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Short communication

# Interesting and new street tree species for European cities

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**Abstract**
Effects of climate change lead to decreasing vitality and increase mortality risk for many native tree species growing under harsh environmental conditions in towns and cities. Taking into account the risks of invasiveness, practical management and scientific experience alternative species and rising floristic biodiversity may help to reduce vulnerability of urban green space.

Regardless of the emotional debate considering foreign species, the potential of urban street tree species originating from China may be considered for European urban places in particular in regions with expected drier and hotter conditions. Preselection for trees with potential high suitability for urban sites in Central Europe was done by winter hardiness zone, native range of low average precipitation sums, tree height, and sensitivity to specific urban site conditions by literature. Species meeting the restrictions were evaluated by their vitality on 70 urban road sites. This final selection of 40 commonly used Chinese tree species took as its starting point observations and local experiences of three research expeditions in September 2010, 2012, and 2015 concentrating on the metropole of Beijing. The results of these research expeditions confirm the potential high suitability for the selected tree species. For the considered species practical and scientific knowledge has to be researched for Central Europe.

**Keywords**
Species selection; urban forestry; drought

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# 1. Introduction

For a successful establishment of street trees in urban areas a wide range of diverse ecological, climatic, site-specific, physiological, and aesthetic criteria has to be considered (Vogt et al., 2017). This challenging task to find appropriate tree species well adapted to the local growing conditions becomes even more complex under changing environmental conditions. East Asia is a hotspot of potential suitable street tree species for Central Europe because of regions with comparable climatic conditions in relation to winter hardiness zones, to precipitation ranges and frequencies, or even already below as expected for the future climate in Central Europe (Fang et al., 2011; IPCC 2014; Parker et al., 2013; Rogelj et al., 2012; Roloff et al., 2009; Wohlgemuth, 2015). In contrast to the North American regions with a long tradition of research, experience, and exchange of tree species with Europe, access to the rich Chinese floristic biodiversity was restricted over long periods of history well until the 19th Century. This is one of the reasons for the lack of practical and scientific knowledge about many Chinese woody plants in Europe.

Besides the demand for robustness as high tolerances to deicing salts, soil compaction, soil sealing, and limited rooting space (Korn, 2016), urban species have to cope with drought stress, longer and drier periods with water shortage, and extremely hot weather conditions during summer time with more frequent temperature extremes up to 100 °C (Roloff, 2016; Sæbø et al., 2005). Weather conditions in the vegetation periods of 2003, 2014 and 2015 resemble the current conditions of East China and can be considered as examples of the future average climatic conditions in Central Europe (Jacob et al., 2014; Orth et al., 2016).

For East Asia, Chinese urban areas with fast-growing megacities are of special interest for urban ecology and research targeting urban green spaces since different climatic zones from boreal to sub-tropic are included (Zhang et al. 2010). For China a large regional expertise is available. Chinese city planners and landscape architects have made notable efforts to establish green spaces within urban structures. There is a tremendous interest of tree species and their potential for urban areas in China. Over past seven years several scientific expeditions, workshops at the Shanghai Tongji University and discussions with decision makers and members of universities, botanical gardens, offices of urban green spaces, managers and practitioners of urban green spaces were realized by aiming to identify a potential pool of suitable tree species.

Introduction of new alien species may carry ecological risks such as the displacement of native species due to their invasive potential (Kumschick et al., 2015; Meyer, 2016; Parker et al., 2013; Rejmánek et al., 2013; Richardson and Rejmánek, 2011). However, in times of changing climatic conditions and increasing demands of city residents on urban green spaces, the planting of foreign tree species along with broad experiences can be helpful to fulfil the requested benefits and ecosystems services of trees (Zhang, 2012). In Central Europe many alien tree species are well adapted to the harsh urban site conditions due to the lack of antagonists or diseases as well as their wider physiological amplitude and tolerance to respective local bio-climatic conditions (Meyer, 2016; Roloff et al., 2009). Paved areas and impervious surfaces can be found at many places in urban regions. Soil infiltration is hampered, and re-radiation and surface run-off are promoted under these conditions. In comparative studies of leaf-gas exchange alien species as Platanus x hispanica and Quercus rubra show higher physiological performance under these site conditions (Gillner et al., 2015). In Central Europe the alien tree species *Ginkgo biloba* L., *Styphnolobium japonicum* (L.) Schott, *Fraxinus angustifolia* Vahl, and *Tilia tomentosa* Moench might be cited as examples for well adapted species also under the harsh urban site conditions (Figure 1).

Aim of the study was to identify some commonly used road-side tree species in Beijing suitable for their use in Central European urban places. The intention was to provide a preselection of tree species matching the requirements and restrictions of Central Europe urban areas.

This background makes a compelling case for the following statement: Street trees of Beijing showing a high vitality may also be appropriate trees in Central European towns and cities.

# 2. Methods and material

## 2.1 Study site

Beijing, the capital of People's Republic of China with more than 20 million inhabitants makes a unique example for using trees in different urban structures and places. Beijing has climatic conditions as expected for the future climate in Central Europe with comparable winter temperatures, dry and warm spring conditions leading to an early start of sprout, leaf folding and shoot growth (Zhang et al., 2013). This "April summer" with restricted water supply is characteristic of a fast change from winter to summer conditions without a longer spring season. Average summer conditions are extreme with long and intensive dry and hot periods with temperatures around 40 °C, only interrupted by heavy rains. In addition pollution due to smog and dust regularly exceeds the statutory thresholds causing additional stress for tree physiology.

**Figure 1.** Ginkgo tree-avenue (*Ginkgo biloba*) at Beijing

The intensive use of de-icing salt significantly increases the drought stress level for street trees.

Tree species were evaluated on 70 urban road-side sites with restricted rooting space and sealing or pavement coverage of a minimum of 50 % in crown area. For each species three different road-sites were considered.

## 2.2 Tree species identification by literature

The starting point of our study was the identification of two main criteria for urban tree species: drought tolerances and winter hardiness via a theoretical approach by a literature review (Roloff et al., 2009). In a further step plant specific traits, environmental conditions and site requirements as well as potential risks of more than 1,000 Chinese tree species were pooled and evaluated (Fang et al., 2011). In a preliminary approach the list of potential trees was filtered by data obtained from Chinese publications (Zhang, 2012; Zhang et al., 2010, 2013). Detailed climatic data on regional and local scales of species areas of origin were taken from Atlas of Woody Plants in China (Fang et al., 2011). Two criteria were chosen for this preselection:

- a minimum average annual precipitation of $<$ 400 mm and
- a minimum winter hardiness zone of 7a (at least ca. -15 °C) (Heinze and Schreiber, 1984)

147 species matched the given climatic restrictions and were again selected according to the following criteria and restrictions (Vogt et al., 2017):

- tree-specific habitus, single-stem tree, straight upright stem shape
- height of adult trees $>$ 8 m
- low risk of invasiveness
- high tolerances to: late frost, alkaline soil conditions, soil sealing/compaction, waterlogging, drought/heat stress, de-icing salt.

After this a list of 98 species remained which was evaluated by Chinese partners according to their use as road-side trees resulting in an exclusion of 23 species again. The criteria were a minimum tree stem length of 4 meters without branches, minimum heights of adult trees of 10 meters.

On the basis of this species pool our data was completed

**Table 1.** Street Trees from China with good to very good prospects of use in Central Europe cities showing vitality classes 0 and 1. Rows marked in grey indicate most frequent tree species in Beijing

| Tree species | WHZ °C Atlas of WP China[1] | WHZ °C Flora Trees[2] | Min. ann. precip. mm[3] | Region China[4] | Available in European nurseries?[5] | Tree height range m | Risks / sensitivities according to Citree (2015) | | | | | remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Late frost | pH >7 | Soil compaction | Water logging | Deicing salt | |
| *Acer truncatum* | -24 | -26 | 305 | CN | ? | 10–12 | | | | | | |
| *Ailanthus altissima* | -16 | -20 | 200 | SCN | XC | 23–25 | | | | | | Notice invasiveness, root suckers |
| *Carpinus cordata* | -20 | -26 | 370 | C | ? | 12–15 | | X | | | X | |
| *Carpinus. turczaninowii* | -18 | -29 | 340 | C | X | 9–12 | | | | | X | |
| *Celtis bungeana* | -20 | -20 | 130 | SCN | ? | 10–15 | | | | | | |
| *Celtis sinensis* | -14 | -23 | 370 | SC | X | 15–20 | | | | | | |
| *Cornus macrophylla* | -12 | -20 | 340 | SC | ? | 10–12 | | | | | X | |
| *Cornus walteri* | -14 | -20 | 370 | C | ? | 9–12 | | | | | | |
| *Eucommia ulmoides* | -16 | -20 | 450 | SC | X | 15–20 | | | | | | |
| *Fraxinus chinensis* | -20 | -23 | 200 | S(C)N | ? | 15–25 | | | | | | Resistance to ash dieback |
| *Ginkgo biloba* | -15 | -26 | 430 | SC | XCCC | 25–30 | | | | X | | |
| *Kalopanax septemlobus* | -20 | -26 | 430 | SC | ? | | | | | | X | |
| *Koelreuteria paniculata* | -16 | -18 | 350 | SCN | XCCC | 10–15 | X | | X | X | | |
| *Maackia amurensis* | -25 | -26 | 290 | N | C | 12–15 | | | | X | | |
| *Malus baccata* | -30 | -40 | 190 | CN | C | 9–12 | | | | | X | |
| *Metasequoia glyptostr.* | -12 | -20 | 430 | S | XCC | 25–30 | | | X | | X | |
| *Morus alba* | -23 | -26 | 380 | SCN | XCCC | 12–15 | X | | X | X | | |
| *Pistacia chinensis* | -14 | -15 | 370 | SC | ? | 10–15 | X | | | X | | |
| *Platycarya strobilacea* | -15 | -20 | 370 | SC | ? | 9–12 | | | | X | | |
| *Populus davidiana* | -30 | – | 60 | CN | ? | 20–25 | | | | X | | Root suckers |
| *Populus laurifolia* | -21 | -29 | 250 | NW | ? | 12–15 | | | | | | |
| *Populus tomentosa* | -12 | – | 225 | C | ? | 22–30 | | | | | | |
| *Pterocarya stenoptera* | -15 | -18 | 370 | SC | XC | 15–25 | X | | | | X | |
| *Pyrus betulifolia* | -15 | -26 | 320 | C | ? | 8–10 | | | | | X | |
| *Pyrus ussuriensis* | -26 | -23 | 290 | CN | ? | 12–15 | | | | | X | |
| *Quercus acutissima* | -15 | -15 | 400 | SC | X | 12–15 | | X | | | | |
| *Quercus mongolica* | -30 | -26 | 400 | CN | ? | 20–30 | | | X | | | |
| *Sorbus alnifolia* | -20 | -23 | 350 | SCN | X | 12–20 | | | | X | | |
| *Styphnolobium japonicum* | -25 | -20 | 20 | SC | XCCC | 17–20 | | | X | X | | |
| *Tetracentron sinense* | -12 | -15 | 370 | S | ? | | | | | X | | |
| *Tetradium daniellii* | -12 | -18 | 190 | C | X | 13–20 | X | | X | X | | |
| *Tilia amurensis* | -30 | -29 | 370 | N | X | 22–30 | | | | X | | |
| *Tilia mandshurica* | -28 | -29 | 380 | (C)N | X | 15–20 | X | | | | | |
| *Tilia mongolica* | -21 | -26 | 260 | CN | X | 8–15 | | | | | X | |
| *Toona sinesis* | -12 | -20 | 390 | S | XC | 12–15 | | | | | X | Root suckers |
| *Ulmus laciniata* | -24 | -29 | 200 | N | ? | 9–12 | | | | | | |
| *Ulmus macrocarpa* | -30 | -29 | 195 | CN | ? | 12–20 | | | | | | |
| *Ulmus parvifolia* | -14 | -20 | 370 | SC | XCC | 20–25 | | | | X | X | Resistance to Dutch elm disease |
| *Ulmus pumila* | -30 | -35 | 20 | CN | XC | 15–20 | | | | X | | Resistance to Dutch elm disease |
| *Ziziphus jujuba* | -21 | -12 | 20 | SCN | X | 8–10 | | | | X | | |

[1] Winter hardiness zone acc. to Fang et al. (2011): annual minimum temperature of the coldest district in the native area of the species
[2] Winter hardiness zone acc. to Roloff and Bärtels (2014)
[3] Minimum annual precipitation of the driest district in the native area of the species
[4] Native area S: south, M: central, N: north, W: west China
[5] Check of availability in nursery lists of 10 large German and Dutch nurseries (X: available, C: cultivars available, ?: only with difficulties available)

by literature reviews including the practical and scientific experiences and knowledge, the advantages and disadvantages of the species in European arboreta, parks, and urban green spaces. Information about site requirements, tolerances, sensitivities, risks and dangers were collected via citree database (Vogt et al., 2017).

## 2.3 Tree species identification by field studies

Year of planting for the measured trees goes back at least 25 years. Five randomly selected trees per site (road-side) for each species were used for the vitality assessment according to Roloff (2016). Over lifetime branching structure of tree's crown modifies by changes in annual shoot lengths and enables the differentiation into four growth stages: exploration, degeneration, stagnation, and retraction Roloff (2016). For each of these growth stages a vitality class can be assigned. Species were considered as suitable for highly sealed urban sites if mean of the five trees per site on five road sites showed "vitality class 0" or "vitality class 1" and species with means of vitality classes of 2 and 3 were excluded. For the vitality class 0 (exploration growth stage) crown structure is closed and domed, mainly formed by long-shoots Roloff (2016). Dominant treetop branches surrounded by dense leaves shaped as longish structures are characteristic of vitality class 1 (degen-

**Table 2.** Most frequent street tree species in Beijing in declining order (source: city administration of Beijing)

| Number | Scientific name | Family | Common name |
|---|---|---|---|
| 1 | *Styphnolobium japonicum* (L.) Schott | Fabaceae | Pagoda-tree |
| 2 | *Fraxinus pennsylvanica* Marshall | Oleaceae | Green ash |
| 3 | *Ginkgo biloba* L. | Ginkgoaceae | Ginkgo |
| 4 | *Populus tomentosa* Carr. | Salicaceae | Chinese white poplar |
| 5 | *Ailanthus altissima* (Mill.) Swingle | Simaroubaceae | Chinese tree-of-heaven |
| 6 | *Koelreuteria paniculata* Laxm. | Sapindaceae | Goldenrain-tree |
| 7 | *Platanus x hispanica* Münchh. (*P. x acerifolia* Ait.) | Platanaceae | London plane |
| 8 | *Salix x sepulcralis* Simonkai | Salicaceae | Golden weeping willow |
| 9 | *Pinus tabuliformis* Carr. | Pinaceae | Southern Chinese pine |
| 10 | *Paulownia tomentosa* (Thunb. ex Murray) Steud. | Paulowniaceae | Foxglove-tree |

eration growth stage) Roloff (2016).

## 3. Results and Discussion

Trees and urban green spaces should deliver ecological as well as social services. This assumes that trees are well adapted under the given site conditions (Vogt et al., 2017). The list of 40 potentially suitable tree species for urban places is given in Table 1. All listed tree species have minimum tree heights up to 10 m and showed mean vitality class of 1 or 0 at the five sites in Beijing. Looking at the species sensitivities, soil compaction may be problematic for only six out of 40 species. For 15 out of 40 species waterlogging may cause problems in the root zone. Except for six species, values of winter hardiness according to Fang et al. (2011) are lower compared to Roloff and Bärtels (2014). Low winter temperatures over longer periods may cause problems for *Pistacia chinensis*, *Quercus acutissima*, *Tetracentron sinense*, *Tetradium daniellii* hup., and *Toona sinensis* since they show highest values in both references. Consequently, these species should not be planted in winter hardiness zones lower to 7b (Heinze and Schreiber, 1984). According to Fang et al. (2011) *Ginkgo biloba* and *Metasequoia glytostroboides* should have problems if winter temperatures drop below -15 °C, -12 °C respectively. However, in the city of Dresden, Germany both species have proofed their excellent winter hardiness in several winters with temperatures lower than -20 °C since their plantation in the 1960ies (DWD, 2017).

Additionally the use of deicing salt and the late-frost risk may stunt the suitability for some species along road sides in temperate climate zone and in areas with a high late-frost risk respectively.

*Ailanthus altissima*, *Ginkgo biloba*, *Koelreuteria paniculata*, *Paulownia tomentosa*, and *Styphnolobium japonicum* belong also to the ten most frequent street tree species of Beijing. This fact clearly underlines their suitability as street trees planted along inner-city road-sides in temperate climate zones. The ten most frequent street tree species in Beijing in declining order (survey 2015, data of Beijing Institute of Landscape Architecture) are shown in Table 2.

Long time monitoring in Beijing for a wide range of different taxa helped to conduct an evaluation of species. For example, the plantations of species belonging to the genera of *Betula* (except for *Betula platyphylla* Sukaczev) have been a failure. This species showed vitality class 3 or even high mortality rates up to 10 years after plantation and in particular after exceptional hot and dry summers high mortality rates have been observed in Beijing.

**Table 3.** 10 most interesting street tree species for European cities, frequently used in Beijing (in alphabetical order)

| **Scientific name** | **Common name** |
|---|---|
| *Acer truncatum* Bunge | Shandong maple |
| *Celtis bungeana* Blume | Bunge's hackberry |
| *Eucommia ulmoides* Oliv. | Gutta-percha-tree |
| *Fraxinus chinensis* Roxb. | Chinese ash |
| *Pistacia chinensis* Bunge | Chinese pistache |
| *Platycarya strobilacea* Siebold & Zucc. | Black dyetree |
| *Populus tomentosa* Carr. | Chinese white poplar |
| *Quercus mongolica* Fisch. ex Ledeb. | Mongolian oak |
| *Tilia mandshurica* Rupr.et Maxim. | Manchurian lime |
| *Ulmus pumila* L. (U. mandschurica Nakai) | Siberian elm |
| *Ziziphus jujube* Mill. | Chinese date |

The problem strand relates to the unclear distribution behaviour of alien species has to be taken into account in testing non-native tree species. For Austria, an exponential spread is documented for *Paulownia tomentosa* since 1970, and the species is predicted to spread beyond disturbed urban areas under rising temperatures (Essl, 2007). For the Chinese Tree of Heaven (*Ailanthus altissima*) an even more serious invasion is documented for temperate and subtropical regions (Kowarik and Säumel, 2007). Besides the invasion risk, the unknown allergenic risk of alien species especially in highly populated areas has to be considered (Ballero et al., 2003). However, besides possible negative impacts alien tree species were introduced because of their ornamental use, benefits for human health or lower sensitivity to air pollution or resistance to herbivory native insects (Sladonja et al., 2015). Consequently, planting experiences and a carefully scientific evaluation is necessary for unknown non-native species. However, only little experiences are available for Central Europe for the following species. These trees should be tested for plantation at dry and hot places with unfavourable growing conditions involving a little available below-ground space, a high risk of soil compaction, and a high pollution due to dust and ozone under scientific research and monitoring.

Besides some well-known, well-established species at street tree sites as there are Ginkgo, Pagoda-tree, and Goldenrain-tree, some less known species in Europe were frequently found in Beijing (Table 3).

An important issue in identifying suitable trees is not only the species selection itself, it is also important to look at the subspecies, provenances, varieties, cultivars for every species. Species show a wide area of natural distribution, a couple of diverging characteristics in habitus, sensitivities and tolerances. *Ailanthus altissima* for example can frequently be found in Chinese towns and cities with remarkable straight upright stem shapes and with only few root suckers which is in strong contrast to its appearance in Europe. This may be a question of provenance with a wide distribution of unsuitable material in Europe implying a strong examination of the provenance.

## 4. Conclusions

Surveys and literature reviews, local tacit knowledge, and interviews with local research and practice experts were the basis for the establishing of a list with 40 frequent street tree species used in Chines cities. Among these species a couple of already widely known species as Ginkgo, Pagoda-tree, and Goldenrain-tree were identified but also many less known and rarely used species were found with high potential for Central European countries. Based on the 40 species a list of 10 favourite tree species was selected. This final species list should be used for further tests and research studies. The potential of invasiveness of the species is low in Central European cities, except for the tree-of-heaven. This is an interesting starting point for a wider perspective in using foreign introduced tree species for urban purposes, since for many of the preselected species only rare information is available.

Preselection was made by a literature review comprising the literature used for citree database (Gillner et al., 2016). This theoretical approach can, however, only be a starting point of establishing a monitoring accompanied by research involving for example physiological, growth and morphological parameters of the species. National action groups, for example GALK in Germany (GALK 2016), will be involved in street tree tests since these specialists have extensive knowledge in this field and capacities and facilities for long-term tests.

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## References

Ballero, M., Ariu, A., Falagiani, P., and Piu, G. (2003). Allergy to *Ailanthus altissima* (tree of heaven) pollen. *Allergy*, 58(6):532–533, doi:10.1034/j.1398-9995.2003.00172.x.

DWD (Deutscher Wetterdienst) (2017). Climate Data Center (CDC): Historical daily observations (temperatures, pressure, precipitation) for Germany. Version v005. Online URL: https://www.dwd.de/DE/klimaumwelt/cdc/cdc_node.html (as of November 11, 2017).

Essl, F. (2007). From ornamental to detrimental? The incipient invasion of central europe by *Paulownia tomentosa*: Probíhající invaze *Paulownia tomentosa* ve střední Evropě. *Preslia*, (79):377–389.

Fang, J., Wang, Z., and Tang, Z. (2011). *Atlas of woody plants in China: Distribution and climate*. Higher Education Press and Springer, Beijing and Heidelberg and New York.

GALK (Deutsche Gartenamtsleiterkonferenz) (2016). Street Tree List. Website. Retrieved October 2, 2016, from www.galk.de.

Gillner, S., Hofmann, M., Tharang, A., and Vogt, J. (2016). Criteria for species selection: Development of a database for urban trees. In Roloff, A. and Auch, E., editors, *Urban tree management*, pages 196–210. John Wiley & Sons Blackwell, Oxford and Chichester and Hoboken, NJ.

Gillner, S., Korn, S., and Roloff, A. (2015). Leaf-gas exchange of five tree species at urban street sites. *Arboriculture & Urban Forestry*, 41(3):113–124.

Heinze, W. and Schreiber, D. (1984). Eine neue Kartierung der Winterhärtezonen für Gehölze in Europa. In *Mitteilungen der DDG*, volume 75, pages 11–56.

IPCC (Intergovernmental Panel on Climate Change), editor (2014). *Climate change 2014: Mitigation of climate change: Working Group III contribution to the fifth assessment report of the intergovernmental panel on climate change*. Cambridge University Press, Cambridge.

Jacob, D., Petersen, J., Eggert, B., Alias, A., Christensen, O. B., Bouwer, L. M., Braun, A., Colette, A., Déqué, M., Georgievski, G., Georgopoulou, E., Gobiet, A., Menut, L., Nikulin, G., Haensler, A., Hempelmann, N., Jones, C., Keuler, K., Kovats, S., Kröner, N., Kotlarski, S., Kriegsmann, A., Martin, E., van Meijgaard, E., Moseley, C., Pfeifer, S., Preuschmann, S., Radermacher, C., Radtke, K., Rechid, D., Rounsevell, M., Samuelsson, P., Somot, S., Soussana, J.-F., Teichmann, C., Valentini, R., Vautard, R., Weber, B., and Yiou, P. (2014). EURO-CORDEX: new high-resolution climate change projections for European impact research. *Regional Environmental Change*, 14(2):563–578, doi:10.1007/s10113-013-0499-2.

Korn, S. (2016). Urban tree roots: Problems and peculiarities. In Roloff, A. and Auch, E., editors, *Urban tree management*, pages 36–46. John Wiley & Sons Blackwell, Oxford and Chichester and Hoboken, NJ.

Kowarik, I. and Säumel, I. (2007). Biological flora of central europe: *Ailanthus altissima* (Mill.) Swingle. *Perspectives in Plant Ecology, Evolution and Systematics*, 8(4):207–237, doi:10.1016/j.ppees.2007.03.002.

Kumschick, S., Gaertner, M., Vilà, M., Essl, F., Jeschke, J. M., Pyšek, P., Ricciardi, A., Bacher, S., Blackburn, T. M., Dick, J. T., Evans, T., Hulme, P. E., Kühn, I., Mrugała, A., Pergl, J., Rabitsch, W., Richardson, D. M., Sendek, A., and Winter, M. (2015). Ecological impacts of alien species: Quantification, scope, caveats, and recommendations. *BioScience*, 65(1):55–63, doi:10.1093/biosci/biu193.

Meyer, M. (2016). Invasive species, indigenous vs. alien dendroflora. In Roloff, A. and Auch, E., editors, *Urban tree management*, pages 185–195. John Wiley & Sons Blackwell, Oxford and Chichester and Hoboken, NJ.

Orth, R., Zscheischler, J., and Seneviratne, S. I. (2016). Record dry summer in 2015 challenges precipitation projections in Central Europe. *Scientific Reports*, 6:28334, doi:10.1038/srep28334.

Parker, J. D., Torchin, M. E., Hufbauer, R. A., Lemoine, N. P., Alba, C., Blumenthal, D. M., Bossdorf, O., Byers, J. E., Dunn, A. M., Heckman, R. W., Hejda, M., Jarosík, V., Kanarek, A. R., Martin, L. B., Perkins, S. E., Pysek, P., Schierenbeck, K., Schlöder, C., van Klinken, R., Vaughn, K. J., Williams, W., and Wolfe, L. M. (2013). Do invasive species perform better in their new ranges? *Ecology*, 94(5):985–994.

Rejmánek, M., Richardson, D. M., and Pyšek, P. (2013). Plant invasions and invasibility of plant communities. In van der Maarel, E., editor, *Vegetation ecology*, volume 20, pages 387–424. Wiley-Blackwell, Hoboken, NJ.

Richardson, D. M. and Rejmánek, M. (2011). Trees and shrubs as invasive alien species - a global review. *Diversity and Distributions*, 17(5):788–809, doi:10.1111/j.1472-4642.2011.00782.x.

Rogelj, J., Meinshausen, M., and Knutti, R. (2012). Global warming under old and new scenarios using IPCC climate sensitivity range estimates. *Nature Climate Change*, 2(4):248–253, doi:10.1038/nclimate1385.

Roloff, A. (2016). Vitality assessment, tree architecture. In Roloff, A. and Auch, E., editors, *Urban tree management*, pages 82–94. John Wiley & Sons Blackwell, Oxford and Chichester and Hoboken, NJ.

Roloff, A. and Bärtels, A. (2014). *Flora der Gehölze: Bestimmung, Eigenschaften und Verwendung*. Verlag Eugen Ulmer, Stuttgart.

Roloff, A., Korn, S., and Gillner, S. (2009). The climate-species-matrix to select tree species for urban habitats considering climate change. *Urban Forestry & Urban Greening*, 8(4):295–308, doi:10.1016/j.ufug.2009.08.002.

Sæbø, A., Borzan, Ž., Ducatillion, C., Hatzistathis, A., Lagerström, T., Supuka, J., García-Valdecantos, J. L., Rego, F., and van Slycken, J. (2005). The selection of plant materials for street trees, park trees and urban woodland. In Konijnendijk, C., Nilsson, K., Randrup, T., and Schipperijn, J., editors, *Urban Forests and Trees*, pages 257–280. Springer-Verlag Berlin Heidelberg, Berlin, Heidelberg.

Sladonja, B., Sušek, M., and Guillermic, J. (2015). Review on invasive tree of heaven (*Ailanthus altissima* (Mill.) Swingle) conflicting values: Assessment of its ecosystem services and potential biological threat. *Environmental management*, 56(4):1009–1034, doi:10.1007/s00267-015-0546-5.

Vogt, J., Gillner, S., Hofmann, M., Tharang, A., Dettmann, S., Gerstenberg, T., Schmidt, C., Gebauer, H., van de Riet, K., Berger, U., and Roloff, A. (2017). Citree: A database supporting tree selection for urban areas in temperate climate. *Landscape and Urban Planning*, 157:14–25, doi:10.1016/j.landurbplan.2016.06.005.

Wohlgemuth, T. (2015). Climate change and tree responses in Central European forests. *Annals of Forest Science*, 72(3):285–287, doi:10.1007/s13595-015-0474-9.

Zhang, D. (2012). *Planning Principles and Methods of Landscape Plants*. China Architecture and Building Press, Beijing.

Zhang, D., You, X., and Wang, C. (2010). New and Excellent Tree Species Selection in Shanghai's Response to Climate Change. *Chinese Landscape Architecture*, (9):72–77.

Zhang, J., Zhang, D., Cheng, G., Xi, J., and Li, X. (2013). *Ecology and Human Settlement*. China Forestry Publishing House, Beijing.