Supplementary methods

We employ two measures of enemy specificity for their victims. In the first, specificity is measured as the differential exploitation of victim genotypes by a given enemy genotype j (1)

$$S_j = \frac{\sum_{i=2}^{v}\left(\mathbf{P}_{1j}-\mathbf{P}_{ij}\right)}{v-1} \tag{1}$$

where v is the total number of victim genotypes present, and $\mathbf{P}$ is a vector of the exploitation levels (see eq. 4 of main text) of enemy genotype j on victim types 1 to v, sorted from the highest to the lowest. Equation (1) returns a value of $S_j=1$ for high specificity and $S_j=0$ for the lowest specificity (i.e., enemy j exploits all victim genotypes equally).

In contrast to the quantitative index given by eqn (1), the second specificity index measures the range of victim genotypes exploited (i.e. 'generality (2)). The generality of enemy j is calculated as

$$G_j = V_{+j}/V, \tag{2}$$

where V_{+j} is the number of victim types sensitive to exploitation by enemy type j and V is the total number of victim genotypes. Henceforth, victim range will be used to describe the number of victim genotypes exploited.

We also investigate specificity in terms of victim defence against different enemy genotypes, and for this employ a measure of 'vulnerability' (2), which is the number of links between a given victim genotype and the enemy genotypes attacking it. The need to jointly consider generality and vulnerability stems from the fact that the potential to exploit and the potential to resist exploitation can be differently distributed in a trophic network. Vulnerability is defined for each victim type i, as

$$U_i=E_{+i}/E \tag{3}$$

where E_{+i} is the number of enemy genotypes that can exploit the victim i, and E is the total number of enemy genotypes.

A widely recognised mechanism for permitting species coexistence and influencing the evolution of specialization is competition for niches (3). We calculate niche overlap between enemies by employing Lloyd's inter-species patchiness measure (4; 5), defined as

$$L_{ab} = v \sum_i \left[\omega_{ai} \omega_{bi} \right]$$ (4)

wherein L is the degree of overlap between a and b, v is victim richness, and x and y are two enemy genotypes. ω_{ai} is the proportion of the total fitness of enemy genotype a realized by exploiting victim genotype i (see equation 5 of main text),

$$\omega_{ag} = \frac{\phi_{ag}}{\sum_i \phi_{ai}}.$$ (5)

All of the above measures are reported as weighted averages, whereby the value of each individual genotype of enemy or victim is weighted by its frequency in the population, such that, for example, with specificity (eqn. 1),

$$\bar{S} = \sum_{i=1}^{v} \frac{S_i V_i}{\sum V_i}.$$ (6)

Finally, other important structural features of the enemy-victim genotypic network are reported. These measures include connectance (6) (the number of interactions for which $\phi_{ij} > 0$ over the total number of potential links), richness (the number of enemy and victim genotypes), and the evenness of genotypic densities for both populations. Connectance in particular is an important property of trophic networks, relating to their stability (7), functioning (8), and resilience to environmental variation.

1.   Poisot T, Lepennetier G, Martinez E, Ramsayer J, Hochberg ME. Resource availability affects the structure of a natural bacteria-bacteriophage community. Biology Letters. 2011 Oct ;7(2):201-204.

2.   Schoener TW. Food webs from the small to the large. Ecology. 1989 ;70(6):1559-1589.

3.   Devictor V, Clavel J, Julliard R, Lavergne S, Mouillot D, Thuiller W, et al. Defining and measuring ecological specialization. Journal of Applied Ecology. 2010 ;4715-25.

4.   Hurlbert SH. The measurement of niche overlap and some relatives. Ecology. 1978 ;59(1):67-77.

5.   Lloyd M. `Mean Crowding'. Journal of Animal Ecology. 1967 Dec 21;36(1):1–30.

6.   Dunne JA. The network structure of food webs. In: Pascual M, Dunne JA, editor(s). Ecological Networks: Linking Structure to Dynamics in Food Webs. Oxford: Oxford University Press; 2006. p. 27-86.

7.   Dunne JA, Williams RJ, Martinez ND. Network structure and robustness of marine food webs. Marine Ecology Progress Series. 2004 ;273291-302.

8.   Gómez JM, Perfectti F, Jordano P. The Functional Consequences of Mutualistic Network Architecture. PLoS One. 2011 Jan ;6(1):e16143.

Appendix 1 – Type II functional response

In the main text, we assume that using a saturating (Type II) functional response will mitigate the impact of resource dynamics. To verify this claim, we performed numerical experiments using a modified version of the model, in which the rate of consumption of victims by the enemy (in eq. 2b and 2c of main text) becomes

$$\frac{aV_i}{1+aV_i}\phi_{ij}V_iE_j \qquad\qquad (1)$$

where a is the saturation constant (Holling, 1959), which mitigates the baseline consumption of victim i by enemy j when the victim is present at low abundances. A value of $a = 4$ was used to generate the figures presented here.

We observe no qualitative changes in the patterns produced by a Type I (linear) response (Fig. A1). The relative quantitative effect of the Type II compared to the linear functional response is greatest at intermediate values of A (amplitude of resource input) and T_R (frequency of resource input). Specifically, using a type II functional response allowed the evolution of specialized enemies only in more productive environments. As hypothesized in main text, using a saturating functional response mitigates the impact of environmental changes.

Holling, C. S. (1959). The components of predation as revealed by a study of small-mammal predation of the European pine sawfly. *Canadian Entomologist*, *91*, 293-320.
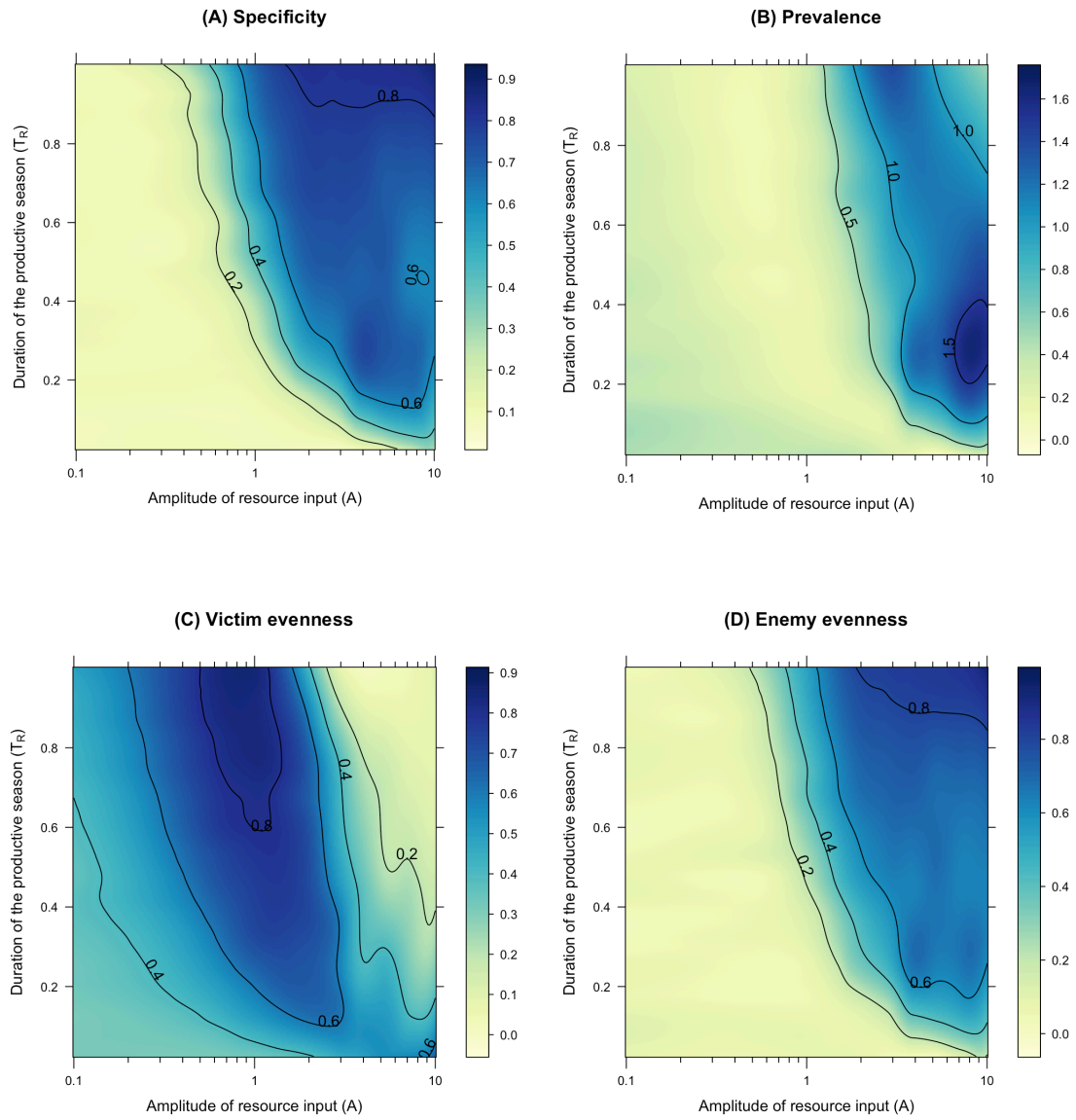
Figure A1 – Values of specificity (A), enemy prevalence (B), victim evenness (C) and enemy evenness (D) when the functional response is saturating. Comparing with the corresponding figures of main text allows seeing that the changes introduced by a different functional responses are only quantitative.

Appendix 2 – Sensitivity analysis

We conducted a sensitivity analysis on seven different measures employed in our study, using the sampling-based rank-correlation method (Helton, Johnson, Sallaberry, & Storlie, 2006). We ran 5000 simulations, each with different values of the model parameters involved in resource dynamics (length of the productive season T_R, resource input during productive season A, basal resource supply S, and resource degradation rate ρ_R), and computed the P-value of Kendall's rank-correlation test. Parameters were varied over realistic ranges for the model. A and T_R were varied over the range presented in main text figures, and ρ_R was varied between 0.01 and 0.9. Parameters values for each simulation were picked at random, uniformly, over their range. The results are reported in the table below. Missing values indicates a *p-value* superior to 0.05. The most important factors affecting the results are the basal resource supply (*S*) and the additional resource supply during the productive season (*A*). This result is intuitive since high values of *S* condition the importance of the other resource parameters.

To better understand the impact of *S*, we ran another 500 simulations with $S = 0.01$ (very low basal resource supply, second columns for T_R and ρ_R) and conducted the sensitivity analysis by varying the resource dynamics parameters that were not significant with higher values of *S*. We find that when S is limiting, both the length of the productive season (T_R) and the resource degradation rate (ρ_R) have an impact index sensitivity, the more important of the two parameters being T_R.

Helton, J., Johnson, J., Sallaberry, C., & Storlie, C. (2006). Survey of sampling-based methods for uncertainty and sensitivity analysis. *Reliability Engineering & System Safety*, *91*(10-11), 1175-1209. doi: 10.1016/j.ress.2005.11.017.

	S	A	T_R		ρ_R	
			High S	Low S	High S	Low S
Generality	$<10^{-6}$	0.04		$<10^{-6}$		0.01
Vulnerability	$<10^{-6}$	0.03				0.006
Specificity	$<10^{-6}$	0.04		$<10^{-6}$		0.01
Enemy evenness	$<10^{-6}$	0.04		$<10^{-6}$		0.04
Victim evenness	$<10^{-6}$	$<10^{-3}$	0.002	$<10^{-4}$		
Enemy investment	$<10^{-6}$	0.04		$<10^{-6}$		0.02
Victim investment	$<10^{-6}$	0.002		$<10^{-3}$		

Appendix 3 – Stochasticity in resource input parameters

In this appendix, we expand the results of main text by considering the case for which resource dynamics include a stochastic component. Rather than being fixed, the length of the productive season (T_R) and amplitude of resource input (A) are drawn at random for each epoch, around a fixed mean value. Numerical simulations showed that increasing the variance of either parameter did not qualitatively affect the results. In the figures below, we present four situations: T_R and A are fixed (as in main text), T_R is stochastic but A is not, A is stochastic but T_R is not, and both A and T_R are stochastic. We found that stochasticity in T_R alone did change the pattern, while stochasticity A did trigger changes, but only when in interaction with stochasticity of T_R. The result for enemy specialization is given in Fig. A3.1.

In addition, using May's criterion of system stability (May, 1972) that incorporates the number of established links, their relative strength and the number of interactive species, we show that stochasticity in resource dynamics does not alter the pattern of stability. We observe nevertheless an increase in stability for low productivities (low T_R and A) when T_R is stochastic (Fig. A3.2).

May, R. M. (1972). Will a large complex system be stable? *Nature*, *238*, 413-414.
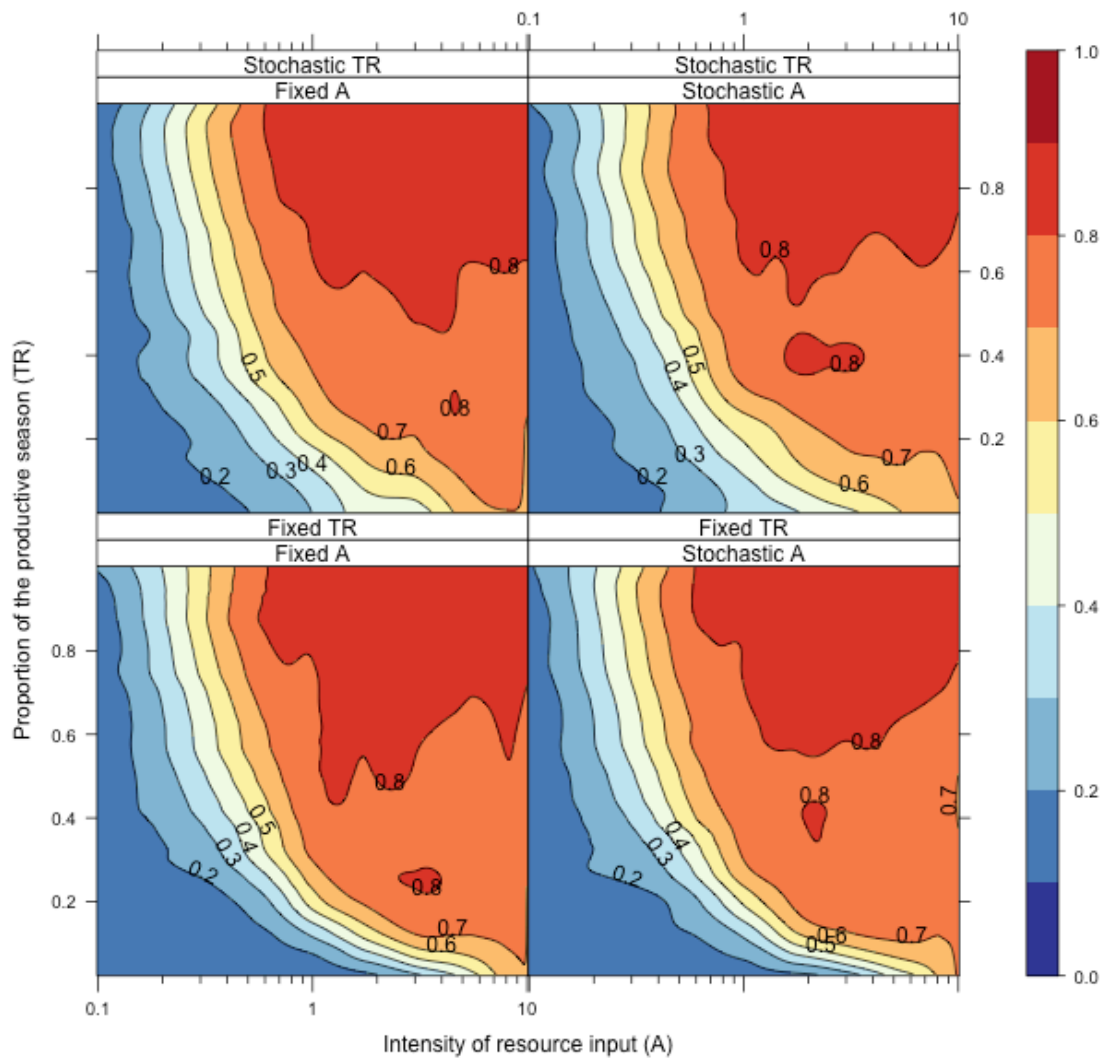
Fig. A3.1 – Stochasticity in T_R and A resulted in greater specialization for low mean values of T_R, but did not change the pattern at high productivities (high T_R and A). Colors represent the degree of enemy specialization.
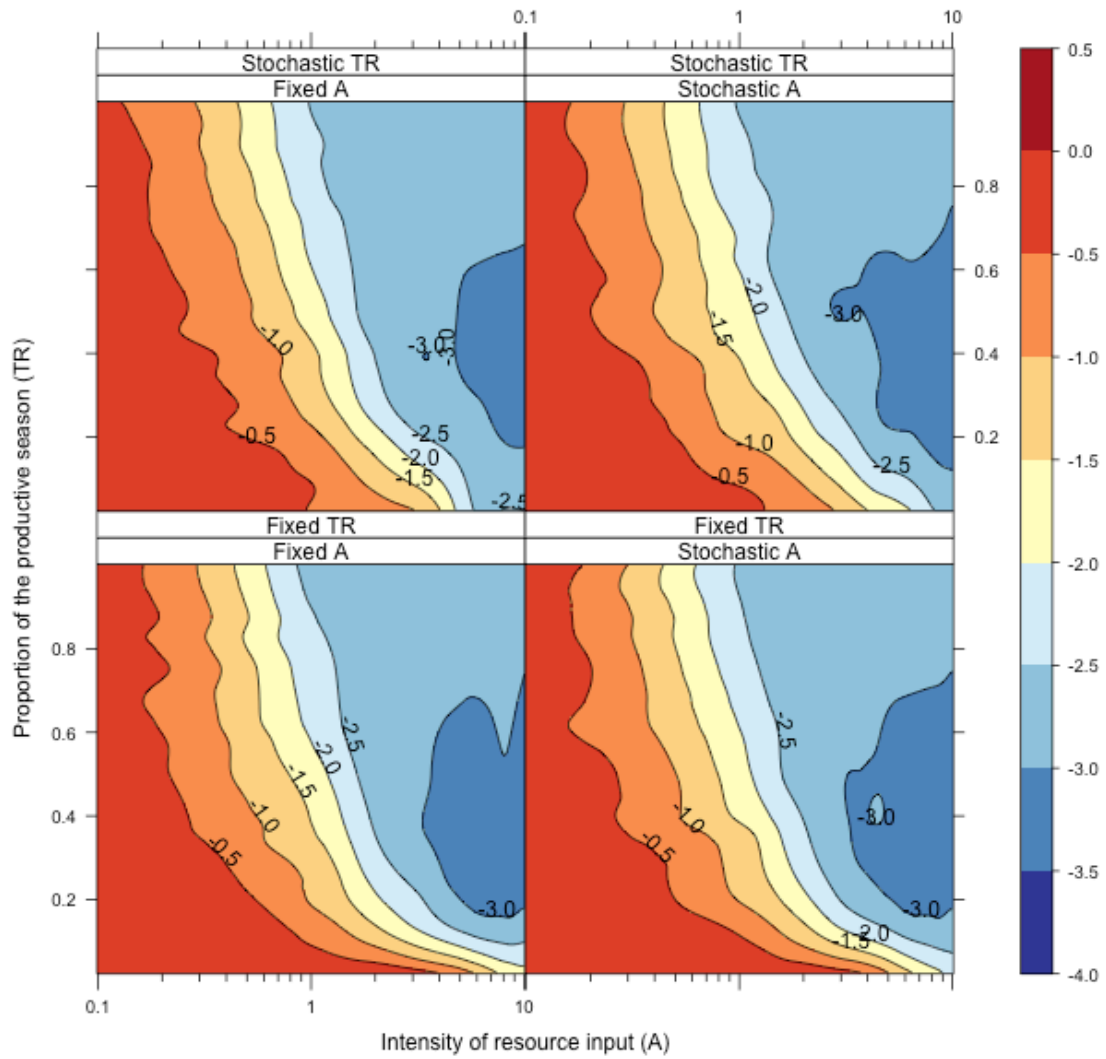
Fig. A3.2 – Adding stochasticity stabilizes the system at low T_R (the more negative values indicate a lower probability that the system will be unstable). Colors represent the degree of stability (closer to blue means that the system is more stable).

Supplementary table 1 – Model parameters, their meanings and values used in the numerical simulations. For a sensitivity analysis of the model to parameters involved in resource dynamics, see Appendix 2.

Parameter	Meaning	Value and range
T_R+T_L	Length of epoch	40
T_R	Length of productive season	1 to 40
S	Basal resource supply	0.01
A	Amount of resource during T_R	0.1 to 10 (log scale)
ϱ_R	Resource degradation rate	0.1 (main text), .5
ϱ_V	Victim mortality rate	0.1 (main text), .2, .5
ϱ_E	Enemy mortality rate	0.1 (main text), .2, .5
ε	Victim conversion rate	10
Φ_0	Basal attack rate	0.01
γ_0	Victim consumption rate	0.01
β_0	Progeny size (enemy)	3
∂	Baseline cost of adaptation	0.4
w	Non-optimal attack score	0.2
k_V	Victim cost of defence	0.25 (main text), 0.5
k_E	Enemy cost of attack	0.25 (main text), 0.5
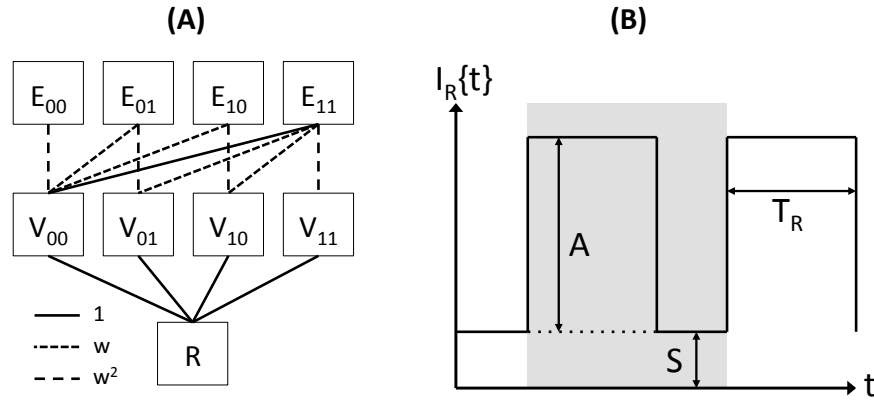
Supplementary Figure 1 – (**A**) An overview of the relationships between enemies, victims and resources employed in this study. The enemies and victims each have two loci. The shape of the line between enemies and victims represents the strength of interaction (eq. 4 in main text). (**B**) Patterns of variation in resource input through time, as in eq. (1a). S is the basal amount of resource flowing in the ecosystem at each time. The simulations are divided in "epochs" (grey part of the graph), during which a productive season of length T_R occurs; in this productive season, the amount of resources entering the system is equal to $S+A$.