Pine recolonization dynamics in Mediterranean human-disturbed treeline ecotones

Urbinati Carlo, Vitali Alessandro, Malandra Francesco, Tonelli Enrico, Garbarino Matteo, Camarero J. Julio

INTRO

After the centuries-long history of transhumant land use of alpine pastures that significantly depressed the upper treelines, the natural establishment of trees near alpine treelines was widespread during the 20th century in Europe. We hypothesized that, with the absence of relevant geomorphological constraints, the synergic influences of climate and human abandonment could have triggered comparable encroachment patterns of four Pinus species above the forest lines on Mediterranean mountains.

METHODS

We collected 964 specimens, measuring their basal diameter, total height, and counting the number of seed cones. We differentiated seedlings (height < 0.5 m) from saplings (0.5m ≤ height < 2 m) and trees (≥ 2 m). We extracted increment cores or counted annual internodes for cambial age determination and tree-ring width measurements. We compared the ground cover around each pine, applied point pattern analyses, modelled the probability of seed cone production, estimated the average distance of seed dispersal and simulated the recent spatial dynamics in the last 15 years.

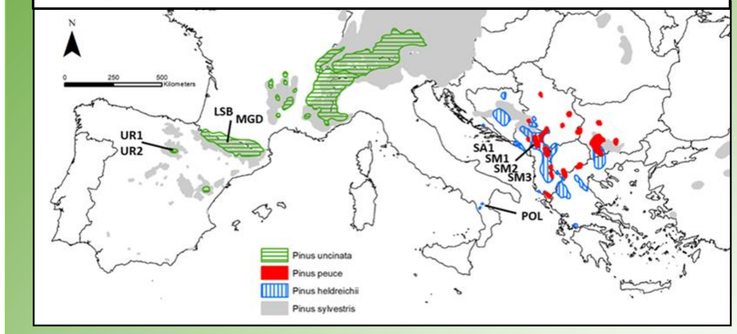
RESULTS

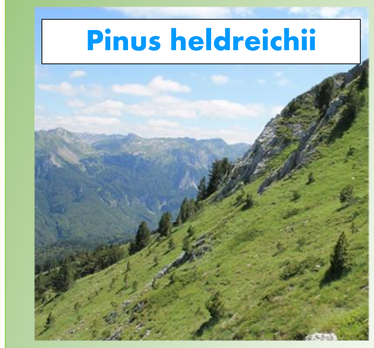
The four species exhibited heterogeneous density values. The overall averaged means ranged 2–7 cm for basal diameter, 54–106 cm for total height and 9–20 years for cambial age, suggesting a recent encroachment process. None of these structural variables decreased with increasing relative altitude and distribution patterns exhibited a few higher density spots but not cohort spatial structure. Ground cover differed between species and more significantly between size classes. Basal area increments increased from 1990 and stabilized in recent years at all species except for *P. peuce*. Height and basal diameter predicted cones production better than cambial age. *P. heldreichii* and *P. peuce* dispersed seeds at longer distances than others, suggesting different potential for further encroaching. The modelled past plots revealed the absence of pine trees (≥ 2 m of height) at most sites, with only two sites with an upward increase of 74 and 23 m respectively of the "tree species line". On the other hand, the infilling process occurred synchronously at all transects, but less on *P. heldreichii* sites.

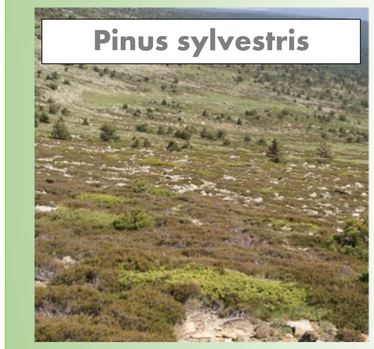
CONCLUSIONS

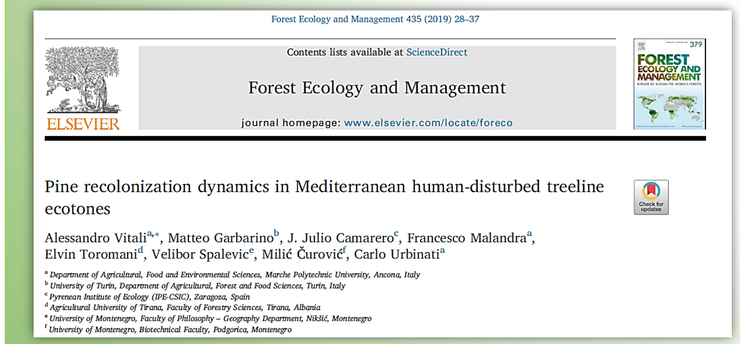
Tree recruitment started 30-35 years ago, and the similarity of structural features and the spatial distribution patterns seem to indicate a coeval and common trend of recolonizing treeless areas above the forest line. These high elevation pine populations featured a rapid encroachment aptitude regardless of slope steepness or exposure. The increasing number of these recent tree cohorts within the treeline ecotones can induce changes in major biogeochemical cycles, soil properties, and mountain eco-hydrological processes, leading to a significant long-term plant diversity decline in species-rich grasslands but also to an increase of slope protection against landslides and snow avalanches.

4 species - 9 sites - 964 specimens









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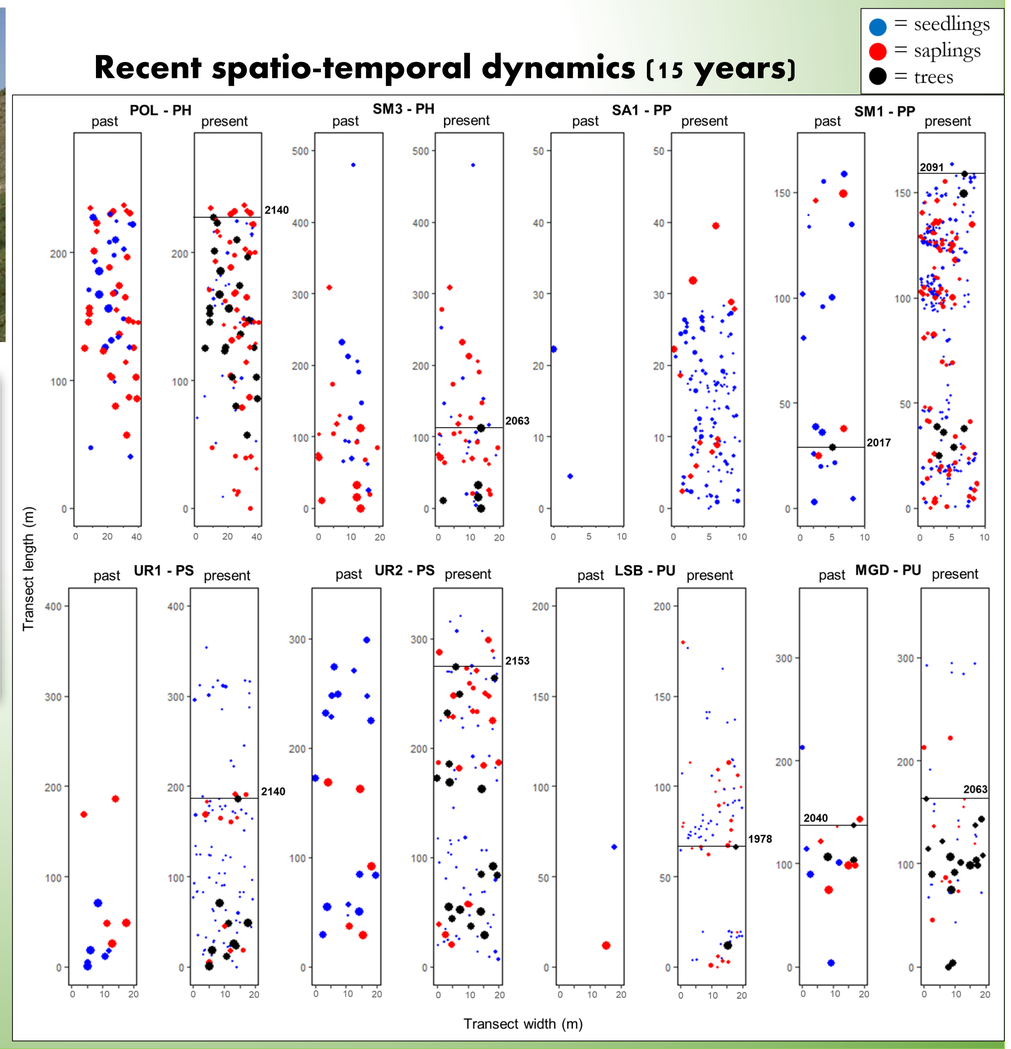
In Iberian System, Pyrenees, Apennines, Dinaric Alps

similar tree structures, growth dynamics, reproduction strategies and spatial distribution patterns

suggest

a synchronic (30-35 years ago) and common recolonizing process in treeless areas above the forest line

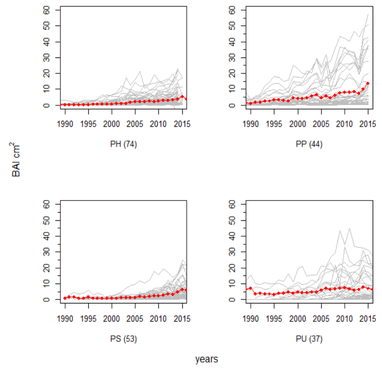
Recent spatio-temporal dynamics (15 years)



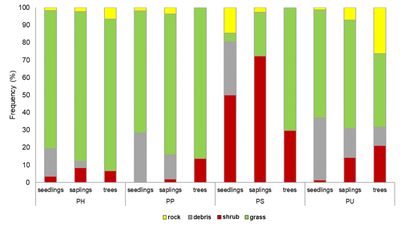
Treeline-ecotone structures

Pine species	Individuals with cones (%)	Sampled seedlings/ saplings/ Trees (No.)	Mean basal diameter ± SD (cm)	Mean height ± SD (cm)	Mean age ± SD (years)
P. heldreichii	6	57/83/30	7 ± 5	106 ± 81	20 ± 10
P. peuce	2	321/107/22	2 ± 2	54 ± 80	9 ± 7
P. sylvestris	7	144/36/27	4 ± 5	67 ± 86	10 ± 6
P. uncinata	15	76/42/19	5 ± 7	95 ± 132	10 ± 8

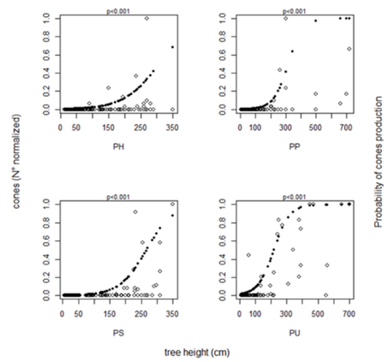
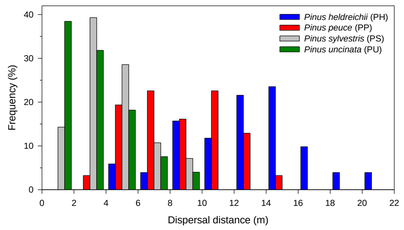
Radial growth



Regeneration substrate



Cone production



Seed dispersal