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Bernardo Gut

Trees in Patagonia

Special collaboration Ing. Ftal. María Paula Guzzetti

Contributions by A. Díaz, P. Lépez, M. Rumboll, and G. Vittone

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Cover illustration: Front cover, left: north-exposed slope of PN Lago Puelo (see p. 19); right: shape of Fitzroya cupressoides (see p. 71). Back cover, from left to right: Islet in the Río Menéndez (see p. 59); Lago Verde, PN Los Alerces (see p. 231); Lago Rivadavia.
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In memory of Patagonia's
scientific discoverers.

Contents

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de Lorenzo Cáceres (2001); More (2003); Parodi (1959); Rodríguez et al. (1983); Tutin et al. (1964-1980) and (1993); White et al. (2005) – Concerning the information about hardiness, I have quoted the lowest temperature according to More (2003). Data on the phenology were taken from Rodríguez et al. (1983) or estimated on grounds of the tables given by Gaida and Grothe (2003) and may be applied to the region of Bariloche-Esquel and Puerto Montt.

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1. Introduction

Fig.1.0: Lago Frías and Monte Tronador (3478 m) (09.03.2004, late afternoon)

The idea underlying the present book was: to provide amateurs as well as naturalists with a guide enabling them to identify the native tree species of **Argentine Patagonia** (comprising the large area from the *Río Colorado* to the south) **and Chilean Patagonia** (taken from *Valdivia* southwards), as well as about 95% of the arboreal species introduced into these regions. As far as the text is concerned, a few explanatory remarks may be helpful:

- *Native* species and cultivated *pines* have received a somewhat more detailed description than the introduced, largely ornamental species. The criterion was to foster the knowledge of the native trees and of those species employed for extensive afforestations.
- The *keys* for the identification lead to *groups* which encompass a maximum of 12 genera or species. Within these groups, the illustrations and the descriptions should easily allow to determine the plant in question.
- The entries on the *toxicity* and the *uses in medicine* are very concise and held in general terms; readers are referred to the works by Harborne et al. (1999), van Wyk and Wink (2004), Chevallier (2001), Roth et al. (1994), and E.H. Rapoport et al. (2003, 2005), respectively.
- Remarks on the use of the *wood* and on *other uses* are based on various sources and on personal observations and experience.

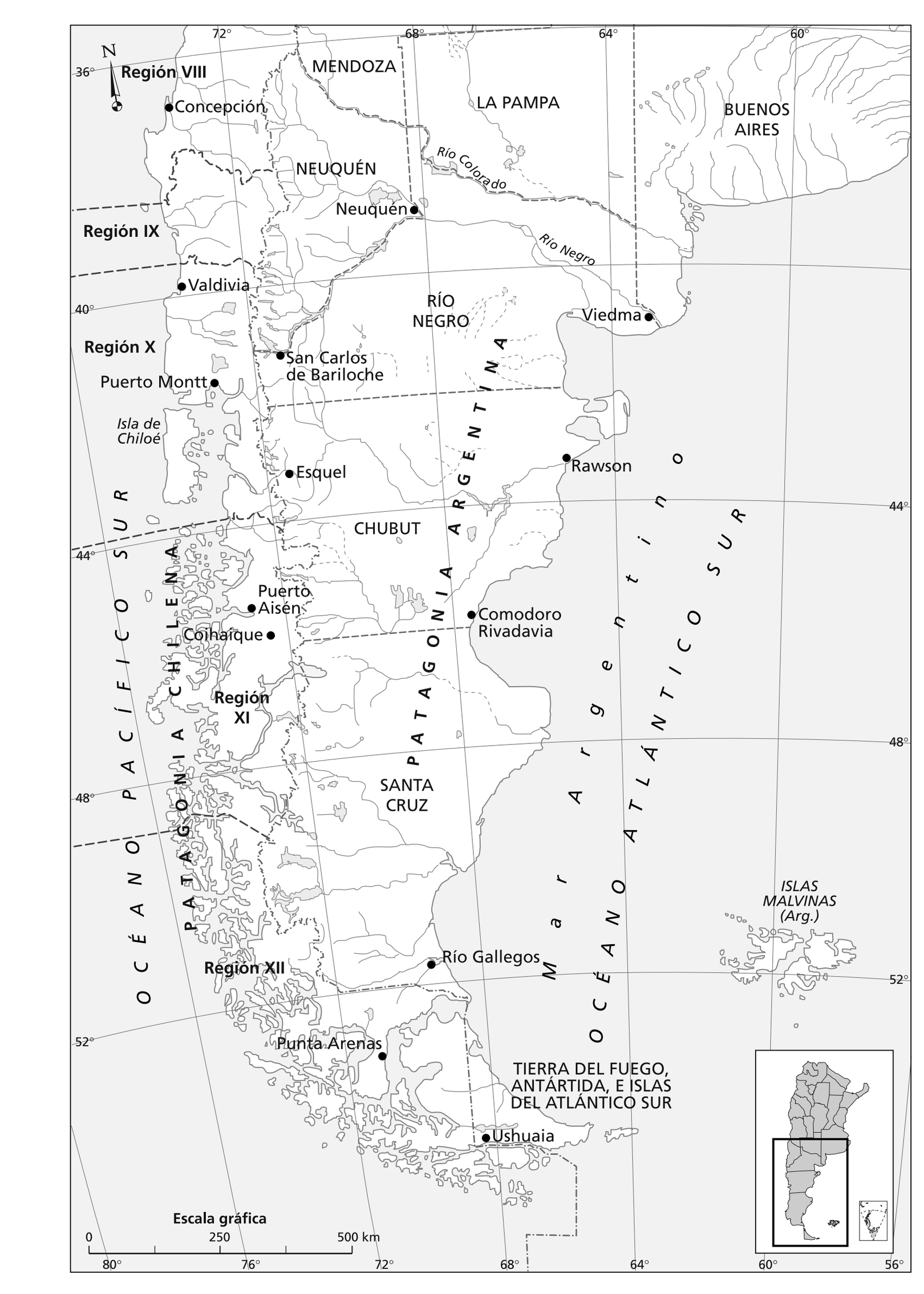
– Regarding the **photographs of the introduced species**, a further remark is necessary: Many of these trees, above all ornamental species, are often pruned in a way or kept under conditions that do not allow them to develop to their full size. In some cases, I was not able to find in Patagonia specimens with a really characteristic and photogenic crown. I then chose to insert photographs showing the *shape* of mature trees of these species growing in other regions of the world. The photographs of the leaves and barks, however, have almost exclusively been taken from Patagonian trees.

The beginnings of the work on this book go back to 1999, when I devised a *Begleiter zu Baumarten Argentiniens,* an elementary "companion" for the identification of about 200 arboreal species of Argentina, which served the Swiss participants of an extensive excursion through Argentina in 2000. That same year, my friend Guido Vittone helped me to get more intimately acquainted with the region of Puerto Blest. Years later, Guido showed me the regions of Los Antiguos and the Río Baker (Chile). In 2001, I conceived the idea of amplifying the modest manual of 1999. In discussions with friends and in several excursions through Argentine territory, I realised that there was no book available for the identification of trees of Argentine and Chilean Patagonia which included the species introduced for afforestations, wind-barriers, and for ornamental reasons. In 2003, Ingeniero Adrián Sáez introduced me to Ingeniera María Paula Guzzetti, who in March 2004 led me through the regions of Esquel - El Bolsón. Excursions to the regions of Valdivia, Puerto Montt, and Chiloé, which I undertook in September-October 2004, contributed to widen my horizon and to increase the number of collected species. In February-March 2005, I devoted a long journey through towns and villages of Argentine Patagonia to collect tree-species I had overlooked in my earlier excursions. Another journey, in September-October 2006, allowed me once more to study the flora of the regions of Valdivia and Puerto Blest. In February 2007, a further excursion led me to Río Gallegos, El Calafate, Puerto Natales, and Punta Arenas. Finally, in January-February 2008, I completed my field work with an excursion to Bariloche, El Bolsón, PN Lago Puelo, PN Los Alerces, Esquel, Futaleufú, PN Lago Rosselot, Coihaique, Lago General Cabrera / Buenos Aires, and Los Antiguos.

Due to the enormous surface and the complexity of the terrain, it is not surprising that the overall concept of the book has undergone several modifications in the course of time and with the progress of my work. Especially, aiming at covering Argentine as well as Chilean Patagonia has made it necessary to consult papers and maps on the geology, climate, soils, and vegetation of both countries. In many cases, I have tried to design diagrams reassembling data from studies on various localities.

The introductory chapters (**2–5**) are conceived to transmit fundamental information on the *delimitation* of what is termed 'Patagonia', as well as on the *geology, climate, soils*, and *vegetation* of Southern South America. In the following chapters **6–11**, I have first described what is being meant by the term 'tree' in our guide, and I have then striven to convey some basic knowledge of the different groups of trees described in the manual. The descriptions of the genera and species are reserved to the chapters **12–14**, whereas the next chapters (**15–18**) are devoted to concise contributions on afforestations, fruit trees, urban trees, and national parks. Finally, chapter **19** is devoted to Carl Skottsberg and his remarkable expedition through Patagonia, a hundred years ago.

Fig. 1.1: Overview of Argentine and Chilean Patagonia


N
72°
68°
64°
60°
36°
Región VIII
MENDOZA
LA PAMPA
BUENOS AIRES
Concepción
Río Colorado
NEUQUÉN
Neuquén
Región IX
Río Negro
Valdivia
40°
RÍO NEGRO
Viedma
Región X
San Carlos de Bariloche
Puerto Montt
Isla de Chiloé
Esquel
Rawson
44°
CHUBUT
Puerto Aisén
Comodoro Rivadavia
Coihaique
Región XI
48°
SANTA CRUZ
ISLAS MALVINAS (Arg.)
Río Gallegos
Región XII
52°
Punta Arenas
TIERRA DEL FUEGO, ANTÁRTIDA, E ISLAS DEL ATLÁNTICO SUR
Ushuaia
OCÉANO PACÍFICO SUR
CHILENA
PATAGONIA
ARGENTINA
PATAGONIA
Mar Argentino
OCÉANO ATLÁNTICO SUR
Escala gráfica
0
250
500 km
80°
76°
72°
68°
64°
60°
56°

2. How to use this guide for identifying trees

Most users of manuals for identifying plants tend to avoid dichotomous keys whenever they can. But to wildly thumb through a book looking at pictures is not the best alternative. That is why I have chosen to offer a list of plant groups which can easily be separated from each other by clearly discernible vegetative traits common to all the species contained in the respective groups. In several cases, I have added synoptic or dichotomous keys in order to provide a better founded identification. This is the case e.g. in *Cupressus, Eucalyptus, Nothofagus, Pinus, Populus, Prunus, Quercus.*

It is my experience that a user quite often has already a general idea of the name or taxonomic position of the tree she or he is looking at. In these cases, it is advisable to search for the illustrations in question – and then to check whether the tree fits the *group-characters* (e.g.: *Are the leaves truly trifoliate and alternate* → G 12?), and finally compare the real tree with the description of the species it presumably belongs to.

Regarding the native trees, as well as those *coniferous species* used on a large scale in *afforestations*, I have described every single species separately, i.e. each species has an entry of its own. In the case of the genera *Pinus* and *Nothofagus*, with numerous species growing in Patagonia, I have first given a characterisation of the genus, which is then followed by the descriptions of the species.

As far as *all the other introduced species* dealt with in this manual are concerned, single entries for every species is the rule if only one or, in some cases, two species of a genus are considered. In certain cases, however, in which several, closely related species of one genus have been introduced into southern South America, I have preferred to offer a description of the characters of the genus, adding a key to distinguish the most common species found in Patagonia. This procedure was used for the following genera: *Acer, Alnus, Betula, Crataegus, Cupressus, Eucalyptus, Fraxinus, Populus, Prunus, Quercus, Sorbus, Tilia,* and *Ulmus*. Heed must be taken that these keys always lead to a *selection* of the species which can be found in Patagonia.

The description of the species included in our manual is reserved to the chapters **12** (gymnosperms [conifers]), **13** (angiosperms–dicots) and **14** (angiosperms–monocots), respectively.

The manual does *not* cover all the tree species grown in the vast territory of Argentine and Chilean Patagonia; but I have attempted to include all the species inhabitants of Patagonia daily live with, as well as those other trees excursionists travelling through this beautiful region of our planet are likely to come across, thereby including many plants which – from a very strict point of view – can hardly be considered to be true trees (e.g. *Cordyline australis, Yucca elephantipes*, *Desfontainia spinosa, Chusquea coleou*). This latter feature is a practice followed by several outstanding, modern books on trees (e.g. More and White (2003), López Lillo and Sánchez de Lorenzo Cáceres (2001)).

3. Southern South America and the term 'Patagonia'

Trees in Patagonia – our book's title – refers in a general, open sense to the vast region in southern South America which is also addressed as *El Cono Sur*, but better known in the entire world as *Patagonia*. The exact meaning of this latter term, however, is still a matter of controversy, a fact that immediately falls into one's attention by looking at several attempts to set clear cut boundaries to the region termed 'Patagonia'. Let us consider a few examples:

R. Magin Casamiquela (in *Guía turística YPF* [of the República Argentina](1998)) distinguishes *Eastern Patagonia* from *Western Patagonia*. According to this author, the northern and southern boundaries of these two regions can be defined as follows:

Eastern Patagonia comprises the area between the river Colorado in the north and the Strait of Magellan in the south.
Western Patagonia (following C. Keller) extends from the lake Todos los Santos and its draining river Petrohué down to the Strait of Magellan, thereby excluding the Isla Grande de Chiloé but with the inclusion of the archipelagos from Chiloé to the Strait of Magellan.
For practical reasons, however, the authors of the *Guía turística YPF* conveyed to the term 'Eastern Patagonia' a very broad meaning, referring by it also to the archipelago of Tierra del Fuego *and* to the Islas Malvinas / Falkland Islands.
On the basis of this pragmatic approach, it would simply be a matter of consequence to incorporate Chiloé and the archipelago of Tierra del Fuego into the realm of what is meant by 'Western Patagonia'.

C. Runcinan (ed.) and the co-authors of *Time Out. Patagonia* (2002) call *Western (Chilean) Patagonia* the entire region to the south of the river Bío Bío, including Temuco and the Lake District. With regard to *Eastern (Argentine) Patagonia*, the guide refers to the region comprised between the river Colorado and the south of Tierra del Fuego.

S. Blackwell (ed.) and the co-authors of *Footprint Patagonia* (2005) define 'Western Patagonia' the same way as Runcinan et al. Concerning *Eastern Patagonia,* this guide even expands the region to some areas located to the north of the river Colorado.

R. Gantzhorn, in *Patagonien – Trekking Guide* (2004), considers the Chilean side of Patagonia to spread from the river Bío Bío in the north (the latitude of which is equivalent to that of the river Colorado on the Argentine side – the northern limit of *Eastern* Patagonia, according to Gantzhorn) down to Cape Horn.

W. Bernhardson, in *Moon Handbooks Patagonia* (2005), admits that the term 'Patagonia' "is notoriously hard to define, but for purposes of this book, it's a pragmatic matter… On the Argentine side, it comprises the provinces of Neuquén, Río Negro, Chubut, Santa Cruz, and Tierra del Fuego, while in Chile it includes the lake-district jurisdictions of La Araucaria (Region IX) and Los Lagos (Region X), plus Patagonia proper, Aisén (Region XI) and Magallanes (Region XII)" (p. 5). This means that for Bernhardson Patagonia covers the same area as for Runcinan and Gantzhorn.

R.R. Rodríguez avoids the term 'Patagonia' (in his article "Forests of southern Chile and its main components" [in Spanish], in J. Grau y G. Zizka (eds.), *Flora silvestre de Chile* (1992)) and only refers to the "Subantarctic Province which in Chile stretches along mountains and valleys from the south of the river Bío Bío (ca. 37°S) to Cape Horn (ca. 56°S)" (p.44). In other words: Rodríguez's term 'Subantarctic Province' is virtually equivalent to what Gantzhorn, Blackwell et al., and Runcinan et al. define as '(Western) Patagonia'.

M. Graham, on the other hand, uses (in *Chile* (2003)) the expression 'Southern Patagonia' to designate the region confined to the comparatively small sector between the National Park Torres del Paine and the Strait of Magellan.

F. Ranft (ed.) and the co-authors of *Chile, Osterinsel* (2004) employ the term 'Patagonia' when describing the "southern cone on the Argentine and the Chilean side of the Cordillera" (p. 61), without entering into any further details.

H.A. Schultz, E. Jones, C. Jones, in *Argentina* (ed. D. Bull, 1988), write that *Patagonia* stretches from the river Colorado in the north to Cape Horn in the south, belonging both to Chile and Argentina (p. 214), and avoid details about its northern limit in Chile.

In *Flora Patagónica (República Argentina),* the masterly reference work directed by M.N. Correa, the limits of Continental Patagonia are defined "to the N by the river Colorado, to the S by the canals of Beagle and Moat, to the W by the Cordillera de los Andes, and to the E by the Atlantic Ocean and the islands of the Southern Atlantic" (vol.VIII, 1998, p. 1).

Grau, in *Flora de Chile (vol. I, 1995),* does not specify the boundaries of Patagonia, but the context seems to indicate that he restricts it to the region confined to the area between the National Park Torres del Paine and the Strait of Magellan (p. 88).

Summing up these selected opinions and taking into consideration that our book includes the arboreal species of the evergreen (Valdivian) rain forests, which extend from Valdivia to the southernmost areas of the continent, I shall use – for *practical reasons* – the term 'Patagonia' in a very wide sense, largely pre-conceived by R.M. Casamiquela:

Western (Chilean) Patagonia: Region that stretches from Valdivia to Cape Horn. It comprises the Administrative Regions X, XI, and XII.

Eastern (Argentine) Patagonia: Region that stretches from the river Colorado to the archipelagos of Tierra del Fuego and includes the islands of the Southern Atlantic. It comprises the Argentine Provinces of Neuquén, Río Negro, Chubut, Santa Cruz, and Tierra del Fuego.

4. Geology, climate, and soils of Patagonia

Fig. 4.0: Río Ibáñez, Chile (01.02.2008, afternoon)

Within the scope of our book, I shall only dwell on a few geologic, climatologic, and edaphic features of *Patagonia* – always in the widest sense of the term –, concentrating on the most important abiotic factors for the development of the vegetation in these regions of the world.

4.1. Geo-morphological structure

From northern Argentina and Chile down to latitude 37° S, the *Cordillera de los Andes* appears as a broad central mountain chain, the highest peaks of which usually determine the political borderline between the two countries. From latitude 37.5° S southwards, the Cordillera separates itself into two chains, divided by the river Bío-Bío which flows from southeast to northwest and runs into the Pacific Ocean to the south of Concepción. Over a long distance, the border-chain is lower than the western chain with its high volcanoes (Tolhuaca [2780 m], Lonquimay [2890 m] and Llaima [3125 m above sea level]).

From 40° S to 52° S the Cordillera de los Andes follows approximately the line of the 73°W meridian. Further to the south, the Cordillera draws a broad arc to the south-east, eventually reaching Cabo San Diego, at the eastern end of Tierra del Fuego, and the Isla de los Estados while running roughly parallel to latitude 54° 45' S. On a length of nearly 1800 km, the Cordillera de los Andes divides the entire Patagonian sector of South America into two completely different regions: *Western Patagonia* and *Eastern Patagonia*.

Fig. 4.1: Patagonian Area of the Geologic Map of South America, 1 : 3 000 000.– **CGMW-CPRM-DNPM-UNESCO, Brasília, 2000.** (Reproduced with the kind permission of C. Schobbenhaus)

Simplifi ed legend of the continental area

A: paleo-archean, metamorphic rocks
paleo-arqueano, rocas metamórficas

My: meso-proterozoic, volcanic rocks, acid and intermediate
meso-proterozoico, rocas volcánicas, ácidas e intermedias

N, N2: neo-proterozoic, metamorphic rocks
neo-proterozoico, rocas metamórficas

P+, CP+, DC+, Є+, PZ1+, PZ2+, Є0+: paleozoic, plutonic rocks, acid and intermediate
paleozoico, rocas .plutónicas, ácidas e intermedias

PZS: paleozoic, metamorphic rocks, undifferentiated
paleozoico, rocas metamórficas, no diferenciadas

CP, D, DC, Є, Є0, O, P, S, SD, PZ1, PZ2: paleozoic, sedimentary rocks★
paleozoico, rocas sedimentarias★

PTR, PZ2MZ1: paleozoic–mesozoic, sedimentary rocks★
paleozoico-mesozoico, rocas sedimentarias★

PTRy: paleozoic–triassic, volcanic rocks★, acid and intermediate
paleozoico-triásico, rocas volcánicas★, ácidas e intermedias

TR, J, K, JK, MZ, TrJ: mesozoic, sedimentary rocks★
mesozoico, rocas sedimentarias★

Jv, Kv, JKv: mesozoic, volcanic rocks★, undifferentiated
mesozoico, rocas volcánicas★ , no diferenciadas

Jy, Ky: mesozoic, volcanic rocks★, acid and intermediate
mesozoico, rocas volcánicas★ , ácidas e intermedias

Jx: jurassic, plutonic rocks, undifferentiated
jurásico, rocas plutónicas, no diferenciadas

J+, K+: mesozoic, plutonic rocks, acid and intermediate
mesozoico, rocas plutónicas, ácidas e intermedias

JT+: jurassic-tertiary, plutonic rocks, acid and intermediate
jurásico-terciario, rocas plutónicas, ácidas e intermedias

T+: tertiary, plutonic rocks, acid and intermediate
terciario, rocas plutónicas, ácidas e intermedias

KT1v: cretaceous-tertiary, volcanic rocks, undifferentiated
cretáceo-terciario, rocas volcánicas, no diferenciadas

T, T1, T2: tertiary, sedimentary rocks★
terciario, rocas sedimentarias★

Tv, T1v, T2v: tertiary, volcanic rocks★, undifferentiated
terciario, rocas volcánicas★ , no diferenciadas

T1y, T2y: tertiary, volcanic rocks★, acid or intermediate
terciario, rocas volcánicas★ , ácidas o intermedias

T^, T1^, T2^: tertiary, volcanic rocks★, basic and intermediate
terciario, rocas volcánicas★ , básicas o intermedias

T2Q^: tertiary-quaternary, volcanic rocks★, basic and intermediate
terciario-cuaternario, rocas volcánicas★ , básicas e intermedias

TQ, T2Q: tertiary-quaternary, sedimentary rocks★
terciario-cuaternario, rocas sedimentarias★

Q: quaternary, sedimentary rocks★
cuaternario, rocas sedimentarias★

Sa: salt pans
salares

Gl: glaciers
glaciares

▲: volcanoes
volcanes

★ **+ volcano-sedimentary rocks**

Western (Chilean) Patagonia is, on the whole, an extremely rugged terrain and, as far as geology matters, one of the most restless regions of the world. It shows a remarkable cenozoic volcanic activity with widespread ash-rich eruptions (in central and southern Chile, more than 30 volcanoes have erupted at least once within the last 100 years), and it is the site of ongoing tectonic movements, a phenomenon correlated to frequent tremors and earthquakes.

A very characteristic feature of Central Chile and the Lake District between Valdivia and Puerto Montt is the classic longitudinal tripartite division into a Coastal Range *(Cordillera de la Costa),* a long fault *(Valle Central)* – which extends from north to south over a length of 1000 km and can be traced down to the southern border of Chiloé –, and the (eastern) *Cordillera de los Andes.*

Beyond the latitude of Puerto Montt (41° 28' S), the Coastal Range forms a chain of approximately 3000 hilly islands – the largest being Chiloé – extending along a fjord-lined coast to Cape Horn, only interrupted by the Península de Taitao (46° 30' S), a relic of the triple longitudinal structure found from Puerto Montt to the north. From Valdivia down to the Península de Taitao, the Cordillera de la Costa consists mainly of paleozoic sediments (PZS in **Fig. 4.1**). These can also be found in the south-western areas of Tierra del Fuego and the adjacent islands.

The Central Valley has thick layers of quaternary sediments (Q), whereas the Cordillera Principal shows a very complex structure, with mesozoic (J+, K+, JKv) and mesozoic-tertiary elements (JT+) predominating down to latitude 46°, followed by a large area of paleozoic rocks till latitude 50°, from where onwards to the south the mesozoic again prevails. Enormous glaciers (Gl) extend from 47° S to 51° S.

Eastern (Argentine) Patagonia represents a stark contrast to the western side: Covering an area of about 765720 km^2 (the surface of the provinces of Neuquén, Río Negro, Chubut, and Santa Cruz, i.e. 27.5% of the total surface of Argentina), the region between the Río Colorado and the Strait of Magellan appears, in very general terms, as a tableland which in the western zone of transition, between the Cordillera and the classical plateau, rises to an altitude of 900 m (at places, 1500 m), descending in a series of broad, flat steps towards the Atlantic coast, where high cliffs of up to 90 m along the shoreline are not uncommon. Several deep valleys cut the steppe from west to east, but only a few of them carry a permanent stream of Andean origin (Ríos Colorado, Negro, Chubut, Senguer, Chico, Santa Cruz). The bays of these larger rivers are those sites of the Patagonian coast where port facilities and settlements have been built.

Above all in the north-western areas, Eastern Patagonia fundamentally has emerged on the remnants of extra-Andean cratons that have hardly undergone any relevant processes of mountain formation since precambrian times. The outcrops of these proterozoic, weathering resistant, crystalline rocks (N in **Fig. 4.1**, e.g. in the region of the Río Limay) form hilly areas which rise above the flat terraces that are basically built up of layers of sedimentary rocks. According to M.E. Teruggi (1998), approximately 66% of extra-Andean Patagonia consists of "soft rocks" (rocas blandas), all of them pyroclastic, issued from volcanic explosions. As regards "hard rocks" of volcanic origin (e.g. Jy), there exist vast outcrops in south-eastern and central areas of the Province of Río Negro and to the south of Río Deseado (Province of Sta. Cruz). Thus, large areas of the Eastern Patagonian Steppe are covered by mighty strata of mainly mesozoic and cenozoic sediments of volcanic origin. Today, vast areas of the Patagonian steppe do not show any volcanic activity and are largely safe from seismic events.

Marine sediments dating from the paleozoic, triassic, and early jurassic periods are due to transgressions from western *Pacific* waters, since the separation of what was to become South America from the ulterior Africa – a process that led to the opening of the Southern Atlantic Ocean and to its advancement to lower (equatorial) latitudes – seems to have begun towards the end of the jurassic period. Parallel to the incipient rise of the Andes at the end of the cretaceous, the Atlantic Ocean flooded at intervals vast areas of Sta. Cruz and Tierra del Fuego, and around Península Valdés. When it receded, the Andes had formed a barrier that holds humidity back on the western slopes. In the course of the Plio-Pleistocene, mean temperature decreased dramatically in Eastern Patagonia and glaciers covered Tierra del Fuego and southern Sta. Cruz, extending in northern Sta. Cruz and in Chubut several hundred kilometres eastwards of the Andean summits. "During the Early Pleistocene, they probably reached the present Atlantic submarine platform several times" (Coronato et al., 2004, p. 49). Later, in the post-glacial period, a gradual warming up set on.

4.2. Climate

Pluviosity: Due to the predominant humid western winds, *Western Patagonia* as a whole relishes a high pluviosity. At latitude 40° S, the western slope of the Coastal Range (Cordillera de la Costa) may receive up to 4000 mm annually (= euhumid climate) (Valdivia, at 39° 48' S, and located in a bay, has an annual mean of 2700 mm); besides, it is particularly prone to become immersed in waves of marine fog. Towards the east, precipitation drops in the Valle Central to 1000–2000 mm (= humid climate), and it increases again on the west-exposed slopes of the Cordillera de los Andes.

On the *Argentine side,* pluviosity diminishes rapidly from west to east. With the exception of Puerto Blest and a few other, minor Andean windows, no major areas, and in particular no towns in *Eastern Patagonia* enjoy more than 1000 mm of annual rain (= semi-humid climate). There is a narrow *zone of transition* running from 39° S down to approximately latitude 47° S that receives about 400 mm of annual rainfall (= semi-arid climate), beyond which pluviosity decreases to 200 mm or less, a volume characteristic of most of Eastern Patagonia (= arid climate). Regarding the seasonal distribution of the scant rainfall, one can roughly say that *west* of longitude 71° W precipitation occurs during the winter months, whereas near the Atlantic coast in northern Patagonia (e.g. Viedma, Río Colorado) and in southernmost Patagonia (e.g. Río Gallegos, Río Grande (Tierra del Fuego)), the summer months have more rain, albeit on an extremely low level (33.8 mm for January in Viedma, compared to 23.1 mm for July; a similar ratio in Río Gallegos).

Temperature: On the *Chilean side,* Valdivia (39° 48' S; 73° 14' W) has a mean January temperature of 23° C and a mean July temperature of 11° C. From Puerto Montt (41° 28' S; 72° 57' W) southwards, daily as well as annual amplitudes diminish, and the coastal areas show an almost isotherm climate (see the climate diagrams of Puerto Montt and Isla Guafa).

On the *Argentine side,* the Atlantic Ocean has a moderating effect on the temperature of the coastal areas. This can clearly be seen by comparing the climates of Esquel Airport (42° 54' S; 71° 12' W; 785 m) and Puerto Santa Cruz (50° 01' S; 68° 31' W; 111 m), located 780 km further to the south: With an annual mean temperature of 8.6° C the latter town is even 0.1° C warmer than the former! Thus, the warming effect of the Atlantic Ocean on southern coastal areas is obviously only partially counterbalanced by the predominant dry and cold west winds. On the tableland, the daily and annual range of temperature-variation is very high.

Towards the southern tip of South America, the land masses narrow so rapidly that the Pacific Ocean partakes in the influence of the water surfaces on the temperature of the eastern sites.

A closer look at **Fig. 4.2.1** and at the climate diagrams of nine sites **(Fig. 4.2.2)** corroborates and illustrates what I have summarised. Particularly revealing is a glance at the changes in mean monthly rainfall and temperature from west to east, roughly along the latitude of S.C. Bariloche (41° 09' S), i.e. comparing the diagrams of Puerto Montt, S.C. Bariloche, Neuquén. As regards the climate diagrams of Bariloche Aéreo and Esquel Aéreo, it must be observed that these airports (both at 71° 12' W) are already located in the zone of transition, the towns of S.C. Bariloche (at 71° 18' W) and Esquel (at 71° 19' W) enjoying a significantly higher annual rainfall than their respective airports.

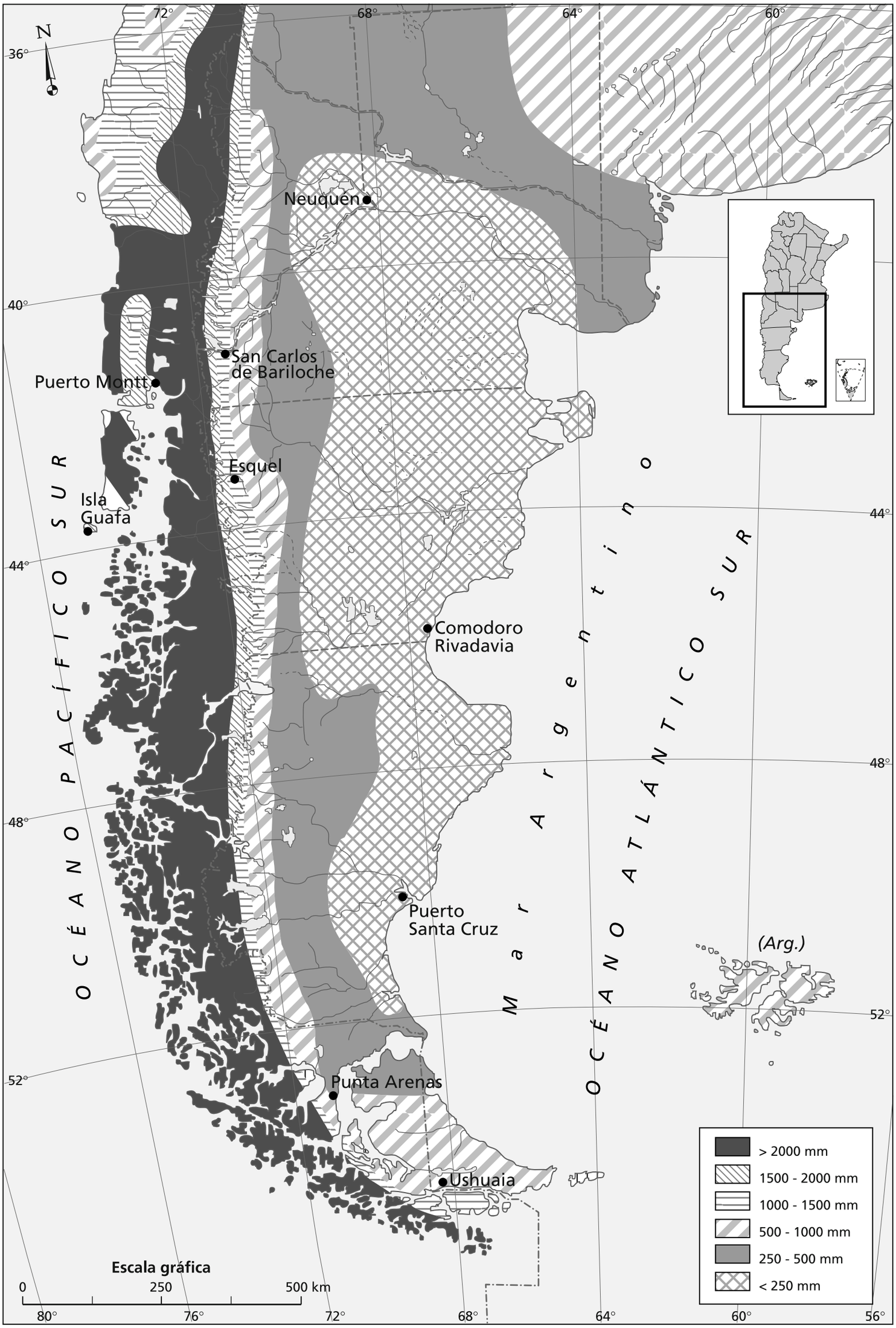

72°
68°
64°
60°
36°
N
Neuquén
40°
San Carlos
de Bariloche
Puerto Montt
Esquel
Isla
Guafa
44°
Comodoro
Rivadavia
48°
Puerto
Santa Cruz
(Arg.)
52°
Punta Arenas
Ushuaia
OCÉANO PACÍFICO SUR
Mar Argentino
OCÉANO ATLÁNTICO SUR
> 2000 mm
1500 - 2000 mm
1000 - 1500 mm
500 - 1000 mm
250 - 500 mm
< 250 mm
Escala gráfica
0
250
500 km
80°
76°
72°
68°
64°
60°
56°

Fig. 4.2.1 (left): Annual rainfall in Patagonia

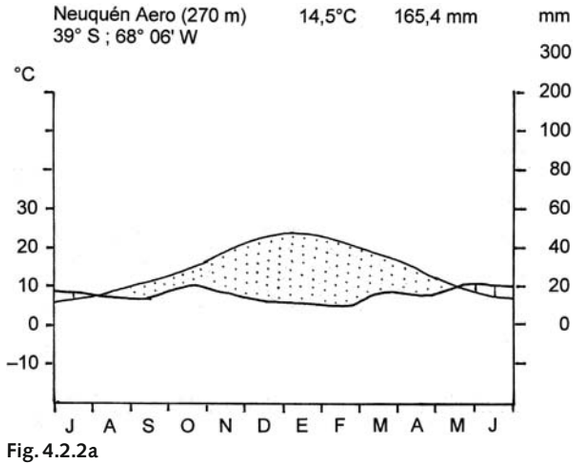


Fig. 4.2.2a

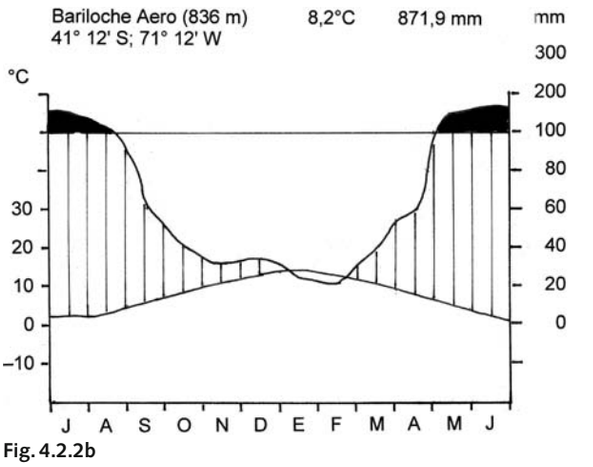


Fig. 4.2.2b

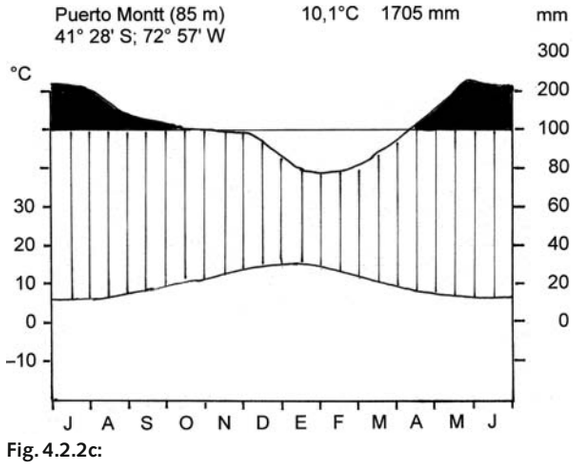


Fig. 4.2.2c:

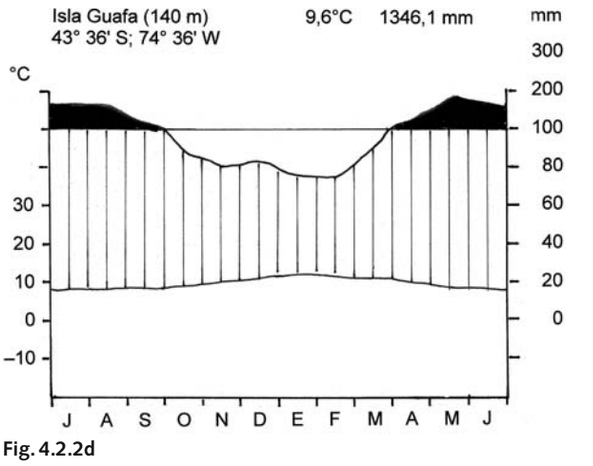


Fig. 4.2.2d

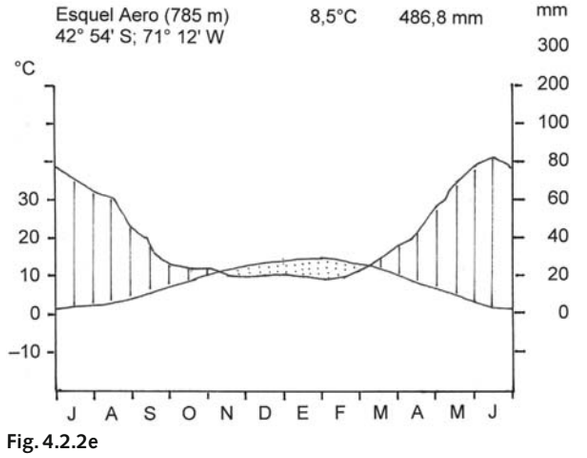


Fig. 4.2.2e

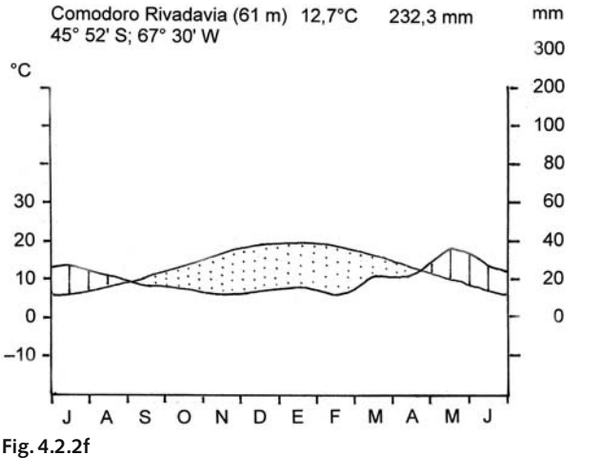


Fig. 4.2.2f

Fig. 4.2.2a–i: Climate diagrams of 9 Patagonian sites: **a:** Neuquén; **b:** San Carlos de Bariloche; **c:** Puerto Montt; **d:** Isla Guafa; **e:** Esquel; **f:** Comodoro Rivadavia; **g:** Puerto Santa Cruz; **h:** Punta Arenas; **i:** Ushuaia

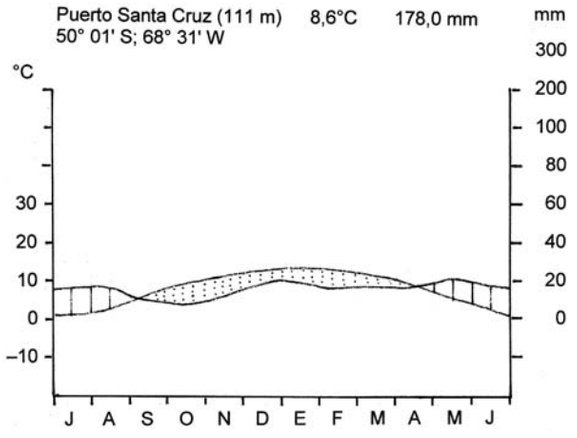


Fig. 4.2.2g

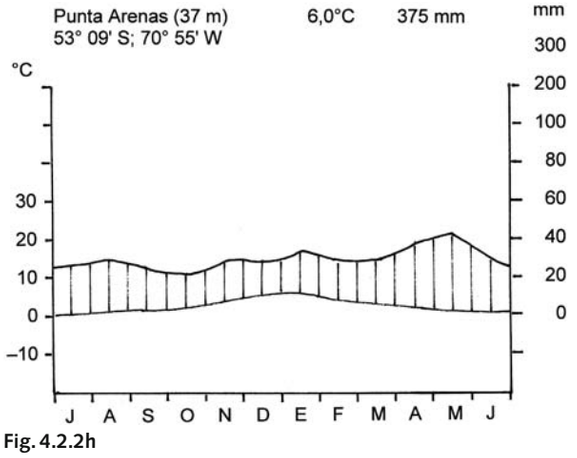


Fig. 4.2.2h

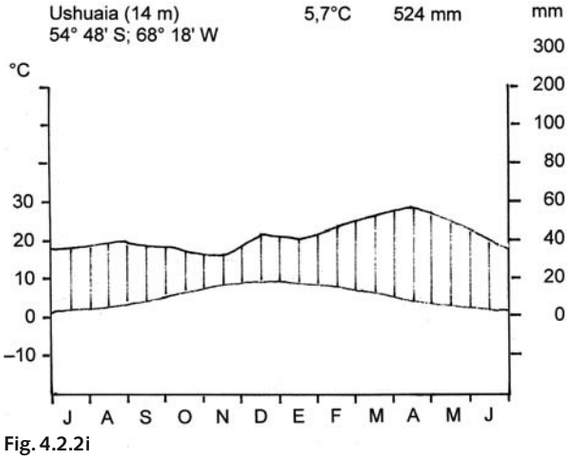


Fig. 4.2.2i

4.3. Soils

Soils have a double function for land plants: (i) they convey them physical support; (ii) they provide them with indispensable nutrients. Neither of these functions can be regarded as a constant. Soils change with time: they evolve, reach a stage of maturity, and they may involve, i.e. degenerate. In a broad sense, the evolution of a soil starts when the underlying mother rock begins to be covered by foreign material, issuing simultaneously in the appearance of an upper *A-horizon* and a *C-horizon* on the parental material. In the course of time, as manifold processes set on, other – *B-horizons* – develop between the *A- and C-horizons.*

When a soil reaches maturity, it has gained in stability. If it starts to degrade, the forming processes gradually invert, leading to soil destruction, often in form of water or wind erosion. Unfortunately, human mismanagement of soils has either initiated or accelerated these degenerating processes in many regions of the world. Vast areas of Eastern and Western Patagonia are sad examples of anthropogenic soil destruction.

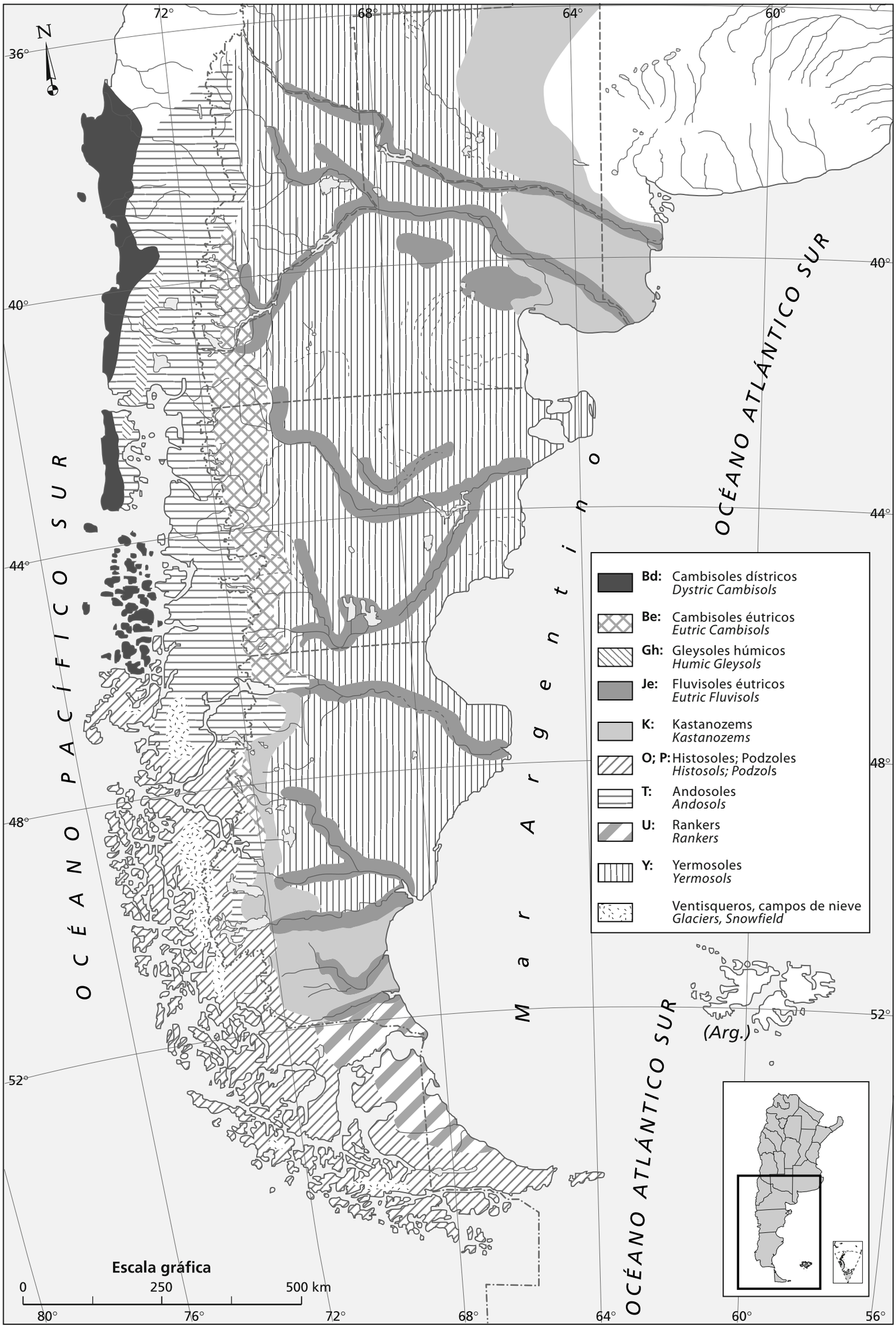
In very general terms, we could state that deep, moist soils with a rich and well developed *horizon A* can almost exclusively be found on the *Chilean side,* whereas on the *Argentine side* soils are mainly superficial, often alkaline, with an elevated amount of salt. Erosion is a serious problem on both sides of the Andes:

In *Chilean Patagonia,* the moist, wet soils are susceptible to be degraded through compaction, and erosion is favoured by the hilly landscape and the elevated rate of rainfall that washes out the organic matter (Ellies, 2000). Erosion is a major problem above all in Region IX on the steep slopes of the Cordillera de la Costa, where soils have evolved on granite rocks. Further to the south, in Region X, the soils have been formed of material stemming from glaciers, and are more recent (Hoffmann, 1982, p. 25).

In *Argentine Patagonia,* it is above all wind erosion, induced or strongly increased by overgrazing, that has caused a severe loss of the surface horizon of the soils (Moscatelli and Pazos, 2000).

Figure 4.3. conveys an extremely simplified overview of the main types of soils of Southern South America. It is a compilation, based on volume IV of the *Soil map of the world* (published by FAO– UNESCO in 1974), W. Zeil's *Südamerika* (1986), and on the *Encyclopaedia Britannica* (vol. 27, 1993, p. 588). I have chosen these publications, because they cover the entire surface of Southern

Fig. 4.3: Soils of Patagonia


N
72°
68°
64°
60°
36°
40°
44°
48°
52°
56°
80°
76°
OCÉANO PACÍFICO SUR
Mar Argentino
OCÉANO ATLÁNTICO SUR
OCÉANO ATLÁNTICO SUR
(Arg.)
Bd: Cambisoles dístricos
Dystric Cambisols
Be: Cambisoles éutricos
Eutric Cambisols
Gh: Gleysoles húmicos
Humic Gleysols
Je: Fluvisoles éutricos
Eutric Fluvisols
K: Kastanozems
Kastanozems
O; P: Histosoles; Podzoles
Histosols; Podzols
T: Andosoles
Andosols
U: Rankers
Rankers
Y: Yermosoles
Yermosols
Ventisqueros, campos de nieve
Glaciers, Snowfield
Escala gráfica
0
250
500 km

South America. Readers who search for more detailed information on the soils of Argentine Patagonia and who are familiar with the classification of the *Soil Taxonomy System* are referred to the publications by G. Moscatelli and M.S. Pazos (2000) and by C.O. Scoppa (1998).

A short description of the **soil types** considered in **Fig. 4.3:**

Bd: *Dystric Cambisols*. Poor, acid soils in mountainous areas with humid climate, having a base saturation of less than 50% and little biological activity. Lack of phosphate. Carbonates absent in the parental material. Rarely apt for agriculture, suitable for forestry and pasture. In Patagonia, above all on the western slopes of the Coastal Range. High risk of water erosion.

Be: *Eutric Cambisols*. Neutral soils in subhumid to semiarid zones of transition, having a base saturation of more than 50% and being biologically active. Carbonates absent in the parental material. Suitable for tree crops, forestry, pasture.

Gh: *Humic Gleysols*. Bluish grey soils, generally sticky, with excess wetness stemming from ground-water, having no abrupt textural change within 100 cm from the soil surface which is often covered by new organic material. In Patagonia, restricted to the fault of the Chilean Valle Central, where they have developed on sediments of Pleistocene age. Suitable for grazing, horticultural crops; if not drained, less suitable for crops with small seeds.

Je: *Eutric Fluvisols*. The better, neutral soils of Eastern Patagonia, developed on alluvial deposits, having a thickness of 25 cm (or more) and a base saturation of more than 50%. Drainage and irrigation may be needed in certain areas.

K: *Kastanozems*. Brown soils, rich in organic matter. Generally, soils in semiarid climates; rich in clay; in principle fertile, with a high content of calcium carbonate. Often with a high salt content that even may increase with inappropriate irrigation. Crops such as quinoa, potatoes, barley, and oats can be grown.

P; O: *Podzols and Histosols*. The *podzols* (**P**) are acid, poor soils, often in mountainous areas with high pluviosity in which generally iron and all weathering products are eluviated, leaving a bleached, ashy upper horizon. Usually, a dark coloured B horizon with illuvial alumino-organic complexes, with or without iron, develops, often combined with hard horizons (pans) cemented together by organic matter.–
The *histosols* (**O**) are peaty, organic soils, having 40 cm or more of organic material; mainly on the offshore islands of southern Chile. Constantly swept by salt-laden winds, these acid soils are low in fertility. When drained and properly managed, such soils may, in certain areas, be suitable for high-value market crops.

T: *Andosols*. Acid soils, common in the volcanic Andes, frequently on steep slopes. They have a very high rate of phosphate fixation and are therefore often not intensively farmed. If drainage is applied, they may shrink rapidly in volume.

U: *Rankers*. In Patagonia, acid, stony soils with a shallow A-horizon laying on rocks or sand rich in silicate, poor in calcium carbonate.

Y: *Yermosols*. Shallow, stony soils on old arid terraces and tablelands. Often saline or alkaline. There is a predominant water deficiency. Very susceptible to wind erosion, particularly when overgrazed. To the north of latitude 40° S (approximately), yermosols often have a strongly developed argilic (clay) B horizon.

Listing up these soils according to their *pH,* we can distinguish:

(i) acid soils: **Bd, O, P, T** – generally soils in semi-humid to euhumid climates;
(ii) neutral soils: **Be, Je** – soils in semi-humid to semiarid climates;
(iii) alkaline soils: **K, Y** – soils in semi-arid to arid climates

Wet soils: **O, Gh**
Mountain soils: **P, T**
Shallow soils on rock bed: **T**
Acid, stony soils: **U**
Alluvial soils: **Je**

5. Vegetation of Patagonia

Fig. 5.0: North-exposed slope of PN Lago Puelo, with strong predominance of *Austrocedrus chilensis*. In the background, Chilean Andes (28.01.2008, afternoon)

5.1. The Vegetation Map of South America by K. Hueck and P. Seibert (1981)

Figure 5.1 reproduces –with the kind permission of the Publisher, Elsevier (Munich) [Urban & Fischer]– the Patagonian sector of the *Vegetationskarte von Südamerika* by K. Hueck and P. Seibert (Stuttgart: G. Fischer, 1981, 2nd ed.). What follows, is a concise characterisation of the vegetation units according to K. Hueck and P. Seibert. Regarding the names of the species, I follow Zuloaga et al.; for Chilean species not mentioned by Zuloaga, I follow Hoffmann; in brackets, the differing synonyms used by Hueck and Seibert.

The fact that I reproduce the map by Hueck and Seibert does not imply that I agree with every detail contained in their publication. But I do believe that Hueck and Seibert's map offers a fitting *overview* of the vegetation units of the southern regions of Argentina and Chile. (For details regarding the biogeographic delimitations of the subantarctic sub region and its provinces, see Morrone (2000).)

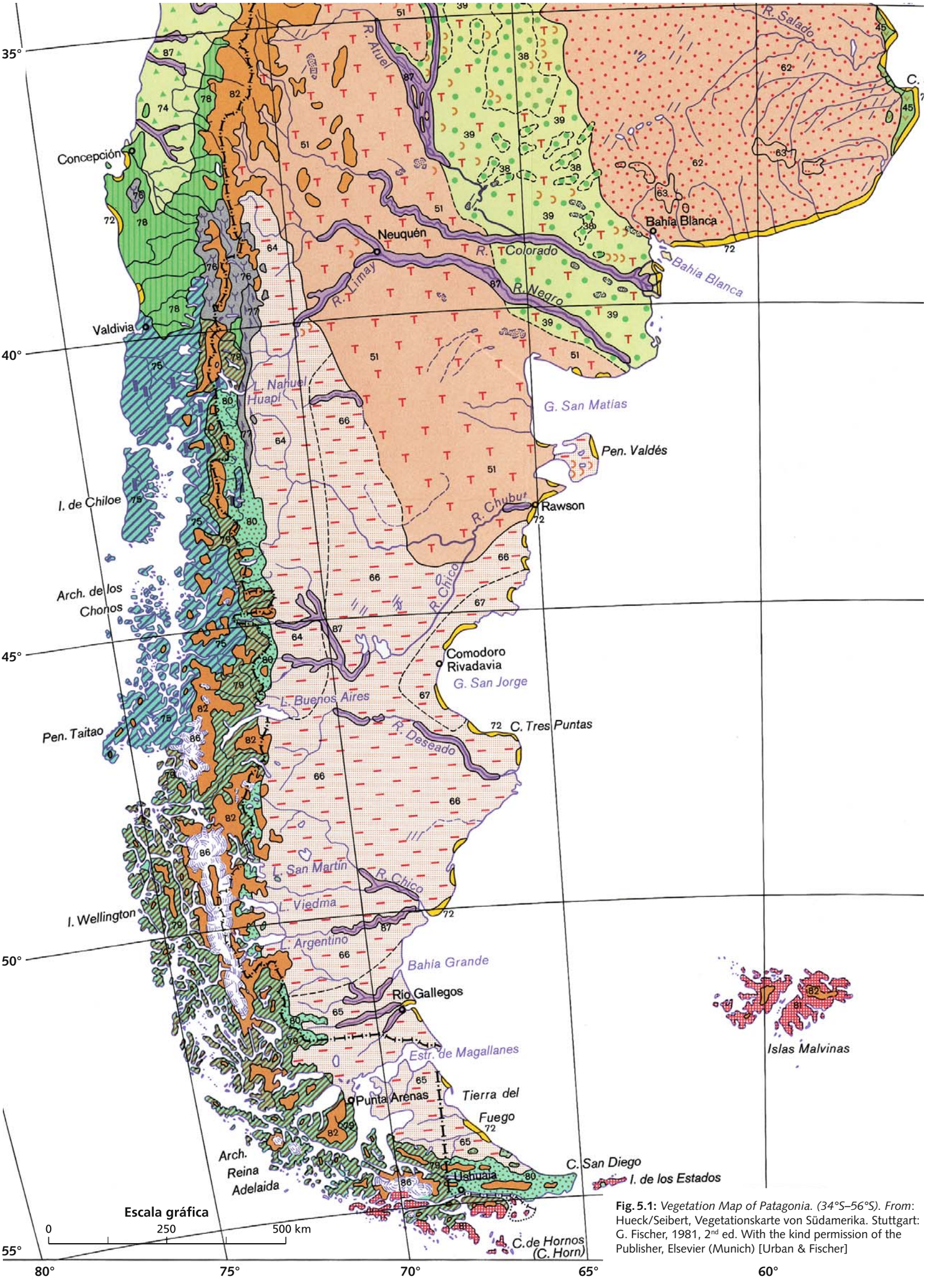


Fig. 5.1: *Vegetation Map of Patagonia. (34°S–56°S). From*: Hueck/Seibert, Vegetationskarte von Südamerika. Stuttgart: G. Fischer, 1981, 2nd ed. With the kind permission of the Publisher, Elsevier (Munich) [Urban & Fischer]


Dry forest of the Espinales
Bosques secos de los Espinales


Zone of transition from the dry forest of the Espinales to the Monte vegetation
Transición del bosque seco de los Espinales a la vegetación de Monte


Shrubby Monte steppe
Estepa arbustiva de Monte


Grassland of the Pampas plains
Praderas de las Pampas planas


Grassland and shrub-land of the hilly Pampas
Praderas y matorral de las Pampas onduladas


Patagonian steppes and half-deserts
Estepas y semidesiertos patagónicos

64 Sub-Andean and western region / *Sector subandino y occidental*

65 Tierra del Fuego and Magellanic region / *Sector de Tierra del Fuego y magallánico*

66 Central region / *Sector central*

67 San Jorge region / *Sector de San Jorge*


Coastal dunes and forests of coastal dunes
Dunas litorales y bosques de dunas litorales


High level of ground-water, very wet; in no. 58, 59, 62, 64–67, 72 flooded periodically or for long intervals
Alto nivel freático, muy mojado, periódicamente o largamente inundado en no. 58, 59, 62, 64–67, 72


Halophyte vegetation of the salt pans in no. 51, 64–67, 69
Vegetación halofitica de los salares en no. 51, 64–67, 69


Interrupted by or alternating with sand dunes in no. 51, 59, 64–67, 69
Interrumpido o alternado por médanos en no. 51, 59, 64–67, 69


Subtropical forests of xerophytes and sclerophytes of central Chile
Bosque subtropical de xerófitas y durifoliadas


Evergreen Valdivian rain forests
Pluviselva valdiviana siempreverde


Forests of *Araucaria araucana*
Bosque de Araucaria araucana


Forests of *Austrocedrus chilensis*
Bosques de Austrocedrus chilensis


Deciduous forests of the warm-temperate region, with *Nothofagus obliqua* and *N. alpina*
Bosques caducifolios de la zona templado-temperada con Nothofagus obliqua *y* N. alpina


Mainly evergreen forests of the temperate region, with *Nothofagus dombeyi* and *N. betuloides*
Bosques predominantemente siempreverdes de la zona templada con Nothofagus dombeyi *y* N. betuloides


Mainly deciduous forests of the temperate region, with *Nothofagus pumilio* and *N. antarctica*
Bosques predominantemente deciduos de la zona templada con Nothofagus pumilio *y* N. antarctica


Patches of *Fitzroya cupressoides* in the Valdivian rain forests
Fitzroya cupressoides *formando rodales en la pluviselva valdiviana*


Subantarctic tundra
Tundra subantártica


High altitude vegetation of the Andes without further differentiations
Vegetación andina de alta montaña sin mayor clasificación


Glaciers and snow fields
Ventisqueros y campos de nieve

Gallery-forests and other types of vegetation along rivers, in otherwise largely or completely treeless areas
Bosques de galería y otros tipos de vegetación asociados a ríos en zonas desarboladas o pobres en bosques

39: Zone of transition from the dry forest of the Espinales to the Monte vegetation

Distribution: In Argentina, between Río Negro and Córdoba.

Climate: 14–18° C mean annual temperature; range of variation: 14° C; 300–600 mm, in summer.

Elevation: 0–400 m.

Species: In dry forests: *Larrea divaricata*, *Prosopis affinis* (*P. algarobilla*), *P. caldenia, P. nigra, P. alba, Acacia caven, Geoffroea decorticans, Jodina rhombifolia, Schinus longifolia, Condalia microphylla* (*C. lineata*), *Celtis tala* (*C. spinosa*).

In palm groves: *Butia yatay*.– Only the south-eastern corner, with *Prosopis caldenia*, belongs to Patagonia, strictly speaking. [39 is equivalent to Roig's unity 14: Shrubby semiarid steppes of *Larrea divaricata* with *Geoffroea, Capparis*, etc.]

51: Shrubby Monte steppe

Distribution: In Argentina, from the foothills of the Andes to the Gulf of San Matías.

Climate: 14–20°C mean annual temp.; range of variation: 16° C; 100–350 mm, in summer. Elevation: 0–1000 m.

Species: **In the shrubby steppe:** *Larrea divaricata, L. ameghinoi, L. cuneifolia, L. nitida, Bougainvillea spinosa, Prosopis alpataco, P. strombulifera, Prosopidastrum globosum (Prosopis globosa), Senna aphylla (Cassia aphylla), Capparis atamisquea (Atamisquea emarginata), Condalia microphylla, Cercidium praecox (C. australe), Tricomaria usillo, Monttea aphylla, Chuquiraga erinacea*.

Halophyte vegetation: *Suaeda divaricata, Atriplex lampa, A. sagittifolia, Cyclolepis genistoides, Frankenia patagonica, Sarcocornia perennis (Salicornia ambigua), Heterostachys* sp., *Allenrolfea patagonica*.

[**51** is equivalent to Roig's unity 15: Shrubby semiarid steppes of *Larrea divaricata* with *Larrea ameghinoi*.]

62: Grassland of the Pampas plains

Distribution: In Argentina, from Río Uruguay to Bahía Blanca.

Climate: 14–17° C mean annual temp.; range of variation: 13°C; 600–1000 mm, in summer.

This region does not belong to Patagonia.

63: Grassland and shrub-land of the hilly Pampas

Distribution: Sierra de la Ventana (Prov. de Buenos Aires), Uruguay, southern Brasil.

Climate: 14–19°C mean annual temp.; range of variation: 13° C; 700–1300 mm, in summer.

Elevation: 0–1200 m.

This region does not belong to Patagonia.

64–67: Patagonian steppes and half-deserts [Shrubby arid steppes, after Roig]

64: Sub-Andean and western region of Argentine Patagonia

Distribution: Areas to the east of the Andes, between 38° S and 47° S.

Climate: 8–13°C mean annual temp.; range of variation: 13–15°C; 200–600 mm, in winter.

Elevation: 400–1500 (1900) m.

65: Tierra del Fuego and Magellanic region

Distribution: From latitude 51° S southwards.

Climate: 5–7°C mean annual temp.; range of variation: 9–10°C; 200–500 mm, in winter.

Elevation: 0–500 m.

66: Central region

Distribution: Central Patagonian, between 41° S and 51° S.

Climate: 8–14° C mean annual temp.; range of variation: 13° C; 100–200 mm, in winter.

Elevation: 0–1500 (1900) m.

67: San Jorge region

Distribution: Surroundings of the Gulf of San Jorge.

Climate: 0–11° C mean annual temp.; range of variation: 14° C; 100–200 mm, in winter.

Elevation: 0–500 m.

72: Coastal dunes [Coastal vegetation, after Roig]

Distribution: In Patagonia, only along the Atlantic coast.

Climate: → neighbouring regions.

Elevation: 0–40 m.