

# Supporting Information

Stouffer and Bascompte 10.1073/pnas.1014353108

## SI Materials and Methods

**Section S1. Empirical Food Webs.** In our study, we report ranges of both connectance and modularity for a set of empirical food webs. We provide a list of the empirical food webs for which we report these values and list their respective values in Table S1.

**Section S2. Correlation Between Connectance and Whole Food-Web Persistence.** In the main text, we perform a multivariate linear regression to simultaneously control for the compartmentalization and connectance of the model food webs to quantify the relationship between these variables and whole food-web persistence. In Fig. S1, we show the relationship between connectance  $C$  and persistence  $P$ , when controlling for compartmentalization  $M$ . Similar to what we observe for compartmentalization, we find that connectance is positively associated with whole food-web persistence and that the benefit of additional connectance is of comparable magnitude to that of compartmentalization.

**Section S3. Null Hypothesis to Measure Influence of Compartmentalization.** We wish to understand how informative compartmentalization is, given our partitioning of the food webs on the basis of modularity (1). A partitioning of the food web provides a list of  $N_C$  compartments of sizes  $\{n_1, n_2, \dots, n_{N_C}\}$ .

Imagine, for example, that we want to determine whether consecutive extinctions tend to occur between species in the same compartment. First, we count the observed number of times  $\tilde{E}^*$  that this occurs in a simulation (Fig. S2). We then randomize the compartments to which each species is assigned, while maintaining  $N_C$  and  $\{n_i\}$  constant, and count the number of within-compartment consecutive extinctions  $\tilde{E}$ . (Note that one could equivalently randomize the order with which the extinctions took place.)

Given an ensemble of randomizations, we compute the  $z$ -score

$$z_{\tilde{E}} = \frac{\tilde{E}^* - \langle \tilde{E} \rangle}{\sigma_{\tilde{E}}}, \quad [\text{S1}]$$

where  $\langle \tilde{E} \rangle$  is the average  $\tilde{E}$  for the randomizations and  $\sigma_{\tilde{E}}$  is the SD of the same quantity. The value  $z_{\tilde{E}}$  provides a measure of the degree to which consecutive extinctions tend to occur within a compartment compared with what one would expect at random.

As we note in *Materials and Methods*, this analysis can be repeated for all such observables. In the main text, we also examine the number of consecutive extinctions between (i) directly connected species,  $D^*$ ; (ii) directly connected species within the same compartment,  $D$ ; and (iii) nondirectly connected species within the same compartment,  $\tilde{N}^*$ .

To estimate the within-compartment effect of intentional species eliminations, we examine (i) the number of extinctions  $W^*$  within the same compartment as an intentionally eliminated species  $i$  in the simulation in which  $i$  is not eliminated, (ii) the number of extinctions  $\tilde{W}^*$  within the same compartment as species  $i$  in the simulation in which  $i$  is eliminated, (iii) the average time of extinction  $T^*$  for extinctions that occur in the same compartment as  $i$  in the simulation in which  $i$  is not eliminated, and (iv) the average time of extinction  $\tilde{T}^*$  for extinctions that

occur in the same compartment as  $i$  in the simulation in which  $i$  is eliminated. We compare these values to the values expected under the null hypothesis as detailed above.

**Section S4. Sensitivity Analysis of Model Results. S4.1. Growth rate function.** For the results presented in the main text, we define growth rates using a neutrally stable Lotka–Volterra competition model defined as

$$G_i = 1 - \sum_{j=\text{prod}} \frac{B_j}{K}, \quad [\text{S2}]$$

where  $K$  is the carrying capacity,  $B_j$  is the biomass of species  $j$ , and the sum is over all basal species.

To determine the sensitivity of our results to this choice, we ran additional simulations with an alternative growth rate model with weak competitive exclusion in the absence of consumer species (2). This growth rate is defined as

$$G_i = 1 - \sum_{j=\text{prod}} \frac{a_{ij}B_j}{K}, \quad [\text{S3}]$$

where  $a_{ij}$  represents the effect of basal species  $i$  on basal species  $j$  and takes the values  $a_{ii} = 1$  and all other  $a_{ij} = 1.05$ . Note that Eq. S2 is equivalent to Eq. S3 when all  $a_{ij} = 1$ .

In Figs. S3–S5, we reproduce each of Figs. 2–4 from the main text but consider the simulations with this different growth rate function. It is visually apparent that, although there are minor quantitative differences, the overall qualitative patterns remain constant.

**S4.2. Functional response.** A general functional response, including predator interference, can be given by

$$F_{ij} = \frac{w_{ij}B_j^h}{B_0^h + d_iB_iB_0^h + \sum_{k=\text{prey}} w_{ik}B_k^h}, \quad [\text{S4}]$$

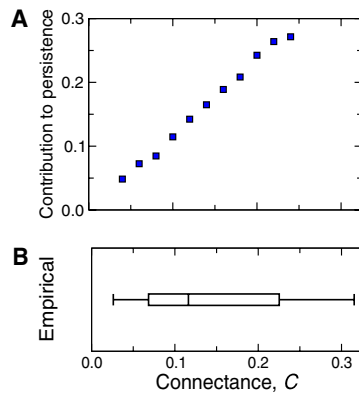
where  $w_{ij}$  is the relative inverse attack rate in a type II functional response and  $B_0$  is the half-saturation density. The Hill coefficient  $h$  changes the shape of the functional response, whereas the parameter  $d_i$  quantifies predator interference; for  $d_i > 0$  individuals in population  $i$  interfere with each other, reducing per capita consumption. For the results presented in the main text, we use a type II functional response that is given by Eq. S4 with  $h = 1$  and  $d = 0$ .

To determine the sensitivity of our results to this choice, we ran additional simulations with a type III functional response, given by Eq. S4 but with  $h = 2$  and  $d = 0$ . Type III functional responses have been shown to stabilize the dynamics of small numbers of species up to those of entire food webs (2–6).

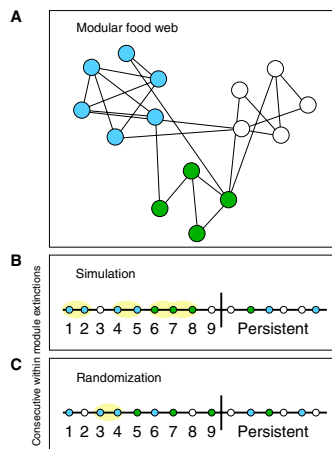
In Figs. S6–S8, we reproduce each of Figs. 2–4 from the main text but consider the simulations with this different functional response. It is visually apparent that, although there are minor quantitative differences, the overall qualitative patterns remain constant.

1. Newman MEJ, Girvan M (2004) Finding and evaluating community structure in networks. *Phys Rev E Stat Nonlin Soft Matter Phys* 69:026113.  
2. Williams RJ (2008) Effects of network and dynamical model structure on species persistence in large model food webs. *Theor Ecol* 1:141–151.  
3. Yodzis P, Innes S (1992) Body size and consumer-resource dynamics. *Am Nat* 139: 1151–1175.

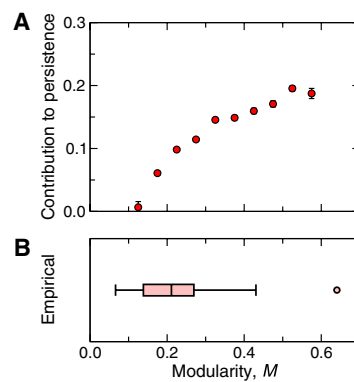
4. Post DM, Conners ME, Goldberg DS (2000) Prey preference by a top predator and the stability of linked food chains. *Ecology* 81:8–14.  
5. Williams RJ, Martinez ND (2004) Stabilization of chaotic and non-permanent food-web dynamics. *Eur Phys J B* 38:297–303.  
6. Brose U, Williams RJ, Martinez ND (2006) Allometric scaling enhances stability in complex food webs. *Ecol Lett* 9:1228–1236.



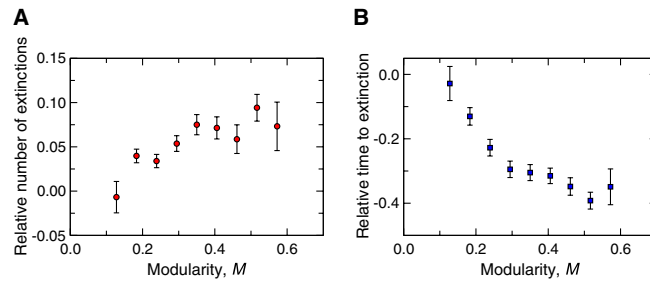
**Fig. S1.** Effect of connectance on food-web persistence. (A) Mean contribution of connectance to the long-term persistence of species in the community. The greater the connectance of a food web is, the greater the persistence of its constituent species. The SEs of the reported averages are shown as error bars but are small. (B) The range of connectance observed in 15 empirical food webs, as in Fig. 4.



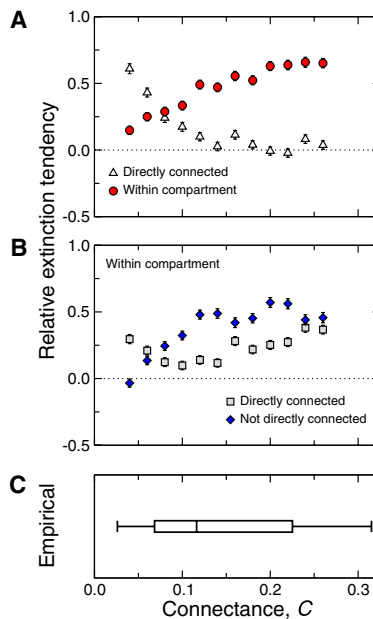
**Fig. S2.** Null hypothesis to measure importance of compartmentalization. (A) A hypothetical compartmentalized food web made of 15 species in three compartments. There are six, five, and four species found in the blue, white, and green compartments, respectively. (B) After running a hypothetical dynamic simulation, we find that nine species (those to the left of the vertical bar) have gone extinct and six have persisted (those to the right of the vertical bar). We have enumerated the species in the order in which they go extinct. That is, species 1 went extinct first, species 2 second, and so on. We can count the number  $\bar{E}^*$  of consecutive extinctions that occur within the same compartment, shown by the pairs of species highlighted in yellow. Here,  $\bar{E}^* = 4$ . (C) We compare  $\bar{E}^*$  to the value  $\bar{E}$  expected at random, given the same number of compartments, number of species within each compartment, and overall number of extinctions. Visually, this randomization corresponds to keeping the species in the same order but randomizing the compartments within which each species is found, denoted here by the species' color. In this randomization,  $\bar{E} = 1$ .



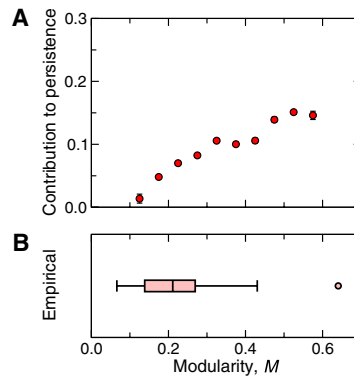
**Fig. S3.** Effect of compartmentalization on food-web persistence when departing from the assumption of neutrally stable basal species. (A) Mean contribution of compartmentalization—quantified by modularity—to the long-term persistence of species in the community. The greater the compartmentalization of a food web is, the greater the persistence of its constituent species. The SEs of the reported averages are shown as error bars but are small. (B) The range of compartmentalization observed in 15 empirical food webs, as in Fig. 2.



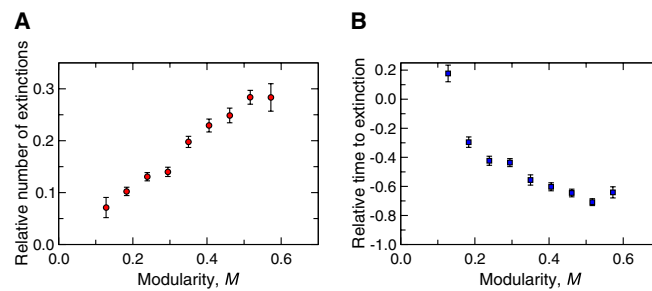
**Fig. S4.** Community response to manipulated species extinctions when departing from the assumption of neutrally stable basal species. (A) Mean relative number of extinctions that occur in the same compartment as an eliminated species, as a function of the web's modularity. Values greater than zero imply that the subsequent species that go extinct as a consequence of the original extinction have a higher probability of belonging to the same compartment. (B) Mean relative time to extinctions that occur in the same compartment as the eliminated species, as a function of the web's modularity. Values less than zero imply that these species tend to go extinct earlier, as a consequence of the original extinction. The SEs of the reported averages are shown as error bars.



**Fig. S5.** Propagation of extinctions within food webs when departing from the assumption of neutrally stable basal species. (A) We compare the ability of different factors to predict the next species to go extinct after the earlier extinction of a species in a food web. As the connectance of the food web increases, the tendency to observe consecutive extinctions of directly connected species decreases (white triangles). For species within the same compartment, the same tendency increases with increasing connectance (red circles). Values close to zero imply that this tendency is close to the random expectation. (B) We separate within-compartment extinctions into those that occur between (i) directly connected species (gray squares) and (ii) nondirectly connected species (blue diamonds). We find that the probability of consecutive extinctions between two nondirectly connected species shows a strong increase with increasing connectance. The SEs of the reported averages are shown as error bars but are small. (C) The range of connectance observed in 15 empirical food webs, as in Fig. 4.



**Fig. 56.** Effect of compartmentalization on food-web persistence when using a type III functional response. (A) Mean contribution of compartmentalization—quantified by modularity—to the long-term persistence of species in the community. The greater the compartmentalization of a food web is, the greater the persistence of its constituent species. The SEs of the reported averages are shown as error bars but are small. (B) The range of compartmentalization observed in 15 empirical food webs, as in Fig. 2.



**Fig. 57.** Community response to manipulated species extinctions when using type III functional response. (A) Mean relative number of extinctions that occur in the same compartment as an eliminated species, as a function of the web's modularity. Values greater than zero imply that the subsequent species that go extinct as a consequence of the original extinction have a higher probability of belonging to the same compartment. (B) Mean relative time to extinctions that occur in the same compartment as the eliminated species, as a function of the web's modularity. Values less than zero imply that these species tend to go extinct earlier, as a consequence of the original extinction. The SEs of the reported average are shown as error bars.

