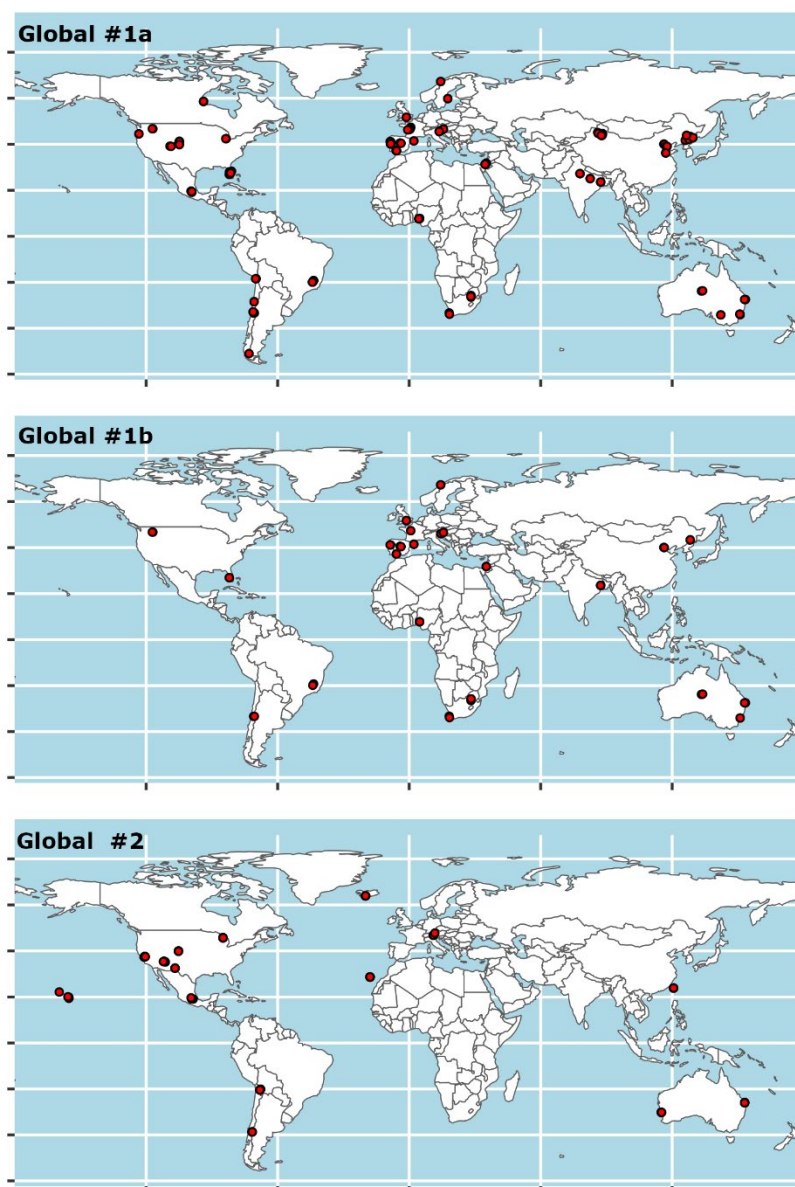


Supplementary Information

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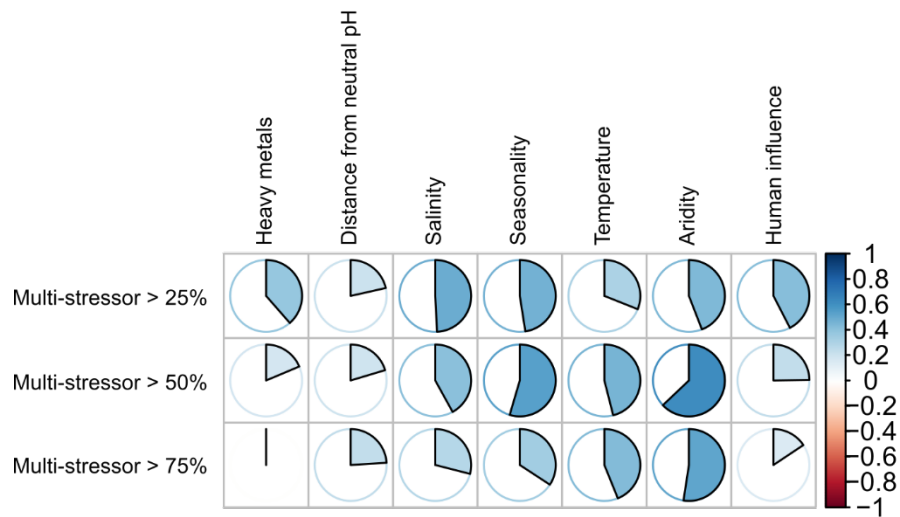


Supplementary Figure 1 | Locations included in two global surveys. Global #1a (n = 131 sites) and #2 (n = 87 sites). Global #1b (n = 48) includes a subset of locations from Global #1a including additional information on pesticides and microplastics. Map created in R.

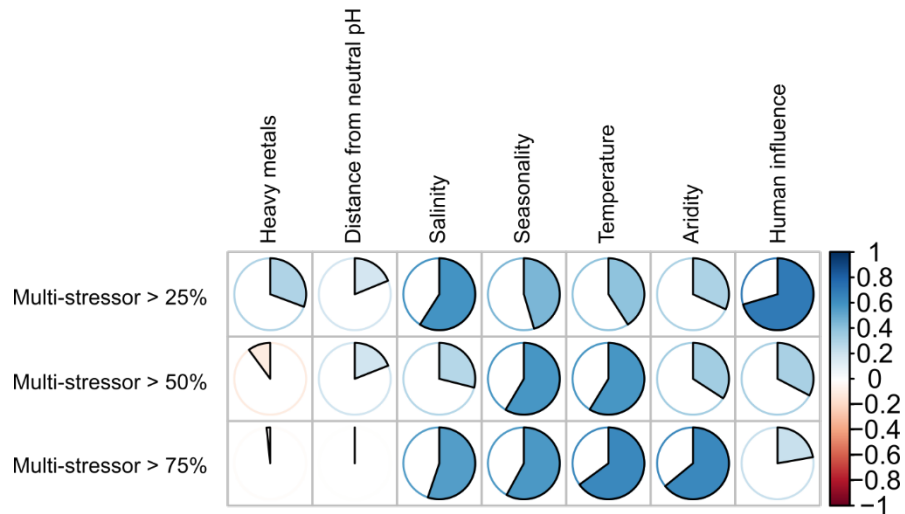


Supplementary Figure 2 | Spearman correlations between environmental conditions selected as surrogates of environmental stress. A correlational plot showing the correlation of all stressors used two by two. On the lower triangle the pie charts indicate the absolute correlation strength from 0 to 1 assuming the filled circle is 1 and empty circle is 0. Negative correlations are colored in red and positive ones in blue. On the upper triangle the correlation values are depicted.

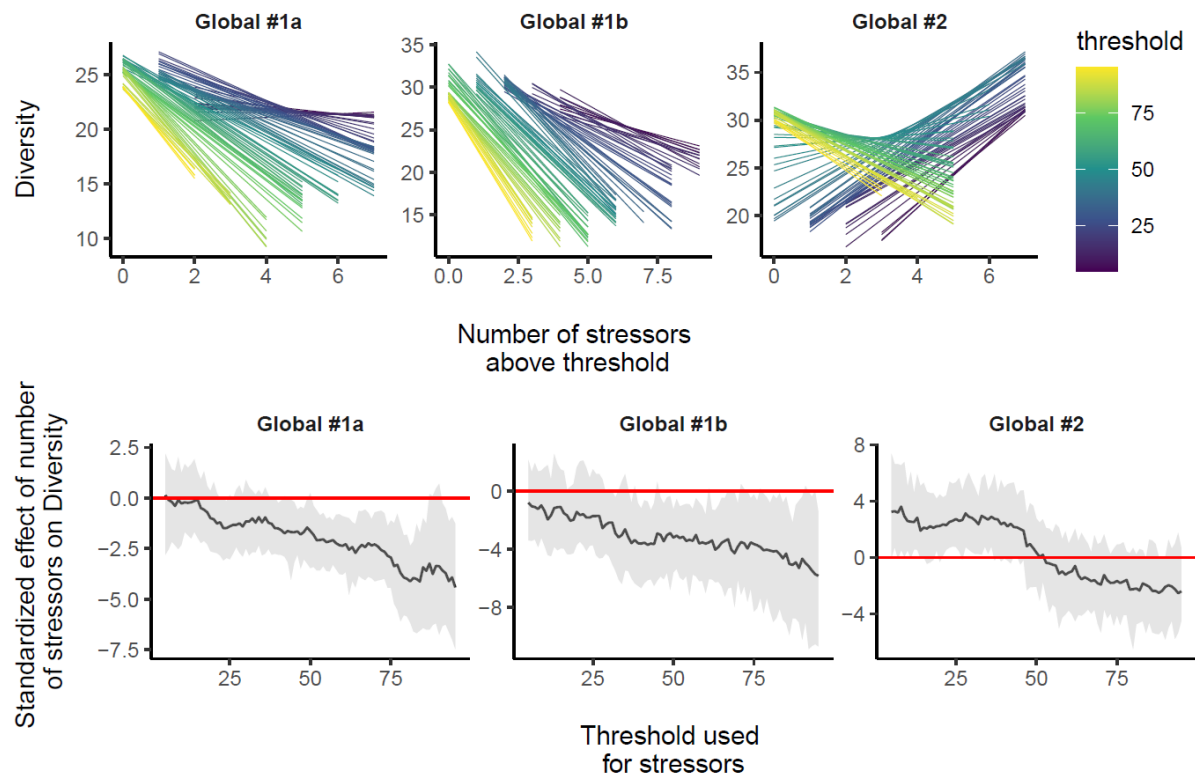
Global #1



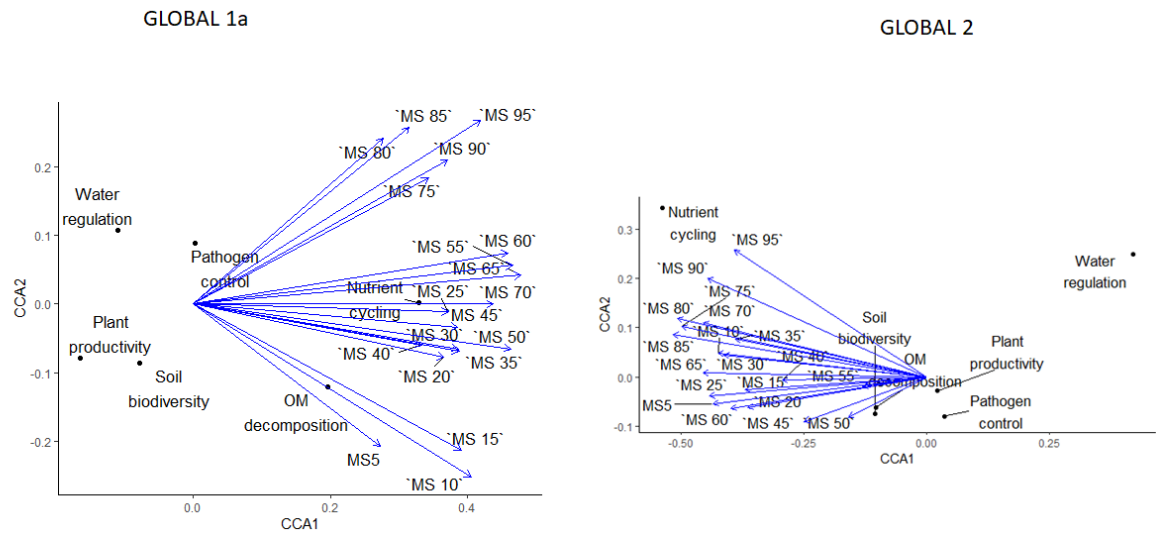
Global #2



Supplementary Figure 3 | Spearman correlations between multi-stressor indices (number of stressors operating at higher than 25/50/75% of maximum stress levels) and the stress level of individual environmental stressors. The pie charts indicate the absolute correlation strength from 0 to 1 assuming the filled circle is 1 and empty circle is 0. Negative correlations are colored in red and positive ones in blue.



Supplementary Figure 4 | Relationships between number of stressors above a threshold and soil biodiversity (as defined in Supplementary Table 2 and excluding other ecosystem services) and its effect in two global surveys. Global #1a (n = 131 sites) and #2 (n = 87 sites) includes seven environmental stressors: aridity, temperature, seasonality, salinity, distance from neutral pH, heavy metals and human influence. Global #1b (n = 48) includes a subset of locations from Global #1a including these seven environmental stressors plus pesticides and microplastics. Shaded areas in bottom panels correspond to 95% confidence intervals of bootstrapped standardized effect size.



Supplementary Figure 5 | Canonical correspondence analysis (CCA) analyses including the relationship between different levels of stress and multiple ecosystem services. MS = Multi-stressor.

Supplementary Table 1 | Environmental stressors

Stressor group	Variables	Additional information
Aridity	Aridity Index x -1	
Temperature	Maximum temperature	
Seasonality	Precipitation and temperature seasonality, and mean diurnal temperature range	
Salinity	Soil electrical conductivity	
Distance from neutral pH	Absolute distance from PH 7	
Heavy metals	Soil As, Cd, Cr, Cu, Ni, Pb, Zn	
Human influence	Human influence index	Global #1 also includes mowing, fertilization and land use (natural vs. urban greenspaces). Global #2 also includes fertilization.
Pesticides	Soil content of fungicides, herbicides and insecticides	Additional information included for the subset of data of in Global #1b
Microplastics	Soil content of microplastics	Additional information included for the subset of data of in Global #1b

Supplementary Table 2 | Ecosystem functions considered in this study

Ecosystem services	Ecosystem function
Organic matter decomposition	Basal respiration
	Glucose respiration
	Lignin respiration
Soil biodiversity	Diversity of Annelids
	Diversity of Arthropods
	Diversity of Nematodes
	Diversity of Platyhelminthes
	Diversity of Tardigrades
	Diversity of mycorrhizal fungi
	Diversity of fungal decomposers
Nutrient cycling	Available P
	Available N
Water regulation	Potential infiltration
Plant productivity	NPP
Pathogen control	Pathogen control

Supplementary Table 3 | Statistical information associated with Figure 1. Results indicate R² and coefficient of a linear regression between number of stressors operating above a threshold and ecosystem multiservices. This regression was bootstrapped 10,000 times (aiming at correcting for multiple testing) and the corresponding probability of resulting coefficient being higher/lower than 0 (if average coefficient was positive/negative) is the reported P value (therefore equivalent to one-sided test of significance).

Threshold	Database	R ²	Coefficient	P value
5	Global #1a	0.02088329	0.073386134	0.7963
6	Global #1a	0.01689526	0.038765163	0.6805
7	Global #1a	0.01536105	0.014540403	0.5791
8	Global #1a	0.01473448	0.004892361	0.5301
9	Global #1a	0.01629674	0.040752364	0.6947
10	Global #1a	0.01974237	0.07049537	0.7977
11	Global #1a	0.0249851	0.09778034	0.8674
12	Global #1a	0.0225954	0.085511494	0.8406
13	Global #1a	0.02424485	0.095331707	0.8658
14	Global #1a	0.02074964	0.072294735	0.7942
15	Global #1a	0.01796778	0.057386101	0.7456
16	Global #1a	0.01659332	0.039249611	0.6756
17	Global #1a	0.01609175	0.027487987	0.6175
18	Global #1a	0.01508876	0.005347133	0.5261
19	Global #1a	0.0175066	-0.044730627	0.3067
20	Global #1a	0.02022886	-0.073924285	0.1965
21	Global #1a	0.02373983	-0.094184095	0.1345
22	Global #1a	0.02505776	-0.103728225	0.1077
23	Global #1a	0.03242106	-0.13523943	0.0535
24	Global #1a	0.0367623	-0.151524285	0.0314
25	Global #1a	0.04331087	-0.171389252	0.0189
26	Global #1a	0.04546505	-0.179449751	0.012
27	Global #1a	0.04846394	-0.187996848	0.0079
28	Global #1a	0.04384585	-0.174369848	0.0145
29	Global #1a	0.04911215	-0.188135045	0.0112
30	Global #1a	0.05261947	-0.199377306	0.0048
31	Global #1a	0.0477078	-0.186257958	0.0099
32	Global #1a	0.04872896	-0.188785624	0.0096
33	Global #1a	0.04515709	-0.178034753	0.0158
34	Global #1a	0.0433139	-0.173982806	0.0156
35	Global #1a	0.04555821	-0.179814828	0.0123
36	Global #1a	0.06203639	-0.220399102	0.0044
37	Global #1a	0.06387398	-0.225290368	0.003
38	Global #1a	0.08594557	-0.270571285	0.0003
39	Global #1a	0.0923732	-0.281221434	0.0006
40	Global #1a	0.09776822	-0.291660079	1.00E-04
41	Global #1a	0.10452664	-0.303068072	0.0003
42	Global #1a	0.11558488	-0.320619126	<1E-4
43	Global #1a	0.11187852	-0.313820229	0.0002

44	Global #1a	0.11898323	-0.325119964	1.00E-04
45	Global #1a	0.14061038	-0.358034952	1.00E-04
46	Global #1a	0.12374993	-0.333759572	1.00E-04
47	Global #1a	0.11934068	-0.327441077	1.00E-04
48	Global #1a	0.10143347	-0.298404469	1.00E-04
49	Global #1a	0.09946831	-0.294618077	0.0002
50	Global #1a	0.11588921	-0.321112888	<1E-4
51	Global #1a	0.12355201	-0.333085204	1.00E-04
52	Global #1a	0.13235067	-0.345509356	1.00E-04
53	Global #1a	0.13593063	-0.350621597	<1E-4
54	Global #1a	0.14299006	-0.360891834	<1E-4
55	Global #1a	0.13611662	-0.351437897	<1E-4
56	Global #1a	0.13400301	-0.34884509	<1E-4
57	Global #1a	0.14077422	-0.357898915	<1E-4
58	Global #1a	0.12963715	-0.342510875	<1E-4
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63	Global #1a	0.12615268	-0.335419752	<1E-4
64	Global #1a	0.12351553	-0.33288405	1.00E-04
65	Global #1a	0.11930847	-0.325932525	0.0005
66	Global #1a	0.12512038	-0.334810069	1.00E-04
67	Global #1a	0.14270129	-0.36012762	<1E-4
68	Global #1a	0.14049723	-0.357384759	<1E-4
69	Global #1a	0.15081019	-0.371735834	1.00E-04
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71	Global #1a	0.17045891	-0.39730225	<1E-4
72	Global #1a	0.1638989	-0.387400393	<1E-4
73	Global #1a	0.17233176	-0.398019763	<1E-4
74	Global #1a	0.16364883	-0.386645735	<1E-4
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76	Global #1a	0.2178855	-0.452370144	<1E-4
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68	Global #1b	0.14547779	-0.334711797	0.009
69	Global #1b	0.14820716	-0.340021494	0.0083
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71	Global #1b	0.1334281	-0.315288092	0.0131
72	Global #1b	0.13316688	-0.317429953	0.0123
73	Global #1b	0.15653169	-0.356158456	0.0055
74	Global #1b	0.15615095	-0.356040571	0.0053
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76	Global #1b	0.19609953	-0.406433906	0.0034
77	Global #1b	0.17396243	-0.37948846	0.0044
78	Global #1b	0.17318423	-0.377469817	0.0049
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84	Global #1b	0.12564639	-0.305536874	0.0192
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94	Global #1b	0.11765218	-0.292226328	0.0171
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11	Global #2	0.02043813	0.041127981	0.6735
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14	Global #2	0.01945106	-0.004962467	0.463
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26	Global #2	0.0360391	0.137633726	0.9613
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44	Global #2	0.03043283	0.104423425	0.8783
45	Global #2	0.0252976	0.069904636	0.7694

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75	Global #2	0.10524316	-0.299372943	1.00E-04
76	Global #2	0.10593906	-0.300139907	0.0009
77	Global #2	0.10644399	-0.301404735	0.0008
78	Global #2	0.10237819	-0.293784886	0.0013
79	Global #2	0.11462043	-0.313403324	0.0014
80	Global #2	0.13200601	-0.3432029	0.0005
81	Global #2	0.13377692	-0.343643372	0.0009
82	Global #2	0.11309455	-0.31189968	0.0014
83	Global #2	0.12861306	-0.337527959	0.0011
84	Global #2	0.13752547	-0.349282542	0.0002
85	Global #2	0.1393583	-0.351481422	0.0003
86	Global #2	0.14203061	-0.35561951	0.0004
87	Global #2	0.14330875	-0.358286095	0.0007
88	Global #2	0.13702383	-0.347852952	0.0005
89	Global #2	0.12295812	-0.32459745	0.0009
90	Global #2	0.09860316	-0.28268557	0.0046
91	Global #2	0.07932919	-0.240054226	0.0186

92	Global #2	0.09207669	-0.266098389	0.012
93	Global #2	0.09676834	-0.27359371	0.01
94	Global #2	0.10018434	-0.277484846	0.0098
95	Global #2	0.07700334	-0.232742818	0.024

Supplementary Table 4 | Statistics associated with Fig. 4. Estimates of effects and P-values (two sided testing) following a linear regression model with interactions (see model description column).

			Estimate	Std. Error	t value	Pr(> t)	Adjusted R2 of model	F statistic	pvalue of model
GLOBAL #1	MODEL 1	(Intercept)	0.41885	0.020305	20.58	<2e-16	0.2703	17.05	2.29E-09
	Temperature	Temperature	-0.00037	0.000372	-1.006	0.3165			
	x	MS75	0.006362	0.015601	0.408	0.6841			
	MS75	Temperature:MS75	-0.00044	0.000214	-2.057	0.0417			
	MODEL 2	(Intercept)	4.04E-01	1.90E-02	21.247	<2e-16	0.2389	14.6	3.16E-08
	Aridity	Aridity	-7.08E-05	3.39E-04	-0.209	0.835			
	x	MS75	4.74E-03	1.57E-02	0.302	0.763			
	MS75	Aridity:MS75	-4.49E-04	2.07E-04	-2.169	0.032			
	MODEL 3	(Intercept)	4.07E-01	1.73E-02	23.556	<2e-16	0.2149	12.86	2.16E-07
	Seasonality	Seasonality	5.02E-05	3.47E-04	0.145	0.8852			
	x	MS75	-6.00E-03	1.38E-02	-0.435	0.6645			
	MS75	Seasonality:MS75	-4.84E-04	2.33E-04	-2.077	0.0398			
GLOBAL #2	MODEL 1	(Intercept)	0.455759	0.037515	12.149	<2e-16	0.07	3.18	0.0282
	Temperature	Temperature	-0.0001	0.000769	-0.134	0.8935			
	x	MS75	-0.06345	0.029178	-2.174	0.0325			
	MS75	Temperature:MS75	0.000407	0.000374	1.088	0.2798			
	MODEL 2	(Intercept)	0.484448	0.033245	14.572	<2e-16	0.2529	10.7	5.09E-06
	Aridity	Aridity	-0.0012	0.000623	-1.922	0.058			
	x	MS75	0.034411	0.02222	1.549	0.1253			
	MS75	Aridity:MS75	-0.00056	0.000296	-1.902	0.0606			
	MODEL 3	(Intercept)	0.462866	0.037285	12.414	<2e-16	0.2309	9.605	1.64E-05
	Seasonality	Seasonality	-0.0011	0.000742	-1.484	0.1416			
	x	MS75	0.038144	0.025786	1.479	0.1429			
	MS75	Seasonality:MS75	-0.00062	0.000353	-1.764	0.0814			

Supplementary Table 5 | Variance Inflation factor (VIF) of the predictors used for multiple linear regressions in the two databases of the study. Variance inflation factors higher than 10 indicate a significant multicollinearity.

Database	Multi-stressor >25%	Multi-stressor >50%	Multi-stressor >75%	Heavy metals	Distance from neutral pH	Salinity	Seasonality	Temperature	Aridity	Human influence
Global #1a	4.20	3.20	2.47	2.02	1.91	1.55	2.34	1.78	3.16	3.06
Global #2	6.44	4.23	5.61	3.26	3.07	2.81	5.89	4.21	3.28	3.15

Supplementary Table 6 | Statistical details of the effects of model averages after multimodel inference approach shown in Figure 2a. Original models are linear regression models. The best models according to akaike criteria (see methods) are selected and averaged to report effect estimates and p-values (two sided test). In full average variables that only exist in some models of the subset are assumed to have 0 effect in the models that they are not chosen; in conditional averaging such effects are assumed to be NAs.

GLOBAL #1a						
(full average)						
	Estimate	Std. Error	Adjusted SE	z value	Pr(> z)	
(Intercept)	4.31E-01	1.63E-02	1.65E-02	26.221	< 2e-16	***
Human.activities	7.18E-04	1.89E-04	1.91E-04	3.762	0.000169	***
MS75	-2.40E-02	7.58E-03	7.65E-03	3.136	0.001713	**
Temperature	-9.94E-04	2.46E-04	2.48E-04	4.005	6.19E-05	***
Heavy_metals	8.52E-05	1.83E-04	1.84E-04	0.464	0.642614	
Aridity	-4.36E-05	1.35E-04	1.36E-04	0.321	0.748279	
Salinity	-9.46E-06	3.83E-05	3.85E-05	0.246	0.805863	
MS50	-1.26E-03	3.86E-03	3.87E-03	0.325	0.744876	
(conditional average)						
	Estimate	Std. Error	Adjusted SE	z value	Pr(> z)	
(Intercept)	4.31E-01	1.63E-02	1.65E-02	26.221	< 2e-16	***
Human.activities	7.18E-04	1.89E-04	1.91E-04	3.762	0.000169	***
MS75	-2.40E-02	7.58E-03	7.65E-03	3.136	0.001714	**
Temperature	-9.94E-04	2.46E-04	2.48E-04	4.005	6.19E-05	***
Heavy_metals	3.62E-04	2.06E-04	2.08E-04	1.739	0.081977	.
Aridity	-3.25E-04	2.12E-04	2.14E-04	1.519	0.128856	
Salinity	-1.02E-04	8.00E-05	8.08E-05	1.265	0.20598	
MS50	-8.51E-03	6.24E-03	6.30E-03	1.352	0.176389	
GLOBAL #2						
(full average)						
	Estimate	Std. Error	Adjusted SE	z value	Pr(> z)	
(Intercept)	2.70E-01	3.61E-02	3.66E-02	7.38	< 2e-16	***
Heavy_metals	1.28E-03	3.53E-04	3.58E-04	3.565	0.000363	***
Human.activities	1.97E-03	4.40E-04	4.47E-04	4.402	1.07E-05	***
MS75	-3.92E-02	9.72E-03	9.85E-03	3.983	6.81E-05	***
Ph_neutro	2.01E-03	3.65E-04	3.70E-04	5.429	1.00E-07	***
Seasonality	-1.60E-04	3.61E-04	3.63E-04	0.442	0.658285	
Salinity	-2.41E-05	1.32E-04	1.33E-04	0.181	0.85675	
Aridity	-2.74E-05	1.51E-04	1.53E-04	0.179	0.857804	
MS25	-6.31E-04	3.57E-03	3.61E-03	0.175	0.861063	
(conditional average)						
	Estimate	Std. Error	Adjusted SE	z value	Pr(> z)	

(Intercept)	2.70E-01	3.61E-02	3.65E-02	7.38000	< 2e-16	***
Heavy_metals	1.28E-03	3.53E-04	3.58E-04	3.56500	0.00036	***
Human.activities	1.97E-03	4.40E-04	4.47E-04	4.40200	0.00001	***
MS75	-3.92E-02	9.72E-03	9.85E-03	3.98300	0.00007	***
Ph_neutro	2.01E-03	3.65E-04	3.70E-04	5.42900	0.00000	***
Seasonality	-7.04E-04	4.35E-04	4.41E-04	1.59500	0.11061	
Salinity	-2.97E-04	3.66E-04	3.72E-04	0.79900	0.42428	
Aridity	-3.40E-04	4.22E-04	4.28E-04	0.79300	0.42777	
MS25	-7.96E-03	1.01E-02	1.03E-02	0.77400	0.43868	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Supplementary Table 7 | Averaged models after a multimodel inference approach confronting multiservices vs individual stressors and multistressor indices. In this particular scenario, all individual stressors have been kept as fixed factor in the model structure during the inference. Original models are linear regression models. The best models according to akaike criteria (see methods) are selected and averaged to report effect estimates and p-values (two sided test). In full average variables that only exist in some models of the subset are assumed to have 0 effect in the models that they are not chosen; in conditional averaging such effects are assumed to be NAs.

GLOBAL #1a						
(full average)						
	Estimate	Std. Error	Adjusted SE	z value	Pr(> z)	
(Intercept)	4.40E-01	2.25E-02	2.27E-02	19.366	< 2e-16	***
Aridity	-2.84E-04	2.44E-04	2.46E-04	1.154	0.2486	
Heavy_metals	3.00E-04	2.08E-04	2.10E-04	1.428	0.1534	
Human influence	5.22E-04	2.12E-04	2.14E-04	2.443	0.0146	*
Distance from Neutral pH	-7.15E-05	2.31E-04	2.33E-04	0.307	0.7586	
Salinity	-1.29E-04	8.67E-05	8.75E-05	1.476	0.14	
Seasonality	-1.92E-04	2.38E-04	2.41E-04	0.798	0.4251	
Temperature	-1.05E-03	2.62E-04	2.65E-04	3.965	7.33E-05	***
Multi-stressor > 75%	-7.45E-03	1.07E-02	1.08E-02	0.693	0.4885	
Multi-stressor > 50%	-7.82E-04	3.49E-03	3.50E-03	0.223	0.8234	
(conditional average)						
	Estimate	Std. Error	Adjusted SE	z value	Pr(> z)	
(Intercept)	4.40E-01	2.25E-02	2.27E-02	19.366	< 2e-16	***
Aridity	-2.84E-04	2.44E-04	2.46E-04	1.154	0.2486	
Heavy_metals	3.00E-04	2.08E-04	2.10E-04	1.428	0.1534	
Human influence	5.22E-04	2.12E-04	2.14E-04	2.443	0.0146	*
Distance from Neutral pH	-7.15E-05	2.31E-04	2.33E-04	0.307	0.7586	
Salinity	-1.29E-04	8.67E-05	8.75E-05	1.476	0.14	
Seasonality	-1.92E-04	2.38E-04	2.41E-04	0.798	0.4251	
Temperature	-1.05E-03	2.62E-04	2.65E-04	3.965	7.33E-05	***
Multi-stressor > 75%	-1.85E-02	9.03E-03	9.12E-03	2.023	0.0431	*
Multi-stressor > 50%	-9.05E-03	8.12E-03	8.20E-03	1.103	0.2702	

GLOBAL #2						
(full average)						
	Estimate	Std. Error	Adjusted SE	z value	Pr(> z)	
(Intercept)	3.11E-01	4.73E-02	4.79E-02	6.50	< 2e-16	***
Multi-stressor > 75%	-1.84E-02	1.99E-02	2.00E-02	0.92	0.35776	
Aridity	-2.96E-04	4.93E-04	4.99E-04	0.59	0.553238	
Heavy_metals	1.06E-03	4.35E-04	4.40E-04	2.40	0.016293	*

Human influence	1.67E-03	5.30E-04	5.37E-04	3.12	0.001812	**
Distance from Neutral pH	1.69E-03	4.31E-04	4.37E-04	3.88	0.000105	***
Salinity	-4.29E-04	4.83E-04	4.87E-04	0.88	0.379158	
Seasonality	-8.79E-04	5.59E-04	5.67E-04	1.55	0.120739	
Temperature	1.04E-04	6.06E-04	6.12E-04	0.17	0.865359	
Multi-stressor > 25%	3.62E-03	1.06E-02	1.06E-02	0.34	0.733188	

(conditional average)

	Estimate	Std. Error	Adjusted SE	z value	Pr(> z)	
(Intercept)	3.11E-01	4.73E-02	4.79E-02	6.50	< 2e-16	***
Multi-stressor > 75%	-3.27E-02	1.53E-02	1.55E-02	2.11	0.034876	*
Aridity	-2.96E-04	4.93E-04	4.99E-04	0.59	0.553238	
Heavy_metals	1.06E-03	4.35E-04	4.40E-04	2.40	0.016293	*
Human influence	1.67E-03	5.30E-04	5.37E-04	3.12	0.001812	**
Distance from Neutral pH	1.69E-03	4.31E-04	4.37E-04	3.88	0.000105	***
Salinity	-4.29E-04	4.83E-04	4.87E-04	0.88	0.379158	
Seasonality	-8.79E-04	5.59E-04	5.67E-04	1.55	0.120739	
Temperature	1.04E-04	6.06E-04	6.12E-04	0.17	0.865359	
Multi-stressor > 25%	1.93E-02	1.71E-02	1.73E-02	1.12	0.264561	