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## General plant strategies and functions in wetlands: global trait-based analyses

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# References

- Ackerly, D.D. & Cornwell, W.K. (2007) A trait-based approach to community assembly: partitioning of species trait values into within- and among-community components. *Ecology Letters*, **10**, 135–145.
- Adema, E.B. & Grootjans, A.P. (2003) Possible positive-feedback mechanisms: Plants change abiotic soil parameters in wet calcareous dune slacks. *Plant Ecology*, **167**, 141–149.
- Adema, E.B., Van de Koppel, J., Meijer, H.A.J. & Grootjans, A.P. (2005) Enhanced nitrogen loss may explain alternative stable states in dune slack succession. *Oikos*, **109**, 374–386.
- Allred, M. & Baines, S.B. (2016) Effects of wetland plants on denitrification rates: a meta-analysis. *Ecological Applications*, **26**, 676–685.
- Armstrong, J. & Armstrong, W. (2001) Rice and Phragmites: Effects of organic acids on growth, root permeability, and radial oxygen loss to the rhizosphere. *American Journal of Botany*, **88**, 1359–1370.
- Armstrong, W. (1980) Aeration in Higher Plants. *Advances in Botanical Research*, pp. 225–332.
- Armstrong, W. & Beckett, P.M. (2011) Experimental and modelling data contradict the idea of respiratory down-regulation in plant tissues at an internal [O<sub>2</sub>] substantially above the critical oxygen pressure for cytochrome oxidase. *New Phytologist*, **190**, 431–441.
- Armstrong, W., Brändle, R. & Jackson, M.B. (1994) Mechanisms of flood tolerance in plants. *Acta Botanica Neerlandica*, **43**, 307–358.
- Armstrong, W., Cousins, D., Armstrong, J., Turner, D.W. & Beckett, P.M. (2000) Oxygen Distribution in Wetland Plant Roots and Permeability Barriers to Gas-exchange with the Rhizosphere: a Microelectrode and Modelling Study with *Phragmites australis*. *Annals of Botany*, **86**, 687–703.
- Atkin, O.K., Bloomfield, K.J., Reich, P.B., Tjoelker, M.G., Asner, G.P., Bonal, D., Bönisch, G., Bradford, M.G., Cernusak, L.A., Cosio, E.G., Creek, D., Crous, K.Y., Domingues, T.F., Dukes, J.S., Egerton, J.J.G., Evans, J.R., Farquhar, G.D., Fyllas, N.M., Gauthier, P.P.G., Gloor, E., Gimeno, T.E., Griffin, K.L., Guerrieri, R., Heskell, M.A., Huntingford, C., Ishida, F.Y., Kattge, J., Lambers, H., Liddell, M.J., Lloyd, J., Lusk, C.H., Martin, R.E., Maksimov, A.P., Maximov, T.C., Malhi, Y., Medlyn, B.E., Meir, P., Mercado, L.M., Mirotnick, N., Ng, D., Niinemets, Ü., O’Sullivan, O.S., Phillips, O.L., Poorter, L., Poot, P., Prentice, I.C., Salinas, N., Rowland, L.M., Ryan, M.G., Sitch, S., Slot, M., Smith, N.G., Turnbull, M.H., Vanderwel, M.C., Valladares, F., Veneklaas, E.J., Weerasinghe, L.K., Wirth, C., Wright, I.J., Wythers, K.R., Xiang, J., Xiang, S. & Zaragoza-Castells, J. (2015) Global variability in leaf respiration in

- relation to climate, plant functional types and leaf traits. *New Phytologist*, **206**, 614–636.
- Aulakh, M.S., Wassmann, R., Bueno, C. & Rennenberg, H. (2001) Impact of root exudates of different cultivars and plant development stages of rice (*Oryza sativa* L.) on methane production in a paddy soil. *Plant and Soil*, **230**, 77–86.
- Baastrop-Spohr, L., Sand-Jensen, K., Nicolajsen, S.V. & Bruun, H.H. (2015) From soaking wet to bone dry: Predicting plant community composition along a steep hydrological gradient. *Journal of Vegetation Science*, **26**, 619–630.
- Bailey-Serres, J. & Voesenek, L.A.C.J. (2008) Flooding stress: Acclimations and genetic diversity. *Annual Review of Plant Biology*, **59**, 313–339.
- Bakker, C., Rodenburg, J. & van Bodegom, P.M. (2005) Effects of Ca- and Fe-rich seepage on P availability and plant performance in calcareous dune soils. *Plant and Soil*, **275**, 111–122.
- Bardgett, R.D., Mommer, L. & De Vries, F.T. (2014) Going underground: Root traits as drivers of ecosystem processes. *Trends in Ecology and Evolution*, **29**, 692–699.
- Bartelheimer, M. & Poschlod, P. (2016) Functional characterizations of Ellenberg indicator values - a review on ecophysiological determinants. *Functional Ecology*, **30**, 506–516.
- Bartholomeus, R.P., Witte, J.M., van Bodegom, P.M. & Aerts, R. (2008) The need of data harmonization to derive robust empirical relationships between soil conditions and vegetation. *Journal of Vegetation Science*, **19**, 799–808.
- Barton, K. (2018) MuMIn: Multi-Model Inference. R package version 1.40.4. <https://CRAN.R-project.org/package=MuMIn>.
- Bechtold, U. (2018) Plant life in extreme environments: How do you improve drought tolerance? *Frontiers in Plant Science*, **9**, 1–8.
- de Bello, F., Lavorel, S., Díaz, S., Harrington, R., Cornelissen, J.H.C., Bardgett, R.D., Berg, M.P., Cipriotti, P., Feld, C.K., Hering, D., da Silva, P.M., Potts, S.G., Sandin, L., Sousa, J.P., Storkey, J., Wardle, D.A. & Harrison, P.A. (2010) Towards an assessment of multiple ecosystem processes and services via functional traits. *Biodiversity and Conservation*, **19**, 2873–2893.
- Bennett, E.M., Peterson, G.D. & Gordon, L.J. (2009) Understanding relationships among multiple ecosystem services. *Ecology Letters*, **12**, 1394–1404.
- Bhullar, G.S., Edwards, P.J. & Olde Venterink, H. (2013a) Variation in the plant-mediated methane transport and its importance for methane emission from intact wetland peat mesocosms. *Journal of Plant Ecology*, **6**, 298–304.
- Bhullar, G.S., Irvani, M., Edwards, P.J. & Olde Venterink, H. (2013b) Methane transport and emissions from soil as affected by water table and vascular plants. *BMC Ecology*, **13**.

- Blom, C., Voeselek, L.A.C.J., Banga, M., Engelaar, W.M.H.G., Rijnders, J.H.G.M., Van de Steeg, H.M. & Visser, E.J.W. (1994) Physiological ecology of riverside species: Adaptive responses of plants to submergence. *Annals of Botany*, **74**, 253–263.
- van Bodegom, P.M. & Price, T. (2015) A traits-based approach to quantifying ecosystem services. *Ecosystem Services: From Concept to Practice*, pp. 40–64. Cambridge University Press, Cambridge.
- van Bodegom, P.M., Douma, J.C. & Verheijen, L.M. (2014) A fully traits-based approach to modeling global vegetation distribution. *Proceedings of the National Academy of Sciences*, **111**, 13733–13738.
- van Bodegom, P.M., Douma, J.C., Witte, J.P.M., Ordoñez, J.C., Bartholomeus, R.P. & Aerts, R. (2012) Going beyond limitations of plant functional types when predicting global ecosystem-atmosphere fluxes: Exploring the merits of traits-based approaches. *Global Ecology and Biogeography*, **21**, 625–636.
- van Bodegom, P.M., Goudriaan, J. & Leffelaar, P. (2001a) A mechanistic model on methane oxidation in a rice rhizosphere. *Biogeochemistry*, **55**, 145–177.
- van Bodegom, P.M., Groot, T., van den Hout, B., Leffelaar, P.A. & Goudriaan, J. (2001b) Diffusive gas transport through flooded rice systems. *Journal of Geophysical Research: Atmospheres*, **106**, 20861–20873.
- van Bodegom, P.M., de Kanter, M., Bakker, C. & Aerts, R. (2005) Radial oxygen loss, a plastic property of dune slack plant species. *Plant and Soil*, **271**, 351–364.
- van Bodegom, P.M. & Scholten, J.C.M. (2001) Microbial processes of CH<sub>4</sub> production in a rice paddy soil: Model and experimental validation. *Geochimica et Cosmochimica Acta*, **65**, 2055–2066.
- van Bodegom, P.M., Sorrell, B.K., Oosthoek, A., Bakker, C. & Aerts, R. (2008) Separating the effects of partial submergence and soil oxygen demand on plant physiology. *Ecology*, **89**, 193–204.
- van Bodegom, P.M., Wassmann, R. & Metra-Corton, T.M. (2001c) A process-based model for methane emission predictions from flooded rice paddies. *Global Biogeochemical Cycles*, **15**, 247–263.
- Bohnert, H.J., Nelson, D.E. & Jensen, R.G. (1995) Adaptations to environmental stresses. *Plant Cell*, **7**, 1099–1111.
- Brauman, K.A., Daily, G.C., Duarte, T.K. & Mooney, H.A. (2007) The nature and value of ecosystem services: An overview highlighting hydrologic services. *Annual Review of Environment and Resources*, **32**, 67–98.
- Bridgman, S.D., Cadillo-Quiroz, H., Keller, J.K. & Zhuang, Q. (2013) Methane emissions from wetlands: Biogeochemical, microbial, and modeling perspectives from local to global scales. *Global Change Biology*, **19**, 1325–1346.

- Burnham, K.P. & Anderson, D.R. (1998) Practical use of the information-theoretic approach. *Model Selection and Inference*, pp. 75–117. Springer New York, New York, NY.
- Cantarel, A.A.M., Pommier, T., Desclos-Theveniau, M., Diquélou, S., Dumont, M., Grassein, F., Kastl, E.M., Grigulis, K., Lainé, P., Lavorel, S., Lemauiel-Lavenant, S., Personeni, E., Schloter, M. & Poly, F. (2015) Using plant traits to explain plant-microbe relationships involved in nitrogen acquisition. *Ecology*, **96**, 788–799.
- Carpenter, S.R. & Lodge, D.M. (1986) Effects of submersed macrophytes on ecosystem processes. *Aquatic Botany*, **26**, 341–370.
- Cebrian, J. & Lartigue, J. (2004) Patterns of herbivory and decomposition in aquatic and terrestrial ecosystems. *Ecological Monographs*, **74**, 237–259.
- Chambers, P.A., Lacoul, P., Murphy, K.J. & Thomaz, S.M. (2008) Global diversity of aquatic macrophytes in freshwater. *Hydrobiologia*, **595**, 9–26.
- Colmer, T.D. (2003a) Aerenchyma and an inducible barrier to radial oxygen loss facilitate root aeration in upland, paddy and deep-water rice (*Oryza sativa* L.). *Annals of Botany*, **91**, 301–309.
- Colmer, T.D. (2003b) Long-distance transport of gases in plants: A perspective on internal aeration and radial oxygen loss from roots. *Plant, Cell and Environment*, **26**, 17–36.
- Colmer, T.D. & Pedersen, O. (2008) Underwater photosynthesis and respiration in leaves of submerged wetland plants: gas films improve CO<sub>2</sub> and O<sub>2</sub> exchange. *New Phytologist*, **177**, 918–926.
- Colmer, T.D., Pedersen, O., Wetson, A.M. & Flowers, T.J. (2013) Oxygen dynamics in a salt-marsh soil and in *Suaeda maritima* during tidal submergence. *Environmental and Experimental Botany*, **92**, 73–82.
- Colmer, T.D. & Voesenek, L.A.C.J. (2009) Flooding tolerance: Suites of plant traits in variable environments. *Functional Plant Biology*, **36**, 665–681.
- Colmer, T.D., Winkel, A. & Pedersen, O. (2011) A perspective on underwater photosynthesis in submerged terrestrial wetland plants. *AoB PLANTS*, **11**, 1–15.
- Cook, C.D.K.K. (1999) The number and kinds of embryo-bearing plants which have become aquatic: a survey. *Perspectives in Plant Ecology, Evolution and Systematics*, **2**, 79–102.
- Cornelissen, J.H.C., Grootemaat, S., Verheijen, L.M., Cornwell, W.K., van Bodegom, P.M., van der Wal, R. & Aerts, R. (2017) Are litter decomposition and fire linked through plant species traits? *New Phytologist*, 653–669.
- Cornwell, W.K. & Ackerly, D.D. (2009) Community assembly and shifts in plant trait distributions across an environmental gradient in Coastal California. *Ecological Monographs*, **79**, 109–126.
- Costanza, R., D'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R.G., Sutton, P. & van den Belt, M.

- (1998) The value of the world's ecosystem services and natural capital. *Nature*, **387**, 253–260.
- Couwenberg, J., Dommain, R. & Joosten, H. (2010) Greenhouse gas fluxes from tropical peatlands in south-east Asia. *Global Change Biology*, **16**, 1715–1732.
- Cyr, H. & Face, M.L. (1993) Magnitude and patterns of herbivory in aquatic and terrestrial ecosystems. *Nature*, **361**, 148–150.
- DeLaune, R.D. & Pezeshki, S.R. (2001) Plant functions in wetland and aquatic systems: Influence of intensity and capacity of soil reduction. *The Scientific World Journal*, **1**, 636–649.
- Diaz, S., Kattge, J., Cornelissen, J.H., Wright, I.J., Lavorel, S., Dray, S., Reu, B., Kleyer, M., Wirth, C., Prentice, I.C., Garnier, E., Bonisch, G., Westoby, M., Poorter, H., Reich, P.B., Moles, A.T., Dickie, J., Gillison, A.N., Zanne, A.E., Chave, J., Wright, S.J., Sheremet'ev, S.N., Jactel, H., Baraloto, C., Cerabolini, B., Pierce, S., Shipley, B., Kirkup, D., Casanoves, F., Joswig, J.S., Gunther, A., Falczuk, V., Ruger, N., Mahecha, M.D. & Gorne, L.D. (2016) The global spectrum of plant form and function. *Nature*, **529**, 167–171.
- Ding, W., Cai, Z. & Tsuruta, H. (2005) Plant species effects on methane emissions from freshwater marshes. *Atmospheric Environment*, **39**, 3199–3207.
- Doherty, J.M., Miller, J.F., Prellwitz, S.G., Thompson, A.M., Loheide, S.P.I. & Zedler, J.B. (2014) Hydrologic regimes revealed bundles and tradeoffs among six wetland services. *Ecosystems*, **17**, 1026–1039.
- Douma, J.C., Bardin, V., Bartholomeus, R.P. & van Bodegom, P.M. (2012) Quantifying the functional responses of vegetation to drought and oxygen stress in temperate ecosystems. *Functional Ecology*, **26**, 1355–1365.
- Dray, S., Choler, P., Dolédec, S., Peres-Neto, P.R., Thuiller, W., Pavoine, S. & Ter Braak, C.J.F. (2014) Combining the fourth-corner and the RLQ methods for assessing trait responses to environmental variation. *Ecology*, **95**, 14–21.
- Ellenberg, H.H. (1988) *Vegetation ecology of central Europe*, 4<sup>th</sup> edition. Cambridge University Press, Cambridge.
- Engelaar, W.M.H.G., Van Bruggen, M.W., Van Den Hoek, W.P.M., Huyser, M.A.H. & Blom, C.W.P.M. (1993) Root porosities and radial oxygen losses of *Rumex* and *Plantago* species as influenced by soil pore diameter and soil aeration. *New Phytologist*, **125**, 565–574.
- Engelhardt, K. a & Ritchie, M.E. (2001) Effects of macrophyte species richness on wetland ecosystem functioning and services. *Nature*, **411**, 687–689.
- Engelhardt, K.A.M. (2006) Relating effects and response traits in submerged aquatic macrophytes. *Ecological Applications*, **16**, 1808–1820.

- Fick, S.E. & Hijmans, R.J. (2017) WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. *International Journal of Climatology*, **37**, 4302–4315.
- Flowers, T.J. & Colmer, T.D. (2008) Salinity tolerance in halophytes. *New Phytologist*, **179**, 945–963.
- Forbes, B.C., Spasojevic, M.J., Berner, L., Lembrechts, J.J., Nielsen, S.S., Kulonen, A., Hülber, K., Hewitt, R.E., Greve, M., Rumpf, S.B., Michelsen, A., Dullinger, S., Tremblay, J.-P., Speed, J.D.M., Hermanutz, L., Rixen, C., Green, P., Eskelinen, A., Bjorkman, A.D., Hudson, J., Cornelissen, J.H.C., Good, M.K., Bai, Y., Shetti, R., Cooper, E.J., Little, C.J., Oberbauer, S.F., Jaroszynska, F., Elberling, B., Iversen, C.M., Morgan, J.W., Henry, G.H.R., Milbau, A., Alexander, H., Mack, M.C., te Beest, M., Weijers, S., Luoto, M., Prevéy, J.S., Kaarlejärvi, E., Haider, S., Klady, R., Molau, U., Harper, K.A., Tremblay, M., Lantz, T., Lavalley, A., Carbognani, M., Lamarque, L.J., Trant, A., Blok, D., Mathakutha, R., Kuleza, S., Wilmking, M., Tomaselli, M., Normand, S., Nabe-Nielsen, J., Jiménez-Alfaro, B., Onipchenko, V.G., Christie, K., Semenchuk, P., Frei, E.R., Korsten, A., Mörsdorf, M.A., Lévesque, E., Johnstone, J., Happonen, K., Venn, S., Tape, K.D., Baruah, G., Suding, K., Wipf, S., Grogan, P., Buchwal, A., Pickering, C., Zamin, T., Iturrate-Garcia, M., Hájek, T., Schaepman-Strub, G., Buras, A., Ninot, J.M., Macek, P., Hollister, R.D., Angers-Blondin, S., Hallinger, M., Björk, R.G., Olofsson, J., Jorgensen, R.H., Dickinson, K.J.M., Thomas, H.J.D., Alatalo, J.M., Street, L.E., Treier, U.A., Virkkala, A.-M., Heijmans, M.M.P.D., Klimešová, J., Anadon-Rosell, A., Myers-Smith, I.H., Petraglia, A., Grau, O., Bruelheide, H., Elmendorf, S.C., Soudzilovskaia, N.A., Vowles, T. & Collier, L.S. (2018) Tundra Trait Team: A database of plant traits spanning the tundra biome. *Global Ecology and Biogeography*, **27**, 1402–1411.
- Freschet, G.T., Cornelissen, J.H.C., van Logtestijn, R.S.P. & Aerts, R. (2010) Evidence of the “plant economics spectrum” in a subarctic flora. *Journal of Ecology*, **98**, 362–373.
- Freschet, G.T., Valverde-Barrantes, O.J., Tucker, C.M., Craine, J.M., McCormack, M.L., Violle, C., Fort, F., Blackwood, C.B., Urban-Mead, K.R., Iversen, C.M., Bonis, A., Comas, L.H., Cornelissen, J.H.C., Dong, M., Guo, D., Hobbie, S.E., Holdaway, R.J., Kembel, S.W., Makita, N., Onipchenko, V.G., Picon-Cochard, C., Reich, P.B., de la Riva, E.G., Smith, S.W., Soudzilovskaia, N.A., Tjoelker, M.G., Wardle, D.A. & Roumet, C. (2017) Climate, soil and plant functional types as drivers of global fine-root trait variation. *Journal of Ecology*, **105**, 1182–1196.
- Funk, J.L., Larson, J.E., Ames, G.M., Butterfield, B.J., Cavender-Bares, J., Firm, J., Laughlin, D.C., Sutton-Grier, A.E., Williams, L. & Wright, J. (2017) Revisiting the Holy Grail: using plant functional traits to understand ecological processes. *Biological Reviews*, **92**, 1156–1173.
- Garssen, A.G., Baattrup-Pedersen, A., Voesenek, L.A.C.J., Verhoeven, J.T.A. & Soons, M.B. (2015) Riparian plant community responses to increased flooding: A meta-analysis. *Global Change Biology*, **21**, 2881–2890.
- Garthwaite, A.J., von Bothmer, R. & Colmer, T.D. (2003) Diversity in root aeration traits



- associated with waterlogging tolerance in the genus *Hordeum*. *Functional Plant Biology*, **30**, 875–889.
- Greenway, H., Armstrong, W. & Colmer, T.D. (2006) Conditions leading to high CO<sub>2</sub> (>5 kPa) in waterlogged-flooded soils and possible effects on root growth and metabolism. *Annals of Botany*, **98**, 9–32.
- Grömping, U. (2006) Relative Importance for Linear Regression in R: The Package relaimpo. *Journal of Statistical Software*, **17**, S218.
- Grootjans, A.P., Ernst, W.H.O. & Stuyfzand, P.J. (1998) European dune slacks: Strong interactions of biology, pedogenesis and hydrology. *Trends in Ecology & Evolution*, **13**, 96–100.
- Güsewell, S. (2002) Variation in nitrogen and phosphorus concentrations of wetland plants. *Perspectives in Plant Ecology, Evolution and Systematics*, **5**, 37–61.
- Hallik, L., Niinemets, Ü. & Wright, I.J. (2009) Are species shade and drought tolerance reflected in leaf-level structural and functional differentiation in Northern Hemisphere temperate woody flora? *New Phytologist*, **184**, 257–274.
- Harrison, P.A., Berry, P.M., Simpson, G., Haslett, J.R., Blicharska, M., Bucur, M., Dunford, R., Egoh, B., Garcia-Llorente, M., Geamănă, N., Geertsema, W., Lommelen, E., Meiresonne, L. & Turkelboom, F. (2014) Linkages between biodiversity attributes and ecosystem services: A systematic review. *Ecosystem Services*, **9**, 191–203.
- Herzog, M. & Pedersen, O. (2014) Partial versus complete submergence: Snorkelling aids root aeration in *Rumex palustris* but not in *R. acetosa*. *Plant, Cell and Environment*, **37**, 2381–2390.
- Hikosaka, K. & Shigeno, A. (2009) The role of Rubisco and cell walls in the interspecific variation in photosynthetic capacity. *Oecologia*, **160**, 443–451.
- Hill, M.O., Roy, D.B., Mountford, J.O. & Bunce, R.G.H. (2000) Extending Ellenberg's indicator values to a new area: An algorithmic approach. *Journal of Applied Ecology*, **37**, 3–15.
- Hobbie, S.E. (2015) Plant species effects on nutrient cycling: revisiting litter feedbacks. *Trends in Ecology and Evolution*, **30**, 357–363.
- Hothorn, T., Bretz, F. & Westfall, P. (2008) Simultaneous inference in general parametric models. *Biometrical Journal*, **50**, 346–363.
- Hu, B., Henry, A., Brown, K.M. & Lynch, J.P. (2014) Root cortical aerenchyma inhibits radial nutrient transport in maize (*Zea mays*). *Annals of Botany*, **113**, 181–189.
- Huber, H., Jacobs, E. & Visser, E.J.W. (2009) Variation in flooding-induced morphological traits in natural populations of white clover (*Trifolium repens*) and their effects on plant performance during soil flooding. *Annals of Botany*, **103**, 377–386.
- Iversen, L.L., Winkel, A., Bastrup-Spohr, L., Hinke, A.B., Alahuhta, J., Baattrup-Pedersen,

- A., Birk, S., Brodersen, P., Chambers, P.A., Ecke, F., Feldmann, T., Gebler, D., Heino, J., Jespersen, T.S., Moe, S.J., Riis, T., Sass, L., Vestergaard, O., Maberly, S.C., Sand-Jensen, K. & Pedersen, O. (2019) Catchment properties and the photosynthetic trait composition of freshwater plant communities. *Science*, **366**, 878–881.
- Jackson, M.B. & Armstrong, W. (1999) Formation of aerenchyma and the processes of plant ventilation in relation to soil flooding and submergence. *Plant Biology*, **1**, 274–287.
- Joabsson, A. & Christensen, T.R. (2001) Methane emissions from wetlands and their relationship with vascular plants: an Arctic example. *Global Change Biology*, **7**, 919–932.
- Joyce, C. (2012) Preface: Wetland services and management. *Hydrobiologia*, **692**, 1–3.
- Jung, V., Hoffmann, L. & Muller, S. (2009) Ecophysiological responses of nine floodplain meadow species to changing hydrological conditions. *Plant Ecology*, **201**, 589–598.
- Justin, S.H.F.W. & Armstrong, W. (1987) The anatomical characteristics of roots and plant response to soil flooding. *New Phytologist*, **106**, 465–495.
- Kattge, J., Diaz, S., Lavorel, S., Prentice, I.C., Leadley, P., Bönisch, G., Garnier, E., Westoby, M., Reich, P.B., Wright, I.J., Cornelissen, J.H.C., Violle, C., Harrison, S.P., van Bodegom, P.M., Reichstein, M., Enquist, B.J., Soudzilovskaia, N.A., Ackerly, D.D., Anand, M., Atkin, O., Bahn, M., Baker, T.R., Baldocchi, D., Bekker, R., Blanco, C.C., Blonder, B., Bond, W.J., Bradstock, R., Bunker, D.E., Casanoves, F., Cavender-Bares, J., Chambers, J.Q., Chapin, F.S., Chave, J., Coomes, D., Cornwell, W.K., Craine, J.M., Dobrin, B.H., Duarte, L., Durka, W., Elser, J., Esser, G., Estiarte, M., Fagan, W.F., Fang, J., Fernández-Méndez, F., Fidelis, A., Finegan, B., Flores, O., Ford, H., Frank, D., Freschet, G.T., Fyllas, N.M., Gallagher, R. V., Green, W.A., Gutierrez, A.G., Hickler, T., Higgins, S.I., Hodgson, J.G., Jalili, A., Jansen, S., Joly, C.A., Kerkhoff, A.J., Kirkup, D., Kitajima, K., Kleyer, M., Klotz, S., Knops, J.M.H., Kramer, K., Kühn, I., Kurokawa, H., Laughlin, D., Lee, T.D., Leishman, M., Lens, F., Lenz, T., Lewis, S.L., Lloyd, J., Llusià, J., Louault, F., Ma, S., Mahecha, M.D., Manning, P., Massad, T., Medlyn, B.E., Messier, J., Moles, A.T., Müller, S.C., Nadrowski, K., Naeem, S., Niinemets, Ü., Nöllert, S., Nüske, A., Ogaya, R., Oleksyn, J., Onipchenko, V.G., Onoda, Y., Ordoñez, J., Overbeck, G., Ozinga, W.A., Patiño, S., Paula, S., Pausas, J.G., Peñuelas, J., Phillips, O.L., Pillar, V., Poorter, H., Poorter, L., Poschlod, P., Prinzing, A., Proulx, R., Rammig, A., Reinsch, S., Reu, B., Sack, L., Salgado-Negret, B., Sardans, J., Shiodera, S., Shipley, B., Siefert, A., Sosinski, E., Soussana, J.F., Swaine, E., Swenson, N., Thompson, K., Thornton, P., Waldram, M., Weiher, E., White, M., White, S., Wright, S.J., Yguel, B., Zaehle, S., Zanne, A.E. & Wirth, C. (2011) TRY - a global database of plant traits. *Global Change Biology*, **17**, 2905–2935.
- Keddy, P.A. (1992) Assembly and response rules: Two goals for predictive community ecology. *Journal of Vegetation Science*, **3**, 157–164.
- Keddy, P.A. (2010) *Wetland ecology: principles and conservation*, 2<sup>nd</sup> edition. Cambridge University Press, UK.

- Kirk, G.J.D. (2003) Rice root properties for internal aeration and efficient nutrient acquisition in submerged soil. *New Phytologist*, **159**, 185–194.
- Kirschke, S., Bousquet, P., Ciais, P., Saunois, M., Canadell, J.G., Dlugokencky, E.J., Bergamaschi, P., Bergmann, D., Blake, D.R., Bruhwiler, L., Cameron-Smith, P., Castaldi, S., Chevallier, F., Feng, L., Fraser, A., Heimann, M., Hodson, E.L., Houweling, S., Josse, B., Fraser, P.J., Krummel, P.B., Lamarque, J.-F.F., Langenfelds, R.L., Le Quéré, C., Naik, V., O'Doherty, S., Palmer, P.I., Pison, I., Plummer, D., Poulter, B., Prinn, R.G., Rigby, M., Ringeval, B., Santini, M., Schmidt, M., Shindell, D.T., Simpson, I.J., Spahni, R., Steele, L.P., Strode, S. a., Sudo, K., Szopa, S., van der Werf, G.R., Voulgarakis, A., van Weele, M., Weiss, R.F., Williams, J.E. & Zeng, G. (2013) Three decades of global methane sources and sinks. *Nature Geoscience*, **6**, 813–823.
- Kleyer, M., Bekker, R.M., Knevel, I.C., Bakker, J.P., Thompson, K., Sonnenschein, M., Poschlod, P., Van Groenendael, J.M., Klimeš, L., Klimešová, J., Klotz, S., Rusch, G.M., Hermy, M., Adriaens, D., Boedeltje, G., Bossuyt, B., Dannemann, A., Endels, P., Götzenberger, L., Hodgson, J.G., Jackel, A.-K., Kühn, I., Kunzmann, D., Ozinga, W.A., Römermann, C., Stadler, M., Schlegelmilch, J., Steendam, H.J., Tackenberg, O., Wilmann, B., Cornelissen, J.H.C., Eriksson, O., Garnier, E. & Peco, B. (2008) The LEDA Traitbase: A database of life-history traits of the Northwest European flora. *Journal of Ecology*, **96**, 1266–1274.
- Kong, D., Ma, C., Zhang, Q., Li, L., Chen, X., Zeng, H. & Guo, D. (2014) Leading dimensions in absorptive root trait variation across 96 subtropical forest species. *New Phytologist*, **203**, 863–872.
- Konnerup, D. & Pedersen, O. (2017) Flood tolerance of *Glyceria fluitans*: the importance of cuticle hydrophobicity, permeability and leaf gas films for underwater gas exchange. *Annals of Botany*, **120**, 521–528.
- Koschorreck, M. & Darwich, A. (2003) Nitrogen dynamics in seasonally flooded soils in the Amazon floodplain. *Wetlands Ecology and Management*, **11**, 317–330.
- Kremen, C. (2005) Managing ecosystem services: What do we need to know about their ecology? *Ecology Letters*, **8**, 468–479.
- Kutzbach, L., Wagner, D. & Pfeiffer, E.M. (2004) Effect of microrelief and vegetation on methane emission from wet polygonal tundra, Lena Delta, Northern Siberia. *Biogeochemistry*, **69**, 341–362.
- Laan, P., Berrevoets, M.J., Lythe, S., Armstrong, W. & Blom, C.W.P.M. (1989) Root morphology and aerenchyma formation as indicators of the flood-tolerance of *Rumex* Species. *The Journal of Ecology*, **77**, 693–703.
- Laanbroek, H.J. (2010) Methane emission from natural wetlands: interplay between emergent macrophytes and soil microbial processes. A mini-review. *Ann Bot*, **105**, 141–153.

- Lai, W.-L., Wang, S.-Q., Peng, C.-L. & Chen, Z.-H. (2011) Root features related to plant growth and nutrient removal of 35 wetland plants. *Water Research*, **45**, 3941–3950.
- Lambers, H., Chapin, F.S. & Pons, T.L. (2008) *Plant Physiological Ecology*, 2<sup>nd</sup> edition. Springer New York, New York.
- Laughlin, D.C. (2014) Applying trait-based models to achieve functional targets for theory-driven ecological restoration. *Ecology Letters*, **17**, 771–784.
- Laughlin, D.C. & Laughlin, D.E. (2013) Advances in modeling trait-based plant community assembly. *Trends in Plant Science*, **18**, 584–593.
- Lavorel, S. (2013) Plant functional effects on ecosystem services. *Journal of Ecology*, **101**, 4–8.
- Lavorel, S. & Garnier, E. (2002) Predicting changes in community composition and ecosystem functioning from plant traits: Revisiting the Holy Grail. *Functional Ecology*, **16**, 545–556.
- Lavorel, S. & Grigulis, K. (2012) How fundamental plant functional trait relationships scale-up to trade-offs and synergies in ecosystem services. *Journal of Ecology*, **100**, 128–140.
- Lavorel, S., Grigulis, K., Lamarque, P., Colace, M.P., Garden, D., Girel, J., Pellet, G. & Douzet, R. (2011) Using plant functional traits to understand the landscape distribution of multiple ecosystem services. *Journal of Ecology*, **99**, 135–147.
- Lemoine, D.G., Mermillod-Blondin, F., Barrat-Segretain, M.-H., Massé, C. & Malet, E. (2012) The ability of aquatic macrophytes to increase root porosity and radial oxygen loss determines their resistance to sediment anoxia. *Aquatic Ecology*, **46**, 191–200.
- Lenssen, J.P.M., Menting, F.B.J., Van der Putten, W.H. & Blom, C.W.P.M. (2000) Vegetative reproduction by species with different adaptations to shallow-flooded habitats. *New Phytologist*, **145**, 61–70.
- Li, H., Ye, Z.H., Wei, Z.J. & Wong, M.H. (2011) Root porosity and radial oxygen loss related to arsenic tolerance and uptake in wetland plants. *Environmental Pollution*, **159**, 30–37.
- Li, L., McCormack, M.L., Ma, C., Kong, D., Zhang, Q., Chen, X., Zeng, H., Niinemets, Ü. & Guo, D. (2015) Leaf economics and hydraulic traits are decoupled in five species-rich tropical-subtropical forests. *Ecology Letters*, **18**, 899–906.
- Li, L., Yang, Y., Tam, N.F.Y., Yang, L., Mei, X.-Q. & Yang, F.-J. (2013a) Growth characteristics of six wetland plants and their influences on domestic wastewater treatment efficiency. *Ecological Engineering*, **60**, 382–392.
- Li, W., Cao, T., Ni, L., Zhang, X., Zhu, G. & Xie, P. (2013b) Effects of water depth on carbon, nitrogen and phosphorus stoichiometry of five submersed macrophytes in an in situ experiment. *Ecological Engineering*, **61**, 358–365.

- Lichvar, R.W., Banks, D.L., Kirchner, W.N. & Melvin, N.C. (2016) The National Wetland Plant List: 2016 wetland ratings. *Phytoneuron*, **30**, 1–7.
- Lissner, J., Mendelssohn, I.A., Lorenzen, B., Brix, H., McKee, K.L. & Miao, S. (2003) Interactive effects of redox intensity and phosphate availability on growth and nutrient relations of *Cladium jamaicense* (Cyperaceae). *American Journal of Botany*, **90**, 736–748.
- Liu, L. & Greaver, T.L. (2009) A review of nitrogen enrichment effects on three biogenic GHGs: The CO<sub>2</sub> sink may be largely offset by stimulated N<sub>2</sub>O and CH<sub>4</sub> emission. *Ecology Letters*, **12**, 1103–1117.
- Liu, R., Wang, L., Tanveer, M. & Song, J. (2018) Seed heteromorphism: An important adaptation of halophytes for habitat heterogeneity. *Frontiers in Plant Science*, **871**, 1–10.
- Loreti, E., Van Veen, H. & Perata, P. (2016) Plant responses to flooding stress. *Current Opinion in Plant Biology*, **33**, 64–71.
- Luo, F., Huang, L., Lei, T., Xue, W., Li, H., Yu, F. & Cornelissen, J.H.C. (2016) Responsiveness of performance and morphological traits to experimental submergence predicts field distribution pattern of wetland plants. *Journal of Vegetation Science*, **27**, 340–351.
- Luo, W., Xie, Y., Chen, X., Li, F. & Qin, X. (2010) Competition and facilitation in three marsh plants in response to a water-level gradient. *Wetlands*, **30**, 525–530.
- Maestre, F.T., Callaway, R.M., Valladares, F. & Lortie, C.J. (2009) Refining the stress-gradient hypothesis for competition and facilitation in plant communities. *Journal of Ecology*, **97**, 199–205.
- Maire, V., Wright, I.J., Prentice, I.C., Batjes, N.H., Bhaskar, R., van Bodegom, P.M., Cornwell, W.K., Ellsworth, D., Niinemets, Ü., Ordóñez, A., Reich, P.B. & Santiago, L.S. (2015) Global effects of soil and climate on leaf photosynthetic traits and rates. *Global Ecology and Biogeography*, **24**, 706–717.
- Mcdonald, M.P., Galwey, N.W. & Colmer, T.D. (2001) Waterlogging tolerance in the tribe Triticeae: the adventitious roots of *Critesion marinum* have a relatively high porosity and a barrier to radial oxygen loss. *Plant, Cell and Environment*, **24**, 585–596.
- McGill, B.J., Enquist, B.J., Weiher, E. & Westoby, M. (2006) Rebuilding community ecology from functional traits. *Trends in Ecology and Evolution*, **21**, 178–185.
- McInnes, R.J. (2011) Managing wetlands for multifunctional benefits. *Wetlands*, pp. 206–218. Springer Netherlands, Dordrecht.
- Meerburg, B.G., Vereijken, P.H., de Visser, W., Verhagen, J., Korevaar, H., Querner, E.P., de Blaeij, A.T. & van der Werf, A. (2010) Surface water sanitation and biomass production in a large constructed wetland in the Netherlands. *Wetlands Ecology and Management*, **18**, 463–470.

- Mei, X.-Q., Yang, Y., Tam, N.F.-Y., Wang, Y.-W. & Li, L. (2014) Roles of root porosity, radial oxygen loss, Fe plaque formation on nutrient removal and tolerance of wetland plants to domestic wastewater. *Water Research*, **50**, 147–159.
- Melton, J.R., Wania, R., Hodson, E.L., Poulter, B., Ringeval, B., Spahni, R., Bohn, T., Avis, C.A., Beerling, D.J., Chen, G., Eliseev, A. V., Denisov, S.N., Hopcroft, P.O., Lettenmaier, D.P., Riley, W.J., Singarayer, J.S., Subin, Z.M., Tian, H., Zürcher, S., Brovkin, V., van Bodegom, P.M., Kleinen, T., Yu, Z.C. & Kaplan, J.O. (2013) Present state of global wetland extent and wetland methane modelling: conclusions from a model inter-comparison project (WETCHIMP). *Biogeosciences*, **10**, 753–788.
- Miller, S.M., Commare, R., Melton, J.R., Andrews, A.E., Benmergui, J., Dlugokencky, E.J., Janssens-Maenhout, G., Michalak, A.M., Sweeney, C. & Worthy, D.E.J. (2016) Evaluation of wetland methane emissions across North America using atmospheric data and inverse modeling. *Biogeosciences*, **13**, 1329–1339.
- Mitsch, W.J. & Gosselink, J.G. (2015) *Wetlands*, 5<sup>th</sup> Edition. John Wiley and Sons, New Jersey.
- Moles, A.T., Perkins, S.E., Laffan, S.W., Flores-Moreno, H., Awasthy, M., Tindall, M.L., Sack, L., Pitman, A., Kattge, J., Aarssen, L.W., Anand, M., Bahn, M., Blonder, B., Cavender-Bares, J., Cornelissen, J.H.C., Cornwell, W.K., Díaz, S., Dickie, J.B., Freschet, G.T., Griffiths, J.G., Gutierrez, A.G., Hemmings, F.A., Hickler, T., Hitchcock, T.D., Keighery, M., Kleyer, M., Kurokawa, H., Leishman, M.R., Liu, K., Niinemets, Ü., Onipchenko, V., Onoda, Y., Penuelas, J., Pillar, V.D., Reich, P.B., Shiodera, S., Siefert, A., Sosinski, E.E., Soudzilovskaia, N.A., Swaine, E.K., Swenson, N.G., van Bodegom, P.M., Warman, L., Weiher, E., Wright, I.J., Zhang, H., Zobel, M. & Bonser, S.P. (2014) Which is a better predictor of plant traits: Temperature or precipitation? *Journal of Vegetation Science*, **25**, 1167–1180.
- Møller, A.P. & Jennions, M.D. (2002) How much variance can be explained by ecologists and evolutionary biologists? *Oecologia*, **132**, 492–500.
- Mommer, L., Lenssen, J.P.M., Huber, H., Visser, E.J.W. & De Kroon, H. (2006) Ecophysiological determinants of plant performance under flooding: a comparative study of seven plant families. *Journal of Ecology*, **94**, 1117–1129.
- Mommer, L., Pedersen, O. & Visser, E.J.W. (2004) Acclimation of a terrestrial plant to submergence facilitates gas exchange under water. *Plant, Cell and Environment*, **27**, 1281–1287.
- Mommer, L. & Visser, E.J. (2005) Underwater photosynthesis in flooded terrestrial plants: a matter of leaf plasticity. *Ann Bot*, **96**, 581–589.
- Moor, H., Rydin, H., Hylander, K., Nilsson, M.B., Lindborg, R. & Norberg, J. (2017) Towards a trait-based ecology of wetland vegetation. *Journal of Ecology*, **105**, 1623–1635.
- Nagai, K., Hattori, Y. & Ashikari, M. (2010) Stunt or elongate? Two opposite strategies by

- which rice adapts to floods. *Journal of Plant Research*, **123**, 303–309.
- Nakagawa, S. & Cuthill, I.C. (2007) Effect size, confidence interval and statistical significance: A practical guide for biologists. *Biological Reviews*, **82**, 591–605.
- van der Nat, F.J.W.A. & Middelburg, J.J. (1998) Seasonal variation in methane oxidation by the rhizosphere of *Phragmites australis* and *Scirpus lacustris*. *Aquatic Botany*, **61**, 95–110.
- Navas, M.L. & Violle, C. (2009) Plant traits related to competition: How do they shape the functional diversity of communities? *Community Ecology*, **10**, 131–137.
- Nepf, H.M. (2012) Flow and transport in regions with aquatic vegetation. *Annual Review of Fluid Mechanics*, **44**, 123–142.
- Niinemets, Ü. & Valladares, F. (2006) Tolerance to shade, drought, and waterlogging of temperate northern hemisphere trees and shrubs. *Ecological Monographs*, **76**, 521–547.
- van Noordwijk, M. & Brouwer, G. (1988) Quantification of air-filled root porosity: A comparison of two methods. *Plant and Soil*, **111**, 255–258.
- van Ommen Kloeke, A.E.E., Douma, J.C., Ordoñez, J.C., Reich, P.B. & van Bodegom, P.M. (2012) Global quantification of contrasting leaf life span strategies for deciduous and evergreen species in response to environmental conditions. *Global Ecology and Biogeography*, **21**, 224–235.
- Onoda, Y., Wright, I.J., Evans, J.R., Hikosaka, K., Kitajima, K., Niinemets, Ü., Poorter, H., Tosens, T. & Westoby, M. (2017) Physiological and structural tradeoffs underlying the leaf economics spectrum. *New Phytologist*, **214**, 1447–1463.
- Ordoñez, J.C., van Bodegom, P.M., Witte, J.-P.M., Bartholomeus, R.P., Van Dobben, H.F. & Aerts, R. (2010) Leaf habit and woodiness regulate different leaf economy traits at a given nutrient supply. *Ecology*, **91**, 3218–3228.
- Ordoñez, J.C., van Bodegom, P.M., Witte, J.P.M., Wright, I.J., Reich, P.B. & Aerts, R. (2009) A global study of relationships between leaf traits, climate and soil measures of nutrient fertility. *Global Ecology and Biogeography*, **18**, 137–149.
- Page, S.E. & Baird, A.J. (2016) Peatlands and global change: Response and resilience. *Annual Review of Environment and Resources*, **41**, 35–57.
- Pagter, M., Bragato, C. & Brix, H. (2005) Tolerance and physiological responses of *Phragmites australis* to water deficit. *Aquatic Botany*, **81**, 285–299.
- Pan, Y., Cieraad, E. & van Bodegom, P.M. (2019) Are ecophysiological adaptive traits decoupled from leaf economics traits in wetlands? *Functional Ecology*, **33**, 1202–1210.
- Pan, Y., Zhang, X., Song, K. & Da, L. (2017) Applying trait-based method to investigate the relationship between macrophyte communities and environmental conditions in a eutrophic freshwater lake, China. *Aquatic Botany*, **142**, 16–24.

- Pedersen, O., Colmer, T.D., Borum, J., Zavala-Perez, A. & Kendrick, G.A. (2016) Heat stress of two tropical seagrass species during low tides - impact on underwater net photosynthesis, dark respiration and diel in situ internal aeration. *New Phytologist*, **210**, 1207–1218.
- Pedersen, O., Pulido, C., Rich, S.M. & Colmer, T.D. (2011) In situ O<sub>2</sub> dynamics in submerged *Isoetes australis*: Varied leaf gas permeability influences underwater photosynthesis and internal O<sub>2</sub>. *Journal of Experimental Botany*, **62**, 4691–4700.
- Pedersen, O., Vos, H. & Colmer, T.D. (2006) Oxygen dynamics during submergence in the halophytic stem succulent *Halosarcia pergranulata*. *Plant, Cell and Environment*, **29**, 1388–1399.
- Pezeshki, S.R. (2001) Wetland plant responses to soil flooding. *Environmental and Experimental Botany*, **46**, 299–312.
- Pezeshki, S.R. & De Laune, R.D. (2012) Soil oxidation-reduction in wetlands and its impact on plant functioning. *Biology*, **1**, 196–221.
- Pierce, S., Brusa, G., Sartori, M. & Cerabolini, B.E. (2012) Combined use of leaf size and economics traits allows direct comparison of hydrophyte and terrestrial herbaceous adaptive strategies. *Annals of Botany*, **109**, 1047–1053.
- Ponnamperuma, F.N. (1972) The chemistry of submerged soils. *Advances in Agronomy*, **24**, 29–96.
- Poorter, H., Niklas, K.J., Reich, P.B., Oleksyn, J., Poot, P. & Mommer, L. (2012) Biomass allocation to leaves, stems and roots: meta-analyses of interspecific variation and environmental control. *New Phytologist*, **193**, 30–50.
- R Core Team (2018) R: A language and environment for statistical computing. R Foundation Statistical Computing, Vienna, Austria. URL <https://www.r-project.org/>.
- Ramsar Convention Secretariat (2016) The Fourth RAMSAR Strategic Plan 2016-2024. *Ramsar handbooks for the wise use of wetlands*, 5<sup>th</sup> edition, vol. 2. Ramsar Convention Secretariat, Gland, Switzerland., pp. 1–54.
- Ramsar Convention Secretariat (2013) *The Ramsar Convention Manual: a guide to the Convention on Wetlands* (Ramsar, Iran, 1971), 6<sup>th</sup> edition. Gland.
- Rascio, N., Cuccato, F., Dalla Vecchia, F., La Rocca, N. & Larcher, W. (1999) Structural and functional features of the leaves of *Ranunculus trichophyllus* Chaix., a freshwater submerged macrophyte. *Plant, Cell and Environment*, **22**, 205–212.
- Reddy, K.R., Patrick, W.H. & Lindau, C.W. (1989) Nitrification-denitrification at the plant root-sediment interface in wetlands. *Limnology and Oceanography*, **34**, 1004–1013.
- Reich, P.B. (2014) The world-wide ‘fast-slow’ plant economics spectrum: A traits manifesto. *Journal of Ecology*, **102**, 275–301.
- Reich, P.B., Ellsworth, D.S. & Walters, M.B. (1998a) Leaf structure (specific leaf area)



- modulates photosynthesis-nitrogen relations: Evidence from within and across species and functional groups. *Functional Ecology*, **12**, 948–958.
- Reich, P.B., Luo, Y., Bradford, J.B., Poorter, H., Perry, C.H. & Oleksyn, J. (2014) Temperature drives global patterns in forest biomass distribution in leaves, stems, and roots. *Proceedings of the National Academy of Sciences*, **111**, 13721–13726.
- Reich, P.B., Machado, J.-L., Wright, I.J., Oleksyn, J., Pregitzer, K.S. & Tjoelker, M.G. (2008) Scaling of respiration to nitrogen in leaves, stems and roots of higher land plants. *Ecology Letters*, **11**, 793–801.
- Reich, P.B. & Oleksyn, J. (2004) Global patterns of plant leaf N and P in relation to temperature and latitude. *Proceedings of the National Academy of Sciences*, **101**, 11001–11006.
- Reich, P.B., Walters, M.B. & Ellsworth, D.S. (1997) From tropics to tundra: Global convergence in plant functioning. *Proceedings of the National Academy of Sciences*, **94**, 13730–13734.
- Reich, P.B., Walters, M.B., Ellsworth, D.S., Vose, J.M., Volin, J.C., Gresham, C. & Bowman, W.D. (1998b) Relationships of leaf dark respiration to leaf nitrogen, specific leaf area and leaf life-span: A test across biomes and functional groups. *Oecologia*, **114**, 471–482.
- Ribaudo, C., Bertrin, V., Jan, G., Anschutz, P. & Abril, G. (2017) Benthic production, respiration and methane oxidation in *Lobelia dortmanna* lawns. *Hydrobiologia*, **784**, 21–34.
- Rich, S.M., Pedersen, O., Ludwig, M. & Colmer, T.D. (2013) Shoot atmospheric contact is of little importance to aeration of deeper portions of the wetland plant *Meionectes brownii*; submerged organs mainly acquire O<sub>2</sub> from the water column or produce it endogenously in underwater photosynthesis. *Plant, Cell and Environment*, **36**, 213–223.
- Riley, W.J., Subin, Z.M., Lawrence, D.M., Swenson, S.C., Torn, M.S., Meng, L., Mahowald, N.M. & Hess, P. (2011) Barriers to predicting changes in global terrestrial methane fluxes: Analyses using CLM4Me, a methane biogeochemistry model integrated in CESM. *Biogeosciences*, **8**, 1925–1953.
- Ringeval, B., De Noblet-Ducoudré, N., Ciais, P., Bousquet, P., Prigent, C., Papa, F. & Rossow, W.B. (2010) An attempt to quantify the impact of changes in wetland extent on methane emissions on the seasonal and interannual time scales. *Global Biogeochemical Cycles*, **24**, 1–12.
- Rubinigg, M., Stulen, I., Elzenga, J.T.M. & Colmer, T.D. (2002) Spatial patterns of radial oxygen loss and nitrate net flux along adventitious roots of rice raised in aerated or stagnant solution. *Functional Plant Biology*, **29**, 1475–1481.
- Santamaría, L. (2002) Why are most aquatic plants widely distributed? Dispersal, clonal growth and small-scale heterogeneity in a stressful environment. *Acta Oecologica*, **23**,

- Sasidharan, R., Bailey-Serres, J., Ashikari, M., Atwell, B.J., Colmer, T.D., Fagerstedt, K., Fukao, T., Geigenberger, P., Hebelstrup, K.H., Hill, R.D., Holdsworth, M.J., Ismail, A.M., Licausi, F., Mustroph, A., Nakazono, M., Pedersen, O., Perata, P., Sauter, M., Shih, M.C., Sorrell, B.K., Striker, G.G., van Dongen, J.T., Whelan, J., Xiao, S., Visser, E.J.W. & Voisenek, L.A.C.J. (2017) Community recommendations on terminology and procedures used in flooding and low oxygen stress research. *New Phytologist*, **214**, 1403–1407.
- Schat, H. (1984) A comparative ecophysiological study on the effects of waterlogging and submergence on dune slack plants: Growth, survival and mineral nutrition in sand culture experiments. *Oecologia*, **62**, 279–286.
- Schenk, H.J. & Jackson, R.B. (2002) Rooting depths, lateral root spreads and below-ground/above-ground allometries of plants in water-limited ecosystems. *Journal of Ecology*, **90**, 480–494.
- Schlesinger, W.H. (2009) On the fate of anthropogenic nitrogen. *Proceedings of the National Academy of Sciences*, **106**, 203–208.
- Segers, R. (1998) Methane production and methane consumption: A review of processes underlying wetland methane fluxes. *Biogeochemistry*, **41**, 23–51.
- Sharma, S., Gray, D.K., Read, J.S., O'Reilly, C.M., Schneider, P., Qudrat, A., Gries, C., Stefanoff, S., Hampton, S.E., Hook, S., Lenters, J.D., Livingstone, D.M., McIntyre, P.B., Adrian, R., Allan, M.G., Anneville, O., Arvola, L., Austin, J., Bailey, J., Baron, J.S., Brookes, J., Chen, Y., Daly, R., Dokulil, M., Dong, B., Ewing, K., De Eyto, E., Hamilton, D., Havens, K., Haydon, S., Hetzenauer, H., Heneberry, J., Hetherington, A.L., Higgins, S.N., Hixson, E., Izmet'eva, L.R., Jones, B.M., Kangur, K., Kasprzak, P., Köster, O., Kraemer, B.M., Kumagai, M., Kuusisto, E., Leshkevich, G., May, L., MacIntyre, S., Müller-Navarra, D., Naumenko, M., Noges, P., Noges, T., Niederhauser, P., North, R.P., Paterson, A.M., Plisnier, P.D., Rigosi, A., Rimmer, A., Rogora, M., Rudstam, L., Rusak, J.A., Salmaso, N., Samal, N.R., Schindler, D.E., Schladow, G., Schmidt, S.R., Schultz, T., Silow, E.A., Straile, D., Teubner, K., Verburg, P., Voutilainen, A., Watkinson, A., Weyhenmeyer, G.A., Williamson, C.E. & Woo, K.H. (2015) A global database of lake surface temperatures collected by in situ and satellite methods from 1985–2009. *Scientific Data*, **2**, 1–19.
- Shipley, B., De Bello, F., Cornelissen, J.H.C., Laliberté, E., Laughlin, D.C. & Reich, P.B. (2016) Reinforcing loose foundation stones in trait-based plant ecology. *Oecologia*, **180**, 923–931.
- Shipley, B., Belluau, M., Kühn, I., Soudzilovskaia, N.A., Bahn, M., Penuelas, J., Kattge, J., Sack, L., Cavender-Bares, J., Ozinga, W.A., Blonder, B., van Bodegom, P.M., Manning, P., Hickler, T., Sosinski, E., Pillar, V.D.P., Onipchenko, V. & Poschlod, P. (2017) Predicting habitat affinities of plant species using commonly measured functional traits. *Journal of Vegetation Science*, **28**, 1082–1095.

- Shipley, B., Vile, D. & Garnier, E. (2006) From plant traits to plant communities: A statistical mechanistic approach to biodiversity. *Science*, **314**, 812–814.
- Silvertown, J., Araya, Y. & Gowing, D. (2015) Hydrological niches in terrestrial plant communities: A review. *Journal of Ecology*, **103**, 93–108.
- Singer, A., Eshel, A., Agami, M. & Beer, S. (1994) The contribution of aerenchymal CO<sub>2</sub> to the photosynthesis of emergent and submerged culms of *Scirpus lacustris* and *Cyperus papyrus*. *Aquatic Botany*, **49**, 107–116.
- Singer, C.E. & Havill, D.C. (1993) Resistance to divalent manganese of salt-marsh plants. *The Journal of Ecology*, **81**, 797.
- Snowden, R.E.D. & Wheeler, B.D. (1993) Iron toxicity to fen plant species. *The Journal of Ecology*, **81**, 35–46.
- Stocker, T.F., Dahe, Q., Plattner, G.-K., Alexander, L. V., Allen, S.K., Bindoff, N.L., Bréon, F.-M., Church, J.A., Cubash, U., Emori, S., Forster, P., Friedlingstein, P., Talley, L.D., Vaughan, D.G. & Xie, S.-P. (2013) Technical Summary. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 33–115.
- Striker, G.G., Insausti, P., Grimoldi, A.A. & Vega, A.S. (2007) Trade-off between root porosity and mechanical strength in species with different types of aerenchyma. *Plant, Cell & Environment*, **30**, 580–589.
- Sutton-Grier, A.E. & Megonigal, J.P. (2011) Plant species traits regulate methane production in freshwater wetland soils. *Soil Biology and Biochemistry*, **43**, 413–420.
- Sutton-Grier, A.E., Wright, J.P. & Richardson, C.J. (2013) Different plant traits affect two pathways of riparian nitrogen removal in a restored freshwater wetland. *Plant and Soil*, **365**, 41–57.
- Vartapetian, B.B. & Jackson, M.B. (1997) Plant adaptations to anaerobic stress. *Annals of Botany*, **79**, 3–20.
- van Veen, H., Muströph, A., Barding, G.A., Vergeer-van Eijk, M., Welschen-Evertman, R.A.M., Pedersen, O., Visser, E.J.W., Larive, C.K., Pierik, R., Bailey-Serres, J., Voeselek, L.A.C.J. & Sasidharan, R. (2013) Two *Rumex* species from contrasting hydrological niches regulate flooding tolerance through distinct mechanisms. *The Plant Cell*, **25**, 4691–4707.
- Verheijen, L.M., Brovkin, V., Aerts, R., Bonisch, G., Cornelissen, J.H.C., Kattge, J., Reich, P.B., Wright, I.J. & van Bodegom, P.M. (2013) Impacts of trait variation through observed trait-climate relationships on performance of an Earth system model: A conceptual analysis. *Biogeosciences*, **10**, 5497–5515.
- Villagra, M., Campanello, P.I., Bucci, S.J. & Goldstein, G. (2013) Functional relationships between leaf hydraulics and leaf economic traits in response to nutrient addition in subtropical tree species. *Tree Physiology*, **33**, 1308–1318.

- Violle, C., Bonis, A., Plantegenest, M., Cudennec, C., Damgaard, C., Marion, B., Le Cœur, D. & Bouzillé, J.-B. (2011) Plant functional traits capture species richness variations along a flooding gradient. *Oikos*, **120**, 389–398.
- Violle, C., Enquist, B.J., McGill, B.J., Jiang, L., Albert, C.H., Hulshof, C., Jung, V. & Messier, J. (2012) The return of the variance: Intraspecific variability in community ecology. *Trends in Ecology and Evolution*, **27**, 244–252.
- Violle, C. & Jiang, L. (2009) Towards a trait-based quantification of species niche. *Journal of Plant Ecology*, **2**, 87–93.
- Violle, C., Navas, M.L., Vile, D., Kazakou, E., Fortunel, C., Hummel, I. & Garnier, E. (2007) Let the concept of trait be functional! *Oikos*, **116**, 882–892.
- Visser, E.J.W., Bögemann, G.M., Van De Steeg, H.M., Pierik, R. & Blom, C.W.P.M. (2000a) Flooding tolerance of *Carex* species in relation to field distribution and aerenchyma formation. *New Phytologist*, **148**, 93–103.
- Visser, E.J.W., Colmer, T.D., Blom, C.W.P.M. & Voeselek, L.A.C.J. (2000b) Changes in growth, porosity, and radial oxygen loss from adventitious roots of selected mono- and dicotyledonous wetland species with contrasting types of aerenchyma. *Plant, Cell and Environment*, **23**, 1237–1245.
- Voeselek, L.A.C.J. & Bailey-Serres, J. (2015) Flood adaptive traits and processes: An overview. *New Phytologist*, **206**, 57–73.
- Voeselek, L.A.C.J. & Bailey-Serres, J. (2013) Flooding tolerance: O<sub>2</sub> sensing and survival strategies. *Current Opinion in Plant Biology*, **16**, 647–653.
- Voeselek, L.A.C.J., Benschop, J.J., Bou, J., Cox, M.C.H., Groeneveld, H.W., Millenaar, F.F., Vreeburg, R.A.M. & Peeters, A.J.M. (2003) Interactions between plant hormones regulate submergence-induced shoot elongation in the flooding-tolerant dicot *Rumex palustris*. *Annals of Botany*, **91**, 205–211.
- Voeselek, L.A.C.J., Colmer, T.D., Pierik, R., Millenaar, F.F. & Peeters, A.J.M. (2006) How plants cope with complete submergence. *New Phytologist*, **170**, 213–226.
- Voeselek, L.A.C.J., Rijnders, J.H.G.M., Peeters, A.J.M., van de Steeg, H.M. & de Kroon, H. (2004) Plant hormones regulate fast shoot elongation under water: From genes to communities. *Ecology*, **85**, 16–27.
- Wania, R., Melton, J.R., Hodson, E.L., Poulter, B., Ringeval, B., Spahni, R., Bohn, T., Avis, C.A., Chen, G., Eliseev, A. V., Hopcroft, P.O., Riley, W.J., Subin, Z.M., Tian, H., van Bodegom, P.M., Kleinen, T., Yu, Z.C., Singarayer, J.S., Zürcher, S., Lettenmaier, D.P., Beerling, D.J., Denisov, S.N., Prigent, C., Papa, F. & Kaplan, J.O. (2013) Present state of global wetland extent and wetland methane modelling: Methodology of a model inter-comparison project (WETCHIMP). *Geoscientific Model Development*, **6**, 617–641.
- Wania, R., Ross, I. & Prentice, I.C. (2010) Implementation and evaluation of a new methane

- model within a dynamic global vegetation model: LPJ-WHyMe v1.3.1. *Geoscientific Model Development*, **3**, 565–584.
- Warton, D.I., Duursma, R.A., Falster, D.S. & Taskinen, S. (2012) smatr 3- an R package for estimation and inference about allometric lines. *Methods in Ecology and Evolution*, **3**, 257–259.
- Warton, D.I. & Hui, F.K.C. (2011) The arcsine is asinine: the analysis of proportions in ecology. *Ecology*, **92**, 3–10.
- Warton, D.I., Wright, I.J., Falster, D.S. & Westoby, M. (2006) Bivariate line-fitting methods for allometry. *Biological Reviews of the Cambridge Philosophical Society*, **81**, 259–291.
- Wasserstein, R.L., Schirm, A.L. & Lazar, N.A. (2019) Moving to a World Beyond “ $p < 0.05$ .” *American Statistician*, **73**, 1–19.
- van der Werf, A., Kooijman, A., Welschen, R. & Lambers, H. (1988) Respiratory energy costs for the maintenance of biomass, for growth and for ion uptake in roots of *Carex diandra* and *Carex acutiformis*. *Physiologia Plantarum*, **72**, 483–491.
- Westoby, M., Falster, D.S., Moles, A.T., Vesk, P.A. & Wright, I.J. (2002) Plant ecological strategies: Some leading dimensions of variation between species. *Annual Review of Ecology and Systematics*, **33**, 125–159.
- Whiting, G.J. & Chanton, J.P. (2001) Greenhouse carbon balance of wetlands: Methane emission versus carbon sequestration. *Tellus, Series B: Chemical and Physical Meteorology*, **53**, 521–528.
- Willby, N.J., Pulford, I.D. & Flowers, T.H. (2001) Tissue nutrient signatures predict herbaceous-wetland community responses to nutrient availability. *New Phytologist*, **152**, 463–481.
- Winkel, A. & Borum, J. (2009) Use of sediment CO<sub>2</sub> by submersed rooted plants. *Annals of Botany*, **103**, 1015–1023.
- Winkel, A., Colmer, T.D., Ismail, A.M. & Pedersen, O. (2013) Internal aeration of paddy field rice (*Oryza sativa*) during complete submergence - importance of light and floodwater O<sub>2</sub>. *New Phytologist*, **197**, 1193–1203.
- Winkel, A., Visser, E.J.W., Colmer, T.D., Brodersen, K.P., Voeselek, L.A.C.J., Sand-Jensen, K. & Pedersen, O. (2016) Leaf gas films, underwater photosynthesis and plant species distributions in a flood gradient. *Plant, Cell and Environment*, **39**, 1537–1548.
- Wolfe, M.D. & Tonsor, S.J. (2014) Adaptation to spring heat and drought in northeastern Spanish *Arabidopsis thaliana*. *New Phytologist*, **201**, 323–334.
- Wright, A.J., de Kroon, H., Visser, E.J.W., Buchmann, T., Ebeling, A., Eisenhauer, N., Fischer, C., Hildebrandt, A., Ravenek, J., Roscher, C., Weigelt, A., Weisser, W., Voeselek, L.A.C.J. & Mommer, L. (2017a) Plants are less negatively affected by

- flooding when growing in species-rich plant communities. *New Phytologist*, **213**, 645–656.
- Wright, I.J., Dong, N., Maire, V., Prentice, I.C., Westoby, M., Díaz, S., Gallagher, R. V., Jacobs, B.F., Kooyman, R., Law, E.A., Leishman, M.R., Niinemets, Ü. & Reich, P.B. (2017b) Global climatic drivers of leaf size. *Science*, **12**, 917–921.
- Wright, I.J., Reich, P.B., Cornelissen, J.H.C., Falster, D.S., Groom, P.K., Hikosaka, K., Lee, W., Lusk, C.H., Niinemets, Ü., Oleksyn, J., Osada, N., Poorter, H., Warton, D.I. & Westoby, M. (2005) Modulation of leaf economic traits and trait relationships by climate. *Global Ecology and Biogeography*, **14**, 411–421.
- Wright, I.J., Reich, P.B., Westoby, M., Ackerly, D.D., Baruch, Z., Bongers, F., Cavender-Bares, J., Chapin, T., Cornelissen, J.H.C., Diemer, M., Flexas, J., Garnier, E., Groom, P.K., Gulias, J., Hikosaka, K., Lamont, B.B., Lee, T., Lee, W., Lusk, C., Midgley, J.J., Navas, M.-L., Niinemets, U., Oleksyn, J., Osada, N., Poorter, H., Poot, P., Prior, L., Pyankov, V.I., Roumet, C., Thomas, S.C., Tjoelker, M.G., Veneklaas, E.J. & Villar, R. (2004) The worldwide leaf economics spectrum. *Nature*, **428**, 821–827.
- Wright, J.P. & Sutton-Grier, A. (2012) Does the leaf economic spectrum hold within local species pools across varying environmental conditions? *Functional Ecology*, **26**, 1390–1398.
- Wright, S.J., Kitajima, K., Kraft, N.J.B., Reich, P.B., Wright, I.J., Bunker, D.E., Condit, R., Dalling, J.W., Davies, S.J., Díaz, S., Engelbrecht, B.M.J., Harms, K.E., Hubbell, S.P., Marks, C.O., Ruiz-Jaen, M.C., Salvador, C.M. & Zanne, A.E. (2010) Functional traits and the growth-mortality trade-off in tropical trees. *Ecology*, **91**, 3664–3674.
- Wu, Z., Dijkstra, P., Koch, G.W., Peñuelas, J. & Hungate, B.A. (2011) Responses of terrestrial ecosystems to temperature and precipitation change: A meta-analysis of experimental manipulation. *Global Change Biology*, **17**, 927–942.
- Xu, X., Riley, W.J., Koven, C.D., Billesbach, D.P., Chang, R.Y.W., Commene, R., Euskirchen, E.S., Hartery, S., Harazono, Y., Iwata, H., McDonald, K.C., Miller, C.E., Oechel, W.C., Poulter, B., Raz-Yaseef, N., Sweeney, C., Torn, M., Wofsy, S.C., Zhang, Z. & Zona, D. (2016) A multi-scale comparison of modeled and observed seasonal methane emissions in northern wetlands. *Biogeosciences*, **13**, 5043–5056.
- Yamori, W., Hikosaka, K. & Way, D.A. (2014) Temperature response of photosynthesis in C<sub>3</sub>, C<sub>4</sub>, and CAM plants: temperature acclimation and temperature adaptation. *Photosynthesis Research*, **119**, 101–117.
- Yang, J., Tam, N.F.Y. & Ye, Z. (2014) Root porosity, radial oxygen loss and iron plaque on roots of wetland plants in relation to zinc tolerance and accumulation. *Plant and Soil*, **374**, 815–828.
- Yoccoz, N.G. (1991) Use, overuse, and misuse of significance tests in evolutionary biology and ecology. *Bulletin of the Ecological Society of America*, **72**, 106–111.
- Yordanova, R.Y., Christov, K.N. & Popova, L.P. (2004) Antioxidative enzymes in barley

- plants subjected to soil flooding. *Environmental and Experimental Botany*, **51**, 93–101.
- Zedler, J.B. (2003) Wetlands at your service: reducing impacts of agriculture at the watershed scale. *Frontiers in Ecology and the Environment*, **1**, 65–72.
- Zedler, J.B. & Kercher, S. (2005) Wetland resources: Status, trends, ecosystem services, and restorability. *Annual Review of Environment and Resources*, **30**, 39–74.
- Zedler, J.J.B. (2000) Progress in wetland restoration ecology. *Trends in ecology & evolution*, **15**, 402–407.
- Zheng, H., Fu, Z., Zhong, J. & Long, W. (2018) Low methane emission in rice cultivars with high radial oxygen loss. *Plant and Soil*, **431**, 119–128.

