# *Supplementary Information*

## Dominant non-native and native graminoids differ in key leaf traits irrespective of nutrient availability

*Broadbent et al. (2020) Global Ecology and Biogeography*

**Figure S1 –** Species % cover at all sites (a-c) and the subset of sites with co-occurring dominant native and non-native species (d-f). Mean effect estimates (i.e. coefficients) and their 95% credible intervals (CRIs) for biogeographic origin (i.e. non-native species = NN), the nutrient addition treatment (NPK) and their interaction (NN:NPK) are shown from Bayesian hierarchical models fit with INLA and a random effects structure of species/site/block. The zero reference line represents the intercept (I) of the model (i.e. the estimate for native species in the nutrient control treatment). Mean effect estimates with 95% CRIs that cross zero are not significant. *ln transformed due to non-normality

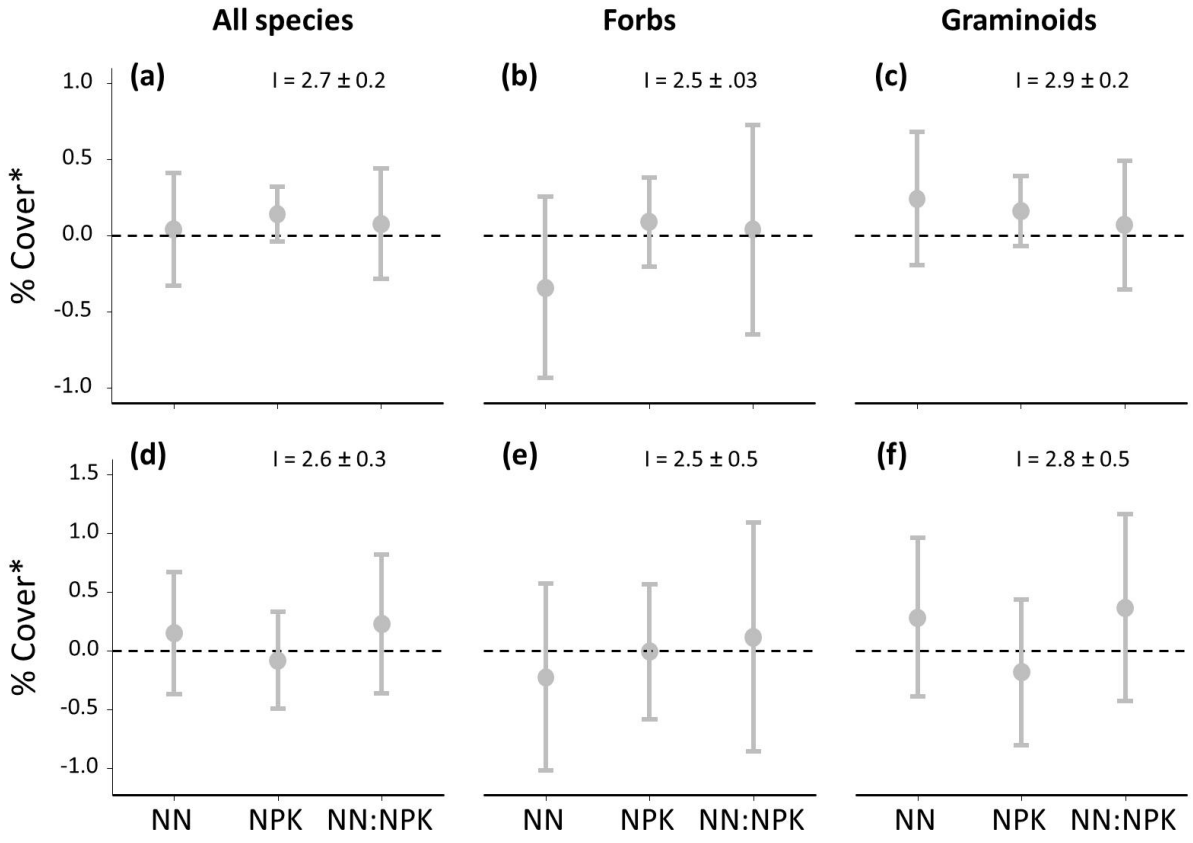

**Figure S2 –** Proportion of variation explained by random effects (species/ site/ block and residuals) of Bayesian hierarchical models of individual leaf traits with fixed effects of biogeographic origin, nutrient addition treatment and their interaction for all species, forbs and graminoids. *SLA, leaf %N, leaf %P and % cover were ln-transformed due to non-normality.

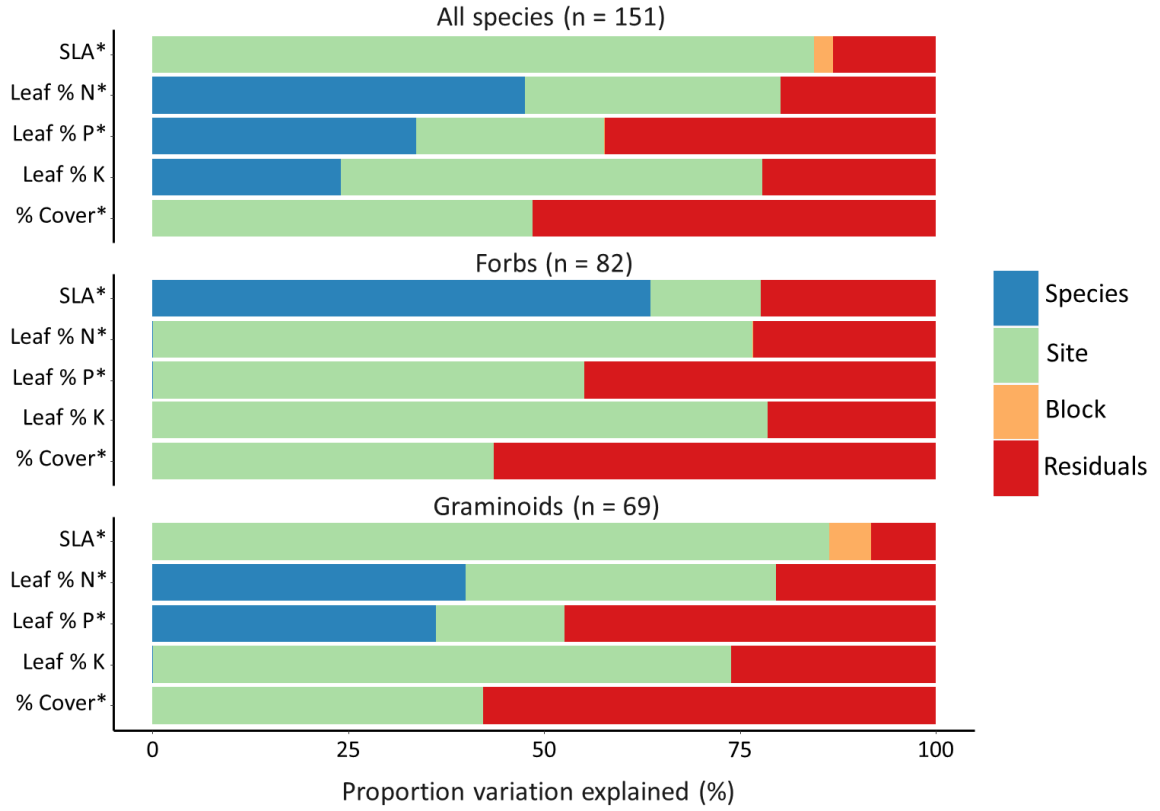

**Figure S3**: Directed Acyclic Graph (DAG) to represent the multilevel regression models in a hierarchical Bayesian framework that was developed to analyse leaf traits. For each of the leaf traits, $y_{ijkl}$ denotes the response and $\boldsymbol{x}_{ijkl} = (x_{1jkl}, x_{2jkl}, \ldots, x_{pjkl})$ denotes the *i*th sample from the *j*th block at the *k*th site of the *l*th plant species. $\mu_{jkl}$ is the mean response associated with block *j* at site *k* and species *l* where $\beta_0$ is the model intercept and $\beta_1$, $\beta_{2, \ldots,}$ $\beta_p$ are slope parameters for each predictor ($x_{1jkl}$, $x_{2jkl}$, …, $x_{pjkl}$). Then $u_l$ is the random effect associated with the *l*th species, $v_{kl}$ is the random effect associated with the *k*th site (within species *l*), $w_{jkl}$ is the random effect associated with *j*th block (within species *l* and site *k*), and $e_{ijkl}$ is the residual error associated with the *i*th response on block *j* at site *k* for species *l*.

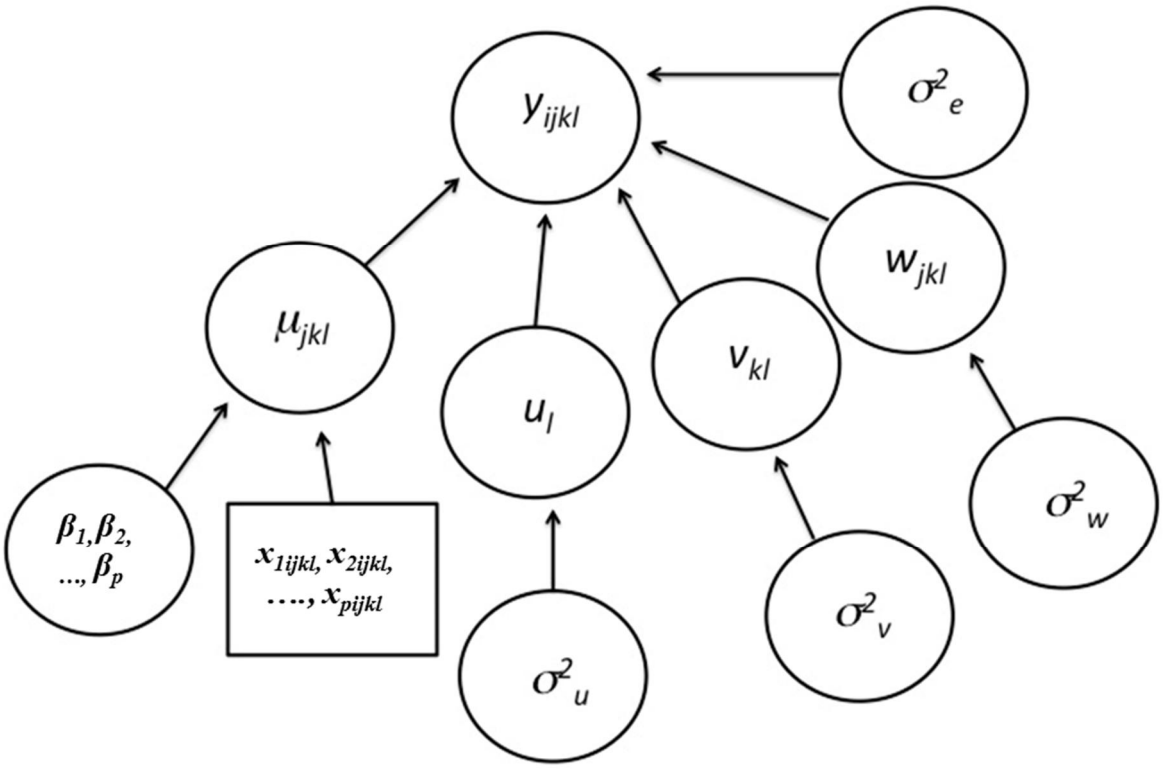

**Figure S4** – Four leaf traits measured at all sites (n = 27). For each leaf trait, means and one standard error of native and non-native species in the control and nutrient addition (NPK) treatments are shown. Means are pooled across sites and blocks.

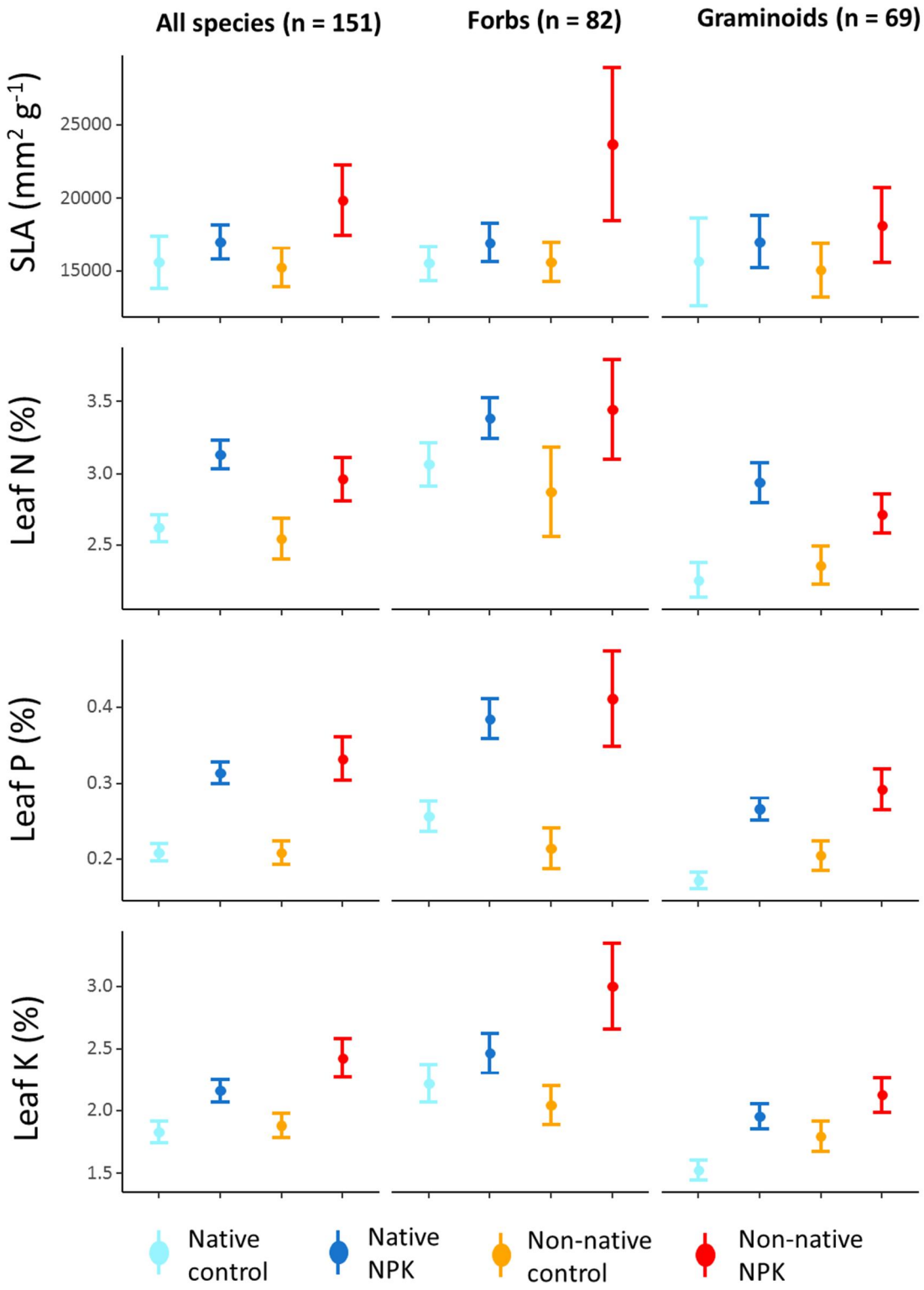

**Figure S5** – Four leaf traits measured at the subset of sites (n = 11) where dominant native and non-native species co-occur. For each leaf trait, means and one standard error of native and non-native species in the control and nutrient addition (NPK) treatments are shown. Means are pooled across sites and blocks.

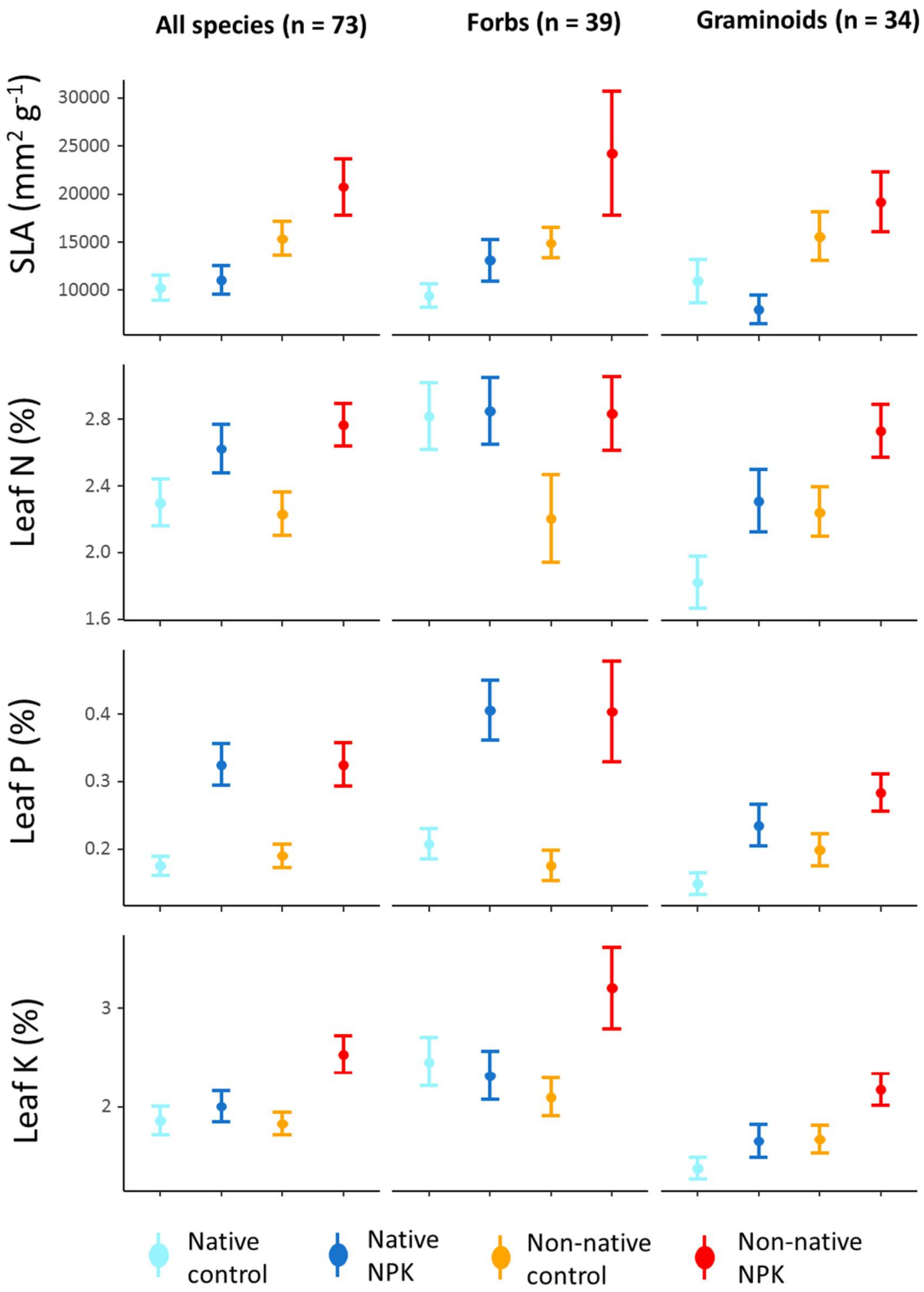

**Table S1** – Abiotic and biotic site conditions, and experimental year that leaves were collected (Exp. year) for 27 sites (AU – Australia, CA – Canada, CH – Switzerland, DE – Germany, PT – Portugal, UK – United Kingdom, US – United States and ZA – South Africa).

| Site | Habitat | Elevation (m) | MAT (°C) | MAP (mm) | Tempvar | MAP var | Soil N (%) | Soil P (ppm) | Soil K (ppm) | Native: Non-native richness | Exp. Year |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bldr (US) | Shortgrass Prairie | 1633 | 9.7 | 425 | 79.52 | 42 | 0.09 | 14 | 87 | 7:15 | 3 |
| Bnch (US) | Montane Grassland | 1318 | 5.5 | 1647 | 60.55 | 65 | 0.57 | 17 | 70 | 40:3 | 4 |
| Bogo (AU) | Alpine Grassland | 1760 | 5.7 | 1592 | 47.59 | 26 | 0.54 | 52 | 203 | 34:3 | 2 |
| Burr (AU) | Semiarid Grassland | 425 | 18.4 | 683 | 50.49 | 36 | 0.11 | 35 | 70 | 31:5 | 3 |
| Cbgb (US) | Tallgrass Prairie | 275 | 9 | 855 | 108.5 | 46 | 0.06 | 72 | 95 | 49:15 | 3 |
| Com (PT) | Annual Grassland | 200 | 16.5 | 554 | 49.77 | 61 | 0.12 | 44 | 90 | 54:1 | 2 |
| Cowi (CA) | Old field | 50 | 9.8 | 764 | 40.44 | 64 | 0.43 | 47 | 88 | 1:20 | 4 |
| Duke (US) | Old field | 141 | 14.6 | 1163 | 35.93 | 87 | 0.14 | 16 | 222 | 35:17 | 4 |
| Elch (US) | Annual Grassland | 200 | 17.2 | 331 | 59.89 | 23 | 0.30 | 55 | 255 | 16:19 | 3 |
| Frue (CH) | Pasture | 995 | 6.5 | 1355 | 76.18 | 11 | 0.13 | 42 | 144 | 22:3 | 3 |
| Gilb (ZA) | Montane Grassland | 1748 | 13.1 | 926 | 34.19 | 67 | 1.26 | 17 | 108 | 73:0 | 2 |
| Hopl (US) | Annual Grassland | 598 | 12.3 | 1127 | 52.78 | 87 | na | na | na | 62:47 | 4 |
| Jena (DE) | Grassland | 320 | 8 | 610 | 62.51 | 27 | 0.55 | 155 | 1340 | 33:1 | 2 |
| Kiny (AU) | Semiarid Grassland | 90 | 15.5 | 426 | 49.26 | 21 | 0.12 | 10 | 387 | 44:36 | 4 |
| Konz (US) | Tallgrass Prairie | 440 | 11.9 | 877 | 99.32 | 50 | NA | NA | NA | 73:3 | 4 |
| Lanc (UK) | Mesic Grassland | 180 | 8 | 1322 | 45.42 | 23 | 1.55 | 21 | 90 | 28:0 | 3 |
| Look (US) | Montane Grassland | 1500 | 4.8 | 1898 | 58.66 | 65 | 1.26 | 71 | 115 | 31:2 | 4 |
| Mcla (US) | Annual Grassland | 641 | 13.5 | 867 | 59.94 | 88 | na | na | na | 34:30 | 4 |
| Mtca (AU) | Savanna | 285 | 17.3 | 330 | 52.55 | 55 | na | na | na | 41:18 | 3 |
| Sage (US) | Montane Grassland | 1920 | 5.7 | 882 | 65.39 | 69 | 0.52 | 28 | 209 | 44:0 | 4 |
| Sali (US) | Mixedgrass Prairie | 440 | 11.8 | 607 | 100.3 | 53 | na | na | na | 84:12 | 4 |
| Sgst (US) | Shortgrass Prairie | 1650 | 8.4 | 365 | 84.82 | 59 | 0.09 | 71 | 255 | 48:4 | 4 |
| Shps (US) | Shrub steppe | 910 | 5.5 | 262 | 95.57 | 37 | 0.23 | 36 | 519 | 52:12 | 4 |
| Sier (US) | Annual Grassland | 197 | 15.6 | 935 | 64.7 | 84 | 0.17 | 20 | 88 | 39:41 | 4 |
| Smit (US) | Mesic Grassland | 62 | 9.8 | 597 | 42.14 | 36 | 0.43 | 82 | 183 | 4:43 | 4 |
| Sum (ZA) | Mesic Grassland | 679 | 18.2 | 939 | 25.51 | 55 | 0.29 | 15 | 97 | 104:0 | 2 |
| Valm (CH) | Alpine Grassland | 2320 | 0.3 | 1098 | 54.23 | 29 | 0.59 | 18 | 64 | 104:0 | 3 |

**Table S2 –** List of the dominant non-native species in our study, the number of sites and the countries in which they were sampled. Species classified as invasive by Weber (2017) are in bold. Species classified as weeds in the country in which they were sampled are indicated with an *, or (*) where only the genus was identified. Weed classification was based on The US Department of Agriculture's "Weeds of the US" list (https://plants.usda.gov/), the Canadian Food Inspection Agency's "List of pests regulated by Canada" (https://www.inspection.gc.ca/) and the Australian Government Department of the Environment and Energy's "Weeds in Australia list" (http://www.environment.gov.au).

| Species name | Functional group | Number of sites and country |
|---|---|---|
| *Alopecurus pratensis* | Graminoid | 1 (Canada) |
| *Alyssum desertorum* | Forb | 1 (US) |
| *Anthoxanthum odoratum* | Graminoid | 1 (US) |
| *Avena barbata* | Graminoid | 1 (Australia) |
| *Avena fatua* | Graminoid | 1 (Australia) |
| **Briza maxima* | Graminoid | 1 (US) |
| **Bromus diandrus* | Graminoid | 2 (US) |
| **Bromus hordeaceus* | Graminoid | 3 (US) |
| **Bromus inermis* | Graminoid | 1 (US) |
| *Bromus rubens* | Graminoid | 1 (Australia) |
| *(*)Bromus sp.* | Graminoid | 1 (US) |
| **Bromus sterilis* | Graminoid | 1 (US) |
| **Carduus pycnocephalus* | Forb | 1 (US) |
| **Chenopodium album* | Forb | 1 (US) |
| **Cirsium arvense* | Forb | 1 (US) |
| **Convolvulus arvensis* | Forb | 1 (US) |
| *Cynosurus echinatus* | Graminoid | 2 (US) |
| **Eragrostis curvula* | Graminoid | 1 (Australia) |
| *Erodium botrys* | Forb | 1 (Australia); 1 (US) |
| **Geranium dissectum* | Forb | 1 (US) |
| *Geranium molle* | Forb | 1 (US) |
| *Glandularia aristigera* | Forb | 1 (Australia) |
| **Hordeum murinum* | Graminoid | 1 (US) |
| *Hordeum murinum ssp. leporinum* | Graminoid | 1 (Australia) |
| **Hypochaeris radicata* | Forb | 1 (Australia); 1 (US) |
| **Lactuca serriola* | Forb | 1 (US) |
| *Lathyrus sphaericus* | Forb | 1 (Canada) |
| *Lespedeza juncea var. sericea* | Forb | 1 (US) |
| **Lolium multiflorum* | Graminoid | 2 (US) |
| **Lonicera japonica* | Forb | 1 (US) |
| *Pentaschistis airoides* | Graminoid | 1 (Australia) |
| **Plantago lanceolata* | Forb | 1 (US) |
| *Poa pratensis* | Graminoid | 1 (Canada) |
| *(*)Schedonorus sp.* | Graminoid | 1 (US) |
| **Taeniatherum caput-medusae* | Graminoid | 2 (US) |
| **Torilis arvensis* | Forb | 2 (US) |
| *Trifolium dubium* | Forb | 1 (Canada) |
| *Vicia sativa* | Forb | 1 (Canada) |
| **Vulpia myuros* | Graminoid | 1 (Australia); 1 (US) |

## References

Weber, E. (2017) *Invasive Plant Species of the World, 2nd Edition: A Reference Guide to Environmental Weeds. Wallingford, UK:* CABI.