SUPPORTING INFORMATION

APPENDIX S1: *SUPPORTING METHODS*

Climatic data

From the SAFRAN database, we focused on two parameters (i.e. temperature and precipitation) known to be important for fish survival and reproduction at local scales, and hence strongly related to their spatial distributions (Mathews, 1998). Here we used precipitation as a surrogate for water flow and air temperature as a surrogate for water temperature. As previous studies showed that stream temperatures increase linearly with air temperatures below 25°C (Mohseni *et al.*, 2003), we first verified that this threshold beyond which a linear extrapolation is likely to overestimate stream temperatures was only exceeded in less than 1% of the daily records (mean = 0.9 % ± 1.03 SD across years). Water temperatures were then obtained by applying a scaling factor of 0.8 to the air temperatures to account for the slower warming rates typical of streams (Morrill *et al.*, 2005; Isaak *et al.*, 2013).

Sampling scheme

Within each time period, both sites surveyed repeatedly and sites surveyed only once were included (‘double sampling scheme’; MacKenzie et al., 2006). The number of resurveyed sites per time period varied from 564 to 780 and represented 38.1 to 84.2% (mean = 69.2% ± 16.6 SD) of the sites, with an average number of 2.39 ± 0.37 visits per site. A low number of sites were revisited across the eight time periods (6.87%) and 35.62% of them were resurveyed across several time periods (Table S1). Nonetheless, the spatial distributions and the environmental conditions of the sites spanned a large range of environmental conditions found in French streams and were comparable both across periods and between the sites surveyed repeatedly and those surveyed once. The climatic conditions also varied more between than within periods (F = 3.532, P = 0.027, Fig. S3), demonstrating that the varying time lengths of the short-time periods would be unlikely to affect our conclusions.

Table S1 Characteristics of the sampling design across the eight time periods.

	P1	*P2*	*P3*	*P4*	*P5*	*P6*	*P7*	*P8*	*Total*
Total number of sites	991	721	703	839	855	1044	1711	964	3622
Number of sites surveyed repeatedly	564	607	588	653	633	602	652	780	1640
Average number of visits per site	3.18	2.40	2.45	2.13	2.06	2.04	2.50	2.33	2.39
Maximum number of visits per site	12	6	4	4	6	4	6	5	12

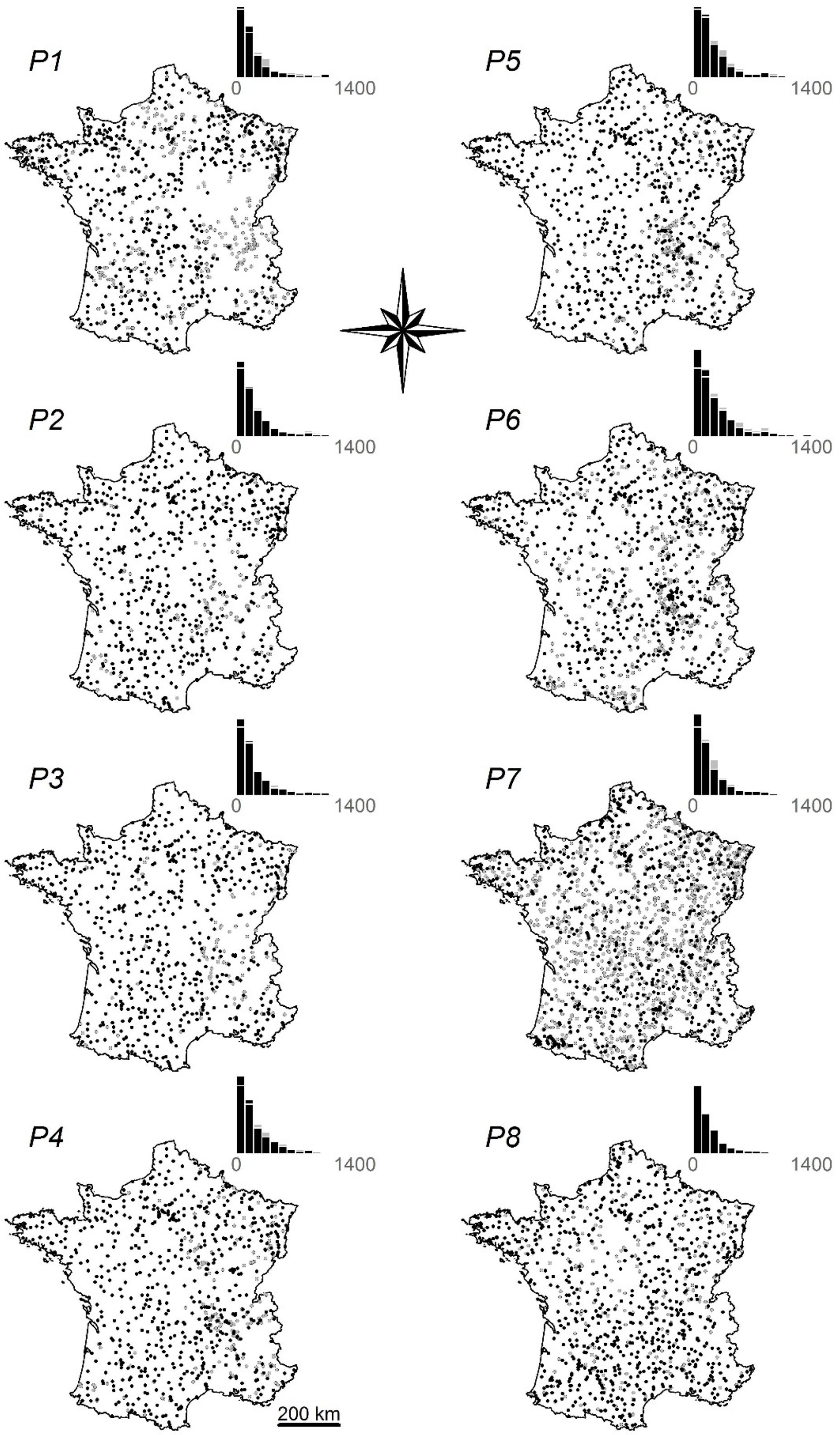

Figure S1 Spatial distribution of the sampling sites in France and along the altitudinal gradient (histogram) across the eight time periods. Black indicate sites that have been surveyed repeatedly and grey sites that have been sampled only once.

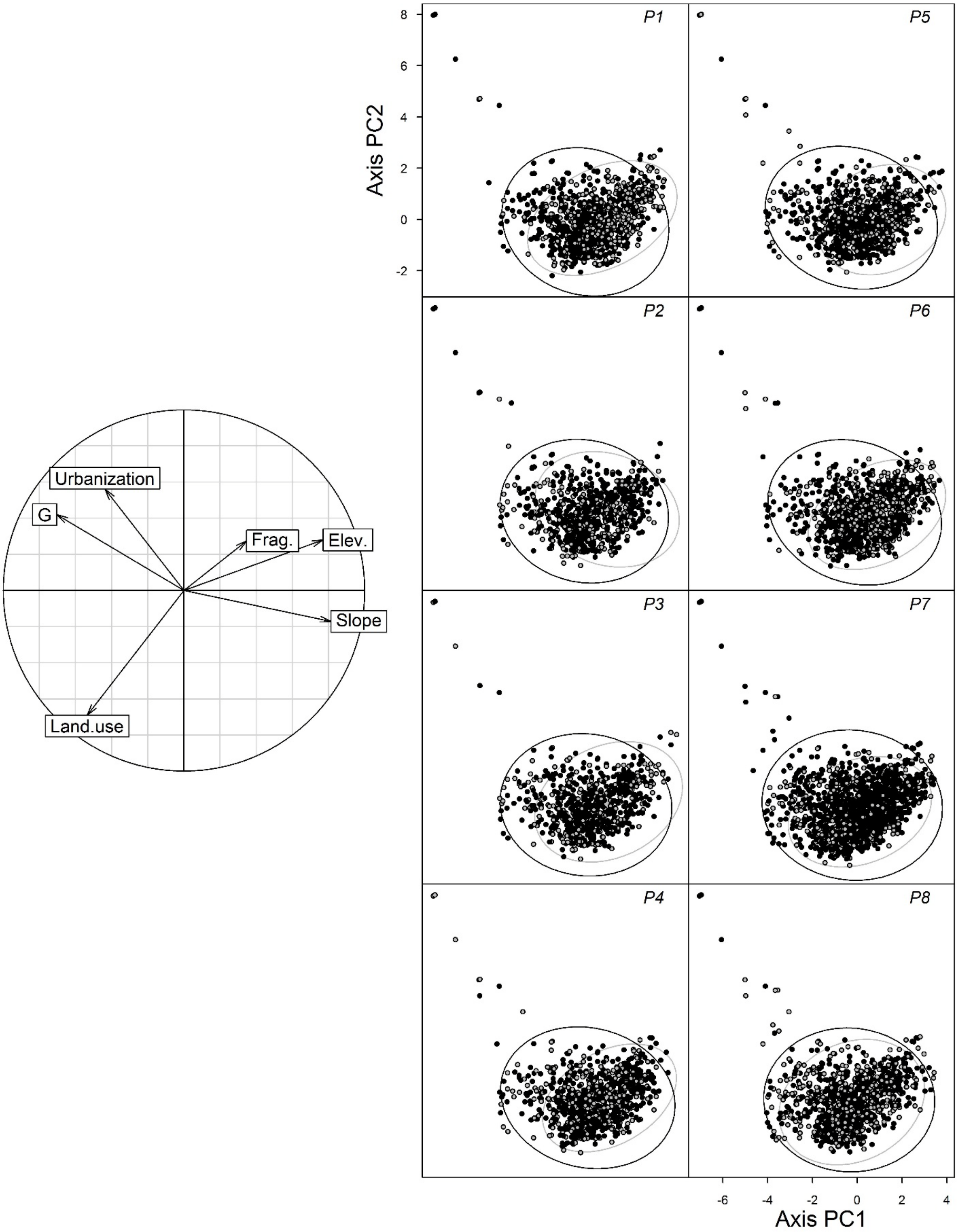

Figure S2 Correlation circle (left) and coordinates of the sites within the bi-dimensional space of a principal component analysis performed on the environmental conditions of the sites (G = upstream-downstream gradient; Frag. = degree of fragmentation; Elev. = elevation) sampled across the eight time periods. Black indicate sites that have been surveyed repeatedly and grey sites that have been sampled only once. Ellipses encompass 95% of sites.

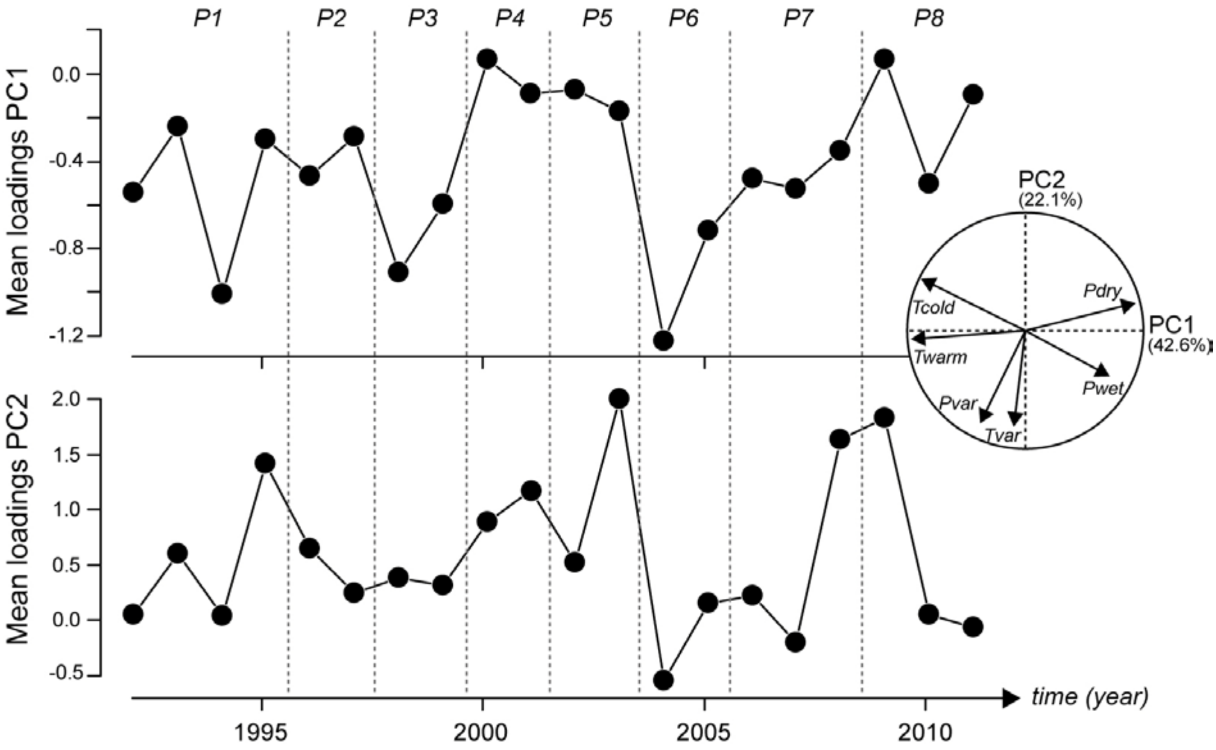

Figure S3 Inter-annual variability in climatic conditions over the study period. The correlation circle shows the projections of the six climatic variables onto the first two axes (accounting for 64.7% of the total variance) of a principal component analysis. PC1 represents a gradient from cooler, wetter areas (positive loadings) to warmer, drier areas (negative loadings), whereas PC2 contrasts areas with relatively stable climatic conditions (positive loadings) with areas showing greater variability (negative loadings). Vertical dashed lines correspond to the transitions between the eight time periods.

Species distribution models

We modeled the distribution of species in each time period using single-season occupancy models explicitly accounting for species detectability (MacKenzie *et al.*, 2006). Although the assumption of independence could be violated by using single-season occupancy models, the models including additional parameters (i.e. colonization and extinction dynamics) were unable to converge due to data limitation. Given prior evidence (Comte & Grenouillet, 2013), we used different parameterizations and allowed the probability of detection (p) to vary with the Julian day and the upstream-downstream position of the survey, known to affect electrofishing efficiency (nine parameterizations with linear and squared effects including an intercept-only model). We first optimized the component for detection probability by fitting the different competing models while keeping the occurrence component constant. The models most supported according to AIC (ΔAIC < 2) were selected to determine the form of the detection function to be used to model the occurrence probability. The probability of occurrence (Ψ) was then modeled as a function of the different combinations of the aforementioned climatic, topographic and anthropogenic covariates (1944 parameterizations with linear and squared effects including an intercept-only model) for each of the best combinations of p. Finally, to take into account the uncertainty in parameter estimates, the models most supported according to AIC (ΔAIC < 2) were selected to perform a model-averaging procedure. The averaged regression coefficients were weighted according to AIC weights (w_i) of each competing model, resulting in one composite model for each species and time period (see Table S2 and Table S3).

Table S2 Variable importance for the occupancy component for each species expressed as the percentage of times the variables were selected within the best set of models across the eight time periods.

	Topographic						Climatic				Anthropogenic		
Species	Elevation	Slope	G	Elevation^2	Slope^2	G^2	Climat PC1	Climat PC2	Climat PC1^2	Climat PC2^2	Land use	Fragmentation	Urbanization
Alburnoides bipunctatus	100	100	100	100	22.33	59.22	58.25	100	36.89	66.02	37.86	29.13	95.15
Alburnus alburnus	89.55	100	100	71.64	29.85	47.76	97.01	92.54	37.31	80.6	100	80.6	17.91
Ameiurus melas	53.85	88.03	70.94	21.37	29.91	18.8	87.18	70.94	82.91	47.01	74.36	55.56	26.5
Barbatula barbatula	90.74	100	100	87.04	75.93	100	81.48	88.89	59.26	44.44	100	98.15	92.59
Cottus gobio	100	80.85	82.27	46.1	36.88	48.94	100	95.04	100	65.25	47.52	53.19	46.81
Cyprinus carpio	84.09	92.05	97.73	75	31.82	67.05	100	78.41	47.73	64.77	97.73	78.41	65.91
Gasterosteus aculeatus	100	85.11	53.9	55.32	43.97	19.86	95.74	92.2	53.19	34.75	44.68	64.54	67.38
Gobio gobio	58.93	100	100	53.57	83.04	16.96	100	75	35.71	40.18	100	70.54	58.04
Gymnocephalus cernua	94.34	88.68	100	28.93	21.38	61.01	55.35	83.65	37.11	75.47	34.59	77.36	59.12
Perca fluviatilis	97.8	96.7	100	31.87	57.14	68.13	73.63	100	29.67	91.21	100	45.05	83.52
Phoxinus phoxinus	98.65	100	100	98.65	43.24	100	90.54	78.38	51.35	29.73	77.03	51.35	100
Salmo trutta	97.41	100	57.76	45.69	39.66	37.07	100	86.21	49.14	47.41	77.59	84.48	82.76
Squalius cephalus	93.94	100	100	69.7	98.48	40.91	98.48	96.97	46.97	81.82	100	84.85	34.85
Tinca tinca	56	100	79	7	41	60	62	100	19	55	61	87	34

Table S3 Average regression coefficients for the occupancy component for each species across the eight time periods based on scaled and centered variables.

	Topographic						**Climatic**				**Anthropogenic**		
Species	Elevation	Slope	G	Elevation^2	Slope^2	G^2	Climat PC1	Climat PC2	Climat PC1^2	Climat PC2^2	Land use	Fragmentation	Urbanization
Alburnoides bipunctatus	0.51	-2.45	1.04	-2.15	0.07	-0.19	0.2	-0.06	-0.06	0	0.04	-0.05	-0.57
Alburnus alburnus	-0.28	-3.31	1.89	-0.97	0.14	-0.09	0.69	0.48	0.01	-0.19	0.83	-0.28	0
Ameiurus melas	-0.27	-2.62	0.14	-0.27	-0.08	-0.02	1.13	0.27	-0.51	-0.22	0.4	-0.26	-0.02
Barbatula barbatula	0.33	-1.64	-0.09	-0.2	0.18	-0.25	0.05	-0.1	-0.09	0.04	0.39	-0.3	-0.29
Cottus gobio	-1.38	-0.25	0	0.06	0	-0.08	-1.89	-0.43	-0.42	0.02	-0.06	0.04	-0.12
Cyprinus carpio	0	-2.79	0.19	-1.15	-0.86	0.23	1.01	0.1	0.18	-0.22	0.63	-0.31	0.02
Gasterosteus aculeatus	-1.62	-3.03	0.06	-0.73	-1.15	-0.03	-0.83	-0.28	-0.07	0.01	-0.04	0.22	0.7
Gobio gobio	0.34	-1.23	0.89	-0.17	0.14	-0.01	0.43	0.16	-0.03	-0.06	0.48	-0.19	-0.1
Gymnocephalus cernua	-1.24	-3.27	1.51	-0.48	0.07	-0.17	-0.22	-0.3	-0.21	-0.4	0.07	-0.3	-0.12
Perca fluviatilis	-0.55	-1.39	0.41	-0.06	0.11	0.23	-0.25	-0.11	-0.02	-0.28	0.42	-0.14	0.46
Phoxinus phoxinus	0.9	-1.13	-0.05	-0.35	0.06	-0.33	0.26	0.15	-0.12	0.03	0.2	-0.07	-0.68
Salmo trutta	1.22	4.64	0	0.45	-0.18	-0.11	-1.02	-0.06	-0.01	0.13	-0.34	0.49	-0.52
Squalius cephalus	0.44	-1.97	0.91	-0.37	0.29	0.05	0.73	0.36	0.12	-0.08	0.49	-0.25	-0.04
Tinca tinca	-0.1	-4.14	0.32	-0.09	0.22	0.37	0.07	-0.03	0.07	-0.18	0.31	-0.32	0.13

Measures of velocity

To take into account the structure of the hydrographic network, the average altitudinal gradient for a given reach was calculated, excluding any missing value, using weightings of two and one for both upstream and downstream reaches directly adjacent to the focal reach and the following ones, respectively (Fig. S4).

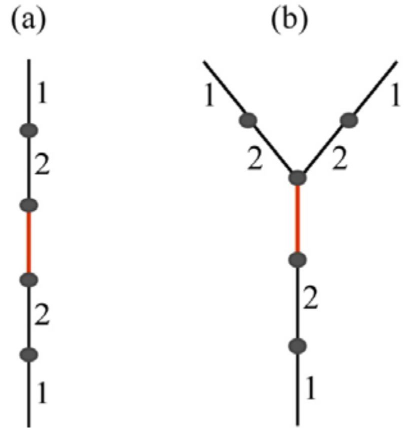

Figure S4 Weightings used to calculate the average altitudinal gradient between a given reach (in red) and upstream and downstream reaches depending on the structure of the hydrographic network: (a) without or (b) with upstream tributaries.

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APPENDIX S2: *CONSISTENCY BETWEEN BIOCLIMATIC AND BIOTIC VELOCITIES*

Table S4 Percentages of hydrographic network for which positive, negative or null bioclimatic velocities are expected, and corresponding consistencies (% of hydrographic network) with biotic velocities for each fish species. Given are mean values (with *SE* in brackets) across transitions (*T1* to *T7*).

	Bioclimatic velocities			**Consistency**			
Species	Positive	Negative	Null	Positive	Negative	Null	Overall
Alburnoides bipunctatus	26.50 (7.44)	48.80 (10.51)	24.70 (4.34)	54.38 (8.98)	53.17 (7.27)	64.17 (3.48)	55.84 (3.15)
Alburnus alburnus	37.34 (12.80)	35.67 (10.08)	26.99 (4.91)	49.63 (7.51)	57.66 (8.63)	66.98 (5.54)	55.83 (6.40)
Ameiurus melas	34.18 (10.58)	47.76 (10.52)	18.06 (2.28)	55.90 (10.24)	54.24 (5.54)	66.09 (10.17)	62.53 (5.52)
Barbatula barbatula	32.71 (4.58)	59.70 (4.88)	7.59 (0.71)	58.50 (7.00)	55.30 (7.72)	25.82 (4.25)	54.07 (2.02)
Cottus gobio	50.62 (14.52)	48.00 (14.44)	1.38 (0.41)	57.71 (5.74)	55.52 (7.09)	13.95 (4.33)	55.13 (4.69)
Cyprinus carpio	36.44 (10.86)	47.32 (12.74)	16.24 (2.96)	49.79 (5.89)	64.95 (6.29)	70.25 (4.31)	57.88 (2.59)
Gasterosteus aculeatus	44.49 (13.84)	42.26 (14.13)	13.25 (3.48)	52.34 (6.23)	56.55 (5.56)	43.69 (5.81)	58.53 (2.72)
Gobio gobio	37.22 (11.66)	58.37 (12.35)	4.41 (0.90)	58.46 (4.42)	57.83 (7.37)	22.16 (3.65)	53.09 (5.13)
Gymnocephalus cernua	27.41 (7.76)	34.10 (6.12)	38.48 (4.24)	55.69 (8.11)	49.59 (9.17)	55.99 (7.48)	51.86 (2.79)
Perca fluviatilis	44.38 (8.91)	46.92 (8.07)	8.70 (1.54)	54.06 (10.85)	54.08 (11.98)	16.07 (5.78)	41.78 (4.50)
Phoxinus phoxinus	41.92 (11.73)	51.06 (11.73)	7.02 (0.81)	53.02 (6.13)	61.81 (3.12)	52.52 (7.28)	56.85 (2.82)
Salmo trutta	49.62 (12.49)	35.82 (12.25)	14.55 (4.45)	61.97 (9.70)	52.33 (6.28)	71.33 (4.38)	59.64 (7.81)
Squalius cephalus	40.54 (11.05)	50.47 (11.59)	8.99 (1.67)	57.68 (6.59)	53.18 (8.24)	41.70 (6.56)	53.08 (5.95)
Tinca tinca	38.39 (7.08)	38.71 (6.41)	22.91 (3.30)	42.85 (6.70)	69.28 (7.04)	55.25 (5.03)	51.02 (2.47)

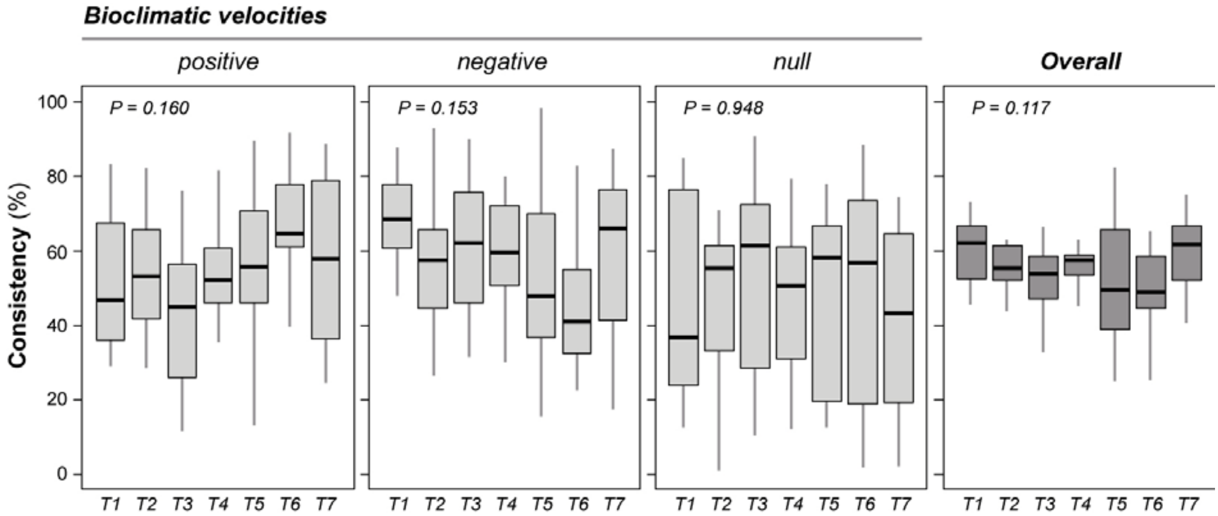

Figure S5 Consistency (% of hydrographic network) between bioclimatic and biotic velocities across species for the different transitions (*T1* to *T7*). No significant differences in consistency among transitions were observed (ANOVA tests, *P* > 0.05).

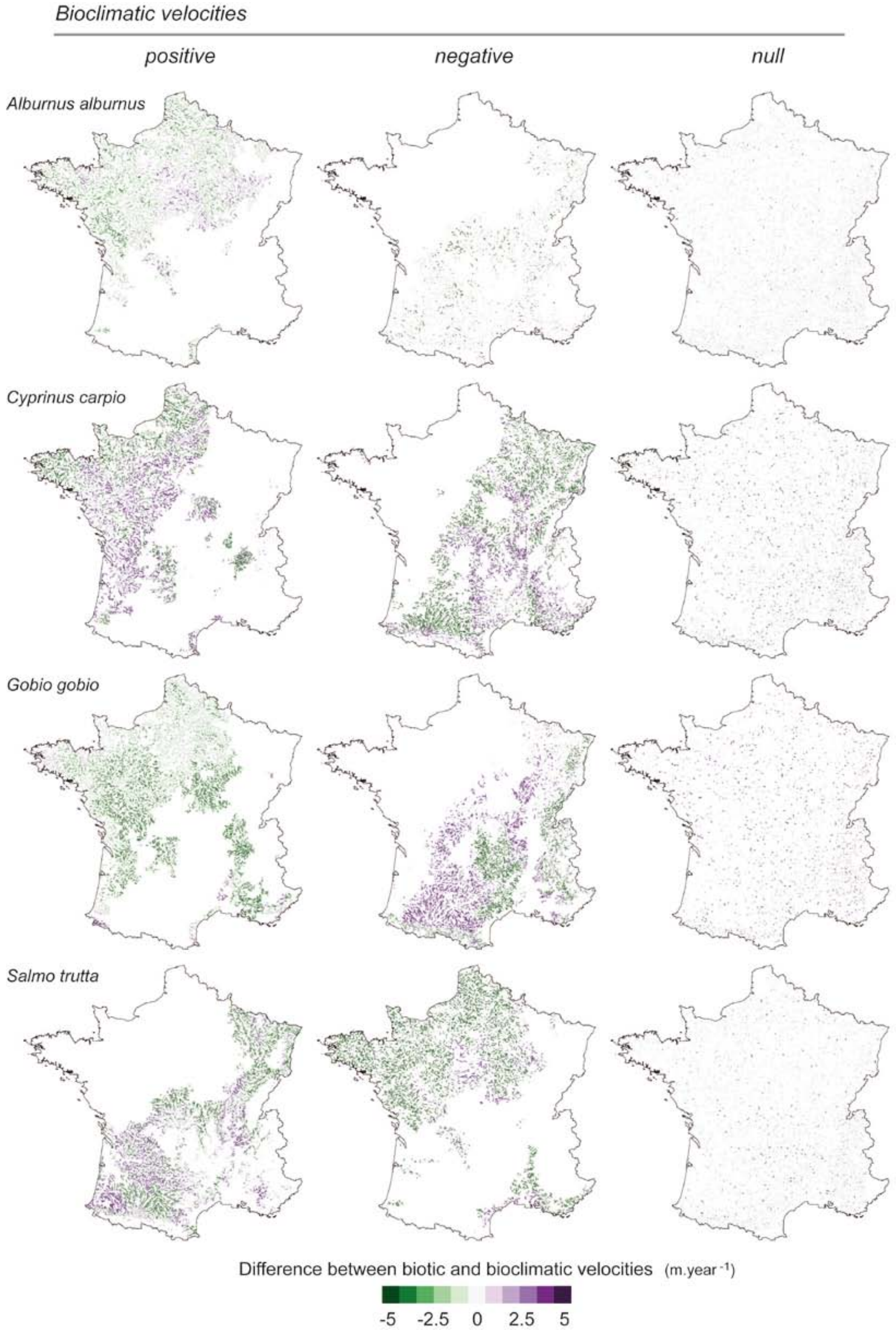

Figure S6 Spatial patterns in differences between biotic and bioclimatic velocities. When compared to expected velocities (i.e. positive or negative), observed species responses can show lags (in green) or credits (in purple) for either gains or losses of suitable habitat. Unexpected shifts (i.e. observed for null bioclimatic velocities) appeared to be rare and showed no spatial pattern.