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Evaluating the ornamental value of the Caucasian flora in Georgia

Bewertung des Zierpflanzenwertes der kaukasischen Flora in Georgien

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Abstract

The flora in the Caucasus Ecoregion is rich in economically important plants. While its value in terms of food crops and medicinal plants has recently been subject to scientific research, the ornamental value of many Caucasian plant species has not yet been fully recognized. In order to assess the ornamental value of the Caucasian flora, vegetation data from two mountainous study regions in Georgia (n = 958 species, mostly grassland vegetation) was compared with the product range of ornamental plants in Germany using an online plant shopping guide. Characterization of the 150 plant species listed in both databases revealed that 121 species are present in central Europe and 117 species are natives or archaeophytes in Germany. Thus, only few species are Caucasian endemics. Furthermore, a list of 79 potential ornamentals endemic to the Caucasus was compiled from the literature. In order to place them in context of the horticultural market, the species characteristics were examined. Following this, a critical discussion of the potentials and risks arising from trade with ornamental plants was carried out with regard to nature conservation, biological invasion control, genetic resource maintenance and socio-economic significance.

Keywords: areal types, Caucasian endemic species, domestication of wild plant species, ecosystem services, Eurasian plant species, floristic status, indicator values, interzonal orobiome, invasive plant species, ornamental horticulture

Erweiterte deutsche Zusammenfassung am Ende des Artikels

1. Introduction

1.1 Ornamental plants and their industry

The cultivation of ornamental plants is a subdiscipline of horticulture, which describes the growing of food crops, medicinal or ornamental plants (USDA NIFA n.d.). Ornamentals are plants not primarily used for nutrition and the production of raw materials, while either the entire plant or parts of it can be used as cut flowers, pot, bedding or park plants (GRUNEWALDT 2010). Even though their use is mostly based on their beauty, ecological func-

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tionality can be an important criterion for cultivation (SCHOLZ 2010). As a result, ornamentals contribute to various ecosystem services. According to the 'Common International Classification of Ecosystem Services' (CICES), ornamental plants reflect a provisioning ecosystem service in the way that biomass is produced for direct use or processing, which 'includes consumptive ornamental uses'. Furthermore, ornamentals provide regulation and maintenance services through mediating mass, liquid and airflows in terms of erosion protection, water cycling, ventilation and more. In addition, they help to maintain the physical, chemical and biological conditions at a location with regard to, among others, soil formation and climate regulation. Indoor plants can contribute to e.g., air quality regulation. Most often, ornamental plants are considered as providing cultural services since the cultivation and keeping of ornamental plants provides experiential, intellectual as well as spiritual interactions with the aesthetics of nature (BRETHOUR et al. 2007, European Environment Agency: CICES-V4–3 Spreadsheet, http://cices.eu/resources/, accessed 2016–11–04).

Corresponding with the importance of ornamental plants regarding human–nature interactions, the ornamental horticulture industry has a large economic significance. Apart from economically strong countries like Germany, many less developed countries attempt to generate economic profit from this industry. In 2015, Germany imported plants summarized under the HS Commodity Code 06 ('Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage') for 2.95 billion USD and exported worth 941 million USD. In contrast, imports in Georgia amounted to approximately 9.65 million USD, while exports made up 757,751 USD (UN Comtrade Database, http://comtrade.un.org/data/, accessed: 2017–02–03). Consequently, the ornamental horticulture market in Georgia currently is much smaller, but a development towards an increasing demand for fresh flowers is noticeable as import values have enlarged during the last decade (EDILASHVILI 2011, UN Comtrade Database). The potential for an expansion of the ornamental horticulture industry has begun to be recognized, but especially the local ornamental flora is still mostly only harvested from the wild and sold at local markets (BEDOSHVILI 2008).

Table 1. Main actors influencing the horticultural industry of ornamentals and their requirements for cultivation (GRUNEWALDT 2010).

Tabelle 1. Den Ziergartenbau prägende Hauptakteure und ihre Anforderungen an die Kultivierung von Zierpflanzen (GRUNEWALDT 2010).

Actors	Requirements
Trade	Homogeneity
	Transportability and storability
	Continuity of supply
	New ornamental plant species
	Price
Producers	Resource-saving production
	High productivity
	High share of high quality plants or plant materials
Legislative	Resistance against diseases and pests
Consumers	New products within existing cultivars
	New ornamental plant species
	Low maintenance effort and long durability
	Adaptation to drought, water scarcity and ozone levels

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Generally, globalized, complicated, dynamic processes characterize the supply chain of ornamental plants nowadays (DE HERTOGH et al. 2012, VAN TUYL et al. 2014). For a plant species to be considered suitable for the ornamental horticulture market, marketability, customer demands, production and trade requirements as well as plant introduction schemes have to be taken into account (SEATON et al. 2014). GRUNEWALDT (2010) identified four main actors influencing the horticultural industry through their demands (Table 1).

Since the standards for plant species cultivation are very high, the ornamental industry uses complex biochemical methods to breed and modify plant cultivars (SEATON et al. 2014). However, plants vary profoundly in their biological characteristics such as life form, life span or leaf habit, and it is not possible to adapt them to any condition. Likewise, the success of commercial or private production of a plant species is determined by certain habitat and cultivation requirements like light, soil or water conditions, the way and time of propagation and planting or the chemical treatment (GANSLMEIER & HENSELER 1985, BRICKELL 2010).

1.2 The Caucasus and Georgia

The 580,000 km^2 large Caucasus Ecoregion is located at the European-Asian boundary and is mainly characterized by two over 1500 km long mountain ranges, the northern Greater Caucasus and the southern Lesser Caucasus (Fig. 1) (NAKHUTSRISHVILI et al. 2009, SOLOMON et al. 2014, CEPF: Caucasus Overview, http://www.cepf.net/resources/hotspots/Europe-and-Central-Asia/Pages/Caucasus.aspx, accessed 2016–10–03). The area has been identified as a biodiversity hotspot, which has an extraordinarily high number of endemic species, while it is significantly threatened by habitat destruction (MYERS et al. 2000, CEPF 2004). Since the Paleolithic Age, the Caucasus has been constantly inhabited and influenced by human activities, hence almost half of the original area has been transformed by human activities (LORDKIPANIDSE 1991, CEPF 2004, NAKHUTSRISHVILI et al. 2009).

Georgia is one out of three countries completely embedded within the Caucasus Ecoregion (Fig. 1). With a size of 69,700 km^2, the country is situated in the west of the South Caucasus region and encompasses parts of the Greater as well as the Lesser Caucasus mountain range. As a result, mountains characterize two-thirds of the country while the rest is represented by intermountain regions in the east and west (NBSAP 2005, SOLOMON et al. 2014). Georgia is very diverse in terms of altitudinal zonation (0–5047 m a.s.l.), mean annual temperatures (-6–15 °C), annual precipitation (200–4500 mm) and soil types, which leads to an exceptional richness and uniqueness in vegetation (SOLOMON et al. 2014). Out of the 4,100 plant species found within the country, 1320 species are Caucasian endemics (GAGNIDZE et al. 2002, SOLOMON et al. 2014).

Like the whole Caucasus, Georgia is influenced by severe social, political, economic and climatic changes (ELIZBARASHVILI et al. 2013). The population's cultural identity is shaped by multiethnicity and its history of a former member of the Soviet Union (WALDHARDT et al. 2011). Since the declaration of independence in 1991, the country has been struggling with the formation of a new political and economic order, resulting in an overthrow of the agricultural sector and a radical redevelopment of the rural land-use system (DIDEBULIDZE & URUSHADZE 2009, VOLZ et al. 2011). While urban areas have begun to benefit from the economic change, many people in rural regions still live in poverty, practicing small-scale subsistence farming (VOLZ et al. 2011).

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Fig. 1. Location and topography of the Caucasus Ecoregion and the study regions Kazbegi district (1) and Bakuriani district (2) (Composed from: WWF; ESRI, DELORME, GEBCO, NOAA NGDC, and other contributors; U.S. GEOLOGICAL SURVEY CENTER FOR EARTH RESOURCE OBSERVATION AND SCIENCE (EROS), NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA), NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY (NGA).

Abb. 1. Lage und Topografie der Ökoregion Kaukasus und der Untersuchungsregionen Kazbegi Distrikt (1) und Bakuriani Distrikt (2).

The plant biodiversity of the Caucasus and Georgia has been recognized for its usage potential by the local population for a long time. Existing food crops allowed agriculture to develop in the Early Neolithic period, when people began cultivating wild fruit trees such as pear, apple or cherry, but also various cereals (AKHALKATSI et al. 2010). Today, the Caucasus is one out of eight global centers of domestication for economically important plants (SOLOMON et al. 2014). Even though documentation of the entire plant biodiversity in the Caucasus is promoted by major players, such as Botanic Gardens Conservation International (BGCI: Botanic Gardens in the Caucasus – Biodiversity Hotspot, http://www.bgci.org/where-we-work/caucasus/, accessed 2017–01–11) and Missouri Botanical Garden (Projects in Asia and the Pacific: Republic of Georgia, http://www.mobot.org/MOBOT/Research/asiaprojects.shtml, accessed 2017–01–11), only the food and medicinal value of Georgia's agricultural biodiversity has recently been subject to international scientific research (e.g., MILLER et al. 2005, AKHALKATSI et al. 2010, BUSSMANN et al. 2014). The significance of its ornamental value does not seem to be have been fully recognized yet, and scientific publications focusing on the ornamental plant diversity are virtually absent.

Following the efforts of the BGCI and Missouri Botanical Garden, the aim of the present study was to investigate the ornamental value of the Caucasian flora in Georgia, and comparing it with the circumstances in Germany. In addition to generally demonstrating the socio-

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ecological and economic significance of ornamental plants, vegetation data from two mountainous study regions in Georgia was analyzed, one located in the Kazbegi district in the Greater Caucasus and the other in the Bakuriani district in the Lesser Caucasus (Fig. 1). The data was compared with the range of ornamental plants traded in Germany, and the results were evaluated with regard to provenance from the Caucasus. Furthermore, a list of ornamentally valuable plant species endemic to the Caucasus and occurring in Georgia was compiled and the species' characteristics were examined. Against this backdrop, a review of the potentials and risks which generally arise from trade in ornamental plants was completed.

2. Material and Methods

2.1 Comparison of the Kazbegi-Bakuriani database and the PPP-Index

For the first part of the analysis, a plant species database recorded at two mountainous study regions in Georgia in the years 2011–2014 served as a baseline. It contains 982 plant species and provides information on the plant species composition. 976 vegetation plots were recorded in the Kazbegi district, with nine plots sampled in high-montane levels (< 700 m a.s.l.), 814 plots in subalpine levels (1700–2500 m a.s.l.) and 116 plots in altitudes above 2500 m a.s.l., and unfortunately, for 37 plots, no altitudinal data were recorded. The majority (approx. 85%) of the vegetation plots originate from grassland (hay meadows, pastures, alpine poor grassland) and approx. 15% from arable fields and fallows as well as Rhododendron and Birch stands. Further 197 vegetation plot samples were recorded in the Bakuriani district, 98 of which were located in high-montane (< 1700 m a.s.l.) and 99 in subalpine (1700–2500 m a.s.l.) open and wooded grassland. For reasons of uniformity and comparability, the plant species nomenclature was adapted to THE PLANT LIST (2013). Due to synonyms the total amount of plant species dropped to 958.

In order to determine whether these species are common ornamentals in Germany, each species was matched with the online database 'Pflanzeneinkaufsführer für Europa' (PPP-Index) (http://www.ppp-index.de/, accessed 2016–10–25). For this analysis, only suppliers in Germany were regarded and each species was searched for with its accepted name as well as the name it was originally listed with in the Kazbegi-Bakuriani database. Cultivars were excluded from the analysis to avoid double counting of suppliers. Since the database also lists suppliers of uncommon and rare species, only species with at least ten suppliers were further considered.

The species recorded by at least ten German suppliers in the index were analyzed regarding their natural distribution range and floristic relationship to the Caucasus and Germany. To determine the species' floristic status in Germany (indigenous, archaeophyte, neophyte), the BIOLFLOR database (KLOTZ et al. 2002) was consulted. It contains information on the floristic status for 3659 plant species found in the wild in Germany (KÜHN & KLOTZ 2002a). For further information on the species' main distribution range, the species were categorized into different range types classified after OBERDORFER (1983) (KORNECK et al. 1998). Lastly, the indicator values after ELLENBERG et al. (2001) provided a basis for additional ecological characterization of the species.

2.2 Literature assessment

In a second step, literature was evaluated with respect to potential herbaceous ornamentals endemic to the Caucasus within Georgia. All native herbaceous species mentioned by SHULKINA (2004) or named by BRANDES (2014) were checked for listing in the 'Red List of the Endemic Plants of the Caucasus' with indication of occurrence in Georgia (SOLOMON et al. 2014). Thus, a list with species matching the criteria was compiled and further analysis was carried out regarding the species' usage status as ornamental plants. Moreover, their characteristics were evaluated with respect to potential ornamental use for a regional or global market.

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3. Results and Discussion

3.1 Comparison of the Kazbegi-Bakuriani database and the PPP-Index

Out of the 958 plant species listed in the Kazbegi-Bakuriani database, 150 species are offered by at least ten German plant suppliers (Supplement E1, column 5). According to THE PLANT LIST (2013), the species belong to 104 genera and 49 families (Table 2). They reveal an overlap with the species-richest genera and families occurring in the wild in both the Caucasus and Germany. For example, *Campanula* is one of the species-richest genera in the Caucasus, and *Carex* is the third most abundant genus within the German flora. In addition, Asteraceae, Rosaceae and Poaceae belong to the eight families with more than 100 species in the Caucasus Ecoregion as well as represent the three most abundant plant families in Germany (KÜHN & KLOTZ 2002b, SOLOMON et al. 2014).

Consultation of the BIOLFLOR database revealed that, from the 150 species analyzed in this study, 23 were not recorded, 106 were listed as indigenous in Germany, eleven as archaeophytes (two being questionable) and ten as neophytes (KLOTZ et al. 2002) (Table 3, Supplement E1, column 6).

In terms of main distribution, 117 of the 150 species can be categorized into different range types classified after OBERDORFER (1983) (KORNECK et al. 1998) (Fig. 2, Supplement E1, column 7). The 33 species grouped under 'no value' were not documented in the original source. A linkage with the floristic status allocation becomes apparent: Among the 33 species without a range type are all 23 species not assigned a floristic status plus the ten plant species assigned the floristic status 'neophyte' (Table 3).

Table 2. The nine most abundant plant genera and ten most abundant plant families. Analysis was based on the 150 plant species from the Kazbegi-Bakuriani database which have at least ten German suppliers in the PPP-Index.The remaining 94 genera and 39 families, which the 150 species consist of, have abundances of two or one species in terms of genera and three, two or one species in terms of families (Supplement E1, column 3, 4).

Tabelle 2. Die neun häufigsten Pflanzengattungen und zehn häufigsten Pflanzenfamilien. Die Analyse beruht auf den 150 Pflanzenarten der Kazbegi-Bakuriani Datenbank, die mindestens zehn deutsche Anbieter im PPP-Index haben. Die übrigen 94 Gattungen und 39 Familien der 150 Arten haben Häufigkeiten von zwei Arten oder einer Art in Bezug auf Gattungen und drei, zwei oder einer Art in Bezug auf Familien (Anhang E1, Spalte 3, 4).

Genus	Species abundance
Geranium	8
Campanula	6
Carex	5
Acer	3
Gentiana	3
Potentilla	3
Salvia	3
Sedum	3
Tanacetum	3

Family	Species abundance
Asteraceae	17
Rosaceae	16
Lamiaceae	11
Poaceae	9
Geraniaceae	8
Campanulaceae	6
Cyperaceae	6
Adoxaceae	5
Plantaginaceae	4
Crassulaceae	3

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Table 3. Thirtyfour plant species from the Kazbegi-Bakuriani database which have at least ten German suppliers in the PPP-Index and no available data regarding their floristic status in Germany, range type and/ or indicator values. Absence of values is represented by dots, presence by check marks (KORNECK et al. 1998, ELLENBERG et al. 2001, KLOTZ et al. 2002).

Tabelle 3. Vierunddreißig Pflanzenarten aus der Kazbegi-Bakuriani Datenbank, die mindestens zehn deutsche Anbieter im PPP-Index und keine verfügbaren Angaben hinsichtlich des floristischen Status in Deutschland, Arealtyp und/ oder der Zeigerwerte haben. Die Nichtverfügbarkeit von Werten ist durch Punkte gekennzeichnet, Verfügbarkeit durch Häkchen (KORNECK et al. 1998, ELLENBERG et al. 2001, KLOTZ et al. 2002).

Species	Floristic status	Range type	Indicator value
Abies nordmanniana (Stev.) Spach	·	·	·
Anthemis marschalliana Willd.	·	·	·
Astrantia maxima Pall.	·	·	·
Campanula alliariifolia Willd.	neophyte	·	·
Campanula collina Sims	·	·	·
Campanula lactiflora M.Bieb.	·	·	·
Campanula sarmatica Ker Gawl.	·	·	·
Cephalaria gigantea (Ledeb.) Bobrov	·	·	·
Centaurea macrocephala Muss.Puschk. ex Willd.	·	·	·
Dianthus cruentus Griseb.	·	·	·
Digitalis ferruginea L.	·	·	·
Doronicum orientale Hoffm.	·	·	·
Gentiana septemfida Pall.	·	·	·
Geranium ibericum Cav.	·	·	·
Geranium platypetalum Fisch. & C.A.Mey.	·	·	·
Geranium pyrenaicum Burm.f.	neophyte	·	✓
Geranium renardii Trautv.	·	·	·
Hesperis matronalis L.	neophyte	·	✓
Inula orientalis Lam.	·	·	·
Iris pumila L.	neophyte	·	·
Lomelosia caucasica (M.Bieb.) Greuter & Burdet	·	·	·
Lysimachia punctata L.	neophyte	·	✓
Muscari armeniacum Leichtlin ex Baker	neophyte	·	·
Nepeta racemosa Lam.	neophyte	·	·
Picea orientalis (L.) Peterm.	·	·	·
Salvia verticillata L.	neophyte	·	✓
Saxifraga juniperifolia Adams	·	·	·
Sedum hispanicum L.	neophyte	·	·
Sedum spurium M.Bieb.	neophyte	·	✓
Symphytum caucasicum M.Bieb.	·	·	·
Tanacetum coccineum (Willd.) Grierson	·	·	·
Tanacetum parthenium (L.) Sch.Bip.	archaeophyte	✓	·
Tripleurospermum caucasicum (Willd.) Hayek	·	·	·
Veronica gentianoides Vahl	·	·	·

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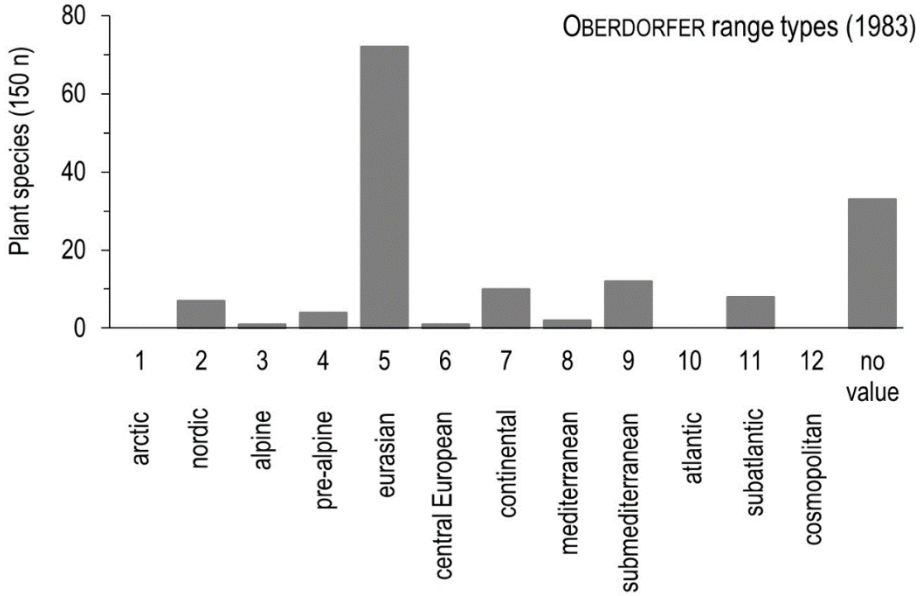

Fig. 2. Range types based on classification by OBERDORFER (1983) for each of the 150 plant species from the Kazbegi-Bakuriani database which have at least ten German suppliers in the PPP-Index. For detailed specification of each number, see original source (KORNECK et al. 1998).

Abb. 2. Arealtypen klassifiziert nach OBERDORFER (1983) für jede der 150 Pflanzenart aus der Kazbegi-Bakuriani Datenbank, die mindestens zehn deutsche Anbieter im PPP-Index hat. Für genaue Spezifizierung jeder Nummer, siehe Originalquelle (KORNECK et al. 1998).

The indicator value allocation according to ELLENBERG et al. (2001) reveals that 29 of the 150 species were not documented in the original source (Fig. 3, Supplement E1, column 8). Among those, overlaps with the species missing a floristic status or range type exist: Out of the 29 species, 28 also lack a characterization regarding their range type. Among the 28 species are the 23 species missing a floristic status and the remaining six are listed as neophytes (five species) or archaeophyte. Note that the archaeophyte, *Tanacetum parthenium*, is the same species out of the 29 species not documented to have indicator values that was assigned a range type. Consequently, there were five species without a characterization regarding their range type and with missing or neophyte floristic status, but with indicator values (Table 3).

3.1.1 Eurasian plant species

So far, the analysis has shown that from the 150 species recorded in Georgia, several have also been identified as native or archaeophytes in Germany (117 species) or present in central Europe after ELLENBERG et al. (2001) (121 species). Figure 2 shows that 72 of the 117 species with assigned range types are potentially distributed among all of Eurasia, which highlights the possibility of a species overlap in Germany and Georgia. Figure 3 and 4 illustrate the indicator values of the 121 plant species recorded in ELLENBERG et al. (2001). The frequency distribution of the continentality values (Figure 3a) also mostly represents ecolo-

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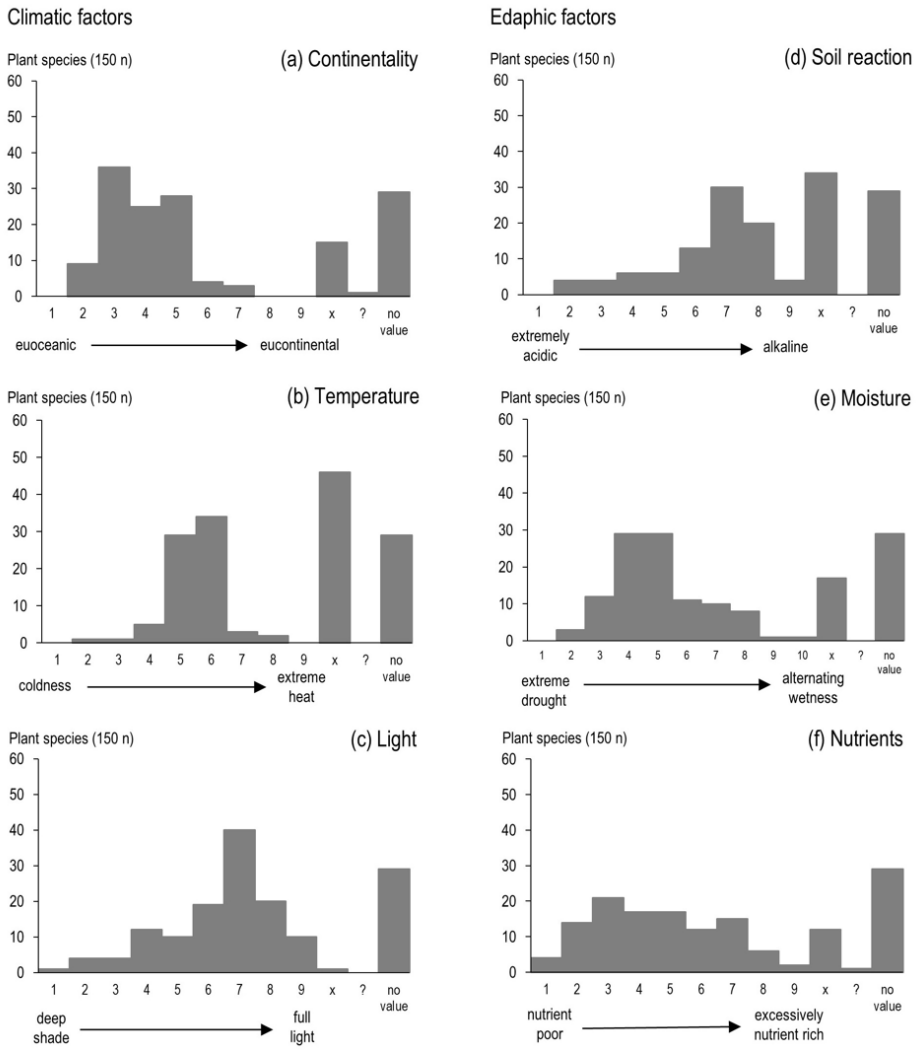

Fig. 3a–f. Indicator value range according to ELLENBERG et al. (2001) for the 150 plant species from the Kazbegi-Bakuriani database which have at least ten German suppliers in the PPP-Index. For detailed specification of each number, see original source. x = indifferent, ? = unclear, 'no value' = species not listed in ELLENBERG et al. (2001).

Abb. 3a–f. Zeigerwerte nach ELLENBERG et al. (2001) für die 150 Pflanzenarten aus der Kazbegi-Bakuriani Datenbank, die mindestens zehn deutsche Anbieter im PPP-Index haben. Für genaue Spezifizierung jeder Nummer, siehe Originalquelle. x = indifferent, ? = unklar, 'no value' = nicht in ELLENBERG et al. (2001) gelistete Arten.

gyical demands which can be met in both countries (KOSTER 2005, SOLOMON et al. 2014). Regarding temperature (Fig. 3b), which also reflects altitudinal zonation, the high number of indifferent species compensates for the differences that Germany and Georgia show in this respect. Species listed in the Kazbegi-Bakuriani database were mostly recorded in the high

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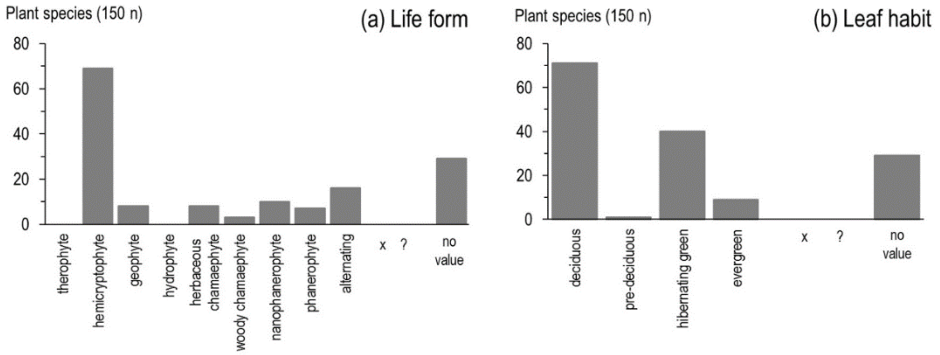

Fig. 4. a) Life form and **b)** leaf habit according to ELLENBERG et al. (2001) for the 150 plant species from the Kazbegi-Bakuriani database which have at least ten German suppliers in the PPP-Index. 'alternating' = alternating life form with site conditions, x = indifferent, ? = unclear, 'no value' = species not listed in ELLENBERG et al. (2001).

Abb. 4. a) Lebensform und **b)** Blattausdauer nach ELLENBERG et al. (2001) für die 150 Pflanzenarten aus der Kazbegi-Bakuriani Datenbank, die mindestens zehn deutsche Anbieter im PPP-Index haben. 'alternating' = Wechsel der Lebensform mit den jeweiligen Standortbedingungen, x = indifferent, ? = unklar, 'no value' = nicht in ELLENBERG et al. (2001) gelistete Arten.

montane to lower alpine altitudinal level, altitudes which are rare in Germany (KOSTER 2005). Apart from indifference, the adaptability of plant species is highlighted by the fact that the second and third most species-abundant indicator values represent an ecological demand for lower altitudinal levels in central Europe than they were documented in for the Kazbegi-Bakuriani database. If the species also occur in lower altitudinal levels in Georgia remains unclear, since no floristic mapping of the entire Georgian territory exists.

Generally, Germany and the Caucasus are climatically and geographically not as different as it might seem. According to WALTER & BRECKLE (1986, 1999), Germany is included in the temperate-nemoral zone of Europe (zonobiome VI). Concerning the Caucasus, the situation is more diverse as a result of its complex topography. WALTER & BRECKLE (1999) divided the ecoregion of the lowlands into three zonobiomes: The temperate-nemoral zone in the North Caucasus plains (zonobiome VI), the arid semi-deserts in the eastern Caspic lowlands (zonobiome VIIa), and the zone of warm-temperate humid climate in the western Colchic plains (zonobiome V). In BOX & FUJIWARA (2015), the warm-temperate region is further characterized as warm-temperate deciduous. The Caucasus mountain ranges separating the three zonobiomes are to be considered separately as an interzonal orobiome (WALTER & BRECKLE 1999). The vegetation map by BOHN et al. (2002/2003) shows that, among the diversity of the Caucasus mountains, areas with a similar natural vegetation structure as in Germany exist. In the analogous zonobiome VI in Germany and the North Caucasus, most of the area is naturally characterized by the formation of 'mesophytic deciduous broad-leaved and mixed coniferous-broad-leaved forests' (F.1–F.7). However, also parts of the intermountain regions and lowest altitudinal zones in the mountains correspond with this natural vegetation formation. Even though the natural vegetation is pushed back due to anthropogenic influences nowadays, the current flora still highlights this resemblance between both regions, as the analyzed species list suggests (BOHN & WELß 2003, NAKHUTSRISHVILI et al. 2009).

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When looking at the remaining indicator values of the Eurasian plant species (Fig. 3c–f, Fig. 4), further characterization can be carried out and significant information on the plants' biological characteristics and habitat requirements can be obtained. Pointed out in Chapter 1.2, those influence the production success and, therefore, a plant species' ornamental value. For example, the figures show that the majority of the plant species prefer open locations with exposure to light (Fig. 3c), grow in approximately neutral soils (Fig. 3d), can tolerate water shortages to a certain extent (Fig. 3e) and are hemicryptophytes (Fig. 4a). As GANSLMEIER & HENSELER (1985) point out, these characteristics give an adequate reflection of the conditions in gardens and resemble typical traits of ornamental plants.

3.1.2 Caucasian plant species

Accordingly, only a small fraction of the 150 plant species recorded in Georgia and marketed as common ornamental plants in Germany represents a wild flora that occurs in the Caucasus and not in central Europe. To answer the question if the 29 and 33 species, respectively, are unique Caucasian plants, their range formula was provided by WELK (2016) (Table 4).

According to the continents or continent sections included in the formulas, 25 plant species are named to occur in the Caucasus ('KAUK') and 13 species have distribution ranges which are limited to this area (e.g., *Campanula alliariifolia*, *Geranium renardii*, *Lomelosia caucasica*). This attribute corresponds with the definition of endemism by GAGNIDZE et al. (2002). However, as the continent (section) classification is rather broad, it is not possible to determine whether the other species are Caucasian subendemics, so only distributed in the ecoregion and directly adjacent areas (GAGNIDZE et al. 2002).

In addition to the large-scale geographic categorization, the range formula further reveals information on the species' altitudinal distribution. Out of the 28 species with indication of their preferred altitude, twelve are montane distributed species ('mo'), four are found on subalpine levels ('salp'), three are distributed among montane to alpine ('mo-alp'), seven montane to subalpine ('mo-salp') and two subalpine to alpine levels ('salp-alp'). Interestingly, only two of the 13 species endemic to the Caucasus are among the montane species, namely *Campanula alliariifolia* and *Symphytum caucasicum*. As a consequence, most of the endemic plant species are bound to higher elevations. This corresponds with the fact, that the proportion of endemic species increases with isolation of suitable habitats as is the case in high mountains (MYERS et al. 2000, FREY & LÖSCH 2014).

3.2 Further Caucasian endemics of ornamental significance

The analysis in Chapter 3.1 uncovered that only a small fraction of the 150 plant species recorded in Georgia and commonly sold as ornamental plants by German suppliers in the PPP-Index reflect the Caucasian ornamental flora. Nevertheless, the biodiversity in the Caucasus is rich in plants of ornamental value as the literature review revealed. (SHULKINA 2004, BRANDES 2014, SOLOMON et al. 2014) (Supplement E2).

As SHULKINA (2004) points out, Caucasian plant species with ornamental value range from trees to shrubs and herbaceous species. To narrow the analysis, the analyzed species were limited to the latter based on life-form attribution. The majority of the species are herbaceous perennials, some with underground perennating buds (bulbs, tubers, rhizomes) (Supplement E2, column 5). After RAUNKIAER (1937), the species can be classified as hemi-

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Table 4. Range formula of the species that are not central European according to ELLENBERG et al. (2001) and/ or have no natural or long-established (pre1500 AD) distribution range in Germany (KORNECK et al. 1998, KLOTZ et al. 2002). Information was provided by WELK (2016) personally.

Tabelle 4. Natürliche Verbreitung der Arten, die nach ELLENBERG et al. (2001) nicht mitteleuropäisch sind und/ oder kein natürliches oder seit längerem bestehendes Verbreitungsgebiet in Deutschland haben (vor 1500 n. Chr.) (KORNECK et al. 1998, KLOTZ et al. 2002). Die Informationen wurden von WELK (2016) bereitgestellt.

Species	Range formula
Abies nordmanniana (Stev.) Spach	m-sm//mo·c3-4 KAUK-WAS
Anthemis marschalliana Willd.	m-sm//mo-alp·c3-5 KAUK-WAS
Astrantia maxima Pall.	m-sm//mo-alp·c4-7 KAUK-WAS
Campanula alliariifolia Willd.	m-sm/mo·c3-6 KAUK
Campanula collina Sims	m-sm//salp-alp·c4-7 KAUK
Campanula lactiflora M.Bieb.	m-sm//mo-salp·c3-6 KAUK
Campanula sarmatica Ker Gawl.	m-sm//mo-salp·c3-6 KAUK
Cephalaria gigantea (Ledeb.) Bobrov	m-sm//mo-salp·c3-6 KAUK
Centaurea macrocephala Muss.Puschk. ex Willd.	m-sm//mo-salp·c3-6 KAUK
Dianthus cruentus Griseb.	sm/mo·c3-6 EUR
Digitalis ferruginea L.	m-sm//mo-salp·c3-6 OEUR-KAUK
Doronicum orientale Hoffm.	sm/mo·c3-4 OEUR
Gentiana septemfida Pall.	sm/salp-alp·c4-7 KAUK-WAS
Geranium ibericum Cav.	sm/salp·c4-6 KAUK
Geranium platypetalum Fisch. & C.A.Mey.	sm/salp·c4-6 KAUK
Geranium pyrenaicum Burm.f.	m-sm//mo·c1-6 EUR-(WAS)
Geranium renardii Trautv.	sm/salp·c4-6 KAUK
Hesperis matronalis L.	m/mo-sm·c2-5 EUR-(WAS)
Inula orientalis Lam.	sm/mo-salp·c4-7 KAUK-WAS
Iris pumila L.	sm·c5-7 OEUR
Lomelosia caucasica (M.Bieb.) Greuter & Burdet	m-sm//mo-salp·c4-6 KAUK
Lysimachia punctata L.	sm-temp·c3-6 OEUR-(WAS)
Muscari armeniacum Leichtlin ex Baker	m-sm·c3-6 OEUR-WAS
Nepeta racemosa Lam.	sm·c4-6 KAUK
Picea orientalis (L.) Peterm.	m-sm/mo·c KAUK-WAS
Salvia verticillata L.	m-temp·c2-5 OEUR-(WAS)
Saxifraga juniperifolia Adams	sm/salp·c3-6 OEUR+KAUK
Sedum hispanicum L.	m-sm//mo·c3-5 OEUR
Sedum spurium M.Bieb.	sm/mo-alp·c3-4 KAUK
Symphytum caucasicum M.Bieb.	m-sm//mo·c3-6 KAUK
Tanacetum coccineum (Willd.) Grierson	m-sm/·c3-7 KAUK-WAS
Tanacetum parthenium (L.) Sch.Bip.	m-sm//mo·c3-5 KAUK-WAS
Tripleurospermum caucasicum (Willd.) Hayek	m-sm//mo·c4-6 KAUK-WAS
Veronica gentianoides Vahl	m-sm//mo·c4-7 KAUK-WAS

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cryptophytes and geophytes. Both dominate in the temperate zone, but also make up a large share of the higher mountain vegetation (FREY & LÖSCH 2014, KALUSCHE 2016). As highlighted in Chapter 3.1.1, the mountain climate in Georgia resembles the climate found in central European mountains forming an extrazonal vegetation, so hemicryptophytes and geophytes also succeed there. In terms of ornamental use, herbaceous perennials with hemicryptophytic and geophytic characteristics are highly valued for their survival capability, durability and variety of uses, as for example in rock gardens, as cushion-formers, potted plants or cut flowers (GANSLMEIER & HENSELER 1985, KREUZER 1990).

In order to serve as an addition to the analysis carried out in Chapter 3.1, only species not yet mentioned were included in Appendix 2. Nevertheless, out of the 79 species, 24 are recorded in the Kazbegi-Bakuriani database with 958 species. While also 28 species are sold by German suppliers in the PPP-Index, only nine species overlap. Since none of these nine species, except for one (*Psephellus dealbatus* (Willd.) K. Koch is listed in the Kazbegi-Bakuriani database and was searched for in the PPP-Index by its accepted name. BRANDES (2014) called this species by one of its synonyms *Centaurea dealbata* Willd. Searched under this name, it became clear that this species is commonly marketed by suppliers listed in the PPP-Index and should therefore have been added to the list analyzed in Chapter 3.1), was offered by equal or more than ten suppliers, they do not occur among the 150 species from the first part of the analysis. Generally, the prominence for ornamental use varies among the 79 species. While 51 plant species are not sold by German suppliers listed in the PPP-Index, the supplier range of the 28 offered species stretches from one to 51. Seven of the 28 species have cultivars, in five cases these are species with high numbers of suppliers (Supplement E2, column 7, 8).

By examining more closely the requirements for an introduction of plants to the ornamental horticultural market (Table 1) with regard to the 79 Caucasian plant species, it becomes apparent that the difficulty to meet these constraints depends on the production and market situation. Introduction to the global ornamental market requires an exhaustive evaluation of each of the requirements as well as maximum breeding effort to improve the plant features to fit the global market, whereas introduction to the regional Georgian market can be less challenging regarding a resource-saving production or transportation risks and costs (SEATON et al. 2014). Consequently, cultivation and sale of the 79 plant species in Georgia could serve as a starting point of the plants' economic use. After proving successful in local ornamental horticulture and gaining in prominence, the demand for global introduction might increase. The same could apply to species which are closely related to species already commonly known as ornamental plants. For example, in the 'Royal Horticultural Society Encyclopedia of Plants and Flowers' published by BRICKELL (2010), 36 of the 47 plant genera, which the plant species belong to, are described as genera with ornamentally valuable species (e.g., *Campanula*, *Galanthus*, *Paeonia*, *Primula*).

3.3 The potentials and risks of trade in ornamental plants

Generally, the labeling of plant species as 'ornamentally valuable' increases prominence, which can lead both to potentials but also risks regarding socio-environmental aspects. In the following, the influences exerted by ornamental plant trade on the fields of nature conservation, biological invasion, genetic resource maintenance and socio-economic significance are highlighted.

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3.3.1 Nature conservation

The usage of plant species can interfere with their preservation. Due to the fact that many Caucasian plants are endemics and therefore have small distribution ranges and limited population numbers, they are more threatened by extinction than cosmopolitan species (FREY & LÖSCH 2014). Consequently, while supra-regional or international rarity and threat each justify protection, species to which both criteria apply are legitimized for particular safeguarding as the 'biodiversity hotspot principle' by MYERS et al. (1988, 2000) suggests. Concerning the plant species in this study, only 19 out of the 150 species (Chapter 3.1) have been assigned a conservation status regarding population abundance and distribution; 15 of them being NE ('not evaluated') or DD ('data deficient') (Supplement E1, column 9). Out of the 79 Caucasian endemics (Chapter 3.2), *Dioscorea caucasica* Lipski, *Primula juliae* Kusn., *Pulsatilla violacea* Rupr. and *Gymnospermium smirnovii* (Trautv.) Takht. were assessed the highest, specifically as 'endangered to become extinct in the wild' (EN) (Supplement E2, column 9, 10). *Gymnospermium smirnovii* is known to occur exclusively in two remote riparian forest locations in eastern Georgia and no other Caucasian country (SOLOMON et al. 2014). Subsequently, Georgia has an eminent responsibility concerning the preservation of the species that is already under threat due to forest clearcuttings and collection for medicinal purposes (KÜHN & KLOTZ 2002a, SOLOMON et al. 2014). The usage of a plant species for ornamental purposes can be seen ambivalent in this regard. On the one hand, it increases the interest in the species and can therefore intensify the search in and extraction from the wild. On the other hand, the cultivation of reduces the need for gathering from the wild and increases the species abundance (SHULKINA 2004).

3.3.2 Biological invasion control

Globalized ornamental horticulture is a major cause for biological plant invasions (KÜHN & KLOTZ 2002a, DEHNEN-SCHMUTZ et al. 2007, PYŠEK et al. 2009). Either the traded good itself ('ergasiophygophytes') or so-called 'passengers of trade' ('xenophytes') can become the introduced alien species (SCHROEDER 1969, PERRINGS et al. 2005, HULME et al. 2008). In Germany, there are 916 recorded naturalized non-indigenous plant species in the wild, which represent 25% of all recorded plant species in the country (3659). Of those, almost a third are recorded as escaped species cultivated for ornamental purposes, which is the biggest share in the total spectrum of introduction pathways (KÜHN & KLOTZ 2002a).

The significance of ornamental plant trade as an introduction pathway can also be detected from the 150 species analyzed in Chapter 3.1. Out of the eleven German archaeophytes and ten German neophytes, one archaeophyte, *Potentilla recta* L., and seven neophytes, *Iris pumila*, *Lysimachia punctata*, *Muscari armeniacum*, *Nepeta racemosa*, *Sedum hispanicum*, *Sedum spurium* and *Campanula alliariifolia*, are reported as escaped ornamental plants. In addition, two archaeophytes, *Viola odorata* L. and *Tanacetum parthenium*, as well as two neophytes, *Hesperis matronalis* and *Salvia verticillata*, are reported as escaped crops and ornamental plants at the same time (KLOTZ et al. 2002).

The close linkage between ornamental horticulture and the introduction of alien species highlights the proficiency of the industry. If plant species meet the requirements to be introduced to the market and can be successfully cultivated in gardens and other green spaces, establishment in the wild is also facilitated. In this regard, indicator value ranges of central Europe can be a suitable reference. Additionally, the multiplicity of introductions from various gardens increases the chances of success (PERRINGS et al. 2005). If an alien species

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eventually becomes invasive depends on its impact in the wild. As HULME (2007) puts it, naturalized alien species that endanger or pressure human health, the economy and/or the native biodiversity are considered invasive.

To justify counteractions against the spreading of alien plant species in Germany, they are categorized into non-invasive ('White List'), potentially invasive ('Grey List') and invasive species ('Black List') based on criteria such as threat for biodiversity, distribution or reproduction potential (NEHRING et al. 2015). Out of the 90 species recorded on the 'Black' and 'Grey List', eleven species are of Caucasian origin (Table 5) (NEHRING et al. 2013, RABITSCH et al. 2013).

When comparing these species to the species analyzed in Chapter 3.1 and 3.2, overlaps become apparent: *Sedum spurium* is found among the 150 species from the first part of the analysis (Table 3, 4, Supplement E1), while *Heracleum mantegazzianum* and *H. sosnowskyi* are listed as two of the 79 Caucasian endemics of ornamental value (Supplement E2). In fact, NEHRING et al. (2013) indicated that all species except *Allium paradoxum* and *Bunias orientalis* are named to have been introduced to Germany through horticulture. Even though RABITSCH et al. (2013) presumes that the not yet introduced invasive *Heracleum sosnowskyi* has the potential to be traded in the future, experiences made regarding *Heracleum mantegazzianum* are likely to act as a reason against it. *Heracleum mantegazzianum* is a very prominent invasive species, which was brought from Western Greater Caucasus to temperate Europe for ornamental purposes. It was first described in Germany in 1849 and is one of the most widely distributed invasive alien species today (PYŠEK et al. 2007).

3.3.3 Genetic resource maintenance

Plant genetic material which has an actual or potential value is described as a plant genetic resource (UN 1992). Regarding ornamental plants, their genetic resources include previously and presently used cultivars, but also their wild equivalents as well as potentially ornamental wild plant species (BEGEMANN et al. 2001). The loss of genetic resource diversi-

Table 5. Invasive ('Black List') or potentially invasive species ('Grey List') in Germany with indication of origin from the Caucasus (NEHRING et al. 2013, RABITSCH et al. 2013).

Tabelle 5. Invasive („Schwarze Liste") oder potentiell invasive Arten („Graue Liste") in Deutschland mit Herkunftsangabe aus dem Kaukasus (NEHRING et al. 2013, RABITSCH et al. 2013).

Species	Invasiveness list
Heracleum mantegazzianum Sommier & Levier	Black List – Management List
Sedum spurium M.Bieb.	
Rhododendron ponticum L.	Black List – Action List
Heracleum sosnowskyi Mandenova	Black List – Warn List
Bunias orientalis L.	Grey List – Action List
Prunus laurocerasus L.	
Rubus armeniacus Focke	
Allium paradoxum (M. Bieb.) G. Don	Grey List – Watch List
Echinops sphaerocephalus L.	
Elaeagnus angustifolia L.	
Telekia speciosa (Schreb.) Baumg.	

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ty is defined as genetic erosion (TAY 2006). Uncontrolled and excessive harvesting of wild species can lead to overexploitation and a decreasing diversity within populations. Moreover, the breeding of ornamentally valuable plant species is driven by the demand for specific aesthetic qualities occurring uniformly within a species. As uniformity is not only strengthened within but also between species, the disproportionate promotion of few modern varieties favours the extinction of traditional, diverse cultivars (TAY 2006).

Nevertheless, ornamental horticulture can also serve to maintain genetic resource diversity as a way of ex-situ conservation management outside of natural habitats. Apart from gene banks and botanic gardens, some private garden owners possess large collections of rare or old ornamental plants that cannot be found anymore on the market or even in the wild (TAY 2006, Netzwerk Pflanzensammlungen, http://www.netzwerkpflanzensammlungen.de/, accessed 2016–11–02).

3.3.4 Socio-economic Significance

Even though ornamental plants provide a wide range of ecosystem services (Chapter 1.2), they are commonly considered a luxury product and do not resemble a central human need. Resulting from this, the level of industrialization and urbanization of countries generally correlates with the demand for ornamental plants. In contrast, the supply with ornamental plants is provided from both, developed and developing countries and the ornamental horticulture industry can be an important economic pillar and create social progress (KARIUKI et al. 2011).

Concerning Georgia, the significance of the ornamental horticulture market is possible to increase in terms of demand and supply. On the one hand, as mentioned in Chapter 1.1, the urban population is benefitting from the economic growth of the country and modernization is taking place in the cities (THE WORLD BANK 2013). Imports of ornamental plants have been rising throughout the last decade and demand is likely to increase further with ongoing economic development (UN Comtrade Database). On the other hand, the rural population is struggling to survive through subsistence farming, extensive grassland management and livestock farming on land degraded as a consequence of the destruction of the agricultural sector and the land use reform (VOLZ et al. 2011).

Currently, ornamental plants are rarely found in the rural residents' home gardens (KÖHL 2015). However, as many Caucasian plant species of ornamental value grow wild in the areas around the villages (SHULKINA 2004), the natural conditions for a cultivation on local scale occupying former garden or arable land are suitable. With potential sales markets in the cities of the country, the cultivated ornamental plants could serve as a source of income in mountainous regions and counteract against rural flight. Likewise, with the cultivation of plants indigenous or endemic to the Caucasus, the awareness for and identity with the local biodiversity could be enhanced.

4. Conclusion

Next to food and medicinal crops, the rich plant diversity of the Caucasus Ecoregion encompasses many plant species of ornamental value. By analyzing plant data collected in the Greater and Lesser Caucasus of Georgia, it was possible to show that among these mountainous species are species commonly known to the ornamental horticulture industry, using the German market as a proxy. To a large extent, these species have a natural distribution range stretching across Eurasia and only few are Caucasian endemics. To highlight the sig-

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nificance of the unique Caucasian flora, further focus was only on species that are endemic to the Caucasus and occur throughout Georgia, including mountain areas but also intermountain lowlands. Even though the assessed species only reflect a small fraction of the entire endemic flora, it became evident that many Caucasian endemic plant species can be considered ornamentally valuable. However, only a third of the assessed herbaceous endemic plant species can currently be bought as ornamental plants by German plant suppliers and many of the offered species are only sold by few sellers. This indicates that the aesthetic and economic value of the Caucasian flora has not yet been completely discovered.

It is to bear in mind, that trade in ornamental plants can be seen ambiguously concerning risks and potentials for humans and nature. While it clearly increases the risk of the introduction of invasive species, it can be a blessing or curse in terms of nature conservation and the maintenance of genetic resources. Lastly, the analysis highlights that an expansion of the ornamental horticulture industry has a remarkable socio-economic potential and can lead to social progress.

After all, regarding the problematic socio-economic situation Georgia is facing as well as the richness and threatened status of the flora in the Caucasus Ecoregion, it is to consider whether the ornamental value of the prevalent plant species cannot be used to a greater extent? In the end, the environmental and social impact, which ornamental plant trade has, always depends on the way it is practiced.

Erweiterte deutsche Zusammenfassung

Einleitung – Zierpflanzen sind dekorative Arten der Gärten und Parks, die nicht für die Nahrungsversorgung oder Rohstoffgewinnung genutzt werden. Neben ihrer Schönheit kann ihre ökologische Funktionalität für die Nutzung ausschlaggebend sein. Somit erfüllen Zierpflanzen verschiedene bereitstellende, regulierende und kulturelle Ökosystemleistungen. Ihre Bedeutung in der Mensch-Umwelt-Beziehung spiegelt sich in ihrem ökonomischen Stellenwert wider.

Die Ökoregion Kaukasus im europäisch-asiatischen Grenzgebiet ist ein Biodiversitäts-Hotspot und heutzutage zu großen Teilen anthropogen überprägt. Georgien liegt als eines von drei Ländern vollständig in der Kaukasus-Ökoregion. Das Land ist von tiefgreifenden sozialen, politischen, wirtschaftlichen und klimatischen Veränderungsprozessen geprägt, die sowohl die Bevölkerung als auch die Natur beeinflussen. Das zu zwei Dritteln von Gebirge geprägte Land hat eine bemerkenswerte Vielfalt hinsichtlich seiner Höhen- und Vegetationsstufung (0–5047 m NN), Jahresmitteltemperaturen (-6–15 °C), mittleren Jahresniederschlagsummen (200–4500 mm) und Bodentypen. Dies resultiert in einer einzigartigen Vegetation mit 4100 Pflanzenarten, von denen 1320 Arten kaukasische Endemiten sind. Obwohl das ökonomische Potenzial der Biodiversität Georgiens in Bezug auf Nutz- und Heilpflanzen bekannt ist, ist der Zierpflanzenwert weitestgehend unerforscht. In dieser Arbeit wurden daher der Zierpflanzenwert eines Teils der kaukasischen Flora in Georgien untersucht sowie die Potenziale und Risiken des Zierpflanzenhandels diskutiert. Hierfür wurde die sozial-ökologische und ökonomische Bedeutung von Zierpflanzen herausgestellt.

Material und Methoden – Im ersten Analyseteil wurde ein Vergleich zwischen Vegetationsdaten aus zwei georgischen Untersuchungsregionen, Kazbegi [größtenteils Grünland der hochmontanen (<1700 m NN) und subalpinen (1700–2500 m NN) Höhenstufe, sowie Höhenlagen >2500 m NN] und Bakuriani [Grünland und Weidewälder der montanen (<1700 m NN) bis oberen subalpinen (1700–2500 m NN) Höhenstufe], und dem Zierpflanzenangebot in Deutschland angestellt. Für letzteres diente die Online-Datenbank „Pflanzeneinkaufsführer für Europa“ (PPP-Index). Es wurden ausschließlich deutsche Anbieter untersucht und nur Arten, die von mindestens zehn Anbietern im PPP-Index angeboten wurden. Die sich in den Datenbanken überschneidenden Arten wurden hinsichtlich ihrer natürlichen Verbreitung analysiert.

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Der zweite Teil umfasste eine Literaturanalyse (SHULKINA 2004, BRANDES 2014, SOLOMON et al. 2014). Darauf basierend wurde eine Liste mit 79 krautigen Zierpflanzenarten zusammengestellt, die kaukasische Endemiten mit Vorkommen in Georgien sind. Ihre aktuelle Nutzung als Zierpflanzen sowie ihre Eigenschaften für eine potenzielle Zierpflanzennutzung wurden analysiert.

Ergebnisse und Diskussion – Die Analyse im ersten Teil zeigt, dass 150 der 958 Arten in der Kazbegi-Bakuriani Datenbank von mindestens zehn Verkäufern im PPP-Index angeboten werden (Anhang E1). Basierend auf ihrem floristischen Status (KLOTZ et al. 2002), Arealtyp (KORNECK et al. 1998) und Zeigerwerten (ELLENBERG et al. 2001) wird deutlich, dass 121 der 150 Arten ebenfalls in Mitteleuropa vorkommen und 117 Arten als indigen oder Archaeophyten in Deutschland gelten; 29 bzw. 33 Arten kommen in Mitteleuropa oder Deutschland nicht wild vor und dreizehn sind ihrer Arealformel nach kaukasische Endemiten (Tab. 4) (GAGNIDZE et al. 2002, WELK 2016). Die Vegetations- und Klimazonierung nach WALTER & BRECKLE (1999) und die natürliche Vegetationsverbreitung nach BOHN et al. (2002/2003) zeigen, dass erhebliche floristische Ähnlichkeiten zwischen Deutschland und einigen Regionen des Kaukasus bestehen.

Die Literaturanalyse verdeutlicht, dass die kaukasisch-endemische Flora viele (potenzielle) Zierpflanzen umfasst (Tab. 5). Von den 79 gelisteten Arten werden 28 im PPP-Index angeboten, meist von wenigen Verkäufern. Fast alle 79 Arten haben für die Zierpflanzennutzung förderliche Eigenschaften, wie beispielsweise die Lebensform Hemikryptophyt oder Geophyt.

Die Kennzeichnung einer Art als wertvoll für eine Zierpflanzennutzung birgt sowohl Potenziale als auch Risiken in Bezug auf verschiedene sozio-ökologische Aspekte. Betrachtet man den generellen Naturschutzaspekt, kann eine Zierpflanzennutzung die Suche und Entnahme einer Pflanze aus der Wildnis intensivieren, eine Kultivierung solche Aktivitäten, die einen Artenrückgang zur Folge haben, aber auch mindern. Hinsichtlich biologischer Invasionen bringt die Zierpflanzennutzung ebenfalls ein Risiko mit sich. Die meisten gebietsfremden Arten in Deutschland sind verwilderte kultivierte Zierpflanzen („Ergasiophygophyten“ nach SCHROEDER 1969). Des Weiteren spielt der Zierpflanzenhandel in der Ausweitung von genetischer Erosion eine Rolle, obwohl manche Privatgärten auch als ex-situ Erhaltungsbestände genetischer Ressourcen gesehen werden können. Aus sozio-ökonomischer Sicht kann sich der Handel mit Zierpflanzen positiv auswirken. In Georgien erlebt ein Großteil der urbanen Bevölkerung wirtschaftlichen Aufschwung, so dass das Interesse an Luxusgütern, wie Zierpflanzen, steigt. Für die ländliche, ärmere Bevölkerung könnte der Anbau wildwachsender Pflanzen eine Einkommensquelle darstellen.

Zusammenfassung – Die Untersuchung zeigt, dass der Kaukasus neben Nutz- und Heilpflanzen eine Vielzahl an (potenziellen) Zierpflanzen besitzt. Während viele dieser Arten weite natürliche Verbreitungsgebiete haben, gibt es auch unter den endemischen Arten solche mit Zierpflanzenpotenzial. Die Identifikation einer Art als Zierpflanze birgt jedoch Potenziale und Risiken für Natur und Gesellschaft. Hinsichtlich der wirtschaftlichen Situation Georgiens könnte eine inländische, fachgerechte Kultivierung von wildwachsenden Arten zu Zierpflanzenzwecken günstig wirken und die heimische Flora vor nicht-nachhaltiger Nutzung schützen.

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Supplements

Additional supporting information may be found in the online version of this article.

Zusätzliche unterstützende Information ist in der Online-Version dieses Artikels zu finden.

Supplement E1. Ecological characteristics of the 150 plant species listed in the Kazbegi-Bakuriani database, which have at least ten German suppliers in the PPP-Index.

Anhang E1. Ökologische Eigenschaften der 150 Pflanzenarten der Kazbegi-Bakuriani Datenbank, die mindestens zehn deutsche Anbieter im PPP-Index haben.

Supplement E2. Herbaceous plant species mentioned by SHULKINA (2004), BRANDES (2014) or SOLOMON et al. (2014), which are listed in the Red List of the Caucasus with indication of occurrence in Georgia.

Anhang E2. Krautige Pflanzenarten, die von SHULKINA (2004), BRANDES (2014) oder SOLOMON et al. (2014) genannt werden und in der Roten Liste des Kaukasus mit Vorkommen in Georgien dokumentiert sind.

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Supplement E1. Ecological characteristics of the 150 plant species listed in the Kazbegi-Bakuriani database, which have at least ten German suppliers in the PPP-Index. Green color marking = synonyms after adaption to The Plant List (2013). Dots indicate that species were not mentioned in the original source and no data is available. For explanation of values, check original sources.

Anhang E1. Ökologische Eigenschaften der 150 Pflanzenarten der Kazbegi-Bakuriani Datenbank, die mindestens zehn deutsche Anbieter im PPP-Index haben. Grüne Farbmarkierung = Synonyme nach Abgleich mit The Plant List (2013). Punkte kennzeichnen keine Nennung der Arten in der Originalquelle, so dass keine Daten vorliegen. Für Erläuterungen der Werte, siehe Originalquellen.

1	2	3	4	5	6	7	8									9
No.	Species	Species	Family	Supplier no. (org. = acc. name)	Floristic status Germany	Range type	Ecological behaviour							Plant type		Red List status Caucasus Ecoregion
							L	T	K	F	R	N	S	Life form	Leaf habit	
	Kazbegi-Bakuriani database	The Plant List (2013)	The Plant List (2013)	PPP-Index	UFZ (2002)	Kornecck et al. (1998)	Ellenberg et al. (2001)									Solomon et al. (2014)
1	*Abies nordmanniana* (Stev.) Spach	*Abies nordmanniana* (Stev.) Spach	Pinaceae	37	·	·	·	·	·	·	·	·	·	·	·	LC
2	*Acer campestre* L.	*Acer campestre* L.	Sapindaceae	38	indigenous	9	((5))	6	4	5	7	6	0	P	S	·
3	*Acer platanoides* L.	*Acer platanoides* L.	Sapindaceae	31	indigenous	7	((4))	6	4	x	x	x	0	P	S	·
4	*Acer pseudoplatanus* L.	*Acer pseudoplatanus* L.	Sapindaceae	30	indigenous	11	((4))	x	4	6	x	7	0	P	S	·
5	*Achillea millefolium* L.	*Achillea millefolium* L.	Asteraceae	40	indigenous	5	8	x	x	4	x	5	1	H,C	W	·
6	*Ajuga genevensis* L.	*Ajuga genevensis* L.	Lamiaceae	12	indigenous	9	8	x	x	3	7	2	0	H	S	·
7	*Ajuga reptans* L.	*Ajuga reptans* L.	Lamiaceae	47	indigenous	11	6	x	2	6	6	6	0	H	W	·
8	*Alchemilla vulgaris* agg.	*Alchemilla xanthochlora* Rothm.	Rosaceae	31	indigenous	11	6	4	2	7	7	7	0	H	S	·
9	*Anthemis marschalliana* Willd.	*Anthemis marschalliana* Willd.	Asteraceae	42	·	·	·	·	·	·	·	·	·	·	·	LC
10	*Anthoxanthum odoratum* L.	*Anthoxanthum odoratum* L.	Poaceae	15	indigenous	2	x	x	x	x	5	x	1	T,H	S	·
11	*Artemisia absinthium* L.	*Artemisia absinthium* L.	Asteraceae	65	archaeophyte, escaped crop	5	9	6	7	4	7	8	0	C	I	·
12	*Artemisia vulgaris* L.	*Artemisia vulgaris* L.	Asteraceae	49	indigenous	5	7	6	x	6	x	8	0	H,C	S	·
13	*Aster alpinus* L.	*Aster alpinus* L.	Asteraceae	47	indigenous	3	9	2	5	5	7	2	0	H,C	W	·
14	*Astrantia maxima* Pall.	*Astrantia maxima* Pall.	Apiaceae	11	·	·	·	·	·	·	·	·	·	·	·	NT
15	*Athyrium filix-femina* (L.) Roth	*Athyrium filix-femina* (L.) Roth	Athyriaceae	62	indigenous	5	3	x	3	7	x	6	0	H	S	·
16	*Berberis vulgaris* L.	*Berberis vulgaris* L.	Berberidaceae	21	indigenous	9	7	x	4	4	8	3	0	N	S	·
17	*Briza media* L.	*Briza media* L.	Poaceae	61	indigenous	5	8	x	3	x	x	2	0	H	S	·
18	*Campanula ochroleuca* Kem.-Nath., *C. alliarifolia* Willd.	*Campanula alliarifolia* Willd.	Campanulaceae	22	neophyte, escaped ornamental plant	·	·	·	·	·	·	·	·	·	·	DD, NE
19	*Campanula collina* Sims	*Campanula collina* Sims	Campanulaceae	12	·	·	·	·	·	·	·	·	·	·	·	·
20	*Gadellia lactiflora* (Bieb.)Schulkina	*Campanula lactiflora* M.Bieb.	Campanulaceae	24	·	·	·	·	·	·	·	·	·	·	·	NE
21	*Campanula latifolia* L.	*Campanula latifolia* L.	Campanulaceae	15	indigenous	2	4	5	5	6	8	8	0	H	S	·
22	*Campanula grossheimii* Charadze, *C. rapunculoides* L.	*Campanula rapunculoides* L.	Campanulaceae	26	indigenous	7	6	6	4	4	7	4	0	H	S	*C. grossheimii* : DD
23	*Campanula sarmatica* Ker-Gawl.	*Campanula sarmatica* Ker Gawl.	Campanulaceae	12	·	·	·	·	·	·	·	·	·	·	·	NE
24	*Carex acuta* L.	*Carex acuta* L.	Cyperaceae	39	indigenous	5	7	5	7	9=	6	4	0	G,A	W	·
25	*Carex digitata* L.	*Carex digitata* L.	Cyperaceae	17	indigenous	5	3	x	4	5	x	4	0	H	W	·
26	*Carex buschiorum* V. Krecz., C. humilis Leyss.	*Carex humilis* Leyss.	Cyperaceae	21	indigenous	7	7	6	5	2	8	3	0	H	S	·
27	*Carex montana* L.	*Carex montana* L.	Cyperaceae	61	indigenous	7	5	x	4	4	6	3	0	H	S	·
28	*Carex sylvatica* Huds.	*Carex sylvatica* Huds.	Cyperaceae	52	indigenous	11	2	5	3	5	6	5	0	H	W	·
29	*Carlina vulgaris* L.	*Carlina vulgaris* L.	Asteraceae	15	indigenous	11	7	5	3	4	7	3	0	H,T	W	·
30	*Carpinus betulus* L.	*Carpinus betulus* L.	Betulaceae	46	indigenous	7	((4))	6	4	x	x	x	0	P	S	·
31	*Carum carvi* L.	*Carum carvi* L.	Apiaceae	27	indigenous	2	8	4	5	5	x	6	1	H	S	·
32	*Grossheimia macrocephala* (Muss.-Puschk. ex Willd.) Sosn.	*Centaurea macrocephala* Muss.Puschk. ex Willd.	Asteraceae	59	·	·	·	·	·	·	·	·	·	·	·	NE
33	*Cephalaria gigantea* (Ledeb.) Bobrov	*Cephalaria gigantea* (Ledeb.) Bobrov	Adoxaceae	30	·	·	·	·	·	·	·	·	·	·	·	NE
34	*Cichorium intybus* L.	*Cichorium intybus* L.	Asteraceae	33	archaeophyte, escaped crop	5	9	6	5	4	8	5	0	H	S	·
35	*Corylus avellana* L.	*Corylus avellana* L.	Betulaceae	43	indigenous	5	6	5	3	x	x	5	0	N	S	·
36	*Cynoglossum officinale* L.	*Cynoglossum officinale* L.	Boraginaceae	11	indigenous	5	8	6	5	4	7	7	0	H	S	·
37	*Daphne mezereum* L.	*Daphne mezereum* L.	Thymelaeaceae	12	indigenous	5	4	x	4	5	7	5	0	N,Z	S	·
38	*Deschampsia cespitosa* (L.) Beauv.	*Deschampsia cespitosa* (L.) P.Beauv.	Poaceae	50	indigenous	5	6	x	x	7–	x	3	0	H	W	·
39	*Avenella flexuosa* (L.) Drej.	*Deschampsia flexuosa* (L.) Trin.	Poaceae	15	indigenous	5	6	x	2	x	2	3	0	H	I	·
40	*Dianthus calocephalus* Boiss.	*Dianthus cruentus* Griseb.	Caryophyllaceae	19	·	·	·	·	·	·	·	·	·	·	·	·
41	*Digitalis ferrugina* L.	*Digitalis ferruginea* L.	Plantaginaceae	14	·	·	·	·	·	·	·	·	·	·	·	·
42	*Doronicum orientale* Hoffm.	*Doronicum orientale* Hoffm.	Asteraceae	47	·	·	·	·	·	·	·	·	·	·	·	·
43	*Dryopteris carthusiana* (Vill.) H. P. Fuchs	*Dryopteris carthusiana* (Vill.) H.P. Fuchs	Dryopteridaceae	15	indigenous	5	5	x	3	x	4	3	0	H	S	·
44	*Dryopteris filix-mas* (L.) Schott	*Dryopteris filix-mas* (L.) Schott	Dryopteridaceae	63	indigenous	5	3	x	3	5	5	6	0	H	S	·
45	*Echium vulgare* L.	*Echium vulgare* L.	Boraginaceae	25	archaeophyte?, escaped crop	5	9	6	3	4	8	4	0	H	W	·
46	*Hippophae rhamnoides* L.	*Elaeagnus rhamnoides* (L.) A.Nelson	Elaeagnaceae	33	indigenous	6	9	6	6	4–	8	3	0	N	I	·
47	*Epilobium angustifolium* L.	*Epilobium angustifolium* L.	Onagraceae	17	indigenous	5	8	x	5	5	5	8	0	H	S	·
48	*Epilobium dodonaei* Vill.	*Epilobium dodonaei* Vill.	Onagraceae	12	indigenous	4	9	x	5	4	9	2	0	C	W	·
49	*Equisetum palustre* L.	*Equisetum palustre* L.	Equisetaceae	12	indigenous	5	7	x	5	8	x	3	0	G	S	·
50	*Euonymus europaea* L.	*Euonymus europaeus* L.	Celastraceae	49	indigenous	11	6	5	3	5	8	5	0	N	S	·
51	*Festuca gigantea* (L.) Vill.	*Festuca gigantea* (L.) Vill.	Poaceae	33	indigenous	5	4	5	3	7	6	6	0	H	S	·
52	*Festuca ovina* var. *vulgaris* Staub, *F. ovina* L.	*Festuca ovina* L.	Poaceae	44	indigenous	5	7	x	3	x	3	1	0b	H	S	·
53	*Filipendula ulmaria* (L.) Maxim.	*Filipendula ulmaria* (L.) Maxim.	Rosaceae	63	indigenous	5	7	5	x	8	x	5	0	H	S	·
54	*Filipendula vulgaris* Moench	*Filipendula vulgaris* Moench	Rosaceae	48	indigenous	5	7	6	5	3–	8	2	0	H	S	·
55	*Fragaria vesca* L.	*Fragaria vesca* L.	Rosaceae	50	indigenous	5	7	x	5	5	x	6	0	H	W	·
56	*Fraxinus excelsior* L.	*Fraxinus excelsior* L.	Oleaceae	33	indigenous	11	((4))	5	3	x	7	7	0	P	S	·
57	*Asperula odorata* L.	*Galium odoratum* (L.) Scop.	Rubiaceae	77	indigenous	5	2	5	2	5	6	5	0	H	W	·
58	*Galium verum* L.	*Galium verum* L.	Rubiaceae	23	indigenous	5	7	6	x	4–	7	3	0	H	W	·
59	*Gentiana schistocalyx* (C.Koch)C.Koch	*Gentiana asclepiadea* L.	Gentianaceae	35	indigenous	4	7	x	4	6–	7	2	0	H	S	·
60	*Gentiana cruciata* L.	*Gentiana cruciata* L.	Gentianaceae	39	indigenous	5	7	6	4	3	8	3	0	H	W	·
61	*Gentiana septemfida* Pall.	*Gentiana septemfida* Pall.	Gentianaceae	10	·	·	·	·	·	·	·	·	·	·	·	·
62	*Geranium ibericum* Cav.	*Geranium ibericum* Cav.	Geraniaceae	10	·	·	·	·	·	·	·	·	·	·	·	NE
63	*Geranium palustre* L.	*Geranium palustre* L.	Geraniaceae	37	indigenous	5	8	5	4	7–	8	7	0	H	S	·
64	*Geranium platypetalum* Fisch. & C. A. Mey.	*Geranium platypetalum* Fisch. & C.A.Mey.	Geraniaceae	21	·	·	·	·	·	·	·	·	·	·	·	NE
65	*Geranium pyrenaicum* Burm. fil.	*Geranium pyrenaicum* Burm.f.	Geraniaceae	12	neophyte, companion	·	8	6	4	5	7	8	0	H	W	·
66	*Geranium renardii* Trautv.	*Geranium renardii* Trautv.	Geraniaceae	70	·	·	·	·	·	·	·	·	·	·	·	LC
67	*Geranium robertianum* L.	*Geranium robertianum* L.	Geraniaceae	10	indigenous	5	5	x	3	x	x	7	0	T,H	W	·
68	*Geranium sanguineum* L.	*Geranium sanguineum* L.	Geraniaceae	73	indigenous	7	7	6	4	3	8	3	0	H	S	·
69	*Geranium sylvaticum* L.	Geranium sylvaticum L.	Geraniaceae	34	indigenous	2	6	4	4	6	6	7	0	H	S	·
70	*Geum rivale* L.	*Geum rivale* L.	Rosaceae	59	indigenous	2	6	x	5	8–	x	4	0	H	W	·
71	*Geum urbanum* L.	*Geum urbanum* L.	Rosaceae	18	indigenous	5	4	5	5	5	x	7	0	H	W	·
72	*Helianthemum nummularium* (L.)Mill.	*Helianthemum nummularium* (L.) Mill.	Cistaceae	38	indigenous	9	7	6	4	3	7	2	0	Z	I	·
73	*Hesperis matronalis* L.	*Hesperis matronalis* L.	Brassicaceae	47	neophyte, escaped crop/ orn. plant	·	6	5	6	7=	7	7	0	H	S	·
74	*Hyoscyamus niger* L.	*Hyoscyamus niger* L.	Solanaceae	12	archaeophyte, escaped crop	9	8	6	x	4	7	9	0	T,H	S	·
75	*Hypericum perforatum* L.	*Hypericum perforatum* L.	Hypericaceae	52	indigenous	5	7	6	5	4	6	4	0	H	S	·
76	*Inula grandiflora* Willd., *I. orientalis* Lam.	*Inula orientalis* Lam.	Asteraceae	25	·	·	·	·	·	·	·	·	·	·	·	*I. grandiflora* : DD
77	*Iris pumila* L.	*Iris pumila* L.	Iridaceae	13	neophyte, escaped ornamental plant	·	·	·	·	·	·	·	·	·	·	·
78	*Iris sibirica* L.	*Iris sibirica* L.	Iridaceae	46	indigenous	5	8	6	5	8–	6	2	0	G	S	·
79	*Juncus effusus* L.	*Juncus effusus* L.	Juncaceae	48	indigenous	5	8	5	3	7	3	4	0	H	S	·
80	*Juniperus communis* L.	*Juniperus communis* L.	Cupressaceae	10	indigenous	5	8	x	x	4	x	x	0	N	I	·
81	*Knautia arvensis* (L.) Coult.	*Knautia arvensis* (L.) Coult.	Adoxaceae	20	indigenous	5	7	6	3	4	x	4	0	H	S	·
82	*Leucanthemum vulgare* Lam.	*Leucanthemum vulgare* (Vaill.) Lam.	Asteraceae	33	indigenous	5	7	x	3	4	x	3	0	H	W	·
83	*Scabiosa caucasica* Bieb.	*Lomelosia caucasica* (M.Bieb.) Greuter & Burdet	Adoxaceae	10	·	·	·	·	·	·	·	·	·	·	·	*S. caucasica* : NE
84	*Lotus corniculatus* L.	*Lotus corniculatus* L.	Leguminosae	15	indigenous	5	7	x	3	4	7	3	0	H	S	·
85	*Luzula pilosa* (L.) Willd.	*Luzula pilosa* (L.) Willd.	Juncaceae	39	indigenous	5	2	x	3	5	5	4	0	H	W	·
86	*Luzula sylvatica* (Huds.) Gaudin	*Luzula sylvatica* (Huds.) Gaudin	Juncaceae	56	indigenous	5	4	4	2	5	4	4	0	H	W	·
87	*Lysimachia verticillaris* Spreng.	*Lysimachia punctata* L.	Primulaceae	74	neophyte, escaped ornamental plant	·	6	7	4	7	8	4	0	H	W	·
88	*Melica transsilvanica* Schur	*Melica transsilvanica* Schur	Poaceae	19	indigenous	7	7	8	4	3	6	4	0	H	S	·
89	*Mentha longifolia* (L.)Huds.	*Mentha longifolia* (L.) L.	Lamiaceae	24	indigenous	9	7	5	4	8=	9	7	0	H	S	·
90	*Mespilus germanica* L.	*Mespilus germanica* L.	Rosaceae	30	archaeophyte, escaped crop	9	((6))	8	6	4	6	x	0	P	S	·
91	*Molinia caerulea* (L.) Moench	*Molinia caerulea* (L.) Moench	Poaceae	34	indigenous	5	7	x	3	7	x	2	0	H	S	·
92	*Muscari szovitsianum* Baker	*Muscari armeniacum* Leichtlin ex Baker	Asparagaceae	13	neophyte, escaped ornamental plant	·	·	·	·	·	·	·	·	·	·	·
93	*Nepeta mussinii* Spreng.	*Nepeta racemosa* Lam.	Lamiaceae	14	neophyte, escaped ornamental plant	·	·	·	·	·	·	·	·	·	·	·
94	*Origanum vulgare* L.	*Origanum vulgare* L.	Lamiaceae	77	indigenous	5	7	x	3	3	8	3	0	H,C	W	·
95	*Oxalis acetosella* L.	*Oxalis acetosella* L.	Oxalidaceae	27	indigenous	5	1	x	3	5	4	6	0	G,H	W	·
96	*Paris quadrifolia* L.	*Paris quadrifolia* L.	Melanthiaceae	10	indigenous	5	3	x	4	6	7	7	0	G	S	·
97	*Phragmites australis* (Cav.) Trin. ex Steud.	*Phragmites australis* (Cav.) Trin. ex Steud.	Poaceae	43	indigenous	5	7	5	x	10	7	7	0	G,A	W	·
98	*Picea orientalis* (L.) Link	*Picea orientalis* (L.) Peterm.	Pinaceae	12	·	·	·	·	·	·	·	·	·	·	·	LC
99	*Pimpinella saxifraga* L.	*Pimpinella saxifraga* L.	Apiaceae	18	indigenous	5	7	x	5	3	x	2	0	H	S	·
100	*Plantago lanceolata* L.	*Plantago lanceolata* L.	Plantaginaceae	18	archaeophyte, companion	5	6	x	3	x	x	x	0	H	W	·
101	*Polygonatum multiflorum* (L.) All.	*Polygonatum multiflorum* (L.) All.	Asparagaceae	59	indigenous	5	2	x	5	5	6	5	0	G	S	·
102	*Polygonatum verticillatum* (L.) All.	*Polygonatum verticillatum* (L.) All.	Asparagaceae	17	indigenous	5	4	4	2	5	4	5	0	G	S	·
103	*Polypodium vulgare* L.	*Polypodium vulgare* L.	Polypodiaceae	74	indigenous	5	5	5	3	4	2	2	0	C	I	·
104	*Populus tremula* L.	*Populus tremula* L.	Salicaceae	19	indigenous	5	((6))	5	5	5	x	x	0	P	S	·
105	*Potentilla argentea* L.	*Potentilla argentea* L.	Rosaceae	15	indigenous	9	9	6	3	2	3	1	0	H	W	·
106	*Potentilla erecta* (L.) Raeusch.	*Potentilla erecta* (L.) Raeusch.	Rosaceae	12	indigenous	5	6	x	3	x	x	2	0	H	W	·
107	*Potentilla recta* L.	*Potentilla recta* L.	Rosaceae	17	archaeophyte, escaped ornamental plant	8	9	7	5	3	5	2	0	H	S	·
108	*Primula vulgaris* Huds.	*Primula vulgaris* Huds.	Primulaceae	40	indigenous	9	6	5	2	5	7	5	0	H	V	·
109	*Prunella vulgaris* L.	*Prunella vulgaris* L.	Lamiaceae	22	indigenous	5	7	x	3	5	7	x	0	H	W	·
110	*Prunus spinosa* L.	*Prunus spinosa* L.	Rosaceae	39	indigenous	5	7	5	5	4	7	x	0	N	S	·
111	*Rosa canina* L.	*Rosa canina* L.	Rosaceae	21	indigenous	5	8	5	3	4	x	x	0	N	S	·
112	*Rosa pimpinellifolia* L.	*Rosa spinosissima* L.	Rosaceae	46	indigenous	5	8	6	5	4	8	3	0	N,Z	W	·
113	*Rubus idaeus* Sanadze	*Rubus idaeus* L.	Rosaceae	10	indigenous	5	7	x	x	x	x	6	0	n	S	·
114	*Rumex acetosa* L.	*Rumex acetosa* L.	Polygonaceae	40	indigenous	5	8	x	x	x	x	6	0b	H	W	·
115	*Salix caprea* L.	*Salix caprea* L.	Salicaceae	25	indigenous	5	7	x	3	6	7	7	0	N,P	W	·
116	*Salvia glutinosa* L.	*Salvia glutinosa* L.	Lamiaceae	33	indigenous	4	4	5	4	6	7	7	0	H	S	·
117	*Salvia nemorosa* L.	*Salvia nemorosa* L.	Lamiaceae	18	indigenous	7	7	7	?	4	9	4	0	H	S	·
118	*Salvia verticillata* L.	*Salvia verticillata* L.	Lamiaceae	17	neophyte, escaped crop/ orn. plant	·	9	6	6	4	7	5	0	H	S	·
119	*Sambucus nigra* L.	*Sambucus nigra* L.	Adoxaceae	39	indigenous	11	7	5	3	5	x	9	0	N	S	·
120	*Sanguisorba officinalis* L.	*Sanguisorba officinalis* L.	Rosaceae	23	indigenous	5	7	5	7	6–	x	5	0	H	S	·
121	*Saxifraga juniperifolia* Adams	*Saxifraga juniperifolia* Adams	Saxifragaceae	13	·	·	·	·	·	·	·	·	·	·	·	·
122	*Saxifraga cartilaginea* Willd., *S. kolenatiana* Regel	*Saxifraga paniculata* Mill.	Saxifragaceae	60	indigenous	4	7	3	3	3	8	2	0	C	I	*S. cartillaginea* : NE, *S. kolenatiana* : DD
123	*Scabiosa columbaria* L.	*Scabiosa columbaria* L.	Adoxaceae	16	indigenous	9	8	5	2	3	8	3	0	H	S	·
124	*Scirpus sylvaticus* L.	*Scirpus sylvaticus* L.	Cyperaceae	20	indigenous	5	6	5	4	8	4	4	0	G	W	·
125	*Coronilla varia* L.	*Securigera varia* (L.) Lassen	Leguminosae	17	indigenous	7	7	6	5	4	9	3	0	H	S	·
126	*Sedum acre* L.	*Sedum acre* L.	Crassulaceae	63	indigenous	5	8	6	3	2	x	1	1	C	W	·
127	*Sedum hispanicum* L.	*Sedum hispanicum* L.	Crassulaceae	11	neophyte, escaped ornamental plant	·	·	·	·	·	·	·	·	·	·	·
128	*Sedum oppositifolium* Sims., *S. spurium* Bieb.	*Sedum spurium* M.Bieb.	Crassulaceae	13	neophyte, escaped ornamental plant	·	8	6	4	3	5	3	0	C	W	NE
129	*Solidago virgaurea* L.	*Solidago virgaurea* L.	Asteraceae	25	indigenous	5	5	x	x	5	x	4	0	H	W	·
130	*Sorbus aucuparia* L.	*Sorbus aucuparia* L.	Rosaceae	41	indigenous	5	((6))	x	x	x	4	x	0	P,N	S	·
131	*Betonica officinalis* L.	*Stachys officinalis* (L.) Trevis.	Lamiaceae	24	indigenous	5	7	6	5	x–	x	3	0	H	S	·
132	*Stachys palustris* L.	*Stachys palustris* L.	Lamiaceae	14	indigenous	5	7	5	x	7–	7	6	0	G	S	·
133	*Stellaria holostea* L.	*Stellaria holostea* L.	Caryophyllaceae	10	indigenous	5	5	6	3	5	6	5	0	C	I	·
134	*Symphytum caucasicum* Bieb.	*Symphytum caucasicum* M.Bieb.	Boraginaceae	10	·	·	·	·	·	·	·	·	·	·	·	·
135	*Pyrethrum carneum* Bieb., *P. coccineum* (Willd.) Woroschk.	*Tanacetum coccineum* (Willd.) Grierson	Asteraceae	14	·	·	·	·	·	·	·	·	·	·	·	*P. carneum* : NE
136	*Pyrethrum demetrii* Manden.	*Tanacetum parthenium* (L.) Sch.Bip.	Asteraceae	28	archaeophyte, escaped crop/ orn. Ppant	9	·	·	·	·	·	·	·	·	·	*P. demetrii* : DD
137	*Tanacetum vulgare* L.	*Tanacetum vulgare* L.	Asteraceae	40	archaeophyte?, escaped crop	5	8	6	4	5	8	5	0	H	S	·
138	*Thalictrum flavum* L.	*Thalictrum flavum* L.	Ranunculaceae	13	indigenous	5	7	6	5	8–	8	5	0	H	S	·
139	*Tripleurospermum caucasicum* (Willd.) Hayek	*Tripleurospermum caucasicum* (Willd.) Hayek	Asteraceae	42	·	·	·	·	·	·	·	·	·	·	·	·
140	*Tussilago farfara* L.	*Tussilago farfara* L.	Asteraceae	10	indigenous	5	8	x	3	6–	8	x	0	G	S	·
141	*Vaccinium myrtillus* L.	*Vaccinium myrtillus* L.	Ericaceae	16	indigenous	2	5	x	5	x	2	3	0	Z	S	·
142	*Vaccinium vitis-idaea* L.	*Vaccinium vitis-idaea* L.	Ericaceae	22	indigenous	2	5	x	5	4–	2	1	0	Z	I	·
143	*Valeriana officinalis* L.	*Valeriana officinalis* L.	Adoxaceae	71	indigenous	7	7	6	5	8–	7	5	0	H	S	·
144	*Verbascum nigrum* L.	*Verbascum nigrum* L.	Scrophulariaceae	53	indigenous	5	7	5	5	5	7	7	0	H	S	·
145	*Verbena officinalis* L.	*Verbena officinalis* L.	Verbenaceae	13	archaeophyte, escaped crop	5	9	6	3	5	7	7	0	H,T	S	·
146	*Veronica gentianoides* Vahl	*Veronica gentianoides* Vahl	Plantaginaceae	45	·	·	·	·	·	·	·	·	·	·	·	·
147	*Veronica officinalis* L.	*Veronica officinalis* L.	Plantaginaceae	17	indigenous	5	6	x	3	4	3	4	0	C	W	·
148	*Viburnum lantana* L.	*Viburnum lantana* L.	Adoxaceae	37	indigenous	9	7	5	2	4	8	4	0	N	W	·
149	*Viola odorata* L.	*Viola odorata* L.	Violaceae	35	archaeophyte, escaped crop/ orn. plant	8	5	6	3	5	x	8	0	H	W	·
150	*Viola reichenbachiana* Jord. ex Boreau	*Viola reichenbachiana* Jord. ex Boreau	Violaceae	10	indigenous	5	4	x	4	5	7	6	0	H	W	·

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Supplement E2. Herbaceous plant species mentioned by Shulkina (2004), Brandes (2014) or Solomon et al. (2014), which are listed in the Red List of the Caucasus with indication of occurrence in Georgia. Green color marking = synonyms after adaption to The Plant List (2013). Species are characterized according to life form (bold = no explicit species data available), number of German suppliers in the PPP-Index, occurrence in the Kazbegi-Bakuriani database (dot = absence, x = presence) and status as indicated in the Red List by Solomon et al. (2014).

Anhang E2. Krautige Pflanzenarten, die von Shulkina (2004), Brandes (2014) oder Solomon et al. (2014) genannt werden und in der Roten Liste des Kaukasus mit Vorkommen in Georgien dokumentiert sind. Grüne Farbmarkierung = Synonyme nach Abgleich mit The Plant List (2013). Die Arten wurden hinsichtlich ihrer Lebensform (fett gedruckt = keine Verfügbarkeit von Daten auf Artebene), der Anzahl deutscher Anbieter im PPP-Index, ihres Vorkommens in der Kazbegi-Bakuriani Datenbank (Punkt = Fehlen, x = Präsenz) und ihres in der Roten Liste von Solomon et al. (2014) genannten Status charakterisiert.

1	2	3	4	5	7	8	9	10
No.	**Species**	**Species**	**Family**	**Life form**	**Supplier no. (orig. + acc. name)**	**Occurrence in the Kazbegi-Bakuriani database**	**Red List status Caucasus Ecoregion**	**Status refers to**
	Shulkina (2004), Brandes (2014), Solomon et al. (2014)	**The Plant List (2013)**	**The Plant List (2013)**		**PPP-Index**		**Solomon et al. (2014)**	
1	*Allium candolleanum* Albov	*Allium candolleanum* Albov	Amaryllidaceae	herb. perennial with bulb[2]	·	·	DD	accepted name
2	*Amberboa moschata* (L.) DC.	*Amberboa moschata* (L.) DC.	Asteraceae	annual/ biennial[1,2]	4	·	NE	accepted name
3	*Anemonastrum fasciculatum* (L.) Holub, *Anemone fasciculata* L.	*Anemone narcissiflora* subsp. *fasciculata* (L.) Ziman & Fedor.	Ranunculaceae	herb. perennial[1,2] (*A. narcissiflora*)	1	x	NE	*A. fasciculata*
4	*Aquilegia gegica* Jabr.-Kolak.	*Aquilegia gegica* Jabr.-Kolak.	Ranunculaceae	herb. perennial (genus)[2]	·	·	VU D2	accepted name
5	*Aquilegia caucasica* (Ledep.) Rupr.	*Aquilegia olympica* Boiss.	Ranunculaceae	herb. perennial[1,2]	6	x	NE	*old & accepted name (indicated as synonyms)*
6	*Asperula abchasica* V.I.Krecz.	*Asperula abchasica* V.I.Krecz.	Rubiaceae	**annual, herb. perennial, semi-shrub (genus)[2]**	·	·	LC	accepted name
7	*Asperula albovii* Manden.	*Asperula prostrata* (Adams) K.Koch	Rubiaceae	**annual, herb. perennial, semi-shrub (genus)[2]**	·	x	DD	*A. prostrata* subsp. *albovii*
8	*Astragalus captiosus* Boriss.	*Astragalus captiosus* Boriss.	Leguminosae	**annual, herb. perennial, shrub (genus)[2]**	·	x	NE	accepted name
9	*Astragalus kazbeki* Kharadze	*Astragalus kazbeki* Kharadze	Leguminosae	**annual, herb. perennial, shrub (genus)[2]**	·	x	NE	accepted name
10	*Astrantia biebersteinii* Fisch. & C.A.Mey.	*Astrantia biebersteinii* Fisch. & C.A.Mey.	Apiaceae	herb. perennial with rhizome[1] (*A. major*)	·	·	NE	accepted name
11	*Asyneuma campanuloides* (M.Bieb. ex Sims) Bornm.	*Asyneuma campanuloides* (M.Bieb. ex Sims) Bornm.	Campanulaceae	**herb. perennial, biennial, annual (genus)[2]**	·	x	NE	accepted name
12	*Campanula bellidifolia* Adam	*Campanula bellidifolia* Adam	Campanulaceae	herb. perennial[1,2]	6	x	NT	accepted name
13	*Campanula albovii* Kolak.	*Campanula collina* subsp. *sphaerocarpa* (Kolak.) Ogan.	Campanulaceae	herb. perennial with underground runners[1] (*C. collina*)	·	·	DD; LC	old & accepted name
14	*Campanula dzyschrica* Kolak.	*Campanula dzyschrica* Kolak.	Campanulaceae	**herb. perennial, annual, biennial (genus)[2]**	·	·	VU D2	accepted name
15	*Campanula trautvetteri* Grossh. ex Fed.	*Campanula glomerata* subsp. *caucasica* (Trautv.) Ogan.	Campanulaceae	herb. perennial with rhizome[1] (*C. glomerata*)	·	x	DD; NE	old & accepted name
16	*Campanula hypopolia* Trautv.	*Campanula hypopolia* Trautv.	Campanulaceae	**herb. perennial, annual, biennial (genus)[2]**	·	·	NE	accepted name
17	*Campanula kolakovskyi* Kharadze	*Campanula kolakovskyi* Kharadze	Campanulaceae	**herb. perennial, annual, biennial (genus)[2]**	·	·	VU D2	accepted name
18	*Campanula mirabilis* Albov	*Campanula mirabilis* Albov	Campanulaceae	biennial[2]	·	·	DD	accepted name
19	*Campanula paradoxa* Kolak.	*Campanula paradoxa* Kolak.	Campanulaceae	**herb. perennial, annual, biennial (genus)[2]**	·	·	VU D2	accepted name
20	*Campanula doluchanovii* Kharadze	*Campanula saxifraga* subsp. *argunensis* (Rupr.) Ogan.	Campanulaceae	herb. perennial[1,2] (*C. saxifraga*)	·	·	DD; NE	old & accepted name
21	*Campanula biebersteiniana* Schult.	*Campanula tridentata* subsp. *biebersteiniana* (Schult.) Ogan.	Campanulaceae	herb. perennial[1,2] (*C. biebersteiniana, C. tridentata*)	·	·	NE	*old & accepted name (indicated as synonyms)*
22	*Cerastium ponticum* Albov	*Cerastium ponticum* Albov	Caryophyllaceae	**herb. perennial, biennial, annual, semi-shrub (genus)[2]**	·	·	VU C2ab(i)	*accepted name*
23	*Cirsium pugnax* Sommier & Levier	*Cirsium pugnax* Sommier & Levier	Asteraceae	**annual, biennial, herb. perennial semi-shrub (genus)[2]**	·	x	LC	*accepted name*
24	*Corydalis emanueli* C.A.Mey.	*Corydalis emanueli* C.A.Mey.	Papaveraceae	**annual, herb. perennial, partly climbing (genus)[2]**	·	·	LC	*accepted name*
25	*Cyclamen abchasicum* (Medw.) Kolak. ex Pobed.	*Cyclamen coum* subsp. *caucasicum* (K.Koch) O.Schwarz	Primulaceae	herb. perennial with tuber[1] (*C. coum*)	6, 1 cult	·	NT	*old name*
26	*Delphinium speciosum* M.Bieb.	*Delphinium speciosum* M.Bieb.	Ranunculaceae	herb. perennial[3]	·	·	NE	*accepted name*
27	*Dianthus abchasicus* Gvin.	*Dianthus abchasicus* Gvin.	Caryophyllaceae	**herb. perennial, annual, biennial, shrub (genus)[2]**	·	·	VU D2	*accepted name*
28	*Dianthus imereticus* (Rupr.) Schischk.	*Dianthus imereticus* (Rupr.) Schischk.	Caryophyllaceae	**herb. perennial, annual, biennial, shrub (genus)[2]**	·	·	NT	*accepted name*
29	*Dioscorea caucasica* Lipsky	*Dioscorea caucasica* Lipsky	Dioscoreaceae	herb. perennial with tuber[1]	3	·	EN B2ab(ii,iii)	accepted name
30	*Dolichorrhiza renifolia* (C.A.Mey.) Galushko	*Dolichorrhiza renifolia* (C.A.Mey.) Galushko	Asteraceae	herb. perennial (genus *Ligularia*)[2]	·	x	NT	accepted name
31	*Epimedium colchicum* Boiss. (Trautv.)	*Epimedium pinnatum* subsp. *colchicum* (Boiss.) N.Busch	Berberidaceae	herb. perennial with rhizome[1]	51	·	NT	old & accepted name (indicated as synonyms)
32	*Fritillaria collina* Adams	*Fritillaria collina* Adams	Liliaceae	herb. perennial with bulb[1]	·	x	NE	accepted name
33	*Fritillaria latifolia* Willd.	*Fritillaria latifolia* Willd.	Liliaceae	herb. perennial with bulb[1]	1	x	NE	accepted name
34	*Galanthus lagodechianus* Kem.-Nath.	*Galanthus lagodechianus* Kem.-Nath.	Amaryllidaceae	herb. perennial with bulb[2]	·	·	NE	accepted name
35	*Galanthus platyphyllus* Traub & Moldenke	*Galanthus platyphyllus* Traub & Moldenke	Amaryllidaceae	herb. perennial with bulb[2]	·	·	NT	accepted name
36	*Galanthus woronowii* Losinsk	*Galanthus woronowii* Losinsk	Amaryllidaceae	herb. perennial with bulb[2]	1	·	NE	accepted name
37	*Gentiana rhodocalyx* Kolak., *G. paradoxa* Albov	*Gentiana paradoxa* Albov	Gentianaceae	herb. perennial[1,2]	6	·	DD; VU B1ab(i)+2ab(i)	both
38	*Geranium psilostemon* Ledeb.	*Geranium psilostemon* Ledeb.	Geraniaceae	herb. perennial with rhizome[1]	34, 6 cult	·	NE	accepted name
39	*Gymnospermium smirnovii* (Trautv.) Takht.	*Gymnospermium smirnovii* (Trautv.) Takht.	Berberidaceae	herb. perennial with tuber (genus)[2]	·	·	EN B1ab(ii,iii,v)+2ab(ii,iii,v)	accepted name
40	*Hedysarum caucasicum* M.Bieb.	*Hedysarum caucasicum* M.Bieb.	Leguminosae	herb. perennial with taproot pleiocorm[1] (*H. hedysaroides*)	·	x	DD	accepted name
41	*Heracleum asperum* M.Bieb.	*Heracleum asperum* M.Bieb.	Apiaceae	biennial/ herb. perennial[2]	·	x	NE	accepted name
42	*Heracleum mantegazzianum* Sommier & Levier	*Heracleum mantegazzianum* Sommier & Levier	Apiaceae	biennial/ herb. perennial[2]	·	x	LC	accepted name
43	*Heracleum sosnowskyi* Manden.	*Heracleum sosnowskyi* Manden.	Apiaceae	biennial/ herb. perennial[2]	·	x	NE	accepted name
44	*Iris iberica* Hoffm.	*Iris iberica* Hoffm.	Iridaceae	**herb. perennial with rhizome, bulb or tuber (genus)[2]**	1	·	NE	accepted name
45	*Iris paradoxa* Steven	*Iris paradoxa* Steven	Iridaceae	**herb. perennial with rhizome, bulb or tuber (genus)[2]**	2	·	NE	accepted name
46	*Kemulariella abchasica* (Kem.-Nath.) Tamamsch.	*Kemulariella abchasica* (Kem.-Nath.) Tamamsch.	Asteraceae	**herb. perennial, annual, biennial, semi-shrub, shrub (genus *Aster*)[2]**	·	·	VU B!ab(ii,iii)+2ab(ii,iii)	accepted name
47	*Kemulariella tugana* (Albov) Tamamsch.	*Kemulariella tugana* (Albov) Tamamsch.	Asteraceae	**herb. perennial, annual, biennial, semi-shrub, shrub (genus *Aster*)[2]**	·	·	LC	accepted name
48	*Cicerbita macrophylla* (Willd.) Wallr.	*Lactuca macrophylla* (Willd.) A.Gray	Asteraceae	herb. perennial[2]	·	·	NE	old name
49	*Lilium kesselringianum* Miscz.	*Lilium kesselringianum* Miscz.	Liliaceae	herb. perennial with bulb[1,2]	·	·	NE	accepted name
50	*Lilium georgicum* (Manden.)	*Lilium monadelphum* M. Bieb.	Liliaceae	herb. perennial with bulb[1,2]	3	x	DD	*L. monadelphum* subsp. *georgicum*
51	*Lilium szovitsianum* Fisch. & Avé-Lall.	*Lilium szovitsianum* Fisch. & Avé-Lall.	Liliaceae	herb. perennial with bulb[1,2]	·	x	NE	accepted name
52	*Muscari dolichanthum* Woronow & Tron	*Muscari dolichanthum* Woronow & Tron	Asparagaceae	herb. perennial with bulb[2]	·	·	VU B2ab(ii,iii); C2a(i)	accepted name
53	*Omphalodes cappadocica* DC.	*Omphalodes cappadocica* DC.	Boraginaceae	herb. perennial with rhizome[1]	19, 4 cult	·	LC	accepted name
54	*Omphalodes kusnetzovii* Kolak.	*Omphalodes kusnetzovii* Kolak.	Boraginaceae	**annual, biennial, herb. perennial (genus)2**	·	·	DD	accepted name
55	*Paeonia caucasica* (Schipcz.) Schipcz.; *P.*	*Paeonia daurica* subsp. *coriifolia* (Rupr.) D.Y.Hong	Paeoniaceae	herb. perennial[1,2] (*P. mascula* subsp. *triternata*)	3	·	LC; EN B1ab(iii,v)+2ab(iii,v)	both old names, not the
56	*Paeonia macrophylla* (Albov) Lomakin; *P. steveniana*	*Paeonia daurica* subsp. *macrophylla* (Albov) D.Y.Hong	Paeoniaceae	herb. perennial[1,2] (*P. mascula* subsp. *triternata*)	·	·	VU B1ab(iii,v); EN	both old names, not the
57	*Paeonia mlokosewitschii* Lomakin	*Paeonia daurica* subsp. *mlokosewitschii* (Lomakin) D.Y.Hong	Paeoniaceae	herb. perennial[1,2]	25	·	VU B1ab(iii,v)+2ab(iii,v)	old name
58	*Paeonia lagodechiana* Kem.-Nath.	*Paeonia lagodechiana* Kem.-Nath.	Paeoniaceae	herb. perennial[1,2] (*P. mascula* subsp. *triternata*)	2	·	NT	accepted name
59	*Primula amoena* M. Bieb.	*Primula amoena* M. Bieb.	Primulaceae	herb. perennial with rhizome[1] (*P. elatior*)	2	x	NE	accepted name
60	*Primula bayernii* Rupr.	*Primula bayernii* Rupr.	Primulaceae	**herb. perennial, annual (genus)[2]**	·	·	NT	accepted name
61	*Primula darialica* Rupr.	*Primula darialica* Rupr.	Primulaceae	herb. perennial[2]	4	·	VU B2ab(ii,iii,v)	accepted name
62	*Primula juliae* Kusn.	*Primula juliae* Kusn.	Primulaceae	herb. perennial with rhizome[1]	21, 8 cult	·	EN B1ab(ii,iii)	accepted name
63	*Primula megaseifolia* Boiss.	*Primula megaseifolia* Boiss.	Primulaceae	herb. perennial[1,2]	·	·	NE	accepted name
64	*Primula woronowii* Losinsk.	*Primula woronowii* Losinsk.	Primulaceae	herb. perennial with rhizome[1] (*P. vulgaris*)	·	x	NE	accepted name
65	*Centaurea abchasica* (Albov) Sosn.	*Psephellus abchasicus* Albov	Asteraceae	**annual, herb. perennial, semi-shrub (genus)[2]**	·	·	VU B1ab(ii,iii)+2ab(ii,iii)	accepted name
66	*Centaurea barbeyi* (Albov) Sosn.	*Psephellus barbeyi* Albov	Asteraceae	**annual, herb. perennial, semi-shrub (genus)[2]**	·	·	VU B1ab(ii,)+2ab(ii)	accepted name
67	*Centaurea dealbata* Willd.	*Psephellus dealbatus* (Willd.) K.Koch	Asteraceae	herb. perennial with pleiocorm[1]	46, 1 cult	x	NE	accepted name
68	*Pulsatilla georgica* Rupr.	*Pulsatilla violacea* Rupr.	Ranunculaceae	herb. perennial with pleiocorm[1] (*P. albana*)	1	x	EN B1ab(iii,v)+2ab(iii,v); NE	old & accepted name
69	*Ranunculus suukensis* N. Busch	*Ranunculus suukensis* N. Busch	Ranunculaceae	**herb. perennial, annual (genus)[2]**	·	·	NT	accepted name
70	*Salvia garedjii* Troitzky	*Salvia garedjii* Troitzky	Lamiaceae	**herb. perennial, annual, shrub, semi-shrub (genus)[2]**	·	·	VU B1ab(v)+2ab(v)	accepted name
71	*Scilla mischtschenkoana* Grossh.	*Scilla mischtschenkoana* Grossh.	Asparagaceae	herb. perennial with bulb[1]	12	·	NE	accepted name
72	*Sempervivum pumilum* M.Bieb.	*Sempervivum pumilum* M.Bieb.	Crassulaceae	herb. perennial (succulent)[2]	4, 1 cult	x	NE	accepted name
73	*Betonica abchasica* (N.P.Popov ex Grossh.) Chinth.	*Stachys abchasica* (N.P.Popov ex Grossh.) Czerep.	Lamiaceae	herb. perennial[1] (*St. nivea*)	·	·	VU B1ab(iii,v)+2ab(iii,v)	old name
74	*Swertia iberica* Fisch. ex Boiss.	*Swertia iberica* Fisch. ex Boiss.	Gentianaceae	herb. perennial[4]	·	x	NE	accepted name
75	*Symphytum grandiflorum* DC.	*Symphytum grandiflorum* DC.	Boraginaceae	herb. perennial with underground runners[1]	51, 9 cult	·	LC	accepted name
76	*Pyrethrum marionii* Albov	*Tanacetum marionii* (Albov) K.Bremer & Humphries	Asteraceae	**herb. perennial, rarely annual or semi-shrub (genus)[2]**	·	·	LC	accepted name
77	*Pachyphragma macrophyllum* (Hoffm.) N.Busch	*Thlaspi macrophyllum* Hoffm.	Brassicaceae	herb. perennial[2]	2	·	NE	old name
78	*Veronica minuta* C. A. Mey	*Veronica telephiifolia* Vahl	Plantaginaceae	herb. perennial[2]	4	·	LC; LC	old & accepted name
79	*Woronowia speciosa* (Albov) Juz.	*Woronowia speciosa* (Albov) Juz.	Rosaceae	herb. perennial (genus *Geum*)[2]	·	·	NE	accepted name

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