



Towards an Excursion Flora for Austria and all the Eastern Alps

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ABSTRACT: This is on the one hand an announcement of the two-volume Fourth Edition of the Excursion Flora for Austria expanded by also including the remaining parts of the Eastern Alps (**chapter 1**), and on the other hand a rough survey of the flora of the Eastern Alps in connection with the main vegetation types (**chapter 2**). The geographical scope includes, besides Austria, the entire Eastern Alps from the Rhine valley in E Switzerland (Grisons) to the Vipava valley in SW Slovenia. Volume 1 mainly contains comprehensive introductory chapters like introductions to plant morphology, taxonomy, and nomenclature, as well as a sketch of ecomorphology and habitat ecology, a survey of vegetation types (phytosociology) and floristic peculiarities of the different natural regions, a rough history of floristic research, a detailed glossary including the meaning of epithets, etc., and drawings of several plant species characteristic of the flora covered. The structure of the keys concentrated in volume 2 is explained: besides the descriptive traits, they include for each taxon comprehensive ecological and plant geographical data, as well as information about Red Lists of the countries involved, plant uses, and taxonomical problems. Genus names are given not only in German, but also in the Romansh (Rumantsch Grischun), Italian, and Slovenian languages. In **chapter 2**, some important chorotypes including endemics are characterised, and an overview of floristic diversity (lists of exemplary taxa) in accordance with the main and most characteristic vegetation types is presented.

KEYWORDS: flora, Alps, chorotypes, endemism, identification keys, Vienna diacritical method, vegetation.

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1 THE FOURTH EDITION OF THE AUSTRIAN EXCURSION FLORA

1.1 INTRODUCTION

1.1.1 Origin and history of the project. Up until 1994, Austrian botanists, florists, and teachers interested in the flora of their country had to use the Excursion Flora for Austria by FRITSCH (1922) – covering most of the Austrian part of the Austro-Hungarian Monarchy, but not the entire small Republic of Austria, and being taxonomically outdated and providing no ecological information – or to rely on more modern Floras of neighbouring countries.

The Excursion Flora by ADLER *et al.* (1994) presented dichotomous keys for all species found in the wild within the boundaries of Austria and also covered the most important cultivated species. It was mainly based on the catalogue (a flora without keys, but with distribution data) by JANCHEN (1956–1960, 1963–1966) and on the Central European checklist by GUTERMANN & NIKL-FELD (1973), the keys being influenced by Flora Europaea (TUTIN *et al.* 1964–1993) and several Floras of adjacent countries. The main authors were three floristic enthusiasts with myself a co-author and the editor. The book was well accepted and became the standard of Austrian floristics. The revised Second Edition was published in 2005. It extended the territory covered by including two neighbouring regions – the Principality of Liechtenstein and the Italian province of Bolzano-South Tyrol [Südtirol (this mainly German speaking “Autonome Provinz Bozen – Südtirol / Provincia Autonoma di Bolzano – Sudtirolo, Alto Adige” was up to 1919 part of Tyrol, Austria)]. The revised and updated Third Edition was published in 2008.

No Flora published so far adequately treats the Eastern Alps, as parts of HEGI’s huge Flora of Central Europe (First Edition 1908–1929) are much outdated, and the more recent editions (1936–2016) are still far from dealing with all families. The impressive “Flora Alpina” by AESCHIMANN *et al.* (2004) contains excellent photographs and ecological and distributional data, but does not provide determination keys. However, it was gratefully used by us for our Flora. The keys for “Excursion Flora of the Alps” by GÖTZ (2017), in the German language, are still not completed.

Austria’s boundaries – like almost any political borders – do not delimit plant geographical regions, but cut across the ranges of mountain species instead. This is inadequate for botanical study, as is evident when looking along the southern boundary with Slovenia and NE Italy (the Carnian Alps and Karawanken), where the ranges of local endemics like *Wulfenia carinthiaca* subsp. *carinthiaca* and *Leucanthemum lithopolitanicum*, each restricted to a single mountain, are cut by the borderline, which makes them elements of two states (Austria and Italy or Slovenia, respectively).

1.1.2 The Excursion Flora for Austria and the Entire Eastern Alps. In view of the situation outlined above, it was quite obviously necessary to expand our Austrian Flora to encompass the closely adjacent parts of the Alps, primarily those in the south (Italy and Slovenia) and also ones in the west (Grisons in Switzerland) and northwest (the Alps of Bavaria) in order to include the entire Eastern Alps.

Our new edition (FISCHER *et al.* in prep.) of ADLER *et al.* (1994) and FISCHER *et al.* (2005, 2008) attempts to be popular and user-friendly, but simultaneously scientific and as complete and informative as possible. This book tries to demonstrate that it is quite possible to achieve both those ends, since it is intended to be used by amateur botanists and floristic enthusiasts; by teachers in educational institutions, from schools to universities; by professional botanists and a wide range of zoologists and other naturalists; by “applied” botanists like foresters (sylviculturists), agriculturists, gardeners (horticulturists), pharmacists, and conservationists; by landscape ecologists, ethnobotanists, and geographers; and by anybody interested in nature and landscape, as well as linguists studying plant names. This ample scope of users calls for careful language, short but critical wording of the texts, and clear explanations of all technical terms used. Furthermore, didactic skills are needed to explain scientific botany at all. A Flora to be used by beginners and autodidacts as well as by highly trained professionals is obliged to raise interest in the study not only of plants, but also of the whole complex world of botany as part of scientific biology.

Our Excursion Flora will consist of two volumes and is planned to be published in 2019. Volume 1 contains general information about morphology, taxonomy, ecology, geography, vegetation, nature conservancy, etc. (see 1.1.4 below); volume 2 contains the keys, the glossary and a combined index of Latin and German names.

1.1.3 General objectives and uses of an excursion flora.

What is a Flora and what is an excursion Flora? By tradition, both are limited to vascular plants, i.e., they do not treat algae, mosses, and liverworts. Excursion Floras are smaller and more concise than “full” Floras, which usually comprise several volumes, like “Flora Europaea” by TUTIN *et al.* (1964–1993); “Flora d’Italia” by PIGNATTI (1982, 2017); “Flora der Schweiz” by HESS *et al.* (1976–1980); “Květěna České Republiky” by HEJNÝ & SLAVÍK (1988, 1990, 1992), SLAVÍK (1995, 1997, 2000), SLAVÍK & HEJNÝ (2004), and ŠTĚPÁNKOVÁ & HEJNÝ (2010) – all of which were used for our Flora –, “Flora Srbije” by JOSIFOVIĆ (1970–1977), and by SARIĆ (1992); and “Flora Hellenica” by STRID & TAN (1997–2002). On the other hand, they may consist of only one volume, like the “New Flora of the British Isles” by STACE (2011), which is something of a hybrid with an excursion Flora. Checklists or catalogues (“enumerationes”) (e.g., WILHALM *et al.* 2006;

HOHLA *et al.* 2009) contain little or no information beyond the plant names.

An excursion Flora, however, is much more comprehensive than a field guide, which often mainly contains colour photographs and short descriptions (“Steckbriefe”) for a selection of common or important and/or showy species. A beautiful example of a “triple-hybrid” between an excursion Flora, a field guide, and a full Flora is the two-volume “Flora Helvetica” by LAUBER *et al.* (2012), which contains excellent photos and a separate, though very short key and was used by us as a source for distributions in Grisons. Typical excursion Floras are those created by W. Rothmaler (ROTHMALER & JÄGER 2011, 2016) for Germany and by MARTINČIČ *et al.* (2007) for Slovenia, while that of MAYER (2015) for Italy is a considerably bigger and heavier example (deviating in this respect). Usually single-volumed, excursion Floras provide no colour photos or drawings of complete plants, but rather only illustrations of selected characters helpful for identification. Moreover, they include neither family nor genus descriptions, no distribution maps, no references or nomenclatural details. Keys and species descriptions are not separate, but combined. However, they treat the flora completely, down to the level of subspecies. Also, a typical excursion Flora fits into a rucksack.

1.1.4 Aims and intention of our flora. Although some users of identification keys may be interested in plant names only, a good Flora, even an excursion Flora, is obliged to provide connections to almost all fields of botany and general biology. Our Flora tries to offer a synthesis of botanical knowledge of our territory. Besides phytography (descriptive terminology), a deeper knowledge of plants implies familiarity not only with comparative morphology, anatomy, karyology, taxonomy (including molecular), evolution, pollination ecology, synecology (including phytocoenology), chorology (plant geography, phylogeography), phytochemistry, and ecophysiology, but also with pedology, geology, plant physiology (C₄-photosynthesis!), and the history of botany (in connection with nomenclature). These scientific fields are treated in the overall characterisations of individual genera and species (as exemplified below) and in the general introductory chapters and appendices. Identifying plants must not be isolated from botany, which means that descriptive botany should be linked to scientific “deep” morphology and other pertinent fields. Thus, the whole of botany is focused in each plant species, because its name is just the least relevant item. Flora writers must be skilful teachers of botany and as such try to arouse or intensify love and understanding of our green world.

In this respect, the introductory chapters play an important role and will be enlarged in comparison with the Third Edition. They will contain (a) introductions to

taxonomy and evolutionary systematics, discussions on traditional and molecular taxonomy, and (b) scientific Latin nomenclature and naming in national languages, including vernacular names. A main chapter deals with (c) phytography (descriptive terms), morphology (scientific, comparative), and karyology (meaning chromosome numbers). Further chapters concentrate on (d) ecomorphology, including pollination biology and flower fragrance (information about which is provided by an expert); (e) the study of plant ranges (chorotypes), flora statistics, and plant species mapping; (f) principles of vegetation science (ecology, coenology); (g) an overview of the vegetation of Austria and the Eastern Alps; (h) floristic and ecological characterisations of the natural regions within the study area; (i) nature conservancy and flora change; (j) a review of the history of floristic research in Austria and the adjacent included countries; (k) advice on how to use the book and how to collect plants and prepare a herbarium. As supplements, a “vegetative” key for identification without flowers (l) and a “winter key” (m) will enable the user to identify woody species from their buds and bark. Moreover, such supplements will contain a survey of the vascular plant system accepted, as opposed to former, traditional systems (n); references to other floras and taxonomic, phytogeographic, etc., literature (o); a detailed glossary of all technical terms used in the book (p); translations of Latin epithets (q); translations of specific Austrian-German words used (*Austriacisms*) (r); and an index of the Latin, German, Romansh, Italian, and Slovenian plant names used (s). Some drawings of whole plants, preferably endemic ones, will also be provided.

In order to realise this, it becomes necessary – in contrast to the Third Edition – to put these general sections in a separate volume (vol. 1), since the main second volume containing all the keys will cover about 1400 pages, which seems to us a maximum for a pocket flora (thin paper taken for granted). Of course, all the introductory general keys leading to the families, together with the genus, species and subspecies keys, must be united within one volume (vol. 2), along with the glossary and index of names.

For the beginner, the identification process starts (in the volume containing the keys) with several “main keys” that eventually lead to the families. For each family, a genus key leads to the genera, and species keys to the species and subspecies. In addition to the text, the keys in our Excursion Flora are accompanied by drawings of characters less easily described in words. We deliberately do not present colour photographs because there are many sources containing excellent photos of the flowering parts in popular books and readily available on the internet. However, it is risky to use such photos for plant determination because they usually neglect vegetative plant parts and do not show variation. Thus, different species sometimes look alike and pictures showing dif-

ferences in fact depict the same species. Although they are tempting, pictures can therefore lead the reader astray. Exact determinations made only by looking at pictures are near to impossible.

1.1.5 Authors and collaborators. Three main authors were responsible for production of the keys: myself, together with Wolfgang ADLER and Karl OSWALD, my co-authors from the First Edition, both amateur botanists to whom the honorary title of professor has been awarded for their contributions to botany. Additionally, we enjoyed the support of many professional and a few amateur colleagues, some of whom should be mentioned here: Gregor DIETRICH (Tulln; water plants, cultivated plants, escapees), Franz G. DUNKEL (Karlstadt; *Ranunculus auricomus* agg.), Peter ENGLMAIER (Vienna; Poaceae, *Batrachium*, neophytes), Franz ESSL (Vienna; neophytes), Božo FRAJMAN (Innsbruck, *Euphorbia*, *Knautia*, phylogeography), Sigurd E. FRÖHNER (Dresden; *Alchemilla*), Günter GOTTSCHLICH (Tübingen; *Hieracium* and *Pilosella*), Thomas GREGOR [Schlitz (Germany); Characeae], Wolfgang GREGOR (Vienna; *Rubus*), Josef GREIMLER (Vienna; *Dianthus*, *Gentianella*), Walter GUTERMANN (Vienna; alpine flora, general consultant for taxonomy and nomenclature), Michael HOHLA (Oberberg am Inn; Upper Austrian flora, neophytes), Nejc JOGAN (Ljubljana; Poaceae, flora of Slovenia), Arndt KÄSTNER (Halle/Saale; drawings), Wolfgang LIPPERT (Munich; *Alchemilla*, Bavarian flora), Alexander Ch. MRKVICKA (Vienna; *Rosa*), Harald NIKLFELD (Vienna; chorology, flora mapping), Norbert NOVAK (Vienna; Orchidaceae), Marie-Louise OSCHATZ (Vienna; flower scents), Konrad PAGITZ (Innsbruck; *Rubus*, neophytes), Filippo PROSSER (Rovereto; Italian flora), Romedi REINALTER (Ardez; flora of Engadin), Walter ROTTENSTEINER (Graz; Delphiniiinae), Johannes SAUKEL (Vienna; *Achillea*), Gerald M. SCHNEEWEISS (Vienna, *Alyssum*, *Androsace*, *Orobanchaceae*), Peter SCHÖNSWETTER (Innsbruck, *Phyteuma*, *Senecio* etc., phylogeography), Luise SCHRATT-EHRENDORFER (Vienna; conservancy, Red Lists), Oliver STÖHR (Lienz; Pteridophytes, East Tyrol), Herwig TEPPNER (Graz; *Onosma*, *Nigritella*), Thomas WILHALM (Bozen/Bolzano; South Tyrolian flora, Poaceae, neophytes), Johannes WALTER (Vienna; Chenopodiaceae, Amaranthaceae, Polygonaceae, neophytes), Wolfgang WILLNER (Vienna; vegetation ecology), and Ingo UHLEMANN (Dresden; *Taraxacum*).

1.1.6 Sources. There are several books on local floras (with or without distribution maps), e.g., JANCHEN (1977; Lower Austria and Northern Burgenland), SEITNER (1977; Liechtenstein), GRABHERR & POLATSCHKE (1986; Vorarlberg), WITTMANN *et al.* (1987; Salzburg: maps), ZIMMERMANN *et al.* (1989; Red Book of Styria), SCHÖNFELDER & BRESINSKY (1990; Bavaria: maps), PEER (1991, 1995; South Tyrol: vegetation maps), HARTL *et al.* (1992; Carinthia: maps), BERNHARD (1994–2002; Liech-

tenstein: vegetation), MAURER (1996–2006; Flora of Styria with keys), POLATSCHKEK (1997, 1999, 2000, 2001) and MAIER *et al.* (2001; Tyrol and Vorarlberg: records, maps), FENAROLI (1998; Italian Alps), JOGAN (2001; Slovenia: maps), POLDINI (2002, Friuli: maps), BERNHARD & BORGMANN (2002; Liechtenstein: vegetation), ADLER & MRKVICKA (2003; Vienna), REINALTER (2004; Engadin), ARGENTI & LASEN (2004; prov. Belluno), BRANDES & GATTO (2005; Monte Baldo), ROSSI & GIACOMINI (2005; mount Grigna), CONTI (2005; Italia), WILHALM *et al.* (2006; South Tyrol), MARTINČIČ *et al.* (2007; Slovenia), HOHLA *et al.* (2009; Upper Austria), PROSSER *et al.* (2009; Monte Baldo), BERGER & EHRENDORFER (2011; Vienna: landscape, ecosystem, biocoenoses), LAUBER *et al.* (2012; Switzerland), MARTINI *et al.* (2012; part of Lombardy: provinces Bergamo and Brescia), POLATSCHKEK & NEUNER (2013a, b; Tyrol and Vorarlberg: records, maps), LIPPERT & MEIEROTT (2014; checklist of Bavaria), PIGNATTI & PIGNATTI (2014, 2017; Dolomites), AMANN (2016; Vorarlberg: Red List), and SCORTEGAGNA *et al.* (2016; Vicenza). – We also tried to consult primary taxonomic and floristic literature as much as possible, among many others, FENAROLI (1954), TITZ (1972), PROSSER & SCORTEGAGLIA (1998), FRAJMAN *et al.* (2016). – Some popular books and regional or local field guides are WRABER (1990, 2006; Slovenian Alps), COSTANTINI & DE KOCK (1993; Mt. Baldo), PEER (2001; South Tyrol), WALDBURGER *et al.* (2003; Liechtenstein), WALDBURGER & STAUB (2006; Liechtenstein), FISCHER & FALLY (2006; Burgenland), HOLZNER (2013–2015; Lower Austria), HARTL *et al.* (2014; Hohe Tauern), and GRABHERR *et al.* (2016; Vorarlberg). Internet web sites such as Flora of Bavaria (<http://daten.bayernflora.de/de/index.php> = <http://wiki.bayernflora.de/web/>) and FloraWeb (<http://www.floraweb.de/index.html>) should also be mentioned.

Current distribution data were provided by the Austrian Floristic Mapping Scheme (H. NIKLFELD & L. SCHRATT-EHRENDORFER and collaborators at the University of Vienna). Additionally, of course, manuals like MEUSEL *et al.* (1965a, b, 1968a, b), MEUSEL & JÄGER (1992a, b), and STAUDINGER *et al.* (2009; Austrian endemics) were consulted, as well as internet sources, particularly the Plant Distribution Atlas of South Tyrol (<http://www.florafaua.it/>), “info flora” of Switzerland (<https://www.infoflora.ch/de/flora/art-abfragen.html>), etc.

Important contributions to study of the vegetation of Austria and the Eastern Alps are a vegetation map of Austria by WAGNER (1971, 1985), floristic maps and analyses by NIKLFELD (1973a, b, 1979), an introductory survey on flora and vegetation geography (NIKLFELD 1993), several biodiversity analyses of Austria (BORSORF 2005; ESSL *et al.* 2008; NIKLFELD *et al.* 2008; SAUBERER & DULLINGER 2008), a significant forest coenology of the Eastern Alps (MAYER 1974), a book on the hemeroby of Austrian forest communities (GRABHERR *et al.* 1998),

catalogues of biotope types (ESSL *et al.* 2002; AIGNER *et al.* 2004; TRAXLER *et al.* 2005; ESSL *et al.* 2015), a catalogue of the syntaxa of Austria by MUCINA *et al.* (1993a, b), GRABHERR & MUCINA (1993), and its emendation pertaining to forests by WILLNER & GRABHERR (2007), which also presents an identification key for forest communities. Some regional and local vegetation studies in Austria include SCHIECHTL & STERN (1975–1982, 1985), HARTL *et al.* (2001), and several studies on the Italian Alps, e.g., PIGNATTI & PIGNATTI (2014, 2017) on the Dolomites.

In order to provide up-to-date information on distribution and taxonomy, several botanical journals were consulted besides international taxonomic ones like Taxon, Botanical Journal of the Linnean Society (Reading), Willdenowia, etc. Among the most important of them for our region: Acta ZooBot Austria (Vienna), Alpine Botany (Botanica Helvetica, Heidelberg), Annalen des Naturhistorischen Museums Wien (Wien), Berichte der Bayerischen Botanischen Gesellschaft (München), Berichte der Botanisch-Zoologischen Gesellschaft Liechtenstein-Sargans-Werdenberg (Vaduz), Carinthia II (Klagenfurt), Folia Geobotanica (Prague), Gredleriana (Bozen), Hacquetia (Ljubljana), Hladnikia (Ljubljana), Joannea Botanik (Graz), Kochia (Berlin), Neilreichia (Wien), Plant Diversity and Evolution (Botanische Jahrbücher, Stuttgart), Preslia (Prague), and Stapfia (Linz).

Study of living plants as well as herbarium specimens is of great importance. Virtually all our authors and collaborators are experienced field botanists with knowledge of the species in their living state.

The data in our Flora are partly based on many studies undertaken in preparing a comprehensive Flora of Austria, a small part of which has been published on the internet [“Wiki” Flora (http://www.flora-austria.at/flora_oesterreich.html)].

1.2 GEOGRAPHIC SCOPE

Six countries are involved (see Fig. 1): Austria (entirely, i.e., including regions outside the Alps in the east and north), Germany (the small southern edge), Liechtenstein (entirely), Switzerland (the easternmost part), Italy (the northeasternmost parts), and Slovenia (the northern and northwestern parts). The Austrian flora is composed of three main plant geographic elements: the Pannonian flora in the northeast, the Central European flora in lowlands and in the north, and the flora of the Alps, comprising most of the country. The area treated extends beyond Austria in the northwest, west, and south (see Fig. 1). Thus, besides Austria, it includes all of the German Alps (in S. Bavaria), ranging from the Allgäuer Alpen in the west to Mt. Untersberg close to the city of Salzburg in the east, continuing and completing the northern calcareous Austrian Alps of Salzburg, Tyrol, and Vorarlberg. The line dividing the Eastern from the Western



Fig 1. Physical map of the Eastern Alps. Red line: boundary of territory covered by the “Flora of Austria and all the Eastern Alps”; reddish-shaded broken lines: national borders. **A:** Pannonian region; **B:** rump mountains of gneiss and granite (“Bohemian Massif” of Mühlviertel and Waldviertel); **C:** lowlands of the “Northern Alpenvorland”; **D:** southeastern foothills of the Alps, eastern Styria and South Burgenland; **E:** Calcareous Northern Alps; **F:** Central Alps; **G:** Calcareous Southern Alps.

Alps is admittedly highly arbitrary, but quite traditional in geography: it runs from Lake Constance at the triangle where Austria, Switzerland, and Germany meet, moving southwards (upstream) along the Rhine river, in the northern part separating Austria and Liechtenstein from Switzerland, further south cutting through Canton Grisons (Graubünden) of Switzerland to pass Splügen (on the Swiss/Italian boundary), and farther through Italy along the rivers Liro and Mera to Lake Como and its eastern branch, following the river Adda down to the very edge of the mountains. In other words, the area of the Eastern Alps outside of Austria is bounded by a line running counter-clockwise between the cities Vienna – Salzburg – Bregenz – Vaduz – Chur – Lecco – Brescia – Verona – Vicenza – Gemona – Gorizia – Ljubljana – Maribor – (now within Austria:) Graz – Vienna.

The southern border of our flora closely follows the southern edge of the Alps – from the town of Lecco to

the town of Maribor, thus including all mountain ranges of the eastern Italian Alps from the Bergamascan Alps in the west to the Julian Alps in the east and covering all the Slovenian Alps from the Julian Alps eastwards to mount Pohorje. In political terms, Austria and Liechtenstein in their entirety are included, together with a small southern part of Germany, the easternmost part of Switzerland (the eastern part of Canton Grisons, i.e., that on the right-hand side of the Rhine river), the Italian autonomous provinces of South Tyrol (prov. Bozen/Bolzano) and Trento (Trentino), and the northern, mountainous parts of the Italian regions Lombardy, Veneto, and Friuli-Venezia Giulia, as well as the northwestern, mountainous parts of Slovenia. In Slovenia, deviating from the border-line in “Flora alpina” (AESCHIMANN *et al.* 2004), we include the foothill region southeast of the Alps (predalpsko območje according to MARTINČIČ *et al.* 2007) and also the southernmost part of the Julian

Alps, which are transitional mountains between the Southern Alps and the Northern Dinarids, i.e., Trnovski gozd with mount Čaven and Hrušica with mount Nanos, sometimes considered the northern end of the Dinarid mountain range.

For a geographic overview of the region treated, see also Chapter 2.3!

As to the floristic status of the taxa treated, see under 1.5!

1.3 TAXONOMIC SCOPE

Though unusual, our excursion flora will also contain keys for identifying Characeae of the area. This is because there is not much literature of the kind, since phylogenists tend to neglect this “non-microscopic” group, whereas ecologists, on the other hand, consider *Characeae* to be “macrophytes” important for their studies.

In terms of the number of taxa (casuals and cultivated taxa excluded in the following), the Flora will include c. 790 genera with c. 4050 terminal taxa {TT, species plus additional subspecies [three taxa but only two terminal taxa are species consisting of two subspecies (families, tribes, genera, sections, etc., are taxa as well)]}, i.e., 30 genera with 100 TT of pteridophytes, eight genera with 16 TT of gymnosperms, and c. 745 genera with c. 3930 TT of angiosperms. The Austrian flora equals c. 85% of that of our Flora. In comparison with Austria including South Tyrol (covered in the Third Edition), 46 genera (several of which are cultivated, like *Olea* and *Nerium*) and 430 species (mainly of the Southern Alps and sub-mediterranean) had to be added.

As in the entire Holarctic realm, the composites (Asteraceae) form the largest family in terms of genera and species (all following numbers are approximate), with 85 genera and 590 TT. In second and third place as to species number are the Rosaceae, with 26/340 (including 120 spp. of *Rubus* and 85 of *Alchemilla*) and the Gramineae (Poaceae), with 75/305. Next come the crucifers (Brassicaceae), with 52/190; Cyperaceae, with 15/157 (112 *Carex* spp.); Fabaceae (consisting of Faboideae only), with 29/200 (including 21 *Astragalus*, both Pannonian and Alpine spp.); Caryophyllaceae, with 28/180 (including 26 *Dianthus* and 25 *Cerastium*); Ranunculaceae, with 24/169 (75 *Ranunculus*, including 30 of *R. auricomus* agg.); Apiaceae, with 52/137; Lamiaceae, with 27/105; Orobanchaceae s. lat., with 10/96; and Orchidaceae, with 27/95. Typical large genera of the mountain flora are *Saxifraga* (49), *Veronica* (45), *Galium* (42), *Campanula* (42), *Primula* (25), and *Androsace* (15).

The arrangement of families is mainly a taxonomic one, but not strictly following APG IV (CHASE *et al.* 2016). We agree, of course, that DNA-based systems are a great scientific achievement, but not without problems of rationale, and that with ongoing refinements they should also be taken into account by compilers of Flo-

ras (see STACE 2009, 2010; KADEREIT *et al.* 2016). Our system, indeed, deviates slightly from the strictly molecular-based and cladistic APG system because we do not strictly avoid paraphyletic taxa (they are designated by the Greek letter Π), but instead try to outline an evolutionary system (HÖRANDL 2010; FISCHER 2012, 2013; WILLNER *et al.* 2014). Within the families, the genera are arranged taxonomically, but not alphabetically (as was done by ROTTENSTEINER 2014 and TISON & FOUCAULT 2014) because this would disrupt closely allied and only recently split ones. It is very unfriendly to the user if, for example, *Pilosella* and *Jacobaea* are placed far away from their closest allies, *Hieracium* s. str. and *Senecio* s. strictiss., because those are treated at the generic level. The same is true for the arrangement of families. Even in discussing taxonomical arrangement, we think it useful to mention synonyms and those taxa included as well as those excluded. At least the annotations of “sensu lato” and “sensu stricto” are never omitted. In some cases, special notes explain why circumscriptions of families, genera, and species and their names have been changed.

1.4 THE KEYS – GENERAL ITEMS

1.4.1 General key structure. Identification keys in the first place serve to identify a plant, a living one as well as a dry (herbarised) one, by use of easily recognisable traits (visible to the naked eye or with a lens), i.e., by use of “key characters” in contrast to taxonomic characters. Often, it is not possible to make the key congruent with taxonomy. As a consequence, multiple keying out will result, which therefore must not be avoided. Trying to combine the key with taxonomy (though welcome, if easily possible) is not always desirable because it often damages usability. The main aim of a key is not to give an introduction to taxonomy, but simply to provide a user-friendly way to achieve the correct result as easily as possible! Many taxonomically important characters are difficult to analyse or hardly visible by lens, to say nothing about chromosome numbers. To understand the taxonomic position of the taxa keyed, a taxonomic survey is provided separately, particularly in the case of large families and genera. To be sure, we consider taxonomy very important as a link between Floras, floristics, and identification keys on the one hand, and scientific botany (including biosystematics, phylogeny, and evolution) on the other.

Our keys aim at a strictly scientific structure (the “Vienna diacritical method”). They are dichotomous (with only very few exceptions) and not indented. Pleasant for authors, for publishers, and – misleadingly! – for users, short keys suffer from enabling misidentifications, as do incomplete descriptions. On the other hand, comprehensive and long lining up of all characters makes it difficult to ascertain the essential differential ones. Another important principle is to avoid repetitions of traits

already mentioned before. Hence, no family character and no genus character should be repeated in the species key. Within each lead, we distinguish “diacritical” characters (not overlapping) and “complementary” ones (which may overlap), providing further traits applicable to the resultant taxon or, alternatively, traits common to all taxa following later in the key; both are separated by an ultra-long dash. A complete description of any taxon results from adding family and genus characters together with all the characters mentioned throughout the key and, of course, the characters given close to the result. Thus, there is no need to provide a complete species description, as is mandatory in big Floras.

For some taxa, additional alternative keys are provided: this is done for *Genisteae*, *Alsineae*, Umbelliferae (using no fruit characters), and the genus group *Lathyrus* + *Vicia* + *Ervilia* + *Ervum*. For the species of *Salix* and *Allium*, three different keys each consider different sexual or developmental stages, respectively.

An important point is the consistent use of exactly defined descriptive terms. It is a regrettable fact that some terms are used in different Floras with different meanings, examples being “lanceolate”, “dentate”, and “bract” (FISCHER 2010; FISCHER & WILLNER 2010). Therefore, all terms must be precisely explained in a glossary in order to enable the keys to be used unequivocally without misunderstandings, which is particularly necessary for non professionally trained persons. Of course, the definitions in the glossary are strongly and consistently congruent with their meaning in the keys – sometimes not easy to accomplish in Floras written by several authors. Qualitative character states are avoided, quantitative ones being much preferred (“petals 4–6 mm long” instead of “petals large”). Writing a good key means coping with the challenge of combining the intuitional and visual knowledge of the experienced author (who “thinks” with his eyes) with the need for an analytical description intelligible to students not equipped with previous botanical knowledge.

The information in our keys will be as complete as possible and include, for example, vegetative characters of the rosettes (important for field ecologists) and flower fragrance. All of the characters are separated by semicolons. The most important characters are underlined. We do not shrink from using abbreviations in a modest degree for often used plant parts like the stem, foliar leaves, flower, style, etc. (in the German language, many of these words are rather long, so the gain of space is obvious). Wherever possible, they should be self-explanatory. However, we do not abbreviate the terms for character states.

In the “diacritical characters” before the ultra-long dash, the sequence of characters presented may follow their significance for identification. After that, however, among the complementary characters it must strictly follow the same “phytographic sequence”, starting

with the roots and ending with the seeds. This makes it easy to spot a certain character needed for comparison.

The diacritical characters are logical and strictly opposite, e.g., there is no “style 4 mm long” vs. “style up to 8 mm long” or “basal rosette present” vs. “stem leafy” or “palea 7–9 mm” vs. “palea as long as the glume” (these examples are not fictitious). Identical characters are described by the same wording, since otherwise the user cannot decide whether or not alteration of expression indicates a difference. Omitted character states (e.g., “pubescent” vs. indument not mentioned) are dangerous because the user does not know whether (a) it is in the default (“normal”) state (glabrous), or (b) it is variable, or (c) it is unknown (unexplored), or (d) it is just omitted because considered unimportant by the author. Some users tend to recognise only those characters mentioned and to neglect those not mentioned.

1.4.2 Families and genera. To include synonyms of family and genus names (as already indicated above) is an essential help for the reader in times of often changing taxa circumscriptions. The genus names are given not only in botanical Latin and German, but also in the Romansh (Rhaeto-Roman), Italian, and Slovenian languages. The German book-name that we qualify as the standard – preferably the one used in Austria, by floristic tradition – is indicated in bold print, but other German book-names used in botanical literature are quoted as well, and even the deviating names in Swiss books are included (see FISCHER 2006), those names being explicitly designated as ones used in Germany or Switzerland, respectively. For genera of larger families, the key numbers in the generic key are indicated (flush right, in lower-case letters), which is to enable the reader to find generic characters given in the genus key. Eponymic genus names are explained in a footnote by a very short biographic note on the persons commemorated.

For each family and each genus, the approximate number of genera and/or species world-wide and in Europe is given in brackets after the genus names.

There are no real family descriptions (they would often be misleading as many families are tropically centred and exhibiting a lot of characters not relevant for the European flora). Instead, in the big families short summaries of characters common to the genera treated are given, accompanied by a brief characterisation of the total geographic range. However, characters of the genera are presented within the generic keys. Hints about special techniques for analysis (like methods of measuring) and explanations of specific terms used in this family or genus are provided as well. Literature sources and, for large families and genera, a conspectus of internal taxonomy (subdivisions) follow.

At the beginning of the family and the genus, in many cases less commonly cultivated species not treat-

ed in the key and even some common indoor plants are mentioned in order to make beginners acquainted with taxonomy and act as a link to the study of the wild flora, since indoor and garden plants are generally much more familiar to many people than wild plants.

1.4.3 Species keys. A frequent shortcoming of keys is that they neglect variation. It is necessary to describe not the “ideal” set of characters most typical for the taxon, but rather its whole range of variation (FISCHER 2010; FISCHER & WILLNER 2010). The specimens to be identified usually do not perfectly comply with what the taxonomist thinks to be a “good” or “typical” taxon. This often makes it necessary to key out the resultant taxon at more than one exit. In such cases of multiple keying out, the relevant exit leads are mutually referenced in order to make reverse keying possible and enable the user to understand the full set of characters.

A general objective of useful keys is that, within a genus, all taxa should be – as far as possible – comparable with all the others, i.e., it should be possible to find the relevant differential traits you need for checking your resultant taxon with other taxa, not simply with those differential traits against the partner taxon within the same lead, but also against all other similar taxa with which they are liable to be confused.

Bracketed derivation numbers immediately after the lead number allow the keys to be used in reverse order, i.e., starting with the result and following the characters backwards. Intermediate results (like subgeneric taxa) are welcome if the key easily allows for that; as explained above, they are not necessary where consideration of taxonomy would detract from the user-friendliness of the key.

As in some other Floras (e.g., TUTIN *et al.* 1964–1993), closely allied or very similar and confusable species are put together in species groups called “species aggregates” (agg.), after GUTERMANN & NIKLFELD (1973).

Keys leading to subspecies follow in fine print. The subspecies comprising the nomenclatural type of the species (the so-called “typical” subspecies – a bad expression!) is named, congruent with the Code, by repeating the species epithet. The species name must not be designated “sensu stricto”, as in certain Floras (e.g., LAUBER *et al.* 2012). Varieties, being no natural units, are treated only exceptionally.

1.5 FURTHER INFORMATION ABOUT THE TAXA

As already mentioned above, we try to give as much information as possible about each species and subspecies by referring to many different fields of botany. A standard set of characters tries to accomplish this objective for each species, such characters including the height range of the plant; its life-form and life-time; the flowering months; a description of the habitat(s), if possible

with ecological indicator values and syntaxonomical entities; the plant’s altitudinal (vertical) range; and its frequency of occurrence within the habitat range mentioned. Distributional information is presented by enumeration of regions, viz., the Austrian Bundesländer, Grisons (i.e., its part on the right-hand side of the Rhine river), Italian regions or provinces, and the Slovenian Alps. In species with local distribution, localities like mountain ranges are additionally provided between brackets. The floristic status of non-native (not autochthonous) taxa is carefully determined, i.e., whether they are naturalized taxa (established aliens), casual taxa (extremely rare casuals are not keyed, but mentioned only by a short annotation), or cultivated and more or less frequently escaped taxa. The external distribution range and/or the chorotype as well as the type of endemism (whether of the Eastern Alps or of the Alps) are designated. Then, the conservational status and degree of threat are given for all countries involved, and a sign (icon) indicating legal protection is provided. For many species, the following ethnobotanical data are briefly summarised: toxicity; use as a medicinal plant (popular, official, homeopathic); economic use for human and animal food; and popular use (as a wild vegetable, salad, spice, etc.). Occasionally, specific physiological traits like C4-photosynthesis and phytochemical ingredients are presented. Indication of the ploidy level is given if it is of taxonomic interest (in polyploid complexes). Critical taxonomic annotations are considered important: doubtful taxa are discussed and references to pertinent literature are provided. Special signs (symbols) are added after the name of a species or subspecies which is difficult to identify, either because its characters are complicated (designated by ♦ after the species name) or because the taxon has still not been adequately studied (explored) (designated by ■). These signs prevent the user from becoming desperate, for inexperienced users are unaware of the fact that several taxa are not easily determined even by trained professionals, and they rather think it their mistake if they fail to identify them.

The nomenclature is treated thoroughly: the accepted species name and the German book-name proposed as standard are given in bold print. Additional names used in other Floras and elsewhere in the botanic literature are given in normal (light-faced) print. National names for species occurring only outside Austria are given in Romansh (= Rhaeto-Romanic, for Grisons), Italian, and Slovenian. The names in minority languages like Croatian, Slovenian, and Hungarian in Austria and Dolomite-Ladinian in South Tyrol are listed for species in the relevant areas. Important regional vernacular (dialect) names are mentioned occasionally (in fine print). Synonyms are supplied: ones used in earlier editions as the accepted names are given in bold print, while those used in the last edition are in bold print and underlined. Synonyms referring to only a part of the tax-

on are designated by the abbreviation “incl.”. Though not required by formal nomenclature rules, this avoids misinterpretation.

The authors of the taxa names are omitted on purpose because they are of no value for exact determination of the taxon. On the contrary, they are misleading because almost all users (many professional botanists included), in consequence of nomenclatural ignorance, fail to recognise their meaning and might think that the names of these nomenclatural authorities refer to the identification and circumscription, which of course is not the case (FISCHER 2000, 2010, 2011; FISCHER & WILLNER 2010). Actually, full (!) nomenclatural author citations are useful and necessary only for the taxonomist who produces new taxa or changes the scope and meaning of a taxon in order to establish the legitimate name. On the other hand, taxonyms (i.e., names appearing in a book where they are accepted and their meaning is intelligible, irrespective of whether or not they are nomenclaturally legitimate, see FISCHER 2015) are often useful, and this is why we indicate taxonyms (i.e. synonyms with a reference symbol) in the case of certain taxa. The pronunciation of Latin names is explained generally, the stressed syllable being indicated by underlining.

Our Excursion Flora also provides notes on possible mistakes and confusion with similar species. Such species are explicitly named, and their similar features (with respect to “overall growth habit”) and most important distinguishing characters are mentioned. Reference to the taxonomic and floristic literature is amply provided (footnotes being used for this purpose).

2. SHORT OVERVIEW OF THE FLORA AND VEGETATION OF AUSTRIA AND ALL THE EASTERN ALPS

2.0. So far, there is no general and summarising information available on the flora and vegetation of the Eastern Alps as a whole. For this reason, the following brief survey is offered as being possibly useful by enabling floristically interested persons to get some first impression.

2.1 EXAMPLES OF SOME CHARACTERISTIC CHOROTYPES

Genera and species absent from Austria are underlined.

2.1.1 Significant chorotypes of Austria and the Eastern Alps. A few examples of characteristic chorotypes of the East-Alpic flora [following MERXMÜLLER (1952, 1953, 1954), we distinguish between ‘alpine’, referring to the altitudinal vegetation belt above the timberline, and ‘Alpic’, referring to the mountain range of the Alps, irrespective of altitude] might throw some light on the complicated florogenetic history of the mainly mountain taxa within a small country like Austria and hint at its varied plant cover.

European: *Ajuga reptans*, *Chaerophyllum temulum*, *Corylus avellana*, *Fumaria officinalis*, *Galium album*, *G. pumilum*, *Mercurialis perennis*, *Moehringia trinervia*, *Papaver rhoeas*, *Quercus petraea*, *Rumex obtusifolius*, *Sanicula europaea*.

Central European: *Carpinus betulus*, *Euphorbia dulcis*, *Fagus sylvatica*, *Galium sylvaticum*, *Genista germanica*, *Potentilla heptaphylla*, *Rosa elliptica*, *Tilia platyphyllos*, *Trifolium rubens*.

Central European-Sarmatic: *Asarum europaeum*, *Tilia cordata*, *Ulmus laevis*.

West European (mainly of the Western Alps and Pyrenees): *Anagallis tenella*, *Chrysosplenium oppositifolium*, *Digitalis purpurea*, *Erica tetralix*, *Erinus alpinus*, *Galium hircynicum*, *Galeopsis segetum*, *Hypericum elodes*, *Ilex aquifolium*, *Lonicera periclymenum*, *Mibora minima*, *Ononis rotundifolia*, *Orobanche hederatae*, *Osmunda regalis*, *Polygala serpyllifolia*, *Teucrium scorodonia*, *Trifolium alpinum*, *Ulex europaeus*, *Viola calcarata* subsp. *calcarata*.

West Alpic (centered in the Western Alps): *Achillea nana*, *Adenostyles leucophylla*, *Astragalus sempervirens* subsp. *alpinus*, *Cephalaria alpina*, *Crepis pygmaea*, *Fritillaria tubiformis*, *Gentiana purpurea*, *Salix foetida*, *Trifolium alpinum*, *T. saxatile*.

West Alpic-Pyrenean: *Colchicum (Bulbocodium) vernum*, *Pinus uncinata*, *Polygala alpina*.

South Alpic (for east-Alpic endemics, see chapter 2.2): *Androsace vandellii*, *A. vitaliana*, *Athamanta turbita*, *Centaurea dichroantha*, *Coincya cheiranthos* subsp. *montana*, *Euphorbia saxatilis* agg., *Grafia golaka*, *Potentilla nitida*, *Primula latifolia*, *Trochiscanthes nodiflora*.

Alpic-Carpathian: *Hypochaeris uniflora*, *Leontopodium alpinum*.

East Alpic-Carpathian: *Asperula neilreichii*, *Biscutella laevigata* subsp. *austriaca* (?), *Campanula alpina*, *Carex firma*, *Cerastium carinthiacum*, *Crepis jacquinii*, *Dianthus glacialis*, *Galium austriacum*, *Gentiana frigida*, *Saponaria pumila*, *Saussurea pygmaea*, *Saxifraga carpatia*, *S. rudolphiana*, *Scorzoneroideis (Leontodon) crocea*, *Senecio subalpinus*, *Viola alpina*.

Alpic-Illyrian: *Cyclamen purpurascens*.

South Alpic-Illyrian or -Dinaric: *Chamaecytisus purpureus*, *Euphrasia cuspidata*, *Medicago carstiensis*, *Lamium orvala*, *Ranunculus traunfellneri*, *Scabiosa hladnikiana*.

South Alpic-Submediterranean: *Epimedium alpinum*, *Omphalodes verna*, *Viola calcarata* subsp. *zoysii*.

South Alpic-Illyrian and/or Dinaric (*also at eastern edge of the Alps): *Astrantia carniolica*, *Cardamine glauca*, *Frangula rupestris*, *Hladnikia pastinacifolia*, *Homogyne sylvestris*, *Moehringia villosa*, *Peltaria alliacea**, *Rhamnus fallax*, *Vicia oroboides**.

East Alpic-Dinaric: *Campanula cespitosa*, *C. pyramidalis*, *Drypis spinosa* subsp. *jacquiniana*, *Phyteuma zahlbruckneri*, *Pedicularis acaulis*, *Rhodothamnus chamaecistus*, *Salix waldsteiniana*, *Viola calcarata* subsp. *zoysii*.

East Alpic-Apennine: *Moltkia suffruticosa*.

Alpic-Pyrenean-Apennine-Dinaric-Balkan-Carpathian-Caucasian: *Rumex alpinus*.

Arctic-alpine [usually including other (South) European mountains]: *Alchemilla alpina*, *Carex norvegica*, *Cerastium alpinum*, *Dryas octopetala*, *Eriophorum scheuchzeri*, *Kalmia (Loiseleuria) procumbens*, *Juncus trifidus*, *Lactuca (Cicerbita) alpina*, *Ranunculus glacialis*, *Salix herbacea*, *Silene acaulis* s. lat., *Veronica alpina*, *Viscaria alpina*.

Alpic-Pyrenean-Illyrian-Carpathian: *Geum montanum*, *Kernera saxatilis*, *Petrocallis pyrenaica*.

Alpic-Pyrenean: *Crepis pyrenaica*, *Ononis rotundifolia*.

(Circum-)boreal-Alpic: *Calla palustris*, *Linnaea borealis*, *Salix reticulata*, *Trientalis europaea*.

Alpic-arctic-Siberian-North American: *Galium triflorum*, *G. trifidum*.

Arctic-alpine-circumpolar: *Lomatogonium carinthiacum*, *Tofieldia pusilla*.

Arctic-alpine-Central Asian: *Arctostaphylos alpinus*, *Astragalus frigidus*, *A. norvegicus*, *Gagea (Lloydia) serotina*, *Kobresia myosuroides*, *Myricaria germanica*, *Persicaria (Bistorta) vivipara*, *Phleum alpinum* agg., *Poa alpina*, *Saxifraga oppositifolia*, *Thalictrum alpinum*.

Alpic-Central Asian: *Comastoma tenellum*.

West Caucasian: *Rhododendron luteum*.

Submediterranean: *Acer opalus*, *Bupleurum veronense*, *Calamintha grandiflora*, *Fraxinus ornus*, *Molopospermum peloponnesiacum*, *Ostrya carpinifolia*, *Pseudofumaria (Corydalis) lutea*.

East Submediterranean: *Eryngium amethystinum*, *Quercus cerris*.

Submediterranean taxa in the Pannonian flora: *Aegonychon (Buglossoides) purpureocaeruleum*, *Dictamnus albus*, *Limodorum abortivum*, *Onosma visianii*, *Quercus pubescens*.

Submediterranean taxa on the northeastern edge of the Alps (= western edge of the Pannonian region south of Vienna): *Convolvulus cantabrica*, *Cotinus coggygia*, *Geranium lucidum*, *Lathyrus venetus*, *Ruscus hypoglossum*.

Submediterranean-Atlantic: *Asplenium ceterach (Ceterach officinarum)*, *Helleborus foetidus*, *Ophrys sphegodes*, *Orchis (Aceras) anthropophora*, *Ruscus aculeatus*.

Mediterranean (southern edge of the Alps; all these genera/species absent from Austria): *Argyrolobium zanonii*, *Arundo donax*, *Capparis spinosa*, *Cistus albidus*, *C. salviifolius*, *Cynoglossum creticum*, *Helichrysum italicum*, *Hermodactylus tuberosus*, *Iris foetidissima*, *Ononis reclinata*, *Paliurus spina-christi*, *Phillyrea latifolia*, *Serapias vomeracea*, *Smyrniolum olusatrum*, *Viburnum tinus*.

Pannonian-Balkan-Pontic-Caucasian: *Inula germanica*.

Pannonian or Pontic-Pannonian: *Acer tataricum*, *Artemisia pancicii*, *Astragalus asper*, *Chamaecytisus aus-*

triacus, *Cirsium brachycephalum*, *Iris pumila*, *I. spuria*, *Rapistrum perenne*, *Suaeda prostrata*, *Veronica spuria*.

Pontic-Pannonian-South Siberian: *Adonis vernalis*, *Astragalus austriacus*, *Atriplex intracontinentalis*, *Bassia laniflora*, *Campanula sibirica*, *Crambe tatarica*, *Festuca valesiaca*, *Hypericum elegans*, *Nepeta nuda*, *Onobrychis arenaria*, *Oxytropis pilosa*, *Phlomis tuberosa*, *Prunus fruticosa*, *Stipa capillata*, *Verbascum phoeniceum*.

Pannonian-South Siberian: *Artemisia laciniata*, *Plantago tenuiflora*.

Pontic-Caucasian: *Echium (Pontechium) maculatum* (doubtful whether native), *Melica picta*.

Pontic-Pannonian & Inside-Alpic: *Astragalus exscapus*, *Dracocephalum austriacum*.

Pannonian-Illyrian: *Dorycnium germanicum*.

Holarctic (Eurasia + North America): *Coeloglossum viride*, *Drosera rotundifolia*, *Epilobium angustifolium*, *Parnassia palustris*, *Urtica dioica*.

Subcosmopolitan: *Pteridium aquilinum*.

2.1.2 Examples of established (naturalized) aliens [see, for example, ESSL & RABITSCH (2002), for a list of all aliens recorded in Austria]. An asterisk* denotes invasive (i.e. still expanding) species.

Northern Europe: *Cochlearia danica**.

Mediterranean: *Dittrichia graveolens**, *Geranium purpureum**.

Caucasian: *Heracleum mantegazzianum**, *Rubus armeniacus**, *Veronica filiformis*.

North American neophytes: *Acalypha virginica*, *Acer negundo**, *Amaranthus powellii*, *A. retroflexus*, *Ambrosia artemisiifolia**, *Bidens frondosa*, *Datura stramonium*, *Echinocystis lobata*, *Epilobium adenocaulon*, *Erechtites hieraciifolia*, *Erigeron annuus*, *E. canadensis*, *Juncus tenuis*, *Matricaria discoidea*, *Parthenocissus quinquefolia* s. lat., *Phytolacca americana*, *Robinia pseudacacia**, *Rudbeckia laciniata*, *Sisyrinchium montanum*, *Solidago gigantea**, *S. canadensis**, *Iva xanthiifolia* remains as a casual.

Central Asian or Southwest or South Asian neophytes: *Dysphania botrys*, *Impatiens glandulifera**, *I. parviflora*, *Oxalis corniculata*, *Potentilla (Duchesnea) indica**, *Veronica persica*.

East Asian neophytes: *Acorus calamus*, *Ailanthus altissima**, *Artemisia verlotiorum*, *Buddleja davidii**, *Cardamine occulta* (still a casual), *Eragrostis multicaulis**, *Fallopia japonica**, *Lycium barbarum*, *Persicaria nepalensis*, *Phytolacca acinosa*, *Rubus phoenicolasius*, *Sedum sarmentosum*, *Setaria faberi**.

South African neophyte: *Senecio inaequidens**.

South American neophytes: *Dysphania pumilio*, *Galinsoga parviflora*, *Xanthium spinosum* (in Austria almost extinct because of vanishing pasture-land in the Pannonian region).

Synanthropic-subcosmopolitan: *Matricaria discoidea (matricarioides)*, *Poa annua*, *Plantago major*, *Senecio vulgaris*, *Veronica persica*.

2.2 ENDEMISM

An important part of chorotypes are the endemic taxa. Just a few examples are presented. (In the following paragraphs, genera or epithets of species absent from Austria are underlined.)

In the Eastern Alps, there are five endemic genera [plus one more (*Berardia*) in the whole Alps, all monospecific]: *Rhizobotrya*, which grows only in the Dolomites, being a sister to *Kernera* (Brassicaceae); *Physoplexis*, which is close to *Phyteuma* (Campanulaceae); *Psilathera* and *Sesleriella* (both Poaceae formerly included in *Sesleria*) (FRAJMAN *et al.* (2016)). The fifth one, *Hladnikia* (Apiaceae), is a local endemic of W Slovenia (Trnovski gozd) at the southern margin of the Julian Alps. All of them occur only in the Southern Alps.

2.2.1 Endemics of the Alps. Some examples of species and subspecies: *Androsace alpina* and *A. brevis* (with a narrow range on the border between the Eastern and Western Alps), *Artemisia atrata* and *A. genipi*, *Astragalus vesicarius* subsp. pastellianus, *Campanula bertolae* and *C. cenisia*, *Cirsium spinosissimum*, *Daphne striata*, *Galium megalospermum*, *Laserpitium halleri*, *Oxytropis fetida* (extinct in the Eastern Alps), *Pedicularis recutita* and *P. rostratospicata* subsp. helvetica, *Phyteuma betonifolium* and *Ph. humile*, *Primula villosa*, *Ranunculus villarsii*, *Saxifraga biflora*, *S. muscoides*, *S. mutata* subsp. mutata and *S. seguieri*, and *Viola cenisia* and *V. thomasiana*.

2.2.2 Some Austrian endemics and subendemics (almost all of them concurrently East-Alpic endemics, see 2.2.3). The restricted distribution ranges of most of the endemics are attributable to Quaternary conditions. The Eastern Alps and most of the Austrian Alps were covered by a huge ice-shield during the last (Würm) glaciation everywhere except for the easternmost parts (east of the eastern reaches of Niedere Tauern) and the north-eastern Calcareous Alps east of the Salzach and Traun rivers approximately. These mountains provided refugial places (NIKLFIELD 1972, 1973a, b), like the mountains on the southern and especially the southeastern margins of the Alps, which is why most of the endemics are restricted to those regions.

In the Northeastern Alps: *Achillea clusiana*, *Alchemilla anisiaca*, *Alyssum neglectum*, *Callianthemum anemonoides*, *Campanula praesignis*, *C. pulla*, *Dianthus alpinus*, *Doronicum glaciale* subsp. calcareum, *Draba stellata*, *Galium meliodorum*, *G. truniacum*, *Gentiana pannonica* (subendemic), *Leucanthemum atratum* s. str., *Euphorbia saxatilis*, *Nigritella archiducis-joannis*, *N. nigra* subsp. austriaca, *N. stiriaca*, *Noccaea* (*Thlaspi*) *crantzii*, *Pedicularis portenschlagii*, *Primula clusiana*, *Pulsatilla alpina* subsp. schneebergensis, *Pulmonaria kernerii*, and *Soldanella austriaca*.

On the eastern edge of the Central Siliceous Alps (mount Koralpe): *Moehringia diversifolia*, *Saxifraga paradoxo*, and *Doronicum cataractarum*.

In the Central Siliceous Alps: *Alchemilla curta*, *A. norica*, *Braya alpina*, *Cochlearia excelsa*, *Oxytropis triflora*, *Saxifraga blepharophylla*, *S. styriaca*, *Sempervivum pittonii* (a local Styrian endemic on ophiolitic bedrock), *S. stiriacum*, and *Valeriana celtica* subsp. norica.

Pannonian rather than Alpic species are *Cochlearia macrorrhiza* (close to *C. pyrenaica*), a local endemic on the verge of extinction in a fen in the Vienna Basin, and *Puccinellia peisonis*, a subendemic in saline habitats in North Burgenland (also in W Hungary).

In contrast, there are several "negative" Austrian subendemic species absent from most of Austria while common elsewhere around: *Dioscorea* (*Tamus*) *communis*, *Gentiana lutea*, and *Persicaria alpina*.

2.2.3 Some other endemics and subendemics of the Eastern Alps. Here we call attention to a few examples of species and subspecies. Note the remarkable concentration of endemics in the Southern Alps (the designation S means: in the S Alps only), particularly on their southeastern edge (the Carnian, Julian, and Kamniške Alps and the Karawanken/Karavanke, designated by SE); and further to the west in the so-called "Judicarian" region (Giudicarie in a larger sense, designated by G), viz., the Brenta group northwest of Lake Garda, the Bergamascan Alps, and the adjacent mountains (mainly in the provinces of Trento, Brescia, and Bergamo), which owe their existence to the presence of glacial refugia [see TRIBSCH & SCHÖNSWETTER (2003), SCHÖNSWETTER *et al.* (2005), and SCHNEEWEISS & SCHÖNSWETTER (2011)].

First of all, we call attention to examples of some notable high mountain families or genera:

Campanulaceae: *Campanula bertolae* (S), *C. carnica* subsp. puberula (SE), *C. elatinoides* (G), *C. martinii* (S), *C. morettiana* (S), *C. petraea* (G), *C. raineri* (S), *C. zoysii* (SE), *Phyteuma globulariifolium* subsp. globulariifolium, *Ph. hedraianthifolium*, *Ph. sieberi* (S), and *Physoplexis comosa* (S). – Gentianaceae: *Comastoma nanum*, *Gentiana bavarica*, *G. brentae* (G), *G. froelichii* (SE), *G. lutea* subsp. vardjanii (S), *G. pannonica*, *G. prostrata*, *G. pumila*, *G. terglouensis* (S), *Gentianella aspera*, *G. engadinensis*, and *G. ramosa*. – Orobanchaceae (s. lat.): *Euphrasia portae* (S), *E. tricuspida* (S), *Pedicularis aspleniifolia*, *P. elongata*, *P. hoermanniana* (SE), *P. julica* (SE), *P. recutita*, and *P. rosea* subsp. rosea. – Primulaceae: *Primula albenensis* (G), *P. carniolica* (SE), *P. daonensis*, *P. glaucescens* (G), *P. glutinosa*, *P. grignensis* (S), *P. recubariensis* (G), *P. spectabilis* (G), *P. tyrolensis* (S), *Androsace hausmannii*, *A. vitaliana* subsp. sesleri (S), and *A. wulfeniana*. – Saxifragaceae: *Saxifraga aphylla* (subendemic), *S. arachnoidea* (G), *S. biflora*, *S. burseriana*, *S. depressa* (S), *S. exarata* subsp. carniolica (SE), *S. facchinii* (S), *S. hohenwartii* (SE), *S. hostii*, *S. berica* (S): a

local endemic of Monti Berici a little south of the Alps), *S. paradoxa* (SE), *S. petraea* (S), *S. presolanensis* (G), *S. squarrosa* (S), *S. stellaris* subsp. *prolifera*, *S. tenella*, *S. tombeanensis* (G), and *S. vandellii* (G).

Examples from further families: *Achillea oxyloba* (S), *Alchemilla compta*, *Allium insubricum* (G), *A. kermsinum* (SE), *Alyssum wulfenianum* subsp. *wulfenianum* (SE), *Aquilegia thalictrifolia* (G), *A. vestinae* (species rank questionable) (G), *Arenaria huteri* (S), *Asplenium presolanense* (G), *Astrantia bavarica*, *Biscutella praealpina* (S), *Callianthemum kernerianum* (G), *Carex baldensis*, *Cerastium carinthiacum*, *C. julicum* (SE), *C. subtriflorum* (SE), *Cirsium carniolicum*, *Cytisus emeriflorus* (S), *Daphne petraea* (G), *Draba sauteri*, *Doronicum glaciale*, *Euphorbia kernerii* (S), *Facchinia (Minuartia) cherlerioides* subsp. *cherlerioides*, *F. (Minuartia) grignensis* (S), *Festuca calva* (SE), *F. laxa* (SE), *Galium baldense*, *G. margaritaceum*, *G. montis-arerae* (G), *G. noricum*, *Gypsophila papillosa* (G), *Helictochloa (Avenula, Helictotrichon) adsurgens* subsp. *ausserdorferi*, *Heracleum austriacum* (subendemic), *Hladnikia pastinacifolia* (SE), *Homogyne discolor* (subendemic), *Hornungia alpina* subsp. *austroalpina* (S), *Laserpitium nitidum* (S), *Leucanthemum lithopolitanicum* (SE), *Linaria tonzigii* (G), *Liparis nemoralis* (S), *Luzula glabrata*, *Minuartia graminifolia* (S), *Moehringia bavarica subsp. insubrica* (G), *M. concarenae* (G), *M. dielsiana* (G), *M. glaucovirens* (S), *M. markgrafii* (G), *M. villosa* (SE), *Nigritella buschmanniae* (G), *N. dolomitensis* (S), *N. lithopolitanica* (SE), *Noccaea (Thlaspi) rotundifolia* subsp. *cepaefolia* (SE) and subsp. *grignensis* (G), *Paederota bonarota* (S), *P. lutea* (SE, subendemic), *Pinguicula poldinii* (S), *Pseudostellaria europaea* (SE), *Pulmonaria carnica* (SE), *P. stiriaca* (subendemic?), *P. vallarsae* (S), *Ranunculus bilobus* (G), *R. venetus* (S), *Rhododendron hirsutum* (subendemic), *Sabulina (Minuartia) austriaca*, *Salix mielichhoferi*, *Sanguisorba dodecandra* (G), *Scabiosa vestina* (S), *Sempervivum dolomiticum* (S), *S. wulfenii*, *Taraxacum handelii*, *T. reichenbachii*, *Trisetum argenteum* (S), *Valeriana saxatilis*, *Viola comollia* (G), *V. culminis* (G), *V. dubyana* (S), *Wulfenia carinthiaca* subsp. *carinthiaca* (SE).

2.3 MAIN NATURAL REGIONS

See also Fig 1. The bracketed numbers refer to the short presentations of vegetation types with examples of their floras given below in chapter 2.4.

The Eastern Alps (Fig. 1) stretch from the Raetian Alps in the west to the Vienna Woods (Wienerwald, including the western margins of the city of Vienna) in the east, i.e., 470 km. Their greatest width between Ammergebirge in Bavaria and Monte Baldo in Italy (close to Lake Garda) and between Höllengebirge in Upper Austria (near Lake Traunsee) and mount Nanos in Slovenia is 210 km in both transects. The highest mountain tops are Piz Bernina (4049 m asl, on the border between

Grisons and Lombardia), mount Ortler (3890 m asl, on the border between South Tyrol and Lombardia), and mount Großglockner (3798 m asl, in the Glockner group on the border between Carinthia, Tyrol, and Salzburg).

Some Austrian regions are outside the Alps, viz., the lowlands east of Vienna (Fig. 1A), most of the Vienna Basin between the Alps and the Small Carpathians, and the adjacent hilly regions to the north (“Weinviertel”) and Northern Burgenland to the south, which are part of the Pannonian vegetation and flora (the Pannonian floristic province), characterised by a warm and dry climate (the planar-colline belt, altitudes of 115–400 m asl, average annual precipitation of 550–650 mm) with comparatively warm and hence dry summers, the (1) natural vegetation being woodland made up mainly of xerothermic subcontinental mixed oak-forests and (7) large riverside forests along the Danube, the March/Morava (7b), and other rivers. These original vegetation types survived in some places only (mostly in nature reserves) because since Neolithic times the landscape has largely changed to become pastures (12a), agricultural land (15), and settlements (16). Most of the Pannonian pastures and large parts of the riverside (floodplain) vegetation disappeared in more recent times. Land-use: growing of cereals (*Triticum aestivum*, *Hordeum vulgare* s. lat.); growing of sugar beet (*Beta vulgaris* cv.); viticulture (*Vitis vinifera*); and growing of vegetables (*Asparagus officinalis*, *Allium cepa*, *Solanum lycopersicum*, *Capsicum annuum*, *Lactuca sativa*, the famous Styrian oil pumpkin *Cucurbita pepo* var. *styriaca*, and fruits (*Prunus armeniaca*, *Prunus avium*, *Fragaria ananassa*, etc.).

The highlands of the so-called “Bohemian Massif”, mostly siliceous Variscian rump mountains mainly north of the Danube (Waldviertel in northwestern Lower Austria and Mühlviertel in northern Upper Austria, Fig. 1B) are for the most part composed of granite and gneiss bedrock. They constitute a submontane to low-montane belt with elevations of c. 500–1000 m asl and precipitation of c. 700–1000 mm that was originally covered by forests of *Fagetalia* (2, 3, 4), which have been replaced by arable land (15), meadows and pastures (13a–f), and artificial economic spruce forests (*Picea abies*). Only very few areas with raised bog vegetation (10) have survived. Land-use: forestry (*Picea abies*, here and there also Douglas fir *Pseudotsuga menziesii*); dairy farming; growing of *Solanum tuberosum*, *Secale cereale*, and *Papaver somniferum*; and in parts growing of special crops like *Silybum marianum* and *Linum usitatissimum*.

The lowland and hilly regions further to the west, the Northern Alpine forelands, between the Danube and the Alps in Lower and Upper Austria up to the northernmost part of Salzburg (Northern Alpenvorland, Fig. 1C) represent a colline belt at elevations of c. 200–600 m asl with precipitation of c. 700–900 mm and almost no more natural vegetation. Land-use: mainly growing of cereals and fruits, and meat production.

The foothills and foreland southeast of the Alps in southern Styria (Steirisches Hügelland south and east of Graz, Fig. 1D) and Southern Burgenland constitute a submontane belt at altitudes of c. 200–450 m asl with precipitation of c. 650–750 mm. Originally they were dominated by sub-Pannonian to sub-Illyrian *Carpinion* communities (2, 3c) and some wetland communities (9, 10), today replaced by vast tracts of agricultural land. In contrast to 1C are some characteristic sub-Mediterranean and sub-Illyrian species like *Castanea sativa* (naturalized), *Erythronium dens-canis*, *Dioscorea* (*Tamus*) *communis*, *Succisella inflexa*, *Crocus exiguus*, and (in Southern Burgenland) *Hemerocallis lilioasphodelus* (of questionable status: autochthonous or naturalized?). Land-use: mainly agriculture, i.e., growing of *Zea mays*, *Triticum aestivum* and some *T. spelta*, *Hordeum vulgare* s. lat., *Sorghum bicolor*, *Cucurbita pepo* var. *styriaca*, and *Glycine max* (*Soja hispida*), as well as some fruits, viz., *Malus domestica* ("pumila"), *Pyrus communis*, *Aronia*, *Sambucus nigra*, and *Castanea sativa*.

The Alps (the montane to nival belt at elevations of c. 500–4049 m asl with precipitation of c. 1000–2000 mm) can be roughly subdivided into the Northern Calcareous Alps (Fig. 1E; 3, 5, 6), the Central Alps (mainly siliceous) (Fig. 1F; 5, 6), and the Southern Calcareous Alps (Fig. 1G; 3, 5, 6). Most parts of the northern and the southern Calcareous Alps are situated relatively close to the outside edges of the Alps, in terms of climate and vegetation, they belong to the Exterior Alps (Randalpen) (see below). The Central Alps reach higher elevations and, concerning climate and vegetation, they belong to the Interior Alps (Innenalpen) (see below). The Calcareous Alps are characterised by strongly accentuated geomorphological relief, i.e., by steep slopes, sharp peaks, precipitous rocks and large scree slopes (6c, 11a).

The Northern Calcareous Alps (Fig. 1E) are almost exclusively carbonatic and extend from Mount Rätikon in southern Vorarlberg eastwards through several mountain ranges like Karwendel (Tyrol), Hochkönig (with glacier, Salzburg), Dachstein (with glacier, Upper Austria/Styria), Hochschwab (Styria), and Rax (Styria / Lower Austria) up to the "Viennese" (c. 60 km south-southwest of Vienna) Schneeberg. There is a remarkable eastward decline in precipitation towards the eastern edge of the Alps at the boundary of the Pannonian region ("Thermenalpen"). The easternmost mountains are characterised by several thermophilous species such as *Bupleurum praealtum* (rare), *Daphne laureola*, *Euphorbia angulata*, *Noccaea* (*Thlaspi*) *montana*, *Staphylea pinnata*, and *Veratrum nigrum*, but several species common to forests further to the west such as *Chrysosplenium alternifolium*, *Helleborus niger* and *Silene dioica*, are rare to absent.

Central Alps / "Zentralalpen" (Fig. 1F). In Austrian terminology, this concept refers only to a geographical position within the Eastern Alps, in contrast to the quite

different meaning of the term applied, for example, by most Italian authors. The Central Alps extend from the Raetian Alps (in Grisons) and mount Bernina, mount Ortler, and the Adamello group (with glaciers) in the west through Vorarlberg (mount Silvretta), Tyrol (the Ötztaler and Zillertaler Alps, with glaciers), Salzburg (mountain range Hohe Tauern, with glaciers), Carinthia (the Gurktaler Alps), Styria (mountain range Niedere Tauern, mount Koralpe), and N Slovenia (mount Pohorje) to Lower Austria (mount Wechsel). Lithologically (tectonics are ignored here because of hardly any pedological or vegetation relevance), viz. with respect to bedrocks, mainly two geologically different types of mountains can be distinguished: the Greywacke zone (Grauwackenzone) between the Northern Calcareous Alps and the Central Alps, with soft rounded mountain shapes, consists of Palaeozoic phyllites, slate, metamorphic vulcanites, slightly metamorphic limestone, and quartzites (the Tuxer and Kitzbüheler Alps in Tyrol, the Salzburgian schistaceous Alps, and the Eisenerzer Alps in Styria). Soils here are generally more or less acid, the vegetation acidophilous (vast *Nardetalia* communities are present, 13f). The main and higher parts of the Central Alps, however, are made up of different types of hard siliceous bedrocks, mainly gneiss, producing strongly acid soils (3a, b, d, e; 6d, e, f, g; 8). The Hohe Tauern range is remarkable because of large areas (e.g., between the Brenner pass and Mauterndorf in Lungau) on Grisons slate (Bündnerschiefer), i.e., metamorphic Jurassic/Cretaceous sediments composed of calcareous and micaceous schists and calcareous and clay shale producing ("intermediate") soils in between carbonate and siliceous, known for their conspicuously rich flora (*Braya alpina*, *Comastoma tenellum*, *Draba pacheri*, *Gentiana prostrata*, *Hornungia alpina* subsp. *brevicaulis*, *Lomatogonium carinthiacum*, *Oxytropis campestris*, *Saxifraga rudolphiana*, *S. biflora*, *Taraxacum pacheri*, *Thalictrum alpinum*).

In the southeast, the easternmost mountains of the Southern Alps are the Kamniške Alps. Further to the east, mount Pohorje (with highest altitudes of 1517 and 1543 m asl) belongs to the Central Alps and is mainly siliceous. The easternmost edge of the siliceous Central Alps follows two low mountain ranges, viz., the Ödenburg (558 m asl) and Güns (884 m asl) mountains, which cross Burgenland and touch Hungary (close to Sopron and Kőszeg, respectively). Special habitats here are produced by local ophiolitic ("serpentine") bedrock rich in magnesium (the Bernstein and Güns mountains): *Pinus sylvestris* forests with "serpentinophilous" vegetation and flora (11c) are present.

The Southern Calcareous Alps (Fig. 1G) extend from southern Grisons in the west through the E Italian Alps [e.g., the Judicarian Alps, Dolomites (see PIGNATTI & PIGNATTI 2014, 2017), Monte Baldo (see PROSSER *et al.* 2009), and the Carnian Alps] to southern Carinthia and

Slovenia (the Julian Alps, Karavanke/Karawanken, and the Kamniško-Savinjske Alps). Calcareous bedrock prevails (3a, d, f; 8), but there are also rather large schistaceous, plutonic, and volcanic areas (porphyries), especially in parts of the Dolomites.

Complementary to the mainly geologically based division outlined above, there also exists a bioclimatic variance leading to important differences in vegetation. In this context, the terms Exterior Alps (“Randalpen”) and Interior Alps (“Innenalpen”) are widely used.

The Exterior Alps are subject to suboceanic climate characterised by high average annual precipitation also in the summer time (c. 1600–2500 mm), but moderate winter temperatures. In the southern Exterior Alps, the suboceanic climate is even more strongly pronounced and the climate slightly warmer. A significant indicator of the ecological difference between the Exterior and Interior Alps is the distribution of beech (*Fagus sylvatica*), which is present only in the montane belt of the Exterior Alps, reaching up to the timberline in the Southern Alps (3), but completely absent from the Interior Alps. The zones intermediate between the Exterior and Interior Alps are called “Zwischenalpen” (“Intermediate Alps”) (see MAYER 1974: “*Abietetum*”), the natural forest vegetation here being characterised by fir-spruce forests.

The Interior Alps, in contrast to the Exterior Alps, exhibit a subcontinental climate with comparatively dry summers and cold winters (precipitation of c. 450–1000 mm), a difference which is clearly paralleled by the vegetation and flora: natural spruce-forest (*Vaccinio-Piceion*) communities dominate (4). The valleys and low belts of the Inner Alps exhibit subcontinental spruce-larch forests and pine forests (5c), rocky slopes with *Juniperus sabina*, and pastures of dry grassland vegetation floristically close to the Pannonian “steppes” in East Austria, e.g., with *Stipa pennata* agg. Such subcontinental Inner Alpic valleys are the Vinschgau in northwestern South Tyrol; the less distinctly subcontinental upper Inn valley of Engadine (Grisons) and “Oberes Gericht” in western North Tyrol; and the even less distinctly subcontinental Virgen valley (northern East Tyrol) (12c), with traces extending eastwards only to the upper Mur valley (Salzburg and Styria). (More distinctly developed Inner Alpic subcontinental dry valleys exist in the Western Alps, e.g., in the Wallis/Valais valley in SW Switzerland, Aosta valley in NW Italy, and several valleys in the French Alps.)

Land-use in the Alps: Wood production [mainly from monocultures of spruce (*Picea abies*), as well as (to a smaller extent) *Larix decidua* and *Pinus cembra*]; meadows and pastures with mountain and alpine farming (dairy farming, herding of livestock) up to the subalpine belt; game.

Altitudinal zonation in the Eastern Alps: The Pannonian region in the east and the plains north of the Alps towards the Danube, the hilly region in E Styria

and Southern Burgenland, the Klagenfurt Basin in Carinthia, the lowland along the Rhine in Vorarlberg, and the valleys of the rivers Mur, Mürz, Enns, Inn, and Drau/Drava are colline to submontane and dominated by anthropogenic vegetation: meadows and pastures (13a, c, d, e, f), arable land (15), and settlements (16). The large valleys of the Southern Alps, e.g., of the rivers Adda (Valtellino), Oglio, Adige/Etsch, Piave, Tagliamento, Soča/Isonzo, and Sava, show forests with a more or less distinct submediterranean flavour characterised by *Acer opalus* (in Lombardy only), *Quercus pubescens*, *Ostrya carpinifolia*, and *Fraxinus ornus* on a calcareous substrate and *Castanea sativa* on a more or less acid substrate. The northeast end of the Alps, the Vienna Woods (Wienerwald), consists of mountains that range from c. 400 to 893 m asl in elevation and are submontane to lower montane. Bedrocks are flysch sandstones or, on the southern edge, carbonate bedrock (limestone or dolomite). Annual precipitation is 700–900 mm. Vegetation is mostly subnatural (with a low degree of hemeroby) and consists of *Carpinion* (2) and *Fagion* (3) forests, and meadows. There is only little arable land.

Both the Northern and the Southern Calcareous Alps, as well as the Central Alps (on mainly siliceous bedrocks), extend through the low-montane (3a, b), high montane (3, 4), and subalpine (5) belts up to the alpine, subnival, and nival (6) belts. The montane belt ranges from c. 400 to 1600 m asl and, in the Exterior Alps, bears low-montane beech forests and high-montane spruce-fir-beech forests (*Fagion sylvaticae*), larch-spruce forests in the Interior Alps (4), *Tilio-Acerion* (see 3e) in the gorges and ravines, and vast more or less artificial spruce forests (with a high degree of hemeroby). Anthropogenic grasslands (13) are present, but there is little arable land. The subalpine belt (5) – c. 1600–1900 m asl in the Exterior Alps and c. 1900–2200 m asl in the Interior Alps – is the transitional belt between the upper border of compact forests and the timberline. It is characterised by a mosaic of scattered trees with scrub communities (5a, b) and natural grassland (5d) and is often (particularly on carbonate rocks) rich in rock and scree vegetation (11a). Man-made habitats here include mainly subalpine pastures (*Poion alpinae*, see 13h). The alpine belt (6) – c. 1900–2300 in the Exterior Alps and c. 2200–2700 m asl in the Interior Alps – is the belt above the timberline (uppermost trees). In the Interior Alps and on shallow soils on rocky slopes in the Exterior Alps, pine forests (8) are developed.

The altitudinal zonation is characterised by a general upward shifting of the vegetation belts in the Interior Alps, with the timberline at 2200–2400 m asl and the lower subalpine belt (5c) having forests of *Pinus cembra* (Swiss pine), in comparison with the Exterior Alps with their relatively suboceanic “beech” climate (more precipitation), where timberline is at about 1800–1900 m asl.

2.4 THE FLORA ARRANGED AS TO MAIN VEGETATION TYPES

In the following, we present a very rough characterisation of the flora of Austria and adjacent parts of the Eastern Alps, arranged by (numbered) vegetational units. Some significant species (common as well as rare) are selected only as examples. "Significant" is understood in two opposite ways: (a) common or (b) exclusive though often rare in the respective vegetation type. Thus, the examples are a mixture of both, (a) ordinary, frequent species and (b) remarkable rarities. We try to mention each species, if possible, only once, i.e., in its most characteristic habitat. Genera or species absent from Austria are underlined.

The classification primarily reflects ecological species groups and thus approximates gross habitat (biotope) types. Syntaxa are indicated, either according to WILLNER & GRABHERR 2007 (forest communities) or according to GRABHERR & MUCINA (1993) and MUCINA *et al.* (1993a, b) (other communities). In several instances, however, syntaxa are combined to arrive at a more compact and clear and ecologically easily understandable arrangement. Not all the taxa mentioned are necessarily diagnostic only for the respective syntaxon, but some are diagnostic for subordinate syntaxa. Taxonomy and nomenclature of the taxa are primarily according to FISCHER *et al.* (2008 and/or in prep.), but important synonyms in brackets.

2.4.1 Zonal natural vegetation

(1) Xerothermic forests:

(1a) Mixed oak forests (*Quercion pubescenti-petraeae*, mainly in A of Fig. 1). Tree species: *Quercus pubescens*, *Qu. cerris*, *Sorbus aria*, *S. domestica*, and *S. torminalis*; shrub species: *Cornus mas*, *Euonymus verrucosus*, *Viburnum lantana*, *Ligustrum vulgare*, *Loranthus europaea* (epiphyte); herbaceous species: *Aegonychon* (*Buglossoides*) *purpureocaerulea*, *Aster amellus*, *Campanula bononiensis*, *Carex halleriana*, *C. michelii*, *Conringia austriaca* (very rare), *Coronilla coronata*, *Corydalis pumila*, *Hierochloë australis*, *Laser trilobum*, *Limodorum abortivum*, *Mercurialis ovata*, *Piptatherum* (*Oryzopsis*) *virescens*, *Primula veris*, *Pseudoturritis* (*Arabis*) *turrita*, *Ranunculus polyanthemus*, *Trifolium rubens*, *Veronica austriaca*, *V. vindobonensis*, and *Vincetoxicum hirundinaria*. [See also 3f!]

(1b) Xerothermic fringe communities (*Geranion sanguinei*): *Prunus fruticosa*, *Rosa spinosissima* (*pimpinellifolia*); *Bupleurum praealtum* (rare), *Centaurea* (*Cyanus*) *triumfetti*, *Clematis recta*, *Crepis pannonica* (very rare), *Dictamnus albus*, *Euphorbia polychroma* (*epithymoides*), *Geranium sanguineum*, *Inula germanica*, *Iris variegata*, *Klasea* (*Serratula*) *lycopifolia* (very rare), *Melampyrum cristatum*, *Phlomis tuberosa* (rare), *Scorzonera hispanica*, *Valeriana officinalis* subsp. *angustifolia* (*walrothii*),

Veronica (*Pseudolysimachion*) *orchidea* (rare), and *V. (Pseudolysimachion) spuria* (very rare).

(1c) Mainly in the sub-Mediterranean Southern Alps (southern parts of G in Fig. 1): *Acer opalus*, *Celtis australis*, *Cotinus coggygria*, *Dioscorea* (*Tamus*) *communis*, *Frangula rupestris*, *Fraxinus ornus*, *Hippocrepis emerus* (*Emerus majus*), *Pistacia terebinthus*, *Prunus mahaleb*, *Ruscus aculeatus*, and *R. hypoglossum*.

(2) Oak-hornbeam forests (*Carpinion betuli*):

(2a) Central European. *Acer campestre*, *Carpinus betulus*, *Prunus avium*, *Quercus petraea*; *Crataegus laevigata*, *Lonicera xylosteum*, and *Staphylea pinnata*; *Anemone nemorosa*, *Carex pilosa*, *Dactylis polygama*, *Fragaria moschata*, *Galium sylvaticum*, *Isopyrum thalictroides*, *Lathyrus niger*, *Melica nutans*, *Oxalis acetosella*, *Poa nemoralis*, *Rosa arvensis*, *Stellaria holostea*, *Tanacetum corymbosum*, *Viola alba*, and *V. riviniana*.

(2b) In SE Styria and Slovenia, forests of Illyric character (e.g., *Erythronio-Carpinion* and *Epimedio-Carpinetum*): *Crocus exiguus* (*vittatus*, "napolitanus"), *Epimedium alpinum*, *Erythronium dens-canis*, *Galium intermedium* (= *schultesii*), *Helleborus dumetorum*, *H. odoratus*, *Poa stiriaca*, *Pseudostellaria europaea*, and *Pulmonaria stiriaca*.

(3) Different further broad-leaved forests (*Fagion sylvaticae*, *Quercion roboris*, and *Tilio-Acerion*):

(3a) General beech forests (*Fagion sylvaticae*): *Acer pseudoplatanus*, *Fagus sylvatica*, *Fraxinus excelsior*; *Ajuga reptans*, *Asarum europaeum*, *Brachypodium sylvaticum*, *Cardamine bulbifera*, *C. enneaphyllos*, *Carex digitata*, *Daphne mezereum*, *Dryopteris carthusianorum* agg., *Euphorbia amygdaloides*, *E. dulcis*, *Galeobdolon montanum*, *Hepatica nobilis*, *Hordelymus europaeus*, *Lactuca (Mycelis) muralis*, *Knautia drymeia*, *Mercurialis perennis*, *Neottia nidus-avis*, *Paris quadrifolia*, *Phyteuma spicatum*, *Prenanthes purpurea*, *Pulmonaria officinalis*, *Salvia glutinosa*, *Sanicula europaea*, *Solidago virgaurea*, and *Viola reichenbachiana*.

(3b) Dry, thermophilous, calcareous beech forests at lower altitude (low-montane, Cephalantherio-Fagenion): *Bromus benekenii*, *Carex alba*, *Cephalanthera damasconium*, *C. rubra*, *Cyclamen purpurascens*, *Daphne laureola*, *Laserpitium latifolium*, *Melittis melissophyllum*, *Primula vulgaris*, and *Veratrum nigrum*.

(3c) Oak and beech forests on acid soil (*Quercion roboris*, *Luzulo-Fagenion*): *Castanea sativa*, *Quercus robur*, *Sorbus aucuparia*. Species generally indicating acid soils: *Avenella flexuosa*, *Blechnum spicant*, *Calluna vulgaris*, *Genista germanica*, *Hieracium murorum*, *H. sabaudum*, *H. umbellatum*, *Lathyrus linifolius* (rare), *Luzula luzuloides*, *L. nivea*, *Majanthemum bifolium*, *Melampyrum pratense*, *Oxalis acetosella*, *Pteridium aquilinum*, *Silene nutans*, *Teucrium scorodonia* (rare in Austria), *Thelypteris limbosperma*, *Vaccinium myrtillus*, and *Viscaria vulgaris* (*Lychnis viscaria*).

(3d) Middle- and high-montane spruce-fir-beech forests: *Abies alba*, *Acer pseudoplatanus*, *Fagus sylvatica*, *Picea abies*, *Sorbus aucuparia*; *Lonicera alpigena*, *Rosa pendulina*; *Adenostyles glabra*, *Aposeris foetida*, *Buphthalmum salicifolium*, *Calamagrostis varia*, *Cardamine trifolia*, *Centaurea montana*, *Cirsium erisithales*, *Dryopteris filix-mas*, *Helleborus niger*, *Knautia maxima*, *Polygonatum verticillatum*, *Primula elatior*, *Ranunculus nemorosus* (*tuberosus*), *Stellaria nemorum*, *Valeriana montana*, and *V. tripteris*. On more distinctly acid soils (mainly in siliceous mountains): *Galium rotundifolium*, *Gentiana asclepiadea*, *Homogyne alpina*, *Luzula sylvatica*, *Melampyrum sylvaticum*, *Oxalis acetosella*, and *Pyrola rotundifolia*.

(3e) Forests in ravines and gorges (Tilio-Acerion): *Acer platanoides* (low altitudes), *A. pseudoplatanus*, *Fraxinus excelsior*, *Tilia platyphyllos*, *Ulmus glabra*; *Staphylea pinnata*; *Aconitum lycoctonum* agg., *A. variegatum* agg., *Aethusa cynapium*, *Aruncus dioicus*, *Asplenium* (*Phyllitis*) *scolopendrium*, *A. viride*, *Campanula latifolia*, *C. trachelium*, *Carex pendula*, *Circaea lutetiana*, *Cystopteris fragilis*, *Euonymus europaeus*, *Festuca* (*Schedonorus*) *gigantea*, *Geranium robertianum*, *Gymnocarpium dryopteris*, *Impatiens noli-tangere*, *Lunaria rediviva*, *Moehringia muscosa*, *Memoremea* (*Omphalodes*) *scorpioides*, *Polystichum aculeatum*, *P. braunii*, *Ranunculus lanuginosus*, *R. platanifolius*, *Ribes uva-crispa*, *Saxifraga rotundifolia*, *Silene dioica*, *Streptopus amplexifolius*, and *Viola biflora*.

(3f) Illyrian broad-leaf forests and spruce-fir forests in the Southern Alps (Ostryo-Fagenion, Hacquetio-Fraxinetum, Laburno alpini-Piceetum, Anemone trifoliae-Abietetum, Ligustro-Piceetum): *Castanea sativa*, *Fraxinus ornus*, *Ostrya carpinifolia*; *Euonymus latifolius*, *Laburnum alpinum*; *Anemone trifolia*, *Anthericum liliago*, *Aremonia agrimonioides*, *Asperula taurina*, *Cardamine heptaphylla*, *C. pentaphyllos*, *C. waldsteinii*, *Dioscorea* (*Tamus*) *communis*, *Euphorbia carniolica*, *Galium aristatum*, *G. laevigatum*, *Geranium nodosum*, *Hacquetia epipactis*, *Homogyne sylvestris*, *Ilex aquifolium* (but also in Vorarlberg), *Lactuca perennis*, *Lamium orvala*, *Lathyrus laevigatus* subsp. *laevigatus*, *L. venetus*, *Lilium carniolicum*, *Luzula nivea*, *Phyteuma ovatum*, *Polystichum setiferum*, *Pulmonaria vallarsae*, and *Saxifraga cuneifolia*.

(3g) Basiphilous spruce and spruce-fir forests (Abieti-Piceion): *Aster bellidiastrum*, *Betonica alopecurus*, *Cephalanthera longifolia*, *Clinopodium* (*Acinos*) *alpinum*, *Epilobium montanum*, *Gymnocarpium robertianum*, *Orthilia secunda*, *Polystichum lonchitis*, and *Veronica urticifolia*.

(4) Euro-Siberian spruce and spruce-fir montane forests on acid soil (Vaccinio-Piceion): *Larix decidua*, *Picea abies*, *Pinus sylvestris*; *Calamagrostis villosa*, *Equisetum sylvaticum*, *Huperzia selago*, *Linnaea borealis*, *Listera*

(*Neottia*) *cordata*, *Luzula luzulina*, *Lycopodium annotinum*, *L. clavatum*, *Moneses uniflora*, *Phegopteris connectilis*, and *Vaccinium myrtillus*.

(5) Subalpine vegetation:

(5a) Green-alder shrubs and tall herb (megaphorb) communities (Adenostyletalia, Alnion viridis) in moist, nutrient-rich places: *Acer pseudoplatanus*, *Alnus alnobetula* (*viridis*), *Sorbus aucuparia*; *Lonicera caerulea*, *Ribes petraeum*, *Salix appendiculata*; *Achillea macrophylla*, *Aconitum lycoctonum* agg., *A. variegatum* agg., *Adenostyles alliariae*, *Alchemilla glabra*, *Astrantia major*, *Athyrium distentifolium*, *Cerintho glabra*, *Chaerophyllum villarsii*, *Cirsium heterophyllum*, *Crepis pyrenaica*, *Delphinium elatum* s. lat., *Doronicum austriacum*, *Epilobium alpestre*, *Geranium sylvaticum*, *Heracleum sphondylium* subsp. *elegans*, *Hypericum maculatum*, *Lactuca* (*Cicerbita*) *alpina*, *Peucedanum ostruthium*, *Rumex alpestris*, *Sanguisorba dodecandra*, *Senecio nemorensis* subsp. *hercynicus*, *Thalictrum aquilegifolium*, and *Tozzia alpina*.

– In the Southern Alps: *Barbarea bracteosa*, *Eryngium alpinum*, *Myrrhis odorata*, and *Rhaponticum scariosum* (*Stemmacantha rhapsantica*) [See also (13h)!]

(5b) Dwarf-pine shrub (Pinion mugo) and dwarf shrub (heath, Ericion carneae, Rhododendro-Vaccinietales) communities in more or less dry places: *Arctostaphylos uva-ursi*, and *Pinus mugo*. Basiphilous: *Arctostaphylos alpinus*, *Clematis alpina*, *Daphne striata*, *Erica carnea*, *Rhododendron hirsutum*, *Rhododendron chamaecistus*, and *Sorbus chamaemespilus*. Acidophilous: *Calluna vulgaris*, *Empetrum nigrum* s. lat., *Hieracium* (*Schlagintweitia*) *intybaceum*, *Juniperus communis* subsp. *nana*, *Rhododendron ferrugineum*, *Salix helvetica*, *Vaccinium uliginosum* subsp. *gaultherioides*, and *V. vitis-idaea*.

(5c) Subalpine Pinus cembra forests (Vaccinio-Pinetum cembrae): *Larix decidua*, *Pinus cembra*, and *Rhododendron ferrugineum*. Note: The timber-line generally has been lowered by c 200 m as a result of alpine pasturing for centuries, which has produced vast alpine pastures (13h), but also 5d and secondary *Pinion mugo* shrubland (5b).

(5d) Subalpine natural grassland (Caricion ferrugineae): *Allium victorialis*, *Anemonastrum narcissiflorum*, *Astragalus australis*, *A. frigidus*, *Campanula barbata*, *C. thyrsoides*, *Carduus defloratus*, *Carex ferruginea*, *Crepis pontana*, *Festuca pulchella*, *Geum montanum*, *Hedysarum hedysaroides*, *Heracleum austriacum*, *Luzula glabrata*, *Narcissus radiiflorus*, *Oxytropis montana*, *Pedicularis foliosa*, *Pulsatilla alpina*, *Rhodiola rosea*, *Scorzonera rosea*, *Senecio doronicum*, *Trifolium badium*, *T. thalii*, and *Trollius europaeus*.

[For the subalpine rock flora, see (11)!]

(6) Alpine vegetation (Seslerietea albicantis, Caricetea curvulae, and Salicetea herbaceae).

(6a) Turfs on calcareous bedrocks and very shallow soil, upper alpine belt [calcareous cushion sedge turf/

swards (*Caricion firmae*): *Carex firma*, *Chamorchis alpina*, *Dryas octopetala*, *Festuca pumila*, *Helianthemum alpestre*, *Homogyne discolor*, *Facchinia (Minuartia) cherlerioides* subsp. *cherlerioides*, *Cherleria (Minuartia) sedoides*, *Potentilla nitida* (S Alps), *Saxifraga caesia*, *S. squarrosa* (S Alps), *Saussurea pygmaea*, *Silene acaulis* subsp. *longiscapa*, and *Primula clusiana* (N Alps). [See also (11)!]

(6b) Turfs on calcareous bedrock of the lower alpine belt (*Seslerion coeruleae*): *Achillea clavennae*, *Androsace chamaejasme*, *Anthyllis vulneraria* subsp. *alpestris*, *Armeria alpina* (also on acid soils), *Aster alpinus*, *Biscutella laevigata*, *Campanula cespitosa*, *Carex sempervirens* (also on acid soils), *Crepis jacquini*, *Dianthus alpinus*, *Euphrasia salisburgensis*, *Galium anisophyllum* (also on acid soils), *Gentiana clusii*, *Globularia cordifolia*, *G. nudicaulis*, *Helianthemum grandiflorum*, *Hieracium villosum*, *Leontopodium alpinum*, *Nigritella archiducis-joannis* (local), *N. miniata*, *Pedicularis rostratocapitata*, *P. verticillata* (also on acid soils), *Primula auricula*, *Scabiosa lucida*, *Selaginella selaginoides*, *Sesleria caerulea*, and *Veronica fruticans* (also on more or less siliceous rocks). – In the Southern Alps (*Caricion austroalpinae*): *Achillea oxyloba* (S Alps), *Allium insubricum*, *Callianthemum kernerianum*, *Carex austroalpina*, *C. baldensis*, *Geranium argenteum*, *Helictotrichon petzense* (SE Alps), *Horminum pyrenaicum*, *Knautia baldensis*, *K. transalpina*, *K. velutina*, *Laserpitium nitidum*, *L. peucedanoides*, *Leucanthemum heterophyllum*, *Pedicularis gyroflexa*, *Primula glaucescens*, *P. spectabilis*, *Scabiosa vestina*, and *Semprevivum dolomiticum* (Dolomites).

(6c) Subalpine and alpine calcareous scree (*Thlaspion rotundifolii*): *Campanula cochleariifolia*, *Cerastium carinthiacum*, *Crepis terglouensis*, *Hornungia alpina* subsp. *alpina*, *Linaria alpina*, *Noccaea rotundifolia*, *Papaver alpinum*, *Scorzoneroides (Leontodon) montana*, and *Valeriana supina*.

(6d) Turfs on siliceous bedrocks (*Caricion curvulae*): *Campanula alpina*, *Carex curvula* subsp. *curvula*, *Gentiana acaulis* s. str., *Helictochloa (Avenula) versicolor*, *Kalmia (Loiseleuria) procumbens*, *Leucanthemopsis alpina*, *Minuartia recurva*, *Oreochloa disticha*, *Pedicularis kernerii*, *Phyteuma hemisphaericum*, *Pulsatilla alpina* subsp. *alba* (*austriaca*), *Saponaria pumila*, *Senecio carniolicus* agg., *Silene acaulis* subsp. *exscapa*, *Valeriana celtica*, and *Veronica bellidioides*. – Alpine siliceous scree (*Androsacion alpinae*): *Achillea moschata*, *Androsace alpina*, *Cerastium pedunculatum*, *Geum reptans*, *Hornungia alpina* subsp. *brevicaulis* (mainly on “intermediate” bedrock), *Oxyria digyna*, *Rumex scutatus*, *Trifolium pallescens*, and *Viola comollia*. [See also (11b)!]

[For the alpine rock flora, see (11)!]

(6e) Special habitats are alpine snowbeds (aa) on acid soils (*Salicion herbaceae*): *Arenaria biflora*, *Cardamine alpina*, *Cerastium cerastoides*, *Gnaphalium supinum*, *Ranunculus pygmaeus*, *Sagina saginoides*, *Salix herba-*

cea, *Sibbaldia procumbens*, and *Soldanella pusilla* or (bb) on alkaline (calcareous) soils (*Arabidion caeruleae*): *Achillea atrata*, *A. clusiana* (NE Alps), *Arabis caerulea*, *Campanula pulla* (NE Alps), *Galium baldense* (S Alps), *G. noricum*, *Gnaphalium hoppeanum* (also on “intermediate” bedrock), *Potentilla brauneana*, *Ranunculus alpestris*, *Rumex nivalis*, *Soldanella alpina*, *S. austriaca* (NE Alps), *S. minima* (SE Alps), and *Veronica alpina*.

(6f) Special habitats in wind-exposed places (*Oxytropido-Elynion*): *Agrostis alpina*, *Cerastium alpinum*, *Comastoma tenellum*, *Draba siliquosa*, *Dianthus glacialis*, *Kalmia (Loiseleuria) procumbens*, *Kobresia (Elyna) myosuroides*, *Lomatogonium carinthiacum*, and *Salix serpyllifolia*.

(6g) Subnival belt: Few vascular plants are present, in detached tufts only: *Androsace alpina*, *Cerastium uniflorum*, *Draba fladnizensis*, *Leucanthemopsis alpina*, *Poa laxa*, *Ranunculus glacialis*, *Saxifraga biflora*, *S. bryoides*, *S. exarata*, and *S. oppositifolia*.

2.4.2 Azonal natural vegetation

(7) Riparian (alluvial, floodplain) forests (*Salicion albae*, *Alnion incanae*):

(7a) General: *Prunus padus*, *Salix alba*, *S. euxina* (*fragilis*), *Ulmus laevis*; *Clematis vitalba*, *Sambucus nigra*, *Solanum dulcamara*, *Viburnum opulus*, *Vitis vinifera* subsp. *sylvestris* (very rare); *Aegopodium podagraria*, *Alliaria petiolata*, *Calystegia sepium*, *Carduus crispus*, *Ficaria verna*, *Gagea lutea*, *Galanthus nivalis*, *Galium aparine*, *G. palustre*, *Geranium phaeum*, *Geum urbanum*, *Glechoma hederacea*, *Humulus lupulus*, *Parietaria officinalis*, *Rubus caesius*, *Scilla bifolia* agg., *Silene (Cucubalus) baccifera*, *Stachys sylvatica*, *Stellaria (Myosoton) aquatica*, *Urtica dioica*, *Veronica sublobata*. – Along mountain rivers and streams: *Alnus incana*, *Salix eleagnos*; *Matteuccia struthiopteris*, *Petasites hybridus*, and *Rumex longifolius* (Upper Engadine only).

(7b) The riverside forests and meadows in the Pannonian region along the March/Morava river forming Austria's eastern border with Slovakia are distinguished by several ecological and floristic features, typical species being [see SCHRATT-EHRENDORFER (1999)] *Fraxinus angustifolia* subsp. *danubialis*; *Barbarea stricta*, *Clematis integrifolia*, *Filipendula ulmaria* subsp. *picbaueri*, *Galium rivale*, *Hierochloë repens* (very rare), *Chaiturus (Leonurus) marrubiastrum*, *Leucojum aestivum*, *Oenanthe silaifolia* (very rare), *Plantago altissima*, *Rumex pseudonatronatus* (very rare), *Selinum dubium (Cnidium venosum)*, and *Urtica kioviensis*.

(7c) Nutrient-rich, nitrophilous, wet riverbank fringes (*Bidentetea tripartiti*): *Alopecurus aequalis*, *Barbarea vulgaris*, *Bidens cernuus*, *B. frondosus* (neophyte), *B. tripartita*, *Glyceria fluitans*, *Oxybasis (Chenopodium) rubra*, *Persicaria dubia (mitis)*, *P. hydrophiper*, *P. lapathifolia*, *Potentilla supina*, *Ranunculus sceleratus*, *Rorippa amphibia*, *R. palustris*, *Rumex palustris*, and *Veronica catenata*.

(8) Dry, montane, calcicolous pine forests (*Erico-Pinion sylvestris*):

(8a) General: *Pinus sylvestris*, *Sorbus aria*; *Amelanchier ovalis*, *Cotoneaster integerrima*, *C. tomentosus*, *Genista radiata* (S Alps); *Arabidopsis lyrata* (*Cardaminopsis petraea*), *Carex ornithopoda* subsp. *ornithopoda*, *Coronilla vaginalis*, *Daphne cneorum*, *Epipactis atrorubens*, *Erica carnea*, *Gymnadenia odoratissima*, *Laserpitium siler*, *Leontodon incanus*, *Polygala chamaebuxus*, *Rubus saxatilis*, *Sesleria caerulea*, *Thesium alpinum*, *Viola collina*, and *Viscum laxum* subsp. *laxum*.

(8b) Austrian pine forest (*Seslerio-Pinetum nigrae*) (NE Alps only): *Pinus nigra* subsp. *nigra*, *Anthericum ramosum*, *Anthyllis montana* subsp. *jacquinii* (very rare), *Carduus defloratus* subsp. *glaucus*, *Euphorbia saxatilis*, *Galium austriacum*, *G. lucidum*, *Leucanthemum adustum* subsp. *margaritae*, *Melampyrum subalpinum*, *Noccaea* (*Thlaspi*) *montana*, *Phyteuma orbiculare*, *Polygala amara* subsp. *amara*, and *Thalictrum minus*.

(8c) South Alpic Austrian pine forests (*Fraxino orni-Pinetum nigrae*) (SE Alps only): *Fraxinus ornus*, *Pinus nigra* subsp. *nigra*; *Asperula aristata*, *A. purpurea*, *Chamaecytisus purpureus*, *Crepis froelichiana* subsp. *dinarica*. – Note: Autochthonous sites of *Pinus nigra* subsp. *nigra* (Austrian pine) in our area are restricted to the very eastern margin of the NE Calcareous Alps (between Vienna and the “Viennese” Schneeberg) and local sites in the SE Alps (Karawanken/Karavanke and Julian Alps), both considered as a relic from pre-glacial times, the main range of distribution extending in the western part of the Balkan Peninsula. In addition, this tree species is frequently planted because of its drought resistance and, in former times, was cultivated (instead of natural broad-leaf forests) for obtaining resin.

(8d) Subcontinental acid Scots pine forests (*Dicrano-Pinion*): *Pinus sylvestris*; *Arabidopsis* (*Cardaminopsis*) *arenosa*, *Atocion* (*Silene*) *rupestre*, *Chimaphila umbellata* (very rare), *Diphasiastrum* (*Lycopodium*) *complanatum*, *Festuca ovina*, *Goodyera repens*, and *Pyrola chlorantha*.

(8e) Scots pine forests on serpentinic (ophiolithic) bedrocks (*Festuco eggleri-Pinetum sylvestris*; in Styria, rare): *Avenula* (*Helictochloa*) *adsurgens*, *Festuca eggleri*, *Knautia norica*, *Poa stiriaca*, and *Pulmonaria stiriaca*. [See also (11c) for rock vegetation!]

(9) Wetland:

(9a) Lakes and lake-sides, rivers, streams (*Lemnetea*, *Potametea*, *Phragmiti-Magnocaricetea*): *Alisma* spp., *Berula erecta*, *Callitriche* spp., *Carex elata*, *Ceratophyllum* spp., *Elatine* spp., *Equisetum fluviatile*, *Eriophorum scheuchzeri*, *Glyceria maxima*, *Hippuris vulgaris*, *Hottonia palustris*, *Lemna minor*, *Lycopus europaeus*, *Myriophyllum* spp., *Najas* spp., *Nuphar lutea*, *Nymphaea alba*, *Nymphoides peltata*, *Oenanthe aquatica*, *Persicaria amphibia*, *Phalaris arundinacea*, *Phragmites australis*, *Potamogeton* spp., *Ranunculus* sect. *Batrachium*, *Schoe-*

noplectus lacustris, *Scutellaria galericulata*, *Sparganium* spp., *Spirodela polyrhiza*, *Stratiotes aloides*, *Trapa natans*, *Typha* spp., *Utricularia* spp., and *Zannichellia palustris*.

(9b) Stream-sides (*Calthion*): *Caltha palustris*, *Cardamine amara*, *Cirsium oleraceum*, *Epilobium hirsutum*, *Geum rivale*, *Hypericum tetrapterum*, *Mentha aquatica*, *Myosotis palustris* agg., *Ranunculus flammula*, *Scirpus sylvaticus*, *Scrophularia umbrosa*, *Tephrosia crispa*, *Veronica anagallis-aquatica*, and *V. beccabunga*.

(9c) Dwarf galingales alliance, dwarf rush communities, poikilohydrous swards on pond banks, wet trails, etc. (*Nanocyperion*): *Carex bohemica*, *Centaurium pulchellum*, *Centunculus* (*Anagallis*) *minimus*, *Coleanthus subtilis* (very rare), *Cyperus fuscus*, *Elatine hexandra*, *E. triandra*, *Eleocharis acicularis*, *E. ovata*, *Gnaphalium uliginosum*, *Gypsophila muralis*, *Juncus articulatus*, *J. bufonius*, *Limosella aquatica*, *Myosurus minimus*, *Peplis* (*Lythrum*) *portula*, *Plantago uliginosa* (*P. major* subsp. *intermedia*), *Stellaria alsine*, and *Veronica anagalloides*.

(10) Swamps, mires:

(10a) Carrs (fenwood, swamp forests) and fens (different communities, viz., *Salicion cinereae*, *Salicion auritae*, *Alnion glutinosae*, and *Scheuchzerio-Caricetea fuscae*): *Alnus glutinosa*, *Betula humilis* (rare), *B. pubescens*, *Frangula alnus*, *Salix aurita*, *Calla palustris*, *Carex elongata*, *C. nigra*, *C. pauciflora*, *Comarum palustre*, *Dryopteris cristata*, *Epilobium palustre*, *Eriophorum angustifolium*, *Galium uliginosum*, *Lythrum salicaria*, *Pedicularis palustris*, *Peucedanum palustre*, *Pinguicula vulgaris*, *Potentilla erecta*, *Primula farinosa*, *Salix cinerea*, *S. repens*, *Stachys palustris*, *Thelypteris palustris*, and *Trichophorum alpinum*.

(10b) Calcareous fens (*Caricion davallianae*): *Carex davalliana*, *Crepis paludosa*, *Epipactis palustris*, *E. latifolium*, *Parnassia palustris*, and *Tofieldia calyculata*.

(10c) Extremely acid and nutrient-poor raised bogs (*Oxycocco-Sphagnetea*): *Andromeda polifolia*, *Betula nana* (rare boreal relic), *Drosera anglica*, *D. rotundifolia*, *Eriophorum vaginatum*, *Rhododendron tomentosum* (*Ledum palustre*), *Vaccinium uliginosum* subsp. *uliginosum*, and *V. oxycoccus*.

(11) Montane, subalpine, and alpine rock (rupestrian) and scree vegetation (*Asplenietea trichomanis*, *Thlaspietea rotundifolii*):

(11a) General: *Anemone baldensis*, *Aquilegia einseleana* (S Alps), *Asplenium ceterach* (mainly in the S Alps), *A. viride*, *Athamanta cretensis*, *Campanula praesignis* (NE Alps only), *Carex rupestris*, *Cystopteris fragilis*, *Hieracium humile*, *H. porrifolium*, *Kernera saxatilis*, *Moehringia bavarica* subsp. *bavarica*, *M. glaucovirens*, *M. markgrafii*, *Potentilla caulescens*, *Rhamnus pumila*, *Saxifraga hostii*, *Scrophularia canina* agg. (mainly in the S Alps), *Valeriana saxatilis*, and *Woodsia pulchella*.

(11b) On South-Alpic rocks and scree (calcifuge species designated by *): *Adenophora liliifolia* (in Austria as a de-alpine very rare relict in moist meadows), *Androsace brevis**, *A. vandellii**, *Artemisia atrata*, *A. nitida*, *Biscutella cichoriifolia*, *Bupleurum petraeum*, *Campanula bertolae**, *C. carnica*, *C. morettiana*, *C. raineri*, *Cerastium subtriflorum*, *Cytisus emeriflorus*, *Grafia golaka*, *Knautia persicina*, *K. velutina*, *Ligusticum lucidum*, *Moehringia bavarica* subsp. *insubrica* and *M. dielsiana* (both Judicarian endemics), *Molopospermum peloponnesiacum**, *Oxytropis fetida*, *Paederota bonarota*, *Phyteuma hedraianthifolium**, *Ph. scorzoniferolium**, *Physoplexis comosa*, *Primula latifolia**, *Sagina glabra**, *Scabiosa velenovskyana*, *Scutellaria alpina*, *Veronica fruticulosa*, *Viola cenisia*, and *V. dubyana*.

(11c) On ophiolithic (serpentinic) rocks: *Asplenium xadulterinum*, *A. cuneifolium*, *Noccaea goesingensis*, *Notholaena marantae*, *Potentilla crantzii* subsp. *serpentina*, *Tephroses integrifolia* subsp. *serpentina*, and *Veronica scardica* (streams).

(11d) A very special habitat are half-caves (*Chenopodium foliosum*, *Blitum virgatum*): *Hackelia deflexa*, *Heliosperma veselskyi*, *Hornungia (Hymenolobus) pauciflora*, *Saxifraga arachnoidea* (Judicarian endemic), *S. petraea*, and *Sisymbrium austriacum*.

(11e) Alluvial scree vegetation (now extremely rare, present in Austria only in very few rivers, e.g., the Lech and Isel and Schwarzach rivers in Tyrol, as well as at the southern foot of the Alps in Friuli (in the Tagliamento river): *Chlorocrepis (Tolpis) staticifolia*, *Chondrilla chondrilloides*, *Epilobium fleischeri* (western East Alps), *Euphorbia kernerii* (endemic on the southeast edge of the Alps), *Hippophaë rhamnoides*, *Leontodon berinii* (S Alps), and *Myricaria germanica*.

2.4.3 Anthropogenic vegetation

(12) Dry grassland (mainly *Festuco-Brometea*, several quite different communities), including other “steppe-like” vegetation. The anthropogenic nature of these habitats in the Pannonian eastern part of Austria is generally more or less questionable: at least to some extent, they are natural.

(12a): More or less Pannonian grassland (primary edaphic steppes and secondary “steppes” in place of original dry forests; mainly *Cirsio-Brachypodium pinneti* and *Festucetalia valesiaca*). Many species are mentioned here because they are characteristic of NE Austria, most of them growing in pastures (“Puszta”) called Pannonian (secondary) “steppes”, which are mainly preserved in nature reserves. Most of the Pannonian steppes are on carbonatic bedrocks (but see also 12e): *Achillea pannonica*, *Adonis vernalis*, *Artemisia campestris*, *A. pontica*, *A. panicii* (very rare Pannonian endemic), *Asperula cynanchica*, *Astragalus austriacus*, *A. exscapus* (very rare), *A. onobrychis*, *A. vesicarius* subsp. *vesicarius* (very rare), *Brachypodium pinnatum*, *Cerastium pumilum* agg.,

Carex humilis, *Centaurea jacea* subsp. *angustifolia* (*pannonica*), *C. paniculata*, *Chamaecytisus austriacus*, *Ch. ratisbonensis*, *Crambe tataria* (very local), *Cuscuta epithymum*, *Dianthus carthusianorum* subsp. *pontederiae*, *Dorycnium germanicum*, *Draba (Erophila) verna* s. lat., *Elymus hispidus*, *Eryngium campestre*, *Erysimum diffusum*, *E. odoratum*, *Euphorbia cyparissias*, *E. seguieriana*, *Festuca rupicola*, *F. valesiaca*, *Fragaria viridis*, *Galatella (Aster) linosyris*, *Galium glaucum*, *Genista pilosa*, *Globularia bisnagarica (punctata)*, *Helianthemum nummularium* subsp. *obscurum (H. ovatum)*, *Helictotrichon desertorum* subsp. *basalticum* (very rare), *Hesperis tristis*, *Himantoglossum adriaticum*, *Holosteum umbellatum*, *Hypochaeris maculata*, *Inula ensifolia*, *I. oculus-christi*, *Iris pumila*, *Jurinea mollis*, *Koeleria macrantha*, *Lathyrus pannonicus*, *Linaria genistifolia*, *Linum flavum*, *L. tenuifolium*, *Marrubium peregrinum*, *Medicago falcata*, *M. minima*, *Melica ciliata*, *Muscari neglectum*, *M. tenuiflorum*, *Myosotis ramosissima*, *Nonea erecta (pulla)*, *Odontites lutea*, *Onobrychis arenaria*, *Onosma arenaria* (very rare), *O. visianii* (rare), *Ophrys apifera* (rare), *O. holoserica*, *O. sphegodes*, *Orchis militaris*, *Ornithogalum comosum (pannonicum)*, *Oxytropis pilosa*, *Petrorhagia saxifraga*, *Phelipanche caesia* (very rare), *Phleum phleoides*, *Pimpinella saxifraga* subsp. *nigra*, *Polygala comosa*, *P. major*, *Prunella grandiflora*, *Pulsatilla grandis*, *P. pratensis* subsp. *nigricans*, *Ranunculus illyricus*, *Rapistrum perenne*, *Salvia austriaca*, *S. nemorosa*, *Sanguisorba minor*, *Scabiosa ochroleuca*, *S. canescens*, *Scorzonera hispanica*, *S. purpurea*, *Senecio jacobaea*, *Seseli annuum*, *S. hippomarathrum*, *Silene otites*, *S. multiflora*, *S. viscosa*, *Stachys recta*, *Stipa capillata*, *S. pennata* agg., *Taraxacum sect. Erythrosperma*, *Tephroses integrifolia*, *Teucrium chamaedrys*, *Thesium linophyllum*, *Thymus pannonicus* agg., *Trinia glauca*, *Verbascum phoeniceum*, *V. lychnitis*, *Veronica prostrata* subsp. *prostrata*, and *V. (Pseudolysimachion) spicata*. – (See also 1b!)

(12b) Calicolous rock steppes and shallow soil turfs in the Pannonian region and in the Southern Alps (+ designates taxa only in the S Alps): *Argyrolobium zanonii*+, *Bupleurum baldense*+, *Campanula pyramidalis*+, *C. sibirica*, *Cytisus emeriflorus*+, *Dianthus lumnitzeri* (local), *Echinops ritro* subsp. *ruthenicus* (local), *Fumana procumbens*, *Genista sericea*+, *Helianthemum canum*, *Hornungia petraea*, *Knautia illyrica*+, *Potentilla incana (arenaria)*, *Scabiosa hladnikiana*+, *S. vestina*+, *Scorzonera austriaca*, *Seseli elatum* agg., *S. kochii*+, *Teucrium montanum*, *Thesium divaricatum*+, and *Thymus praecox*. (12c) Inner Alpic “steppes” (*Ononido rotundifoliae*-*Pinion* and *Stipo-Poion xerophilae*): *Achillea tomentosa*, *Astragalus exscapus*, *A. monspessulanus*, *A. vesicarius* subsp. *pastellianus*, *Carex liparocarpus*, *Cleistogenes (Kengia) serotina* (acidophilous), *Dracocephalum austriacum*, *Ephedra distachya*, *Fumana ericifolia*+, *Helianthemum apenninum*, *Heteropogon contortus*, *Onobrychis arenaria* subsp. *taurerica*, *Ononis rotundifolia*, *Onosma*

helvetica, *Phleum phleoides*, *Scabiosa triandra* (*gramuntia*), *Stipa capillata*, and *S. pennata* agg.

(12d) Pannonian saline steppes and marshes in North Burgenland (*Puccinellio-Salicornietea*): *Artemisia santonicum*, *Atriplex intracontinentalis* (*A. littoralis* agg.; very rare), *A. prostrata*, *Bolboschoenus maritimus* s. str., *Bupleurum tenuissimum*, *Camphorosma annua*, *Centaureum littorale* subsp. *uliginosum*, *Chenopodium chenopodioides*, *Crypsis aculeata*, *Cyperus pannonicus*, *Festuca pseudovina*, *Iris spuria* (very rare), *Juncus gerardii*, *Lepidium cartilagineum*, *Lotus tenuis*, *Oxybasis* (*Chenopodium*) *glauca*, *Plantago maritima*, *P. tenuiflora* (very rare), *Puccinellia peisonis*, *Salicornia prostrata*, *Schoenoplectus tabernaemontani*, *Scorzonera parviflora*, *Spergularia maritima*, *Suaeda pannonica*, *S. prostrata*, *Taraxacum bessarabicum*, *Trifolium fragiferum*, *Triglochin maritima*, and *Tripolium pannonicum* (*Aster tripolium*).

(12e) Acid Pannonian steppes (e.g., on the western margin of Weinviertel; *Koelerio-Phleotalia phleoidis* p. p.; more likely to 4.2.2 azonal vegetation): *Achillea nobilis*, *A. setacea*, *Agrostis vinealis*, *Anacamptis* (*Orchis*) *morio*, *Artemisia austriaca*, *Bothriochloa ischaemum*, *Cleistogenes* (*Kengia*) *serotina* (mainly in the S), *Cruciata pedemontana*, *Cytisus procumbens*, *Eremogone graminifolia* (*Arenaria procera* subsp. *glabra*; very rare), *Gagea bohemica*, *Iris humilis* subsp. *arenaria* (very rare), *Myosotis stricta*, *Potentilla argentea*, *Scleranthus perennis* (siliceous rocks), *S. polycarpus* (rare), *Sedum* (*Petrosedum*) *rupestre*, *Veronica dillenii*, *V. verna*, and *Vicia lathyroides*.

(12f) Colline sand vegetation, including sand dunes along the Morava river; most of these species rare to very rare; *Koelerio-Corynephoretea*, *Festucetalia vaginatae*; more likely to 4.2.2 azonal vegetation): *Anthemis ruthenica* (rare), *Armeria elongata* (also on siliceous rocks), *Bassia* (*Kochia*) *laniflora* (very rare), *Corynephorus canescens* (rare), *Dianthus collinus* (local), *Equisetum ramosissimum*, *Eryngium planum* (very rare), *Festuca vaginata* (very rare), *Filago arvensis*, *F. minima*, *Helichrysum arenarium* (rare), *Jasione montana*, *Plantago arenaria*, *Saxifraga tridactylitis* (also frequently semi-ruderal), *Silene conica* (rare), *Spergula morisonii* (rare), *Trinia kitaibelii* (*ucrainica*) (very rare), and *Vulpia myuros*.

(13) Meadows and pastures (*Molinio-Arrhenatheretea*): Most of these species are widespread and common to Central Europe and the Balkan Peninsula, and therefore only a few examples are given here, mainly from

(13a) Colline to submontane more or less nutrient-rich meadows (*Pastinaco-Arrhenatheretum*): *Achillea collina*, *Arrhenatherum elatius*, *Campanula patula*, *Colchicum autumnale*, *Crepis biennis*, *Dactylis glomerata*, *Galium album*, *Geranium pratense*, *Lathyrus pratensis*, *Leontodon hispidus*, *Leucanthemum irtutianum*, *Lotus corniculatus*, *Medicago lupulina*, *Plantago lanceolata*, *Poa pratensis*, *Ranunculus acris*, *Rumex acetosa*, *Taraxacum* sect. *Ruderalia*, and *Veronica arvensis*.

(13b) More or less nutrient-rich montane meadows (*Polygono-Trisetion*): *Achillea millefolium*, *Centaurea pseudophrygia*, *Chaerophyllum aureum*, *Festuca nigrescens*, *Geranium phaeum* subsp. *lividum*, *Heracleum sphondylium*, *Persicaria bistorta* (*Bistorta officinalis*), *Pimpinella major*, *Rhinanthus alectorolophus*, *Trifolium pratense*, *Trisetum flavescens*, *Trollius europaeus*, and *Veronica chamaedrys*.

(13c) Submontane more or less dry calcareous or poikilohydrous meadows (*Ranunculo bulbosi-Arrhenatheretum* and *Filipendulo vulgaris-Arrhenatheretum*): *Anthyllis vulneraria*, *Avenula* (*Homalotrichon*) *pubescens*, *Briza media*, *Centaurea jacea* subsp. *jacea*, *C. scabiosa*, *Filipendula vulgaris*, *Galium boreale*, *Knautia arvensis*, *Ranunculus bulbosus*, *Rhinanthus minor*, *Salvia pratensis*, *Tragopogon orientalis*, *Trifolium montanum*, and *Veronica vindobonensis*.

(13d) Nutrient-rich pastures (*Cynosurion*): *Bellis perennis*, *Carum carvi*, *Cynosurus cristatus*, *Euphrasia officinalis*, *Lolium perenne*, *Prunella vulgaris*, *Scorzoneroideis* (*Leontodon*) *autumnalis*, *Trifolium repens*, and *Veronica serpyllifolia*.

(13e) Nutrient-poor pastures (calcareous or *acidic): *Anthoxanthum odoratum**, *Carlina acaulis*, *Galium pumilum*, *Luzula campestris**, *Ononis spinosa*, *Pilosella officinarum* (*Hieracium pilosella*)*, *Plantago media*, *Saxifraga bulbifera*, *S. granulata**, and *Thymus pulegioides**.

(13f) Montane acidic pastures (*Nardetalia*) are characterised by *Antennaria dioica*, *Arnica montana*, *Botrychium lunaria*, *Calluna vulgaris*, *Carex pallescens*, *C. pilulifera*, *Cirsium acaule* (W and S), *Deschampsia cespitosa*, *Genista tinctoria*, *Gymnadenia conopsea*, *Nardus stricta*, *Pilosella* (*Hieracium*) *lactucella*, *Polygala vulgaris*, *Pseudorchis albida*, and *Veronica officinalis*.

(13g) Moist to wet meadows (*Molinietalia*) (many of the following species have become rare, and especially those left in the Pannonian Basin are of high botanical and conservational value): *Achillea aspleniifolia*, *A. ptarmica* (not Pannonian), *Anacamptis* (*Orchis*) *palustris* (rare), *Carex panicea*, *C. tomentosa*, *Cirsium canum*, *C. palustre*, *C. rivulare*, *Dianthus superbus* subsp. *superbus* (rare), *Equisetum palustre*, *Euphorbia villosa* (*illyrica*) (rare), *Euphrasia kernerii* (rare), *Gentiana pneumonanthe* (rare), *Gladiolus palustris* (rare), *Holcus lanatus*, *Inula britannica*, *Iris sibirica*, *Juncus inflexus*, *Laserpitium prutenicum*, *Liparis loeselii* (rare), *Lychnis flos-cuculi*, *Lysimachia nummularia*, *L. vulgaris*, *Molinia caerulea*, *Ophioglossum vulgatum* (rare), *Potentilla erecta*, *Ranunculus repens*, *Sanguisorba officinalis*, *Scorzonera humilis*, *Selinum carvifolia*, *Serratula tinctoria*, *Spiranthes aestivalis* (rare), *Symphytum officinale*, *Succisa pratensis*, *Taraxacum* sect. *Palustria*, *Valeriana dioica*, and *Veronica* (*Pseudolysimachion*) *maritima* (*longifolia*) (rare).

(13h) Subalpine and alpine pastures, in Austria commonly called "Almen" (*Poo alpinae-Trisetetalia*), are widespread though regionally diminishing in recent times

due to reductions of alpine dairy farming and livestock raising (cattle breeding): *Aconitum napellus*, *Alchemilla* spp., *Anthoxanthum alpinum*, *Campanula scheuchzeri*, *Cirsium spinosissimum*, *Crepis aurea*, *Crocus albiflorus*, *Euphrasia minima*, *Festuca nigrescens*, *Persicaria (Bistorta) vivipara*, *Phleum alpinum* agg., *Plantago alpina*, *Poa alpina*, *Potentilla aurea*, *Ranunculus montanus*, *Rumex alpinus* (strongly nitrophilous, dominant in *Rumicetum alpinae*), *Sagina saginoides*, *Scorzoneroides (Leontodon) helvetica*, *Senecio cordatus* (W), *S. subalpinus* (E), *Trifolium badium*, *Veratrum album*, and *Veronica serpyllifolia* subsp. *humifusa*.

(14) Forest clearings (*Epilobietea angustifolii*), [different communities dependent on pH, moisture, and age (because of vegetational succession)]. *Populus tremula*, *Rubus idaeus*, *R. sect. Rubus*, *Salix caprea*, *Sambucus racemosa*, and *Sorbus aucuparia*; *Atropa belladonna*, *Calamagrostis epigejos*, *Centaureum erythraea*, *Cirsium arvense*, *Digitalis grandiflora*, *Epilobium angustifolium*, *Erechtites hieraciifolia* (neophyte), *Eupatorium cannabinum*, *Fragaria vesca*, *Galeopsis pubescens*, *G. speciosa*, *Gnaphalium sylvaticum*, *Hypericum hirsutum*, *H. perforatum*, *Juncus effusus*, *Pteridium aquilinum*, *Rumex acetosella*, *Senecio nemorensis* subsp. *fuchsii* (*S. ovatus*), *Stachys alpina*, and *Verbascum densiflorum*.

(15) Arable land, including vineyards (*Stellarietea mediae* s. str.). Some common species and some endangered species, most of the latter characteristic of the Pannonian region.

(15a) Basiphilous (alkaline), mainly in cereal fields (*Caucalidion lappulae* etc.): *Adonis aestivalis* (rare), *A. flammea* (rare), *Androsace maxima* (rare), *Anagallis foemina*, *Anthemis (Cota) austriaca*, *Buglossoides incrassata* subsp. *splitgerberi*, *Bupleurum rotundifolium* (rare), *Camelina microcarpa*, *Caucalis platycarpa*, *Ceratocephala orthoceras* (very rare), *Conringia orientalis* (rare), *Consolida regalis*, *Descurainia sophia* (common), *Diploaxis muralis*, *Erysimum repandum*, *Euphorbia helioscopia*, *Fumaria vaillantii*, *F. rostellata* (rare), *Galium spurium*, *G. tricornutum* (very rare), *Hibiscus trionum* (rare), *Kickxia elatine*, *K. spuria*, *Lamium amplexicaule*, *Lathyrus tuberosus*, *Legousia speculum-veneris* (rare), *Neslia paniculata*, *Ranunculus arvensis* (rare), *Scandix pecten-veneris* (very rare), *Sherardia arvensis*, *Sinapis arvensis*, *Sisymbrium orientale*, *Stachys annua*, *Valerianella carinata*, *Veronica triloba*, *V. polita*, *V. praecox*, *V. triphyllus*, and *Viola arvensis* (very common).

(15b) Nutrient-rich fields and gardens: *Amaranthus powellii*, *A. retroflexus*, *Chenopodiastrum (Chenopodium) hybridum*, *Chenopodium album*, *Mercurialis annua*, *Solanum nigrum*, *S. villosum* (rare), *Thlaspi arvense*, and *Urtica urens*.

(15c) Acidophilous (missing or rare in the Pannonian region): *Anthemis arvensis*, *Aphanes australis* (rare),

Arabidopsis thaliana, *Arnoseris minima* (very rare), *Galeopsis tetrahit*, *Raphanus raphanistrum*, *Scleranthus annuus*, *Trifolium arvense*, and *Veronica agrestis*.

(16) Ruderal communities (*Artemisietea vulgaris* and *Sisymbrietalia*). (Neophytes are designated by an asterisk*.)

(16a) General. *Acer negundo**, *Ailanthus altissima**, *Buddleja davidii**, *Lycium barbarum**, and *Robinia pseudacacia** (causing nitrogen accumulation in the soil and thus giving rise to a ruderal flora); *Artemisia vulgaris*, *Asperugo procumbens*, *Atriplex sagittata*, *Ballota nigra*, *Bassia (Kochia) scoparia*, *Berteroa incana*, *Blitum (Chenopodium) bonus-henricus*, *Bromus sterilis*, *Carduus acanthoides*, *Chelidonium majus*, *Conium maculatum*, *Crepis foetida (rheoadifolia)*, *Diploaxis tenuifolia*, *Echium vulgare*, *Fumaria schleicheri* (rare), *Galeopsis angustifolia* (railroad gravel), *Helminthotheca echioides* (rare), *Hyoscyamus niger*, *Lactuca serriola*, *Leonurus cardiaca*, *Lepidium (Cardaria) draba*, *L. campestre*, *Malva neglecta*, *Onopordum acanthium*, *Oxybasis (Chenopodium) urtica* (very rare), *Potentilla (Duchesnea) indica**, *Reseda luteola*, *Sisymbrium loeselii* (urbanophilous), and *Tussilago farfara*.

(16b) Trampled turfs (*Polygono-Poetea annuae* p. p.): *Erodium cicutarium*, *Hordeum murinum*, *Lepidium coronopus (Coronopus squamatus)* (rare), *Lolium perenne*, *Matricaria discoidea (matricarioides)**, *Plantago major*, *Poa annua*, *Polygonum aviculare* s. lat., and *Potentilla anserina*, including pavement cracks (fissures): *Chenopodium vulvaria*, *Cynodon dactylon*, *Dysphania (Chenopodium) pumilio**, *Eragrostis minor*, *E. multicaulis**, *Herniaria glabra*, *H. hirsuta*, *Lepidium ruderales*, *Sagina procumbens*, and *Spergularia rubra*.

2.5 NATURE RESERVES, NATIONAL PARKS

Nature conservation, not only maintaining habitats in close to natural conditions, but also protecting traditional anthropogenic biocoenoses with high biodiversity, is an important commitment of our times.

2.5.1 Austria. The national parks (NP) in Austria are comparatively young, 15 to 35 years old only. There are six of them acknowledged by IUCN. The largest one is the NP "Hohe Tauern", situated on both flanks of the main ridge (divide) of the Central Alps, in the source regions of the rivers Isel and Möll on the southern flank and Salzach and Mur on the northern flank. This national park stretches 100 km from east to west and 40 km from north to south. It consists of Tyrolian, Salzburgian, and Carinthian parts, with a total area of 1856 km² (1212 km² core area), and includes a variety of communities ranging from the montane up to the nival belt (3d, 4, 5) that owe their existence to the presence of different bedrock types ranging from strongly sili-

ceous gneiss to different schists, primarily the Bündnerschiefer (Grisons slate) with a remarkably rich flora (see above). The highest mountains are Großglockner (3798 m asl, the highest peak of Austria), Großvenediger (3657 m asl), and Ankogel (3246 m asl), all covered with large glaciers. A very unusual special habitat is the Special Reserve “Gamsgrube”, which represents a wind-borne sand steppe of calcareous micaceous schists inhabited by alpine cushions of *Silene acaulis* with *Salix serpyllifolia*, *Saxifraga biflora*, *S. rudolphiana*, *Artemisia genipi*, and *Braya alpina*. – The NP “Neusiedler See – Seewinkel”, situated within the Pannonian region (1) in N Burgenland, is bi-national, as it is continued in the adjacent area of Hungary. It comprises the lake Neusiedler See (in Hungarian: Fertő), 320 km² large, and parts of the adjacent plain “Seewinkel” (90 km² of protected areas). The Seewinkel extends from the eastern shore to the Hungarian part. This national park is, besides the lake area, botanically characterised by Pannonian grassland (12a) and saline halophile vegetation (salt steppes, 12d) and small saline lakes, interspersed with large vineyard areas. – The NP “Donau-Auen” (Danube River Floodplanes, riparian forests) is 93 km² large and consists of a Viennese part and a Lower Austrian part. Extending mainly in the planar belt along the left bank of the Danube between Vienna and the city of Hainburg on the Slovakian border, it includes riverside forests remarkably close to the natural condition (7) with different wetland communities (9). Floristically significant are some single relict specimens of *Vitis vinifera* subsp. *sylvestris*, the ancestor of the grape-vine. – The NP “Gesäuse” in (Upper) Styria is 110 km² large and the NP “Kalkalpen” in Upper Austria is 208 km² large. Both of them are situated within the Northern Calcareous Alps, including montane to alpine belts (3a, d, e) and housing many endemics of this region (see above, chapter 2.2). – With an area of 13 km², the smallest of the Austrian national parks is the NP “Thayatal” (c. 300–450 m asl) in northern Lower Austria (Fig. 1B), which is bi-national because it is continued beyond the border with the Czech Republic, where its larger part (Národní park Podyjí in Czech) is situated. It extends along the Thaya (Dyje) river and includes montane silicicolous forests (3c), but also a hill alongside an impressive narrow river sward (“Umlaufberg”) with dry Pannonian vegetation (1) on gneiss bedrock.

There exist in Austria 195 natural forest reserves (“Naturwaldreservate”), which preserve the natural development of forest communities (process conservation).

In addition to them, the country also has three biosphere reserves (“Biosphärenparks”; acknowledged by UNESCO): Kärntner Nockberge (in northern Carinthia) with an adjacent southern part of Lungau (Salzburg region) in the Gurktaler Alpen (southeastern Central Alps), housing mainly montane to alpine vegetation (up to 2440 m asl; 4, 5a, 6d) on petrologically varied substrates, including comparatively large *Pinus cembra*

(Swiss pine) forests (5c). The “Biosphärenpark Wienerwald” includes most of the Vienna Woods west of Vienna, small parts of it belonging to Vienna, but most to Lower Austria. It includes soft mountains (the submontane to lower montane belt) of flysch sandstone bedrocks (partly more or less calcareous, partly more or less siliceous) in its northern sectors (up to 893 m asl, 2, 3a, c), but in its the southern part covers the northeastern-most end of the Calcareous Alps (up to 834 m asl, 2, 3a, b), there comprising primary forests of autochthonous Austrian pine (*Pinus nigra*) (8). The northeastern rim of the Alps forms the western margin of the Pannonian region (1, 12a). Comprising montane to alpine belts (from 580 to 2704 m asl), the “Großes Walsertal” is located in Vorarlberg on the border between the western Calcareous Alps and the flysch zone of Bregenzer Wald.

The only Austrian wilderness reserve is located in the Calcareous Northern Alps in Lower Austria on the border with Styria. This is the Wildnisgebiet Dürrenstein-Lassingtal (including “Rothwald”), a primary mountain forest which has never been logged, although it has been used for hunting on account of having suffered greatly from game damage that seriously endangered its continued existence. The size of this natural upper-montane spruce-fir-beech forest (3a, d) is 24 km². According to IUCN standards, it can be classified partly as a “wilderness” and partly even as a “strict nature reserve”.

Additionally, there are many small nature reserves in Austria, established mainly to protect the Pannonian “steppes” (12a). They include riverside forests along the March river (on the border between Slovakia and the Czech Republic, hopefully a future national park (7b), raised bogs and fens (10), moist meadows (13g), and upper montane (3d), subalpine (5), and alpine (6) vegetation. Mainly for touristic purposes, several so-called nature parks provide some degree of protection of landscape and biotopes.

2.5.2 Alpic Bavaria. The National park Berchtesgaden (on the eastern edge of the German Alps close to Salzburg, 208 km², 603–2713 m asl) belongs to the Northern Calcareous Alps and Exterior Alps. In addition to it, the nature reserve “Nagelfluhkette” is located across the border from the northern part of the Bregenzer Wald in Vorarlberg. The Hochgrat (1834 m asl) is the highest peak in this nature reserve, which lies on bedrock of Nagelfluh (a Palaeogene conglomerate).

2.5.3 Liechtenstein. The Principality contains some mountain forest reserves, but mainly several wetland (fen) nature reserves, the most important one being the “Ruggeller Riet”.

2.5.4 E Alpic Italy. The largest nature reserve in the NE Italian Alps, i.e., within our area, is the Parco Nazion-

ale dello Stelvio / Nationalpark Stilfser Joch, comprising the Ortler-Gruppe/Gruppo Ortles-Cevedale, whose highest peak is the Ortler/Ortles (3905 m asl), which is the second highest mountain of the Eastern Alps and is the meeting place of several provinces: South Tyrol/Bozen, Trentino/Trento, and Brescia and Sondrio (these two in the Lombardy region). The mountains consist of siliceous bedrocks (quartz phyllite and phyllite gneiss), and also carbonates (limestone and dolomite). The Parco Nazionale delle Dolomiti Bellunesi in the province of Belluno (Veneto region) is located mainly within the carbonate ranges of the Southern Dolomites. There are several “nature parks“, more or less equivalent to national parks, for example the Parco Naturale Paneveggio – Pale di San Martino in the Dolomites (Trento province) and the Parco regionale dell’Adamello and Parco naturale Adamello-Brenta (Trento and Brescia provinces).

2.5.5 Switzerland: E Grisons. The Swiss National Park (Schweizerischer Nationalpark/Parc Naziunal Svizzer) is the oldest national park of the Alps (in existence since 1914) and the largest Swiss nature reserve. Situated in Engadin (canton Graubünden) between Zernez and the Italian border with an area of 170 km², it extends mainly from the upper-montane to subalpine belts [1400 to 3174 (Piz Pisoc) m asl] and is dominated by Inner-Alpic forests of larch (*Larix decidua*) with *Pinus cembra* (5c) and pine forests of *Pinus uncinata* and *P. mugo* (5b) on carbonate rocks.

2.5.6 Alpic Slovenia. The Triglav National Park (Triglavski narodni park) in the Julian Alps is the only national park of Slovenia and has an area of 838 km². Triglav (2864 m asl) is the highest mountain of Slovenia and its heraldic symbol. The park encompasses the source areas of the rivers Soča/Isonzo and Sava and is dominated by the montane to alpine vegetation and flora of the SE Calcareous Alps (3f, 6a, b, 11b). It includes the lake Bohinjsko jezero and a few smaller alpine lakes. Apart from this national park, there are several nature reserves, mainly in the Julian Alps.

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Botanica SERBICA



REZIME

U susret Ekskurzionalnoj flori Austrije i čitavih istočnih Alpa

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Ovaj rad predstavlja, s jedne strane, najavu drugog volumena četvrtog izdanja Ekskurzionalne flore Austrije uvećanog obuhvatanjem preostalog dela istočnih Alpa (poglavlje 1) i, sa druge strane, grubi prikaz flore istočnih Alpa povezan sa glavnim tipovima vegetacije (poglavlje 2). Geografski obuhvata, pored Austrije, čitave istočne Alpe od doline Rajne u Švajcarskoj do doline Vipave u JZ Sloveniji. Volumen 1 sadrži uglavnom sveobuhvatna uvodna poglavlja kao što su uvod u morfologiju biljaka, taksonomiju i nomenklaturu, kao i prikaz ekomorfologije i ekologije staništa, prikaz tipova vegetacija (fitocenologija) i florističke specifičnosti pojedinih regiona, grubi prikaz florističkih istraživanja, detaljan rečnik koji uključuje i značenje epiteta itd., kao i nekoliko crteža biljaka karakterističnih za datu floru. Struktura ključeva koji su koncentrisani u drugom volumenu je objašnjena: pored opisa osobina, za svaki takson je dat i obiman prikaz ekoloških i geografskih podataka, kao i informacije o prisustvu na crvenim listama uključenih zemalja, upotrebi biljaka, taksonomskim problemima. Nazivi rodova su dati ne samo na nemačkom, već i na retoromanskom, italijanskom i slovenačkom jeziku. U drugom poglavlju prikazane su odlike nekih važnih horotipova, uključujući endemite, kao i floristički diverzitet u skladu sa glavnim i najkarakterističnijim vegetacijskim tipovima.

KLJUČNE REČI: flora, Alpi, horotipovi, endemizam, ključevi za identifikaciju, bečki dijakritički metod, vegetacija.

