

## Supporting Information Methods S1 and S2

**Methods S1** Studies included in the analyses: B, used in Biomass response to light/water/nutrient analysis; L, used in SLA response to light analysis; RS, used in root:shoot ratio response to nutrient/water analysis.

- Aerts, R. & Decaluwe, H. (1994) Effects of nitrogen supply on canopy structure and leaf nitrogen distribution in *Carex* species. *Ecology*, **75**, 1482-1490. B
- Aspelmeier, S. & Leuschner, C. (2006) Genotypic variation in drought response of silver birch (*Betula pendula* Roth): leaf and root morphology and carbon partitioning. *Trees-Structure and Function*, **20**, 42-52. RS
- Avramov, S., Pamac, D. & Tucic, B. (2007) Phenotypic plasticity in response to an irradiance gradient in *Iris pumila*: adaptive value and evolutionary constraints. *Plant Ecology*, **190**, 275-290. L
- Baquedano, F. J. & Castillo, F. J. (2006) Comparative ecophysiological effects of drought on seedlings of the Mediterranean water-saver *Pinus halepensis* and water-spenders *Quercus coccifera* and *Quercus ilex*. *Trees-Structure and Function*, **20**, 689-700. B, RS
- Baruch, Z., Pattison, R. R. & Goldstein, G. (2000) Responses to light and water availability of four invasive Melastomataceae in the Hawaiian islands. *International Journal of Plant Sciences*, **161**, 107-118. B, L, RS
- Berg, H., Becker, U. & Matthies, D. (2005) Phenotypic plasticity in *Carlina vulgaris*: effects of geographical origin, population size, and population isolation. *Oecologia*, **143**, 220-231. B
- Bloor, J. M. G. & Grubb, P. J. (2004) Morphological plasticity of shade-tolerant tropical rainforest tree seedlings exposed to light changes. *Functional Ecology*, **18**, 337-348. B
- Bonser, S. P. & Geber, M. A. (2005) Growth form evolution and shifting habitat specialization in annual plants. *Journal of Evolutionary Biology*, **18**, 1009-1018. B
- Brainard, D. C., Bellinder, R. R. & DiTommaso, A. (2005) Effects of canopy shade on the morphology, phenology, and seed characteristics of Powell amaranth (*Amaranthus powellii*). *Weed Science*, **53**, 175-186. B, L
- Burns, J. H. (2004) A comparison of invasive and non-invasive dayflowers (Commelinaceae) across experimental nutrient and water gradients. *Diversity and Distributions*, **10**, 387-397. B
- Cai, Z. Q., Poorter, L., Han, Q. & Bongers, F. (2008) Effects of light and nutrients on seedlings of tropical *Bauhinia* lianas and trees. *Tree Physiology*, **28**, 1277-1285. L
- Cardillo, E. & Bernal, C. J. (2006) Morphological response and growth of cork oak (*Quercus suber* L.) seedlings at different shade levels. *Forest Ecology and Management*, **222**, 296-301. B

- Castro-Diez, P., Navarro, J., Pintado, A., Sancho, L. G. & Maestro, M. (2006) Interactive effects of shade and irrigation on the performance of seedlings of three Mediterranean *Quercus* species. *Tree Physiology*, **26**, 389-400. L
- Cedergreen, N. & Madsen, T. V. (2002) Nitrogen uptake by the floating macrophyte *Lemna minor*. *New Phytologist*, **155**, 285-292. RS
- Chambel, M. R., Climent, J. & Alia, R. (2007) Divergence among species and populations of Mediterranean pines in biomass allocation of seedlings grown under two watering regimes. *Annals of Forest Science*, **64**, 87-97. B, RS
- Chartzoulakis, K., Therios, I. & Noitsakis, B. (1993) Effects of shading on gas-exchange, specific leaf weight and chlorophyll content in 4 kiwifruit cultivars under field conditions. *Journal of Horticultural Science*, **68**, 605-611. B, RS
- Chen, Y. J., Bongers, F., Cao, K. F. & Cai, Z. Q. (2008) Above- and below-ground competition in high and low irradiance: tree seedling responses to a competing liana *Byttneria grandifolia*. *Journal of Tropical Ecology*, **24**, 517-524. L
- Cheplick, G. P. (2004) Recovery from drought stress in *Lolium perenne* (Poaceae): Are fungal endophytes detrimental. *American Journal of Botany*, **91**, 1960-1968. B
- Chun, Y. J., Collyer, M. L., Moloney, K. A. & Nason, J. D. (2007) Phenotypic plasticity of native vs. invasive purple loosestrife: A two-state multivariate approach. *Ecology*, **88**, 1499-1512. B, RS
- Clabby, G. & Osborne, B. A. (1997) Irradiance and nitrate-dependent variation in growth and biomass allocation of *Mycelis muralis*. An analysis of its significance for a functional categorization of 'sun' and 'shade' plants. *New Phytologist*, **135**, 539-545. B, L
- Clevering, O. A. (1998) An investigation into the effects of nitrogen on growth and morphology of stable and die-back populations of *Phragmites australis*. *Aquatic Botany*, **60**, 11-25. B
- Climent, J. M., Aranda, I., Alonso, J., Pardos, J. A. & Gil, L. (2006) Developmental constraints limit the response of Canary Island pine seedlings to combined shade and drought. *Forest Ecology and Management*, **231**, 164-168. L
- de Kovel, C. G. F. & de Jong, G. (1999) Responses of sexual and apomictic genotypes of *Taraxacum officinale* to variation in light. *Plant Biology*, **1**, 541-546. B
- Dias, M. B. (1999) Physiological responses of two tropical weeds to shade. I. Growth and biomass allocation. *Pesquisa Agropecuaria Brasileira*, **34**, 945-952. L
- Dong, M. (1995) Morphological responses to local light conditions in clonal herbs from contrasting habitats, and their modification due to physiological integration. *Oecologia*, **101**, 282-288. B, L
- Dong, M. & Dekroon, H. (1994) Plasticity in morphology and biomass allocation in *Cynodon dactylon*, a grass species forming stolons and rhizomes. *Oikos*, **70**, 99-106. B
- Dong, M., During, H. J. & Werger, M. J. A. (1996) Morphological responses to nutrient availability in four clonal herbs. *Vegetatio*, **123**, 183-192. B

- Duan, B. L., Xuan, Z. Y., Zhang, X. L., Korpelainen, H. & Li, C. Y. (2008) Interactions between drought, ABA application and supplemental UV-B in *Populus yunnanensis*. *Physiologia Plantarum*, **134**, 257-269. B, RS
- Dudley, S. A. & Schmitt, J. (1995) Genetic differentiation in morphological responses to simulated foliage shade between populations of *Impatiens capensis* from open and woodland sites. *Functional Ecology*, **9**, 655-666. B
- Egilla, J. N., Davies, F. T. & Drew, M. C. (2001) Effect of potassium on drought resistance of *Hibiscus rosa-sinensis* cv. Leprechaun: Plant growth, leaf macro- and micronutrient content and root longevity. *Plant and Soil*, **229**, 213-224. B, RS
- Feng, Y. L., Cao, K. F. & Zhang, J. L. (2004) Photosynthetic characteristics, dark respiration, and leaf mass per unit area in seedlings of four tropical tree species grown under three irradiances. *Photosynthetica*, **42**, 431-437. L
- Fernandez, R. J. & Reynolds, J. F. (2000) Potential growth and drought tolerance of eight desert grasses: lack of a trade-off? *Oecologia*, **123**, 90-98. B, RS
- Fernandez, R. J., Wang, M. B. & Reynolds, J. F. (2002) Do morphological changes mediate plant responses to water stress? A steady-state experiment with two C-4 grasses. *New Phytologist*, **155**, 79-88. B
- Forster, M. A. & Bonser, S. P. (2009) Heteroblastic development and the optimal partitioning of traits among contrasting environments in *Acacia implexa*. *Annals of Botany*, **103**, 95-105. L
- Funk, J. L. (2008) Differences in plasticity between invasive and native plants from a low resource environment. *Journal of Ecology*, **96**, 1162-1173. B
- Funk, J. L. & Zachary, V. A. Physiological responses to short-term water and light stress in native and invasive plant species in southern California. *Biological Invasions*, **12**, 1685-1694. B, RS
- Geng, Y. P., Pan, X. Y., Xu, C. Y., Zhang, W. J., Li, B. & Chen, J. K. (2006) Phenotypic plasticity of invasive *Alternanthera philoxeroides* in relation to different water availability, compared to its native congener. *Acta Oecologica-International Journal of Ecology*, **30**, 380-385. B, L
- Gianoli, E. (2002) Maternal environmental effects on the phenotypic responses of the twining vine *Ipomoea purpurea* to support availability. *Oikos*, **99**, 324-330. L
- Gibson, K. D., Fischer, A. J. & Foin, T. C. (2004) Compensatory responses of late watergrass (*Echinochloa phyllopogon*) and rice to resource limitations. *Weed Science*, **52**, 271-280. B, L
- Gramig, G. G. & Stoltenberg, D. E. (2009) Adaptive Responses of Field-Grown Common Lambsquarters (*Chenopodium album*) to Variable Light Quality and Quantity Environments. *Weed Science*, **57**, 271-280. L
- Guarnaschelli, A. B., Lemcoff, J. H., Prystupa, P. & Basci, S. O. (2003) Responses to drought preconditioning in *Eucalyptus globulus* Labill. provenances. *Trees-Structure and Function*, **17**, 501-509. B, RS

- Guarnaschelli, A. B., Prystupa, P. & Lemcoff, J. H. (2006) Drought conditioning improves water status, stomatal conductance and survival of *Eucalyptus globulus* subsp *bicostata* seedlings. *Annals of Forest Science*, **63**, 941-950. B, RS
- Guo, W., Li, B., Zhang, X. & Wang, R. (2007) Architectural plasticity and growth responses of *Hippophae rhamnoides* and *Caragana intermedia* seedlings to simulated water stress. *Journal of Arid Environments*, **69**, 385-399. RS
- Hale, B. K., Herms, D. A., Hansen, R. C., Clausen, T. P. & Arnold, D. (2005) Effects of drought stress and nutrient availability on dry matter allocation, phenolic glycosides, and rapid induced resistance of poplar to two lymantriid defoliators. *Journal of Chemical Ecology*, **31**, 2601-2620. B
- He, W. M. & Dong, M. (2003) Plasticity in physiology and growth of *Salix matsudana* in response to simulated atmospheric temperature rise in the Mu Us Sandland. *Photosynthetica*, **41**, 297-300. B, L
- Hermanutz, L. A. & Weaver, S. E. (1996) Agroecotypes or phenotypic plasticity? Comparison of agrestal and ruderal populations of the weed *Solanum ptycanthum*. *Oecologia*, **105**, 271-280. B, RS
- Hoffmann, W. A. & Franco, A. C. (2003) Comparative growth analysis of tropical forest and savanna woody plants using phylogenetically independent contrasts. *Journal of Ecology*, **91**, 475-484. L
- Huber, H. (1996) Plasticity of internodes and petioles in prostrate and erect *Potentilla* species. *Functional Ecology*, **10**, 401-409. B
- James, J. J. (2008) Effect of soil nitrogen stress on the relative growth rate of annual and perennial grasses in the Intermountain West. *Plant and Soil*, **310**, 201-210. B
- Jimenez, M. D., Pardos, M., Puertolas, J., Kleczkowski, L. A. & Pardos, J. A. (2009) Deep shade alters the acclimation response to moderate water stress in *Quercus suber* L. *Forestry*, **82**, 285-298. B, L
- Khurana, E. & Singh, J. S. (2004) Germination and seedling growth of five tree species from tropical dry forest in relation to water stress: impact of seed size. *Journal of Tropical Ecology*, **20**, 385-396. B, RS
- Kitajima, K. (1994) Relative importance of photosynthetic traits and allocation patterns as correlates of seedling shade tolerance of 13 tropical trees. *Oecologia*, **98**, 419-428. L
- Kitajima, K. & Hogan, K. P. (2003) Increases of chlorophyll a/b ratios during acclimation of tropical woody seedlings to nitrogen limitation and high light. *Plant Cell and Environment*, **26**, 857-865. L
- Kitao, M., Lei, T. T., Koike, T., Kayama, M., Tobita, H. & Maruyama, Y. (2007) Interaction of drought and elevated CO<sub>2</sub> concentration on photosynthetic down-regulation and susceptibility to photoinhibition in Japanese white birch seedlings grown with limited N availability. *Tree Physiology*, **27**, 727-735. B, RS
- Laclau, J.-P., Almeida, J. C. R., Goncalves, J. L. M., Saint-Andre, L., Ventura, M., Ranger, J., Moreira, R. M. & Nouvellon, Y. (2009) Influence of nitrogen and potassium fertilization on leaf lifespan

- and allocation of above-ground growth in Eucalyptus plantations. *Tree Physiology*, **29**, 111-124. B
- Lal, C., Hariprasanna, K., Rathnakumar, A. L., Misra, J. B., Samdur, M. Y., Gor, H. K., Chikani, B. M. & Jain, V. K. (2009) Response of peanut genotypes to mid-season moisture stress: phenological, morpho-physiological, and yield traits. *Crop & Pasture Science*, **60**, 339-347. B
- Latham, R. E. (1992) Co-occurring tree species change rank in seedling performance with resources varied experimentally. *Ecology*, **73**, 2129-2144. L
- Lenssen, J. P. M., Menting, F. B. J. & Van der Putten, W. H. (2003) Plant responses to simultaneous stress of waterlogging and shade: amplified or hierarchical effects? *New Phytologist*, **157**, 281-290. B, L
- Li, B., Suzuki, J. I. & Hara, T. (1999) Competitive ability of two Brassica varieties in relation to biomass allocation and morphological plasticity under varying nutrient availability. *Ecological Research*, **14**, 255-266. B, RS
- Liu, Y., Schieving, F., Stuefer, J. F. & Anten, N. P. R. (2007) The effects of mechanical stress and spectral shading on the growth and allocation of ten genotypes of a stoloniferous plant. *Annals of Botany*, **99**, 121-130. B, L
- Luken, J. O., Kuddes, L. M., Tholemeier, T. C. & Haller, D. M. (1997) Comparative responses of *Lonicera maackii* (Amur honeysuckle) and *Lindera benzoin* (spicebush) to increased light. *American Midland Naturalist*, **138**, 331-343. B, L
- Lusk, C. H., Contreras, O. & Figueroa, J. (1997) Growth, biomass allocation and plant nitrogen concentration in Chilean temperate rainforest tree seedlings: Effects of nutrient availability. *Oecologia*, **109**, 49-58. B
- Lusk, C. H. & Del Pozo, A. (2002) Survival and growth of seedlings of 12 Chilean rainforest trees in two light environments: Gas exchange and biomass distribution correlates. *Austral Ecology*, **27**, 173-182. B, L
- Maestre, F. T., Quero, J. L., Valladares, F. & Reynolds, J. F. (2007) Individual vs. population plastic responses to elevated CO<sub>2</sub>, nutrient availability, and heterogeneity: a microcosm experiment with co-occurring species. *Plant and Soil*, **296**, 53-64. B, RS
- Maurer, D. A. & Zedler, J. B. (2002) Differential invasion of a wetland grass explained by tests of nutrients and light availability on establishment and clonal growth. *Oecologia*, **131**, 279-288. B, RS
- Meier, I. C. & Leuschner, C. (2008) Genotypic variation and phenotypic plasticity in the drought response of fine roots of European beech. *Tree Physiology*, **28**, 297-309. RS
- Monaco, T. A., Johnson, D. A. & Creech, J. E. (2005) Morphological and physiological responses of the invasive weed *Isatis tinctoria* to contrasting light, soil-nitrogen and water. *Weed Research*, **45**, 460-466. B, L, RS
- Myers, C. V., Anderson, R. C. & Byers, D. L. (2005) Influence of shading on the growth and leaf photosynthesis of the invasive non-indigenous plant garlic mustard [*Alliaria petiolata* (M. Bieb)

- Cavara and Grande] grown under simulated late-winter to mid-spring conditions. *Journal of the Torrey Botanical Society*, **132**, 1-10. B, L
- Nagakura, J., Shigenaga, H., Akama, A. & Takahashi, M. (2004) Growth and transpiration of Japanese cedar (*Cryptomeria japonica*) and Hinoki cypress (*Chamaecyparis obtusa*) seedlings in response to soil water content. *Tree Physiology*, **24**, 1203-1208. B, RS
- Oguchi, R., Hikosaka, K., Hiura, T. & Hirose, T. (2006) Leaf anatomy and light acclimation in woody seedlings after gap formation in a cool-temperate deciduous forest. *Oecologia*, **149**, 571-582. L
- Olf, H., Vanandel, J. & Bakker, J. P. (1990) Biomass and shoot root allocation of 5 species from a grassland succession series at different combinations of light and nutrient supply. *Functional Ecology*, **4**, 193-200. B, RS
- Onoda, Y., Schieving, F. & Anten, N. P. R. (2008) Effects of light and nutrient availability on leaf mechanical properties of *Plantago major*: A conceptual approach. *Annals of Botany*, **101**, 727-736. B, L
- Padilla, F. M., Miranda, J. D., Jorquera, M. J. & Pugnaire, F. I. (2009) Variability in amount and frequency of water supply affects roots but not growth of arid shrubs. *Plant Ecology*, **204**, 261-270. RS
- Pardos, M., Puertolas, J., Aranda, I. & Pardos, J. A. (2006) Can CO<sub>2</sub> enrichment modify the effect of water and high light stress on biomass allocation and relative growth rate of cork oak seedlings? *Trees-Structure and Function*, **20**, 713-724. B, RS
- Peperkorn, R., Werner, C. & Beyschlag, W. (2005) Phenotypic plasticity of an invasive acacia versus two native Mediterranean species. *Functional Plant Biology*, **32**, 933-944. B, L
- Pilon, J. & Santamaria, L. (2002) Clonal variation in morphological and physiological responses to irradiance and photoperiod for the aquatic angiosperm *Potamogeton pectinatus*. *Journal of Ecology*, **90**, 859-870. L
- Portsmouth, A. & Niinemets, U. (2006) Interacting controls by light availability and nutrient supply on biomass allocation and growth of *Betula pendula* and *B. pubescens* seedlings. *Forest Ecology and Management*, **227**, 122-134. B, L
- Portsmouth, A. & Niinemets, U. (2007) Structural and physiological plasticity in response to light and nutrients in five temperate deciduous woody species of contrasting shade tolerance. *Functional Ecology*, **21**, 61-77. L
- Puertolas, J., Pardos, M., Jimenez, M. D., Aranda, I. & Pardos, J. A. (2008) Interactive responses of *Quercus suber* L. seedlings to light and mild water stress: effects on morphology and gas exchange traits. *Annals of Forest Science*, **65**. B, L, RS
- Puri, S. & Swamy, S. L. (2001) Growth and biomass production in *Azadirachta indica* seedlings in response to nutrients (N and P) and moisture stress. *Agroforestry Systems*, **51**, 57-68. B, RS
- Quiroz, C. L., Choler, P., Baptist, F., Gonzalez-Teuber, M., Molina-Montenegro, M. A. & Cavieres, L. A. (2009) Alpine dandelions originated in the native and introduced range differ in their responses to environmental constraints. *Ecological Research*, **24**, 175-183. B

- Ramirez-Vallejo, P. & Kelly, J. D. (1998) Traits related to drought resistance in common bean. *Euphytica*, **99**, 127-136. B
- Reich, P. B., Tjoelker, M. G., Walters, M. B., Vanderklein, D. W. & Bushena, C. (1998) Close association of RGR, leaf and root morphology, seed mass and shade tolerance in seedlings of nine boreal tree species grown in high and low light. *Functional Ecology*, **12**, 327-338. B, L
- Robakowski, P., Montpied, P. & Dreyer, E. (2003) Plasticity of morphological and physiological traits in response to different levels of irradiance in seedlings of silver fir (*Abies alba* Mill). *Trees-Structure and Function*, **17**, 431-441. B, L
- Rodiyati, A., Arisoelaningsih, E., Isagi, Y. & Nakagoshi, N. (2005) Responses of *Cyperus brevifolius* (Rottb.) Hassk. and *Cyperus kyllingia* Endl. to varying soil water availability. *Environmental and Experimental Botany*, **53**, 259-269. B, RS
- Rodriguez-Echeverria, S., Crisostomo, J. A., Nabais, C. & Freitas, H. (2009) Belowground mutualists and the invasive ability of *Acacia longifolia* in coastal dunes of Portugal. *Biological Invasions*, **11**, 651-661. B, RS
- Ryser, P. & Lambers, H. (1995) Root and leaf attributes accounting for the performance of fast-growing and slow-growing grasses at different nutrient supply. *Plant and Soil*, **170**, 251-265. B
- Sack, L. & Grubb, P. J. (2002) The combined impacts of deep shade and drought on the growth and biomass allocation of shade-tolerant woody seedlings. *Oecologia*, **131**, 175-185. B, L
- Sanchez-Gomez, D., Valladares, F. & Zavala, M. A. (2006) Functional traits and plasticity in response to light in seedlings of four Iberian forest tree species. *Tree Physiology*, **26**, 1425-1433. B, L
- Sanford, N. L., Harrington, R. A. & Fownes, J. H. (2003) Survival and growth of native and alien woody seedlings in open and understory environments. *Forest Ecology and Management*, **183**, 377-385. B, L
- Schlaepfer, D. R., Glattli, M., Fischer, M. & van Kleunen, M. A multi-species experiment in their native range indicates pre-adaptation of invasive alien plant species. *New Phytologist*, **185**, 1087-1099. B, RS
- Shem-Tov, S. & Gutterman, Y. (2003) Influence of water regime and photoperiod treatments on resource allocation and reproductive successes of two annuals occurring in the Negev Desert of Israel. *Journal of Arid Environments*, **55**, 123-142. B
- Shipley, B. & Almeida-Cortez, J. (2003) Interspecific consistency and intraspecific variability of specific leaf area with respect to irradiance and nutrient availability. *Ecoscience*, **10**, 74-79. L
- Slama, I., Messedi, D., Ghnaya, T., Savoure, A. & Abdelly, C. (2006) Effects of water deficit on growth and proline metabolism in *Sesuvium portulacastrum*. *Environmental and Experimental Botany*, **56**, 231-238. B, RS
- Sleeman, J. D., Dudley, S. A., Pannell, J. R. & Barrett, S. C. H. (2002) Responses of carbon acquisition traits to irradiance and light quality in *Mercurialis annua* (Euphorbiaceae): Evidence for weak integration of plastic responses. *American Journal of Botany*, **89**, 1388-1400. L

- Stuefer, J. F. & Huber, H. (1998) Differential effects of light quantity and spectral light quality on growth, morphology and development of two stoloniferous *Potentilla* species. *Oecologia*, **117**, 1-8. B, L
- Sultan, S. E. (1996) Phenotypic plasticity for offspring traits in *Polygonum persicaria*. *Ecology*, **77**, 1791-1807. B
- Sultan, S. E., Barton, K. & Wilczek, A. M. (2009) Contrasting patterns of transgenerational plasticity in ecologically distinct congeners. *Ecology*, **90**, 1831-1839. B
- Sun, Y., Ding, J. Q. & Rena, M. X. (2009) Effects of simulated herbivory and resource availability on the invasive plant, *Alternanthera philoxeroides* in different habitats. *Biological Control*, **48**, 287-293. B, RS
- Suzuki, R. O. (2008) Dwarf morphology of the annual plant *Persicaria longisetata* as a local adaptation to a grazed habitat, Nara Park, Japan. *Plant Species Biology*, **23**, 174-182. B, RS
- Thorne, M. A. & Frank, D. A. (2009) The effects of clipping and soil moisture on leaf and root morphology and root respiration in two temperate and two tropical grasses. *Plant Ecology*, **200**, 205-215. B, RS
- Trubata, R., Cortina, J. & Vilagrosa, A. (2008) Short-term nitrogen deprivation increases field performance in nursery seedlings of Mediterranean woody species. *Journal of Arid Environments*, **72**, 879-890. B, RS
- Urbas, P. & Zobel, K. (2000) Adaptive and inevitable morphological plasticity of three herbaceous species in a multi-species community: Field experiment with manipulated nutrients and light. *Acta Oecologica-International Journal of Ecology*, **21**, 139-147. B
- Valladares, F., Arrieta, S., Aranda, I., Lorenzo, D., Sanchez-Gomez, D., Tena, D., Suarez, F. & Pardos, J. A. (2005) Shade tolerance, photoinhibition sensitivity and phenotypic plasticity of *Ilex aquifolium* in continental Mediterranean sites. *Tree Physiology*, **25**, 1041-1052. L
- Valladares, F., Dobarro, I., Sanchez-Gomez, D. & Pearcy, R. W. (2005) Photoinhibition and drought in Mediterranean woody saplings: scaling effects and interactions in sun and shade phenotypes. *Journal of Experimental Botany*, **56**, 483-494. L
- Valladares, F., Hernandez, L. G., Dobarro, I., Garcia-Perez, C., Sanz, R. & Pugnaire, F. I. (2003) The ratio of leaf to total photosynthetic area influences shade survival and plastic response to light of green-stemmed leguminous shrub seedlings. *Annals of Botany*, **91**, 577-584. L
- Valladares, F. & Sanchez-Gomez, D. (2006) Ecophysiological traits associated with drought in Mediterranean tree seedlings: Individual responses versus interspecific trends in eleven species. *Plant Biology*, **8**, 688-697. B, RS
- vanHinsberg, A. & vanTinderen, P. (1997) Variation in growth form in relation to spectral light quality (red/far-red ratio) in *Plantago lanceolata* L in sun and shade populations. *Oecologia*, **111**, 452-459. L



- Vignolio, O. R., Biel, C., de Herralde, F., Araujo-Alves, J. P. L. & Save, R. (2002) Growth of *Lotus creticus creticus* and *Cynodon dactylon* under two levels of irrigation. *Australian Journal of Agricultural Research*, **53**, 1375-1381. B, RS
- Villar-Salvador, P., Planelles, R., Oliet, J., Penuelas-Rubira, J. L., Jacobs, D. F. & Gonzalez, M. (2004) Drought tolerance and transplanting performance of holm oak (*Quercus ilex*) seedlings after drought hardening in the nursery. *Tree Physiology*, **24**, 1147-1155. B, RS
- Vincent, G. (2006) Leaf life span plasticity in tropical seedlings grown under contrasting light regimes. *Annals of Botany*, **97**, 245-255. B, L
- Walls, R., Appel, H., Cipollini, M. & Schultz, J. (2005) Fertility, root reserves and the cost of inducible defenses in the perennial plant *Solanum carolinense*. *Journal of Chemical Ecology*, **31**, 2263-2288. B, RS
- Weijsschede, J., Martinkova, J., de Kroon, H. & Huber, H. (2006) Shade avoidance in *Trifolium repens*: costs and benefits of plasticity in petiole length and leaf size. *New Phytologist*, **172**, 655-666. B, L
- Wikbergi, J. & Ogreni, E. (2007) Variation in drought resistance, drought acclimation and water conservation in four willow cultivars used for biomass production. *Tree Physiology*, **27**, 1339-1346. B
- Williams, D. G. & Black, R. A. (1994) Drought response of a native and introduced Hawaiian grass. *Oecologia*, **97**, 512-519. B
- Xie, Y., Luo, W., Ren, B. & Li, F. (2007) Morphological and physiological responses to sediment type and light availability in roots of the submerged plant *Myriophyllum spicatum*. *Annals of Botany*, **100**, 1517-1523. B
- Xu, B. C., Li, F. M., Shan, L., Ma, Y. Q., Ichizen, N. & Huang, J. (2006) Gas exchange, biomass partition, and water relationships of three grass seedlings under water stress. *Weed Biology and Management*, **6**, 79-88. B, RS
- Xu, G., Duan, B. & Li, C. Y. (2008) Different adaptive responses of leaf physiological and biochemical aspects to drought in two contrasting populations of seabuckthorn. *Canadian Journal of Forest Research-Revue Canadienne De Recherche Forestiere*, **38**, 584-591. B, L, RS
- Yang, V., Liu, Q., Han, C., Qiao, Y.Z., Yao, X.Q., Yiu, H.J. (2007) Influence of water stress and low irradiance on morphological and physiological characteristics of *Picea asperata* seedlings. *Photosynthetica*, **45**, 613-619. L
- Zhang, L. L. & Wen, D. Z. (2009) Structural and physiological responses of two invasive weeds, *Mikania micrantha* and *Chromolaena odorata*, to contrasting light and soil water conditions. *Journal of Plant Research*, **122**, 69-79. L
- Zhang, L. L., Wen, D. Z. & Fu, S. L. (2009) Responses of photosynthetic parameters of *Mikania micrantha* and *Chromolaena odorata* to contrasting irradiance and soil moisture. *Biologia Plantarum*, **53**, 517-522. L

Zollinger, N., Kjelgren, R., Cerny-Koenig, T., Kopp, K. & Koenig, R. (2006) Drought responses of six ornamental herbaceous perennials. *Scientia Horticulturae*, **109**, 267-274. B, RS

## **Methods S2** Construction and application of species phylogenies.

The topology of the phylogenies was obtained via the online program Phylomatic (Webb & Donoghue, 2005), using the angiosperm supertree from the angiosperm phylogeny website (Stevens, 2001 onwards) as the base tree. Polytomies within families were solved as far as possible using published phylogenies obtained through molecular analysis, in particular for the Asteraceae (Goertzen *et al.*, 2003; Funk *et al.*, 2005; Kim *et al.*, 2005), and the Poaceae (Bouchenak-Khelladi *et al.*, 2008). Branch length estimates were obtained and included in phylogenetic trees by calibrating the topology according to 'known' fixed ages of the tree root and divergence at a number of tree nodes from estimates derived from multiple phylogenetic studies listed in the Angiosperm Phylogeny Website (Stevens, 2001 onwards), and using the program Phylocom version 4.1 (Webb & Donoghue, 2008). Each individual effect size was represented by a branch tip in the phylogeny, and as some species had more than one effect size, these species resembled polytomies in the phylogeny. The branch lengths of these polytomies within a species were set a nominal length (0.0001 million years), such that they did not contribute to subsequent analyses that incorporated phylogenetic relatedness. Effect sizes of trait responses were assumed to have a Gaussian error distribution throughout. In addition to the above GLS analyses, we also calculated overall mean effect sizes of trait responses and bootstrapped 95 % confidence intervals using Metawin (Rosenberg *et al.*, 2000). All GLS analyses were conducted using the program R version 2.9.1 (R Development Core Team, 2009).

## **References**

- Bouchenak-Khelladi, Y., Salamin, N., Savolainen, V., Forest, F., van der Bank, M., Chase, M.W. & Hodkinson, T.R. (2008) Large multi-gene phylogenetic trees of the grasses (Poaceae): progress towards complete tribal and generic level sampling. *Molecular Phylogenetics and Evolution*, 47, 488-505.
- Funk, V.A., Bayer, R.J., Keeley, S., Chan, R., Watson, L., Gemeinholzer, B., Schilling, E., Panero, J.L., Baldwin, B.G., Garcia-Jacas, N., Susanna, A. & Jansen, R.K. (2005) Everywhere but Antarctica: using a supertree to understand the diversity and distribution of the Compositae. *Biologiske Skrifter Kongelige Danske Videnskabernes Selskab* 55, 343-374.

Goertzen, L.R., Cannone, J.J., Gutell, R.R. & Jansen, R.K. (2003) ITS secondary structure derived from comparative analysis: implication for sequence alignment and phylogeny of the Asteraceae. *Molecular Phylogenetics and Evolution*, 29, 216-234.

Kim, K-J., Choi, K-S. & Jansen, R.K. (2005) Two chloroplast DNA inversions originated simultaneously during the early evolution of the Sunflower family (Asteraceae). *Molecular Biology and Evolution*, 22, 1783-1792.

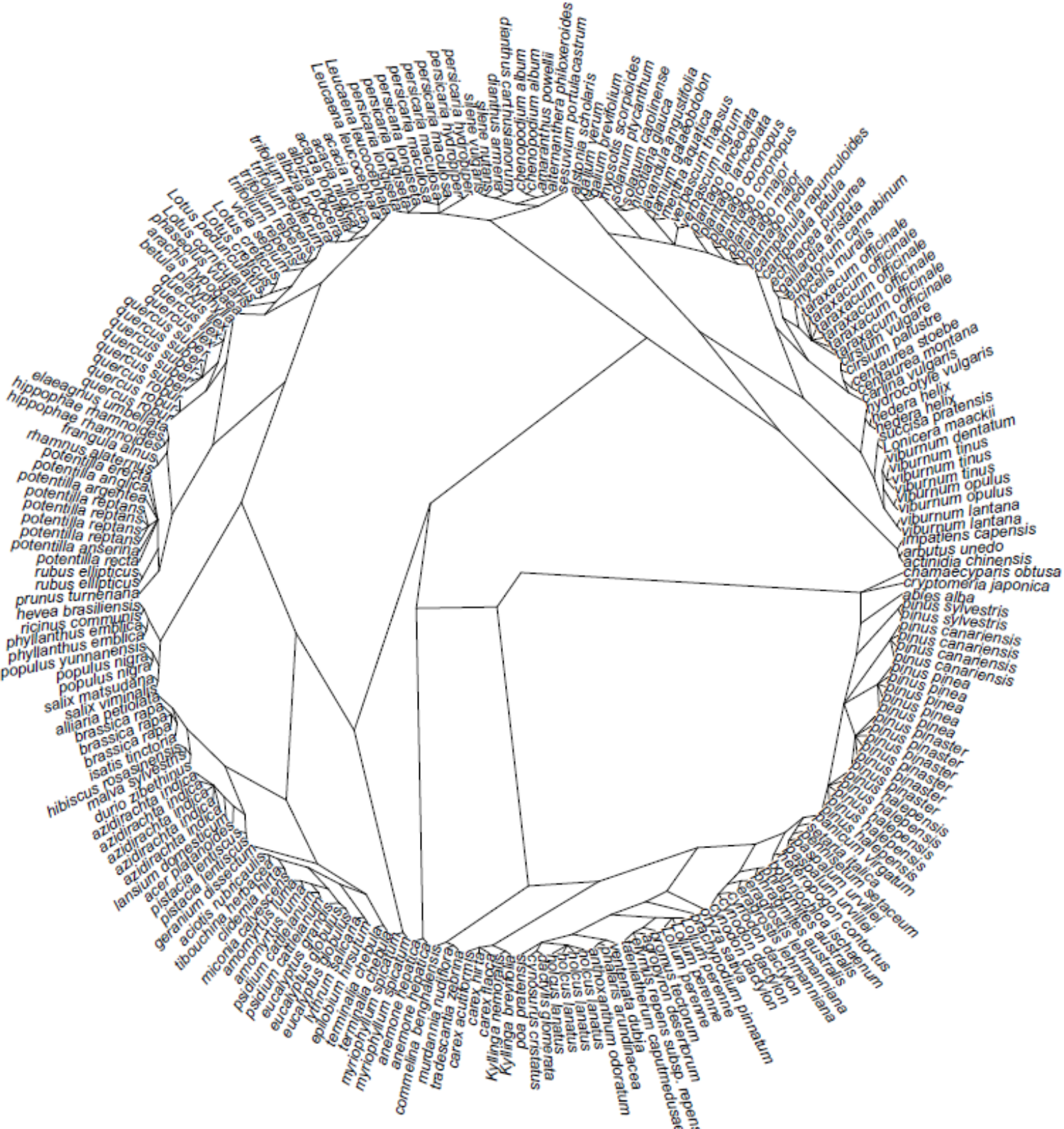
Stevens, P.F. (2001 onwards). Angiosperm Phylogeny Website. Version 9.

<http://www.mobot.org/MOBOT/research/APweb/> [Accessed June 2010].

Webb, C.O. & Donoghue, M.J. (2005) Phylomatic: tree assembly for applied phylogenetics. *Molecular Ecology Notes*, 5, 181-183.

Webb, C.O. & Donoghue, M.J. (2008) Phylocom: Software for the analysis of phylogenetic community structure and character evolution, version 4.1. *Bioinformatics*, 24, 2098-2100.

Phylogeny for biomass responses to light/nutrient/water increase. NB: branch lengths not to scale.





Phylogeny for SLA responses to light increase. NB: branch lengths not to scale.

