RESULTS

Below we describe patterns of variation functional dispersion as they relate to the hydrological metrics described in Table 2 Statistics for all univariate regression models are shown in Table 5.

Table 5. Statistics for univariate linear regression models comparing FDis with hydrological metrics. p.adj represents p values which have been adjusted to control the false discovery rate. Relationships which remained significant following adjustment are shown in bold typeface. \* All models are linear apart from M\_MinM for which a quadratic model (df = 2,12) provided a substantially better fit.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| metric | p | p.adj | R2 | F(1,13) |
| CVAnnHSPeak | **0.0010** | **0.0152** | **0.5773** | **17.7500** |
| M\_MinM | **0.0094** | **0.0278** | **0.5404** | **\*7.0560** |
| MDFMDFSummer | **0.0031** | **0.0230** | **0.5032** | **13.1700** |
| CVMDFSummer | **0.0218** | **0.0325** | **0.4716** | **\*5.3560** |
| CVMDFWinter | **0.0096** | **0.0278** | **0.4143** | **9.1940** |
| CVAnnMRateRise | **0.0110** | **0.0278** | **0.4031** | **8.7810** |
| CVAnnMRateFall | **0.0129** | **0.0278** | **0.3896** | **8.2990** |
| MDFMDFSpring | **0.0134** | **0.0278** | **0.3862** | **8.1800** |
| AS20YrARI | **0.0148** | **0.0278** | **0.3774** | **7.8790** |
| M\_MDFM | **0.0209** | **0.0325** | **0.3470** | **6.9080** |
| M\_MaxM | **0.0258** | **0.0325** | **0.3275** | **6.3300** |
| CVMDFSpring | **0.0260** | **0.0325** | **0.3269** | **6.3130** |
| CVMDFAutumn | **0.0342** | **0.0386** | **0.3009** | **5.5950** |
| CVAnnHSNum | **0.0360** | **0.0386** | **0.2961** | **5.4680** |
| HSPeak | 0.0648 | 0.0648 | 0.2384 | 4.0690 |
| MDFMDFWinter | 0.0881 | 0.0780 | 0.2073 | 3.4010 |
| C\_MaxM | 0.0885 | 0.0780 | 0.2069 | 3.3920 |
| C\_MDFM | 0.1086 | 0.0861 | 0.1859 | 2.9680 |
| MDFMDFAutumn | 0.1091 | 0.0861 | 0.1854 | 2.9590 |
| C\_MinM | 0.1361 | 0.1021 | 0.1626 | 2.5240 |
| MRateRise | 0.1556 | 0.1072 | 0.1488 | 2.2720 |
| MRateFall | 0.1572 | 0.1072 | 0.1477 | 2.2530 |
| MDFAnnHSNum | 0.7270 | 0.4741 | 0.0097 | 0.1273 |

*Comparisons with regional environmental variables and species richness*

No significant relationships were identified between FDis and latitude (p = 0.717, F(1,13) = 0.137), elevation above sea level (p = 0.518, F(1,13) = 0.441) and a weak, non-significant relationship was found between FDis and catchment area (p = 0.069, F(1,13) = 3.925). Across species used in the functional diversity analysis (i.e. present at above 1 % plot cover), FDis was independent of species richness (p = 0.274, F(1,13) = 1.302) and Simpson diversity (p = 0.513, F(1,13) = 0.454).

*Is functional diversity related to the frequency and magnitude of flooding disturbance?*

Functional dispersion was positively associated with metrics describing intense but rare episodes of flooding disturbance. FDis was significantly explained by the magnitude of the 20 year average return interval flood (AS20YrARI, Fig 2a.). FDis was significantly explained by interannual variability in high flow magnitude (CVAnnHSPeak, Fig. 2b) and rates of flow rise (CVAnnMRateRise, Fig. 2c) and fall (CVannMRateFall, Fig. 2d), whereas relationships with metrics describing average conditions (mean high flow magnitude, HSPeak; mean flood rise rate, MRateRise; mean flood fall rate, MRateFall) were not significant. Likewise, while interannual variability in flood frequency (Fig. 2e) bore some relationship with FDis, mean annual flood frequency did not. These results indicate that functional diversity is elevated at sites which experience extreme flooding events and patterns of flow which diverge strongly from average conditions.



Figure 2. Relationships between FDis and hydrological metrics describing a) magnitude of the 20 year average return interval flood (AS20YrARI), b) interannual variability in high flow magnitude (CVAnnHSPeak), c) interannual variability in flood rise rate (CVAnnMRateRise), d) interannual variability in flood fall rate (CVAnnMRateFall), e) interannual variability in high flow frequency. Fitted lines depict ordinary least squares regression models. All models are linear fits. Shaded areas depict the smoothed 95% confidence interval around the regression model.

*Is functional diversity related to variability in seasonal water availability in the riparian zone?*

Higher functional diversity was positively associated with variability in seasonal flow patterns throughout the hydrological record. Functional dispersion was increased when seasonal patterns of minimum (M\_MinM, Fig. 3a), maximum (M\_MaxM, Fig. 3b) and average (M\_MDFM, Fig. 3c) flows became less uniform (smaller values of M) between years. In other words, at high FDis, the season which these flows were associated with was not consistent through the record. FDis was not significantly explained by interseasonal uniformity of minimum (Fig. 3d, C\_MinM) or average (Fig. 3e, C\_MDFM) flows, although visual inspection of the scatterplots for these relationships indicates two sites at the lower bound of the x axis (i.e. strongly seasonal patterns of flow), with substantially lower FDis than predicted by the regression model. If we consider this trend, we can infer that functional dispersion was increased when discharge patterns differed strongly between seasons, but the season with which those patterns were associated was not consistent between years.



Figure 3. Relationships between FDis and hydrological metrics describing a) contingency of monthly minimum daily flow (M\_MinM), b) contingency of monthly maximum daily flow (M\_MaxM), c) contingency of monthly mean daily flow (M\_MDFM), d) constancy of monthly minimum daily flow (C\_MinM), e) constancy of monthly mean daily flow (C\_MDFM). Fitted lines depict ordinary least squares regression models. a. is a quadratic fit, b. – e. are linear fits. Shaded areas depict the smoothed 95% confidence interval around the regression model.

This finding was corroborated by positive relationships between FDis and variability in mean daily flows for autumn (CVMDFAutumn, Fig. 4a), winter (CVMDFWinter, Fig. 4b), spring (CVMDFSpring, Fig. 4c). Summer flow variability (CVMDFSummer, Fig. 4d) exhibited a humped relationship with FDis. Mean daily flows for both summer and spring were associated with FDis, however. This relationship was positive for summer (MDFMDF Summer, Fig. 4e) and negative for spring (MDFMDFSpring, Fig. 4f). Note that this metric actually represents the ratio of seasonal mean daily flow to the general mean of daily flow for a given river, since metrics describing discharge were standardised by mean daily flow. Even though FDis was highest at sites where average flow is not associated with any particular season (low M\_MDFM), these sites still had high values for mean daily flow in summer. Pearson correlation confirms a significant negative relationship between M\_MDFM and MDFMDFSummer (r = -0.657, p = 0.008) but not C\_MDFM and MDFMDFSummer (r = -0.423, p = 0.1164). Summer mean daily flow may have been inflated by exceptional periods where very high average flows occurred during summer. Mean daily flow in spring, conversely, was strongly positively correlated with M\_MDFM (r = 0.8357, p = 0.0001) and C\_MDFM (r =0.7839, p = 0.0005), indicating that where mean daily flows in spring are high, this pattern is stable and consistent between years.



Figure 4. Relationships between FDis and hydrological metrics describing a) variability in autumn mean daily flow, b) variability in winter mean daily flow, c) variability in spring mean daily flow, d) variability in summer mean daily flow, e) mean daily flow in summer, f) mean daily flow in spring. Fitted lines depict ordinary least squares regression models. All models are linear fits except d. which is a quadratic fit. Shaded areas depict the smoothed 95% confidence interval around the regression model.

*A minimal multiple regression model to explain functional diversity according to hydrology*

We used an information theoretic procedure to select the best fitting, most parsimonious multiple regression model from the factorial set of possible models which included FDis as the dependent variable, and the following independent variables: interannual variability in high flow frequency (CVAnnHSNum), interannual variability in high flow magnitude (CVAnnHSPeak) and mean daily flow during summer (MDFMDFSummer). This set of models is described in Table 6.

Table 6. Multiple regression models with associated fitting parameters. \* in the model formula denotes both summation as well as interaction between variables. R2 values have been adjusted for multiple regression for models using more than one variable. The optimal model according to AICc is indicated by bold typeface.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| # | Model | R2 | AICc | delta AIC |
| 1 | FDis ~ CVAnnHSNum | 0.2961 | -46.1414 | 12.78193 |
| 2 | FDis ~ CVAnnHSPeak | 0.5773 | -53.7899 | 5.13339 |
| 3 | FDis ~ MDFMDFSummer | 0.5032 | -51.3678 | 7.55549 |
| 4 | FDis ~ CVAnnHSNum + CVAnnHSPeak | 0.6359 | -54.5235 | 4.39977 |
| 5 | FDis ~ CVAnnHSNum + MDFMDFSummer | 0.6809 | -56.5027 | 2.4206 |
| 6 | FDis ~ CVAnnHSPeak + MDFMDFSummer | 0.5609 | -51.7131 | 7.21018 |
| 7 | FDis ~ CVAnnHSNum \* CVAnnHSPeak | 0.6545 | -51.9494 | 6.97387 |
| 8 | FDis ~ CVAnnHSNum\* MDFMDFSummer | 0.6647 | -52.3972 | 6.52611 |
| 9 | FDis ~ CVAnnHSPeak \* MDFMDFSummer | 0.5663 | -48.538 | 10.38533 |
| 10 | FDis ~ CVAnnHSNum + CVAnnHSPeak + MDFMDFSummer | 0.7036 | -54.2478 | 4.67554 |
| 11 | FDis ~ CVAnnHSNum \* CVAnnHSPeak + MDFMDFSummer | 0.7093 | -50.138 | 8.78527 |
| **12** | **FDis ~ CVAnnHSNum + CVAnnHSPeak \* MDFMDFSummer** | **0.8382** | **-58.9233** | **0** |
| 13 | FDis ~ CVAnnHSNum \* CVAnnHSPeak \* MDFMDFSummer | 0.9437 | -48.6223 | 10.30101 |

Model 12 was determined to be the optimal model according to AICc. Models 4, 5 and 10 were close to optimal but offered lower explanatory power according to the adjusted of the model R2. Although Model 13 offered higher explanatory power, it was less parsimonious according to AICc and exhibited multicollinearity. Multicollinearity was determined not to be of importance for Model 12 according to variance inflation factor scores (all < 3 on centred variables). All terms in Model 12 were individually significant; a full description of the model is given in Table 7**.** Notably, the coefficient of the interaction term was negative, indicating a diminishing influence on FDis when values of CVAnnHSPeak and MDFMDFSummer are both high.

Table 7. Regression summary for Model 12. Beta values are regression coefficents standardised by the standard deviation of the term.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | B | SE | beta | t | p |
| CVAnnHSNum | 0.240 | 0.054 | 0.540 | 4.414 | 0.0013 |
| CVAnnHSPeak | 0.071 | 0.026 | 0.498 | 2.773 | 0.0197 |
| MDFMDFSummer | 0.074 | 0.024 | 0.506 | 3.056 | 0.0121 |
| CVAnnHSPeak\*MDFMDFSummer | -0.190 | 0.060 | -0.459 | -3.186 | 0.0097 |