European Plant Diversity in the Global Context

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The distribution of plant diversity across the Earth is highly uneven (Barthlott et al., 2005, Kier et al., 2005, Mutke & Barthlott, 2005, Figure **1**). For instance, the small South American country of Ecuador which has a surface area comparable to the British Isles harbours some 30-40 percent more species than continental Europe.

Generating a world map of plant diversity

Plant diversity is documented in thousands of inventories such as floras and checklists world-wide. Based on this literature, we compiled a dataset with numbers of native plant species of c. 3,000 operational units such as countries, provinces, islands, mountain ranges, and conservation areas. As these units differ very much in area, only a subset of c. 1,400 of these was used for our mapping approach. Species richness figures of the selected units were standardized using classical models of the relation of area and species richness. To interpolate between areas with suitable raw data, additional datasets of environmental parameters have been used (Barthlott et al., 2005, Mutke & Barthlott, 2005, Figure **1**). The same dataset was the basis for further macroecological analyses (e.g. Mutke & Barthlott, 2005, Kreft & Jetz 2007, Figures **2**, **4**),

Global Centres of plant diversity

Global centres of species richness are located in the humid tropics and subtropics, especially in areas with a high heterogeneity of the abiotic environment ('geodiversity') like mountains and regions of steep climatic gradients. Five global centres of plant species richness reach species densities of more than 5,000 vascular plant species per 10,000 km² (compare Table **1**, Figure **1**). In total, there are 20 centres of plant diversity with more than 3,000 species per 10,000 km². Important extra-tropical centres are the Mediterranean-type climate areas of the world with hot and dry summers and cool, wet winters: the Mediterranean Basin, California, central Chile, the South African Cape Region, and South and Southwest Australia. These regions are characterized by comparatively diverse and highly endemic floras and are considered as Biodiversity Hotspots by Conservation International.

High numbers of endemic species can be found on the oceanic islands of the world. Some 70,000 species of vascular plants or 20 % of the world's flora are endemic to islands – thus, occurring nowhere else (Kreft et al., 2008).

Environmental and historical controls of plant diversity

Plant richness changes systematically along environmental and latitudinal gradients (Mutke & Barthlott, 2005, Kreft & Jetz, 2007, Figure **2**).

At high latitudes, where temperature and the length of the thermal vegetation period are limiting factors, species richness is closely correlated with measures of thermal energy like potential evapotranspiration (PET). On the other hand, water availability and the spatial heterogeneity of the environment appear to be more important at lower latitudes (Kreft & Jetz, 2007, compare Figure **4**). In addition to richness-environment relationships, the regional history of the environment, especially of the climate, has considerably influenced today's diversity patterns. Due to severe impacts of the harsh climate during the ice ages, the woody plant flora of Central Europe is highly impoverished compared to similar vegetation in East Asia or eastern North America. The same holds true for the number of native vascular plant families in Europe (169) which is much lower as compared to North America (excl. Mexico: 210) or China (260).

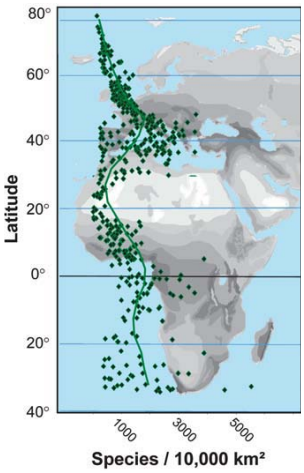

Figure 2. Latitudinal gradient of vascular plant diversity in Europe and Africa. Each dot represents the number of native plant species of a geographic unit (e.g. flora, checklist). Species numbers were standardized for disparities in area size (modified from Mutke & Barthlott 2005).

European plant diversity

Europe is home to some 11,500 of the estimated 320,000 vascular plant species on earth. The Flora Europaea lists c. 10,600 flowering plants, c. 160 of the c. 13,000 global fern species, and c. 40 of c. 1,000 species of gymnosperms. While these species numbers are much lower than those of the top global centres of plant diversity listed in Table **1**, parts of the European mountain regions or the Mediterranean show a level of richness comparable with, e.g., tropical Africa (Figure **2**).

The non-vascular plant flora of Europe is relatively well documented compared to many other regions. It harbours more than 30,000 documented species of bryophytes, algae, fungi, and lichens. Especially for algae and fungi, there are still many species to be discovered.

On a European scale, highest species richness can be found in the Mediterranean and the Caucasus. Especially the geodiverse mountainous areas surrounding the Mediterranean like the Balkans region, the Alps, the Pyrenees and the mountain ranges of SE Spain are important centres of plant species richness and endemism (Araújo et al., 2005). The Balkan, the Iberian Peninsula, and Italy have been

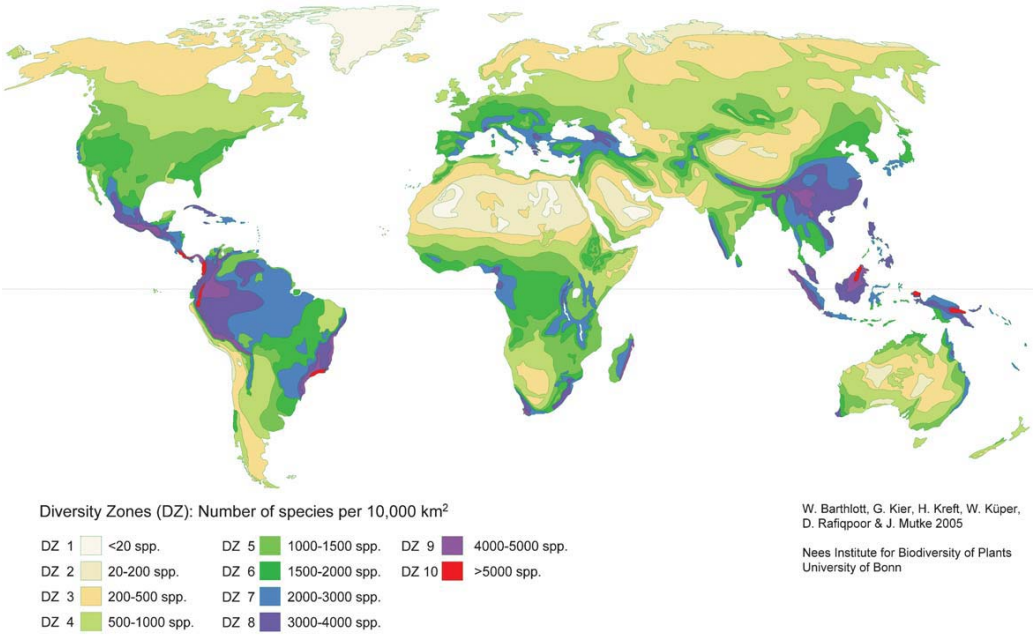

Figure 1. World map of species richness of vascular plants (Barthlott et al. 2005, Mutke & Barthlott, 2005). The map is based on species richness figures for c. 1,400 geographical units word-wide.

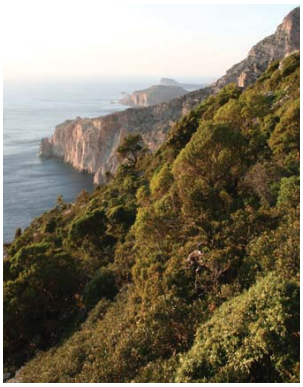

Figure 3. Global and European Centres of Plant Diversity: Tropical Andes, Caucasus, South African Cape Region, Mediterranean. Photos: Nils Köster, Jens Mutke.

Table 1. Global and European Centres of Plant Diversity (modified after Barthlott et al., 2005).

	Centre	Area (km²)	Total spp.	Endemism		Percent protected
				spp.	%	
The top 5 Global Centres of Plant Diversity						
1	Costa Rica-Chocó	78,000	≥ 12,500	5,500	44%	18,8%
2	Tropical Eastern Andes	62,000	10,000	3,000	30%	19,1%
3	Atlantic Brazil	50,000	≥ 6,000	4,500	75%	6,3%
4	Northern Borneo	57,000	9,000	3,500	39%	7,7%
5	New Guinea	87,000	≥ 6,000	2,000	33%	1,8%
European Centres of Plant Diversity						
	Mediterranean basin	2,085,000	22,500	11,700	52%	4,3%
	Caucasus	440,000	6,400	1,600	25%	2,8%
	Alps	200,000	5,500	350	6%	23 %

important refugia where many plant species survived during the ice ages.

Especially the Mediterranean is a centre of origin of important crop species including grape vine (*Vitis vinifera*), beet (*Beta vulgaris*), carrot (*Daucus carota*), rape seed (*Brassica napus*), and the garden pea (*Pisum sativum*). The laurel tree (*Laurus nobilis*) and the olive tree (*Olea europaea*) are characteristic plants of the region. Several important species of spices are native to the Mediterranean, such as marjoram, rosemary, thyme, or sage.

Priorities for nature conservation

Major drivers of biodiversity loss at the global scale are habitat conversion, over-exploitation, pollution, invasive species, and climate change as documented by the Millennium Ecosystem Assessment published in 2005 under the leadership of the UN Environmental Program (UNEP). At the European level, habitat loss has highest importance, mostly due to intensification of agriculture, urbanisation, and infrastructure development.

Although only the Mediterranean basin and the Caucasus belong to centres of plant species richness at the global scale, Europe houses a large amount of specific and unique biological diversity. Vegetation types like the "European-Mediterranean montane mixed forests", the "Caucasus mixed forests", and the "Fenno-Scandia alpine tundra and taiga" have been selected as priority regions for the Global 200 Ecoregions by the WWF. Some 3,500 vascular plant species are endemic to Europe, occurring nowhere else. Typical vegetation such as European beech forests, bogs, and species rich grasslands plays an important role for ecosystem functioning and provide crucial ecosystem services. This includes essential ecological functions such as nutrient cycling, provision of clean water, wood, and genetic resources, but also the recreational and aesthetic values of our landscapes and their biological diversity. Due to the long history of human settlement and agriculture in Europe, specifically adapted ecosystems have developed. Nature conservation in these mosaic-like landscapes has therefore to integrate forms of traditional extensive agriculture as well. Good knowledge about our flora and fauna, well trained conservation managers and staff, a good infrastructure, and a comprehensive political framework are the basis for effective nature conservation in Europe.

As global action is needed to tackle the challenges of the different aspects of global environmental change, European countries are needed as promoters for effective conservation and management of the environment. Additionally, in a globalized economy, all decisions and actions may also have important impacts on other continents. Thus, the conservation of our environment, landscapes, and biological diversity not only has an important impact on the well-being of Europeans, but on a global scale, as well.

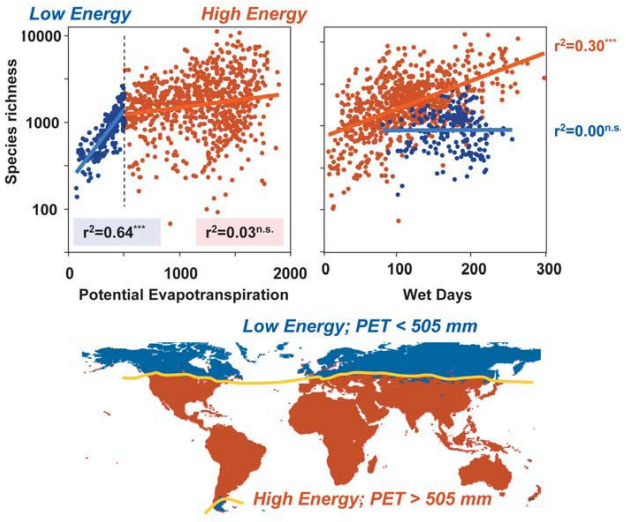

Figure 4. Global relationship between environmental predictors and species richness of vascular plants in low-energy regions (blue dots) and high-energy regions (red dots). Each dot represents one of more than 1,000 geographic regions for which species numbers have been derived from the literature. In regions with low thermal energy (PET < 505 mm) a close relationship with species richness is observed. In contrast, PET is a non-significant predictor in high-energy regions where water availability is a strong predictor (modified from Kreft & Jetz, 2007)

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Figure 5. Complex species rich central European landscapes including human land use and semi-natural vegetation in the Mosel valley, Germany and north of Budapest, Hungary.