

Habitat use of *Philaenus spumarius* populations in Mediterranean regions

Supplementary material

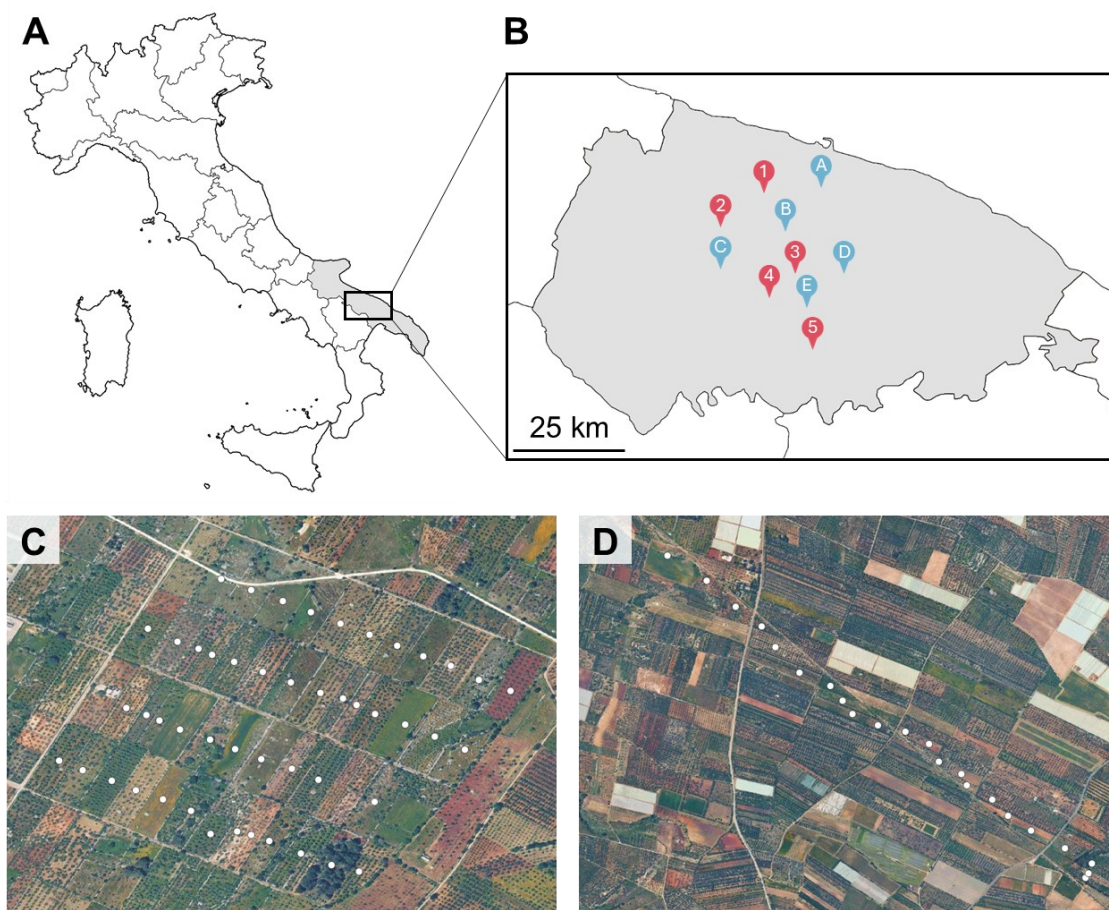


Fig. S1. Location of investigated areas in Italy (A) and Bari province (B), with example of landscape (C) and transect (D). Red pointers: investigated 600 x 600 m landscapes (1: Bitonto; 2: Palombaio; 3: Sannicandro; 4: Mellitto; 5: Curtomartino); Blue pointers: investigated transect between ephemeral stream channels (A: Carbonara; B: Grumo; C: Toritto; D: Le Monacelle; E: Cassano).

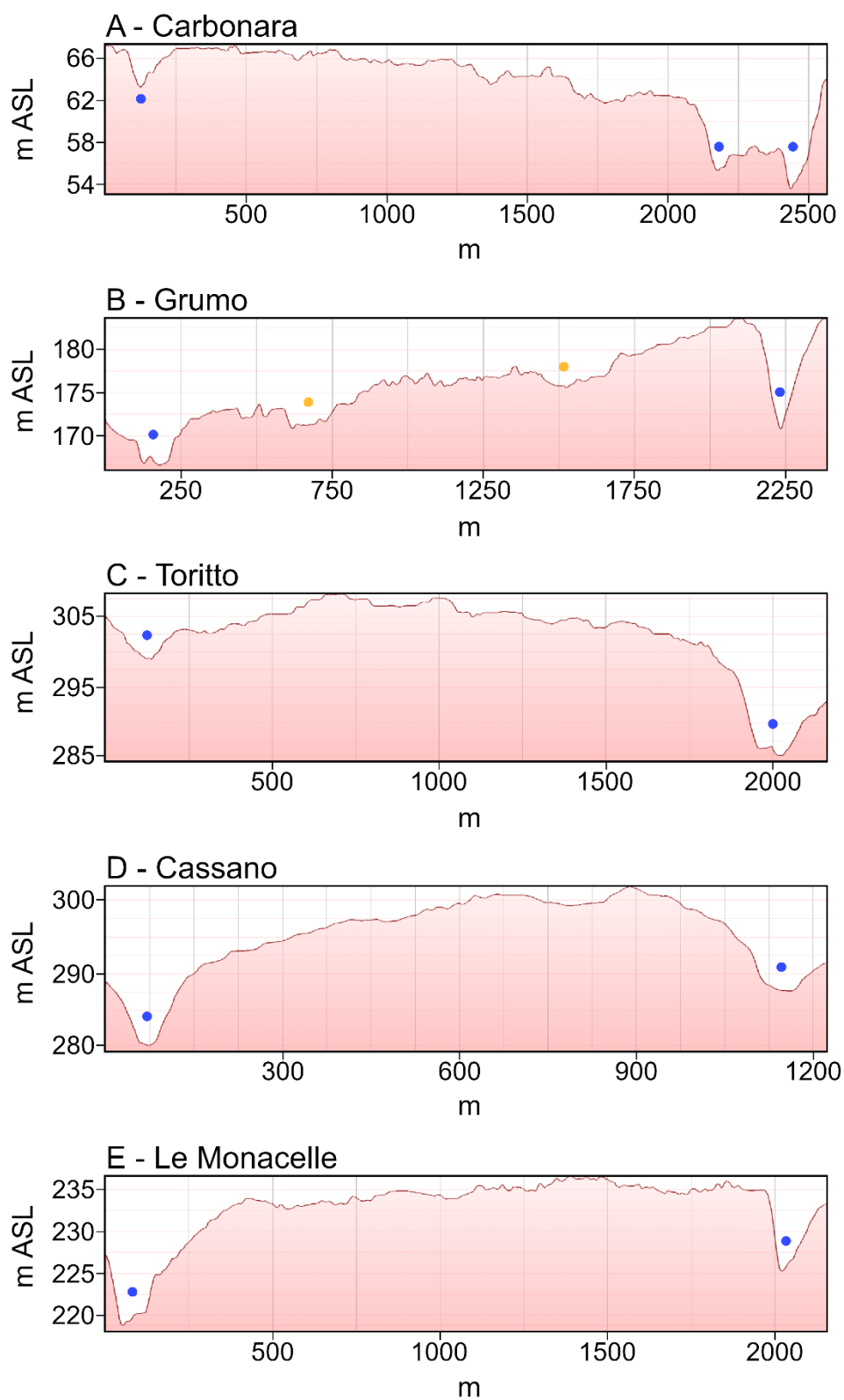


Fig. S2. Altimetric profiles of the investigated transects. Blue dots represent major topographical depressions included in the final analysis, whereas yellow dots indicate secondary, dry depressions.

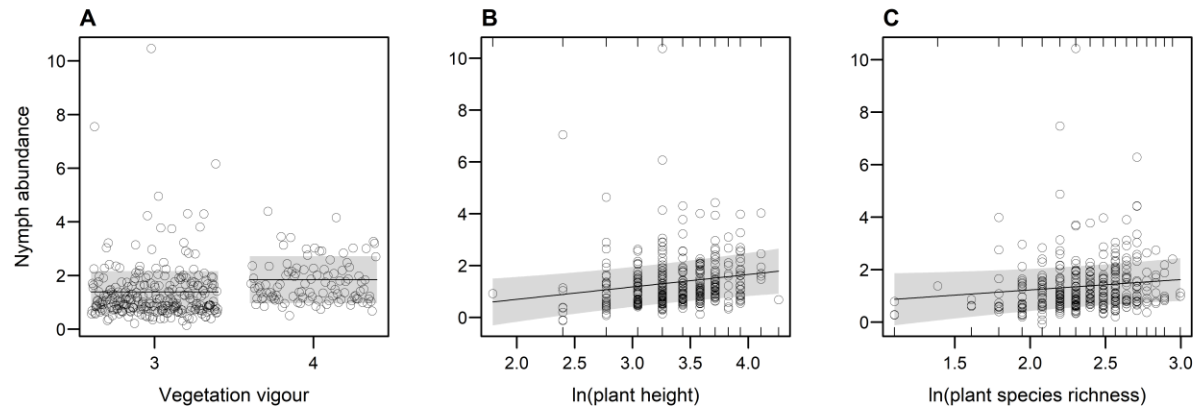


Fig. S3. Partial effect of vegetation vigour (A), log-transformed plant height (B), and log-transformed plant species richness (C) on the abundance of *P. spumarius* nymphs at the quadrat level in non-recently managed woody crops. Plots were obtained using visreg with conditional effects (type = "conditional") on the linear predictor scale (scale = "linear"). Points represent partial residuals, solid lines represent the fitted conditional effects, and grey shaded areas indicate 95% confidence intervals. Because partial residuals are displayed on the linear predictor (log-link) scale and include the fitted conditional effect, they are not expected to be centred around zero.

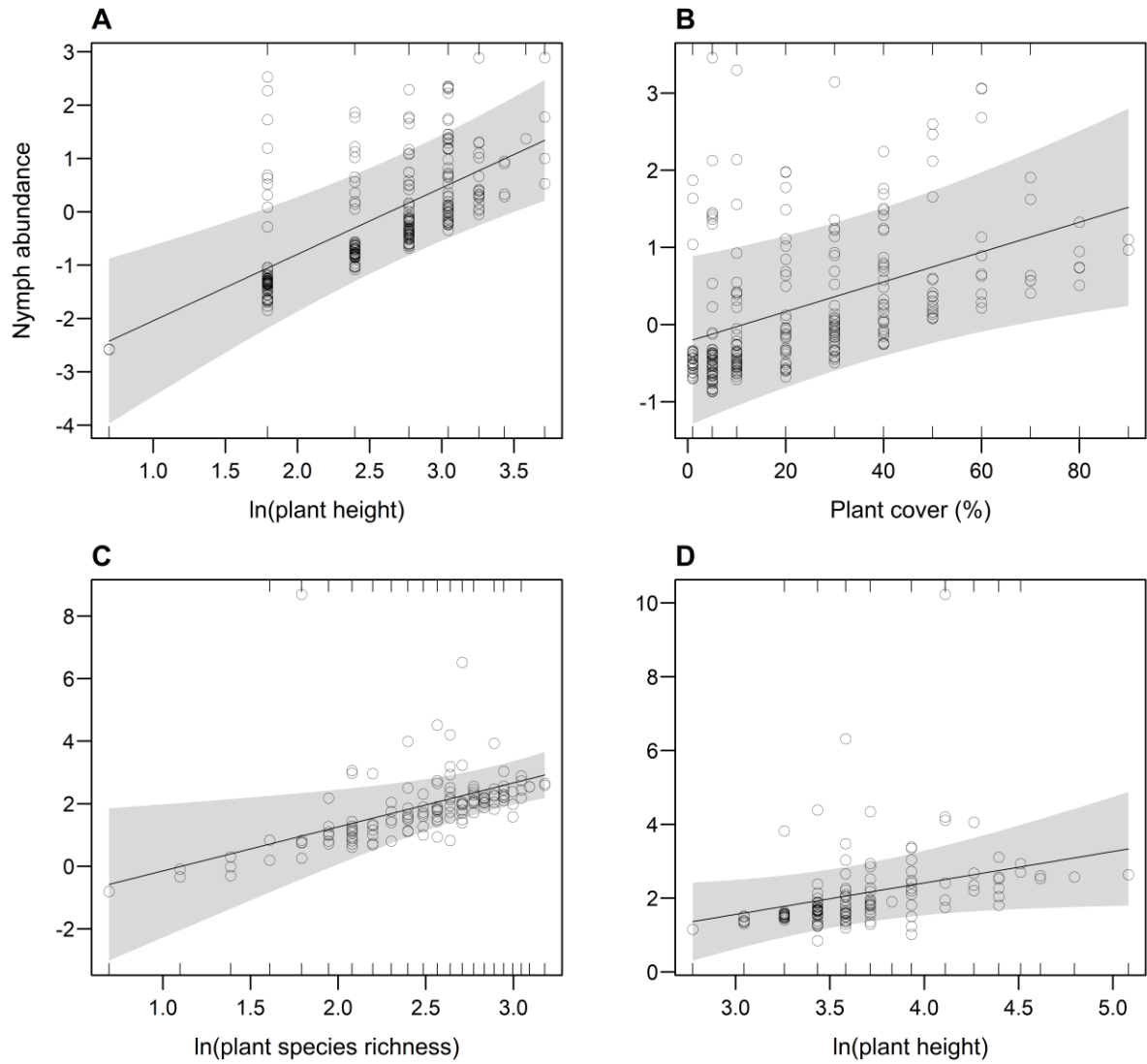


Fig. S4. Partial effect of log-transformed herbaceous vegetation height (A) and cover (B) on the abundance of *P. spumarius* nymphs at the quadrat level in recently managed woody crops, and of log-transformed species richness (C) and vegetation height (D) in unmanaged habitats. Plots were obtained using visreg with conditional effects (type = "conditional") on the linear predictor scale (scale = "linear"). Points represent partial residuals, solid lines represent the fitted conditional effects, and grey shaded areas indicate 95% confidence intervals. Because partial residuals are displayed on the linear predictor (log-link) scale and include the fitted conditional effect, they are not expected to be centred around zero.

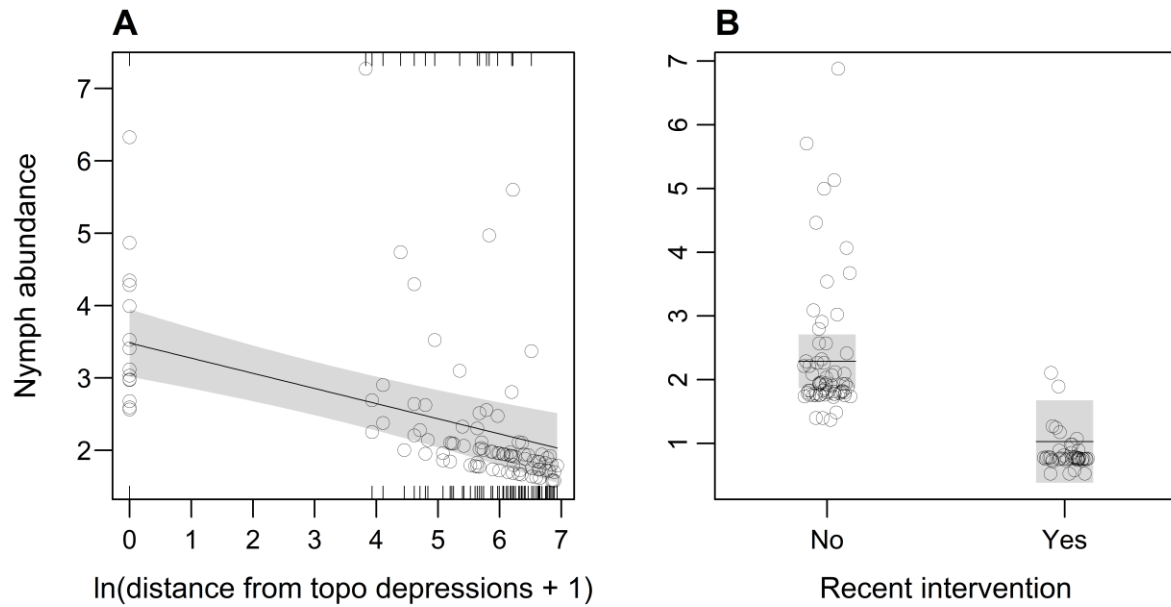


Fig. S5. Partial effect of log-transformed shortest distance from topographical depressions (A) and recent intervention (B) on the abundance of *P. spumarius* nymphs at the plot level. Plots were obtained using visreg with conditional effects (type = "conditional") on the linear predictor scale (scale = "linear"). Points represent partial residuals, solid lines represent the fitted conditional effects, and grey shaded areas indicate 95% confidence intervals. Because partial residuals are displayed on the linear predictor (log-link) scale and include the fitted conditional effect, they are not expected to be centred around zero.

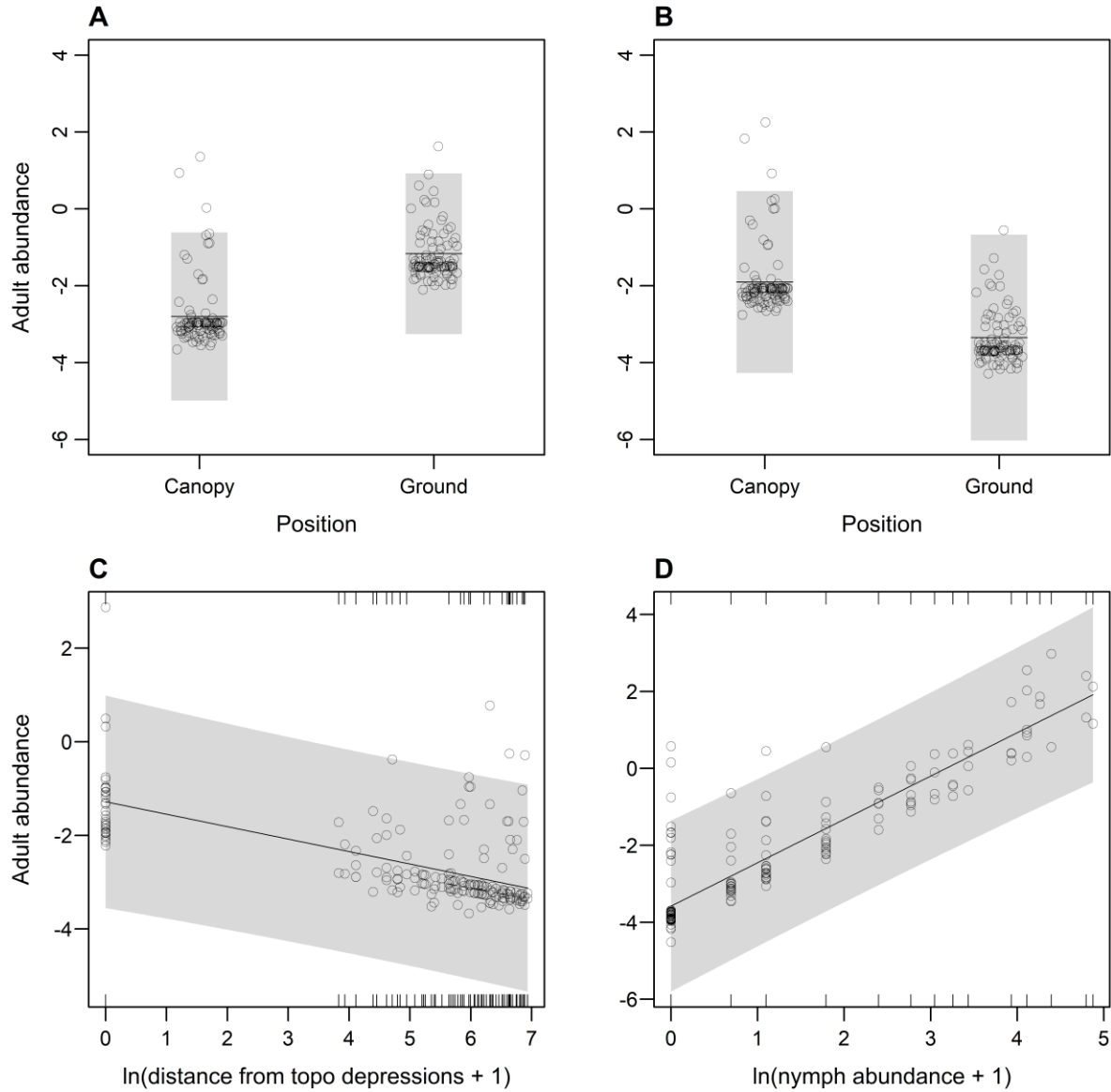


Fig. S6. Partial effect of the interaction between recent intervention and position (A, B), shortest distance from topographical depressions (C), nymph abundance (D) on the abundance of *P. spumarius* adults at the plot level in May. Plots were obtained using visreg with conditional effects (type = "conditional") on the linear predictor scale (scale = "linear"). Points represent partial residuals, solid lines represent the fitted conditional effects, and grey shaded areas indicate 95% confidence intervals. Because partial residuals are displayed on the linear predictor (log-link) scale and include the fitted conditional effect, they are not expected to be centred around zero.

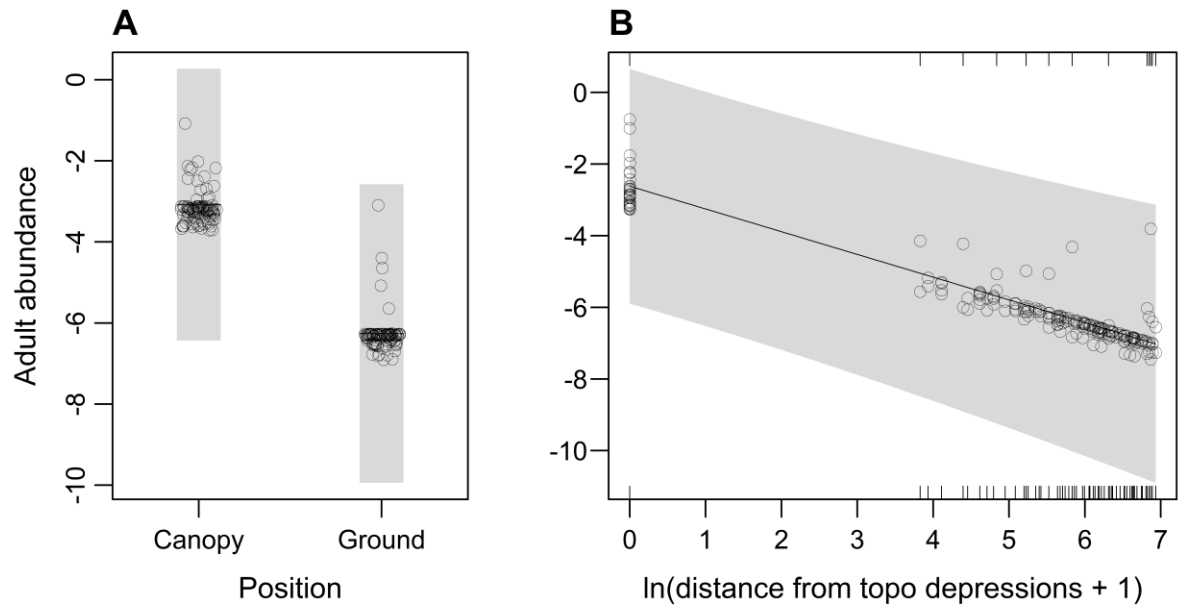


Fig. S7. Partial effect of sweep position (A) and of shortest distance from topographical depressions (B) on the abundance of *P. spumarius* adults at the plot level in August. Plots were obtained using visreg with conditional effects (type = "conditional") on the linear predictor scale (scale = "linear"). Points represent partial residuals, solid lines represent the fitted conditional effects, and grey shaded areas indicate 95% confidence intervals. Because partial residuals are displayed on the linear predictor (log-link) scale and include the fitted conditional effect, they are not expected to be centred around zero.

Table S1. Results of the GLMMs (family: binomial) testing the response of *Philaenus spumarius* nymph abundance at the quadrat level to herbaceous vegetation vigour (3: Growth is reduced or stunted, possibly due to drought or other environmental stress; 4: Vegetation is thriving, with active growth), height, species richness and cover in landscape surveys. Marginal (mR^2) and conditional (cR^2) pseudo-R-squared, model estimate (Est), standard error (SE), Z and P values, as well as number of levels (N°), variance (σ^2) and standard deviation (SD) of random effects, are presented for each model.

	Woody crops with no recent intervention				Woody crops with recent intervention				Unmanaged habitats			
	Total observations: 370				Total observations: 262				Total observations: 140			
	Groups	N°	σ^2	SD	Groups	N°	σ^2	SD	Groups	N°	σ^2	SD
	Plot:Lands.	74	0.467	0.684	Plot:Lands.	57	1.332	1.154	Plot:Lands.	28	1.924	1.387
	Landscape	5	0.016	0.126	Landscape	5	0.142	0.377	Landscape	5	0.359	0.599
	$mR^2 = 0.135$		$cR^2 = 0.71$		$mR^2 = 0.30$		$cR^2 = 0.72$		$mR^2 = 0.13$		$cR^2 = 0.93$	
	Est	SE	Z	P	Est	SE	Z	P	Est	SE	Z	P
Vigour (4, vs 3)	0.455	0.212	2.141	0.0323	/	/	/	/	0.323	0.961	0.336	0.7371
ln(plant height)	0.459	0.176	2.609	0.0091	1.126	0.272	4.145	<0.0001	0.861	0.440	1.958	0.0502
ln(plant species richness)	0.357	0.207	1.723	0.0849	0.419	0.280	1.494	0.1352	1.304	0.473	2.756	0.0058
Plant cover	0.002	0.003	0.58	0.5617	0.019	0.008	2.505	0.0122	0.001	0.008	0.157	0.8753

Table S2. Results of the GLMMs (family: binomial) testing the response of *Philaenus spumarius* nymph abundance at the quadrat level to recent ground management in woody crops in landscape surveys. Marginal (mR^2) and conditional (cR^2) pseudo-R-squared, model estimate (Est), standard error (SE), Z and P values, as well as number of levels (N°), variance (σ^2) and standard deviation (SD) of random effects, are presented.

	Total observations: 655			
	Groups	N°	σ^2	SD
	Plot:Landscape	131	0.659	0.812
	Landscape	5	0.014	0.118
	$mR^2 = 0.48$		$cR^2 = 0.84$	
	Est	SE	Z	P
Recent intervention (yes, vs no)	-1.909	0.190	-10.06	<0.0001

Table S3. Results of the GLMMs (family: binomial) testing the response of *Philaenus spumarius* adult abundance to macrohabitat in August in Acquaviva in landscape surveys. Marginal (mR^2) and conditional (cR^2) pseudo-R-squared, model estimate (Est), standard error (SE), Z and P values, as well as number of levels (N°), variance (σ^2) and standard deviation (SD) of random effects, are presented.

	Total observations: 91			
	Groups	N°	σ^2	SD
	Plot	46	0.219	0.468
	$mR^2 = 0.38$		$cR^2 = 0.45$	
	Est	SE	Z	P
Macrohabitat (woody crops, vs unmanaged)	-2.514	0.660	-3.81	0.0001

Table S4. Results of the GLMMs (family: binomial) testing the response of *Philaenus spumarius* juvenile abundance in April 2025 to juvenile abundance in April 2024 and recent ground management in landscape surveys. Marginal (mR^2) and conditional (cR^2) pseudo-R-squared, model estimate (Est), standard error (SE), Z and P values, as well as number of levels (N°), variance (σ^2) and standard deviation (SD) of random effects, are presented.

	Woody crops				Unmanaged habitats			
	Total observations: 125				Total observations: 29			
	Groups	N°	σ^2	SD	Groups	N°	σ^2	SD
	Landscape	5	0.133	0.365	Landscape	5	0.379	0.616
	$mR^2 = 0.74$		$cR^2 = 0.89$		$mR^2 = 0.24$		$cR^2 = 0.47$	
	Est	SE	Z	P	Est	SE	Z	P
ln(2024 juvenile abundance + 1)	0.41839	0.0572	7.311	2.66E-13	0.3472	0.1271	2.731	0.00631
Recent intervention (yes, vs no)	-0.926	0.213	-4.35	<0.0001	/	/	/	/

Table S5. Results of the GLMMs (family: binomial) testing the response of *Philaenus spumarius* juvenile abundance in April 2025 to adult abundance in October 2024 (canopy and ground abundances summed) and recent ground management in landscape surveys. Marginal (mR^2) and conditional (cR^2) pseudo-R-squared, model estimate (Est), standard error (SE), Z and P values, as well as number of levels (N°), variance (σ^2) and standard deviation (SD) of random effects, are presented. Landscape ID was not included as random effect as it did not explain any variance.

	Woody crops				Unmanaged habitats			
	Total observations: 129				Total observations: 28			
	$R^2 = 0.36$				$R^2 = 0.12$			
	Est	SE	Z	P	Est	SE	Z	P
ln(2024 adult abundance + 1)	0.281	0.088	3.188	0.0014	0.424	0.370	1.146	0.2518
Recent intervention (yes, vs no)	-1.122	0.212	-5.305	<0.0001	/	/	/	/

Table S6. Results of the GLMMs (family: binomial) testing the response of *Philaenus spumarius* juvenile abundance to distance from topographical depressions and recent ground management in transect surveys. Marginal (mR^2) and conditional (cR^2) pseudo-R-squared, model estimate (Est), standard error (SE), Z and P values, as well as number of levels (N°), variance (σ^2) and standard deviation (SD) of random effects, are presented. Transect ID was not included as random effect as it did not explain any variance.

	Total observations: 111			
	$R^2 = 0.30$			
	Est	SE	Z	P
ln(Distance from topo depressions + 1)	-0.209	0.044	-4.768	<0.0001
Recent intervention (yes, vs no)	-1.259	0.301	-4.185	<0.0001

Table S7. Results of the GLMMs (family: binomial) testing the response of *Philaenus spumarius* adult abundance to distance from topographical depressions, recent ground management, sweep position, recent ground management and their significant interactions in transect surveys. Marginal (mR^2) and conditional (cR^2) pseudo-R-squared, model estimate (Est), standard error (SE), Z and P values, as well as number of levels (N°), variance (σ^2) and standard deviation (SD) of random effects, are presented. Transect ID was not included as random effect in the May adult sampling model as it did not explain any variance.

	May adult sampling				August adult sampling			
	Total observations: 206				Total observations: 203			
	Groups	N°	σ^2	SD	Groups	N°	σ^2	SD
	Plot:transect	103	1.177	1.085	Plot:transect	102	2.076	1.441
	Transect	/	/	/	Transect	5	8.220	2.867
	$mR^2 = 0.70$		$cR^2 = 0.88$		$mR^2 = 0.32$		$cR^2 = 0.93$	
	Est	SE	Z	P	Est	SE	Z	P
ln(distance from topo depressions + 1)	-0.266	0.079	-3.379	0.0007	-0.635	0.170	-3.733	0.0002
Recent intervention (yes, vs no)	0.896	0.716	1.252	0.2105	/	/	/	/
Position (ground, vs canopy)	1.633	0.334	4.829	<0.0001	-3.177	0.629	-5.052	<0.0001
ln(juvenile abundance + 1)	1.127	0.133	8.450	<0.0001	0.437	0.261	1.676	0.094
Sweep position X recent intervention	-3.078	1.054	-2.919	0.0035	/	/	/	/