Online Supplementary Material

Appendices to *Looking for compensation at multiple scales in a wetland bird community.* Barraquand F., Picoche C., Aluome C., Carassou L., and Feigné C.

Appendix S1 - Temporal patterns of in the Teich bird community

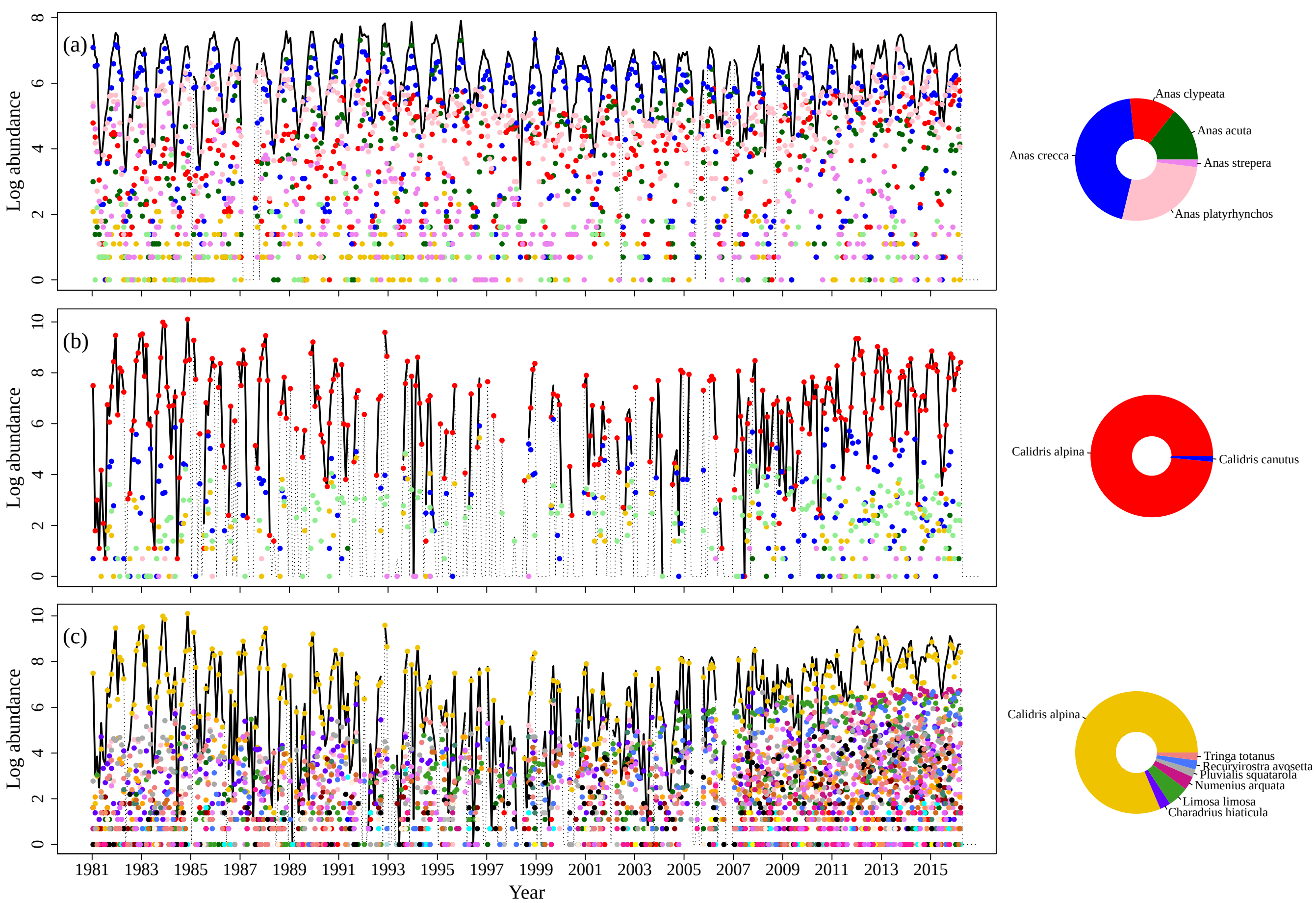


Figure S1: Time series of counts for ducks of the genus *Anas* (a), calidrids (b, *Calidris* genus), and all waders (c, including calidrids). The solid black lines represent trends in summed abundances for each guild when abundances are strictly positive, thin dotted lines connect positive to zero abundances. The coloured symbols below the curves represent each species abundances, with species composition on the right side on the donut plots for the most abundant species (over 1% of relative abundance in the group considered).

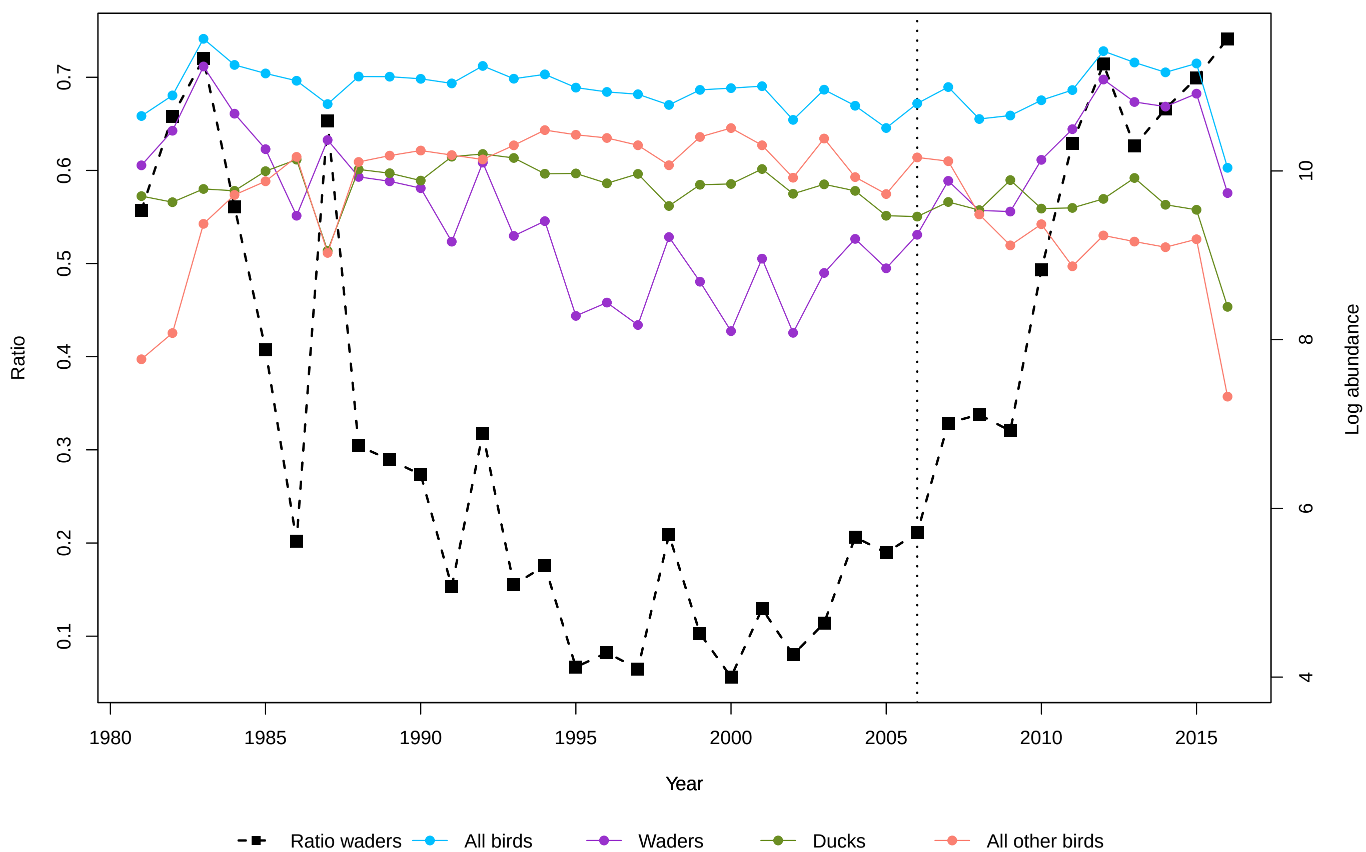


Figure S2: Temporal trends in the abundance of all birds and the main functional groups (waders and ducks), with one point per year. The duck category actually includes all species functionally similar to ducks (i.e., anatids and the common coot). The dashed line presents the ratio of wader individuals in the whole community, which changes over time.

Appendix S2 - Gross synchrony index at the whole community level

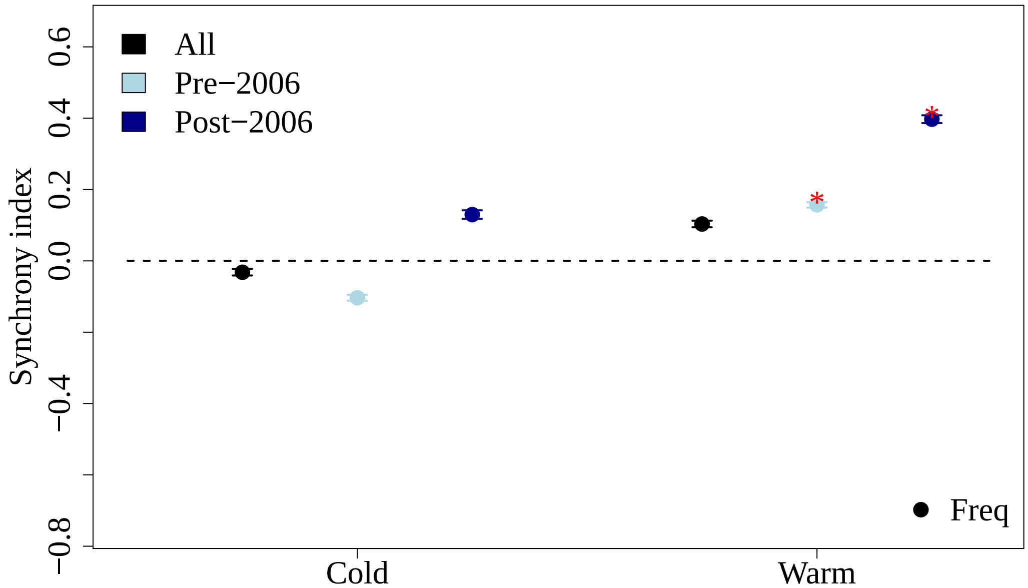


Figure S3: Gross' synchrony index as a function of the season (cold and warm seasons), calculated among the 60 most frequent species in the Teich reserve. The index was computed in each panel on the whole dataset (black) or using two periods: before and after 2006 (light and dark blue), the year of the change in water level management. Red stars correspond to synchrony values significantly different from the null model (independent species), at the Bonferroni-corrected 10% threshold.

Appendix S3 - Correlation in log-scale betwen cormorant and heron+egret

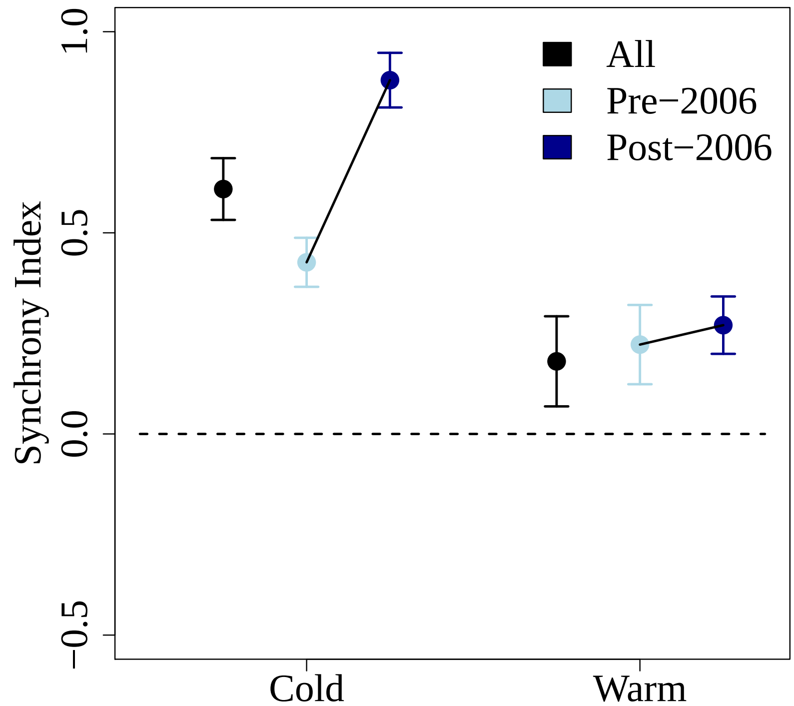


Figure S4: Gross' synchrony index as a function of the season (cold and warm seasons), calculated on log-transformed abundance data for the two groups formed by cormorant and heron+egret. The index was computed in each panel on the whole dataset (black) or using two periods: before and after 2006 (light and dark blue), the year of the change in water level management.

We noted on Fig. 4 in the main text that cormorants, herons and egrets seemed to compensate each other, at least for the first period of the time series. This compensation was seen on a log scale, and seemed conspicuous on that scale. We thus wondered if log-transforming the abundance would affect the values of the synchrony index observed for this group, and make compensation more likely. It appears to be the reverse: synchrony values are higher with log-transformed abundances.

Appendix S4 - Properties of the Gross whole community synchrony index η when two groups react in opposite ways

Here, we make η vary with the number of species, richness of the community, and the strength of the effect of the environment. Starting from the model developped by Gross et al. [1] (developed in their Appendix D), we explored the effect of a ~~common~~shared environmental driver on a community formed by two groups reacting oppositely to this driver.

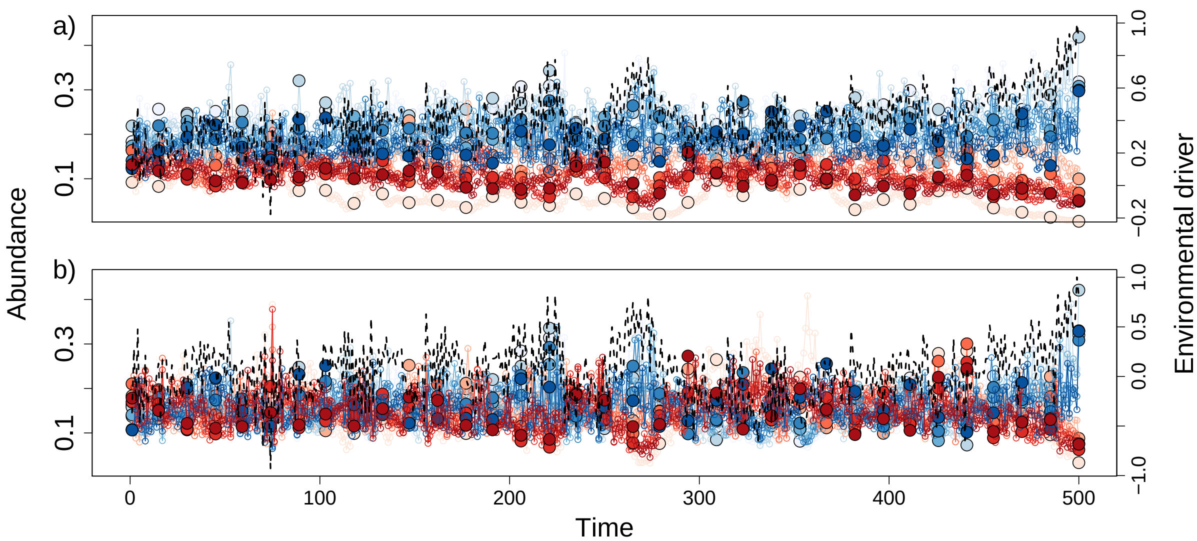


Figure S5: Time series for a community of 10 species, with a strong effect of the environment (b=0.75, see eq. 1) and a time series of 500 time steps. Open circles represent all points of the time series while large filled circles correspond to the sub-sampling of the time series (keeping only 35 points). Cold colors indicate species which react positively to the environmental signal and warm colors indicate species which have a negative reaction to the same signal. The environmental signal is shown in black, dashed lines, and indexed on the right axis. This signal either follows an increasing trend (a), or just an autocorrelated signal (b).

We assume that the environmental driver $U(t)$ is an autocorrelated signal (see below for details).

The dynamics of species i then follows the equation 1:

$$x_i(t+1) = x_i(t) \exp\left(r_i \left(1 - \frac{x_i(t) + \sum_{i \neq j}^{n} \alpha x_j(t)}{K} \right) + b_i U(t) + \epsilon_i(t) \right) \tag{1}$$

where the whole community is formed by $N = 2n$ species, with 2 groups of n species who have exactly opposite reaction to the environmental driver, that is $\forall i \in [1,n], \exists j \in [1,n], b_j = -b_i = b$. The growth rate r_i follows a normal distribution with mean 1 and standard deviation 0.25. All interaction coefficients α are set to 0.5 and $K = \frac{1+\alpha(N-1)}{N}$, to keep the model in other ways exactly similar to Gross et al. [1]. The noise $\epsilon_i(t)$ is normally distributed, centered on 0 with a standard deviation of 0.1.

We compared results for time series of length 35 (the length of our data set when computing η), 100 and 500. For all simulation experiments, the dynamics are first run for 500 time steps as a burn-in. To take into account different observational designs, we either take the first 35 or 100 time steps of the following 500-time steps series, or subsample the time series ~~after burn-in~~in order to get 35 or 100 time points (which removes some autocorrelation in the dynamics). We also considered several community richness (10, 30, 60 and 100 species), and several strengths of the response to the environmental signal (b =[0.1, 0.5, 0.75]). For each combination of parameters, we computed 10 repetitions (i.e., replicates).

We considered different types of environmental driver (simply autocorrelated or with a linear trend), crossed with subsampling / no subsampling as described above. We considered in total three scenarios, and present below ~~the results~~how an increasing strength of response to the environment changes expectations ~~-~~for all three:~~-~~

- Scenario 1: $U_t = u_t$ where u_t is an autocorrelated signal (standardized); no subsampling of the data

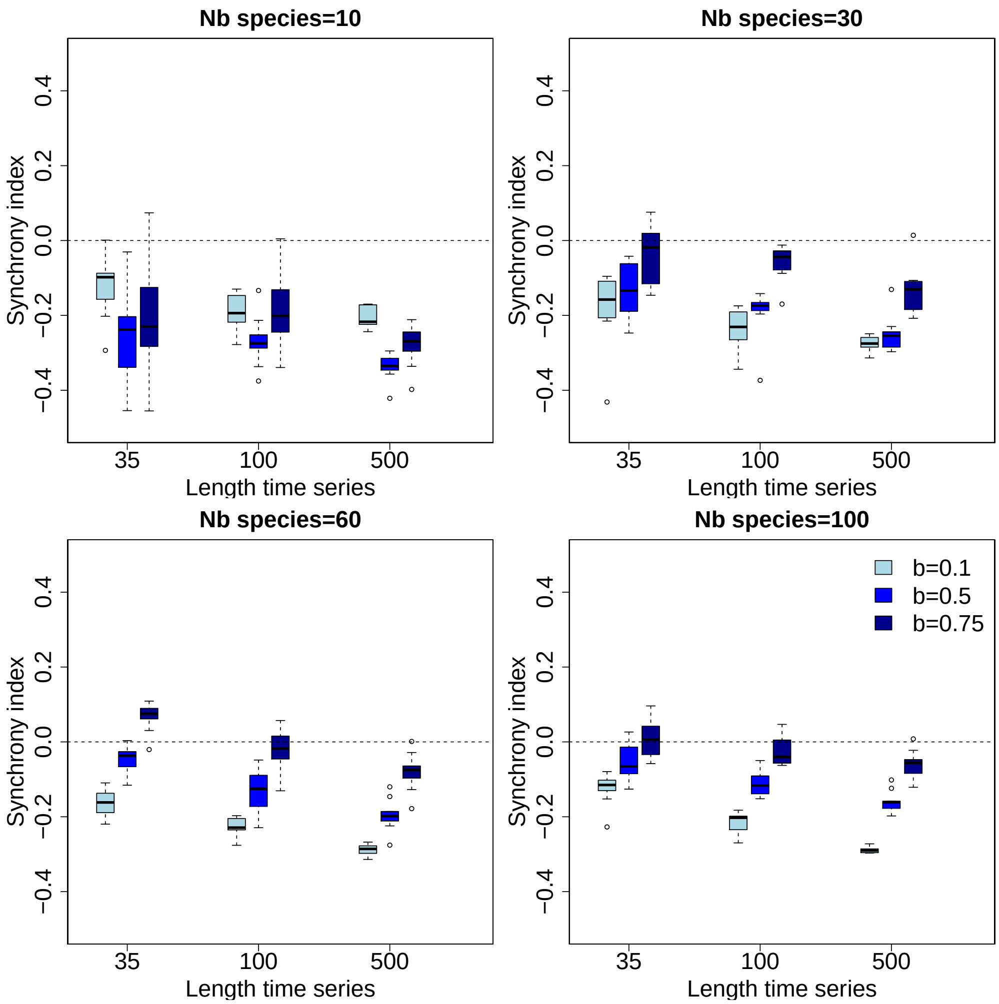


Figure S6: Evolution of Gross' synchrony index for different time series length and number of species in the community, in simulations where there is no trend in the environmental signal and the data is not subsampled, keeping the autocorrelation of the environment.

- Scenario 2: $U_t = u_t$; data subsampling

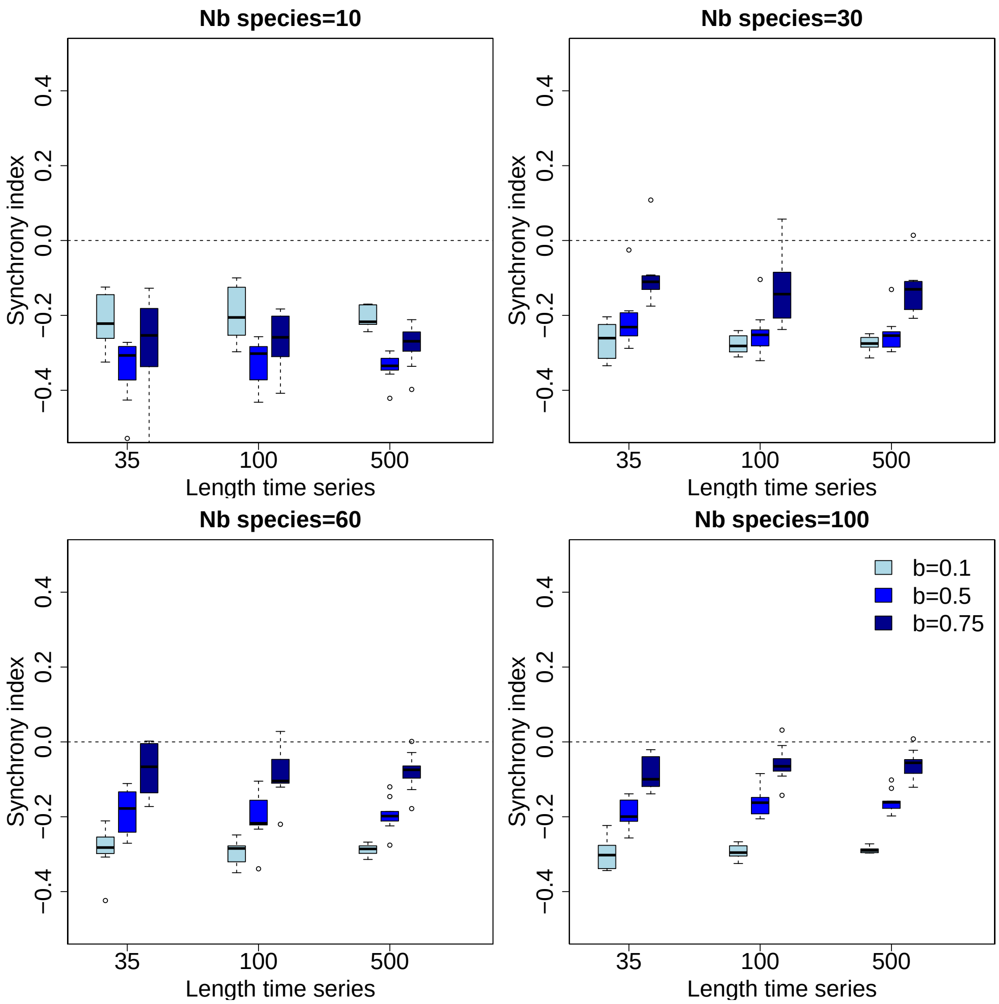


Figure S7: Gross' synchrony index for different time series length and number of species in the community, in simulations where there is no trend in the environmental signal and the data is subsampled (keeping 35 or 100 time steps), removing in effect the autocorrelation of the environment.

- Scenario 3: $U_t = U_{\min} + (U_{\max} - U_{\min})(u_t + x_t)/2$ where $x_t \in [0, 1]$ follows an increasing trend; data subsampling

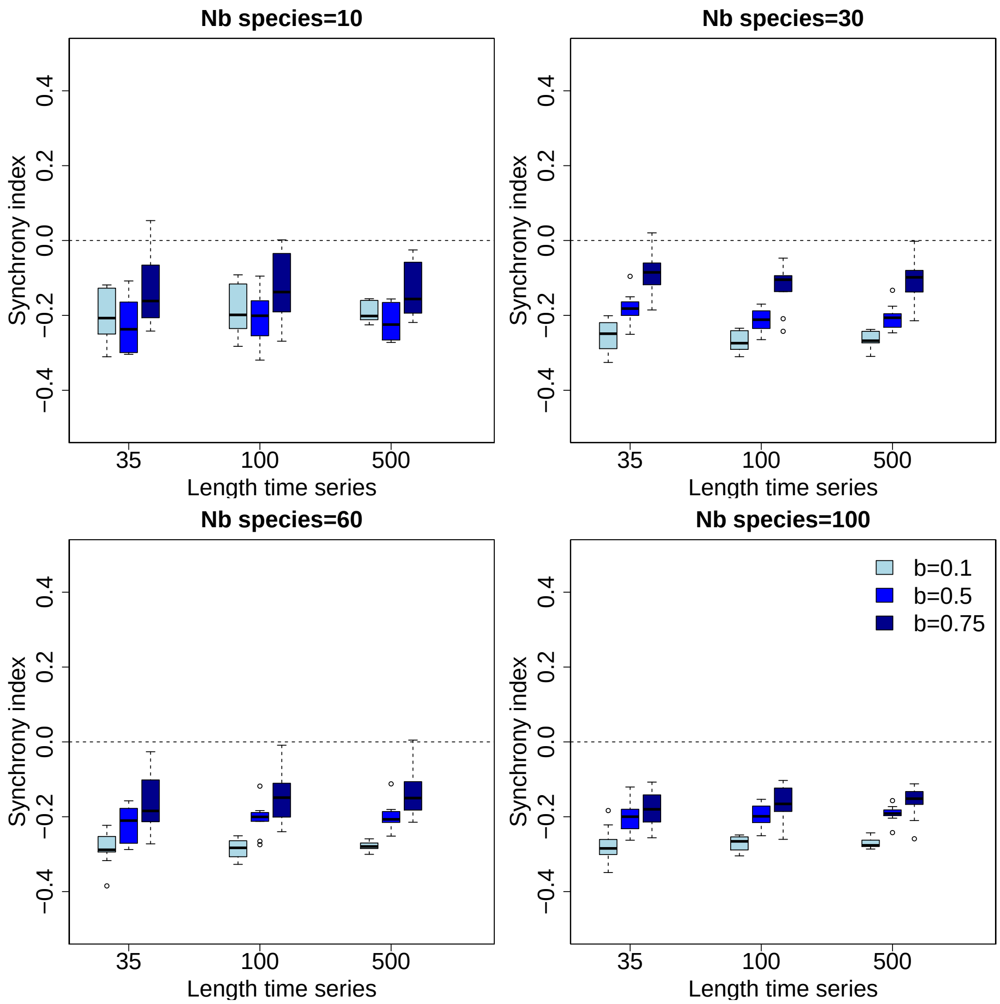
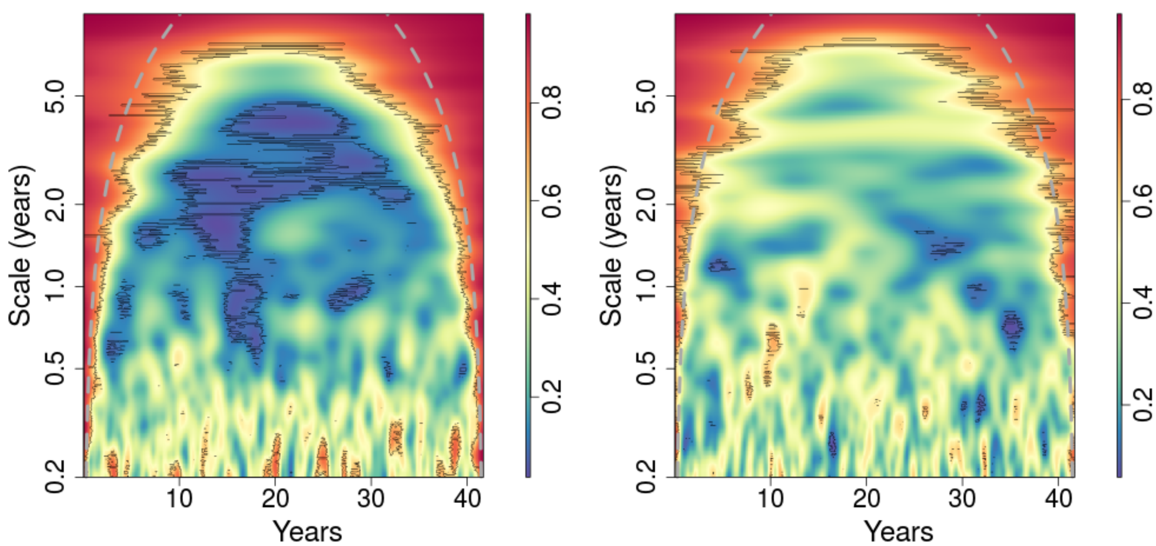


Figure S8: Gross' synchrony index for different time series length and number of species in the community, in simulations where there is an increasing trend in the environmental signal and the data is subsampled (for 35 or 100 time steps), removing part of the autocorrelation of the environment in the dynamics of the species

We first confirm that unless there is a very high temporal autocorrelation in the driver (as in Fig. S6), if we consider two groups which have opposite reactions to the same driver, the Gross index is not sensitive to the length of the time series or to the number of species in the community, in the sense that it will not indicate falsely synchrony. The main finding of these analyses, aside from the robustness of the η index, is that f~~F~~or large~~r~~ communities (over 10 species), synchrony is always higher when the response to the driver is stronger. ~~For our~~Coming back to the interpretation of our ~~data~~results in the Teich reserve case, this means that the more bird~~s are sensitive~~ population growth rates respond to changes in the water levels, the less we can expect compensation at the whole community level, even though compensation may be manifest at the functional group level (here, the group of species responding similarly to the environmental variable).

Appendix S5 - Effect of "missing" values on wavelet analyses

We investigate here if exactly-zero abundances can distort the compensation patterns evidenced by the wavelet coherence. We chose a "worst case" simulation with –10% missing values for all species, and few species ~~10)~~below that 10% level. The results show that while the statistical significance of the values can change (i.e., the data is more compatible with the null hypothesis of time series uncorrelated between species, assuming the null is true), the occurrence of compensation (blue values in Fig.S9) does not. The wavelet coherence index is therefore robust to the presence of zeroes in the time series.



(a) Without missing data

(b) With missing data

Figure S9: Wavelet coherence for a community with compensatory dynamics, without (~~left~~a) and with (~~right~~b) missing data

References

[1] Gross, K., Cardinale, B. J., Fox, J. W., Gonzalez, A., Loreau, M., Wayne Polley, H., Reich, P. B. & van Ruijven, J., 2013 Species richness and the temporal stability of biomass production: a new analysis of recent biodiversity experiments. *The American Naturalist* **183**, 1–12.