Chair of Plant ecology and ecosystems research

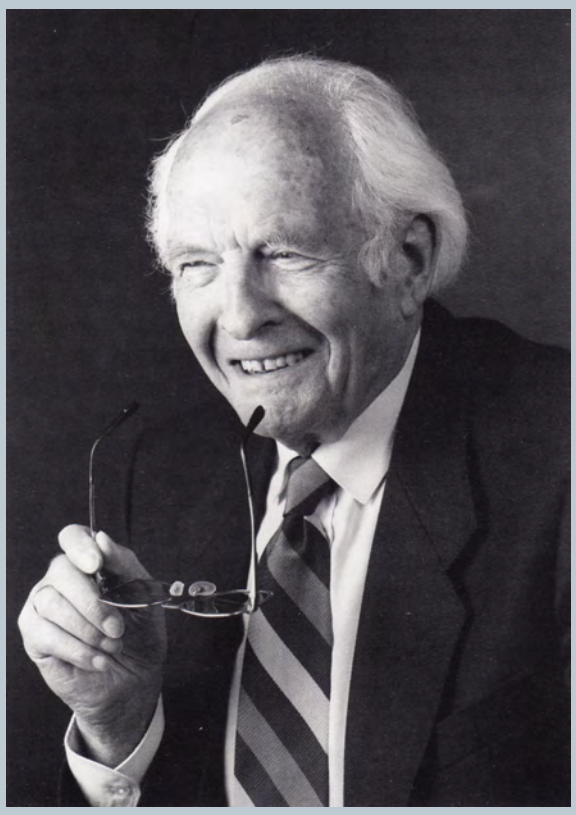
Albrecht von Haller Institute for plant sciences

Georg August University Göttingen

In memoriam

Heinz Ellenberg

(1913 – 1997)



On August 1, 2013, Heinz Ellenberg would have been 100 years old. We use this anniversary to remember this pioneer of vegetation and plant ecology and recall his main achievements and contribution to the development of the discipline.

Heinz Ellenberg shaped half a century of Central European vegetation ecology. The Ellenberg Indicator Values (Zeigerwerte) are well known to nearly every student of the discipline and are widely used in practical application.

This little brochure reflects the main steps in Heinz Ellenberg's scientific life and presents a selection of his most influential publications. Another intention of this hand-out is to inform about the recent research activities of the Chair for Plant Ecology and Ecosystems Research at Göttingen University, the chair Ellenberg filled from 1966 until 1981.

The scientist's life

Heinz Ellenberg was born in 1913 in Hamburg-Harburg (northern Germany). After finishing school in Hannover, he moved to Montpellier in 1932 to study botany as well as zoology, chemistry and geology. He continued his studies at the universities of Heidelberg, Hannover and Göttingen and, in 1938, received a PhD in botany under the supervision of the paleobotanist Franz Firbas in Göttingen. In 1947, he joined the group of Heinrich Walter, plant ecologist and biogeographer, at the Botanical Institute of the Agricultural University in Stuttgart-Hohenheim, and was able to complete his 'habilitation' thesis in 1948. From 1953 to 1958, he was a Senior Lecturer at the Botanical Institute, University of Hamburg. In 1958, he became Full Professor of Geobotany at the Swiss Technical University Zürich (ETHZ). From 1966 till his retirement in 1981, he was Director of the Systematisch-Geobotanisches Institut (Institute of Plant Systematics and Geobotany) at the University of Göttingen.

Ellenberg was a member of several scientific academies and received numerous awards (including four honorary doctorates and a Tansley Lecture in 1977). His scientific work includes more than 250 publications and several highly influential books.

His main research topics

- The fundamental methodology of vegetation description and classification
- Physiognomic-ecological classification of plants and plant formations
- Relationships between soil factors and forest community composition
- Nitrogen and soil acidity as determinants of vegetation composition
- Plant species as indicators of environmental conditions
- The ecological interpretation of large-scale vegetation patterns in Central Europe, South-Eastern Europe, the Andes and elsewhere
- The development of multi-disciplinary perspectives of ecosystem functioning
- Environmental-friendly farming concepts based on ecological information
- The mutual interrelationship between landscape factors and human settlements

Twelve selected publications of Heinz Ellenberg with largest influence

1) Ellenberg H (1952) Physiologisches und ökologisches Verhalten derselben Pflanzenarten. Berichte der Deutschen Botanischen Gesellschaft 65: 350-361. (Physiological and ecological response of plant species). – *lays the foundation for distinguishing between fundamental and realized plant niches*

2) Ellenberg H, Ellenberg C (1954) Ökologische Klimakarte Baden-Württemberg 1 : 350 000. Ministerium f. Ern., Landw. u. Umwelt, Stuttgart (Growth climate map of Baden-Württemberg, SW Germany) – *demonstrates the usefulness of phenological geographical data for mapping growth climates in a larger area*

3) Ellenberg H (1956) Aufgaben und Methoden der Vegetationskunde. Ulmer, Stuttgart. 136 pp. (Aims and Methods of Vegetation Ecology). – *first comprehensive treatise on concepts and methodology of vegetation analysis and vegetation ecology from a Central European perspective*

4) Ellenberg H (1963–1996) Vegetation Mitteleuropas mit den Alpen in kausaler, dynamischer und historischer Sicht. 1st to 5th ed. Ulmer, Stuttgart. (Vegetation Ecology of Central Europe) – *Ellenberg's monumental book on the vegetation ecology of all major natural and man-made vegetation types in Central Europe with roughly 10,000 copies sold*

5) Horvat I, Glavac V, Ellenberg H (1974) Vegetation Südosteuropas. G. Fischer, Stuttgart, 752 pp. (Vegetation of South-eastern Europe) – *first comprehensive monograph on the vegetation of the Balkans*

6) Mueller-Dombois D, Ellenberg H (1974) Aims and Methods of Vegetation Ecology. Wiley, New York, 547 pp. – *for decades the standard volume of the methodology in vegetation ecology*

7) Ellenberg H (1977) Stickstoff als Standortsfaktor, insbesondere für mitteleuropäische Pflanzengesellschaften. Oecologia Plantarum 12: 1-22. (Nitrogen as an environmental factor in plant communities of Central Europe) – *by summarizing the early literature on N effects, Ellenberg highlights the outstanding role N nutrition is playing for community composition*

8) Ellenberg H (1979) Man's influence on tropical mountain ecosystems in South America. Journal of Ecology 67: 401-416. – *summarizes three decades of research on the physiognomy and ecology of the Andean vegetation (mostly Peru and Bolivia)*

9) Ellenberg H, Mayer R, Schauermann J (eds.) (1986) Ergebnisse des Sollingprojekts 1966-1986. Ulmer, Stuttgart, 507 pp. *(Results of the Solling IBP ecosystem research project) – summarizes the results of Germany's first comprehensive forest ecosystem research project which subsequently promoted ecosystem research in Central Europe*

10) Ellenberg H (1988) Vegetation Ecology of Central Europe. Cambridge Univ. Press, Cambridge, 731 pp. – *English edition of 'Vegetation Mitteleuropas mit den Alpen'*

11) Ellenberg H (1990) Bauernhaus und Landschaft in ökologischer und historischer Sicht. Ulmer, Stuttgart, 585 pp. (Farmsteads and landscape in an ecological and historical perspective) – *brings together the architectural history of Central European farmsteads and landscape ecology*

12) Ellenberg H, Weber HE, Düll R, Wirth V, Werner W, Paulissen D (1992) Zeigerwerte von Pflanzen in Mitteleuropa. Scripta Geobotanica 18. Göttingen, 258 pp. (Ecological indicator values of Central European plant species) – *the world's most complete compendium of plant indicator values of a defined region*

For a more detailed outline of Ellenberg's scientific achievements see Leuschner (1997) Phytocoenologia 27: 457-462.

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The department at Untere Karspüle 2 in the centre of Göttingen

Laboratory and outdoor research facilities at Grisebachstraße 1 in Göttingen-Weende

The scientists at the department (as of May 2013):

Prof. Dr. Christoph Leuschner

Prof. Dr. Markus Hauck
Dr. Heinz Coners
Dr. Choimaa Dulamsuren
Dr. Ann-Catrin Fender
PD Dr. Dirk Gansert
Dr. Dietrich Hertel
Dr. Jürgen Homeier
Dr. Mascha Jacob
Dr. Lars Köhler
Dr. Ina C. Meier
Dr. Stefan Meyer
Dr. Bernhard Schuldt
Dr. Bettina Wagner

History of the chair

Franz Firbas (1952 – 1964)

Heinz Ellenberg (1966 – 1981)

Michael Runge (1982 – 1999)

Christoph Leuschner (2000 –)

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The Göttingen Canopy Walkway in a 9-species mixed forest

Air humidity manipulation facility on the forest floor

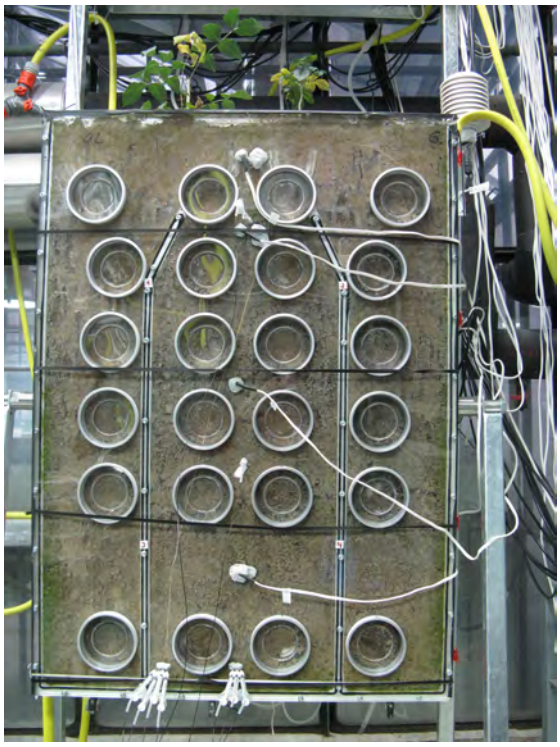
Experiment for studying the functions of diversity in a permanent grassland (GrassMan-Experiment Solling)

Transmission microscope with digital image analysis unit

Sulawesi Throughfall Exclusion Experiment (Indonesia) for simulating drought in a tropical rainforest

Rainfall and nitrogen manipulation experiment on the Tibetan Plateau

Mobile elevator for canopy research (30 m)



Rhizotrons for root system analysis and manipulation

The Göttingen Rhizolab with minirhizotron access tubes

(photographs D. Hertel, Ch. Leuschner, M. Hauck, H. Coners)

MAIN RESEARCH ACTIVITIES TODAY

- **Functional diversity of Central European trees**

We compare mature and juvenile trees of European beech, little-leaf linden, European hornbeam, sycamore maple, European ash and other species with respect to light capture, carbon gain, water status and turnover, and nutrient cycling (Niedersachsen, Thüringen).

- **Climate change responses of Central European trees and forests**

We study beech forests along precipitation gradients and expose juvenile trees to defined drought stress for analysing tree growth under a future drier climate (Niedersachsen, Thüringen, Sachsen-Anhalt)

- **Process dynamics in European old-growth forests**

By analysing the structure, phytodiversity and carbon and nutrient pools in Central European protected old-growth forests and comparing them to managed stands, we seek for a better understanding of the role old-growth forests are playing in forest biogeochemical cycles (Northern Germany, Slovakia)

- **Climate change response of the southern boreal forest in Central Asia**

We analyse the growth decline of southern boreal conifer forests and its causes (Mongolia, Kazakhstan, Tibet)

- **Climate change response of tropical forests**

The possible effects of a warmer and drier climate on tropical forests are studied along elevation (temperature) gradients in tropical mountains and in a Throughfall Exclusion Experiment (Ecuador, Indonesia, Costa Rica)

- **Response of tropical forests to nutrient addition**

The effects of a future higher deposition of N (and P) is simulated in the Nutrient Manipulation Experiment NUMEX in Andean tropical montane forests (Ecuador)

- **Taxonomic and functional diversity of tropical trees**

Changes in tree species diversity, tree hydraulic architecture and nutrition are studied along altitudinal and topographic gradients (Ecuador, Indonesia)

- **Root functioning in the rhizosphere**

We investigate the distribution, abundance, turnover and functioning of tree and grassland root systems and the interaction with soil chemistry (Central Europe, Central Asia, Tropics)

- **Ecology of the lichen symbiosis**

We study the functioning of the lichen symbiosis, especially with respect to nutrition, pollutants and climate, with a special focus on the functional role of lichen substances

- **Land-use impact on forest and grassland ecosystems**

We study the impact of agricultural intensification on the structure and composition of managed grasslands (GrassMan project, Niedersachsen), of ecosystems in the forest-steppe ecotone and alpine ecosystems in Central Asia (Mongolia, Tibet, Kazakhstan)

- **Long-term vegetation change in the agricultural landscape of northern Germany**

The multi-disciplinary project BioChange quantifies the phytodiversity loss in Central Europe's arable fields, grasslands and running waters due to agricultural intensification since the 1950s (Niedersachsen, Sachsen-Anhalt, Thüringen, Schleswig-Holstein)

- **Conservation of endangered arable field vegetation**

The applied project '100 fields for diversity' establishes a nation-wide network of sanctuaries for highly endangered arable field communities (Germany)

Publication list of the chair by topics (since 2000)

I PEER-REVIEWED PUBLICATIONS

(1) Carbon relations of trees and forests (temperate and boreal)

Battulga P, Tsogtbaatar J, Dulamsuren Ch, Hauck M (in press) Equations for estimating the above-ground biomass of *Larix sibirica* in the forest-steppe of Mongolia. Journal of Forestry Research.

Dulamsuren Ch, Khishigjargal M, Hauck M, Leuschner C (in press) Response of tree-ring width to climate warming and selective logging in larch forests of the Mongolian Altai. Journal of Plant Ecology doi: 10.1093/jpe/rtt019.

Jacob M, Bade C, Calvete H, Dittrich S, Leuschner C, Hauck M (2013) Significance of over-mature and decaying trees for carbon stocks in a Central European natural spruce forest. Ecosystems 16: 336-346.

Legner, N., Fleck, S., Leuschner, C. (in press) Low-light acclimation in five temperate broad-leaved tree species of different successional status: the significance of a shade canopy. Annals of Forest Science.

Müller, A., Horna, V., Kleemann, F., Vornam, B., Leuschner, C. (in press) Physiological vs. morphological traits controlling the productivity of six aspen full-sib families. Biomass and Bioenergy.

Hauck M, Zimmermann J, Jacob M, Dulamsuren Ch, Bade C, Ahrends B, Leuschner C (2012) Rapid recovery of stem increment in Norway spruce at reduced SO_2 levels in the Harz Mountains, Germany. Environmental Pollution 164: 132-141.

Köcher P, Horna V, Leuschner C (2012) Environmental control of daily stem growth patterns in five temperate broad-leaved tree species. Tree Physiology 32: 1021-1032.

Müller, A, Horna, V, Zhang, C, Leuschner, C (2012) Different growth strategies determine the carbon gain and productivity of aspen collectives to be used in short-rotation plantations. Biomass and Bioenergy 46: 242-250.

Dulamsuren Ch, Hauck M, Leuschner HH, Leuschner C (2011) Climate response of tree-ring width in *Larix sibirica* growing in the drought-stressed forest-steppe ecotone of northern Mongolia. Annals of Forest Science 68: 275-282.

Fender A-C, Mantilla-Contreras J, Leuschner C (2011) Multiple environmental control of leaf area and its significance for the productivity in beech saplings. Trees 25: 847-857.

Kleemann F, von Fragstein u. Niemsdorff M, Vornam B, Müller A, Leuschner C, Holzschuh A, Tscharntke T, Finkeldey R, Polle A (2011) Relating ecologically important tree traits to associated organisms in full-sib aspen families. European Journal of Forest Research 130: 707-716.

Mölder I, Leuschner C, Leuschner HH (2011) $\delta^{13}C$ signature of tree rings and radial increment of *Fagus sylvatica* trees as dependent on tree neighborhood and climate. Trees 25: 215-229.

Müller A, Leuschner C, Horna V, Zhang C (2011) Photosynthetic characteristics and growth performance of closely related aspen taxa: on the systematic relatedness of the Eurasian *Populus tremula* and the North American *P. tremuloides*. Flora 207: 87-95.

Jacob M, Leuschner C, Thomas FM (2010) Productivity of temperate broad-leaved forest stands differing in tree species diversity. Annals of Forest Science 67 (503): 1-9.

Meier IC, Leuschner C (2010) Variation of soil and biomass carbon pools in beech forests across a precipitation gradient. Global Change Biology 16: 1035-1045.

Dulamsuren Ch, Hauck M, Khishigjargal M, Leuschner HH, Leuschner C (2010) Diverging climate trends in Mongolian taiga forests influence growth and regeneration of *Larix sibirica*. Oecologia 163: 1091-1102.

Dulamsuren Ch, Hauck M, Leuschner HH, Leuschner C (2010) Gypsy moth-induced growth decline of *Larix sibirica* in a forest-steppe ecotone. Dendrochronologia 28: 207-213.

Hauck M, Dulamsuren Ch, Heimes C (2008) Effects of a gypsy moth invasion on the performance of *Larix sibirica* in a forest-steppe ecotone of northern Mongolia. Environmental and Experimental Botany 62: 351-356.

Leuschner C, Voss S, Foetzki A, Clases Y (2006) Variation in leaf area index and stand leaf mass of European beech (*Fagus sylvatica* L.) across gradients of soil acidity and precipitation. Plant Ecology 186: 247-258.

Thomas FM, Blank R, Hartmann G (2002) Abiotic and biotic factors and their interactions as causes of oak decline in Central Europe. Forest Pathology 32: 277-307.

(2) Carbon relations of trees and forests (tropical)

Wittich B, Horna V, Homeier J, Leuschner C (2012) Altitudinal change in the photosynthetic capacity of tropical trees - a case study from Ecuador and a pantropical literature analysis. Ecosystems 15: 958-973.

Moser G, Leuschner C, Hertel D, Graefe S, Soethe N, Iost S (2011) Elevation effects on the carbon budget of tropical mountain forests (S Ecuador): The role of the belowground compartment. Global Change Biology 17: 2211-2226.

Culmsee H, Leuschner Ch, Moser G, Pitopang R (2010) Forest aboveground biomass along an elevational transect in Sulawesi, Indonesia, and the role of Fagaceae in tropical montane rain forests. Journal of Biogeography 37: 960-974.

Homeier J, Englert F, Leuschner C, Weigelt P, Unger M. (2010) Factors controlling the abundance of lianas along an altitudinal transect of tropical forests in Ecuador. Forest Ecology and Management 259: 1399-1405.

Zach A, Horna V, Leuschner C (2010) Patterns of wood carbon dioxide efflux across an 2,000-m elevation transect in an Andean moist forest. Oecologia 162: 127-137.

Zach A, Horna V, Leuschner C (2010). Diverging temperature response of tree stem CO_2 release under dry and wet season conditions in a tropical montane moist forest. Trees 24: 285-296.

Hertel D, Moser G, Culmsee H, Erasmi S, Horna V, Schuldt B, Leuschner C (2009) Below- and aboveground biomass and net primary production in a paleotropical natural forest (Sulawesi, Indonesia) as compared to neotropical forests. Forest Ecology and Management 258: 1904-1912.

Köhler L, Hölscher D, Leuschner C (2008) High litterfall in old-growth and secondary upper montane forest of Costa Rica. Plant Ecology 199: 163-173.

Zach A, Horna V, Leuschner C (2008) Elevational change in woody tissue CO_2 efflux in a tropical mountain rain forest in southern Ecuador. Tree Physiology 28: 67-74.

Moser G, Hertel D, Leuschner C (2007) Altitudinal change in LAI and stand leaf biomass in tropical montane forests: a transect study in Ecuador and a pan-tropical meta-analysis. Ecosystems 10: 924-935.

Leuschner C, Moser G, Bertsch C, Röderstein M, Hertel D (2007) Large elevational increase in tree root/shoot ratio in tropical mountain forests of Ecuador. Basic and Applied Ecology 8, 219-230.

Leuschner C, Bohman K, Keßler P, Pitopang R (2006) Detecting tree functional types: influence of sampling strategy on the distinction between tropical primary and secondary forest species. Ecotropica 12: 151-160.

Hölscher D, Leuschner C, Bohman K, Hagemeier M, Juhrbandt J, Tjitrosemito S (2005) Leaf gas exchange of trees in old-growth and young secondary forest stands of Central Sulawesi, Indonesia. Trees 19: 628-637.

Röderstein M, Hertel D, Leuschner C (2005) Above- and below-ground litter production in three tropical montane forests in southern Ecuador. Journal of Tropical Ecology 21: 483-492.

Hölscher D, Leuschner C, Bohman K, Juhrbandt J, Tjitrosemito S (2004) Photosynthetic characteristics in relation to leaf traits in eight co-existing pioneer tree species in Central Sulawesi, Indonesia. Journal of Tropical Ecology 19: 157-164.

Juhrbandt J, Leuschner C, Hölscher D (2004) The relationship between maximal stomatal conductance and leaf traits in eight Southeast Asian pioneer tree species. Forest Ecology and Management 202: 245-256.

(3) Tree water relations and forest hydrology (temperate and boreal)

Gebauer T, Horna V, Leuschner C (2012) Canopy transpiration of pure and mixed forest stands with variable abundance of European beech. Journal of Hydrology 442-443: 2-14.

Köcher P, Horna V, Beckmeyer I, Leuschner C (2012) Hydraulic properties and embolism in small-diameter roots of five temperate broad-leaved tree species with contrasting drought tolerance. Annals of Forest Science 69: 693-703.

Dulamsuren Ch, Hauck M, Leuschner C (2010) Recent drought stress leads to growth reductions in *Larix sibirica* in the western Khentey, Mongolia. Global Change Biology 16: 3024-3035.

Dulamsuren Ch, Hauck M, Bader M, Osokhjargal D, Oyungerel S, Nyambayar S, Runge M, Leuschner C (2009) Water relations and photosynthetic performance in *Larix sibirica* growing in the forest-steppe ecotone of northern Mongolia. Tree Physiology 29: 99-110.

Dulamsuren Ch, Hauck M, Bader M, Oyungerel S, Osokhjargal D, Nyambayar S, Leuschner C (2009) The different strategies of *Pinus sylvestris* and *Larix sibirica* to deal with summer drought in a northern Mongolian forest-steppe ecotone suggest a future superiority of pine in a warming climate. Canadian Journal of Forest Research 39: 2520-2528.

Dulamsuren Ch, Hauck M, Nyambayar S, Bader M, Osokhjargal D, Oyungerel S, Leuschner C (2009) Performance of Siberian elm (*Ulmus pumila*) on steppe slopes of the northern Mongolian mountain taiga: drought stress and herbivory in mature trees. Environmental and Experimental Botany 66: 18-24.

Gebauer T, Horna V, Leuschner C, Köcher P (2009) Leaf water status and stem xylem flux in relation to soil drought in five temperate broad-leaved tree species with contrasting water use strategies. Annals of Forest Science 66: 101.

Lendzion J, Leuschner C (2009) Temperate forest herbs are adapted to high air humidity - Evidence from growth cabinet and humidity manipulation experiments in the field. Canadian Journal of Forest Research 39: 2332-2342.

Leuschner C, Lendzion J (2009) Air humidity, soil moisture and soil chemical factors as determinants of the herb layer composition in beech forests. Journal of Vegetation Science 20: 288-298.

Rose L, Leuschner C, Köckemann B, Buschmann H (2009) Are marginal beech provenances a source for drought tolerant ecotypes? European Journal of Forest Research 128: 335-343.

Gebauer T, Horna V, Leuschner C (2008) Variability in radial sap flux density patterns and sapwood area among seven co-occurring temperate broad-leaved tree species. Tree Physiology 28:1821-1830.

Lendzion J, Leuschner C (2008) Growth of European beech (*Fagus sylvatica* L) seedlings is limited by elevated atmospheric vapor pressure deficits. Forest Ecology and Management 256: 648-655.

Meier IC, Leuschner C (2008) Leaf size and leaf area index in *Fagus sylvatica* forests: competing effects of precipitation, temperature and nitrogen availability. Ecosystems 11: 655-669.

Srur AM, Villalba R, Villagra PE, Hertel D (2008) Influencias de las variaciones en el clima y en la concentración de CO_2 sobre el crecimiento de *Nothofagus pumilio* en la Patagonia. Revista Chilena de Historia Natural 81: 239-256.

Thomas F, Bartels C, Gieger T (2006) Alterations in vessel size in twigs of *Quercus robur* and *Q. petraea* upon defoliation and consequences for water transport under drought. IAWA Journal 27: 395-407.

Aspelmeier S, Leuschner C (2005) Genotypic variation in drought response of silver birch (*Betula pendula* Roth): leaf and root morphology and allometry. Trees 20: 42-52.

Gieger T, Thomas F (2005) Differential response of two Central-European oak species to single and combined stress factors. Trees 19: 607-618.

Hölscher D, Koch O, Leuschner C (2005) Sap flux of five co-occurring tree species in a temperate broad-leaved forest during seasonal soil drought. Trees 19: 628-637.

Schipka F, Heimann J, Leuschner C (2005) Regional variation in canopy transpiration of Central European beech forests. Oecologia 143: 260-270.

Aspelmeier S, Leuschner C (2004) Genotypic variation in drought response of silver birch (*Betula pendula* Roth): leaf water status and carbon gain. Tree Physiology 24: 517-528.

Gieger T, Thomas FM (2002) Effects of defoliation and drought stress on biomass partitioning and water relations of *Quercus robur* and *Quercus petraea*. Basic and Applied Ecology 3: 171-181.

Leuschner C (2002) Air humidity as an ecological factor for woodland herbs: leaf water status, nutrient uptake, leaf anatomy and productivity of eight species when grown at low or high vpd. Flora 197: 262-274.

Leuschner C, Backes K, Hertel D, Schipka F, Schmitt U, Terborg O, Runge M (2001) Drought responses at leaf, stem and fine root levels of competitive *Fagus sylvatica* L. and *Quercus petraea* (Matt.) Liebl. trees in dry and wet years. Forest Ecology and Management 149: 33-46.

Backes K, Leuschner C (2000) Leaf water relations of competitive *Fagus sylvatica* L. and *Quercus petraea* (Matt.) Liebl. trees during four years differing in soil drought. Canadian Journal of Forest Research 30: 335-346.

Schmull M, Thomas FM (2000) Morphological and physiological reactions of young deciduous trees (*Quercus robur* L., *Q. petraea* [Matt.] Liebl., *Fagus sylvatica* L.) to waterlogging. Plant and Soil 225: 227-242.

Thomas FM (2000) Growth and water relations of four deciduous tree species (*Fagus sylvatica* L., *Quercus petraea* [Matt.] Liebl., *Q. pubescens* Willd., *Sorbus aria* [L.] Cr.) occurring at Central-European tree-line sites on shallow calcareous soils: physiological reactions of seedlings to severe drought. Flora 195: 104-115.

Thomas FM, Gausling T (2000) Morphological and physiological responses of oak seedlings (*Quercus petraea* and *Q. robur*) to moderate drought. Annals of Forest Science 57: 325-333.

(4) Tree water relations and forest hydrology (tropical)

Schuldt B, Brock N, Leuschner C, Brix S, Horna V (2013) Changes in wood density, wood anatomy and hydraulic properties of the xylem along the root-to-shoot flow path in tropical rainforest trees. Tree Physiology 33: 161-174.

Horna V, Schuldt B, Brix S, Leuschner C (2011) Environment and tree size controlling stem sap flow in a perhumid tropical forest of Central Sulawesi, Indonesia. Annals of Forest Science 68: 1027-1038.

Schuldt B, Leuschner C, Horna V, Moser G, Köhler M, Barus H (2011) Change in hydraulic properties and leaf traits in a tall rainforest tree subjected to long-term throughfall exclusion in the perhumid tropics. Biogeosciences 8: 2179-2194.

Schwendenmann L., Veldkamp E, Moser G, Hölscher D, Köhler M, Clough Y, Anas I, Djajakirana G, Erasmi S, Hertel D, Leitner D, Leuschner C, Michalzik B, Propastin P, Tjoa A, Tscharntke T, van Straaten O (2010) Effects of an experimental drought on the functioning of a cacao agroforestry system, Sulawesi, Indonesia. Global Change Biology 16: 1515-1530.

Zach, A., Schuldt B, Brix S, Horna V, Culmsee H, Leuschner C (2010) Vessel diameter and xylem hydraulic conductivity increase with height in tropical rainforest trees in Sulawesi, Indonesia. Flora 205: 506-512.

Dietz J, Hölscher D, Leuschner C, Hendrayanto (2007) Rainfall partitioning in relation to forest structure in differently managed montane forest stands in Central Sulawesi, Indonesia. Forest Ecology and Management 237: 170-178.

Dietz J, Leuschner C, Hölscher D, Kreilein H (2007) Vertical patterns and duration of surface wetness in an old-growth tropical montane rainforest, Indonesia. Flora 202: 111-117.

Köhler L, Tobón C, Frumau KFA, Bruijnzeel LA (2007) Biomass and water storage dynamics of epiphytes in old-growth and secondary montane cloud forest stands in Costa Rica. Plant Ecology 193: 171-184.

Hölscher D, Köhler L, Van Dijk AIJM, Bruijnzeel LA (2004) The importance of epiphytes to total rainfall interception by a tropical montane rain forest in Costa Rica. Journal of Hydrology 292: 308-322.

(5) Nutrient relations of trees and forests (temperate and boreal)

Jacob M, Viedenz K, Polle A, Thomas FM (2010). Leaf litter decomposition in temperate deciduous forest stands with a decreasing fraction of beech (*Fagus sylvatica*). Oecologia 164:1083–1094

Guckland A, Jacob M, Flessa H, Thomas FM, Leuschner C (2009) Acidity, nutrient stocks and organic-matter content in soils of a temperate deciduous forest with different abundance of European beech (*Fagus sylvatica* L.). Journal of Plant Nutrition and Soil Science 172: 500-511.

Jacob M, Weland N, Leuschner C, Schaefer M, Thomas FM (2009) Nutrient release from decomposing leaf litter of temperate deciduous forest trees along a gradient of increasing tree species diversity. Soil Biology and Biochemistry 41: 2122-2130

Köckemann B, Buschmann H, Leuschner C (2009) The relationship between abundance, range size and niche breadth in Central European tree species. Journal of Biogeography 36: 854-864.

Leuschner C, Meier IC, Hertel D (2006) On the niche breadth of *Fagus sylvatica*: soil nutrient status in 50 Central European beech stands on a broad range of bedrock types. Annals of Forest Science 63: 355-368.

Meier IC, Leuschner C, Hertel D (2005) Nutrient return with leaf litter fall in *Fagus sylvatica* forests across a soil fertility gradient. Plant Ecology 177: 99-112.

Hölscher D, Hertel D, Koenies H (2002) Soil nutrient supply and biomass production in a mixed forest on a skeleton-rich soil and an adjacent beech forest. Journal of Plant Nutrition and Soil Science 165, 668-674.

Hölscher D, Schade E, Leuschner C (2001) Effects of coppicing in temperate deciduous forests on ecosystem nutrient pools and soil fertility. Basic and Applied Ecology 2: 155-164.

Thomas FM, Hilker C (2000) Nitrate reduction in leaves and roots of young pedunculate oaks (Quercus robur) growing on different nitrate concentrations. Environmental and Experimental Botany 43: 19-32.

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