

Assessment of spectral eco-physiological traits of forests affected by black locust and black cherry in Central Europe

Flavio Marzialetti^{1,2}, Sebastian Bury³, André Große-Stoltenberg^{4,5}, Vanessa Lozano^{1,2}, Giuseppe Brundu^{1,2}, Marcin K. Dyderski³

¹Department of Agricultural Sciences, University of Sassari, Viale Italia 39/A, 07100 Sassari, Italy; ²National Biodiversity Future Center (NBFC), Piazza marina 61, 90133 Palermo, Italy; ³Institute of Dendrology, Polish Academy of Sciences, Parkowa 5, 62-035 Kórnik, Poland; ⁴Institute for Landscape Ecology and Resources Management (ILR), Research Centre for BioSystems, Land Use and Nutrition (iFZ), Justus Liebig University Gießen, Gießen; ⁵Center for International Development and Environmental Research (ZEU), Justus Liebig University Gießen, Gießen.

1 INTRODUCTION

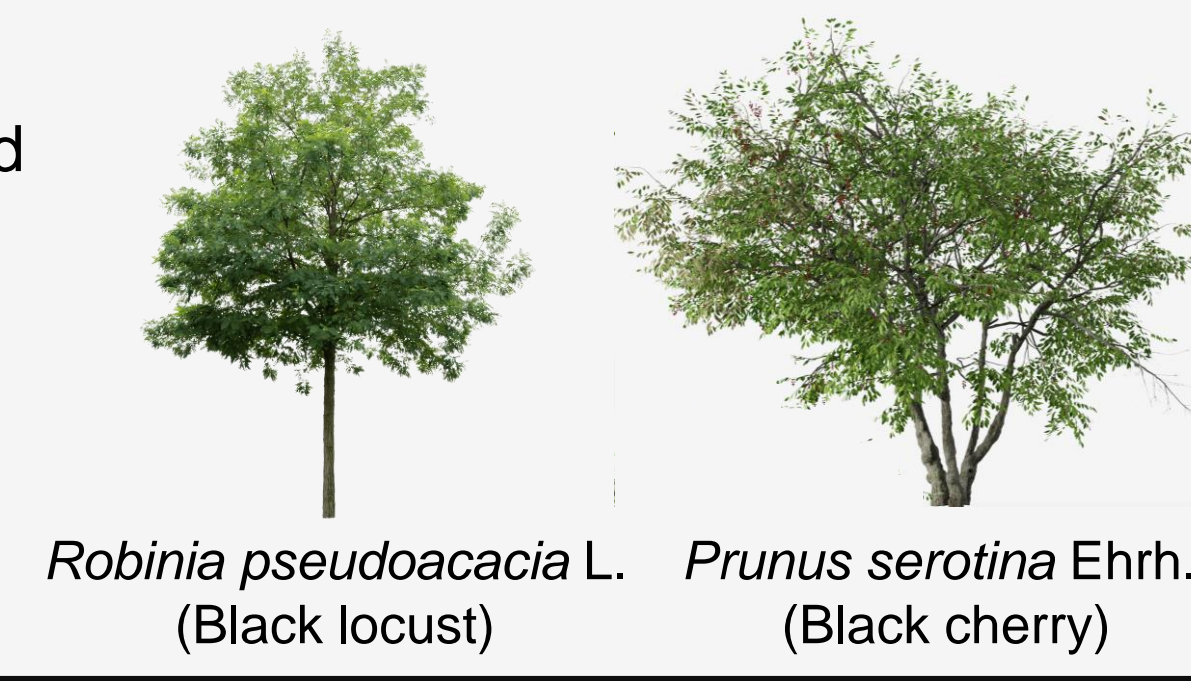
Biological invasions are considered one of the main drivers of global change, altering biodiversity, ecosystem services, environmental quality and conservation status of native communities (Roy et al. 2023)

Invasion success depends of the eco-physiological traits of invasive non-native species (e.g. higher photosynthetic activity, rapid growth, and phenotypic plasticity; Pyšek & Richardson 2007)

Remote sensing offers spatial and temporal continuous data highly efficient to estimate spectral eco-physiological traits on invaded and native vegetation (Große-Stoltenberg et al. 2018)

Prunus serotina Ehrh (Black cherry) and *Robinia pseudoacacia* L. (Black locust) are the most widespread invasive trees in Central Europe causing impacts on native ecosystems (e.g. alter litter dynamics, physical and chemical soil properties; Bury & Dyderski 2024)

Bury, S., Dyderski, M.K., 2024 No effect of invasive tree species on aboveground biomass increments of oaks and pines in temperate forests. *Forest Ecosystem* 11, 100201. Große-Stoltenberg, A., Hellmann, C., Thiele, J., Oldeland, J., Werner, C., 2018. Invasive acacias differ from native dune species in the hyperspectral/ biochemical trait space. *J. Veg. Sci.* 29, 325-335. Pyšek, P., Richardson, D.M., 2007. Traits Associated with Invasiveness in Alien Plants: Where Do we Stand?, in: Nentwig, W. (Eds) *Biological Invasions*. Ecological Studies, vol 193. Springer, Berlin, pp. 97-125. Roy, H.E., Pauchard, A., ..., Vandvik, V., 2023. The thematic assessment report on invasive alien species and their control, first ed. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Germany.



2 AIMS

The present work sets out to investigate the potential of multitemporal and multispectral Sentinel-2 imagery to identify spectral eco-physiological traits altered by *R. pseudoacacia* and *P. serotina* invasion in two temperate forests Scots pine dominated by *Pinus sylvestris* L. and Oak dominated by *Quercus robur* L. and *Q. petraea* (Matt.) Liebl.. Furthermore, we also compared the effects of woody evenness changes on monthly spectral eco-physiological between invaded and not invaded forest.



3 METHODOLOGY

Study area

160 circular plot (500 m²) in 2021/23

In each forests types, plots are:

- 32 invaded by *P. serotina* (PS)
- 32 invaded by *R. pseudoacacia* (RP)
- 16 not invaded (control)

Measured data: Diameter at breast height (DBH) of woody species

Calculated data: Basal Area (BA) and Pielou's Evenness.

Sentinel-2 database

18 monthly S2 imagery.

Level BOA 2A

Cloud cover < 20%

Season analyzed: Spring / Summer / Autumn.

Spectral ecophysiological traits

- Photosynthetic rate: Green Atmospherically Resistant Vegetation Index (GARI)
- Cholorophyll leaf content: Cholorophyll Vegetation Index (CVI)
- Carotenoid leaf content: Structure Insensitive Pigment Index (SIPI)

Difference in spectral ecophysiological traits

Linear Mixed Models (LMMs)

Sp. traits ~ Invasion Status * Month + (1 | Year/Month) + (1 | Pielou Evenness)

ANOVA – Estimated Marginal Means

Relation between woody evenness and spectral eco-physiological traits

Generalized Linear Models (GLMs)

Pielou Evenness ~ Monthly Sp. traits * Invasion Status

4 RESULTS

Difference in spectral ecophysiological traits between plots invaded and not invaded

Oak (Cond. R²: 0.87 – 0.79)

Control v.s.	RP		PS		RP		PS		RP		PS	
	GARI	CVI	SIPI	GARI	CVI	SIPI	GARI	CVI	SIPI	GARI	CVI	SIPI
March	↑**	↑***	↓***	↓***	↓***	↓***	↑***	↑***	↓***	↓***	↓***	↓***
April	↑***	↑***	↓***	↓***	↓***	↓***	↑***	↑***	↓***	↓***	↓***	↓***
May							↑**	↑**	↓***	↓***	↓***	↓***
June							↑**	↑**	↓***	↓***	↓***	↓***
July									↑*	↑*	↓***	↓***
August					↓**	↓**	↑***	↑***	↑***	↑***	↓***	↓***
September												
October							↑**	↑**	↓**	↓**	↓**	↓**
November	↑***	↑***	↓***	↓***	↓***	↓***	↑***	↑***	↓***	↓***	↓***	↓***

Scots pine (Cond. R²: 0.67 – 0.66)

Control v.s.	RP		PS		RP		PS		RP		PS	
	GARI	CVI	SIPI	GARI	CVI	SIPI	GARI	CVI	SIPI	GARI	CVI	SIPI
March	↓***	↓***	↓***	↓***	↓***	↓***	↑***	↑***	↓***	↓***	↓***	↓***
April							↑***	↑***	↓***	↓***	↓***	↓***
May							↑**	↑**	↓***	↓***	↓***	↓***
June							↑**	↑**	↓***	↓***	↓***	↓***
July									↑*	↑*	↓***	↓***
August					↑***	↑***	↑***	↑***	↓***	↓***	↓***	↓***
September												
October							↑**	↑**	↓**	↓**	↓**	↓**
November	↑***	↑***	↓***	↓***	↓***	↓***	↑***	↑***	↓***	↓***	↓***	↓***

Most significant relation between woody evenness vs: spectral eco-physiological traits

Example in Oak – Control vs. *R. pseudocacia*
Pielou Evenness ~ GARI November – R²: 0.30; RMSE: 0.08

	Estimate	Std. Error	Z	p-value
Intercept	0.67	0.02	29.588	***
Pielou Evenness	0.03	0.04	0.79	> 0.05
Invasion status	0.20	0.03	6.26	***
Pielou Evenness : Invasion status	-0.18	0.06	-3.25	**

Example in Scots pine – Control vs. *R. pseudocacia*
Pielou Evenness ~ GARI August – R²: 0.57; RMSE: 0.03

	Estimate	Std. Error	Z	p-value
Intercept	0.91	0.005	169.98	***
Pielou Evenness	0.15	0.020	7.52	***
Invasion status	0.05	0.007	6.27	***
Pielou Evenness : Invasion status	-0.03	0.03	-0.95	> 0.05

5 DISCUSSION AND CONCLUSION

We detected differences in the eco-physiological monthly responses across two temperate forest type (Oak, Scots pine) affected or not by invasion of *R. pseudoacacia* and *P. serotina*. The monthly variations in evenness are associated with changes in spectral eco-physiological traits. Stronger relationship have been confirmed within Scots pine plots invaded by *P. serotina* and to a lesser extent by *R. pseudoacacia*.