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Synthesizing the impacts of baseflow contribution on concentration–discharge (C–Q) relationships across Australia using a Bayesian hierarchical model

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Table S1. Recommendations on the filtering of flow and water quality data for analysis based on quality code (QC), obtained from individual state agencies.

<table>
<tr><th>State</th><th>NSW</th><th>SA</th><th>TAS</th><th>VIC</th><th>NT</th><th>QLD</th><th>WA</th></tr>
<tr><td>State agency contacted</td><td>WaterNSW</td><td>SA DEW</td><td>TAS DPIPWE</td><td>VIC DELWP</td><td>NT DEPWS</td><td>QLD DNRME</td><td>WA DER</td></tr>
<tr><td>QC recommendation for filtering flow data</td><td>QC<152 identifies suitable flow data for analysis</td><td>QC<=30 identifies suitable flow data for analysis</td><td rowspan="2">QC>=51 identifies suitable flow and water quality data for analysis</td><td rowspan="2">QC<=150 identifies suitable flow and water quality data for analysis</td><td rowspan="2">QC<100 identifies suitable flow and water quality data for analysis</td><td rowspan="2">QC<=26 identifies suitable flow and water quality data for analysis</td><td rowspan="2">QC<=3 identifies suitable flow and water quality data for analysis</td></tr>
<tr><td>QC recommendation for filtering water quality data</td><td>No QC records</td><td>QC for WQ not generally used for filtering data</td></tr>
</table>

Table S2. The ranges and medians of percentage of water quality data with multiple records in the same day for individual study catchments and for each water quality variable.

Water quality variable	min/%	median/%	max/%
TSS	0	3.36	65.4
TP	0	1.10	44.5
SRP	0	1.51	40.1
TN	0	0.54	44.5
NOx	0	0.89	28.3
EC	0	12.7	65.9

Table S3. The ranges and medians of percentage missing/erroneous flow data (which were then in-filled with AWRA-L model) for individual study catchments and for each water quality variable.

Water quality variable	min/%	median/%	max/%
TSS	0	0.13	46.3
TP	0	0	46.3
SRP	0	2.81	46.3
TN	0	0.72	46.3
NOx	0	3.98	46.3
EC	0	0.01	61.0

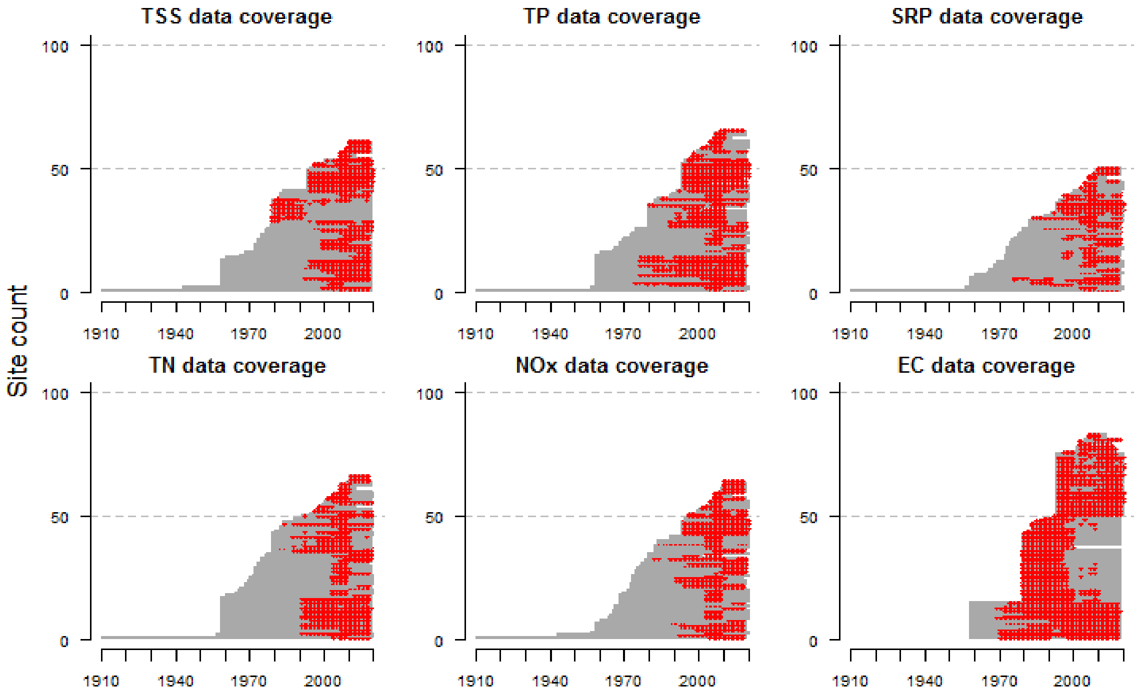

Figure S1. The temporal coverage of flow data (grey bars) and water quality data (red dots) across all catchments studied for individual water quality variables.

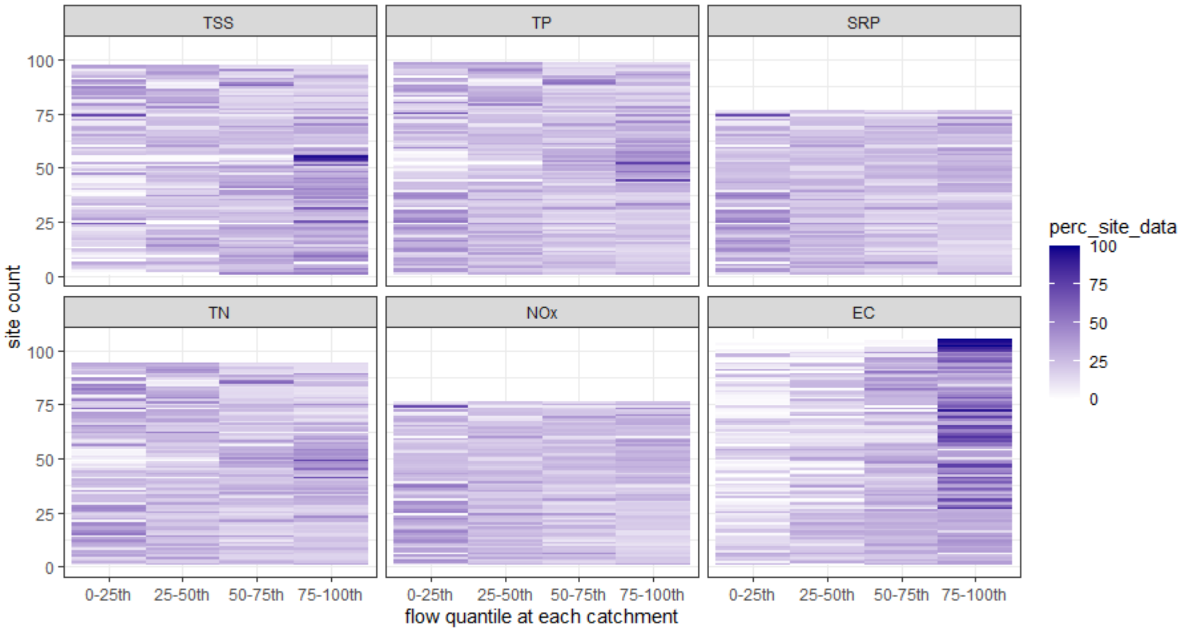

Figure S2. Flow regimes covered by the samples of each water quality variable, shown as the percentage of samples within each 25th percentile of the long-term daily flow. Each plot summarizes all catchments studied for individual water quality variables.

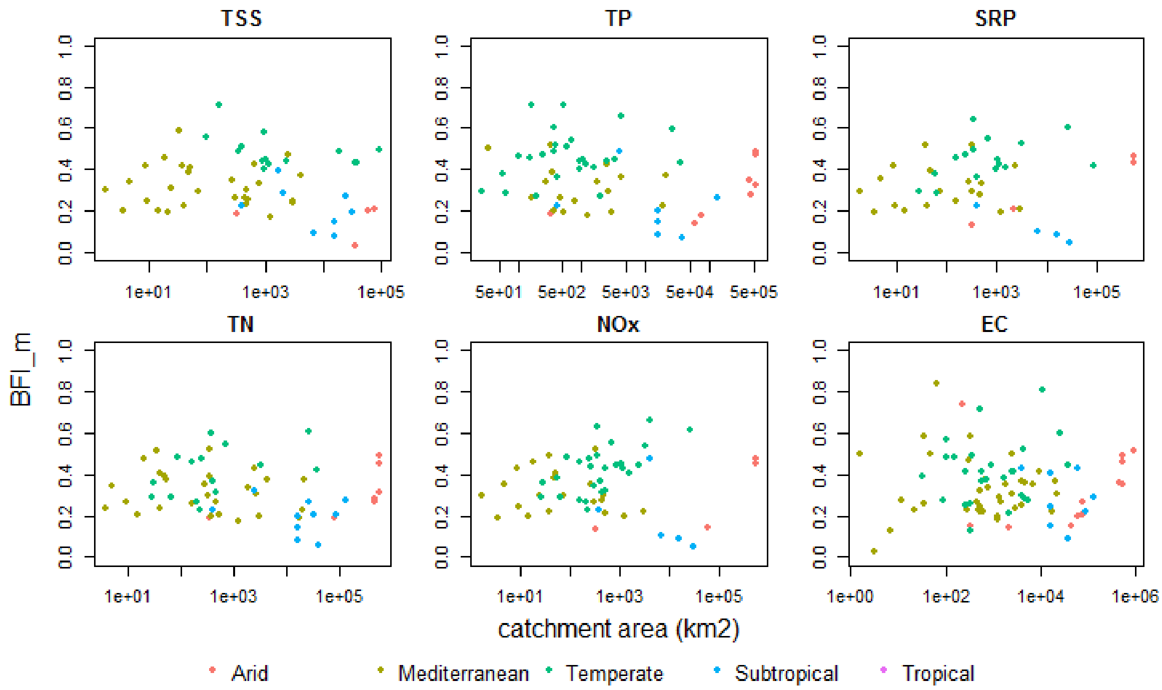

Figure S3. Relationship between *BFI_m* and catchment area (km2) for catchments analysed in each water quality variable.

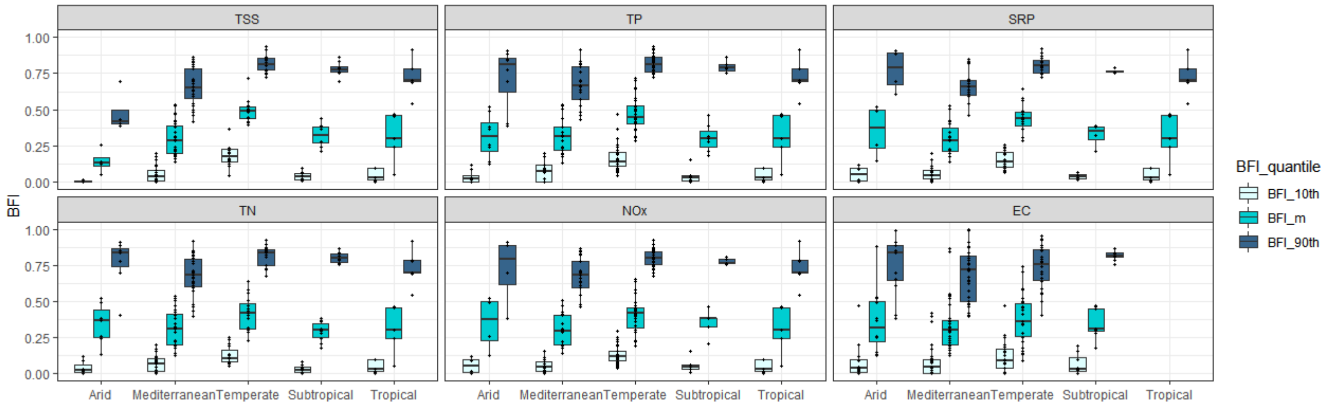

Figure S4. Range *BFI_m*, *BFI_10th* and *BFI_90th*, for catchments in each climate zone for each water quality variable analysed.

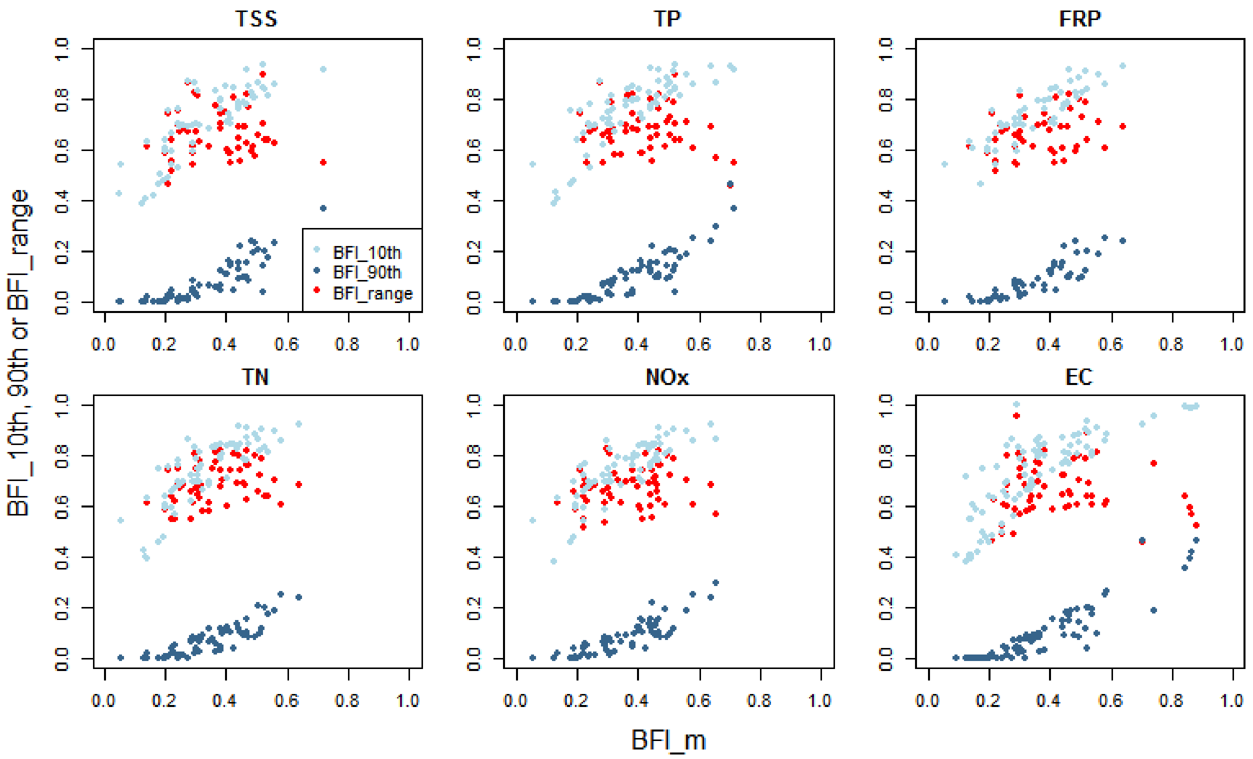

Figure S5. The 10th and 90th percentiles of daily BFI (*BFI_10th* and *BFI_90th*), and *BFI_range* (*BFI_90th – BFI_10th*) versus *BFI_m*, each panel shows all catchments analysed in each water quality variable.

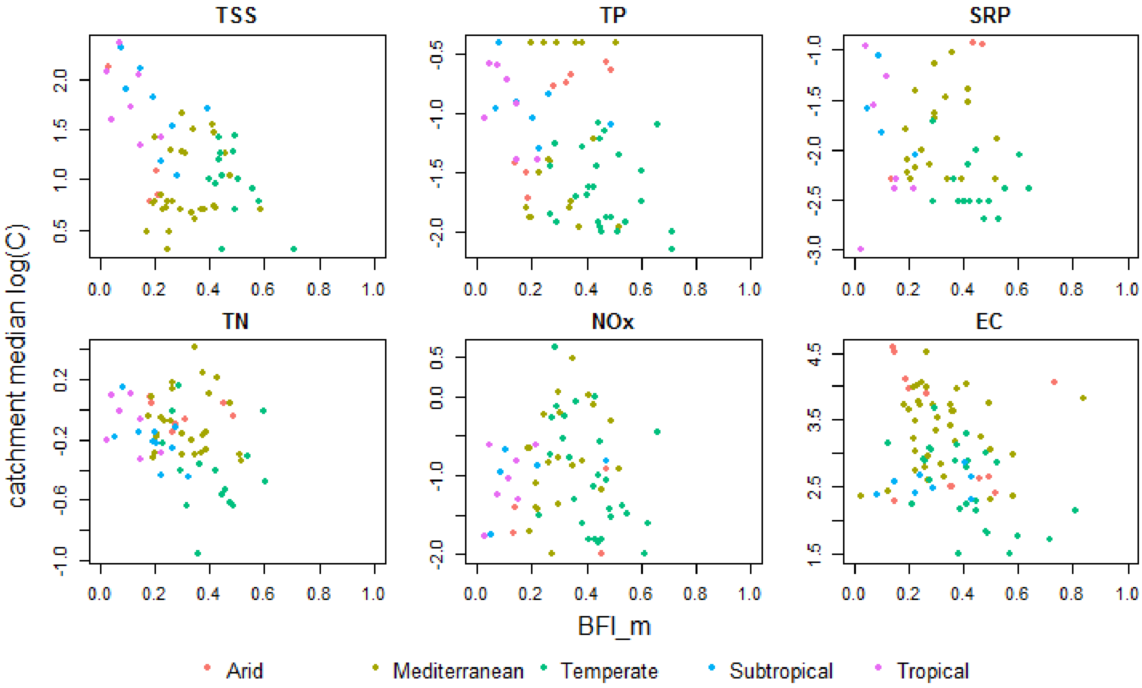

Figure S6. Relationship between *BFI_m* and catchment median concentration (in log scale) for each water quality variable.

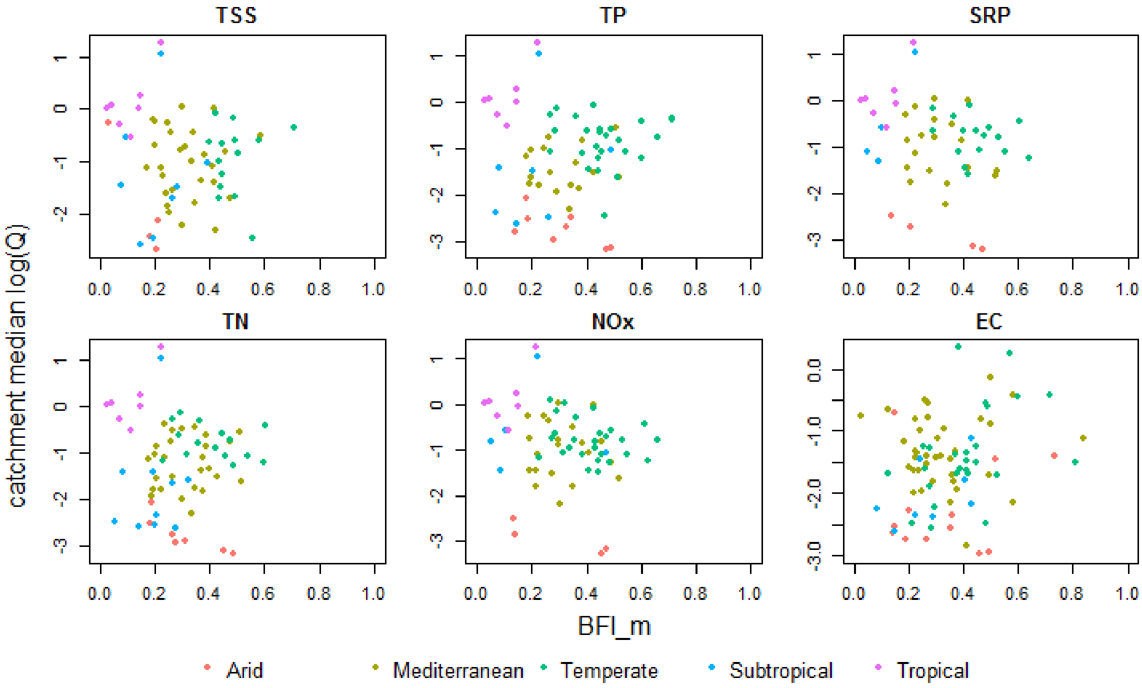

Figure S7. Relationship between *BFI_m* and catchment median flow (in log scale) for catchments analysed in each water quality variable.

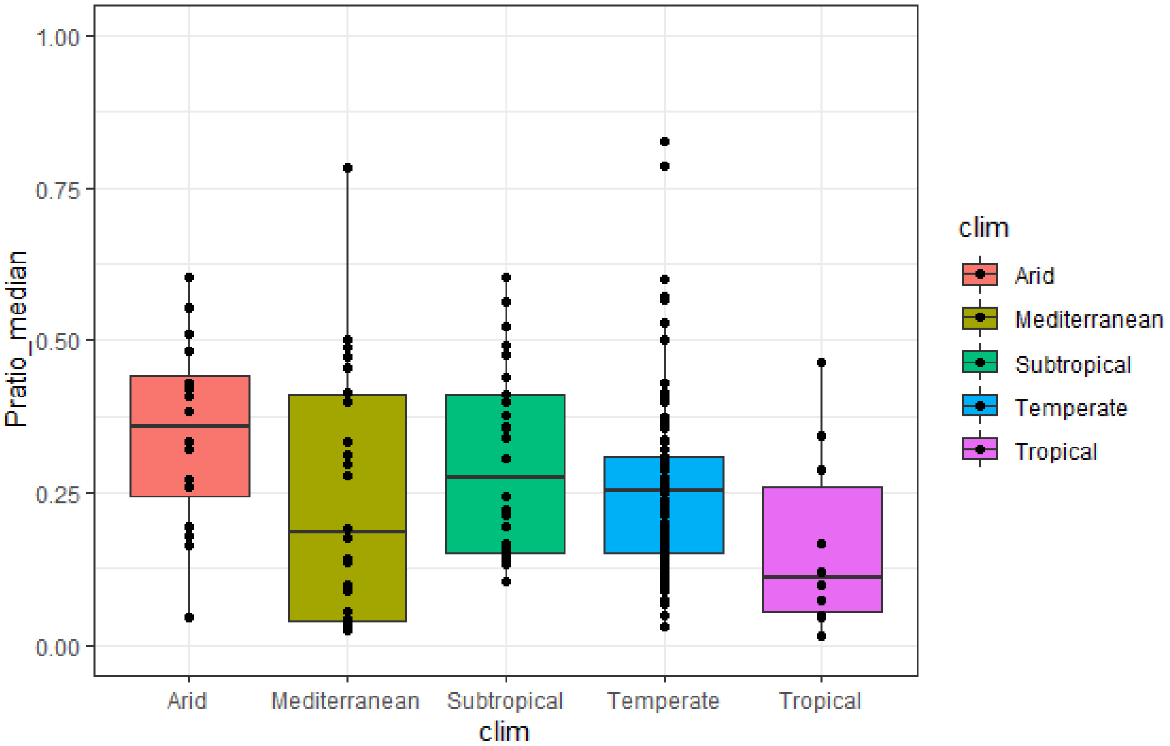

Figure S8. median SRP:TP ratio at individual catchments, by climate zones

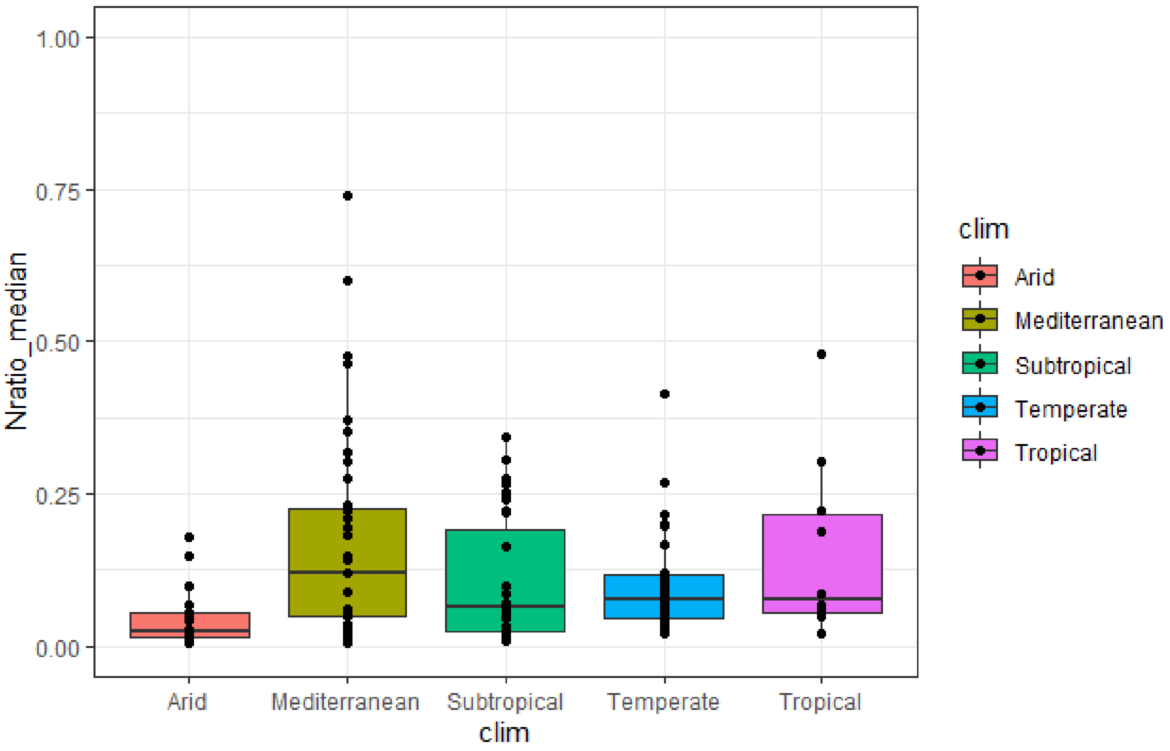

Figure S9. median NOx:TN ratio at individual catchments, by climate zones

```
data {
  int<lower=1> N;                              // total data points
  int<lower=1> Nsite;                          // total number of catchments

  int<lower=1,upper=Nsite> site[N];            // Catchment ID
  int<lower=1,upper=5> catkoppen[Nsite];       // climate zone - all catchments

  real C[N];                                   // water quality data - all catchments
  real Q[N];                                   // flow matched to water quality data - all catchments

  real catBFI[Nsite];                          // catchment median BFI (BFI_m)
}
parameters {
  real Betamu;                                 // modelled grand-mean of climate-specific effect (beta_0) of catchment median BFI
  real eff_catBFI[5];                          // modelled climate-specific effect of catchment median BFI

  real Alpha[Nsite];                           // modelled CQ intercept
  real<lower=0> sign;                          // SD for modelled water quality

}
transformed parameters {
  real yhat[N];
  vector[Nsite] BetaQ;                                          // modelled CQ slope

  for (n in 1:Nsite) {
    BetaQ[n] = Betamu + eff_catBFI[catkoppen[n]] * catBFI[n];   // climate-specific effect of BFI_m on CQ slope (Eqn. 2)
  }
  for (n in 1:N) {
    yhat[n] =  Alpha[site[n]] + Q[n]*BetaQ[site[n]];            // classic CQ relationship (Eqn. 1)
  }
}
model {                                        // Bayesian MCMC
  sign ~ normal(0,10);                         // SD for modelled water quality - minimally informative prior
  Betamu ~ normal(0,10);                       // beta_0 - minimally informative prior

  for (n in 1:Nsite) {
    Alpha[n] ~ normal(0,10);                   // CQ intercept for each site - minimally informative prior
  }

  for(j in 1:5){
    eff_catBFI[j] ~ normal(0,10);              // modelled climate-specific effect of catchment median BFI for each climate zone - minimally informative prior
  }

  C ~ normal(yhat,sign);                       // modelled water quality
}
```

Figure S10. Rstan codes for the model with *BFI_m* as the main predictor

```
data {
  int<lower=1> N;                              // total data points
  int<lower=1> Nsite;                          // total number of catchments

  int<lower=1,upper=Nsite> site[N];            // Catchment ID
  int<lower=1,upper=5> catkoppen[Nsite];       // climate zone - all catchments

  real C[N];                                   // water quality data - all catchments
  real Q[N];                                   // flow matched to water quality data - all catchments

  real BFIrange[Nsite];                        // catchment BFI range (range between 10th and 90th BFI, BFI_range)
}
parameters {
  real Betamu;                                 // modelled grand-mean of climate-specific effect (beta_0) of catchment median BFI
  real eff_BFIrange[5];                        // modelled climate-specific effect of BFI_range

  real Alpha[Nsite];                           // modelled CQ intercept
  real<lower=0> sign;                          // SD for modelled water quality

}
transformed parameters {
  real yhat[N];
  vector[Nsite] BetaQ;                                          // modelled CQ slope

  for (n in 1:Nsite) {
    BetaQ[n] = Betamu + eff_BFIrange[catkoppen[n]] * BFIrange[n];   // climate-specific effect of BFI_range on CQ slope (Eqn. 2)
  }
  for (n in 1:N) {
    yhat[n] =  Alpha[site[n]] + Q[n]*BetaQ[site[n]];            // classic CQ relationship (Eqn. 1)
  }
}
model {                                        // Bayesian MCMC
  sign ~ normal(0,10);                         // SD for modelled water quality - minimally informative prior
  Betamu ~ normal(0,10);                       // beta_0 - minimally informative prior

  for (n in 1:Nsite) {
    Alpha[n] ~ normal(0,10);                   // CQ intercept for each site - minimally informative prior
  }

  for(j in 1:5){
    eff_BFIrange[j] ~ normal(0,10);            // modelled climate-specific effect of BFI_range for each climate zone - minimally informative prior
  }

  C ~ normal(yhat,sign);                       // modelled water quality
}
```

Figure S11. Rstan codes for the model with *BFI_range* as the main predictor