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Digital supplementary material

Digital supplementary material to

HOVORKOVÁ, M., HOLEC, M., MUDRÁK, O. & FROUZ, J. 2025: Consistent successional trajectories of ant species richness, composition, and functional traits on post-mining sites in European deciduous forest. – Myrmecological News 35: 61-71.

The content of this digital supplementary material was subject to the same scientific editorial processing as the article it accompanies. However, the authors are responsible for copyediting and layout.

Supplementary information

Appendix S1: Analysis of destroyed and newly established plots on spoil heaps and in the surrounding landscape.

As the mining activities continued to excavate the surrounding landscape and to overlay the already existing sites by deposition substrates, some of our original sites were destroyed. In such cases we selected a surrogate site of the same habitat (e.g. forest dominated by the same species) as close to the original site as possible. Most of the original and newly established sites represented one continuous habitat before the mining progressed. We therefore expected that mining destroyed the sites randomly, i.e. sites sampled in 2001 did not differ from the ones we were able to sample repeatedly. We also expect that newly established sites in 2020 did not systematically differ from related sampled sites. Additionally, between 2001 and 2020, we did not expect significant changes in ant communities in the surrounding landscape of the heaps, as the succession had already rather progressed.

To test these expectations, we applied redundancy analysis (RDA), where we tested the differences in ant communities for each successional series (unreclaimed, reclaimed) and year (2001, 2020) separately. In this test, numbers of ant species were log-transformed (similarly to other RDA tests, see Methods). The explanatory variable identified plots which were sampled in both years and which were sampled in one year only. We used site age as covariate to account for successional development. Significance was tested with the Monte-Carlo permutation test with 499 permutations. We also used RDA in the same arrangement to compare plots in the surrounding landscape between 2001 and 2020.

We did not find any significant differences between repeatedly sampled sites and sites sampled just once in series and year (Table S1). This was also found for the sites in the surrounding landscape, where the ant community did not significantly differ between 2001 and 2020 (explained variability 1.2%, F= 1.2%, P= 0.297).

These results support our assumptions that mining destroyed the sites randomly and that the newly selected sites were able to replace them, as they were comparable to still existing sites.

Table S1. Results of RDA testing differences between repeatedly and newly sampled sites for each year and successional series.

Year	Series	Explained variability	F	P
2001	Unreclaimed	2.7%	1.4	0.216
2001	Reclaimed	0.0%	1	0.427
2020	Unreclaimed	0.0%	0.8	0.573
2020	Reclaimed	0.5%	1.2	0.293

Table S2: Mean abundance (number of individuals per 100 m^2) of ant species in the studied habitats. The first number (before the slash) indicates ant abundance in the year 2001, the second in the year 2020. Species are sorted alphabetically within subfamilies. Numbers in brackets show total numbers of ants captured with pitfall trapping only.

	post-mining sites						surrounding landscape	
	spontaneous succession (years)			reclamation (years)			meadow (years)	forest (years)
	0–20	21–40	>40	0–20	21–40	>40	60–80	60–80
Formicinae								
Camponotus ligniperda	0/21	0/5	0/140	0	0	0	0	0
Formica cunicularia	14/3	260/9	0	269/0	538/1	0	368/890	0
F. fusca	278/375	624/1,376	0/298	109/0	290/94	0/366	218/54	0/225
F. lemani	0/108	0/1	0	(20)/0	0/1	0	0	0
F. pratensis	0	0/1	0	0	105/1	0	417/42	0
F. rufa	0	10,000/40	0/8	0	0/3	0/54	0	0/21
F. rufibarbis	0	0/922	0	(55)/0	0/1	0	0	0
F. sanguinea	1667/0	0	0	1/0	0	0	168/0	0
Lasius brunneus	0	0	0	0	0	0	0	0/91
L. flavus	0	0	0	667/0	4,526/1,680	0/37	29,167/15,300	3,500/0
L. fuliginosus	0	0	0	0	53/0	0/52	0	0/50
L. niger	7,178/5,320	15,300/11,585	0/2,425	31,251/0	19,833/11,877	0/2586	15,835/5,350	1,253/829
L. platythorax	0/27	0	0	0	0	0/362	0	500/738
Myrmicinae								
Leptothorax acervorum	36/0	220/8	0/60	26/0	26/3	0/4	20/4	40/21
Manica rubida	528/1,817	1,620/217	0	0	0/3	0	0	0
Myrmica gallienii	0	0	0	133/0	0/27	0	0	0
M. lobicornis	0	0	0	0	0/1	0	42/0	0
M. rubra	0	2,140/299	0/4,400	200/0	2,300/2,090	0/4,462	6,675/5,621	5,513/4,889
M. ruginodis	0	160/1	0/3,885	11/0	97/242	0/1,537	492/5,692	9,125/5,544
M. rugulosa	0	0/2	0	0	6/0	0	0	0
M. sabuleti	0	0/4	0/20	0	5/95	0	417/0	0
M. scabrinodis	0	0	0/24	0	21/34	0/40	4,117/901	0
M. schencki	0	0	0	0	0/2	0	183/21	0
Tetramorium caespitum	0	0/4	0	0	0	0	0	0

Table S3: Selected functional traits of recorded ant species. Ants are further divided into functional groups based on their habitat requirements.

	Functional group	Hierarchy position	Mode of colony founding
Formicinae			
Camponotus ligniperda	Forest	Subdominant	Claustral
Formica cunicularia	Open	Subordinate	Claustral
F. fusca	Eurytopic	Subordinate	Claustral
F. lemani	Open	Subordinate	Claustral
F. pratensis	Open	Dominant	Social parasitism
F. rufa	Forest	Dominant	Social parasitism
F. rufibarbis	Open	Subordinate	Claustral
F. sanguinea	Eurytopic	Subdominant	Social parasitism
Lasius brunneus	Forest	Subordinate	Claustral
L. flavus	Open	Subordinate	Claustral
L. fuliginosus	Forest	Subdominant	Social parasitism
L. niger	Eurytopic	Subdominant	Claustral
L. platythorax	Forest	Subdominant	Claustral
Myrmicinae			
Leptothorax acervorum	Forest	Subordinate	Semi-claustral
Manica rubida	Open	Subordinate	Semi-claustral
Myrmica gallienii	Open	Subordinate	Semi-claustral
M. lobicornis	Forest	Subordinate	Semi-claustral
M. rubra	Eurytopic	Subdominant	Semi-claustral
M. ruginodis	Forest	Subordinate	Semi-claustral
M. rugulosa	Open	Subordinate	Semi-claustral
M. sabuleti	Open	Subordinate	Semi-claustral
M. scabrinodis	Open	Subordinate	Semi-claustral
M. schencki	Open	Subordinate	Semi-claustral
Tetramorium caespitum	Open	Subdominant	Claustral

Table S4. Results of the general linear model explaining Sørensen dissimilarity by site age, reclamation status (unreclaimed vs reclaimed), and interaction between both variables. Significant F values are marked in bold and by asterisks (**p < 0.01, *p < 0.05).

	Site age	Reclamation	Interaction
Dissimilarity to reference in 2001	2.41	0.20	3.22
Dissimilarity to reference in 2020	**11.47****	0.09	0.04
Dissimilarity between 2001 and 2020	**4.60***	0.16	0.45

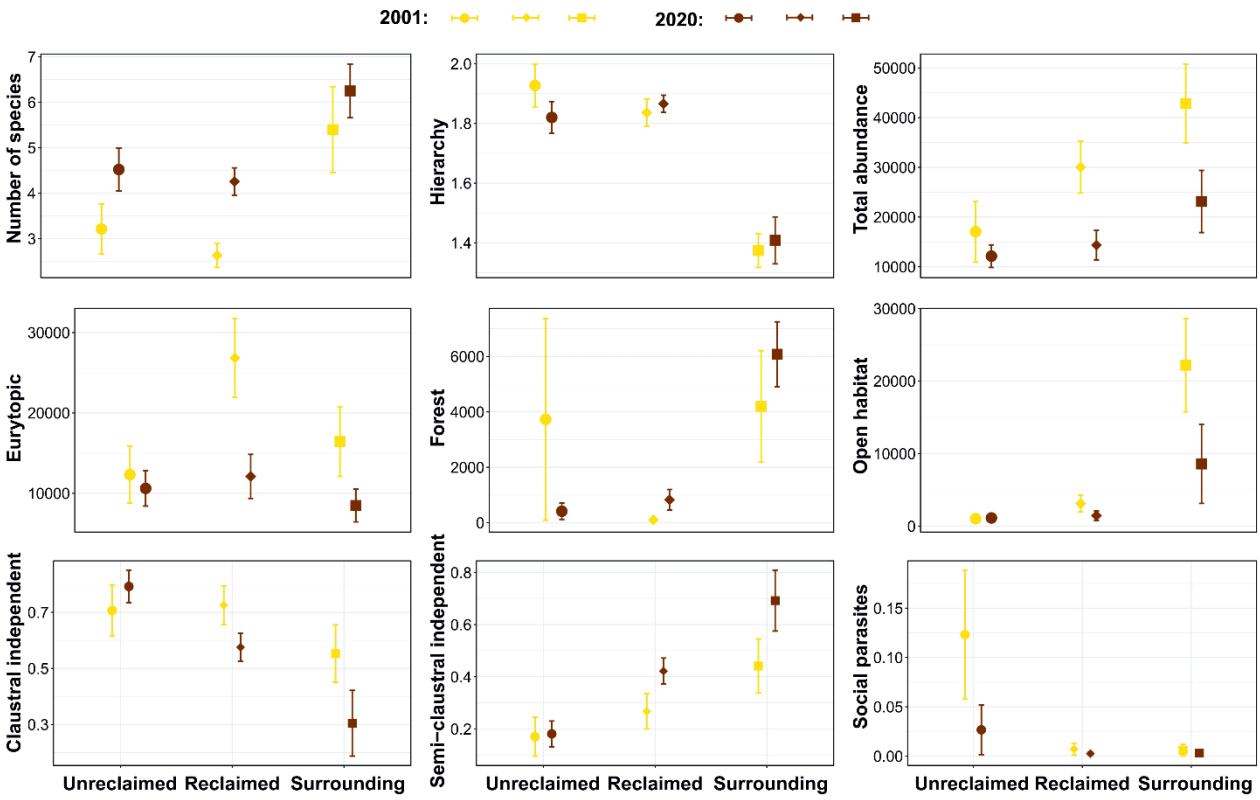

Figure S1. Number of ant species, individuals in functional groups, and mean values or representation of functional traits in ant communities of individual series. Mean values of each parameter are shown for each sampling year (2001, 2020). Error bars show the standard error of the mean.

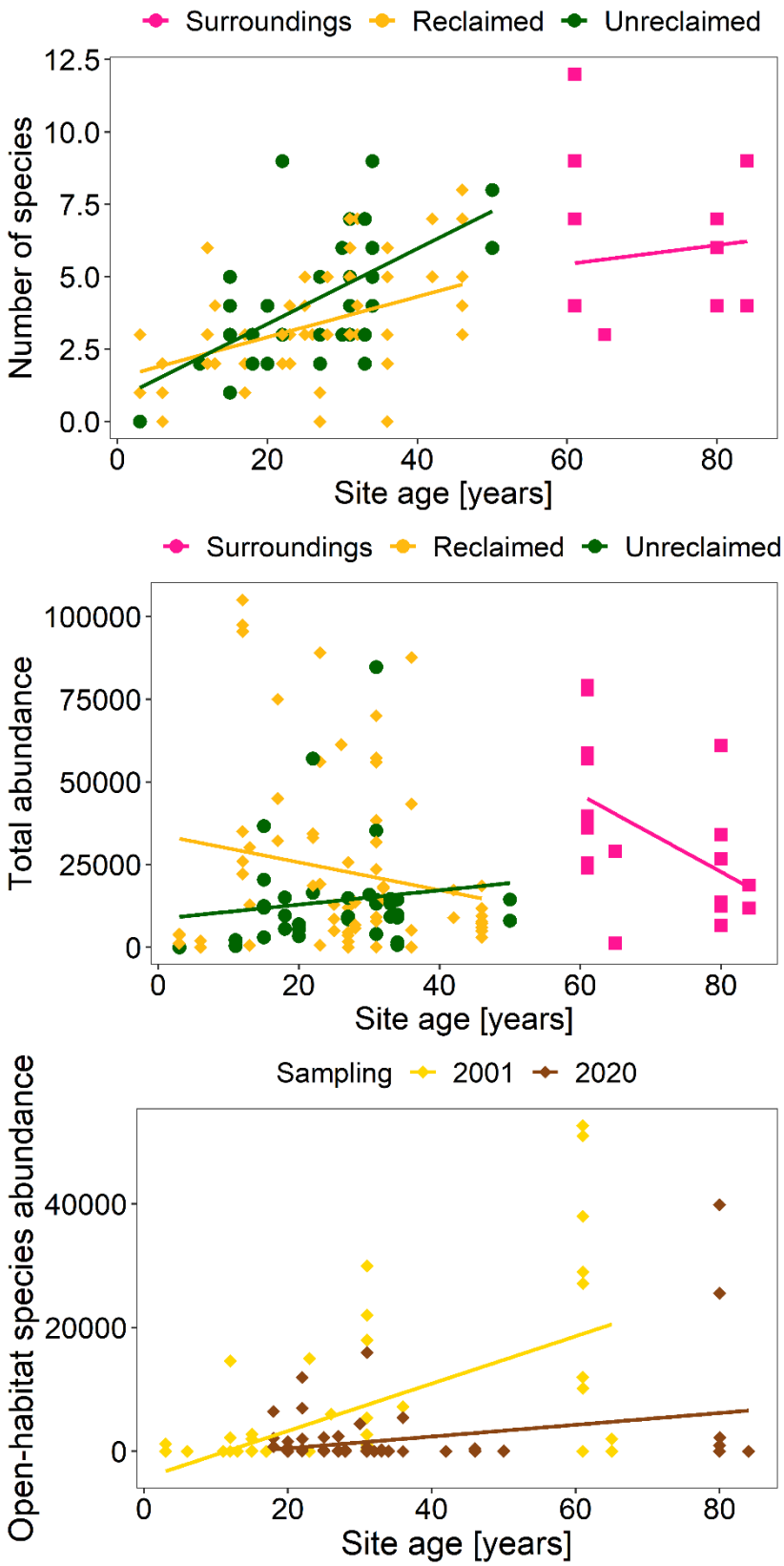

Figure S2. Changes in number of species, total abundance, and abundance of species preferring open habitats between series and sampling years. Only parameters in which interactions are significant are shown.

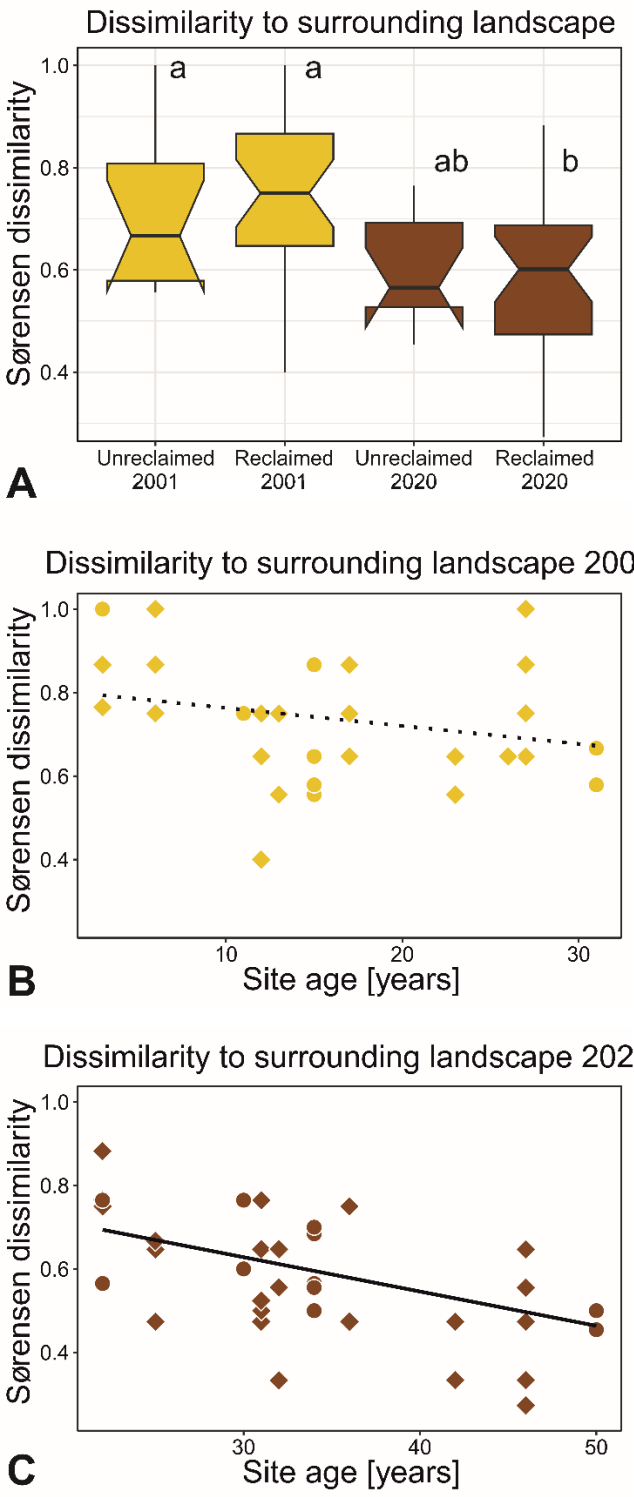

Figure S3. Comparison of Sørensen dissimilarity to the surrounding landscape between unreclaimed and reclaimed sites in individual sampling years (upper panel) and correlation between this Sørensen dissimilarity and site age in individual sampling years (lower two panels). Diamonds denote unreclaimed sites, circles denote reclaimed sites. The dotted line marks insignificant relationship. Different letters in the upper panel mark significant ($p < 0.05$) difference in ANOVA and the Tukey post-hoc test.

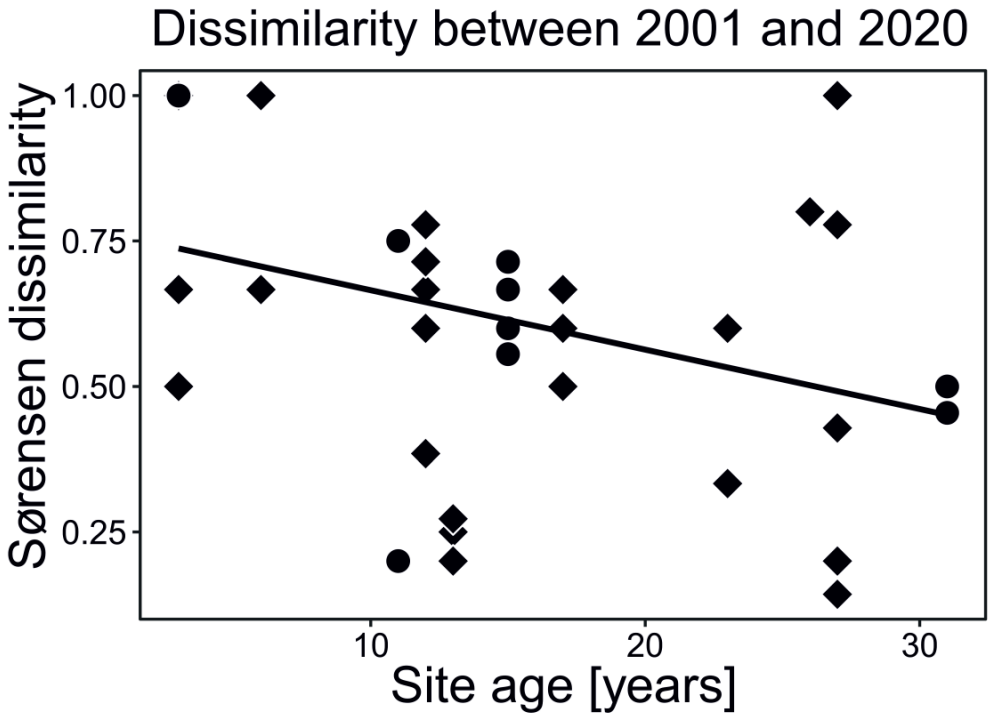

Figure S4. Sørensen dissimilarity between the 2001 and 2020 sampling years (computed at the same site) correlated with site age (in 2001). Diamonds denote unreclaimed sites, circles denote reclaimed sites.