Fire and Herbivory as Architects of Mediterranean Biodiversity

- Supplementary materials -

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Abstract: This research breaks new ground by showing that, contrary to generally accepted key role of fire in shaping plant communities, herbivores shaped both landscape heterogeneity and fire-prone habitats in the Mediterranean area. The interconnected roles of fire and herbivores predisposed habitat resilience, highlighting the need to integrate grazing for fire risk mitigation and biodiversity conservation. The recent decline in pastoralism coincides with the expansion of highly flammable vegetation, exacerbating fire risks under current climate conditions. These insights advocate for conservation strategies that balance fire management and sustainable herbivory to preserve Mediterranean biodiversity in the face of increasing anthropogenic and climatic pressures.

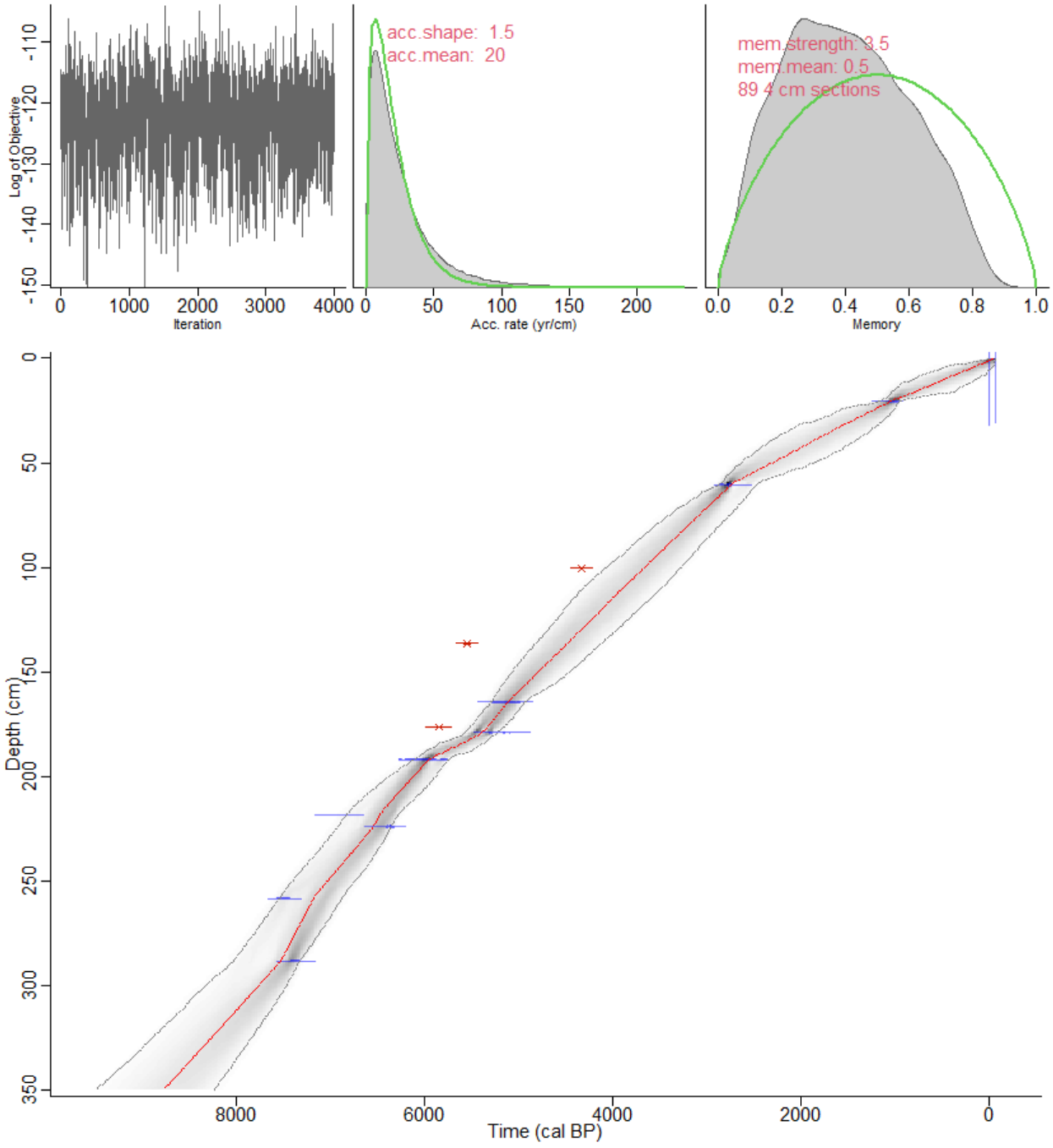

Fig. S1.

Age-depth model of etang des Aulnes computed with 'rbacon' and based on 9 AMS radiocarbon dates; red dots correspond to ^{14}C dates not taken into account in the age-depth model. The shaded area corresponds to the 95% confidence interval, and the dotted red curve represents the mean model.

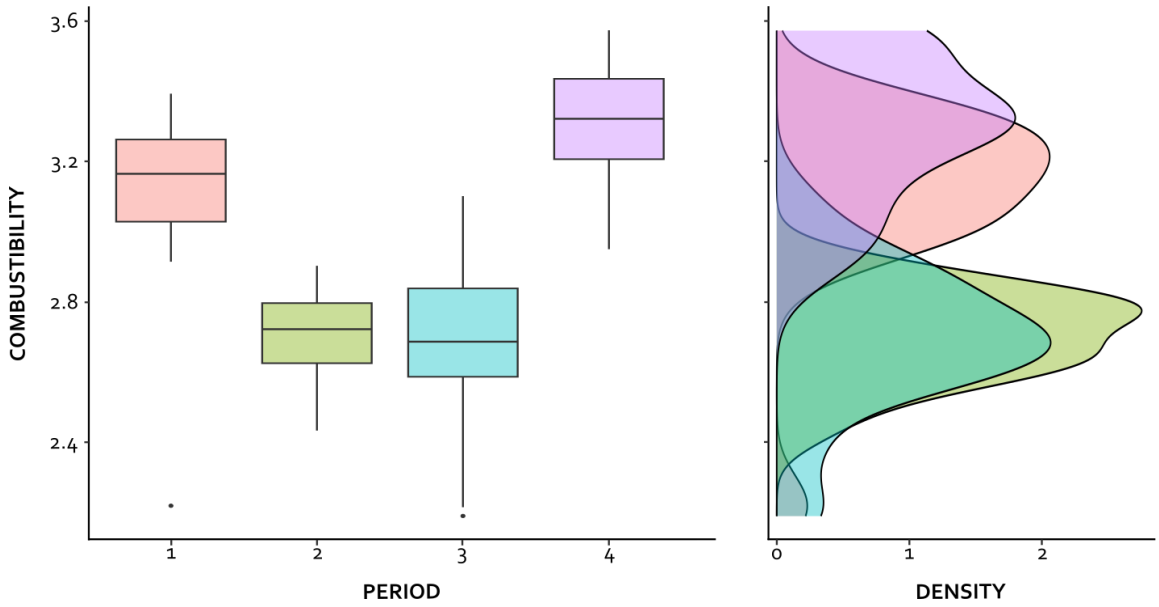

Fig. S2.

Mean combustibility and distribution across periods. The mean combustibility per sample was calculated as a weighted average, using the formula:

$$\text{Mean combustibility} = \frac{\sum(\boldsymbol{influx}\,(\boldsymbol{i}) * \boldsymbol{combustibility}\,(\boldsymbol{i}))}{\boldsymbol{total\ influx}}$$

where *i* corresponds to the habitat type. Significant differences between periods were determined using a non-parametric Mann-Whitney U test. Periods 1 and 2, 1 and 3, 2 and 4, 3 and 4 are significantly different (respectively: p-value = $1.754e^{-08}$; p-value = $1.004e^{-08}$; p-value = $1.281e^{-06}$; p-value = $1.677e^{-06}$). Periods 1 and 4, 2 and 3 are not significantly different (respectively: p-value = 0.1036; p-value = 0.9324).

Table S1.

Accelerator mass spectrometry radiocarbon dating of macroremains and of bulk sediments. The median depth is use for the depth-age model. Three dates were not used to make the age model (in red) because they correspond to unreliable bulk sediment dates.

Sample ID	Material	Lab. No.	Age	Methods	Age cal. BP. (2σ)
2A-1B-101	macroremains	Poz-164674	6020 ± 40 BP	AMS	5980-6060
2B-1B-35.5	macroremains	Poz-165279	4475 ± 35 BP	AMS	4440-4510
2B-1B-50	macroremains	Poz-165280	4550 ± 35 BP	AMS	4515-4585
2B-1B-63	macroremains	Poz-164675	5230 ± 40 BP	AMS	5190-5270
2B-1B-95	macroremains	Poz-164676	5600 ± 40 BP	AMS	5560-5640
2A-1A-20	bulk	Poz-171849	1115 ± 30 BP	AMS	1080-1150
2A-1A-60	bulk	Poz-171850	2645 ± 30 BP	AMS	2610-2680
2A-1A-100	bulk	Poz-171851	4330 ± 35 BP	AMS	4295-4365
2A-1B-136	bulk	Poz-171852	5545 ± 35 BP	AMS	5510-5580
2A-1B-176	bulk	Poz-171854	5850 ± 40 BP	AMS	5810-5890
2B-1B-258	bulk	Poz-171855	6590 ± 40 BP	AMS	6550-6630
2B-1B-288	bulk	Poz-171856	6450 ± 40 BP	AMS	6410-6490

Table S2.

Combustibility classes, pollen percentages, and associated taxa for Mediterranean habitats, providing insights into vegetation dynamics and fire behavior. Pollen taxa contributing less than 1% of the total pollen record are written in grey. A total of 72.48% of the identified pollen has been attributed to a Trabaud habitat, classified by combustibility (1: Very Low to 5: Very High) based on vegetation flammability and fire spread potential. Total pollen percentages represent each habitat's abundance over the entire sequence, while maximum percentages highlight peak dominance in specific levels. Key habitats include Beech Forest (e.g., *Fagus*), White Oak Coppice (e.g., *Quercus pubescens*), Green Oak Coppice (e.g., *Quercus ilex*), Pine Forest (e.g., *Pinus*), Garrigue/Heathland (e.g., *Thymus*, *Calluna*), and Grassland (Poaceae, Fabaceae). An "Other" category encompasses 27.52% of the pollen, representing diverse taxa not tied to a Trabaud habitat, including riparian or floodplain vegetation (e.g., *Alnus*, *Abies*, *Ulmus*), which fall outside the habitats defined by Trabaud (17).

Habitat	Combustibility	% total	% max	Associated pollen
Beech forest	1	2.48	8.92	Fagus (FAGACEAE)
White oak coppice	1	23.28	28.57	Acer (SAPINDACEAE) Corylus (BETULACEAE) Mercurialis-type (EUPHORBIACEAE) Pistacia (ANACARDIACEAE) Quercus pubescens/robur-type (FAGACEAE)
Green oak coppice	2	4.75	1.51	CAPRIFOLIACEAE Erica-type (ERICACEAE) Hedera (ARIALACEAE) Lonicera-type (CAPRIFIOLACEAE) Phillyrea (OLEACEAE) Quercus cerris-type (FABACEAE) Quercus ilex/coccifera-type (FAGACEAE) ROSACEAE Stachys-type (LAMIACEAE)
Pine forest	3	9.99	3.36	Pinus (PINACEAE)
Garrigue / Heathland	4	15.99	23.38	CUPRESSACEAE CYPERACEAE Calluna-type (ERICACEAE) EUPHORBIACEAE LAMIACEAE LILIACEAE Olea (OLEACEAE) Plantago coronopus-type (PLANTAGINACEAE) Plantago tenuiflora-type (PLANTAGINACEAE) Plantago-type (PLANTAGINACEAE) RANUNCULACEAE Thymus-type (LAMIACEAE)
Grasssland	5	14.98	22.59	APIACEAE CONVOLVULACEA Cerealia-type (POACEAE) FABACEAE Medicago-type (FABACEAE) Mentha-type (LAMIACEAE) Ononis-type (FABACEAE) POACEAE Polygonum (POLYGONACEAE) Sanguisorba minor-type (ROSACEAE) Triticum-type (POACEAE)
Other	/	28.52	30.48	Abies (PINACEAE) Alchemilla (ROSACEAE) Alnus (BETULACEAE) Ambrosia/Xanthium-type (ASTERACEAE) Anthriscus-type (APIACEAE) Artemisia (ASTERACEAE) Aruncus (ROSACEAE) Asteroideae (ASTERACEAE) BRASSICACEAE Betula (BETULACEAE) Buxus (BUXACEAE) CHENOPODIACEAE Cannabis (CANNABACEAE) Carpinus/Ostrya-type (BETULACEA) Cedrus (PINACEAE) Celtis (CANNABACEAE) Centaurea (ASTERACEAE) Cerastium-type (CARYOPHYLLACEAE) Cichorioidae (ASTERACEAE) Cirsium-type (ASTERACEAE) Cistus (CISTACEAE) Cotinus (ANACARDIACEAE) DIPSACACEAE Draba-type (BRASSICACEAE) Ephedra fragilis-type (EPHEDRACEAE) Fraxinus (OLEACEAE) GENTIACEAE Gagea-type (LILIACEAE) Galium (RUBIACEAE) Geranium (GERANIACEAE) Helianthemum (CISTACEAE) Herniari, Paronychia, Illecebrum-type (CARYOPHYLLACEAE) Hottenia (PRIMULACEAE) Hypericum (HYPERICACEAE) Juglans (JUGLANDACEAE) Legum-type (ERICACEAE) Ligustrum (OLEACEAE) Linium (LINACEAE) Lythrym (MYTHRACEAE) MALVACEAE Myrica (MYRICACEAE) Odontite (OROBANCHACEAE) Ornithogalum-type (LILIACEAE) Paronychia-type (CARYOPHYLLACEAE) Picea (PINACEAE) Pimpinella-type (APIACEAE) Platanus (PLATANACEAE) Polycnemum-type (AMARANTHACEAE) Popolus (SALICACEAE) Potentilla (ROSACEAE) Reseda-type (RESEDACEAE) Rhamnus (RHAMNACEAE) Rhus (ANACARDIACEAE) Ribes-type (GROSSULACEAE) Rumex (POLYGONACEAE) SCROPHULARIACEAE Salix (SALICACEAE) Sammel-gp (APIACEAE) Scabiosa-type (CAPRIFIOLACEAE) Silene-type (CARYOPHYLLACEAE) Taxus (TAXACEAE) Thalictrum (RANUNCULACEAE) Tilia (MALVACEAE) Trifolium-type (FABACEAE) URTICACEAE Ulmus (ULMACEAE) Veronica (PLANGINACEAE) Vitis (VITACEAE)

Table S3.

List of coprophilous fungal spore taxa used in the analysis. Taxa highlighted in gray are those not commonly referenced in the scientific literature as indicators of herbivory or pastoralism. In contrast, well-documented taxa, such as *Sporormiella*, *Podospora*, *Sordaria*, *Ascobolus*, and *Ascodesmis*, are recognized as reliable indicators of herbivore presence or grazing activity. These spores alone do not allow for a clear distinction between wild and domestic herbivores. Our interpretations are supported by a bibliographic review and comparisons with existing literature to contextualize the results **(*63*)**.

Taxa	Max count	Reference(s)
Sporormiella-type	20	(*3*, *14*, *64–66*)
Podospora-type	8	(*65*, *67–70*)
Sordaria-type	5	(*65*, *67–69*, *71*, *72*)
Ascobolus-type	3	(*65*, *67–69*, *73*, *74*)
Ascodesmis-type	3	(*67–69*, *75*, *76*)
Coniochaeta-type	14	(*65*, *66*, *77*)
Apiosordaria/*Cercophora*-type	5	(*65*, *66*, *72*, *78*, *79*)
Chaetomium-type	3	(*65*, *66*, *78*)
Arnium-type	2	(*65*, *80*, *81*)
Xylariales-type	3	(*3*, *65*, *66*, *78*)
Delitschia-type	2	(*3*, *65*, *82*)
Neurospora/*Gelasinospora*-type	2	(*65*, *66*, *82*)