

# Why do some plant species become so successful and wide-spread away from home?

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Invasions by alien plants threaten the integrity of agricultural and natural systems, causing enormous economic and ecological cost. Throughout western North America, plant invasions have resulted in the replacement of vast areas of native perennial grasses with Eurasian and Mediterranean plants. Various factors have been shown to contribute to the negative impact of invasive alien plants, but their relative importance remains unclear. We assessed the relative effects of neighbouring plant community and soil biota in explaining the negative impact of spotted knapweed, *Centaurea stoebe* L., during the invasion of new sites in North America.

We conducted a greenhouse experiment with both European and North American spotted knapweed competing with/without European vs. North American neighbouring community and with the two neighbouring communities growing without knapweed. Plants were grown in sterilized commercial soil inoculated with soil originating either from the home or the introduced range, and half of which was sterilized to remove soil biota.

Our results suggest that during the colonization of new sites in North American grasslands, the impact of spotted knapweed is strongly driven by the lower competitive ability of

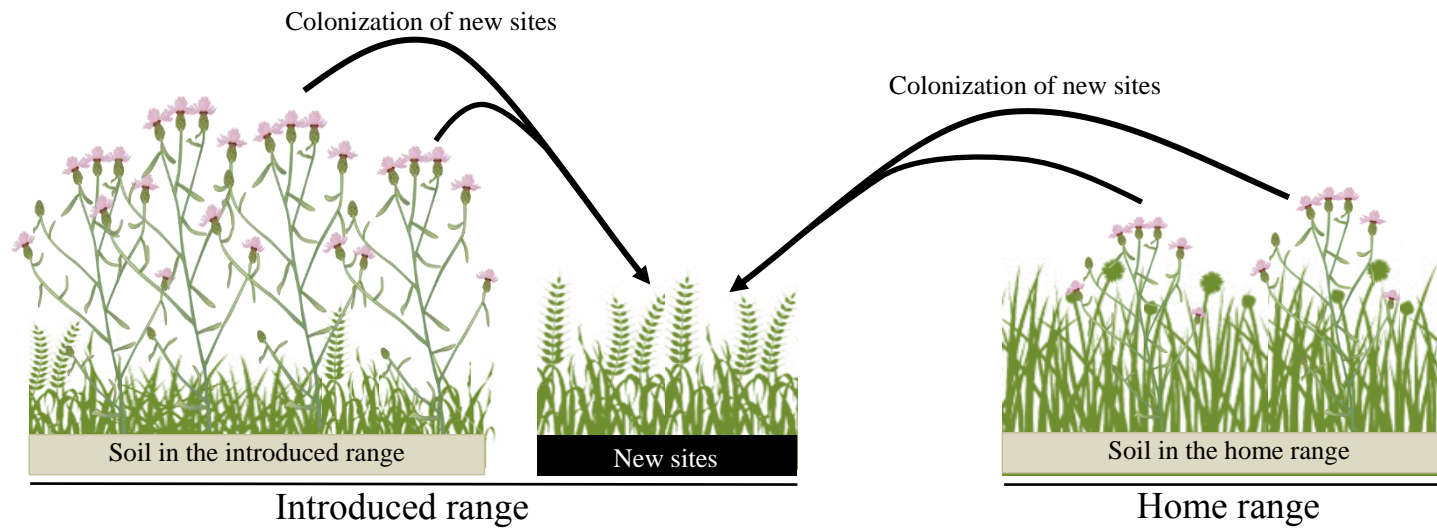


*Spotted knapweed in USDA Field Station in Missoula, USA (left) and a knapweed individual (right). Courtesy of Norman E. Rees & Ivan Bliet.*

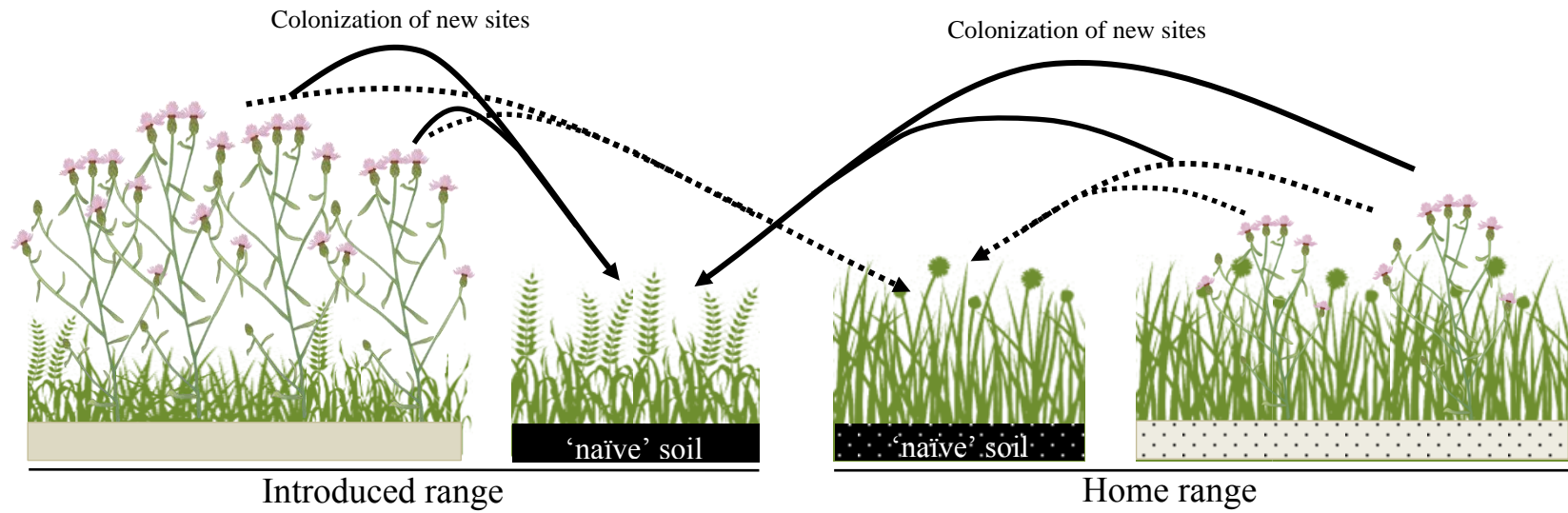
new (North American) neighbours compared with old (European) neighbours, while altered biotic soil conditions in the introduced range are of less importance. Interestingly, this differential impact appears to be due to inherently different mechanisms, as biomass of knapweed explained a substantial amount of the variation in biomass of the coevolved European neighbours, but not of the new "naïve" North American neighbours. Thus, impact in the home range appears to be driven by simple competition for the same limiting resources, but by other factors in the introduced range, possibly by exploitation of resources that are not used by the new neighbours or by a direct chemical impact on those neighbours (e.g. allelopathy effects). These findings, if applicable to other species, have important implications for the management of alien invasive plants, in that ecosystem recovery is less likely after a simple removal of their biomass.

**Supplementary:**

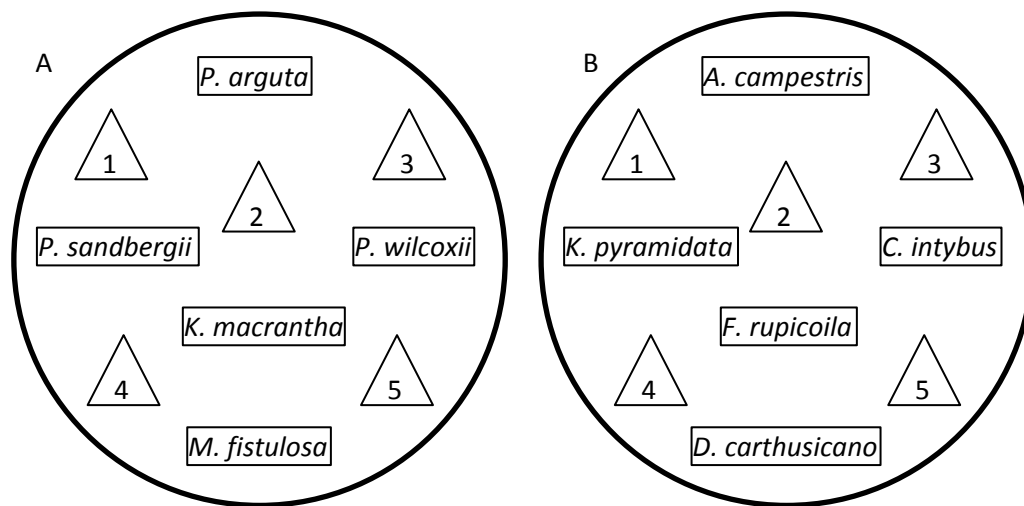
**Fig. S1.** Graphical layout of the study concept: soil origin, i.e. soils in the introduced range and home range, native community origin and genotypes of the invader all might contribute to the impact of invader at new sites in the introduced range. Thus we set up a full-factorial experiment to assess the relative importance of these three factors, i.e. soils, native communities and invader from both the introduced and home range.



**Fig. S2.** Graphical layout of our full-factorial experimental design of three factors: ‘naïve’ soils, native communities and invader from both the introduced and home range.



**Fig. S3.** The arrangement of five North American (A) and European (B) native neighbour plants and five *C. stoebe* in the interspecies competition pot, triangles are *C. stoebe*. We used this 1:1 competition ratio (i) to maximise interaction between *C. stoebe* and its neighbours, and (ii) to have the same number of the target (*C. stoebe*) and the response plants (the neighbouring community) assuming differences between them. The same ratio has also been used by other authors for their greenhouse competition experiments with *C. stoebe* (Callaway, DeLuca & Belliveau 1999; Marler, Zabinski & Callaway 1999).



## References

- Callaway, R.M., DeLuca, T.H. & Belliveau, W.M. (1999) Biological-control herbivores may increase competitive ability of the noxious weed *Centaurea maculosa*. *Ecology*, **80**, 1196-1201.
- Marler, M.J., Zabinski, C.A. & Callaway, R.M. (1999) Mycorrhizae indirectly enhance competitive effects of an invasive forb on a native bunchgrass. *Ecology*, **80**, 1180-1186.

**Supplementary:**

**Table S1.** Origin of *Centaurea stoebe* populations.

	Site code	Longitude	Latitude
Germany (Europe)	DE3	11 °08'56.49" E	49 °41'68.40" N
	DE4	10 °63'14.38" E	49 °99'36.74" N
	DE5	10 °65'75.61" E	50 °29'83.27" N
Montana (North America)	U.S.MT3	113 °97'49.00" W	45 °83'46.47" N
	U.S.MT5	111 °39'43.88" W	44 °85'53.10" N
	U.S.MT6	110 °83'19.50" W	45 °29'59.71" N
	U.S.MT9	112 °12'56.61" W	47 °30'05.66" N

**Table S2.** Soil collection sites.

	Area	Longitude	Latitude
Switzerland (Europe)	Zetzwil	8 °15'28.68" E	47 °28'23.59" N
	Gortenschwil	8 °14'25.04" E	47 °28'07.87" N
	Bière	6 °34'44.53" E	46 °52'56.75" N
Montana (North America)	Grant creek	114 °01'06.6" W	46 °56'07.7" N
	Jumbo	113 °58'22.89"W	46 °52'14.08"N
	Kleinschmidt	113 °4'58.95"W	46 °57'55.87"N

**Table S3.** Statistical results of Figures 1, 2 & 3 (chi-square value of zero indicates no significant treatment effect).

Fig. 1.		biomass of neighbouring community		reduction in biomass	
		chi-square	P-value	chi-square	P-value
un-sterilized soil	neighbour origin	18.46	<b>&lt;0.001</b>	21.35	<b>&lt;0.001</b>
	soil origin	2.23	0.14	2.18	0.14
	Neighbour $\times$ soil	1.29	0.26	2.78	0.10
sterilized soil	neighbour origin	38.23	<b>&lt;0.001</b>	38.49	<b>0.01</b>
	soil origin	0.36	0.55	3.74	0.05
	Neighbour $\times$ soil	0.37	0.54	0.49	0.48
Sterilization		62.74	<b>&lt;0.001</b>	25.37	<b>&lt;0.001</b>

Fig. 2.		biomass of <i>C. stoebe</i>		reduction in biomass	
		chi-square	P-value	chi-square	P-value
un-sterilized soil	neighbour origin	6.44	<b>0.01</b>	4.44	<b>0.03</b>
	soil origin	4.86	<b>0.03</b>	0.01	0.92
	Neighbour $\times$ soil	0.04	0.84	0.06	0.81
sterilized soil	neighbour origin	18.36	<b>&lt;0.001</b>	6.37	<b>0.01</b>
	soil origin	2.63	0.11	0.86	0.35
	Neighbour $\times$ soil	0.73	0.39	0.52	0.47
Sterilization		17.14	<b>&lt;0.001</b>	1.99	0.16

Fig. 3.		REI	
		chi-square	P-value
un-sterilized soil	neighbour origin	53.52	<b>&lt;0.001</b>
	soil origin	0	ns.
	Neighbour $\times$ soil	0.06	0.81
sterilized soil	neighbour origin	41.43	<b>&lt;0.001</b>
	soil origin	0	ns.
	Neighbour $\times$ soil	0.67	0.41
Sterilization		0.008	0.93