

Jacob Usinowicz, S. Joseph Wright, and Anthony R. Ives. 2012. Coexistence in tropical forests through asynchronous variation in annual seed production. *Ecology* 93:2073–2084.

Appendix A. Comparison of coexistence in the forest dynamics model under different parameter values.

Our forest dynamics model can exhibit both the storage effect and classical resource partitioning. These two mechanisms can be compared by asking how easy they make coexistence, where “easy” is assessed by the range of values of mean recruitment rates  $R_i$  that allow coexistence. Using the model parameterized for *S. mombin* and *S. radlkoferi*, we illustrate how several parameters of our forest dynamics model are related to coexistence between species pairs.

First consider the case of classical resource partitioning. Decreasing the strength of interspecific competition (measured by the product  $\alpha_{ij}\alpha_{ji}$ ) by increasing resource partitioning among seedlings produces a larger region of the ratio of mean recruitment rates  $\overline{R}_i / \overline{R}_j$  that permit coexistence (Fig. A1.A). Even though sufficiently high values of  $\overline{R}_i / \overline{R}_j$  lead to the exclusion of *S. radlkoferi*, and sufficiently small values lead to exclusion of *S. mombin*, coexistence is more likely as  $\alpha_{ij}\alpha_{ji}$  decreases. Asynchrony in recruitment has a similar impact on coexistence through the storage effect. As  $\rho$  decreases, there is a greater range of values of  $\overline{R}_i / \overline{R}_j$  over which species coexist (Fig. A1.B). Thus, classical resource partitioning and the storage effect can be compared directly in terms of how each increases the range of values of  $\overline{R}_i / \overline{R}_j$  over which species coexist.

In addition to  $\rho$ , both the species-specific variances and survival rates can impact the ease of coexistence (Fig. A1.C and A1.D). Thus, in models of the storage effect there is no simple set of

parameters (or pair of parameters) that dictates coexistence like the alpha competition coefficients in classical resource competition models. A comparison between resource partitioning and the storage effect requires a metric like  $A_{ij}A_{ji}$  that incorporates all parameters that affect coexistence.

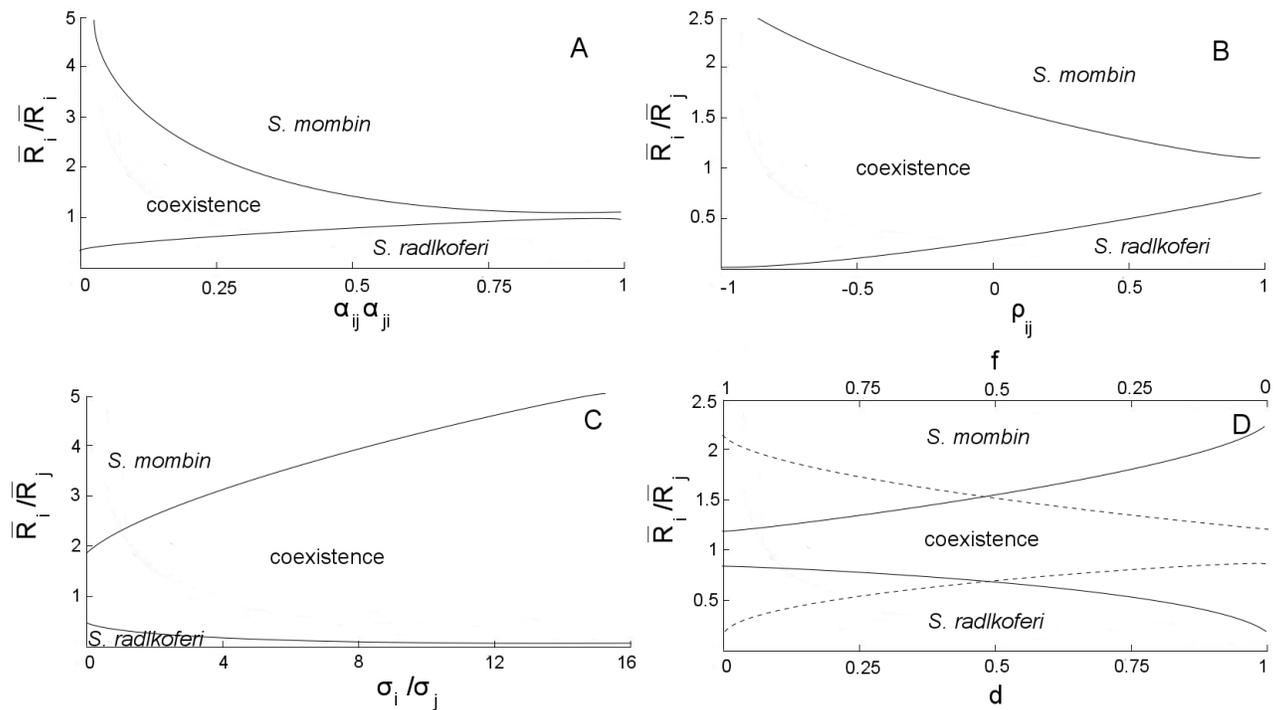


FIG. A1. Comparison of classical resource partitioning and the storage effect as coexistence mechanisms. (A) Classical resource partitioning (reduction in  $\alpha_{ij}\alpha_{ji}$ ) increases the region in which the ratio  $\bar{R}_i / \bar{R}_j$  allows coexistence. The storage effect has been removed by setting  $\sigma^2$  to 0. The storage effect depends on: (B) asynchrony  $\rho$ , (C) the variance in recruitment of one species relative to another  $\sigma_i / \sigma_j$ , and (D) longevity. In (D) we have plotted both the adult survival,  $d_i$  (solid lines), and sapling survival,  $f_i$  (dashed lines), on the same axis to demonstrate that the combined effect of longevity across multiple stages is not additive, but is instead redundant. In all simulations baseline parameter values

were those observed for the *Spondias* species:  $\sigma^2_{S. mombin} = 1.68$ ,  $\sigma^2_{S. radlkoferi} = 0.66$ ,  $\rho = -0.16$ ,  $d_i = d_j = 0.975$  and  $f_i = f_j = 0.6$ . For (C-D) resource partitioning was removed by setting  $\alpha_{ij} = \alpha_{ji} = \alpha_{ii} = \alpha_{jj} = 1$ . The parameter values not varied in all panels were  $\beta_{ii} = \beta_{jj} = 0$  and  $\kappa_{ii} = \kappa_{jj} = 0$ .

In general increasing intraspecific density dependence in the sapling stage,  $\beta_{ii}$  and  $\kappa_{ii}$  in Eq. 1, increases potential coexistence by decreasing values of  $A_{ij}A_{ji}$ . The results of holding  $\beta_{ii}$  constant and increasing  $\kappa_{ii}$ , and holding  $\kappa_{ii}$  constant and increasing  $\beta_{ii}$ , are illustrated for one parameter set in Fig. A2. This result is not dependent on the specific values of the parameters used; we tested for this relationship (i.e., the negative slope with increasing parameter values) for every pairwise combination of species presented in this manuscript and found it in every case.

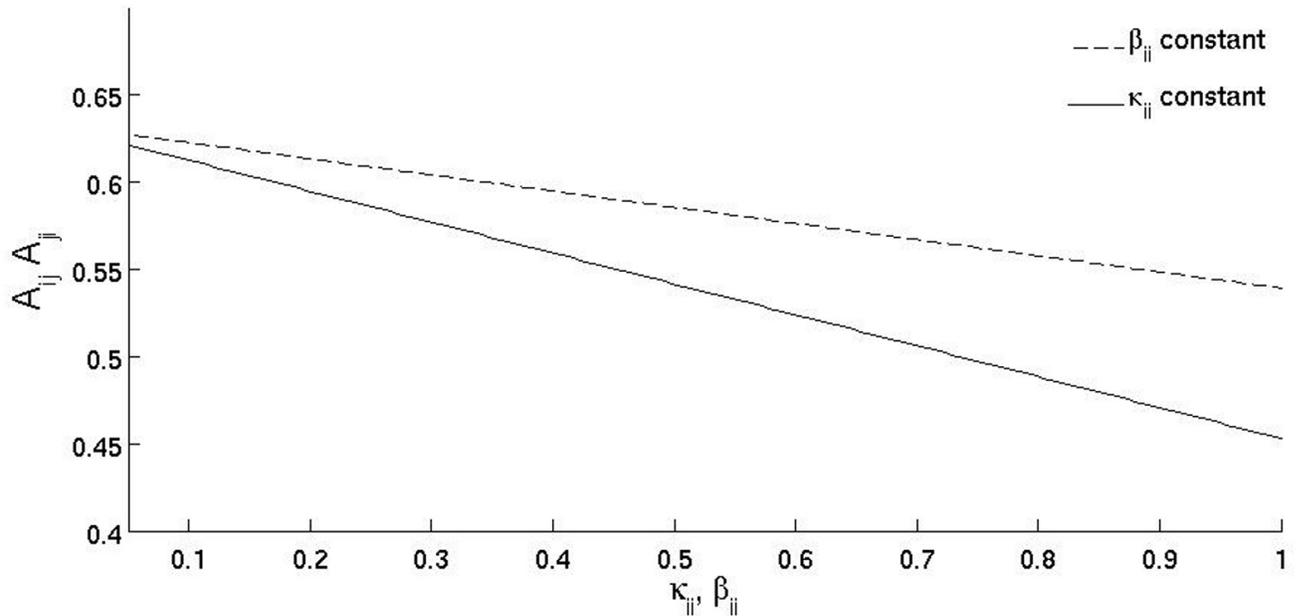


FIG. A2. The relationships between  $A_{ij}A_{ji}$ , and  $\beta_{ii}$  and  $\kappa_{ii}$ , are shown by holding  $\kappa_{ii}$  constant and increasing  $\beta_{ii}$ , and by holding  $\beta_{ii}$  constant and increasing  $\kappa_{ii}$ . In both cases,  $A_{ij}A_{ji}$  decreases with increasing values of the parameters. Other parameters were:  $\alpha_{ij} = \alpha_{ji} = \alpha_{ii} = \alpha_{jj} = 1$ ,  $d_i = d_j = 0.95$ ,  $f_i = f_j = 0.6$ ,  $\bar{R}_i = \bar{R}_j = 1$ ,  $\sigma^2_i = 0.95$ ,  $\sigma^2_j = 0.92$ , and  $\rho = -0.08$ .