



Wild ungulates influence the secondary succession of a salvaged silver fir forest after windthrow

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Introduction & aim

Windstorms are natural agents of vegetation dynamics, but their increasing frequency and intensity are undermining forest resilience, with dramatic ecological and economic impacts. Hence, post-windthrow management is a key aspect of forestry, especially in the Mediterranean area, where secondary successions are affected also by other disturbances, including ungulate pressure. Wild herbivores are usually attracted by food availability in the new clearings hampering the recolonization of tree and herbaceous communities, but studies on their impacts mainly focused only on tree regeneration.

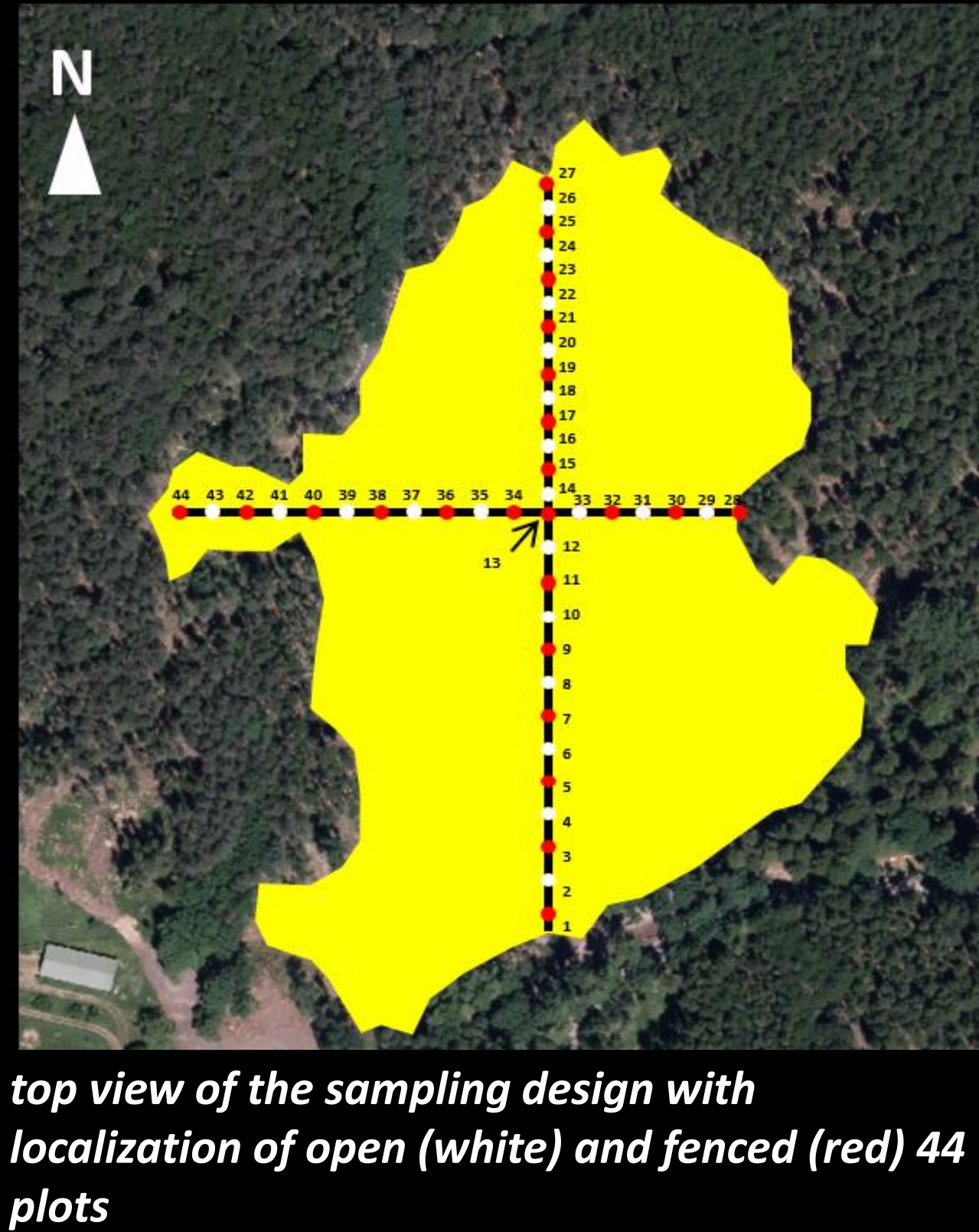


Study aim: To advance our understanding of ungulates influence at the early stages of the whole plant community (trees, shrubs and herbs) after a catastrophic windstorm in a mountain silver fir stand in the Mediterranean area

Material & methods

The windstorm event and study area

On 5th March 2015, a windstorm (>165 km/h) hit most part of Tuscany (central Italy). The event caused extensive damages to many parts of Vallombrosa forest, where the vegetation consists mainly of silver fir (*Abies alba*) stands of artificial origin cultivated by monks since the 11th century.



top view of the sampling design with localization of open (white) and fenced (red) 44 plots

The administration, Reparto Carabinieri Biodiversità di Vallombrosa, decided to leave one of the destroyed stands (in total 230 ha), named "Acquabella", as a permanent monitoring area to evaluate the chances for natural regeneration of the silver fir.

We performed an ungulate exclusion monitoring and a diachronic analysis of the successional stages of the whole plant community in the area that was logged and left to natural regeneration in 2016

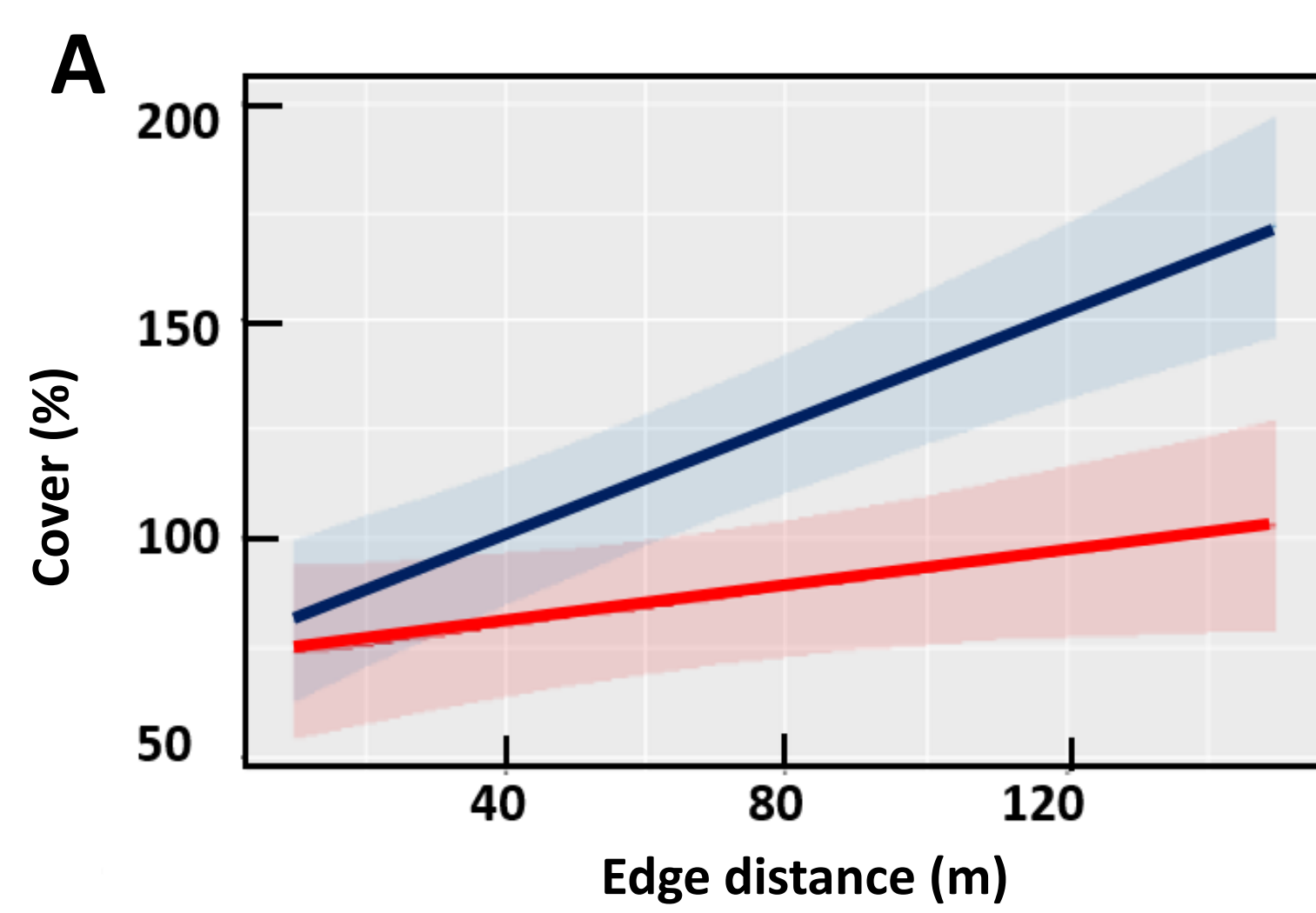
Sampling design and data collection

The following variables were measured and analysed along 6 years after the logging, accounting for the effect of time, fauna presence and forest edge distance:

- ✓ **vegetation recovery:** % of total ground cover of the plot
- ✓ **α-diversity:** species richness (SR) and Shannon index (H')
- ✓ **Indicator species, with main ecological characteristics:** proportion of light-demanding and forest specialists (according with Heinken classification HC), endo-/epi-zoochorous species
- ✓ **Tree regeneration:** tree seedling density per plot

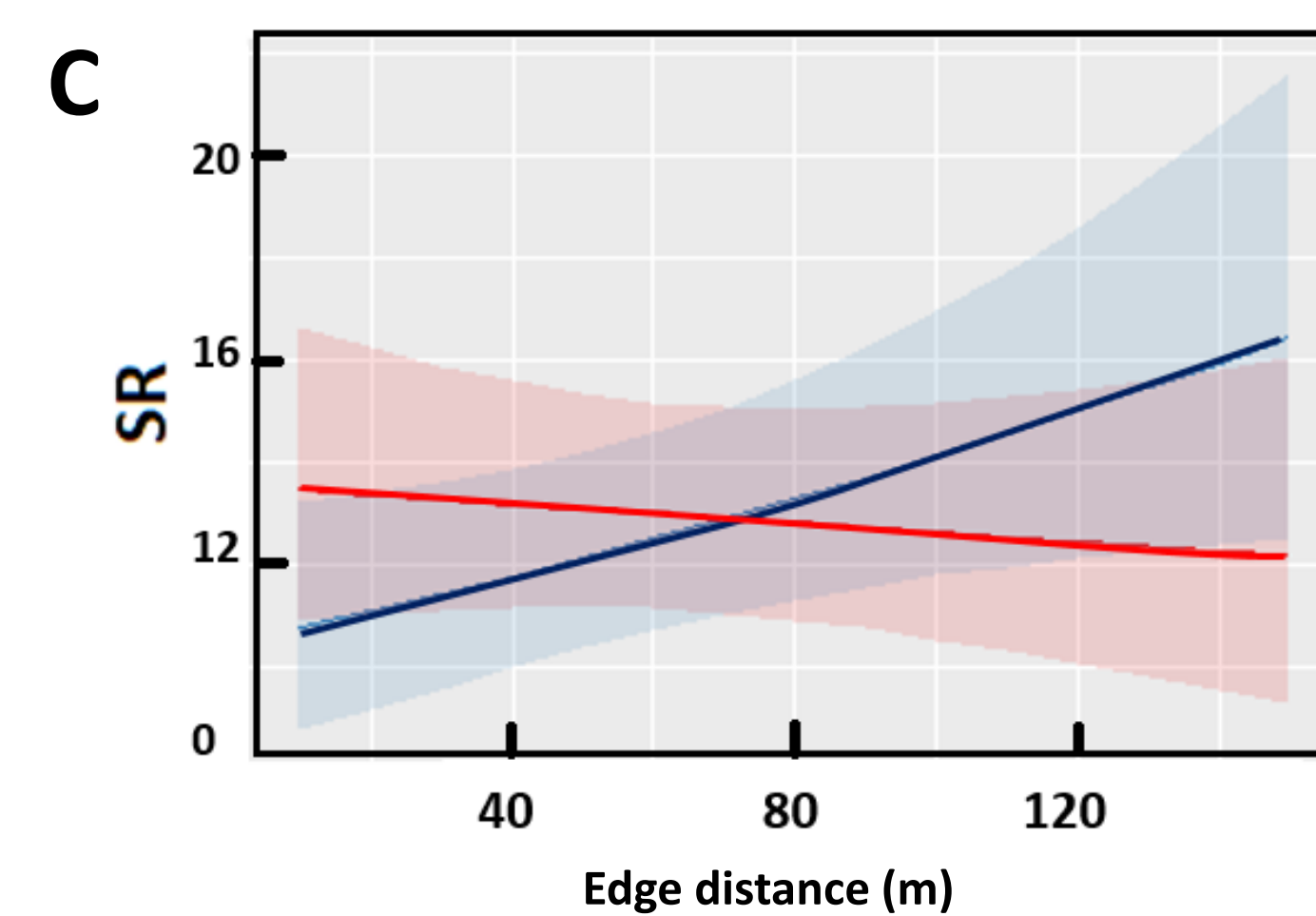
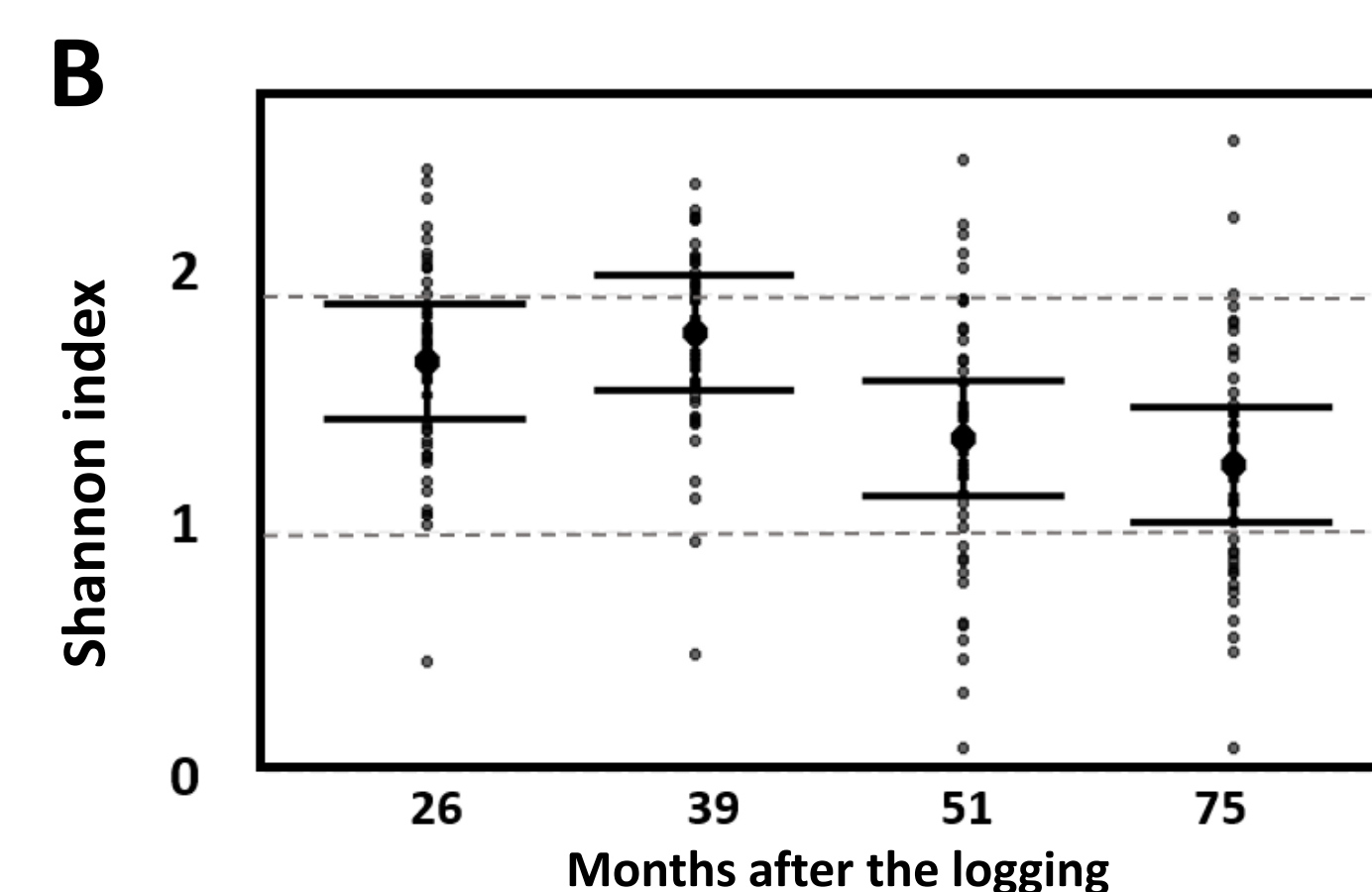
Results: how wild ungulates influence plant succession after windstorm, differences between open and fenced plots

Vegetation recovery



- ✓ Cover increased with distance to forest edge due to higher light availability
- ✓ Ungulates significantly slow down the vegetation recovery of the whole community, in terms of cover, but such negative effect was reduced at forest edge (A)

Plant diversity



- ✓ We recorded a total of 151 plant species
- ✓ Diversity decreased with time (B)
- ✓ Mean diversity was similar in fenced and open plots, however:
 - SR increased in the fenced plots while it almost decreased in the open with the edge distance (C)

The negative effect on species diversity caused by wild fauna was reduced close to the forest edge

Plant composition

✓ Open and fenced plots were associated to different groups of indicator species:

Open	HC	Fenced	HC
<i>Carex divulsa</i>	1.2	<i>Luzula nivea</i>	1.1
<i>Rubus ideaus</i>	1.2	<i>Hieracium racemosum</i>	1.2
<i>Cirsium arvense</i>	2.2	<i>Anemonoides trifolia</i>	1.1
<i>Stachys sylvatica</i>	1.2	<i>Vicia tenuissima</i>	2.2
<i>Cirsium vulgare</i>	2.2	<i>Salvia glutinosa</i>	1.1
<i>Pinus nigra</i>	2.1		
<i>Brachypodium rupestre</i>	2.2		
<i>Clinopodium vulgare</i>	2.2		
<i>Physospermum cornubiense</i>	1.1		



- ✓ The presence of ungulates in the open plots favored generalist plants according to Heinken classification (HC: 2.2)
- ✓ Open plots were associated to a higher proportion of endozoochorous plants.



Tree regeneration

- ✓ Seedling density was high (>10000/ha on average) but reduced by ungulates especially for *A. alba* (the most heavily browsed species), *Ostrya carpinifolia*, *Castanea sativa* and *Populus nigra*.

- ✓ More light-demanding and less palatable *Pinus nigra*, together with *Ulmus minor*, took advantage of the lower vegetation cover in the open plots

	N. of tree seedlings per species per plot	
	open	fenced
<i>Abies alba</i>	-	+
<i>Pinus nigra</i>	+	-
<i>Ulmus minor</i>	+	-
<i>Ostrya carpinifolia</i>	-	+
<i>Castanea sativa</i>	-	+
<i>Populus nigra</i>	-	+
TOTAL DENSITY (no. seedlings/ha)	13454.5	6863.7



Conclusions

Summing up, ungulates could alter the timing of vegetation recovery, species diversity and composition, and reduce the regeneration potential of different tree species. In most cases, however, the intensity and direction of fauna effects depended on the distance from the forest edge. Seedling density of different trees found in the plots, despite a negative effect of ungulates, supports natural tree regeneration as a feasible strategy if mixed and less vulnerable forests are desired for the future (rather than artificial silver fir stands). The present study underlies the importance of forest monitoring.