykiss	alien	alien	alien	alien
29	Perca fluviatilis	native	native	native	native
30	Phoxinus phoxinus	native	native	native	native
31	Pseudorasbora parva	alien	alien	alien	alien
32	Pungitius pungitius	alien		native	native
33	Rhodeus sericeus	native	native	native	native
34	Rutilus frisii	native			
35	Rutilus rutilus	native	native	native	native
36	Salmo trutta fario	native	native	native	native
37	Salmo trutta lacustris	native		native	
38	Salvelinus alpinus	native	alien	native	native
39	Salvelinus fontinalis	alien	alien	alien	alien
40	Sander lucioperca	native	alien	alien	alien
41	Scardinius erythrophthalmus	native	native	native	native
42	Silurus glanis	native	alien	native	alien
43	Thymallus thymallus	native	alien	native	native
44	Tinca tinca	native	native	native	native
45	Zingel streber	native			

Out of the total number of 45 fish speices in ER 4 41 fish species occur in the Danube catchment (35native and 6 alien), 36 species in the “Mediterranean Sea” catchment (21 native and 15 alien), 38 species in the Rhine region (32 native and 6 alien) and 38 species in the Rhone region (28 native and 10 alien).

Due to the topography of the Alps, rhithral rivers with brown trout predominate (Fig. 7). The mean number of species occurring at each fishing occasion was 2.7 (sd 2,12, n=692) and site with the highest number contained 13 fish species (Fig. 8). One site in one Austrian river lacked species at all fishing occasions (Venter Ache).

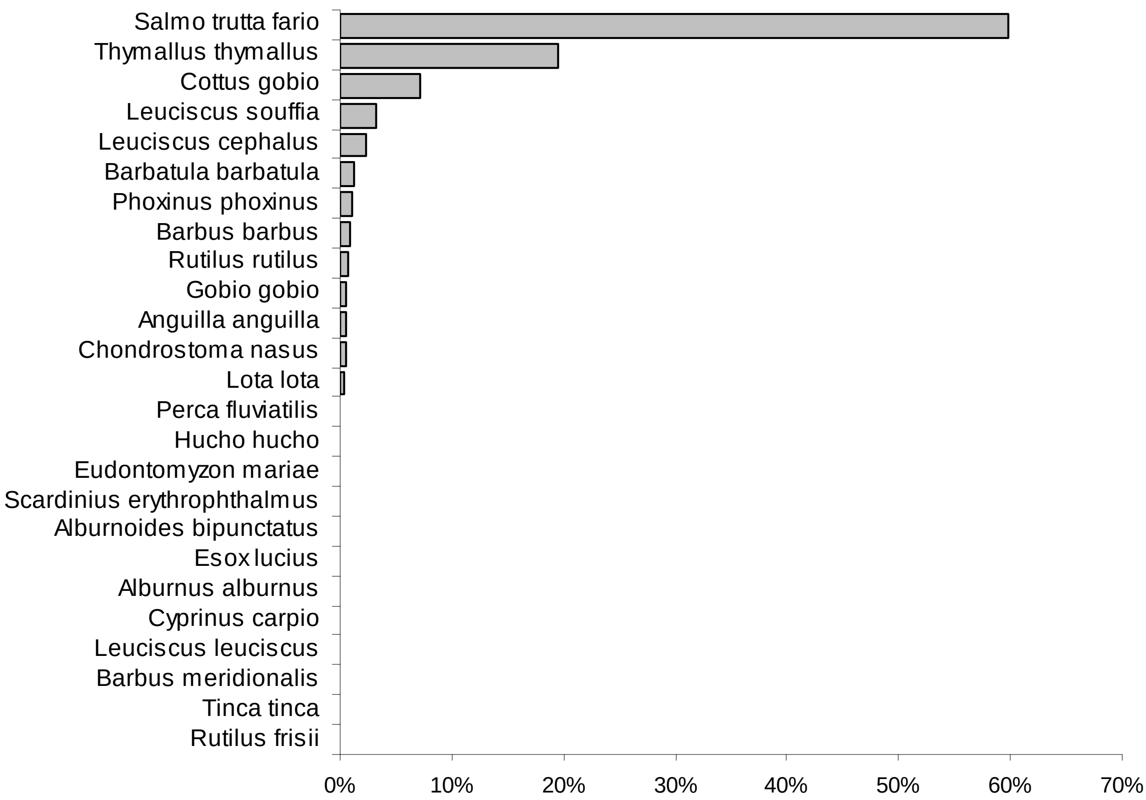


Figure 7: Relative occurence of native species per fishing occasion in the Alps based on FIDES

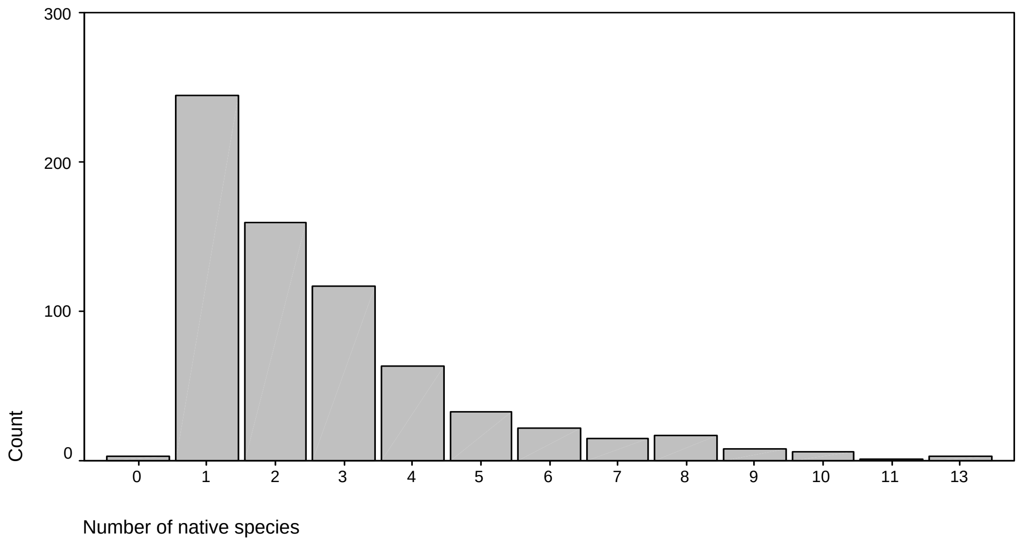


Figure 8: Frequency of number of occurring native fish species per fishing occasion in the Alps based on FIDES

Calibration dataset

The analyses of river types should in principle be based on reference sites only. Due to the very low number of reference sites in FIDES also sites have been selected where the impact status for 5 environmental key variables (hydrological regime, morphological condition, toxic acidification and nutrient enrichment, connectivity segment) was classified as 2. These sites form the so called "calibration dataset" which was the basis for the description of the river types. In the calibration dataset for the Alps also sites were included with classification of "connectivity segment" higher than 2 because it was possible to compensate this information through the historical distribution of migratory species (Tab. 4, Fig. 9).

Table 4: Cumulative number of fishing occasions (*without connectivity segment)

Impact class	1	<=2	<=3	<=4	<=5
1	32 / 50*				
2		274 / 377*			
3			424 / 561*		
4				514 / 644*	
5					692

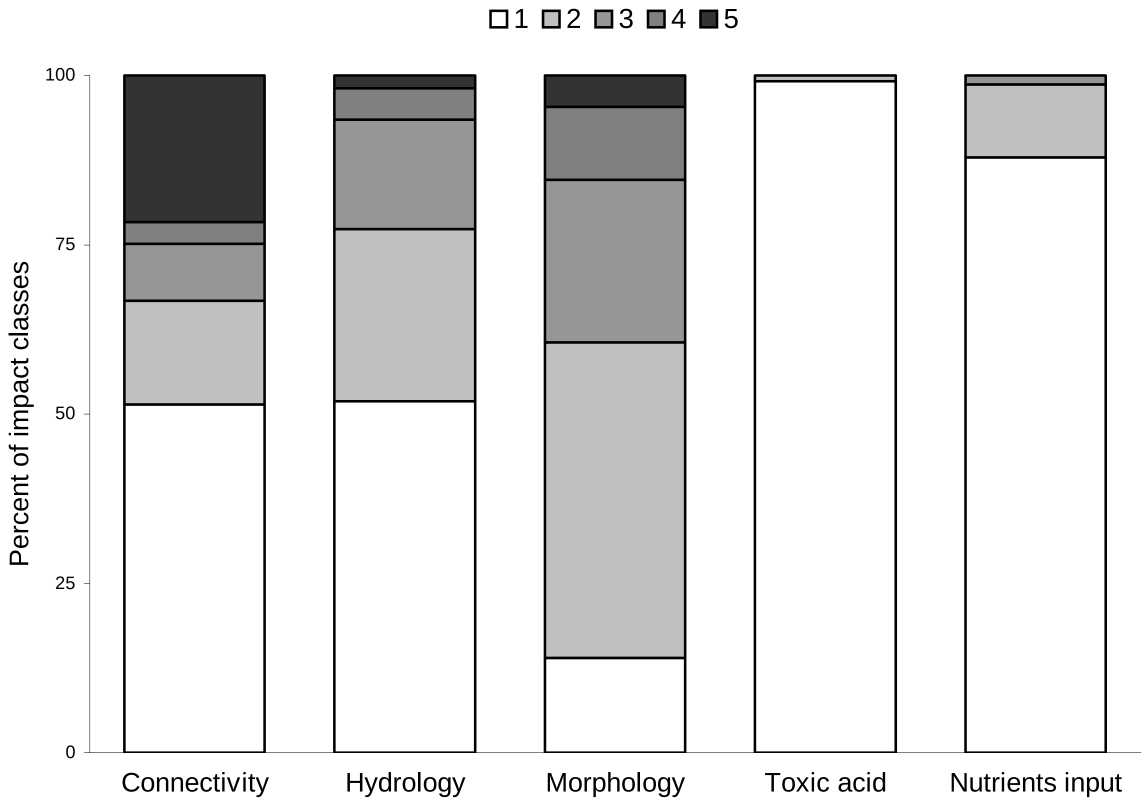


Figure 9: Distribution of 5 different impact variables per fishing occasion in the Alps based on FIDES

The calibration dataset for the Alps comprises 377 near-natural or only slightly impacted fishing occasions for the analysis. A random sample per site (n=558) of these 692 fishing occasions was taken (Fig. 10). These are 80 % of the fishing occasions.

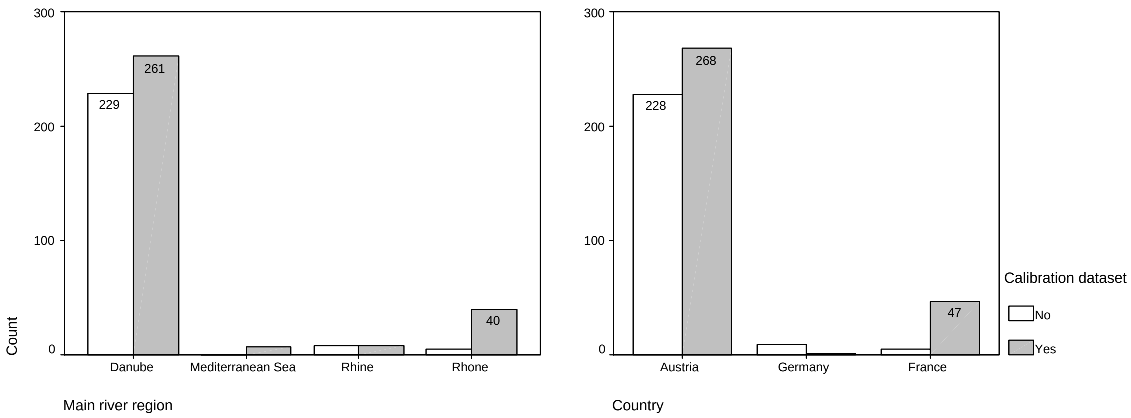


Figure 10: Frequency of sites per MRR and country in comparison to calibration dataset

3 Cluster analysis of actual data

This approach follows the fish region concept, yet is based on statistical analyses of fish data. First, fish samples are clustered into fish communities. Relative species abundance was used as input data for the cluster analysis. It was done by hierarchical-cluster-analysis method after Ward (distance measure –phi square), processed by SPSS© 11.5.

Basic types

On the first level 2 clusters (A and B) are figured out. Cluster A represents sites with a low number of species whereas cluster B is characterized by a higher species number. At the lowest step 9 community types could be distinguished (Fig 11).

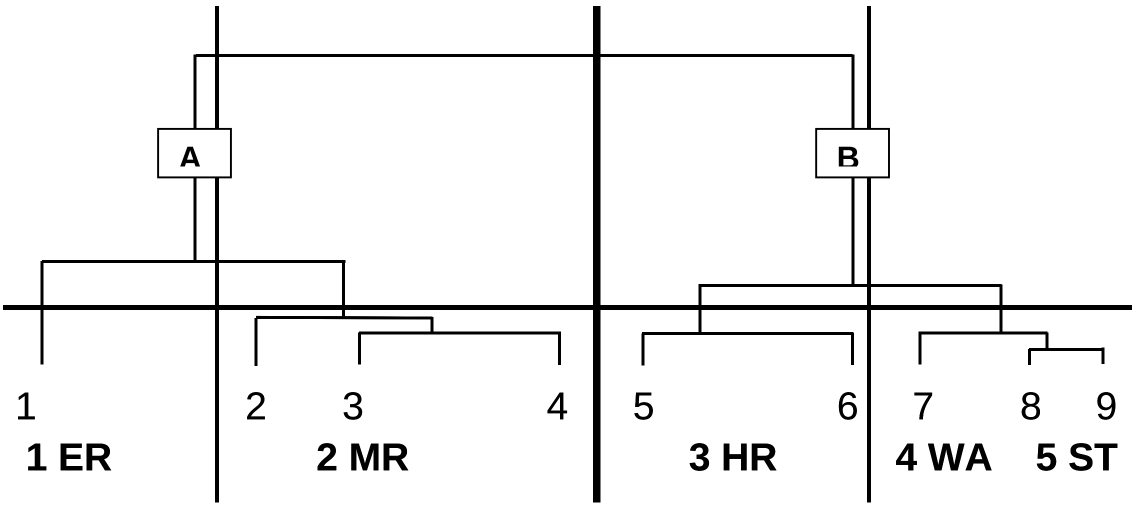


Figure 11: Cluster dendrogram of fish community types in the Alps based on FIDES (simplified)

Looking at the second level, 4 groups were separated: The first group was assigned to the epirhithral (ER), the second to the metarithral (MR), the third to the hyporhithral (HR). The last cluster was split into two types. One is only located in the western Alps (WA) and the other was named "special type" (ST) because of its very strong influence by lakes (outflow of lakes). Due to the low number of sites (Tab. 5) these two types are seperated only at the last level.

Table 5: Five basic fish community types, number of sites and fishing occasions

Fish type	Abbreviation	Fishing occassion		Site	
		Frequency	Percent	Frequency	Percent
Epirhithral	ER	202	54	177	56
Metarhithral	MR	98	26	76	24
Hyporhithral	HR	51	14	43	14
Rhithral western Alps	ST	13	3	11	4
Special type with lake influence	WA	13	3	9	3
	Total	377	100	316	100
No calibration data		315		242	
	Total	692		558	

The decision to divide at the second level and to apply five types was based on the analyses of the abiotic characteristics of the nine types. Several clusters of the last level showed no significant difference concerning wetted width or distance from source. Hence it was not possible to identify abiotic features for all these nine types by using discriminant analysis.

Differentiation of epirhithral types

In the next step the ER, where the highest proportion of sites, remained in the first analysis, was analyzed again. This type with mainly 2 species, is predominated by brown trout. Therefore biomass [kg/ha] and density [n/ha] was used for another cluster analyses (Ward, euklidian distance).

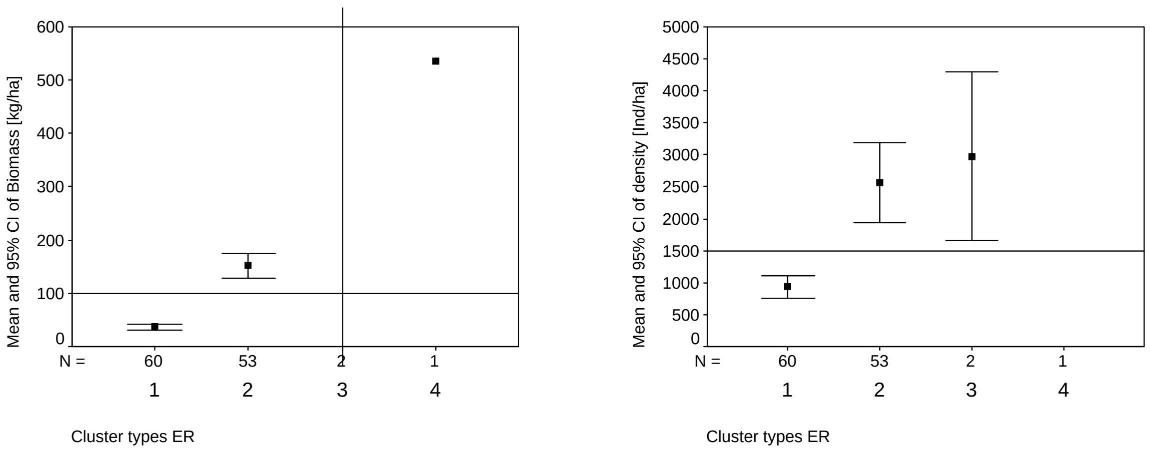


Figure 12: Mean value and 95% confidence interval (CI) of density and biomass of brown trout types

Clusteranalyses revealed 4 types. Type 1 is characterized by low biomass (< 100 kg/ha) and density (< 1500 Ind/ha) (Fig. 12). Type 3 and 4 not considered due to low number of sites. Two additional epirhithral types were figured out:

ER 1 - Epirhithral with a biomass below 100 kg/ha resp. 1500 Ind./ha

ER 2 - Epirhithral with a biomass more than 100 kg/ha resp. 1500 Ind./ha

4 Biotic description of fish-based types

Cluster analyses finally exhibit 6 fish types that in principle are organized along the longitudinal continuum of rivers as the fish region concept. Data mainly originate from the upper river regions, which results in a low number of native species per fish type (Fig. 13). ER 1 and 2 are characterised by only two species. The mean number of species increases up to seven (ST).

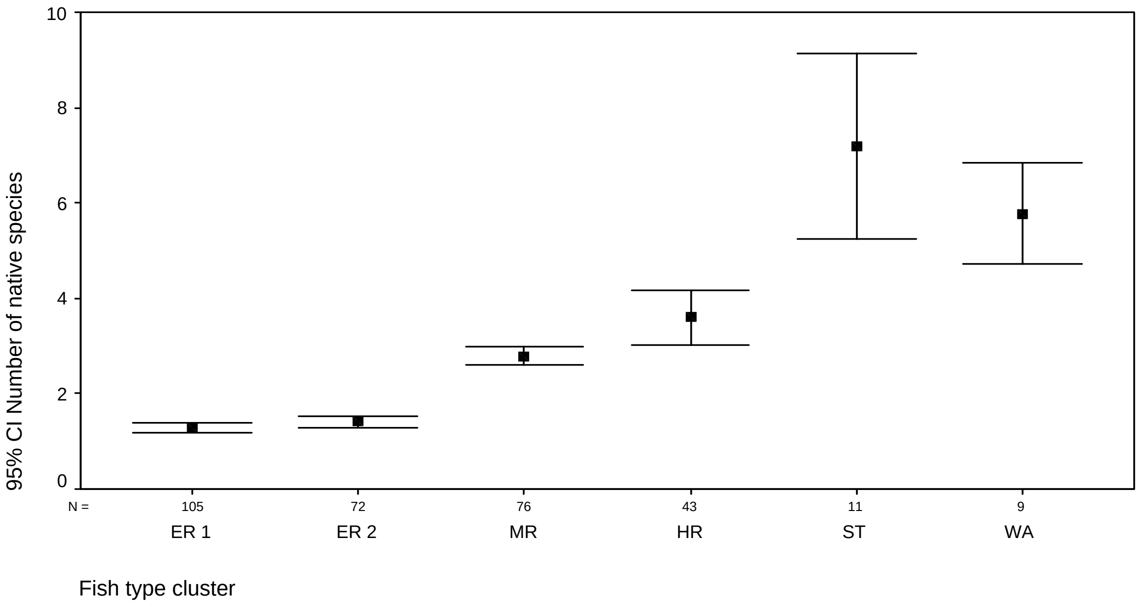


Figure 13: Mean value and 95% confidence interval (CI) of native species richness per fish type and site

The 6 main fish community types are described by the species composition and abundance in Table 6. Type one and two, ER1 (n=105 sites) and ER 2 (n=72 sites), are dominated by brown trout – they belong to the upper trout zone. The difference between these types can be found in biomass and abundance values as described above (Fig. 12).

Type 3 (MR, lower trout zone) is also dominated by brown trout but the number of species could increase up to five or six. In some sites grayling may occur (n=76 sites)

Type 4 (HR) belongs to the grayling zone. Grayling is the dominating species (n=43 sites).

Type 5 (ST) is characterized by the dominance of cyprinids and higher species density and the lack of salmonids (n=11 sites).

In type 6 (WA), *L. souffia* and *B. barbatula* are very abundant, but also *S. trutta fario* is present. This type seems to be typical for the western alps (n=9 sites).

Table 6: Mean percentage of species distribution per fish type and site.

N= 316	105	72	76	43	11	9
			Fish Type			
	ER 1	**ER 2**	**MR**	**HR**	**ST**	**WA**
Alburnoides bipunctatus				0,5%		0,1%
Alburnus alburnus					3,0%	
Anguilla anguilla			0,7%			
Barbatula barbatula			0,5%	0,8%		9,6%
Barbus barbus				0,5%		4,2%
Barbus meridionalis			0,2%			
Chondrostoma nasus				0,5%		
Chondrostoma toxostoma						0,1%
Cottus gobio	9,9%	6,7%	10,1%	8,0%		4,9%
Cyprinus carpio					4,3%	
Esox lucius				0,1%	12,1%	
Eudontomyzon mariae			0,1%	0,8%		
Gobio gobio				0,3%	4,9%	
Hucho hucho				1,6%		
Lampetra planeri			0,1%			
Leuciscus cephalus			1,0%	1,9%	19,0%	1,3%
Leuciscus leuciscus					0,3%	
Leuciscus souffia			0,2%			60,4%
Lota lota			0,3%	1,6%	1,1%	
Perca fluviatilis			0,3%		6,8%	
Phoxinus phoxinus			1,8%	0,1%		6,6%
Rhodeus sericeus					0,2%	
Rutilus rutilus			0,1%		30,2%	
Salmo trutta fario	90,1%	93,3%	76,4%	22,7%		12,8%
Salmo trutta lacustris				0,1%		
Scardinius erythrophthalmus					9,8%	
Silurus glanis					7,5%	
Thymallus thymallus			8,1%	60,4%		
Tinca tinca			0,1%		0,8%	
Zingel streber				0,1%		
Total	100%	100%	100%	100%	100%	100%

Table 7: Median 1 st run CPUE (n/ha) per native fish species in each group of the 6 types described by actual data.

	Fish Type					
	ER1	**ER2**	**MR**	**HR**	**ST**	**WA**
Abramis brama					8	
Alburnoides bipunctatus				174		21
Alburnus alburnus				8	36	
Anguilla anguilla			505	6		17
Barbatula barbatula			11	7		611
Barbus barbus			25	84		217
Barbus meridionalis			100			11
Carassius carassius				6		
Chondrostoma nasus				73		22
Chondrostoma toxostoma						21
Cottus gobio	213	147	84	24		125
Cyprinus carpio					150	
Esox lucius			17		75	
Eudontomyzon mariae			10	2		
Gobio gobio			157	108	720	
Hucho hucho				9		
Lampetra planeri			11			
Leuciscus cephalus			69	6	250	54
Leuciscus leuciscus					50	
Leuciscus souffia			46			1777
Lota lota			233	12	67	
Perca fluviatilis			266		67	
Phoxinus phoxinus			57			586
Pseudorasbora parva				12		
Rhodeus sericeus					17	
Rutilus rutilus			33		867	
Salmo trutta fario	617	2289	708	100		592
Salmo trutta lacustris			22	7		
Scardinius erythrophthalmus					167	
Silurus glanis					33	
Thymallus thymallus			74	250		
Tinca tinca			106	6	33	
Zingel streber				24		

S. trutta fario is the most common species in the alps. The probability of occurrence per site is in general very high. In all types, except “ST” the percentage is much more than 90%. The distribution of *C. gobio* is quite the same.

T. thymallus dominates the “HR”, and never occurs in the upper trout zones (Tab. 8).

Table 8: Percent occurrence of fish species (% of fishing occasions per type where the species is recorded).

	Fish Type					
	ER 1	**ER 2**	**MR**	**HR**	**ST**	**WA**
Abramis brama					7,7%	
Alburnoides bipunctatus				2,6%		14,3%
Alburnus alburnus				2,6%	30,8%	
Anguilla anguilla			2,2%			14,3%
Barbatula barbatula			7,6%	20,5%		71,4%
Barbus barbus			1,1%	2,6%		85,7%
Barbus meridionalis			3,3%			14,3%
Carassius carassius				2,6%		
Chondrostoma nasus				5,1%		
Chondrostoma toxostoma						14,3%
Cottus gobio	27,7%	40,3%	60,9%	59,0%		57,1%
Cyprinus carpio					61,5%	
Esox lucius			1,1%	5,1%	92,3%	
Eudontomyzon mariae			5,4%	12,8%		
Gobio gobio			2,2%	2,6%	15,4%	
Hucho hucho				33,3%		
Lampetra planeri			1,1%	10,3%		
Leuciscus cephalus			5,4%	23,1%	76,9%	71,4%
Leuciscus leuciscus					7,7%	
Leuciscus souffia			3,3%			100,0%
Lota lota			1,1%	15,4%	23,1%	
Perca fluviatilis			1,1%	2,6%	61,5%	
Phoxinus phoxinus			9,8%	2,6%		71,4%
Rhodeus sericeus					23,1%	
Rutilus rutilus			1,1%		69,2%	
Salmo trutta fario	100,0%	100,0%	98,9%	94,9%		100,0%
Salmo trutta lacustris			1,1%	2,6%		
Scardinius erythrophthalmus					61,5%	
Silurus glanis					53,8%	
Thymallus thymallus			73,9%	92,3%		
Tinca tinca			1,1%	2,6%	53,8%	
Zingel streber				2,6%		

Table 9: Summary of fish community types in the Alps based on FIDES calibration data

Fish Type		**Total number of species per type > 1 %**	**Dominant fish species**
ER 1	Epirhithral high	2	Salmo trutta fario
ER 2	Epirhithral low	2	Salmo trutta fario
MR	Metarhithral	5	Salmo trutta fario
HR	Hyporhithral	6	Thymallus thymallus
ST	Sp. type lake influence	10	Rutilus rutilus
WA	Rhithral western Alps	7	Leuciscus souffia

5 Abiotic description of fish-based types

Types ER1 and ER2, the two types dominated by brown trout were mainly characterised by the highest altitude and gradient (Fig. 14 and 16) and the lowest July air temperatures, whilst the HR shows the lowest gradient. The French type from the western alps (WA) on the other hand has the highest mean air temperature with 9,5°C (Fig. 15).

Type HR differed both in distance from source and wetted width from types ER1, ER 2 and MR showing the highest distance and wetted width.

Type ST is located very close to lakes, this is shown by the lowest distances to source.

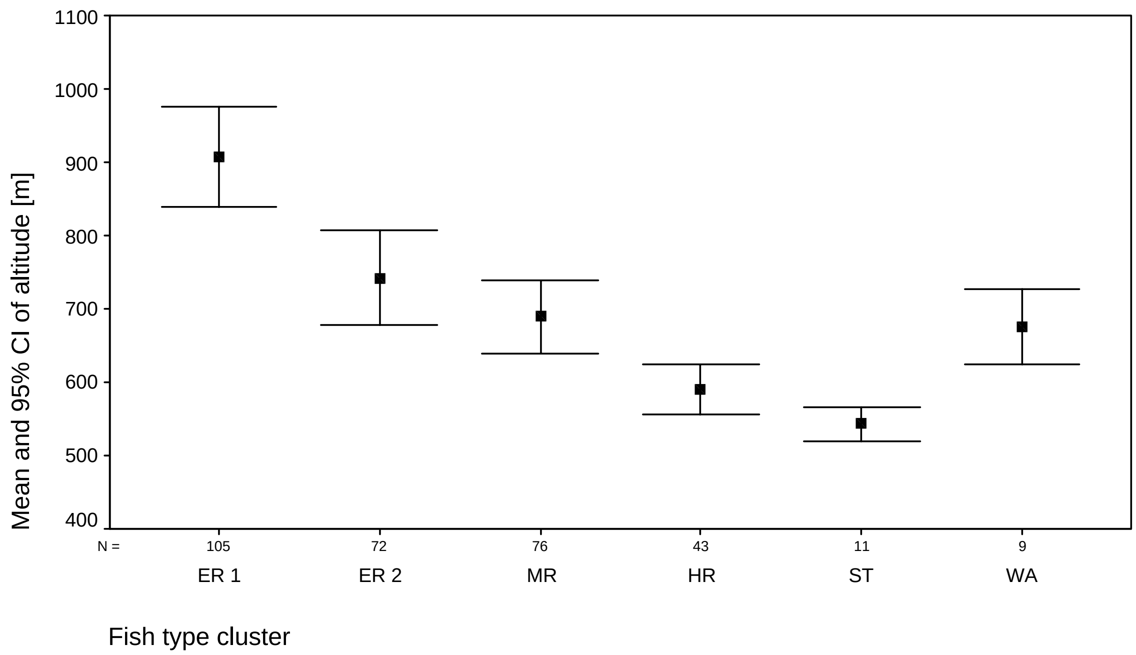


Figure. 14: Mean value and 95% confidence interval (CI) of altitude per fish type

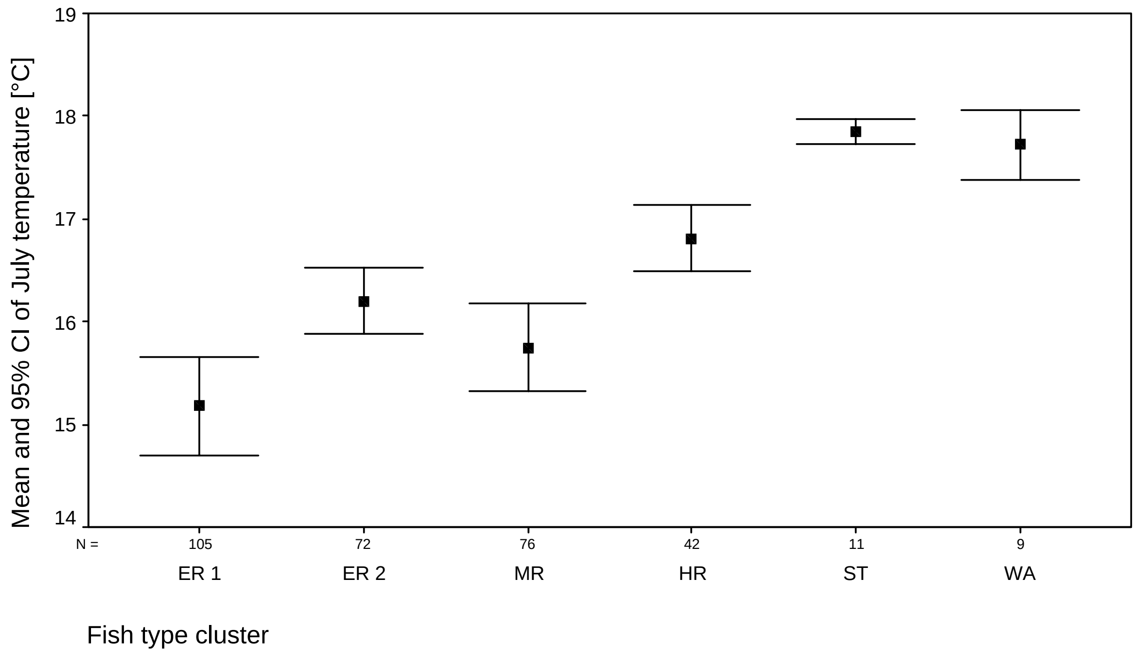


Figure 15: Mean value and 95% confidence interval (CI) of mean air temperature per fish type

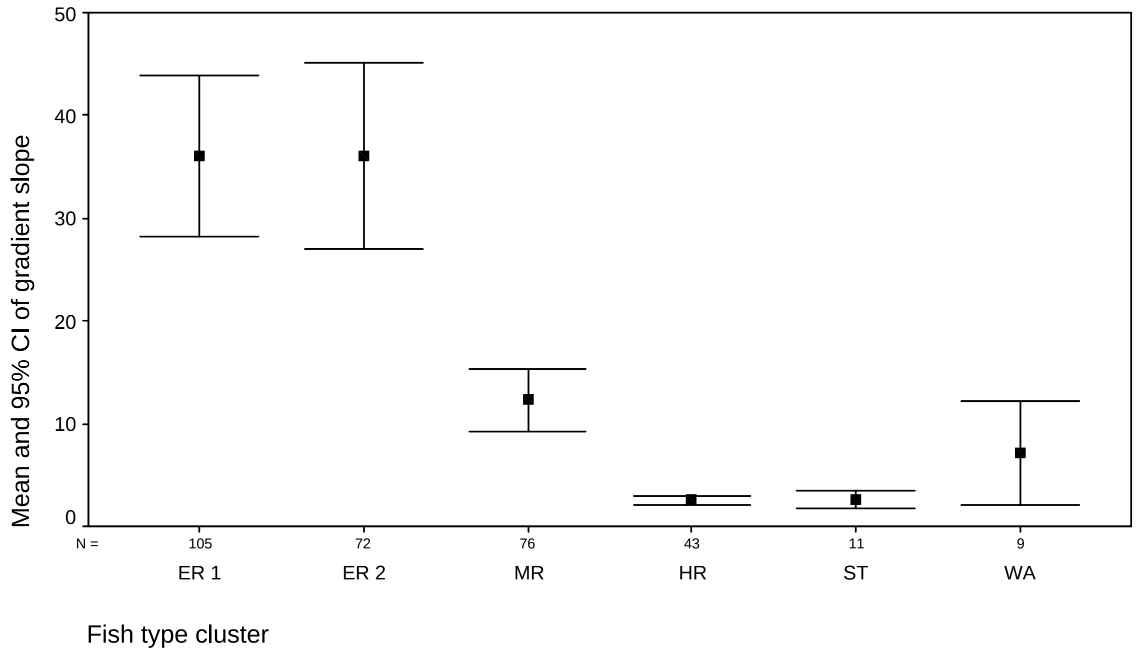


Figure 16: Mean value and 95% confidence interval (CI) of gradient slope per fish type

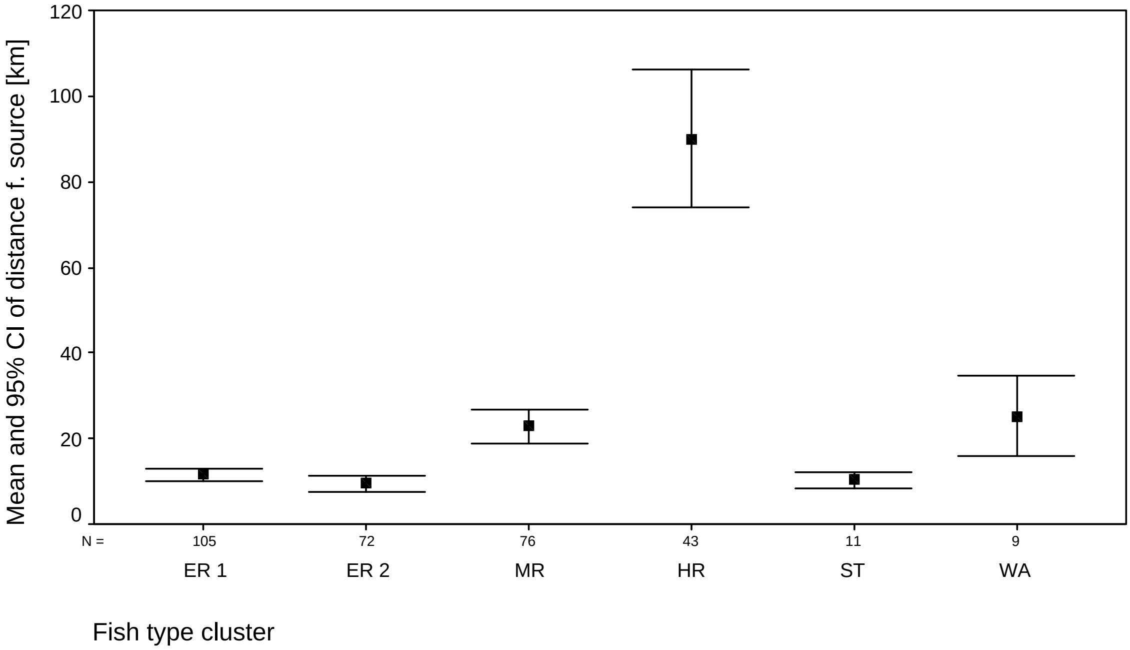


Figure 17: Mean value and 95% confidence interval (CI) of distance from source per fish type

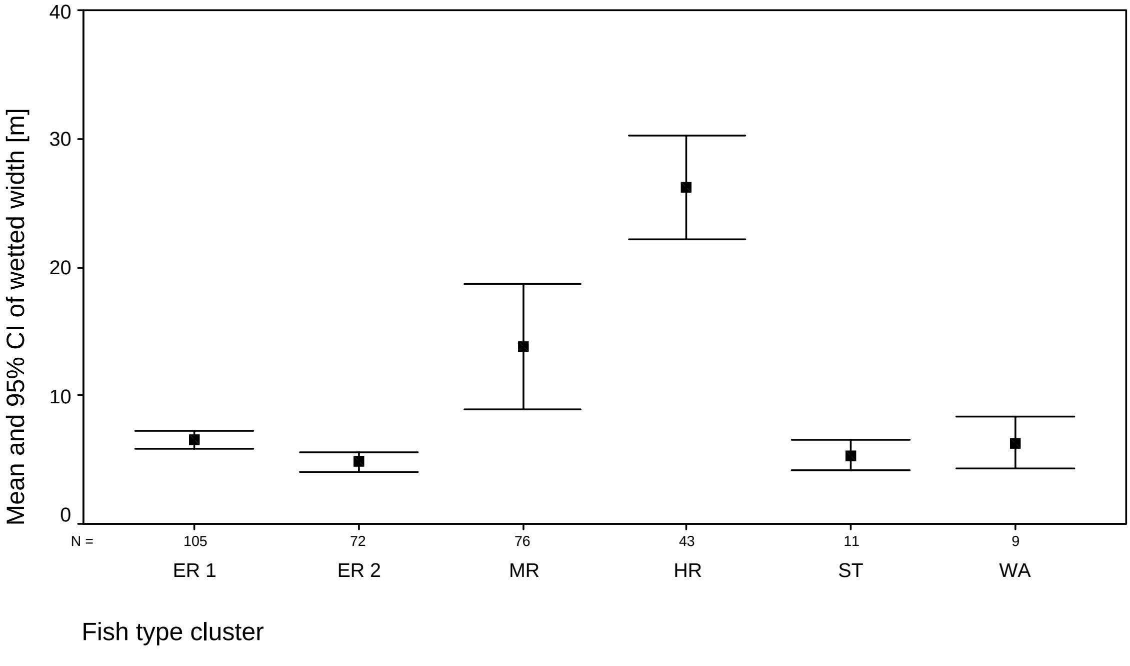


Figure 18: Mean value and 95% confidence interval (CI) of wetted width per fish type

6 Discriminant analysis to predict fish types

Discriminant analysis is used to determine the abiotic characteristics which best discriminate between the six fish types identified by cluster analysis.

A stepwise discriminant analysis was undertaken using critical values of Wilk´s Lambda to determine exclusion or inclusion of an abioitic variable at each step of the analysis. Critical values of F=3,84 and F=2,71 were used to determine variable entry or removal respectively. A six-step analysis was undertaken and included MRR, geological typology, size of catchment, altitude, mean July temperature and distance from source. (Tab. 10).

The first five canonical discriminant functions were used in the analysis (Tab. 11).

Mean air temperature [°C], Mean_Jan_temperature [°C], Gradient slope, Wetted width [m] and Water source type are statistically excluded from this analysis (Tab. 12).

Table 10: Abiotic variables included in a stepwise discriminant analysis for six fish types

Step		Tolerance	F to Remove	Wilks' Lambda
1	Distance from source [km]	1,000	98,312	
2	Distance from source [km]	1,000	95,555	,752
	Main river region	1,000	19,090	,386
3	Distance from source [km]	1,000	90,856	,631
	Main river region	,857	19,564	,335
	Altitude [m]	,857	9,720	,295
4	Distance from source [km]	,994	91,389	,575
	Main river region	,624	21,358	,311
	Altitude [m]	,427	6,470	,255
	Mean_Jul_temperature [°C]	,483	6,305	,254
5	Distance from source [km]	,729	35,546	,332
	Main river region	,623	21,095	,282
	Altitude [m]	,426	6,699	,232
	Mean_Jul_temperature [°C]	,473	6,867	,233
	Size of catchment [km²]	,717	6,161	,231
6	Distance from source [km]	,726	34,672	,300
	Main river region	,581	18,527	,249
	Altitude [m]	,389	6,195	,210
	Mean_Jul_temperature [°C]	,465	5,391	,208
	Size of catchment [km²]	,686	7,281	,214
	Geological typology	,857	5,921	,209

Table 11: Eigenvalues and canonical correlations for the five discriminant functions

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	1,790	71,6	71,6	0,801
2	,360	14,4	86	0,514
3	,214	8,5	94,5	0,419
4	,131	5,2	99,8	0,34
5	,006	0,2	100	0,078

The first abiotic discriminant function was strongly correlated with the distance from source of the site (canonical correlation = 0,897) (Table 12) and explained 71,6% of the variance in the discriminant model (Table 11). Function 2, which is negatively correlated with the variable Main river region distinguishes Type 8, a type which is mainly in the western alps. Function 3, which is strongly positively correlated with gradient slope and altitude distinguishes Type HR. Function 4 correlates with mean July temperature (Table 2.9).

Table 12: Canonical correlation structure matrix

	Function				
	1	2	3	4	5
Distance_from_source	,897*	-,129	,243	,173	,085
Size_of_catchment_class	,715*	-,353	-,074	-,221	-,053
Wetted_width (a)	,401*	-,180	-,149	-,389	,275
Main_river_region	-,152	-,741*	-,059	,511	-,030
Mean_Jan_temperature (a)	-,090	-,486*	-,249	,222	-,043
Geological_typology	,081	,361*	-,060	,196	,249
Altitude	-,241	-,197	,698*	-,033	,473
Gradient_slope	-,264	,157	,608*	,005	-,515
Mean_air_temperature (a)	,095	-,107	-,557*	,474	-,360
Mean_Jul_temperature	,183	,190	-,483*	,480	-,451
Water_source_type (a)	-,103	-,222	-,181	,319*	-,136

* Largest absolute correlation between each variable and any discriminant function
(a) This variable not used in the analysis

Analysis of the distribution of actual fish types between the types predicted by the discriminant analysis indicates that many of the actual community types area spread between different predicted groups (Figure 13). The majority (55,5%) of type ER1 sites are retained in type ER1 by the discriminant model although some are predicted to type ER2 or MR.

It was able to predict type HR by 95% - and only a few sites were assigned to the ER2 and MR.

Table 13: Discriminant classification of original fish types after clustering amongst predicted (%)

		Predicted group						Totall
Fish type		**ER 1**	**ER 2**	**MR**	**HR**	**ST**	**WA**	
	ER 1	55,5	33,6	10,9	0	0	0	100
	ER 2	8,3	72,2	19,4	,0	0	0	100
Original	**MR**	4,2	31,6	55,8	8,4	0	0	100
	HR	0	1,6	3,2	95,2	0	0	100
	ST	0	0	0	0	100	0	100
	WA	0	0	0	0	0	100	100

7 Historical data analysis

In addition to current fish data of near-natural reference sites, historical presence/absence data are used for hierarchical cluster analysis. Historical data are mainly available for larger rivers and the more common or economically valuable species. Rare species are less frequently described in historical records. Besides fish data dealing with the current situation, FIDES includes information on historical fish occurrence. These data are mainly based on an Austrian-wide literature survey (Haidvogl & Waidbacher 1997) and literature surveys carried out for the development of reference conditions (Leitbild) for numerous river management plans. Historical data mainly refer to the 19th century and are available for 22 rivers subdivided into upper-, middle- and lower sections (in total 83 sections).

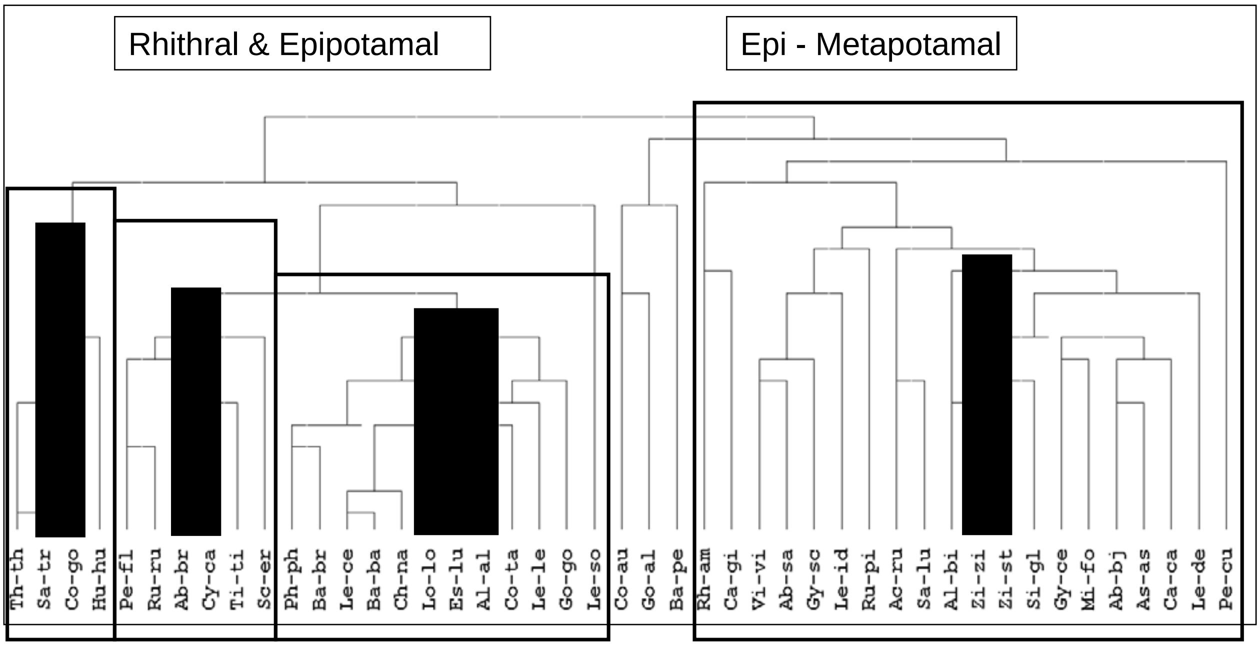


Figure 19: Dendrogram of the historical presence/absence fish data

Because of precence/absence data hierachical clusteranalyses after Jaccard was done.

The dendrogram (Fig. 19) of historical data reflects four main groups:

1. rheophilic-rhithral species: *Salmo trutta*, *Cottus gobio*, *Thymallus thymallus* and *Hucho hucho*,
2. rheophilic-epipotamal species: with the typical epipotamal species *Chondrostoma nasus* and *Barbus barbus* and further rheophilic, mostly small-sized species such as *Phoxinus phoxinus, Barbatula barbatula*, *Gobio gobio*, etc.,
3. indifferent species in hyporhithral/epipotamal rivers associated with side-arms and oxbows in the former inundated floodplains such as *Abramis brama*, *Perca fluviatilis*, *Scardinius erythrophthalmus* and *Tinca tinca*,
4. a diverse group of species associated with medium-sized and large lowland rivers including Danube endemics. But these are not located in the alps, but in the central highlands and hungarian plains.

8 Synthesis historical and current data analysis / conclusions

The first and the second step – the cluster analysis with current data – distinguished 5 main types. Further cluster analysis within type 1 (epirhithral) distinguish between epithitral with low and high biomass/density of brown trout, resulting in 6 types in total.

According to the historic data the metarhithral transition region is subdivided into river sections without and with Danube salmon, the latter more closely related to the hyporhithral. Current data clearly separates the hyporhithral from other types, but are unable to distinguish between rivers with and without Danube salmon. However, the former distribution of the Danube salmon in Austrian rivers is very well known, showing that this species was excluded from some hyporhithral sections.

The historical approach produced two additional types, the hyporhithral/epipotamal-floodplain and the metapotamal with a high proportion of Danube endemics. The floodplain type was added to the types identified with current data. Thus, the total number of fish types increases to 8 (Tab. 14).

Table 14: Synthesis of actual and historical data

Fish type	Definition	Data source
1 ER 1	Epirhithral high	Actual data
2 ER 2	Epirhithral low	Actual data
3 MR	Metarhithral	Actual data
4 MR Hu	Metarhithral Hucho hucho	Historic data
5 HR	Hyporhithral	Actual data
6 HR Bw	Hyporhithral backwater	historic data
7 ST	Type lake influence	Actual data
8 ST	Rhithral western Alps	Actual data

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