

*Ecological Archives*

**Yan Sun, Alexandra R. Collins, Urs Schaffner, and Heinz Müller-Schärer. 2013. Dissecting impact of plant invaders: do invaders behave differently in the new range? *Ecology*, 94(10): 2124–2130.**

APPENDIX A (TABLE. A1). Origin and description of tetraploid *Centaurea stoebe* populations.

	Country/State	Site code	Longitude	Latitude
Europe	Germany	DE3	11.085649	49.416840
	Germany	DE4	10.631438	49.993674
	Germany	DE5	10.657561	50.298327
North America	Montana	U.S.MT3	-113.974900	45.834647
	Montana	U.S.MT5	-111.394388	44.855310
	Montana	U.S.MT6	-110.831950	45.295971
	Montana	U.S.MT9	-112.125661	47.300566

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APPENDIX B. Details on the methods and statistics.

### Plant growing conditions

On 13<sup>th</sup> December 2010, we sowed seeds of all 17 EU and 19 NA species into seedling trays with 150 (10×15) cell plugs of 15 ml volume filled with commercial potting soil (TKS-1, Florigard, Berlin, Germany). The seedling trays were kept in a greenhouse of the University of Fribourg and exposed to natural light condition, supplemented by metal halide bulbs (18h-light, 6h-dark), and at a temperature of 15-22°C. On 24<sup>th</sup> January 2011, we first transplanted seedlings of 11 EU species, 13 NA species and of EU and NA 4x *C. stoebe* into 1L pots (first cohort, C1). On 14<sup>th</sup> February 2011, we transplanted seedlings of 7 EU species, 5 NA species and of EU and NA *C. stoebe* from the second sowing date into 1L pots (second cohort, C2; Table B1). Due to low germination, a few species had to be excluded from the experiment. The planting arrangement resulted in a distance of c. 8cm between individuals in the competition pots, corresponding to a commonly observed neighborhood distance in the field (Callaway et al. 2011, Mráz et al. 2012).

To mimic the low nutrient and moisture conditions in North-Western U.S., where *C. stoebe* is an aggressive invader of dry rangeland, pots were filled with a low nutrient soil (TKS-1; Florigard, Berlin, Germany) mixed with sand and vermiculite (Vermica AG, Bözen, Switzerland) in the ratio 1:1:1 by volume up to 1cm beneath the edge of the pot, and irrigated with 100 ml water per pot every three or four days to ensure that each pot was given an equal amount of water. Pots in each block were re-randomized every fortnight. We measured soil-moisture content (SMC) of 10 randomly selected competition pots across all treatments on each of the five benches every week, 3 hours after irrigation to ensure the moisture stayed at a low level (5-10%, lowest soil moisture percentage in top 10 cm soil during summer in Montana; data from the National Resources Conservation Service (NRCS) Water and Climate Center (<http://www.wcc.nrcs.usda.gov>)) using a ThetaProbe soil moisture sensor type-ML2 (Delta-T Devices, Cambridge, UK) at 10 cm below the rooting medium surface.

(TABLE. B1). Native neighbor species of North America and Europe, functional groups and transplanting time (C1, C2: cohort 1 or 2, cf. Material and Methods for details) used in experimental assemblages. Functional groups of NA species according to Maron and Marler (2008). The superscript numbers behind each species represent the source of seeds: collected from field (bulk samples of 10-20 mother plants per population adjacent to a *C. stoebe* infested site) (1), B-and-T World Seeds, Paguignan, France (2), UFA-Samen, Winterthur, Switzerland (3), and Jelitto, Schwarmstedt, Germany (4).

Functional group	NA neighbours	Cohort	EU neighbours	Cohort
Grass	<i>Festuca idahoensis</i> <sup>1</sup>	C2	<i>Festuca valesiaca</i> <sup>3,4</sup>	C1&2
	<i>Koeleria macrantha</i> <sup>1</sup>	C1	<i>Koeleria pyramidata</i> <sup>2,3</sup>	C1
	<i>Poa sandbergii</i> <sup>1</sup>	C1&2	<i>Bromus erectus</i> <sup>2,3,4</sup>	C1
Early season, rhizomatous	<i>Antennaria microphylla</i> <sup>1</sup>	C1		
	<i>Geum triflorum</i> <sup>1</sup>	C1	<i>Sanguisorba minor</i> <sup>1,3</sup>	C1&2
	<i>Penstemon procerus</i> <sup>1</sup>	C1	<i>Veronica teucrium</i> <sup>3,4</sup>	C1
Midseason, spreading rhizomes	<i>Achillea millefolium</i> <sup>1</sup>	C1	<i>Achillea millefolium</i> <sup>1,3</sup>	C1
	<i>Arnica sororia</i> <sup>1</sup>	C1	<i>Dianthus carthusianorum</i> <sup>1,3</sup>	C1
	<i>Monarda fistulosa</i> <sup>1,2</sup>	C1	<i>Galium verum</i> <sup>2,3,4</sup>	C1
Midseason, woody root crowns	<i>Gaillardia aristata</i> <sup>1</sup>	C1&2	<i>Artemisia campestris</i> <sup>2,3,4</sup>	C1
	<i>Penstemon wilcoxii</i> <sup>1</sup>	C1	<i>Leontodon hispidus</i> <sup>3,4</sup>	C2
	<i>Potentilla arguta</i> <sup>2</sup>	C1	<i>Scabiosa columbaria</i> <sup>1,3</sup>	C1
Late season, deep taproot	<i>Artemisia frigida</i> <sup>2</sup>	C2	<i>Cichorium intybus</i> <sup>3,4</sup>	C1&2
	<i>Aster ericoides</i> <sup>2</sup>	C1	<i>Echium vulgare</i> <sup>2,3,4</sup>	C2
	<i>Aster falcatus</i> <sup>1</sup>	C1&2		
Spring ephemerals, shallow taproot			<i>Plantago media</i> <sup>2,3,4</sup>	C2
			<i>Ranunculus bulbosus</i> <sup>3,4</sup>	C2

## Statistical analyses (further details)

### *Effect of neighbor and C. stoebe origin on RGR, SMC and REI*

In all these general linear mixed models, even though cohort significantly affected RGR, SMC and REI ( $P < 0.05$ ), all interactions between cohort and origin of neighbor plants and of *C. stoebe* were non-significant ( $P > 0.14$ ). Furthermore, the REI of those six species from C1 that were re-sown in C2 did not differ between two cohorts (Chi-square = 1.424,  $P = 0.233$ ).

### *Relationship between biomass of neighbors and C. stoebe in the competition pots*

In the mixed-effects regression models, origin of native neighbors was included as fixed effects in a combined analysis of all data set; as to the random structure, we compared a random intercept and slope model with a random intercept model using species identity. We used the likelihood ratio test from restricted maximum likelihood fits for significance. The results indicated no difference between the common slope and the slopes of each of the species (interaction between *C. stoebe* biomass and EU species identity,  $P = 0.051$ ; NA species identity,  $P = 0.153$ ).

All analyses were performed using R statistical software, version 2.15.1 (R Development Core Team, 2012).

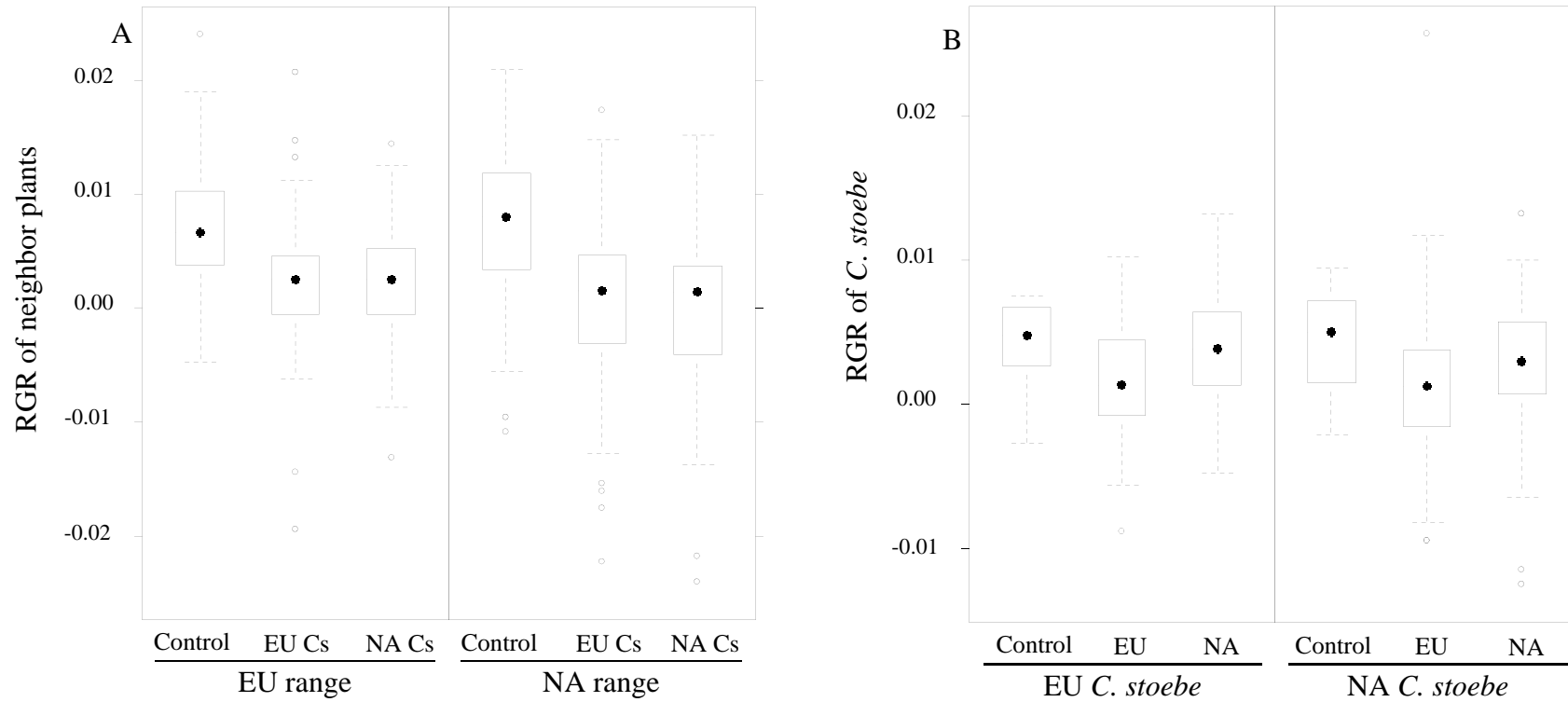
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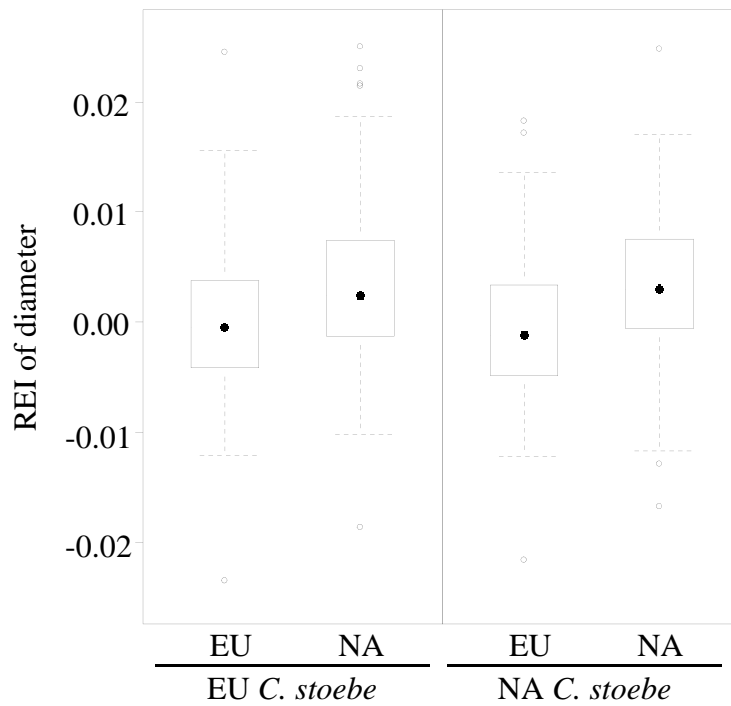
APPENDIX C. (FIG. C1). Mean relative growth rate (RGR) of neighbors (A) and of tetraploid EU and NA *Centaurea stoebe* (B) when grown under non-competition (control) and competition condition. EU = EU neighbors, NA = NA neighbors; EU Cs = EU *C. stoebe*; NA Cs = NA *C. stoebe*.



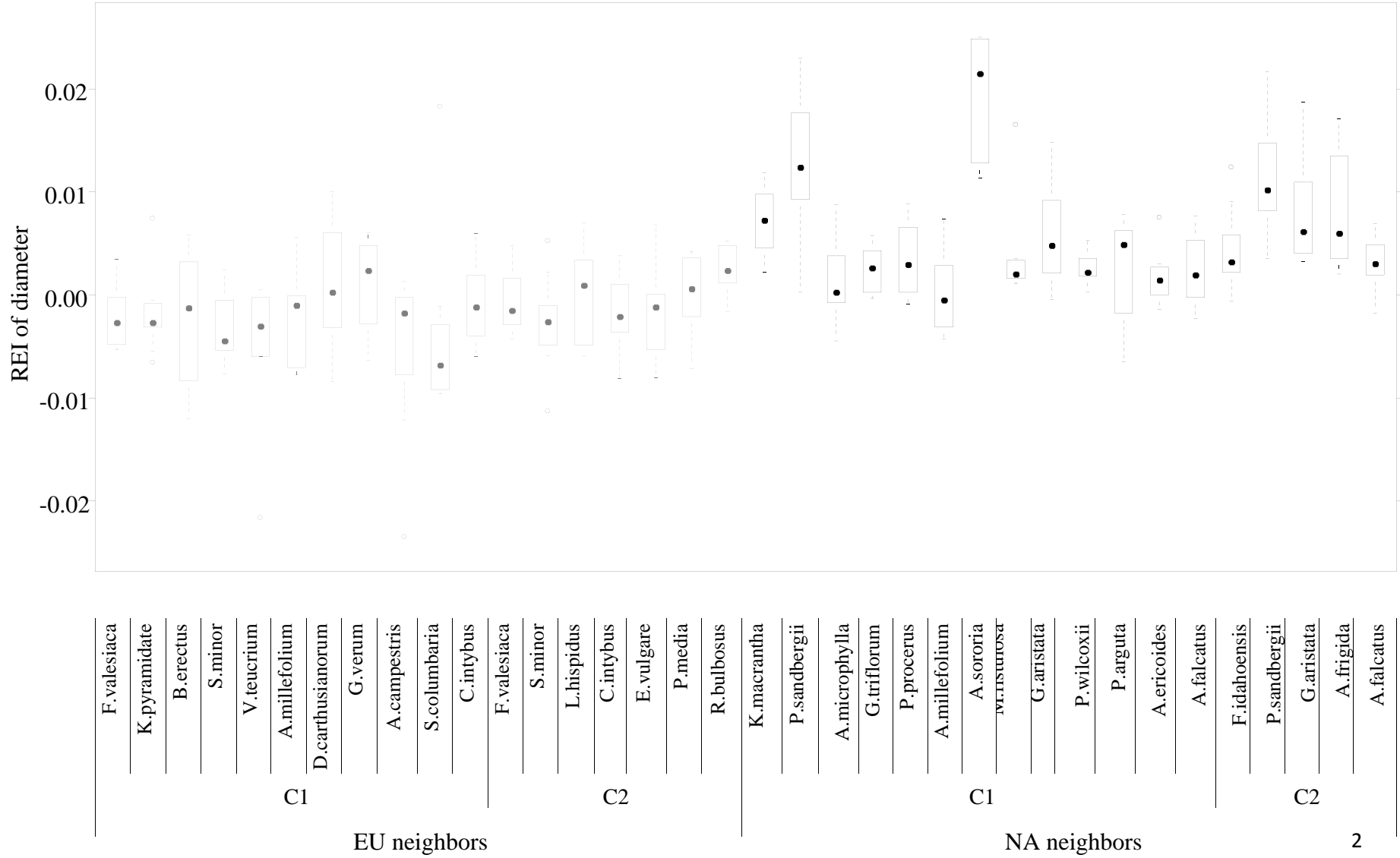
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APPENDIX D. (FIG. D1). Comparison between competitive performance of EU and NA  
neighbors with tetraploid EU and NA *Centaurea stoebe*, using a size-independent  
index, the Relative Efficiency Indices (REIs) based on plant diameter.



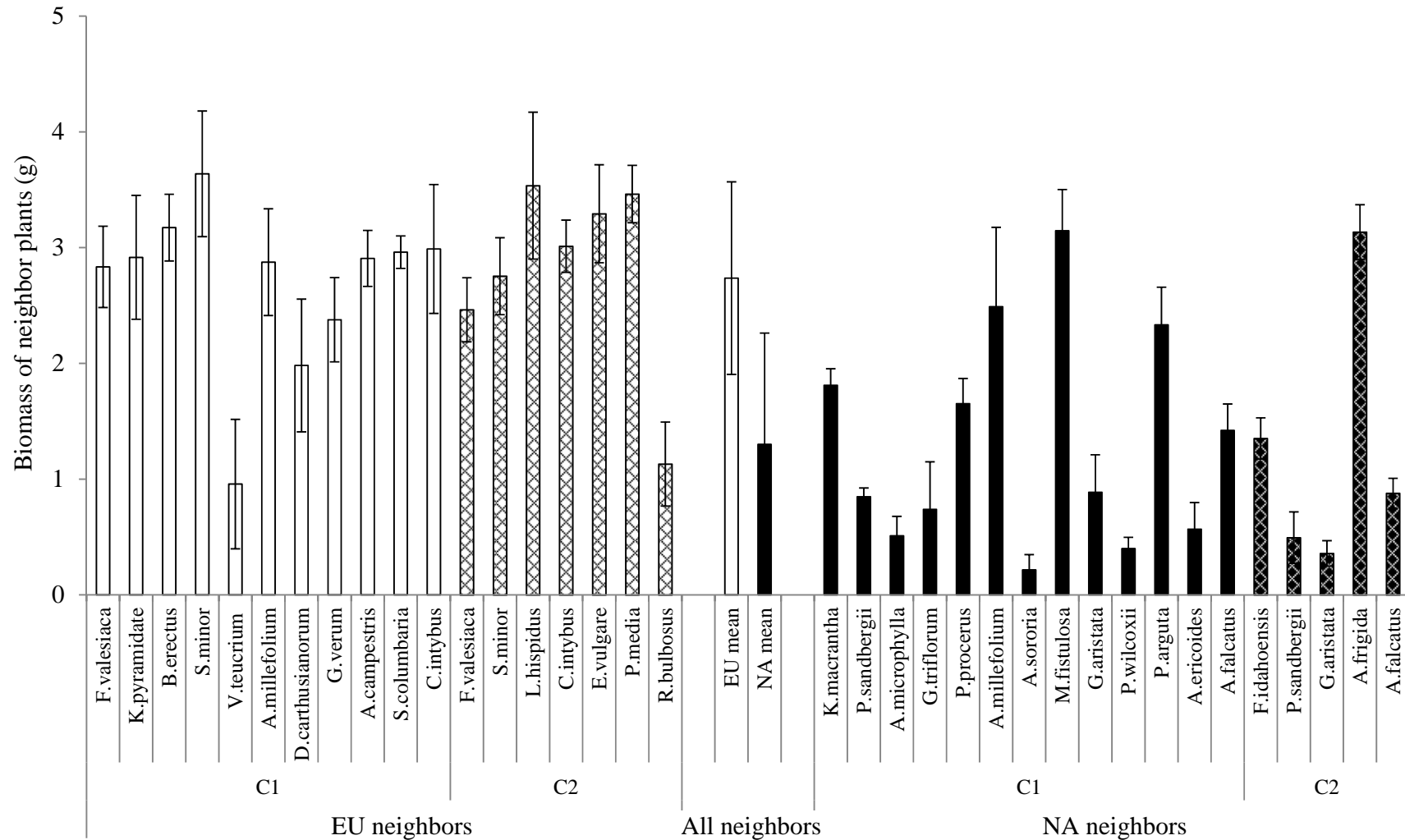
(FIG. D2). Comparison between competitive performance of EU (gray) and NA neighbor species (black) with tetraploid *Centaurea stoebe*, using a size-independent index, the relative efficiency indices (REIs) based on plant diameter.



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APPENDIX E (FIG. E1). Biomass (mean  $\pm$  1SE) of native European (white bars) and North American neighbors (black bars) when grown alone. Solid bars result from Cohort 1, outlined diamond bars result from Cohort 2. EU = European neighbors, NA = North American neighbors. Bars in the middle of the graphs are the means for all neighbors within a region.





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APPENDIX F (FIG. F1). Relationship between soil moisture and A) biomass (g dry weight) of EU or NA neighbors at the end of the experiment in the absence of competition, and B) total biomass (tetraploid *Centaurea stoebe* and neighbor species) in the competition treatments. Each point represents a pot. The ellipses indicate 95 % confidence intervals.

