

BASES DA BIOGEOGRAFIA ECOLÓGICA

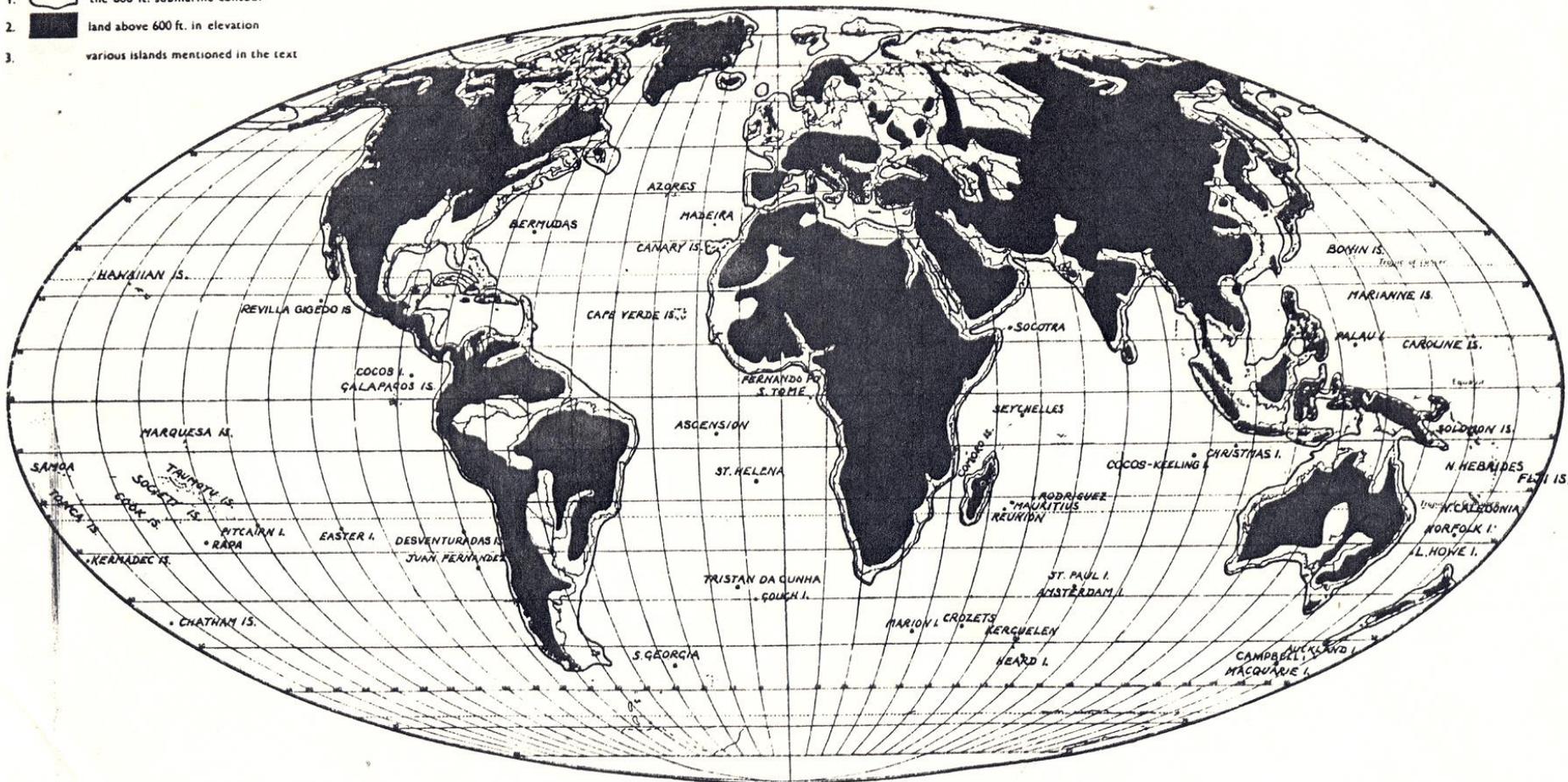
Explicar a distribuição geográfica de um organismo envolve:

- Ecologia da dispersão da espécie**
 - Variações do ambiente físico**
- Interações ecológicas com outros organismos**

PLATE 3

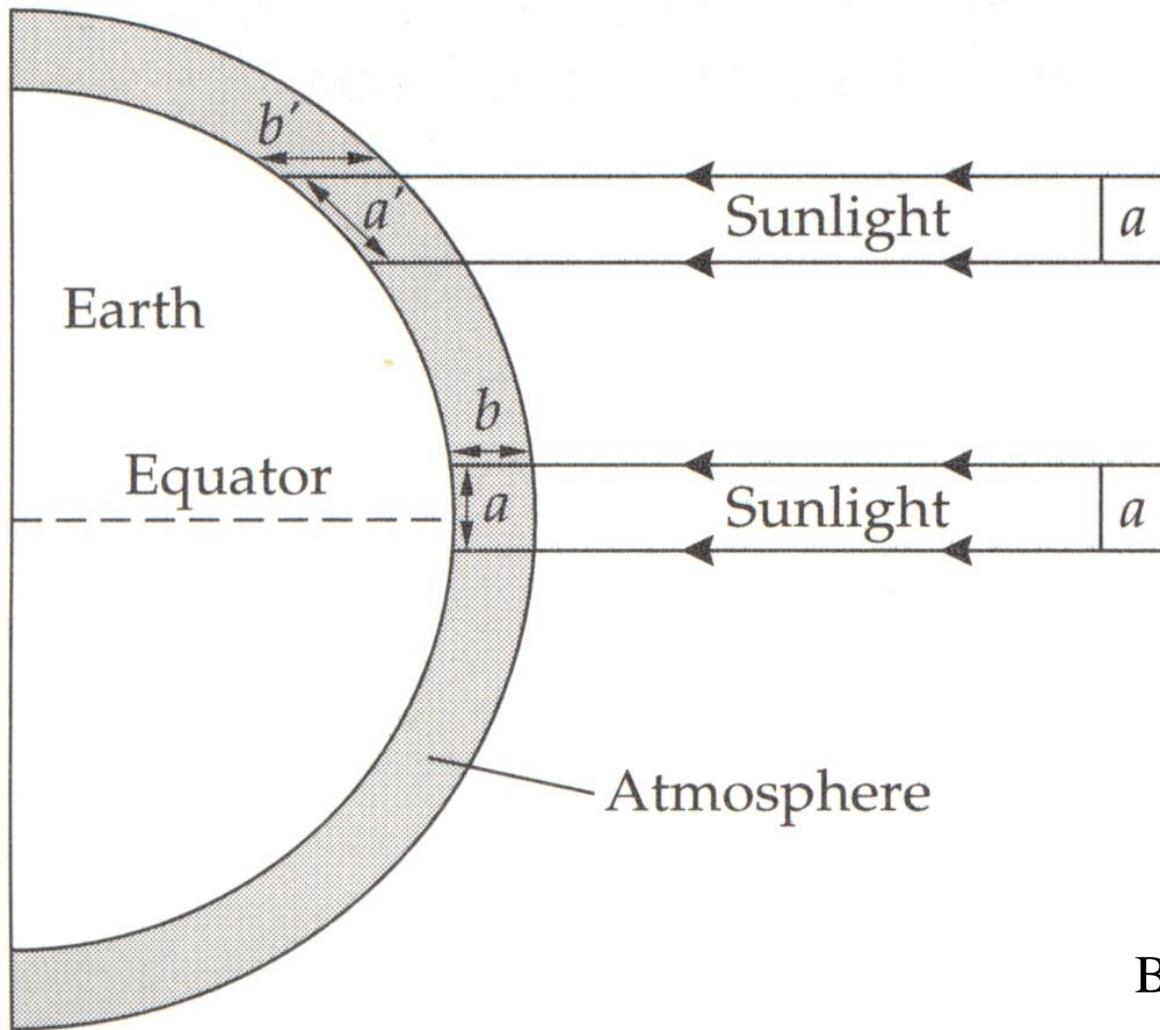
Map of the World showing, from various sources:

1.  the 600 ft. submarine contour
2.  land above 600 ft. in elevation
3.  various islands mentioned in the text



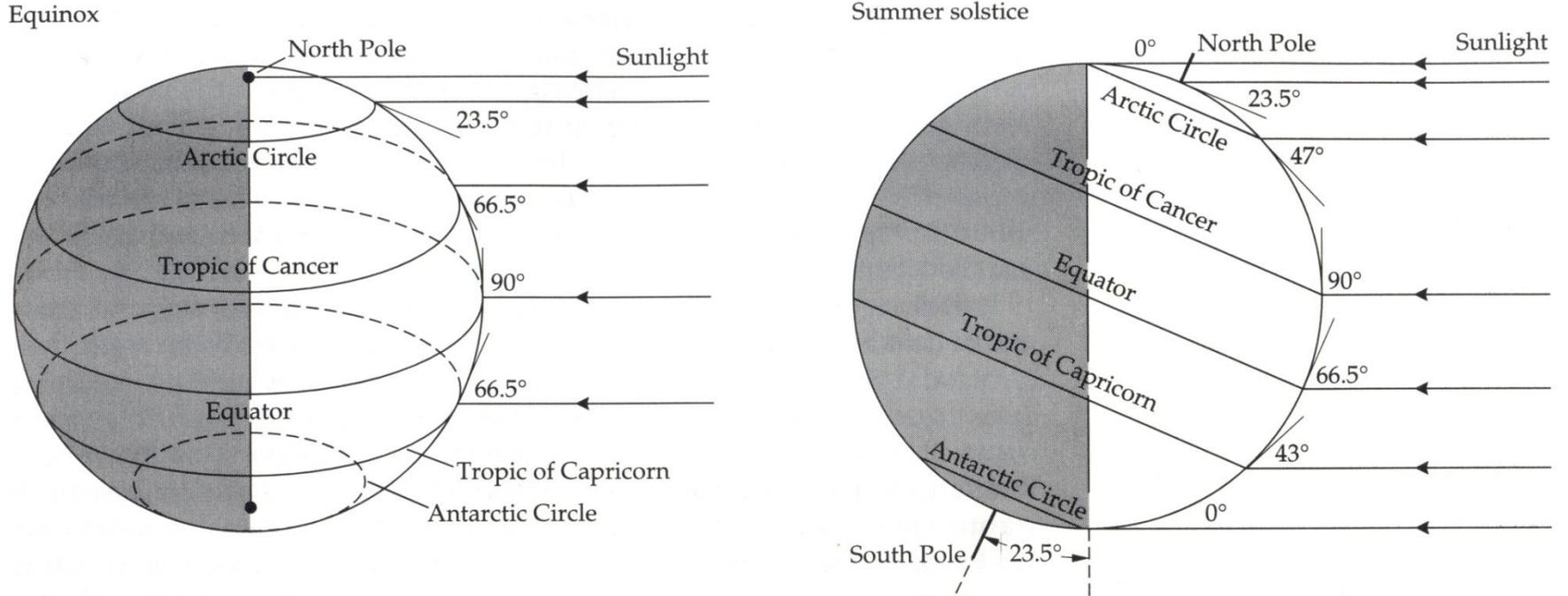
Areas correct Distortion increasing towards border of map.
 Approximate Scale 1:100,000,000 (1600 miles - 1 inch) along Equator
 on Mollweide's Homolographic Projection

Good 1974



Brown & Lomolino 1998

Average input of solar radiation to the earth's surface as a function of latitude. Heating is most intense when the sun is directly overhead, so that incoming solar radiation strikes perpendicular to the earth's surface. The higher latitudes are cooler than the tropics because the same quantity of solar radiation is dispersed over a greater surface area (a' as opposed to a) and passed through a thicker layer of filtering atmosphere (b' as opposed to b).



Seasonal variation in day length with latitude is due to the inclination of the earth on its axis.

Brown & Lomolino 1998

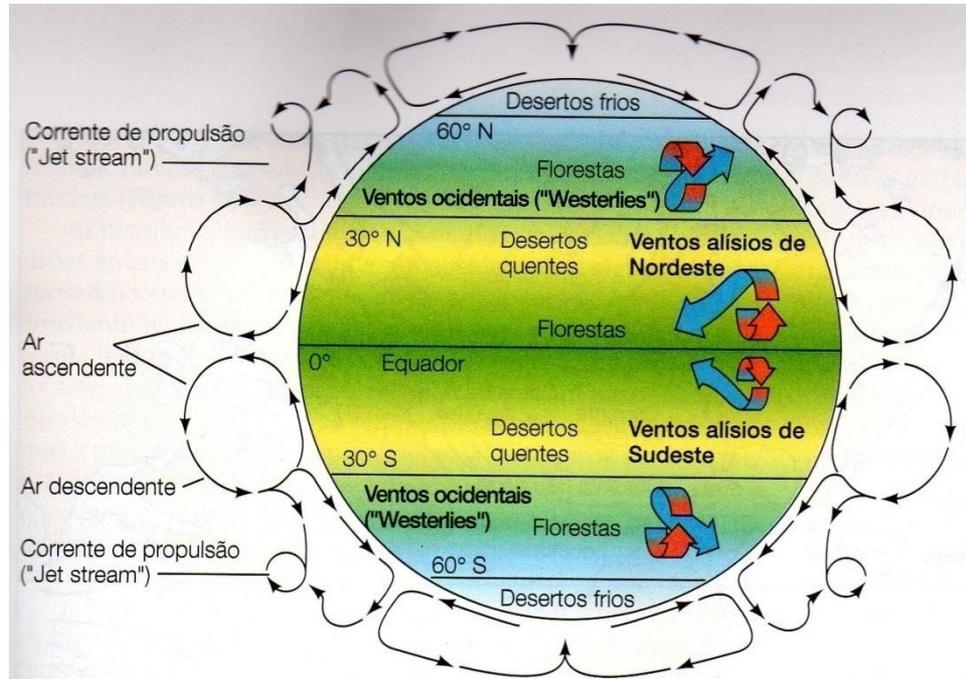
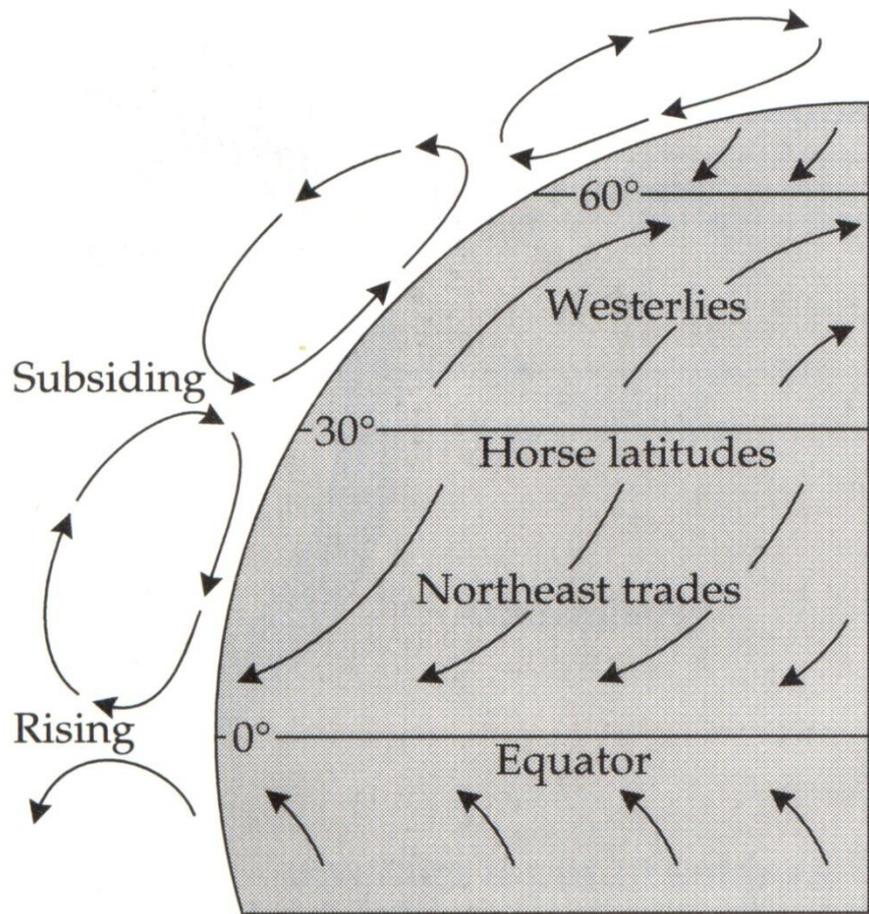
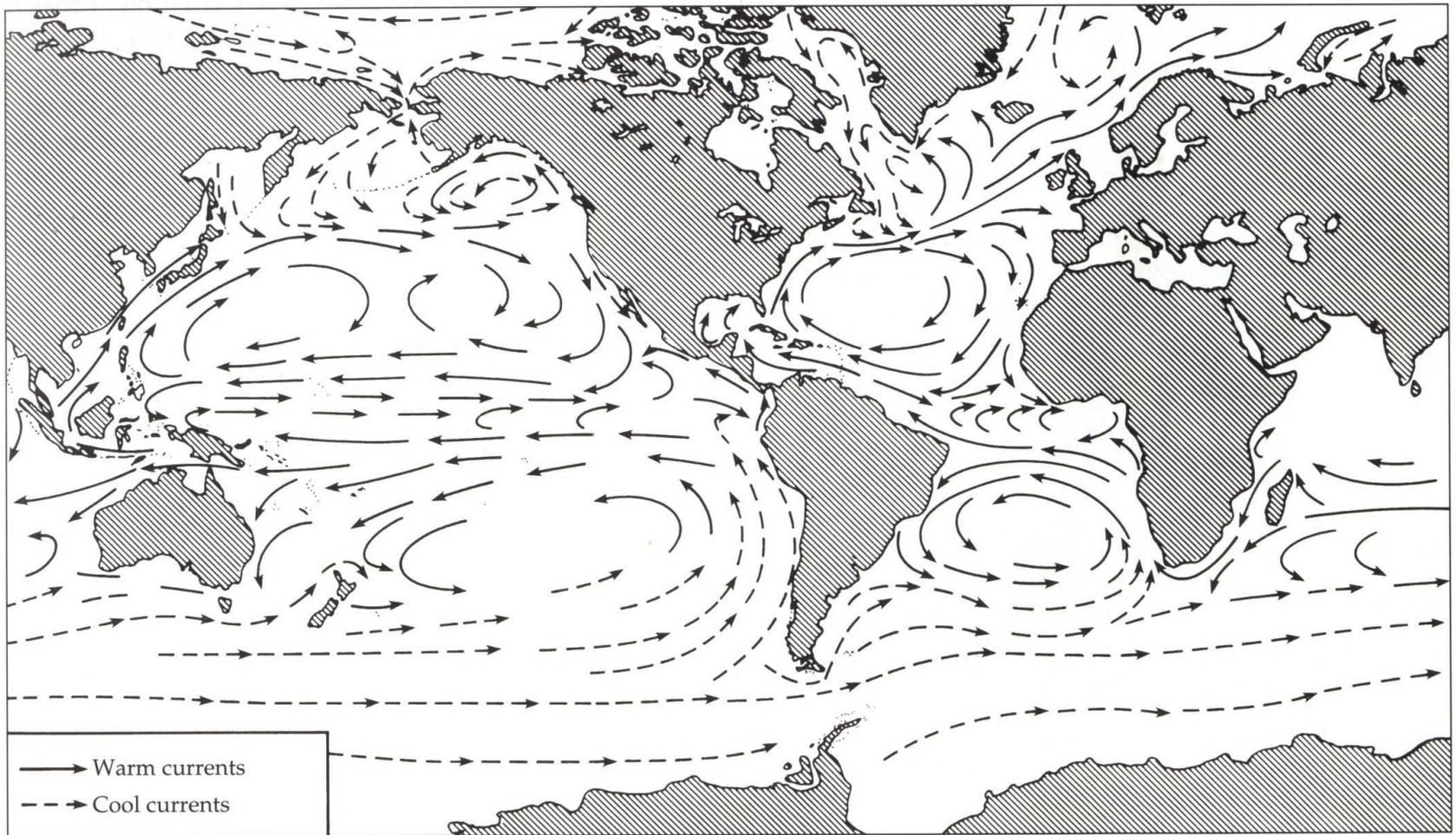


Figura 34.2 Circulação da atmosfera da Terra Se pudéssemos ficar fora da Terra e observássemos os movimentos de ar na sua atmosfera, poderíamos ver padrões de circulação de ar verticais semelhantes aqueles indicados pelas setas pretas e vermelhas e ventos de superfície semelhantes aqueles mostrados pelas setas azuis.

Sadava et al. 2009

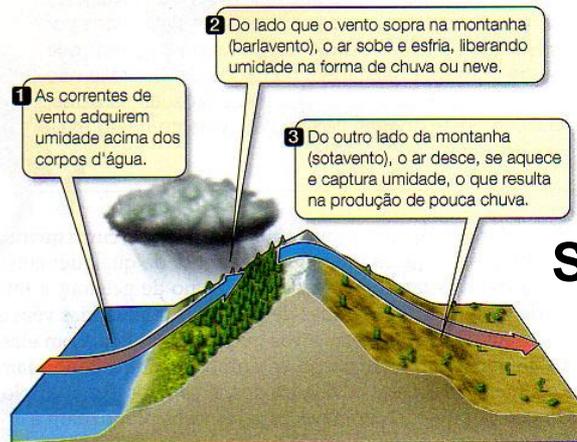
Relationship between vertical circulation of the atmosphere and wind patterns on the earth's surface. There are three convective Hadley cells of ascending and descending air in each hemisphere. As the winds move across the earth's surface in response to this vertical circulation, they are deflected by the Coriolis effect, producing easterly trade winds in the tropics and westerlies at temperate latitudes.

Brown & Lomolino 1998



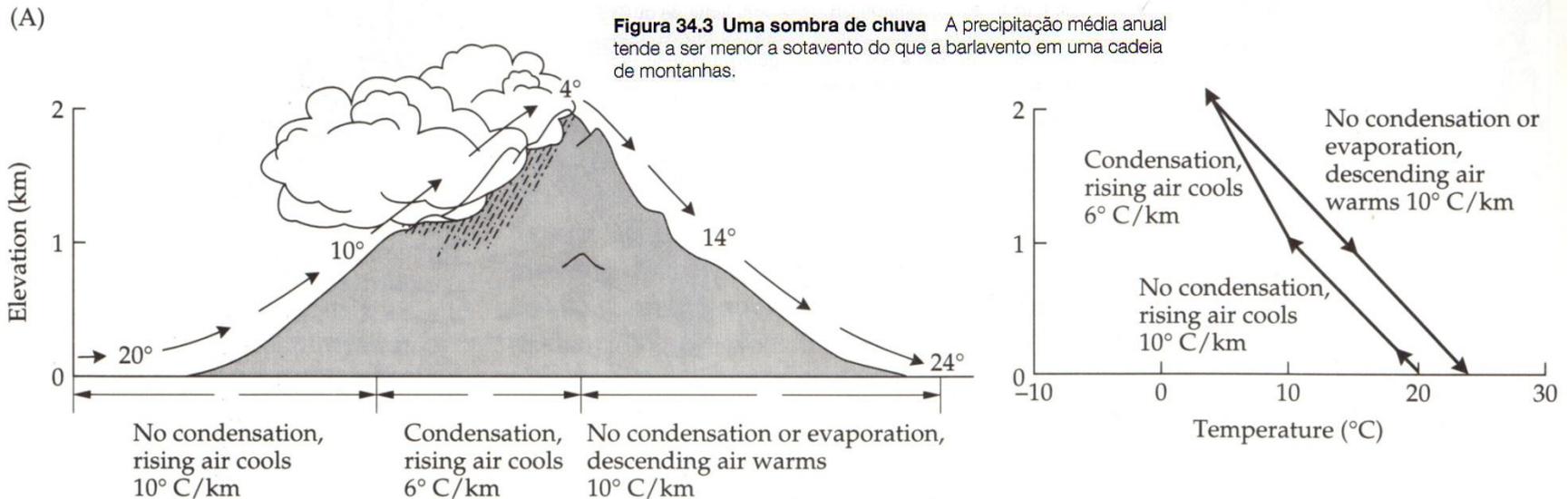
Main patterns of circulation of the surface currents of the oceans. In each ocean, water moves in great circular gyres, which move clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere.

Brown & Lomolino 1998



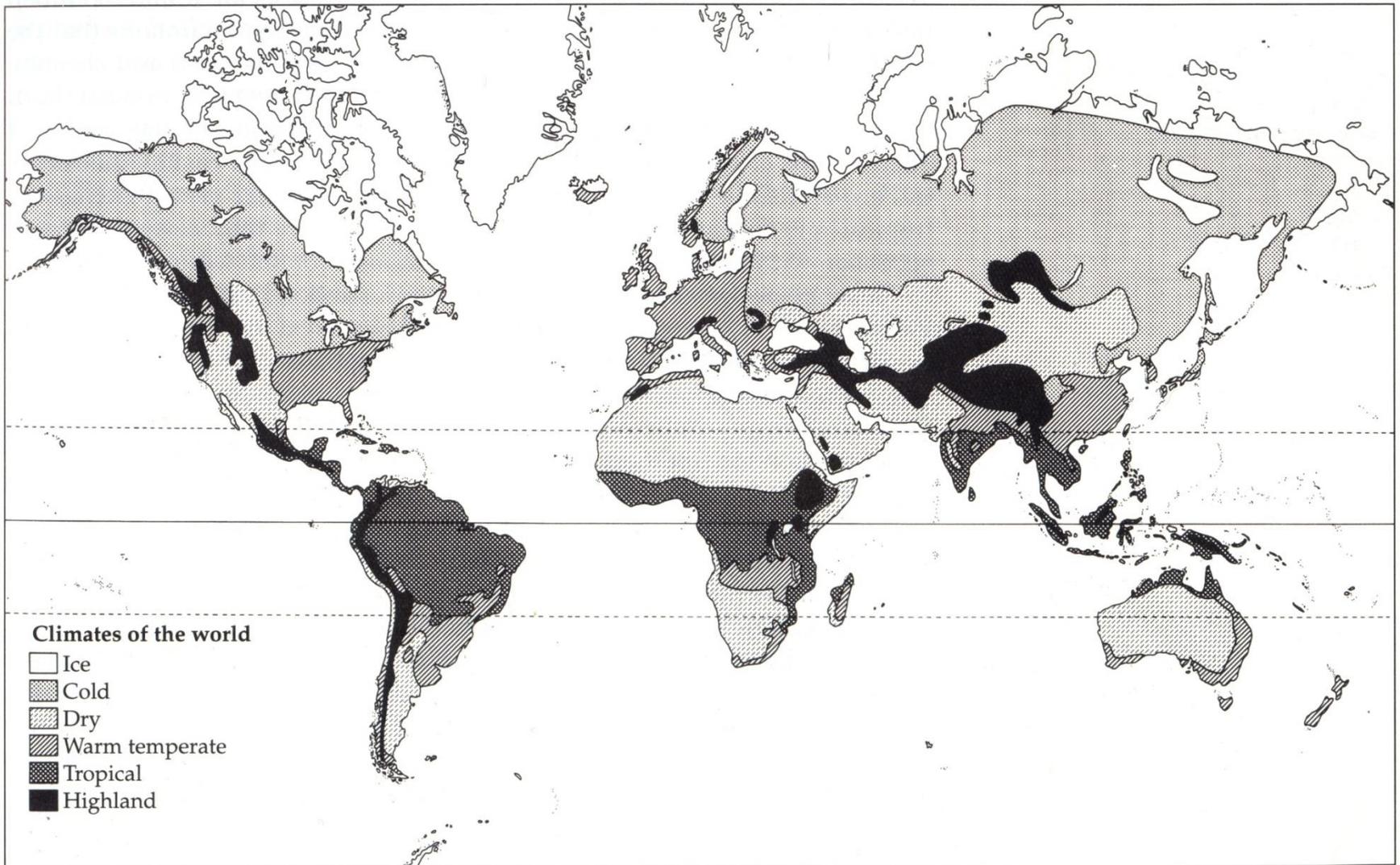
Sadava et al. 2008

Figura 34.3 Uma sombra de chuva A precipitação média anual tende a ser menor a sotavento do que a barlavento em uma cadeia de montanhas.



Factors causing **rain shadow** deserts. (A) Air blowing over a mountain cools as it rises, water vapor condenses, and the air loses much of its moisture as rain on the windward side, so that the leeward side experiences warm, dry winds. (B) The rate of change in air temperature with elevation is affected by the presence of condensed water vapor, resulting in warmer, drier conditions on the leeward side than at the same elevation on the windward side. (After Flohn 1969.)

Brown & Lomolino 1998



Major climatic regions of the world. Note that these regions occur in distinct patterns with respect to latitude and the positions of continents, oceans, and mountain ranges. (After Strahler 1973)

Brown & Lomolino 1998

Componentes do CLIMA:

Temperatura anual média

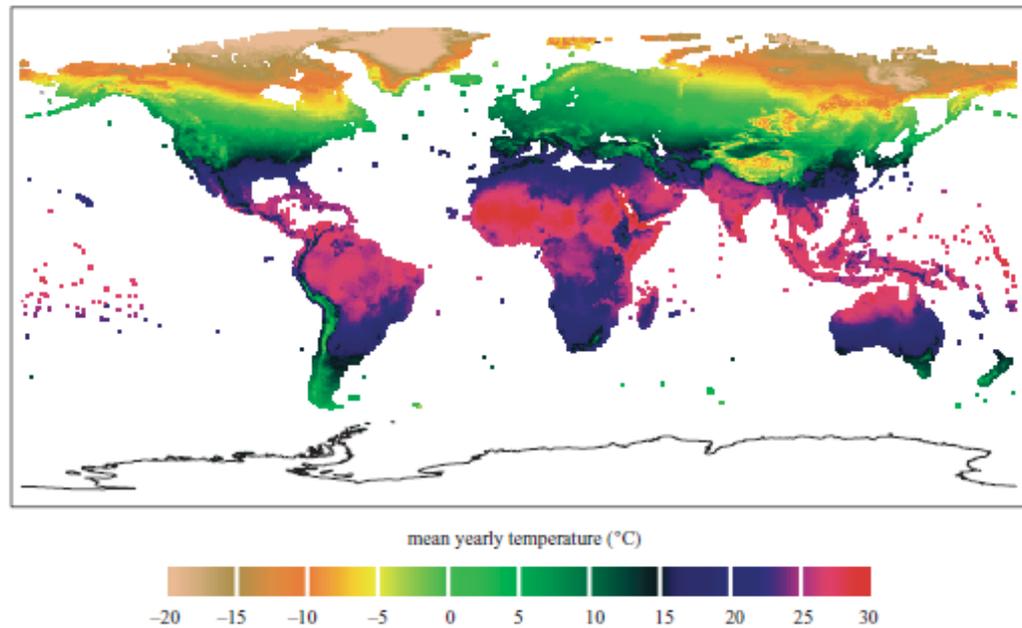


Figure 6. Mean annual temperature for 1901 to 1970. (Modified from New *et al.* 2000.)

Precipitação anual média

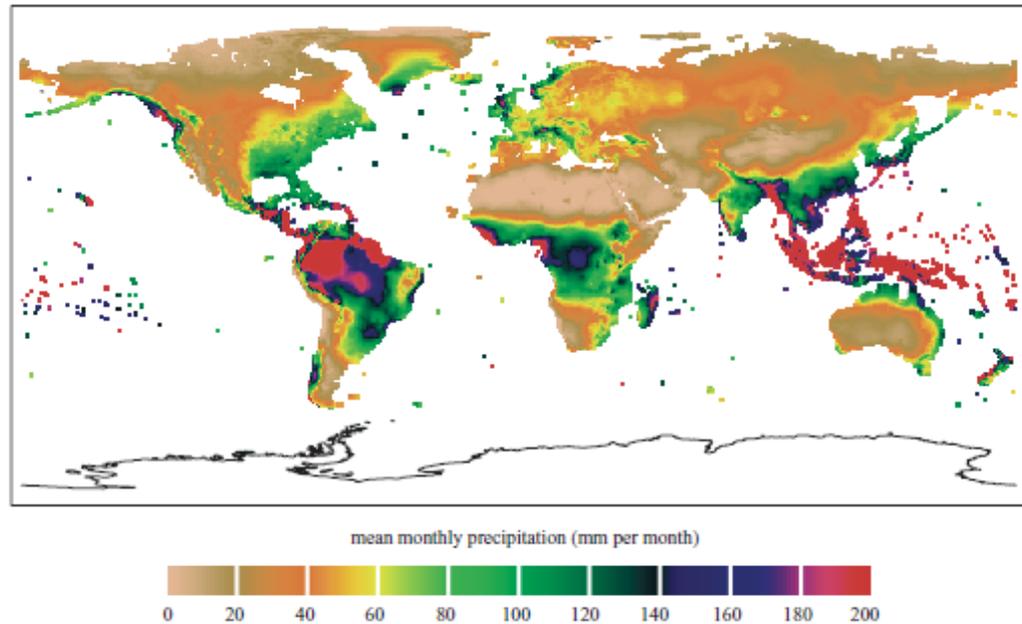
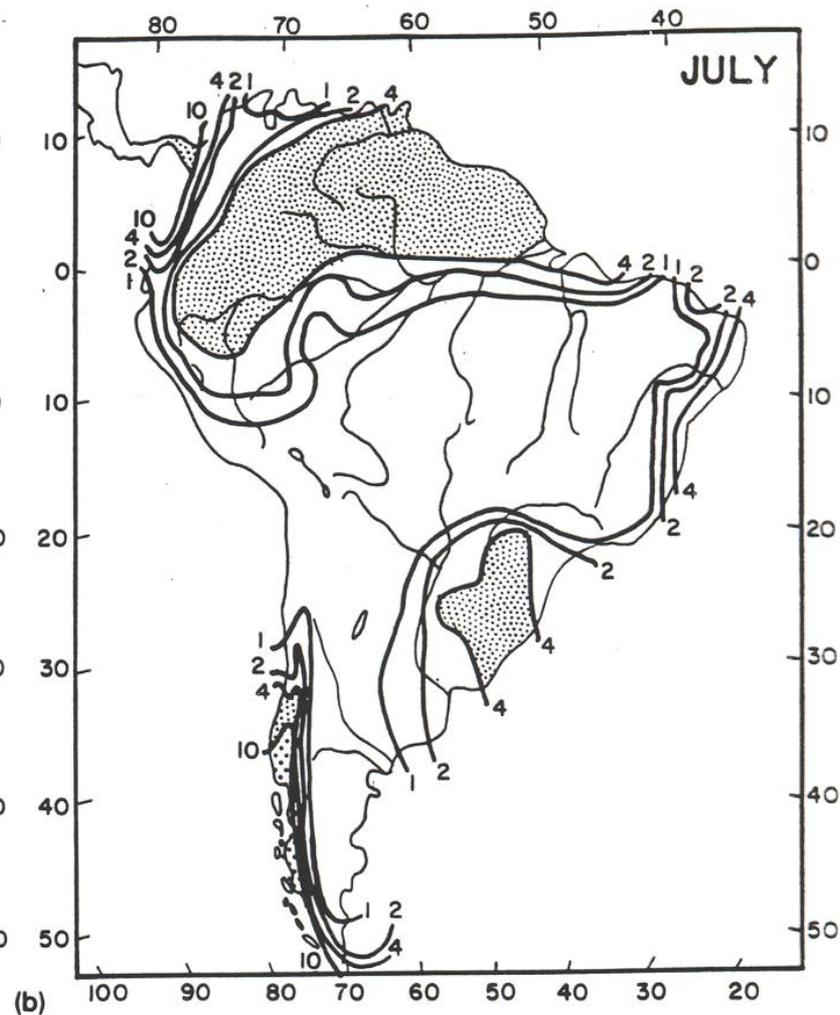
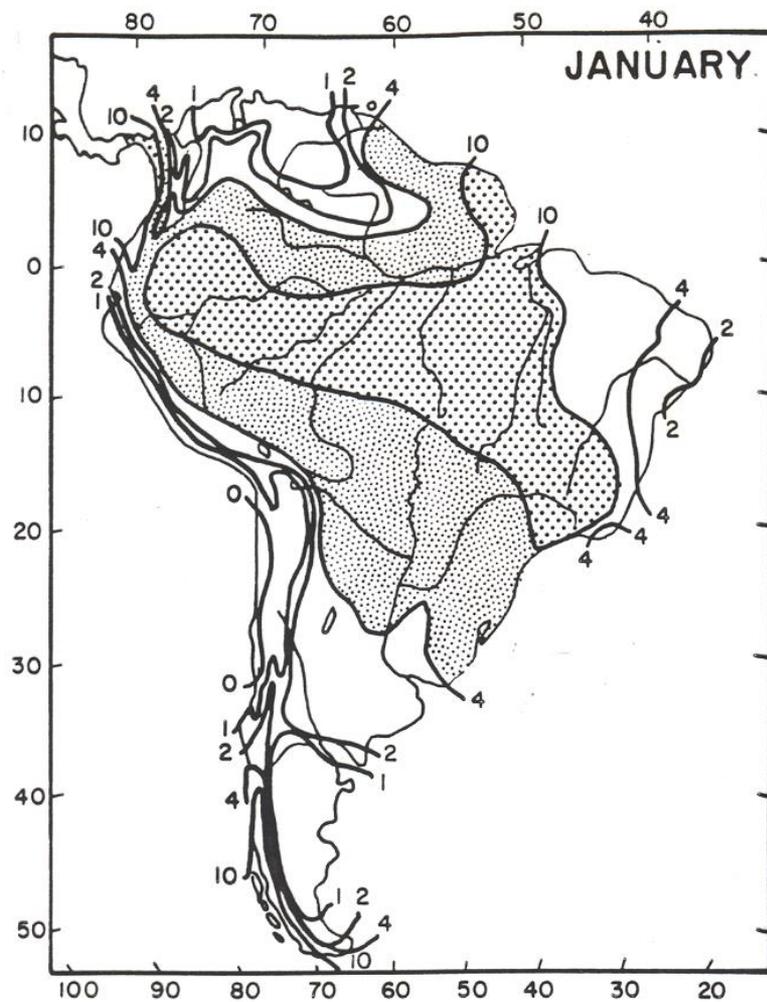


Figure 7. Mean monthly precipitation for 1901 to 1970. (Modified from New *et al.* 2000.)

Woodward et al. 2004



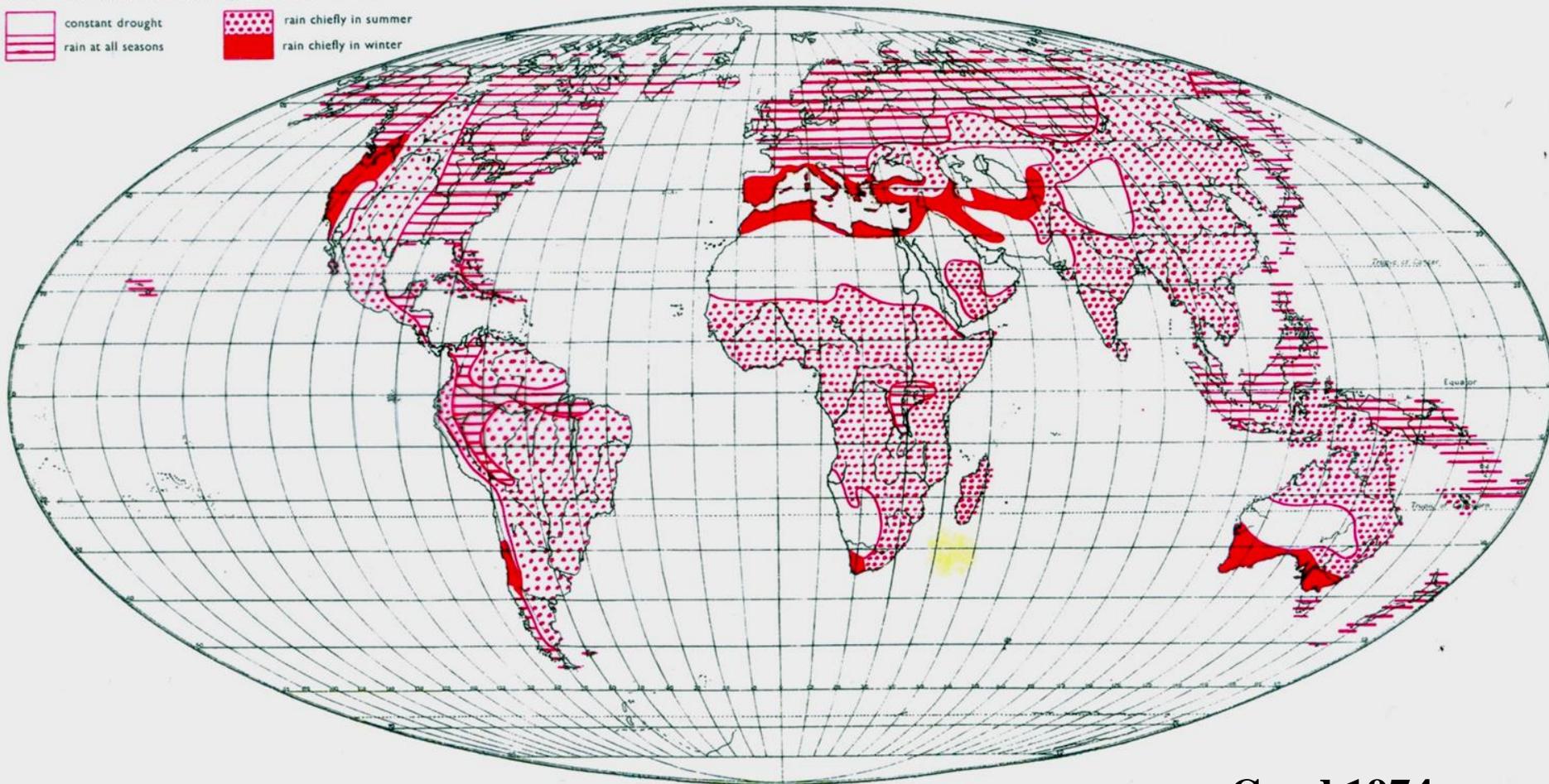
Mapa mostrando a média de precipitação na América do Sul nos meses de Janeiro e Julho. Valores em *cm*.

Clapperton 1993

CLIMA: distribuição anual da precipitação

Map of the World showing the seasonal distribution of rain. After Bartholomew's *Physical Atlas*, vol. III.

PLATE 26



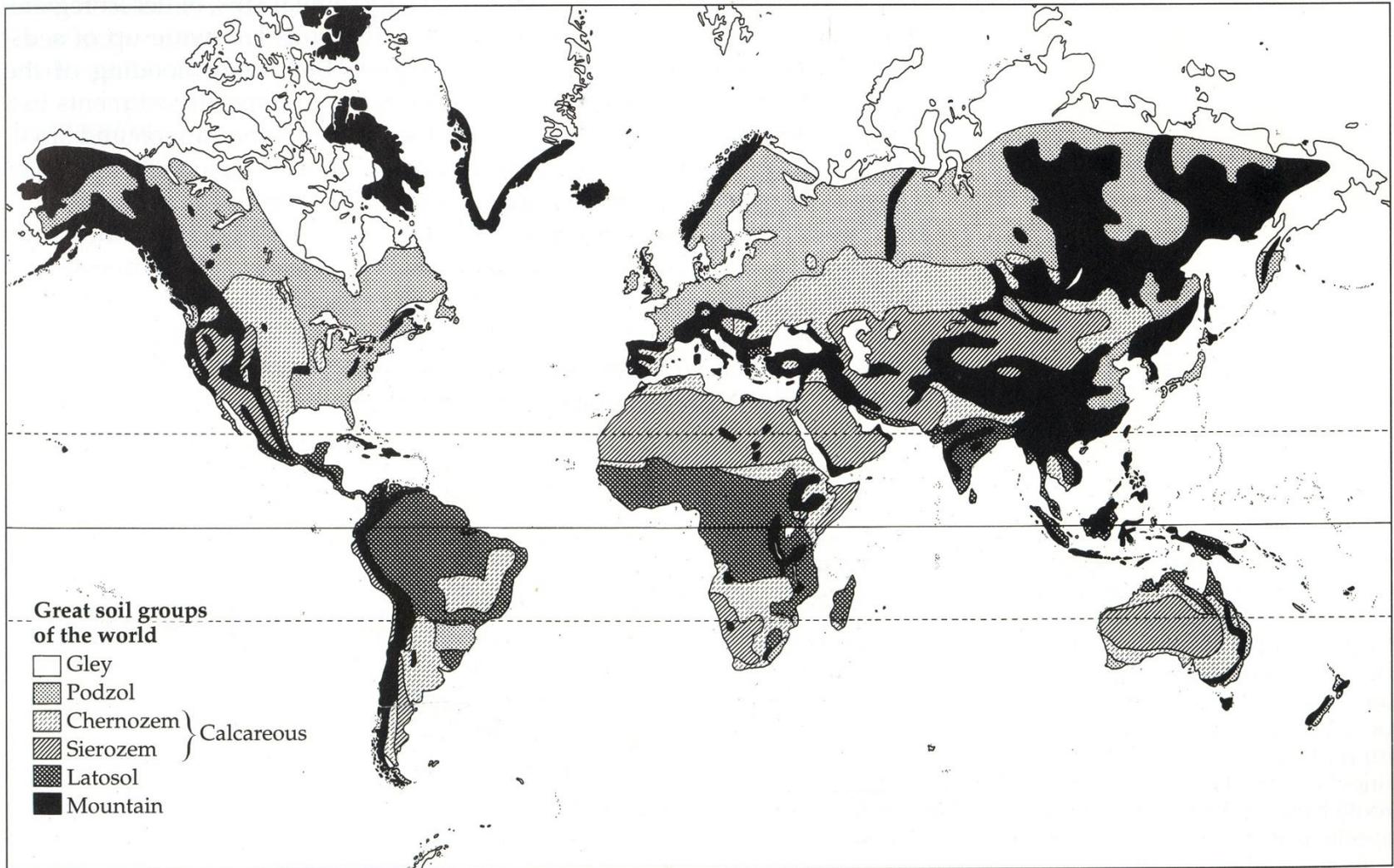
Areas correct Distortion increasing towards border of map.

Approximate Scale 1:100,000,000 (1600 miles - 1 inch) along Equator

on Mollweide's Homolographic Projection

Copyright

Good 1974



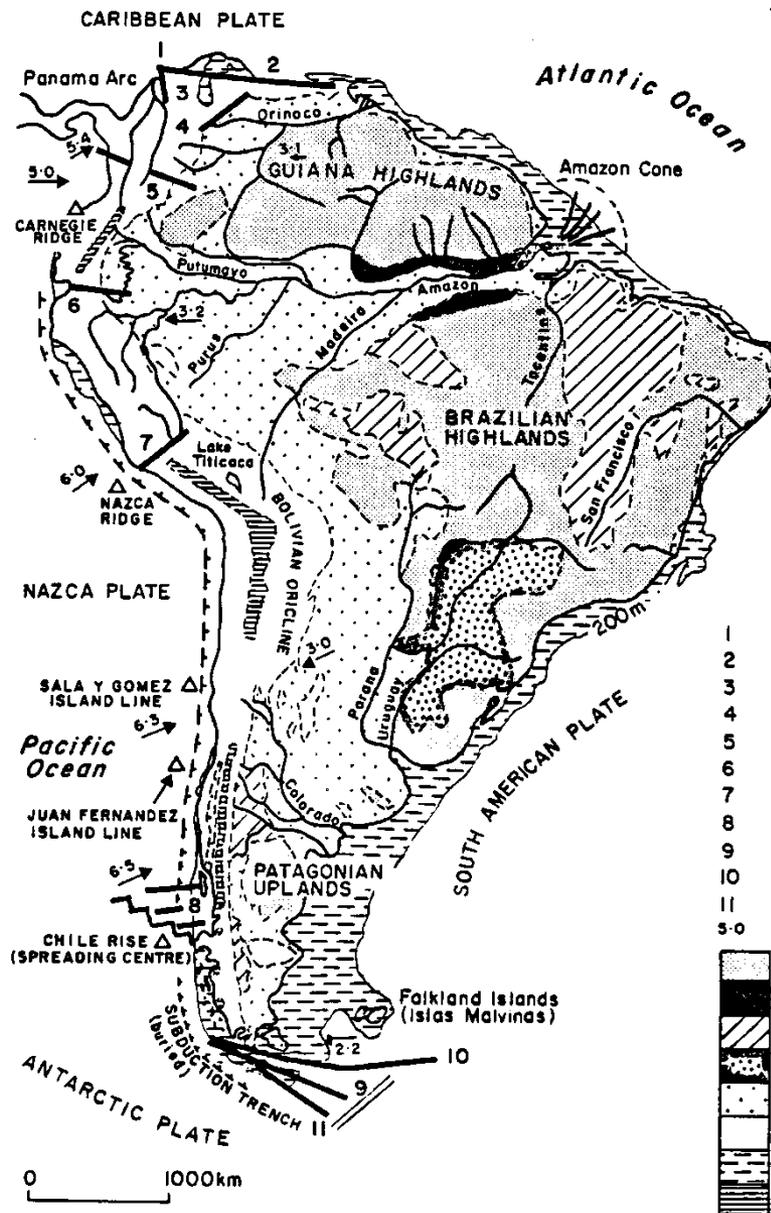
World distribution of major soil types. Note the dose correlation of these soil types with the climatic zones shown in Figure 3.6, reflecting the influence of temperature and precipitation on soil formation.

Brown & Lomolino 1998

Escudos cristalinos proterozóicos

*Escudo das Guianas
(2 bilhões de anos – formação mais antiga da
Terra)*

*Escudo Brasileiro
(+ ou - estável nos últimos 600 m. a.)*

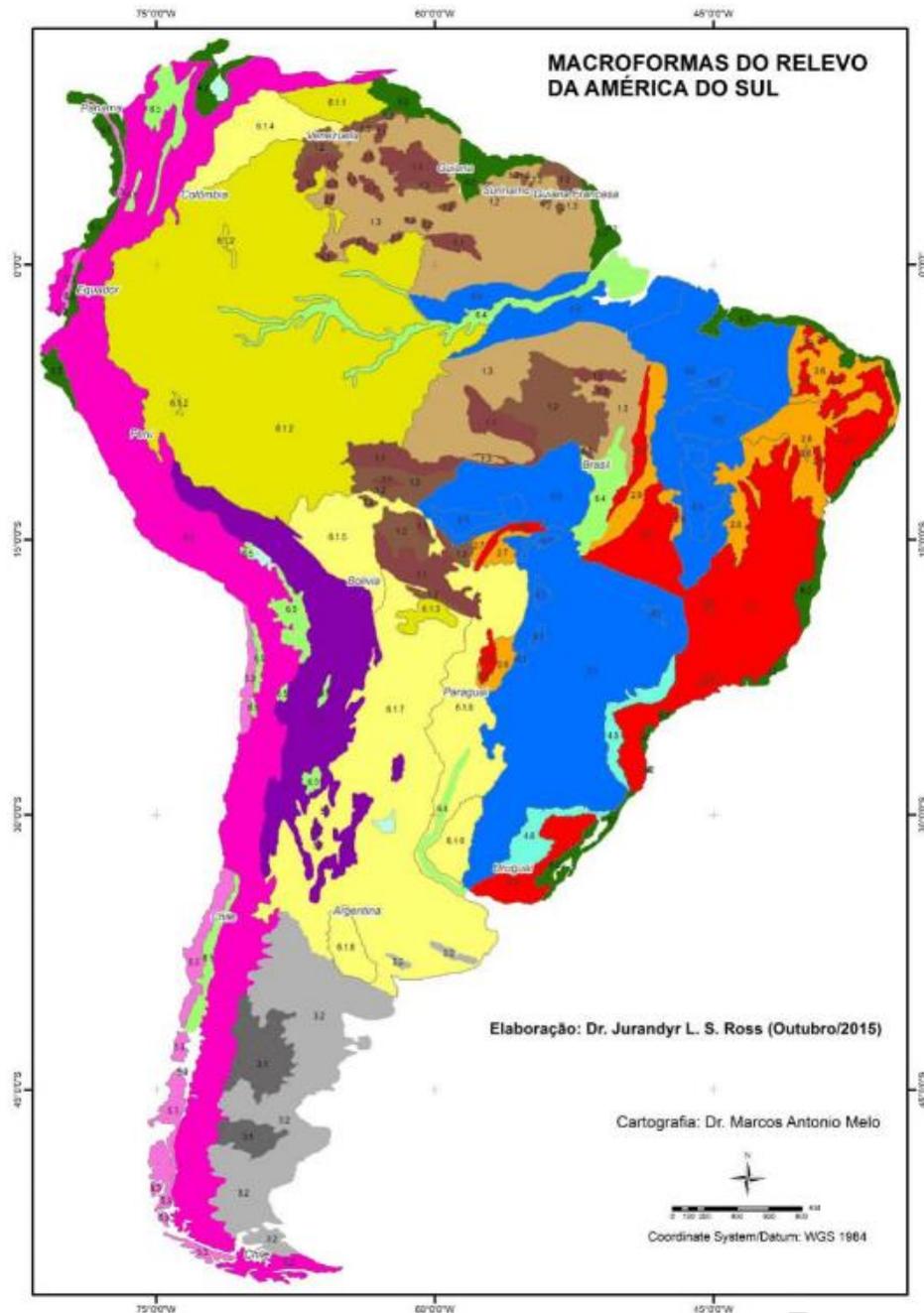


- 1 Oca Fault Zone
- 2 El Pilar Fault Zone
- 3 Santa Marta Fault Zone
- 4 Bocono Fault Zone
- 5 Bahia Salana - Marcarena Cross (mega shear)
- 6 Amatape Cross (mega shear)
- 7 Abancay Deflection (mega shear)
- 8 Fracture Zones
- 9 Magellan Fracture Zone
- 10 Malvinas Trough
- 11 Shackleton Fracture Zone
- 5-0 Plate motion (cm yr⁻¹)

- Pre-Cambrian crystalline basement
- Palaeozoic Sedimentary rocks
- Palaeozoic-Mesozoic rocks
- Jurassic flood basalts
- Tertiary-Quaternary sediments
- Andean fold and thrust belt
- Continental Shelf
- Quaternary volcanic rocks

Clapperton 1993

Generalized tectonic, structural and topographic features of South America



Macroformas do Relevo da América do Sul

Morfoestruturas do Cráton Amazônico

- 1.1, Planaltos Residuais em Coberturas de Plataformas - Norte e Sul Amazônicos
- 1.2, Planaltos em Estruturas Igneas e Metamórficas - Norte e Sul Amazônicos
- 1.3, Depressões Marginais e Interplanálticas - Norte e Sul Amazônicos

Morfoestruturas dos Cinturões Orogenéticos Antigos

- 2.1, Planaltos e Serras do Atlântico Leste-Sudeste
- 2.2, Planaltos e Serras de Goiás-Minas
- 2.3, Planaltos do Nordeste Oriental
- 2.4, Planaltos Uruguaio-Sulriograndense
- 2.5, Planaltos e Serras do Alto Paraguai/Bodoquena
- 2.6, Depressões Sertaneja e do São Francisco
- 2.7, Depressões Cuiabana e do Alto Paraguai
- 2.8, Depressões do Miranda-Bodoquena
- 2.9, Depressões do Tocantins

Morfoestruturas da Plataforma da Patagônia

- 3.1, Planaltos em Estruturas Vulcano-Sedimentares
- 3.2, Planaltos em Coberturas Sedimentares Meso-Cenozóicas

Morfoestruturas em Bacias Sedimentares Paleo-mesozóicas

- 4.1, Planaltos e Chapadas da Bacia do Paraná
- 4.2, Planaltos e Chapadas da Bacia do Parnaíba
- 4.3, Planaltos e Chapadas da Bacia do Parecis
- 4.4, Planaltos e Tabuleiros da Bacia da Amazônica Oriental
- 4.5, Depressão Periférica da Borda Leste da Bacia do Paraná
- 4.6, Depressão Periférica Central Gaúcha-Uruguaia

Morfoestruturas em Cinturões Orogenéticos Meso-cenozóicos

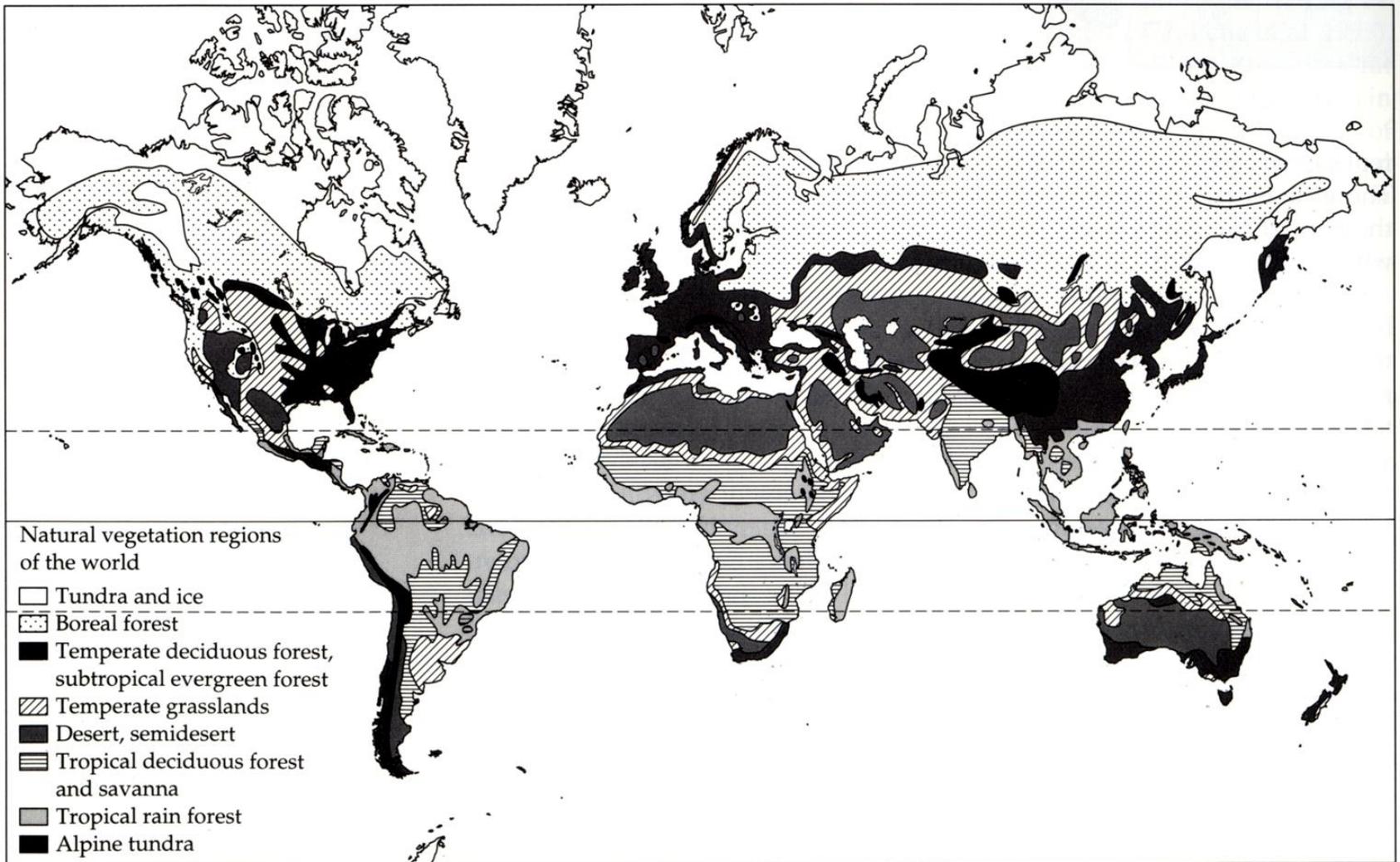
- 5.1, Cordilheira dos Andes Oriental
- 5.2, Cordilheira dos Andes Centro-Occidental
- 5.3, Cordilheira dos Andes Costeira

Morfoestruturas das Bacias Sedimentares Cenozóicas

- 6.1 Depressão Central Sulamericana
 - 6.1.1, Tabuleiros e Colinas da Bacia do Orenoco
 - 6.1.2, Tabuleiros e Colinas da Bacia do Solimões
 - 6.1.3, Tabuleiros e Colinas do Alto Paraguai
 - 6.1.4, Planícies e Pantanaís da Bacia do Orenoco
 - 6.1.5, Planícies e Pantanaís das Bacias Beni-Mamoré (Chaco)
 - 6.1.6, Planícies e Pantanaís das Bacias Paraguai-Paraná (Chaco)
 - 6.1.7, Planícies e Colinas das Bacias Paraguai-Paraná-Prata
 - 6.1.8, Planícies e Campos de Dunas Fixas das Bacias do Salado-Colorado
- 6.2, Tabuleiros e Planícies Costeiras do Atlântico
- 6.3, Tabuleiros e Planícies Costeiras do Pacífico
- 6.4, Planícies Fluviais Interiores
- 6.5, Planícies e Colinas em Vales Sinclinaís Intermontanos

Figura 2. Mapa do relevo da América do Sul: nova compartimentação (legenda a seguir).

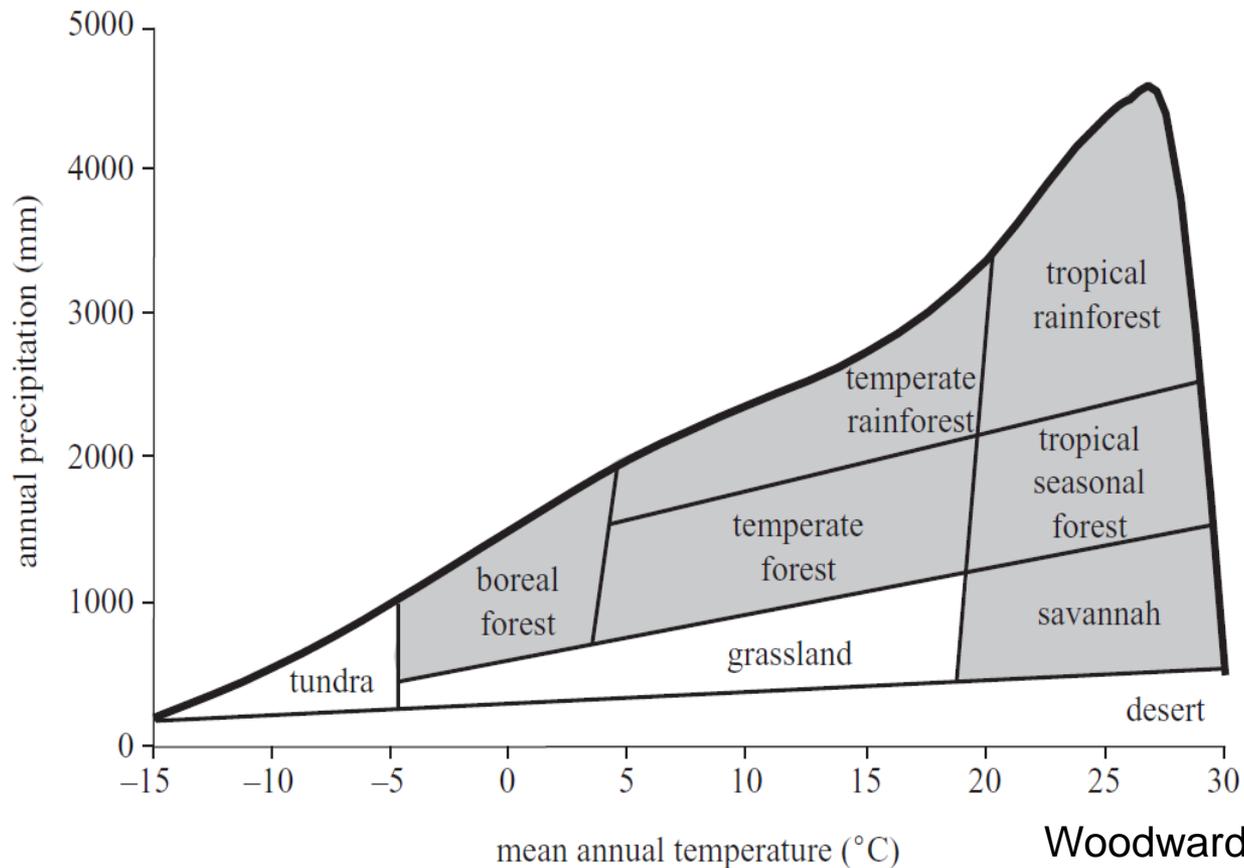
Ross 2016



The world distribution of the major terrestrial biomes. Note that the locations of these vegetation types correspond closely to the distribution of climatic regimes and soil types. Several different vegetation types (e.g., tropical deciduous forest and savanna) have been grouped together in some cases so that the general zonal pattern of biomes can be observed.

Biomas = áreas com vegetação caracterizada pelo mesmo tipo de forma de vida.

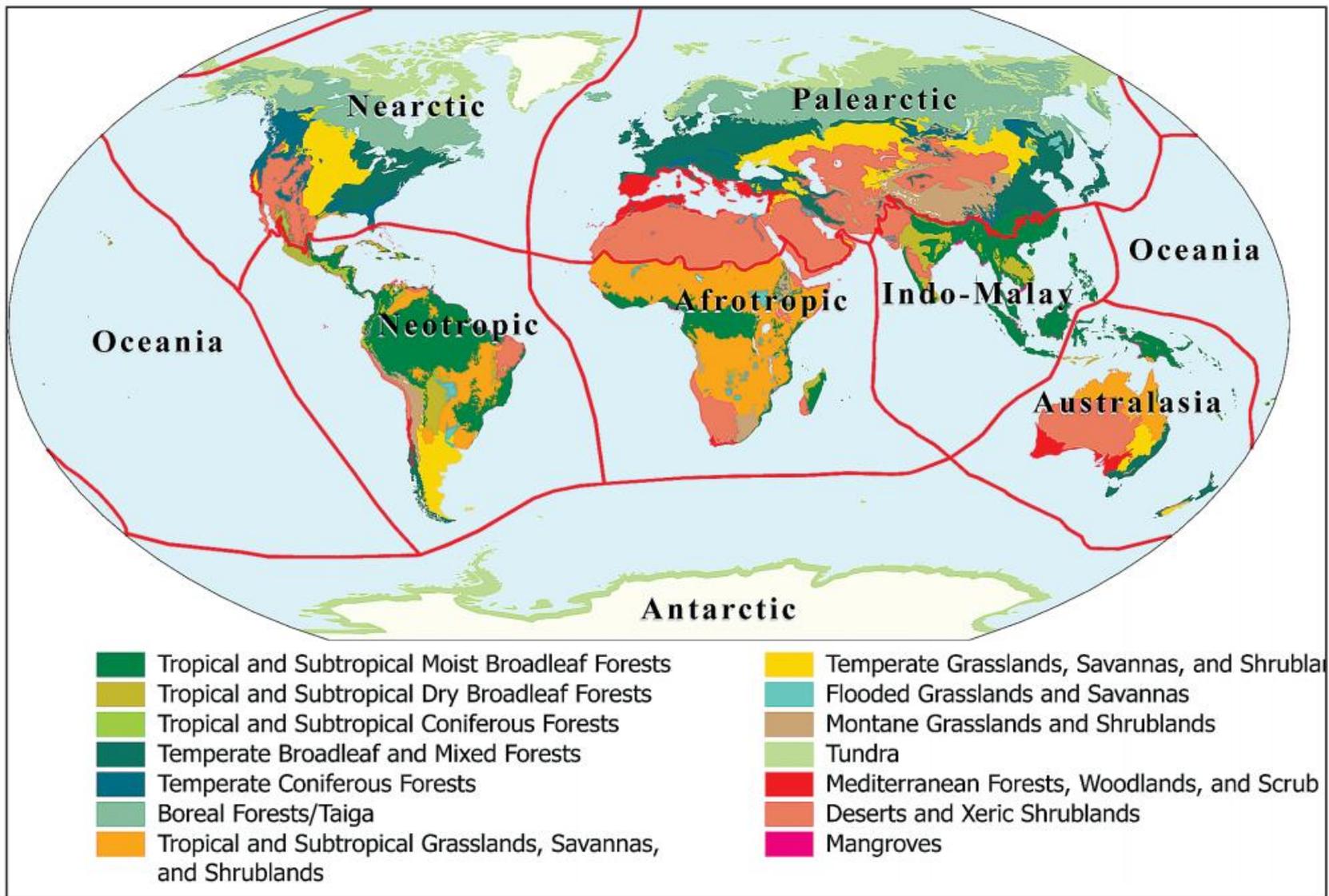
Definição tradicional de bioma - feita com base no CLIMA:



Woodward et al. 2004

Figure 1. The distribution of traditionally defined biomes in terms of annual temperature and precipitation. The shaded area includes all biomes that contain trees. (Modified from Woodward & Lomas 2004.)

Uma elaboração e simplificação da proposta de Whitaker (1975)



14 biomes and 8 biogeographic realms Olson et al. 2001

Uma elaboração da proposta de Whittaker 1975

Breve histórico da evolução do conceito de BIOMA

Humboldt 1807 – ocorrência de formações vegetacionais análogas em regiões geograficamente disjuntas mas climaticamente similares.

Schimper (1903) – o primeiro a definir e nomear os biomas do mundo de modo essencialmente moderno: as **formas de vida dominantes** em cada bioma possuem **atributos fisiológicos convergentes** como resultado de seleção permitindo sobreviver no **clima** predominante.

Muitos dos primeiros conceitos de bioma incorporavam explicitamente **parâmetros climáticos**: e.g. **Holdridge (1947)** - Zonas de Vida = amplas formações vegetacionais mapeadas em eixos de precipitação, temperatura e evapotranspiração potencial.

Walter (1973) - Zonobiomes em termos da zona climática em que ocorrem, com modificações causadas por solos (pedobiomas) and altitude (orobiomas).

Uso do **clima** para delimitar os biomas traz implícitas algumas características funcionais que são difíceis de quantificar ou mapear em escala global. Por exemplo, 'floresta tropical pluvial' é, por definição, composta de plantas sensíveis ao frio ou geada e não-decíduais.

Muitas classificações propostas no século XX: e.g. Odum 1959, Kormondy 1969, Colinvaux 1993, Cox & Moore 1993.

Sensoriamento remoto da cobertura terrestre por meio de satélites possibilitou elaboração de novos mapas de distribuição global de biomas, com limites das unidades de vegetação definidos bem objetivamente (e.g. Woodward et al. 2004; Arino et al. 2007; Olson et al. 2001) - *analisaremos essa abordagem mais à frente.*

Tabela 1. Classificação dos Zonobiomas de Walter (1986) com seus respectivos climas e tipos de vegetação zonal.

Zonobioma	Clima	Vegetação Zonal
I	Equatorial, úmido e quente, cujas variações térmicas maiores ocorrem dentro de períodos diários	Florestas pluviais tropicais sempre verdes
II	Tropical, com chuvas de verão e inverno seco	Florestas tropicais estacionais ou savanas
III	Subtropical árido	Desertos quentes
IV	Mediterrâneo, com chuvas de inverno e verão seco	Vegetação esclerófila (chaparral, maqui)
V	Quente-temperado sempre úmido	Florestas subtropicais sempre verdes
VI	Temperado úmido, com inverno curto	Florestas temperadas caducifólias
VII	Temperado árido	Estepes ou desertos com inverno frio
VIII	Boreal	Florestas de coníferas (Taiga)
IX	Polar	Tundras

Walter 1986:

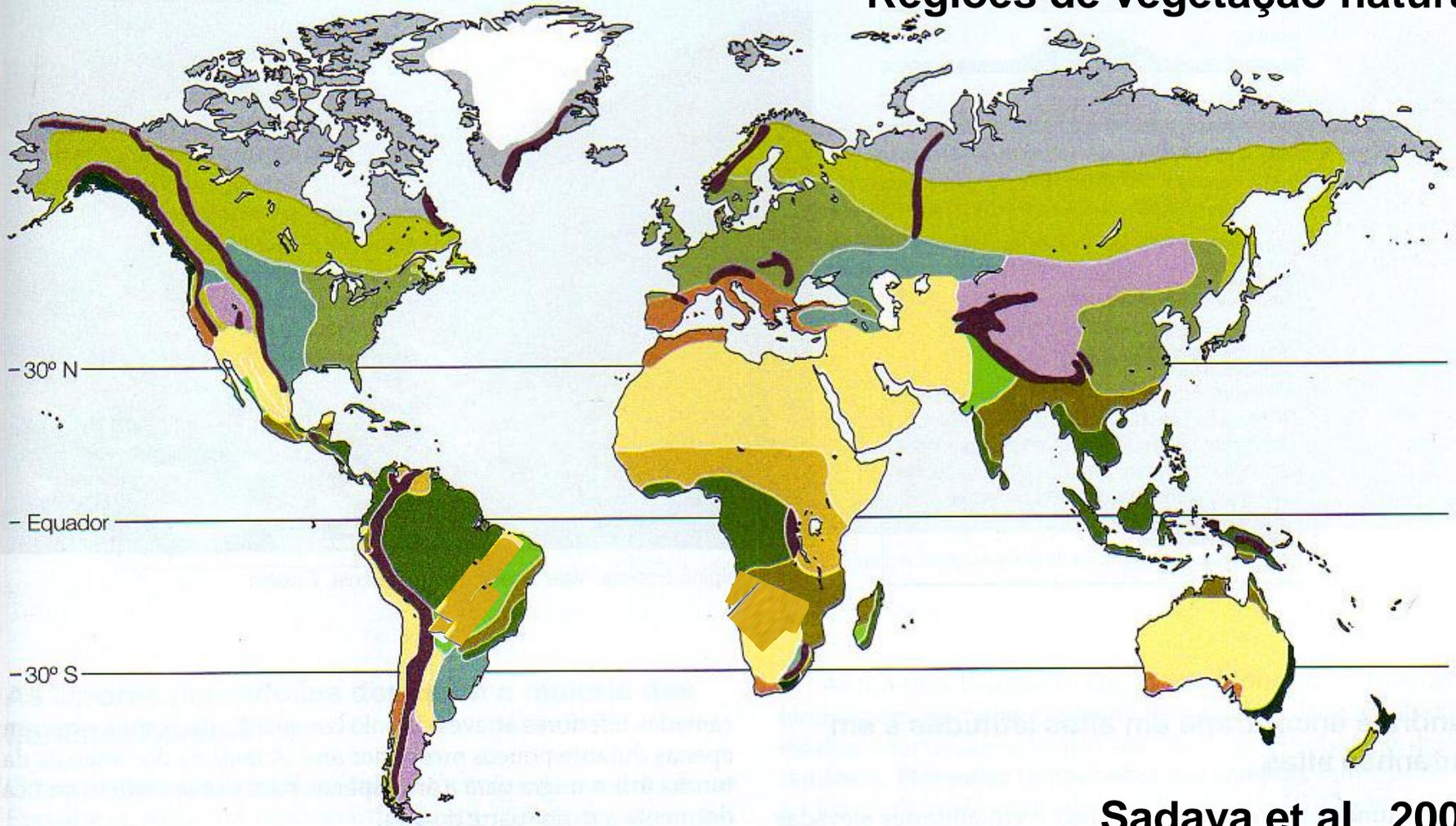
Zonobiomas, orobiomas, pedobiomas (litobioma, psamobioma, halobioma, helobioma, hidrobioma, peinobioma), pirobioma.

Classificações de biomas do mundo

Tabela 2. Comparação dos sistemas de classificação dos tipos de biomas do mundo, segundo diversos autores. Fl = floresta; Tr = tropical; Pl = pluvial; STr = subtropical; Dec = decídua; Est = estacional; SVerd = sempre verde; Temp = temperada; Lat = latifoliada; Sav = savana; Escr = escrube; Woodl = woodland; Medit = mediterrâneo

Odum (1959) Kormondy (1969)	Walter (1986)	Cox & Moore (1993) Colinvaux (1993)	Olson <i>et al.</i> (2001)
Fl. Tr. Pl.	ZB I Fl. Tr. Pl.	Fl. Tr. Pl.	Fl. Tr. e STr. Úmidas
Fl. Tr. Dec.	ZB II Fl. Tr. Dec.	Fl. Tr. Est.	Fl. Tr. e STr. Secas
Sav. e Campo Tr.	ZB II Sav. Tr.	Sav., Campo e Escr. Tr.	Fl. Tr. e STr. de coníferas
Deserto	ZB III Deserto STr.	Deserto	Fl. Temp. Lat. e Mista
Chaparral	ZB IV Chaparral	Chaparral	Fl. Temp. de coníferas
Escr. Tr.	ZB V Fl. Quente Temp. SVerd.	Fl. Temp.	Fl. Boreal (Taiga)
Fl. Temp. Dec. e Pl.	ZB VI Fl. Temp. Dec.	Campo Temp.	Sav., Campo e Escr. Tr. e STr.
Campo Temp.	ZB VII Estepe	Fl. Boreal (Taiga)	Sav., Campo e Escr. Temp.
Fl. Boreal (Taiga)	ZB VII Deserto Temp.	Tundra	Sav. e Campo inundável
Tundra	ZB VIII Fl. Boreal (Taiga)	Montanhas	Sav. e Campo montano
Montanhas	ZB IX Tundra		Tundra
	Orobiomas (I a IX)		Fl., Woodl. e Escr. Medit.
	Pedobiomas (I a IX)		Deserto e Escr. Xéricos
			Manguezal

Regiões de vegetação natural

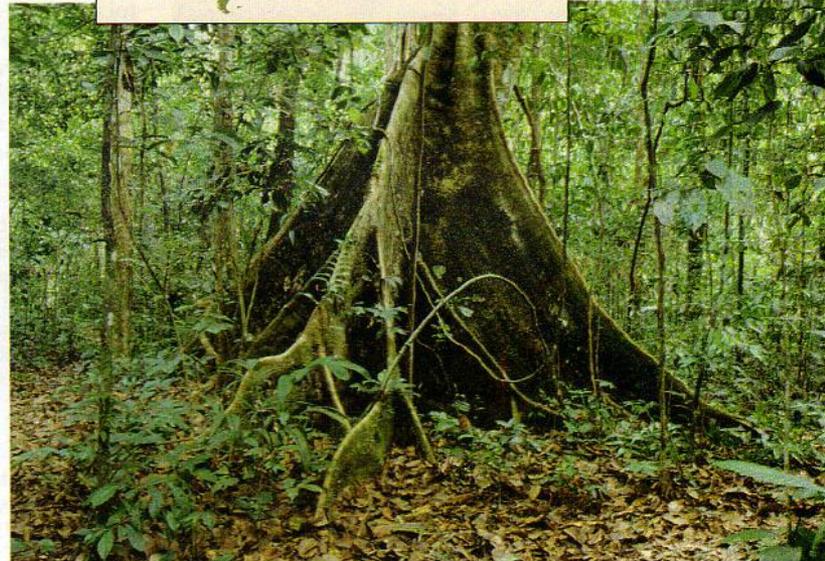
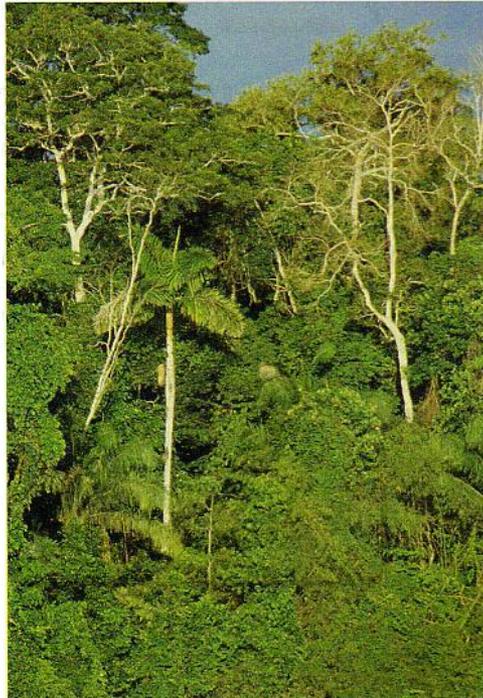
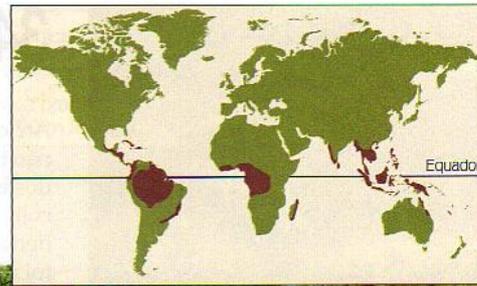


- | | | |
|-------------------------------|--|----------------------------|
| Floresta tropical perenifolia | Chaparral | Floresta temperada decídua |
| Floresta tropical decídua | Deserto frio | Floresta boreal (taiga) |
| Caatinga | Montanhas altas (floresta boreal e tundra) | Tundra ártica |
| Savana tropical | Floresta temperada perenifolia | Pradaria temperada |
| Deserto quente | | Calota glacial polar |

Sadava et al. 2008

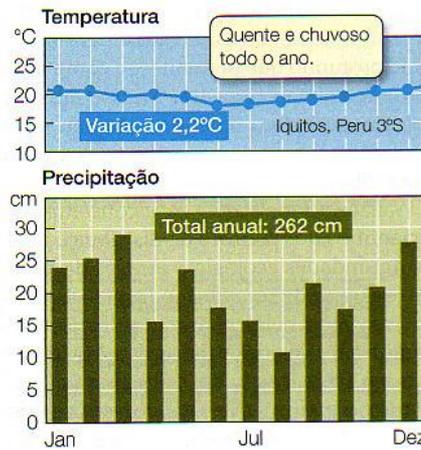
Figura 34.5 Os biomas têm distribuições geográficas distintas A distribuição dos biomas é fortemente influenciada pelos padrões de temperatura e chuva.

FLORESTA TROPICAL PERENIFÓLIA



Uma floresta úmida de planície vista de fora...

...e em seu interior, Cocha Cashu, Peru



Composição da comunidade

Plantas dominantes

Árvores e cipós

Riqueza de espécies

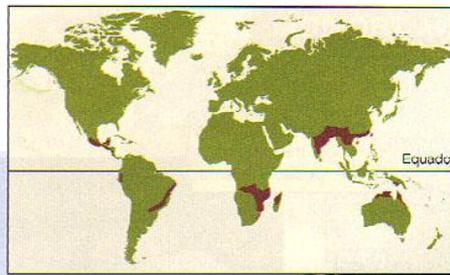
Plantas: Extremamente alta
Animais: Extremamente alta em mamíferos, aves, anfíbios e artrópodos

Biota do solo

Muito rica, mas pouco conhecida

A atividade biológica alta durante todo o ano.

FLORESTA TROPICAL DECÍDUA



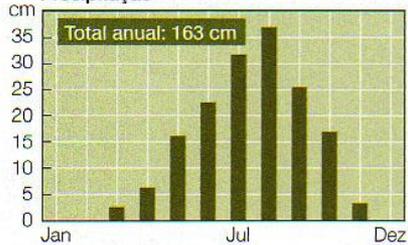
Temperatura

O inverno é muito quente e seco.

O verão é quente e úmido.



Precipitação



Atividade biológica

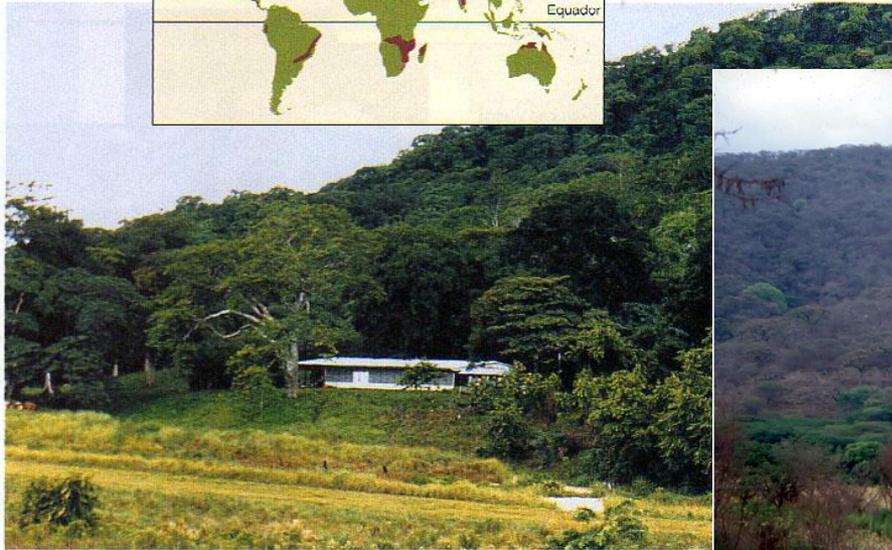


Composição da comunidade

Plantas dominantes
Árvores decíduas

Riqueza de espécies
Plantas: Moderadamente rica em espécies de árvores
Animais: Comunidades ricas em mamíferos, aves, répteis, anfíbios e insetos

Biota do solo
Rica, mas pouco conhecida



Parque Nacional Palo Verde, Costa Rica, na estação chuvosa...



Loja, Equador

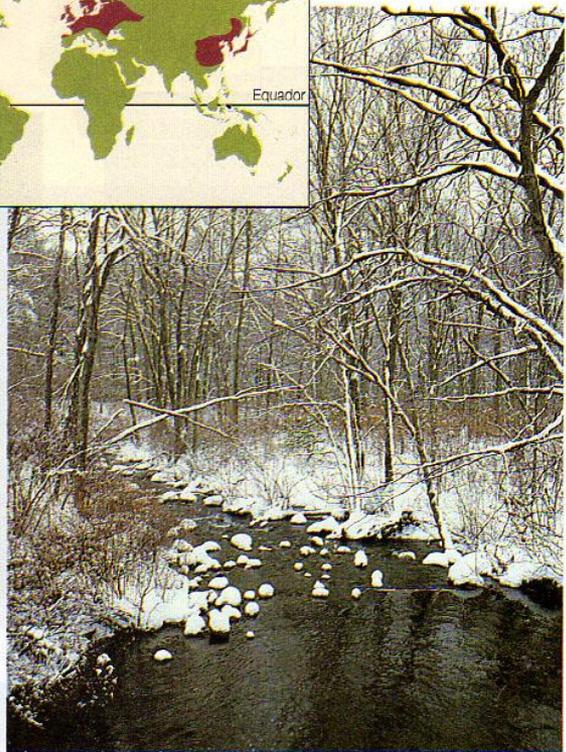
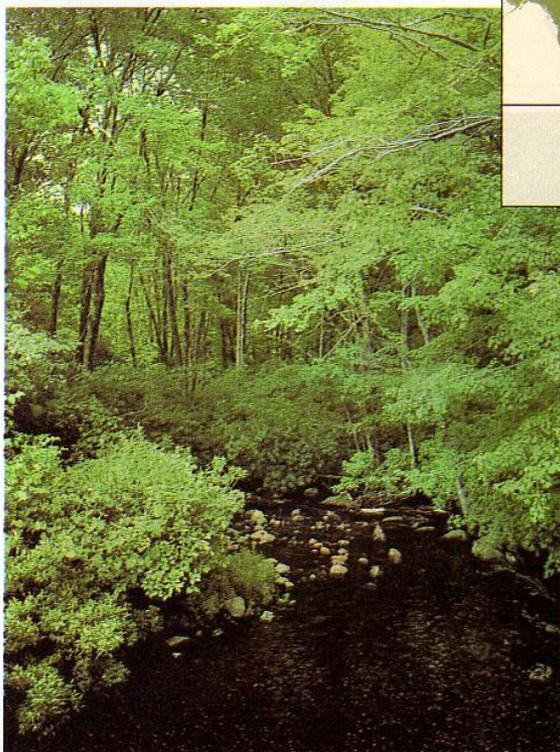
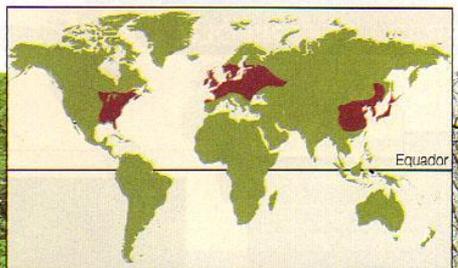


...e na estação seca.



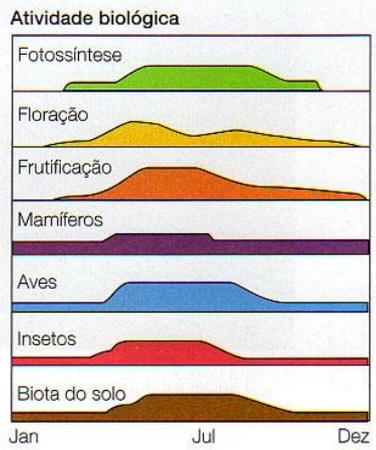
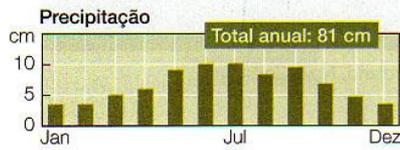
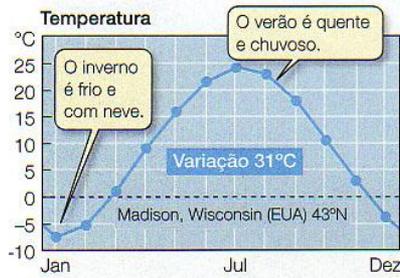
México

FLORESTA TEMPERADA DECÍDUA



Uma floresta de Rhode Island (EUA) no verão e...

...no inverno



Composição da comunidade

Plantas dominantes
Árvores e arbustos

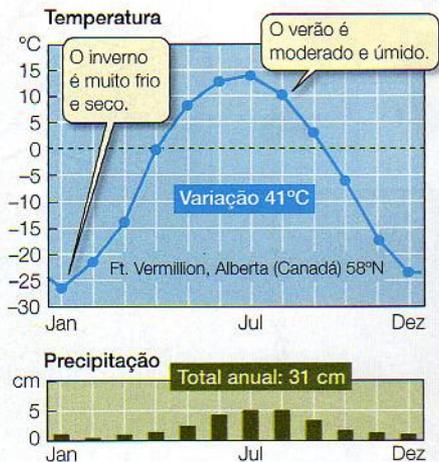
Riqueza de espécies

Plantas: Muitas espécies de árvores no sudeste dos EUA e no leste da Ásia, camada de arbustos rica

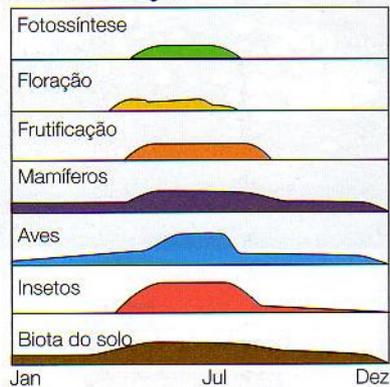
Animais: Rica; muitas aves migratórias, comunidades de anfíbios mais ricas da Terra, fauna de insetos rica no verão

Biota do solo
Rica

FLORESTA BOREAL e FLORESTA TEMPERADA PERENIFÓLIA



Atividade biológica



Composição da comunidade

Plantas dominantes

Árvores, arbustos e ervas perenes

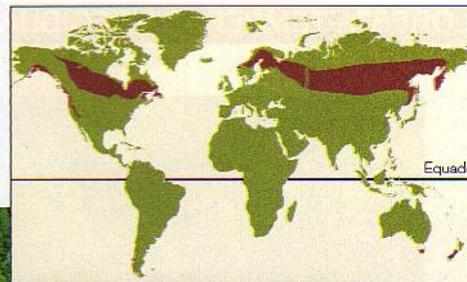
Riqueza de espécies

Plantas: Baixa em árvores, alta no sub-bosque

Animais: Baixa, mas com picos de aves migratórias no verão

Biota do solo

Muito rica na camada profunda de serapilheira



Floresta boreal do norte, Floresta Nacional Gunnison, Colorado (EUA)



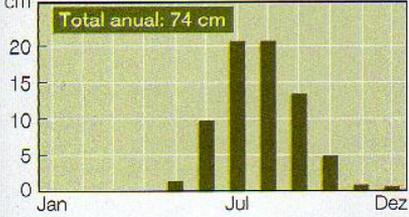
Floresta boreal do sul, Parque Nacional Fiordland, Nova Zelândia

CAATINGA e SAVANA TROPICAL

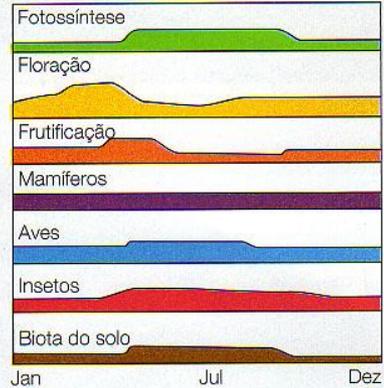
Temperatura



Precipitação



Atividade biológica



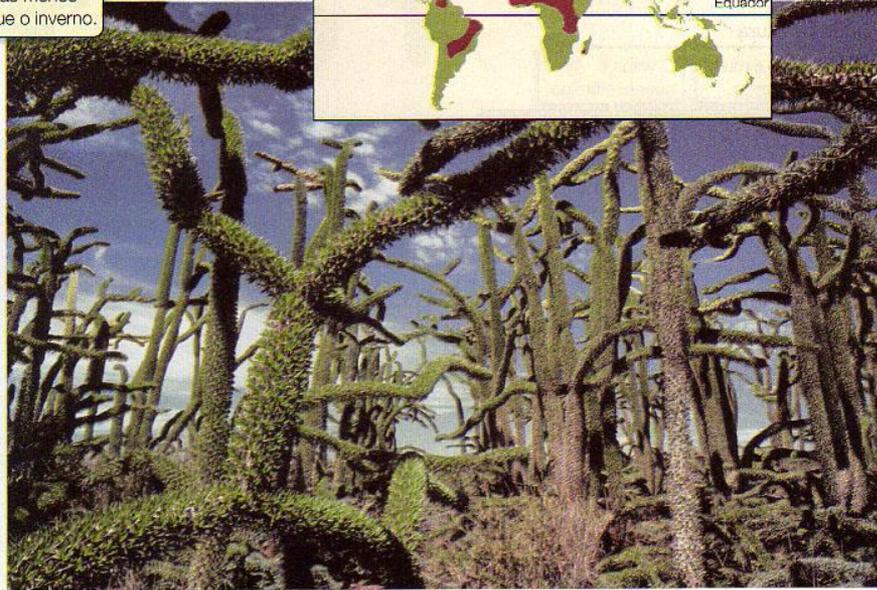
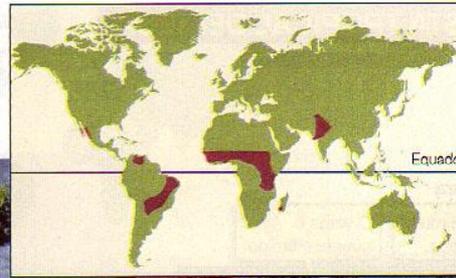
Composição da comunidade

Plantas dominantes
Arbustos e pequenas árvores; gramíneas

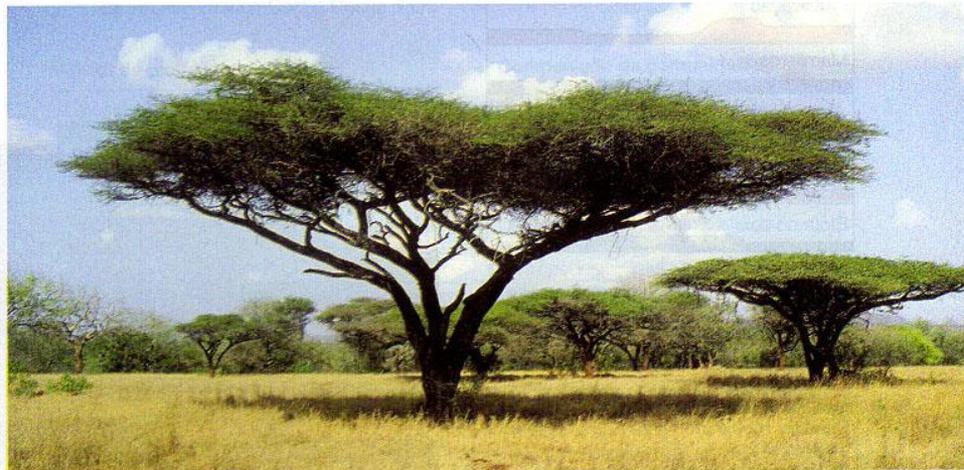
Riqueza de espécies
Plantas: Moderada na caatinga; baixa na savana

Animais: Fauna de mamíferos rica; moderadamente rica em aves, répteis e insetos

Biota do solo
Rica



Caatinga em Madagascar

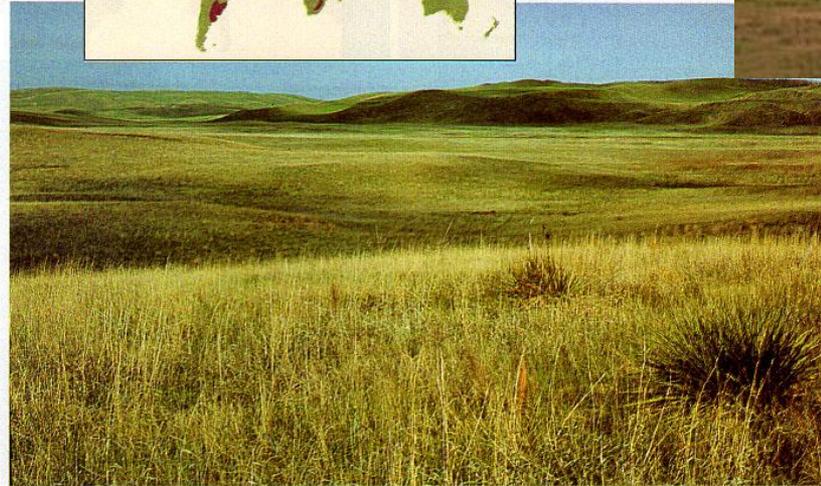
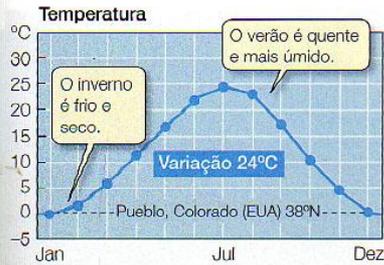
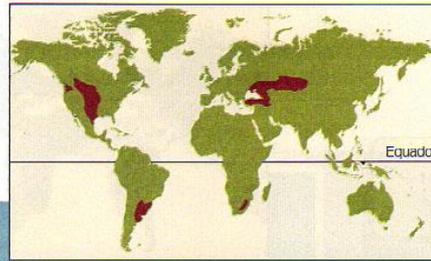


KwaZulu-Natal, África do Sul



PRADARIA TEMPERADA

= Estepes



Pradaria de Nebraska (EUA) na primavera



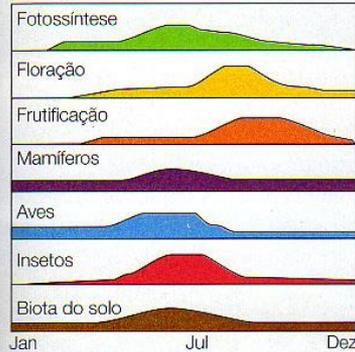
A estepe, Natal, África do Sul



S Patagônia - Graham 2011



Atividade biológica



Composição da comunidade

Plantas dominantes
Gramíneas e forbs perenes

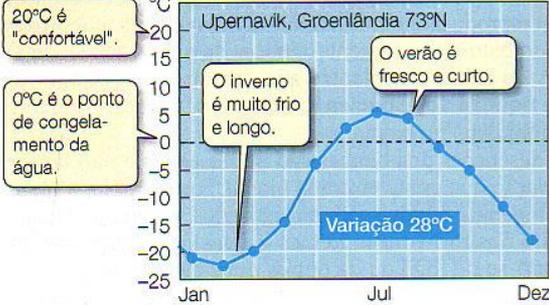
Riqueza de espécies
Plantas: Razoavelmente alta
Animais: Relativamente pobre em aves por causa da estrutura simples; razoavelmente rica em mamíferos

Biota do solo
Rica

Sadava et al. 2008

TUNDRA

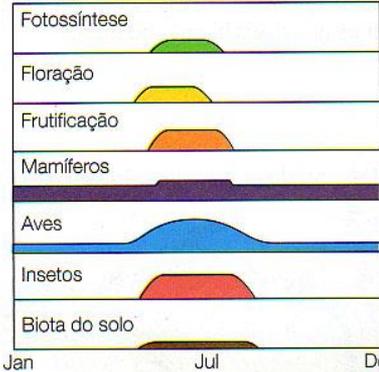
Temperatura



Precipitação



Atividade biológica



Composição da comunidade

Plantas dominantes

Ervas perenes e pequenos arbustos

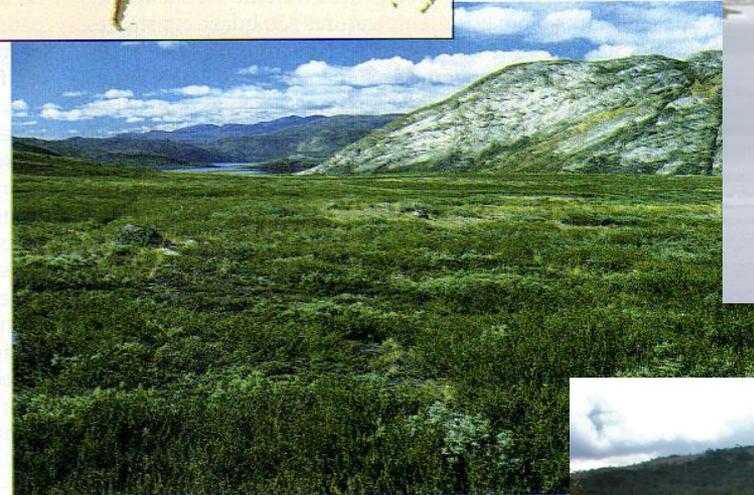
Riqueza de espécies

Plantas: Baixa; mais alta em tundras alpinas tropicais

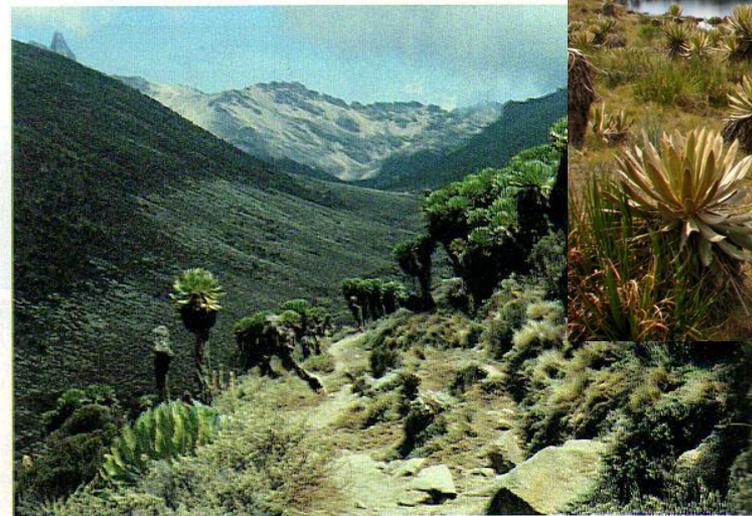
Animais: Baixa; muitas aves migram para a tundra no verão; umas poucas espécies de insetos são abundantes no verão

Biota do solo

Poucas espécies



Tundra ártica, Groenlândia



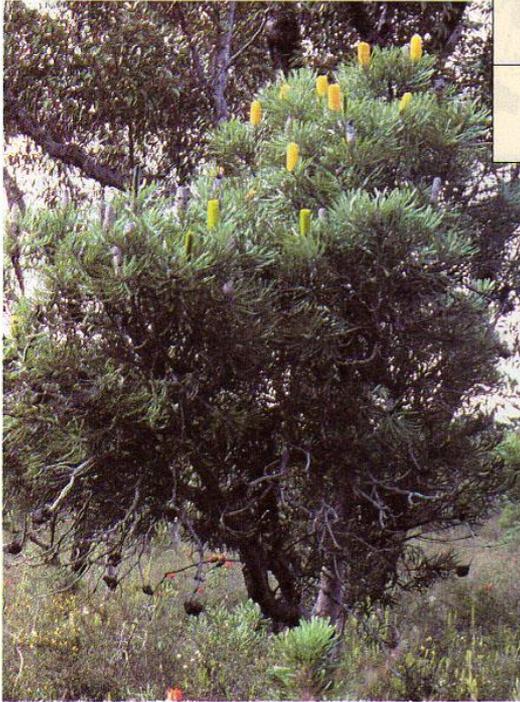
Tundra alpina tropical: Vale Teleki, Monte Quênia, Quênia



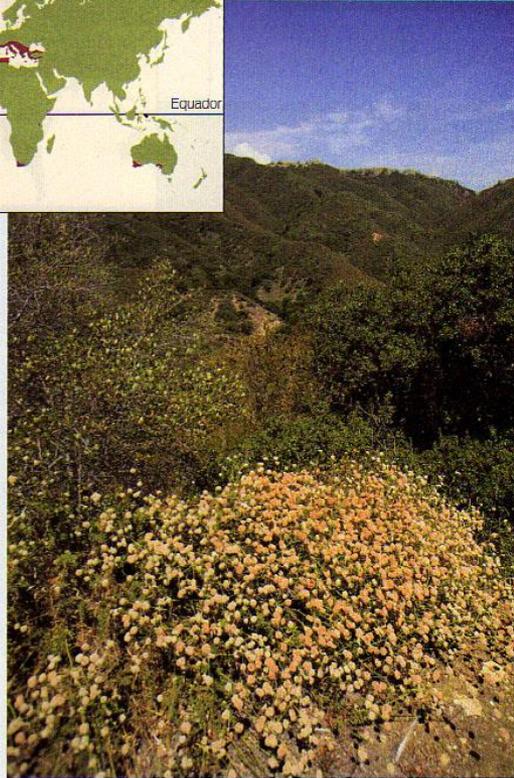
G. Heiden

páramo, Andes, Colômbia

CHAPARRAL



Sudoeste da Austrália



Santa Bárbara, Califórnia (EUA)

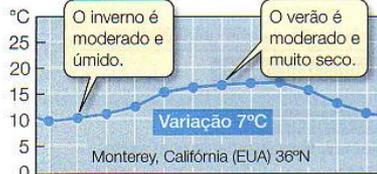


FYNBOS, sul da África



Mediterrâneo

Temperatura



Atividade biológica



Composição da comunidade

Plantas dominantes

Arbustos baixos e plantas herbáceas

Riqueza de espécies

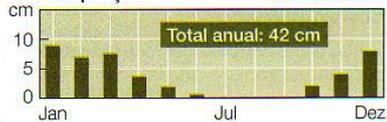
Plantas: Extremamente alta na África do Sul e Austrália

Animais: Rica em roedores e répteis; muito rica em insetos, especialmente abelhas

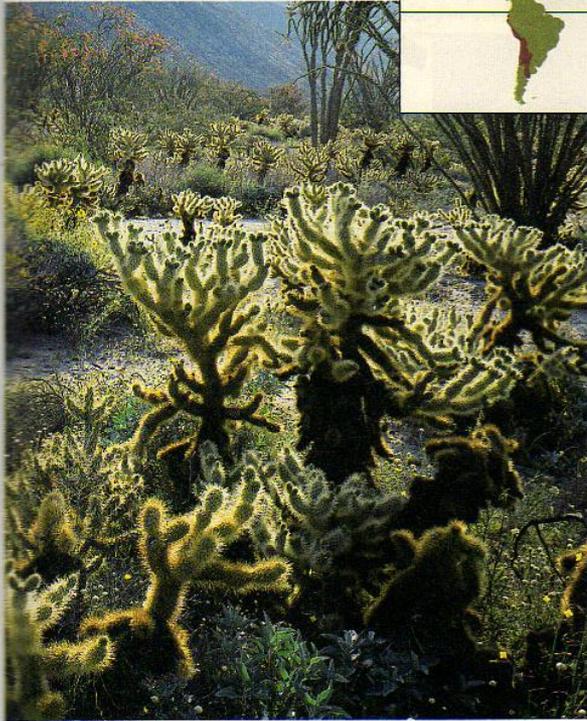
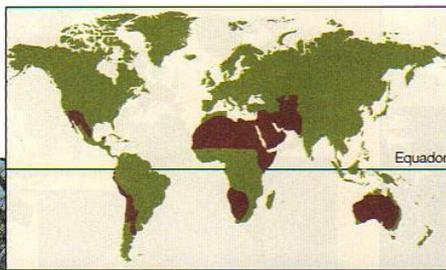
Biota do solo

Moderadamente rica

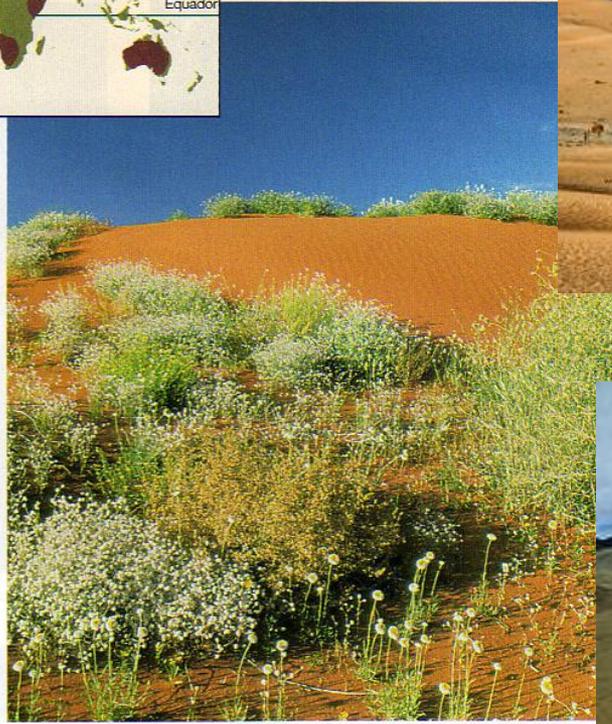
Precipitação



DESERTO QUENTE



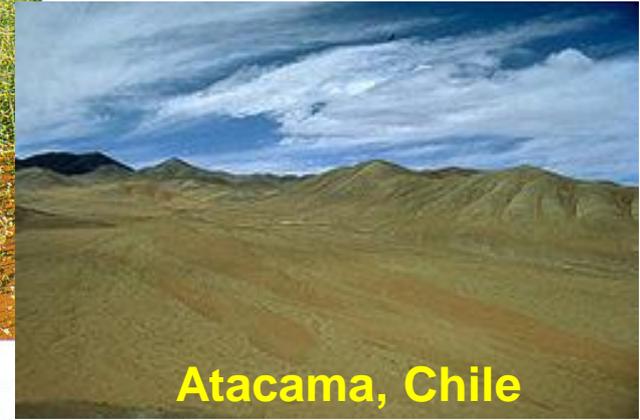
Deserto Anzo Borrego, Califórnia (EUA)



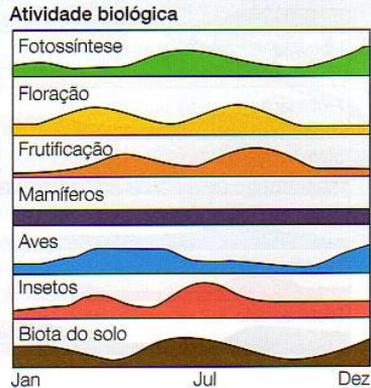
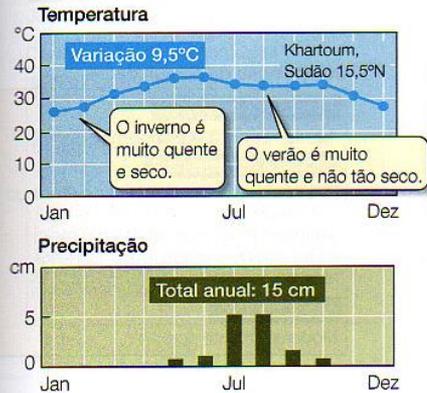
Deserto Simpson, Austrália, após chuva



Saara



Atacama, Chile



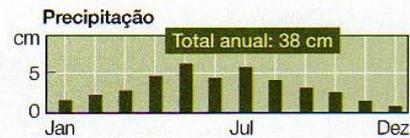
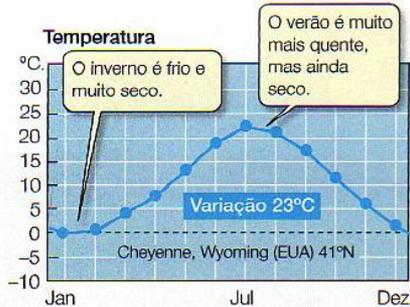
Composição da comunidade

Plantas dominantes
Muitas formas de vida diferentes

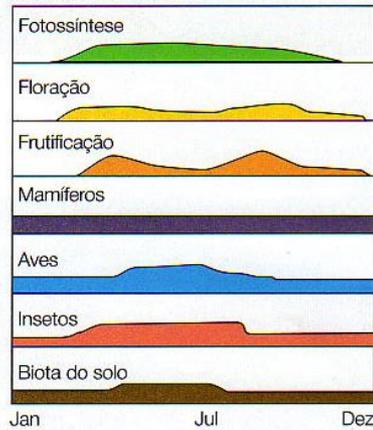
Riqueza de espécies
Plantas: Razoavelmente rica; muitas anuais
Animais: Muito rica em roedores, répteis e borboletas. A mais rica comunidade de abelhas da Terra.

Biota do solo
Pobre em espécies

DESERTO FRIO



Atividade biológica



Composição da comunidade

Plantas dominantes

Arbustos baixos e plantas herbáceas

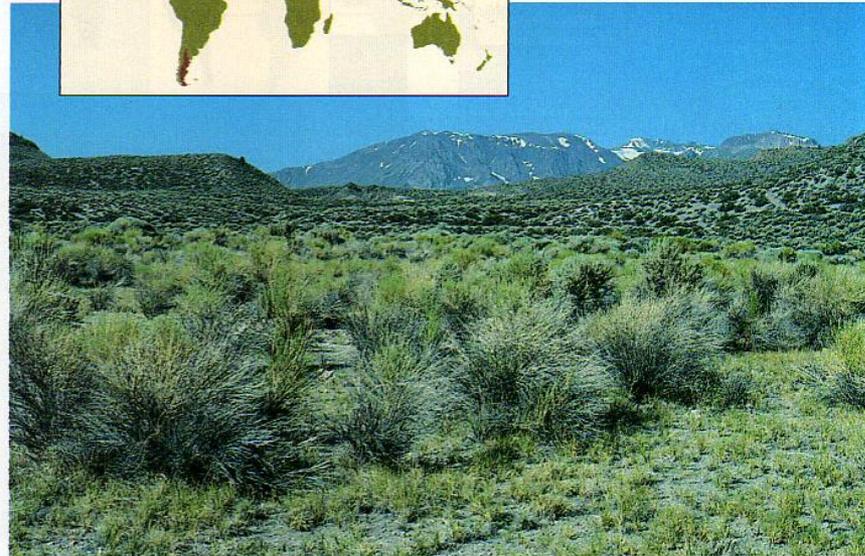
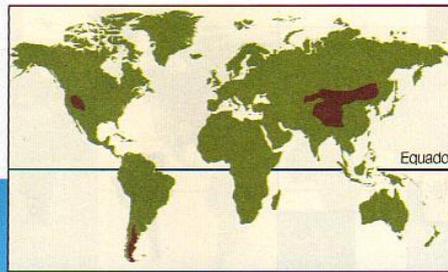
Riqueza de espécies

Plantas: Poucas espécies

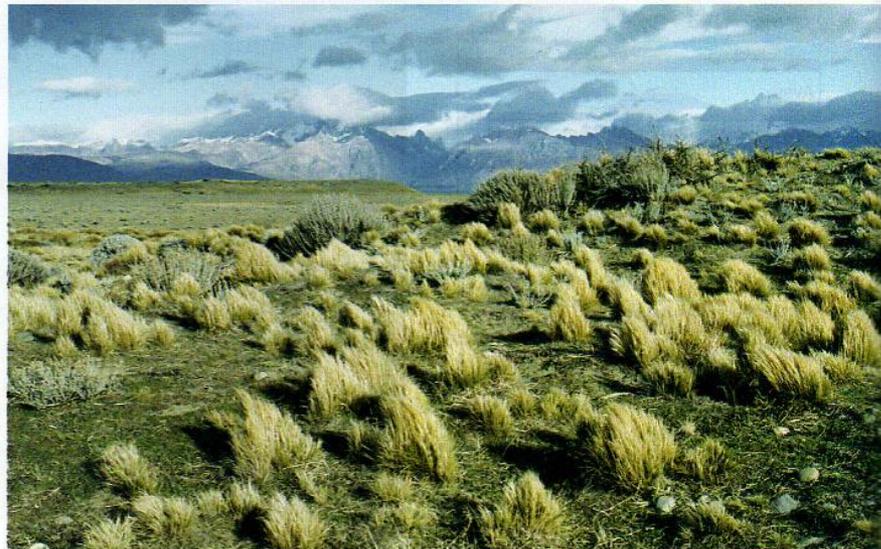
Animais: Rica em aves, formigas e roedores granívoros; baixa em todos os outros taxa

Biota do solo

Pobre em espécies



Estepe de artemísias próximo ao Lago Mono, Califórnia (EUA)



Patagônia, Argentina

desertos e semidesertos na América do Sul



Limites altitudinais dos biomas no mundo

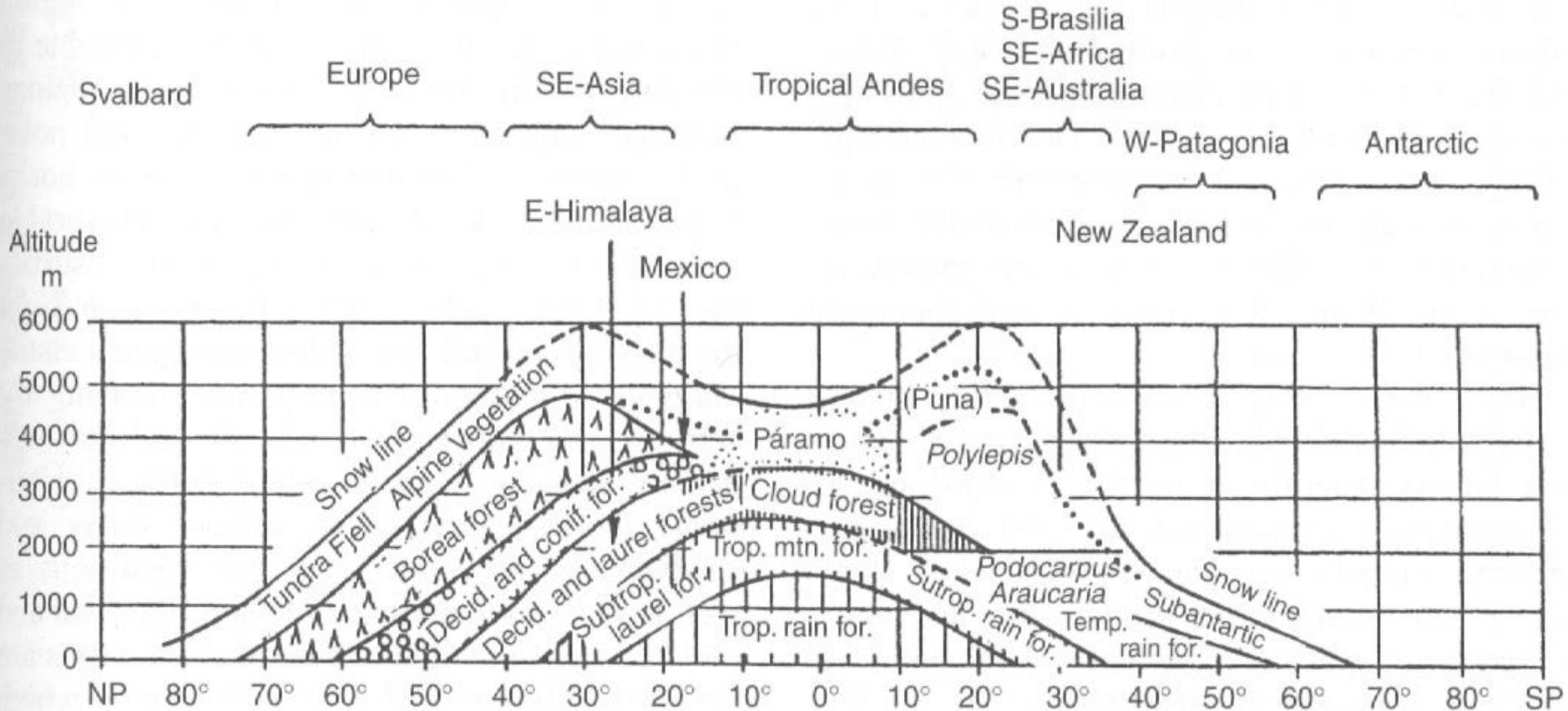
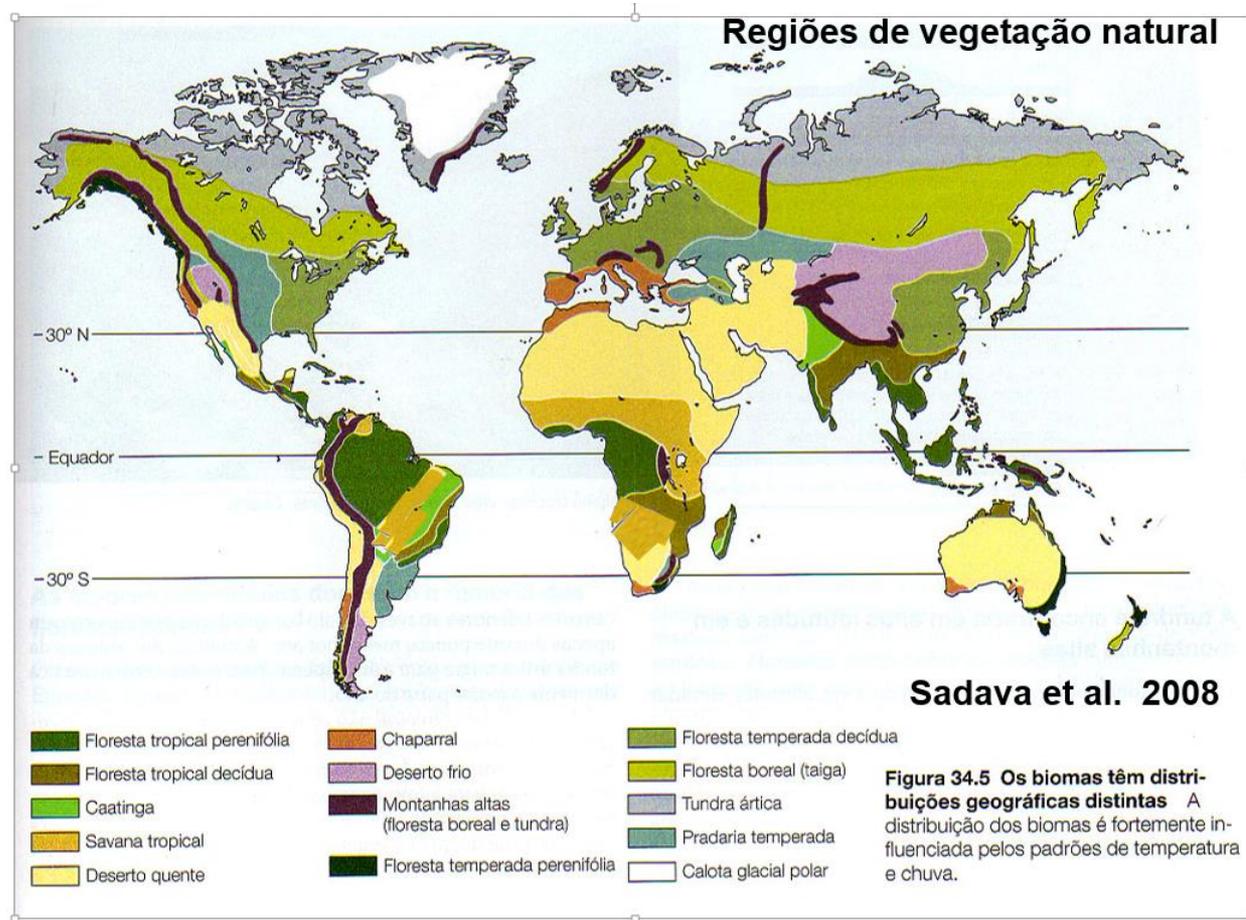


Figure 8.12 Latitudinal transect showing altitudinal vegetation belts and snow line (after Troll, 1948; Ellenberg, 1996; Holtmeier, 2009; modified)

Millington et al. 2011

Segundo Dajoz (1973), Crawley (1989) afirma:
 “The great biomes of the world show a remarkable degree of convergence in their physiognomy, despite wide differences in the taxonomic affinities of their floras... rain forest of Brazil resembles rain forest in southeast Asia...”



Revising the biome concept for understanding and predicting global change impacts

Glenn R. Moncrieff^{1,2*}, William J. Bond^{1,3} and Steven I. Higgins^{4,5}

Table 1 An overview of some well known biome concepts used for vegetation modelling, mapping and understanding the determinants of global vegetation patterns.

Biome concept	Term	Defined based on	Mapping variables	Actual or potential vegetation	Hierarchical	Reference
Walter	Zonobiome	Climate	Climate	Potential	Yes	Walter, 1973
Schultz	Ecozone	Climate	Climate	Potential	Yes	Schultz, 2002
WWF	Biome	Climate, Structure, Orography	Climate, Soils, Expert knowledge, Structure	Potential	Yes	Olson <i>et al.</i> , 2001
MODIS-IGBP	Land cover	Structure, Function, Human influence	Spectral reflectance, Temperature, Topography, Snow/Ice	Actual	No	Friedl <i>et al.</i> , 2002
DGVMs	Biome	Structure, Function	Structure, Function (Combination of PFTs)	Actual and Potential	No	Sitch <i>et al.</i> , 2003; Prentice <i>et al.</i> , 2007

Ênfase atual em características estruturais e funcionais das plantas e na vegetação atual (além da potencial)

Sensoriamento remoto da cobertura terrestre por meio de satélites possibilitou elaboração de novos mapas de distribuição global de biomas, com limites das **unidades de vegetação definidos bem objetivamente** (e.g. Woodward et al. 2004; Arino et al. 2007; Olson et al. 2001).

O método permite **alta frequência de observações repetidas ao longo do ano**, provendo medidas em ampla escala da fenologia e dinâmica dos biomas.

Nessa abordagem, a classificação de biomas ignora explicitamente o contexto geográfico e o clima, e **ênfatisa fenologia e estrutura, e consistências na combinação e dominância relativa de PFTs** (traços funcionais das plantas - Woodward et al. 2004; Moncrieff et al. 2016).

Porcentagem de cobertura do terreno por árvores, determinada por sensoriamento remoto

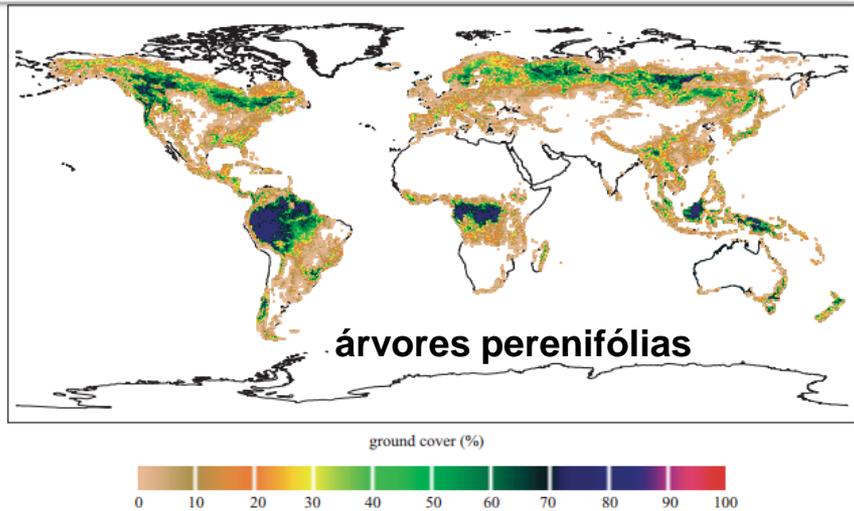


Figure 2. Global-scale distribution of evergreen trees (percentage of ground cover). All tree data are from the University of Maryland Global Land Cover Facility, continuous fields tree cover project, available at: <http://glcf.umd.edu/data/treecover/latlongProjection.shtml>.

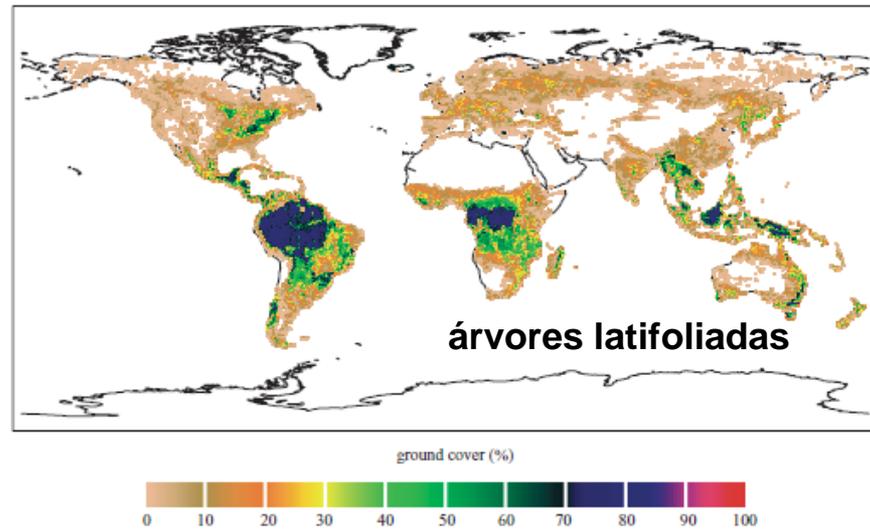


Figure 4. Global-scale distribution of broadleaf trees (percentage of ground cover).

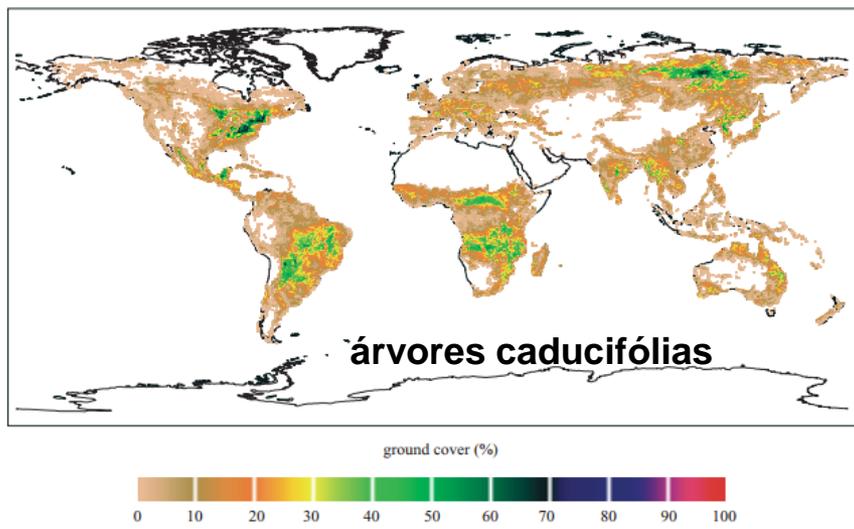


Figure 3. Global-scale distribution of deciduous trees (percentage of ground cover).

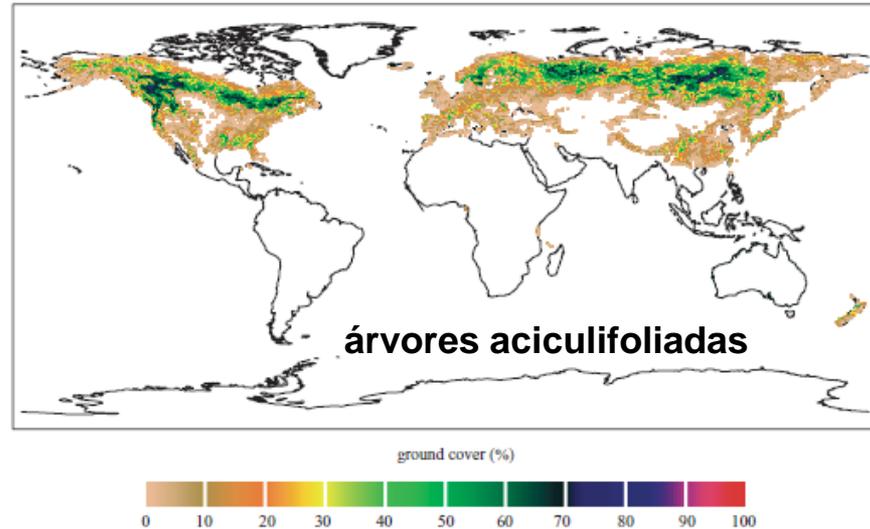
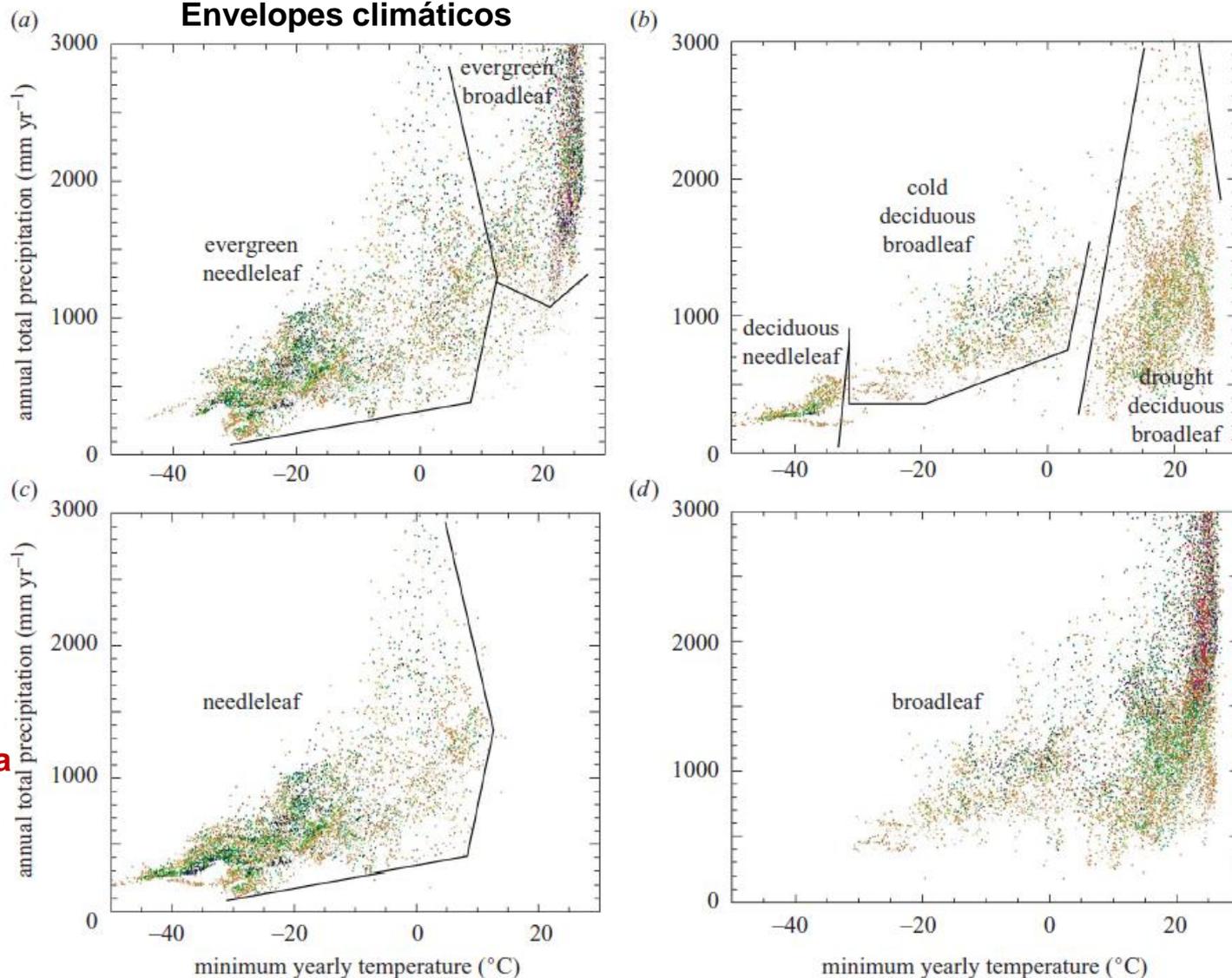


Figure 5. Global-scale distribution of needleleaf trees (percentage of ground cover).

Envelopes climáticas



Apenas um bioma tem envelope climático único: floresta aciculifoliada decidual

Figure 9. Scatter diagrams of tree cover (percentage of ground cover) against mean minimum annual temperature (°C) and annual total precipitation (mm). (a) Evergreen; (b) deciduous; (c) needleleaf; and (d) broadleaf. Precipitation totals are capped at 3000 mm to provide greater resolution for climates with low precipitation. The colour scheme is as for figure 2 to 5. Boundary lines are drawn by eye.

Table 1. The IGBP–DIS land cover classification. (Modified from Woodward *et al.* 2001.)

classification	comment	
5 grandes biomas florestais	evergreen needleleaf forests	Lands dominated by trees with a canopy cover of more than 60% and height exceeding 2 m. Almost all trees remain green all year. Canopy is never without green foliage.
	evergreen broadleaf forests	Lands dominated by trees with a canopy cover of more than 60% and height exceeding 2 m. Almost all trees remain green all year. Canopy is never without green foliage.
	deciduous needleleaf forests	Lands dominated by trees with a canopy cover of more than 60% and height exceeding 2 m. Consists of seasonal needleleaf tree communities with an annual cycle of leaf-on and leaf-off periods.
	deciduous broadleaf forests	Lands dominated by trees with a canopy cover of more than 60% and height exceeding 2 m. Consists of seasonal broadleaf tree communities with an annual cycle of leaf-on and leaf-off periods.
	mixed forests	Lands dominated by trees with a canopy cover of more than 60% and height exceeding 2 m. Consists of tree communities with interspersed mixtures or mosaics of the other four forest cover types. None of the forest types exceeds 60% of the landscape.
5 grandes biomas "abertos"	closed shrublands	Lands with woody vegetation less than 2 m tall and with shrub canopy cover more than 60%. The shrub foliage can be either evergreen or deciduous.
	open shrublands	Lands with woody vegetation less than 2 m tall and with shrub canopy cover between 10 and 60%. The shrub foliage can be either evergreen or deciduous.
	woody savannahs	Lands with herbaceous and other understorey systems, and with forest canopy cover of between 30 and 60%. The forest cover height exceeds 2 m.
	savannahs	Lands with herbaceous and other understorey systems, and with forest canopy cover between 10 and 30%. The forest cover height exceeds 2 m.
	grassland	Lands with herbaceous types of cover. Tree and shrub cover is less than 10%.

C3 x C4 : A superposição nos envelopes climáticos não é realizada geograficamente:

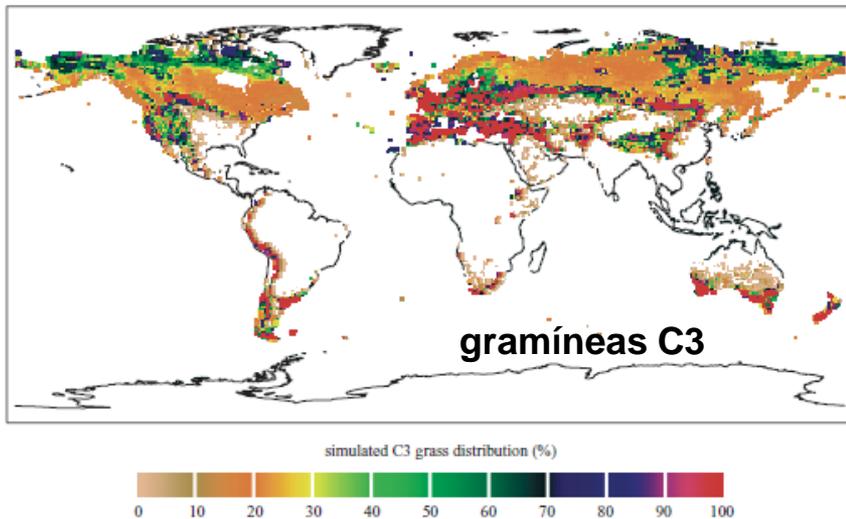


Figure 10. Simulated distribution of C3 grasses for 1990 to 2000. (Modified from Woodward & Lomas 2004.)

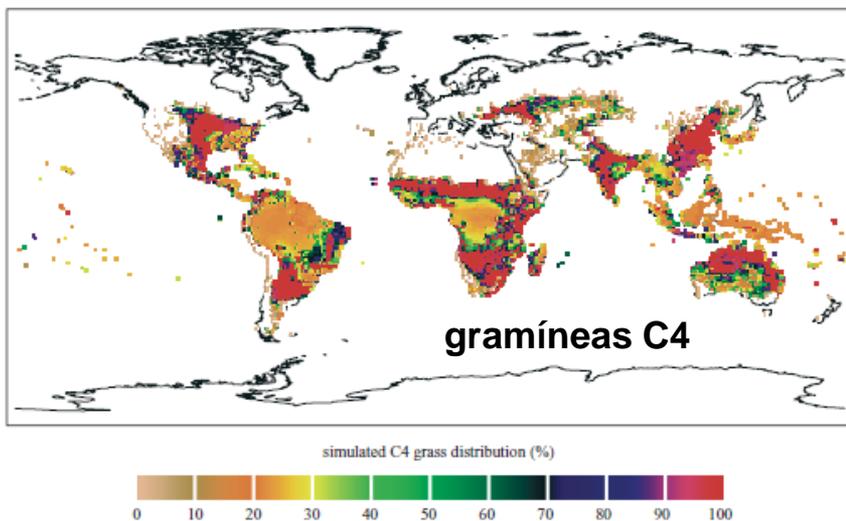


Figure 11. Simulated distribution of C4 grasses for 1990 to 2000. (Modified from Woodward & Lomas 2004.)

gramíneas C4 predominam em latitudes tropicais e no Hemisfério Sul

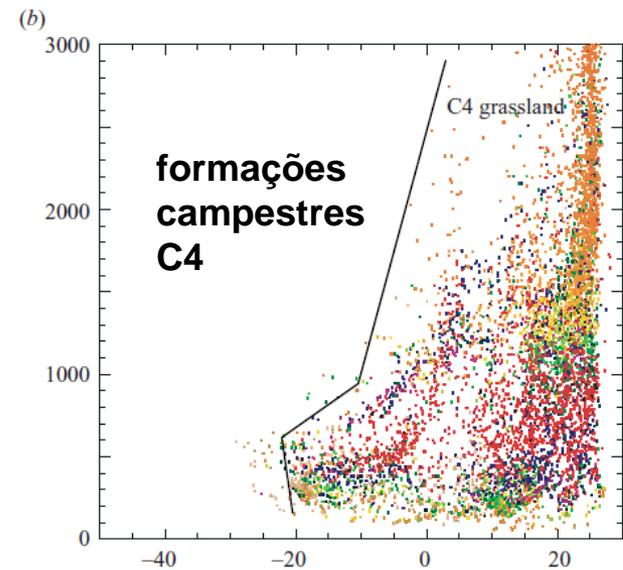
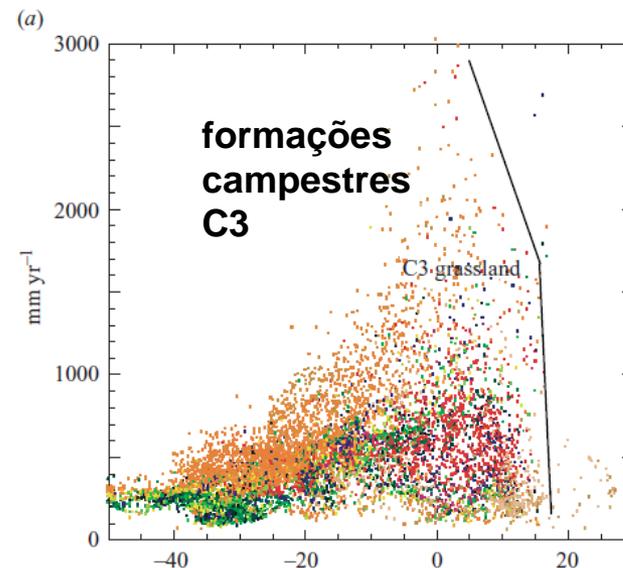
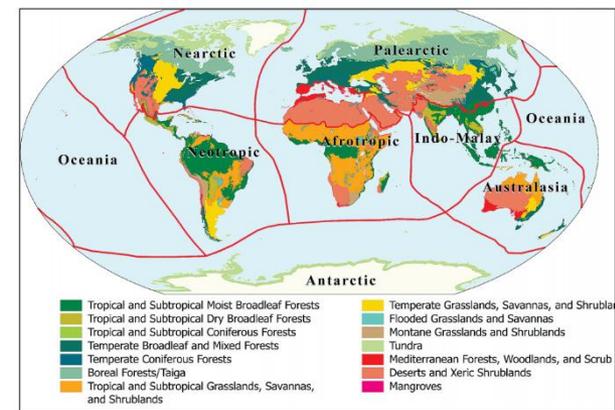


Figure 12. Scatter diagrams of grass cover (percentage) against mean minimum annual temperature (°C) and annual total precipitation (mm). (a) C3 grasses; and (b) C4 grasses. The colour scheme is as for figures 10 and 11. Boundary lines are drawn by eye.

Definições e mapas (antigos e atuais) reconhecem **níveis hierárquicos inferiores de formações vegetacionais dentro dos biomas globais**, definidos em contexto geográfico (e.g. 867 ecorregiões - Olson et al. 2001, ou Biomas *sensu strictu* - Walter 1973).

“While these lower hierarchical levels are useful for purposes such as conservation planning and regional analyses, we concern ourselves with **biomes defined globally without reference to geographical context or environmental conditions**. This approach allows **the distribution of PFTs and biomes in relation to the environment to be analysed without circularity**, and this biome concept is implicit in global vegetation models and meta-analyses of global biogeochemical cycling or species richness”.
(Woodward et al. 2004).

Olson et al. 2001:
8 domínios (ou reinos, 7 terrestres)
14 biomas terrestres



867 ecorregiões terrestres:

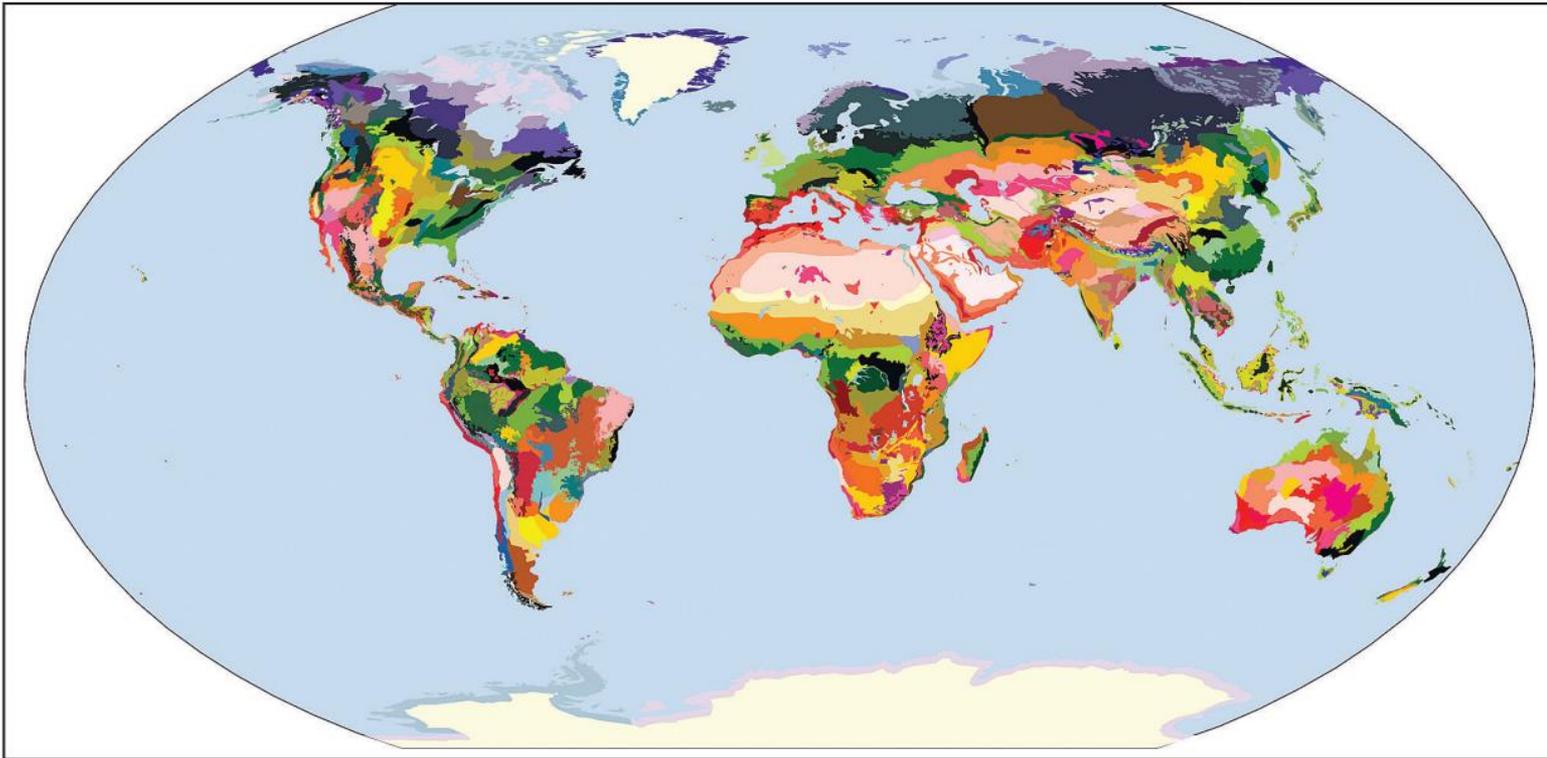


Figure 2. The map of terrestrial ecoregions of the world recognizes 867 distinct units, roughly a fourfold increase in biogeographic discrimination over that of the 193 units of Udvardy (1975). Maps of freshwater and marine ecoregions are similarly needed for conservation planning.

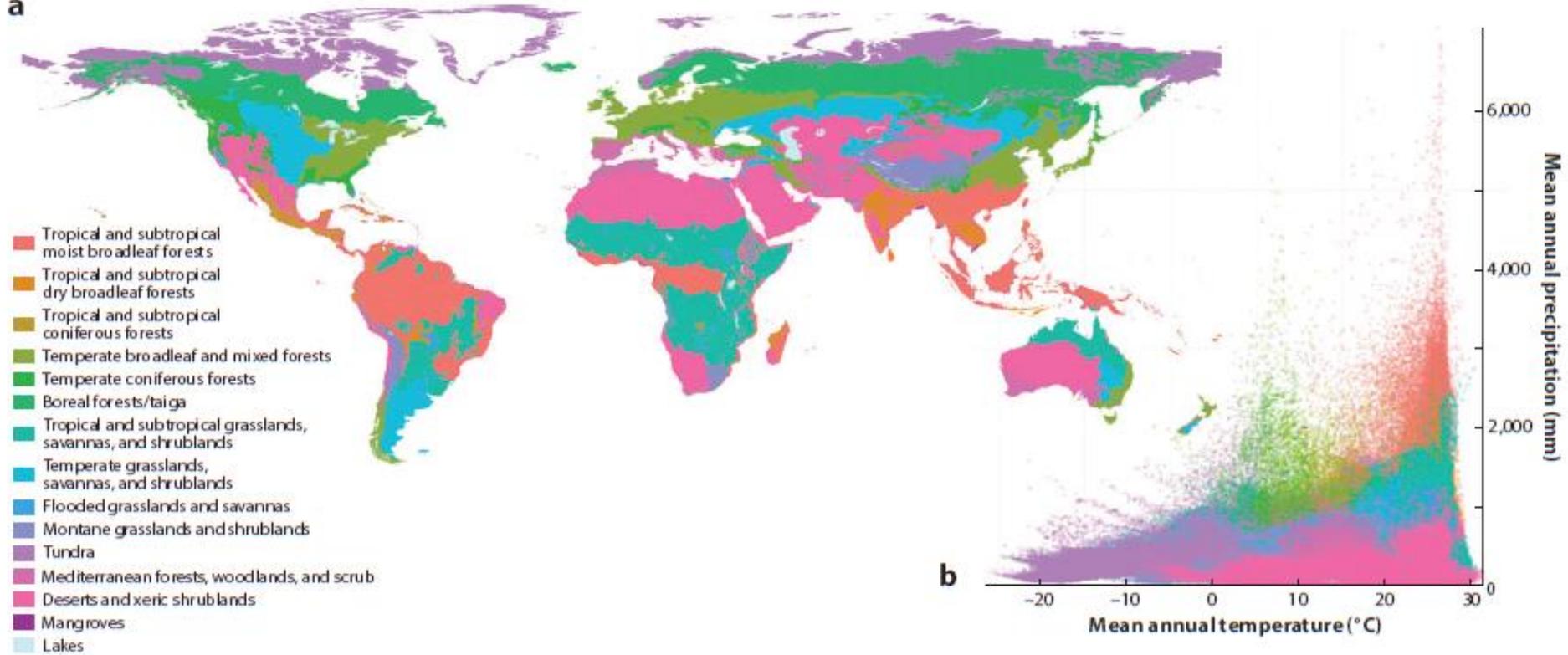
Global climate and the distribution of plant biomes

F. I. Woodward^{1*}, M. R. Lomas¹ and C. K. Kelly²

2004

Biomes are areas of vegetation that are characterized by the same life-form. Traditional definitions of biomes have also included either geographical or climatic descriptors. This approach describes a wide range of biomes that can be correlated with characteristic climatic conditions, or climatic envelopes. The application of remote sensing technology to the frequent observation of biomes has led to a move away from the often subjective definition of biomes to one that is objective. Carefully characterized observations of life-form, by satellite, have been used to reconsider biome classification and their climatic envelopes. Five major tree biomes can be recognized by satellites based on leaf longevity and morphology: needleleaf evergreen, broadleaf evergreen, needleleaf deciduous, broadleaf cold deciduous and broadleaf drought deciduous. Observations indicate that broadleaf drought deciduous vegetation grades substantially into broadleaf evergreen vegetation. The needleleaf deciduous biome occurs in the world's coldest climates, where summer drought and therefore a drought deciduous biome are absent.

 Traditional biome definitions are quite static, implying no change in their life-form composition with time, within their particular climatic envelopes. However, this is not the case where there has been global ingress of grasslands and croplands into forested vegetation. The global spread of grasses, a new super-biome, was probably initiated 30–45 Myr ago by an increase in global aridity, and was driven by the natural spread of the disturbances of fire and animal grazing. These disturbances have been further extended over the Holocene era by human activities that have increased the land areas available for domestic animal grazing and for growing crops. The current situation is that grasses now occur in most, if not all biomes, and in many areas they dominate and define the biome. Croplands are also increasing, defining a new and relatively recent component to the grassland super-biome. In the case of both grassland and croplands, various forms of disturbance, particularly frequent disturbance, lead to continued range extensions of the biomes.

a

WorldClim climate layers – Hijmans et al. 2005

Figure 1

Geography and climate of the world's biomes. (a) Map of the World Wildlife Fund "Ecoregions" (<https://worldwildlife.org/publications/terrestrial-ecoregions-of-the-world>; Olson et al. 2001). These regions generally correspond to Whittaker's (1975) original biome types but are slightly broader; although they are suboptimal for some biological purposes (e.g., Särkinen 2011; Hughes et al. 2013) and in need of refinement, they provide a globally manageable number of categories for present purposes. (b) The same biomes in relation to mean annual temperature and precipitation estimated from WorldClim climate layers (Hijmans et al. 2005). The relationships depicted by Whittaker (1975) are broadly evident but with substantial climate overlap among biomes.

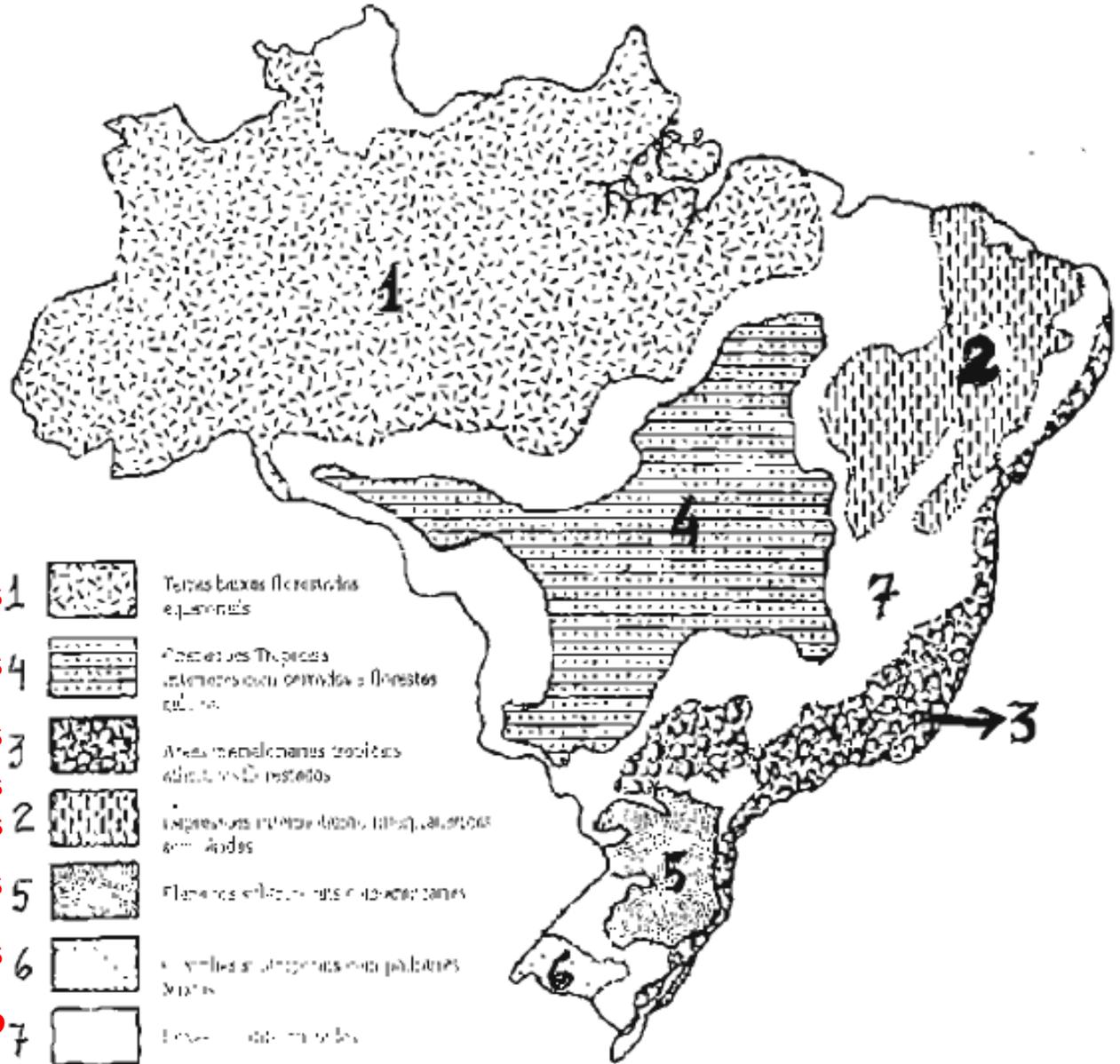
Donoghue & Edwards 2014

Aplicação do conceito de biomas
em escala continental ou regional

**DOMÍNIOS
morfoclimáticos**



DOMÍNIOS morfoclimáticos Ab'Saber 1965



Terras baixas equatoriais 1



Terras baixas florestadas equatoriais

Chapadões tropicais 4



Florestas Tropicais interiores com cerrados e florestas galeria

Mares de morros 3



Áreas mediterrâneas tropicais adiantadas e costeiras

Depressões interplanálticas semiáridas 2



Vegetação interior árida, semiárida e com áreas

Planaltos subtropicais 5



Planaltos e áreas de mata e florestas

Coxilhas 6



Vegetação arbustiva com palmeiras e mata

Zonas de transição 7

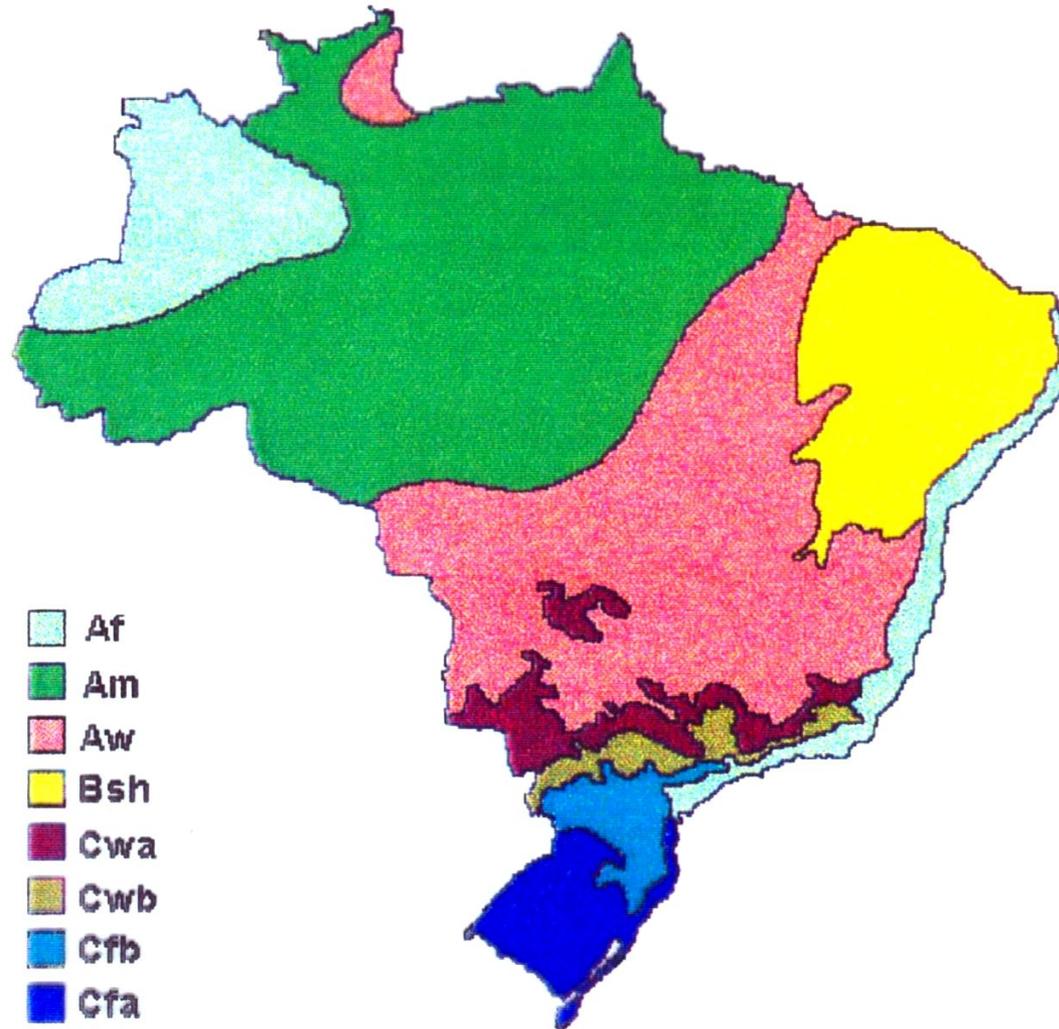


Vegetação de mata

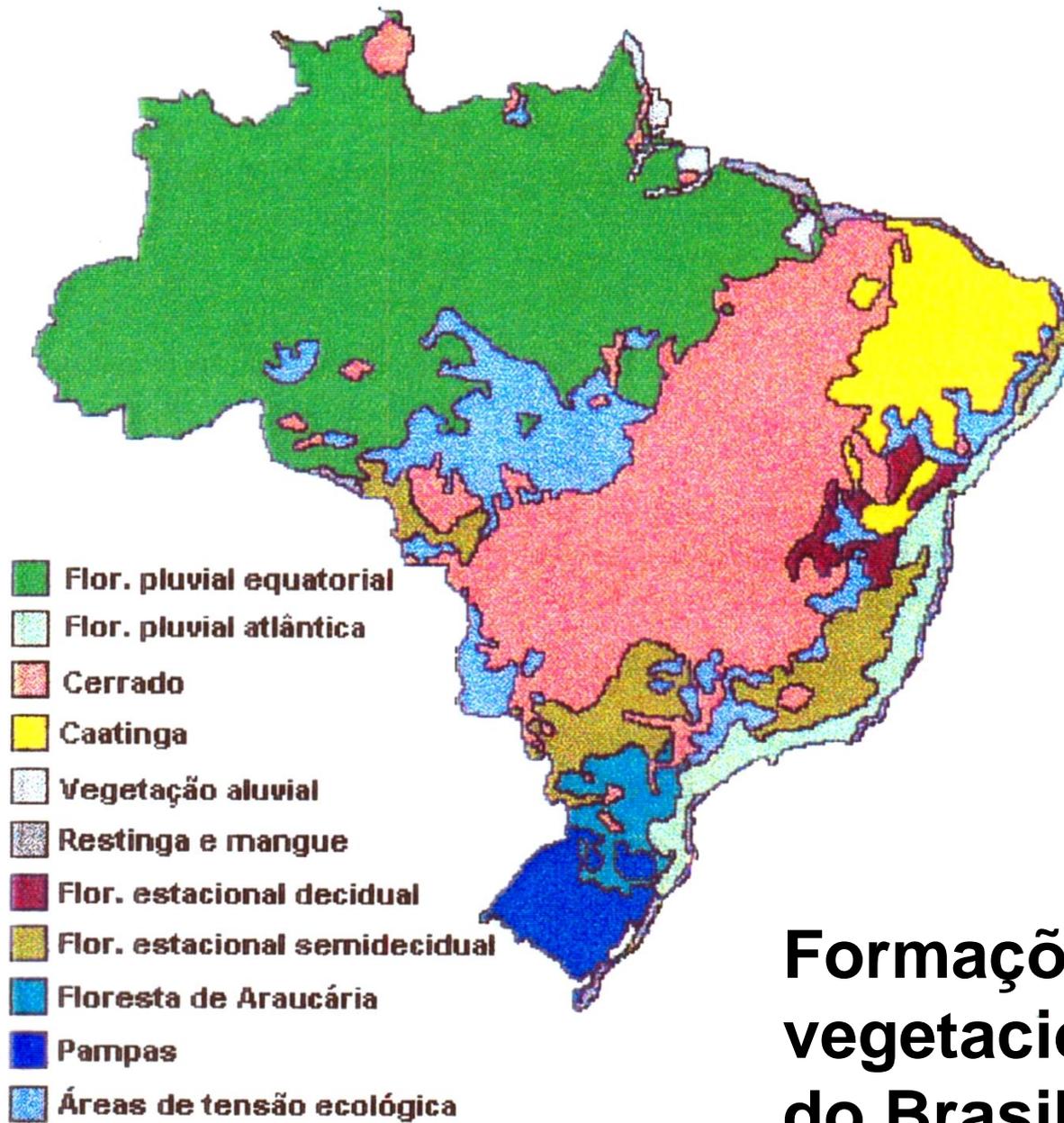
DOMÍNIOS morfoclimáticos Ab'Saber 2003



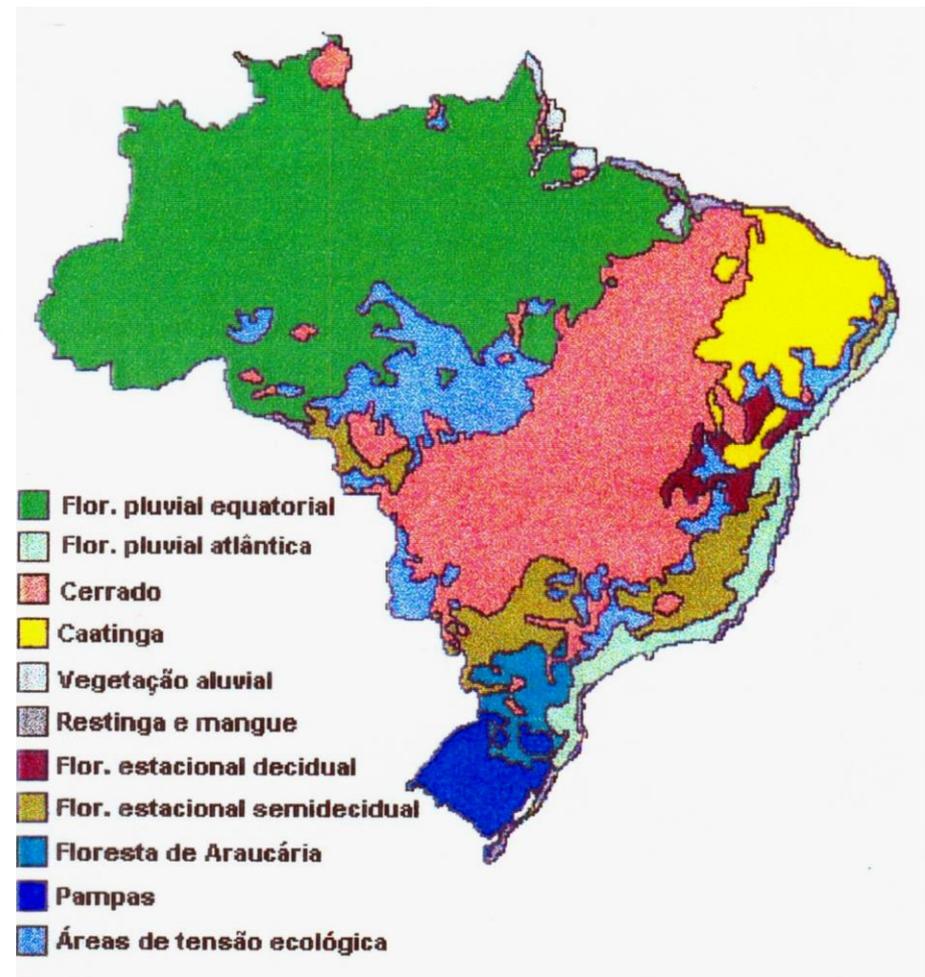
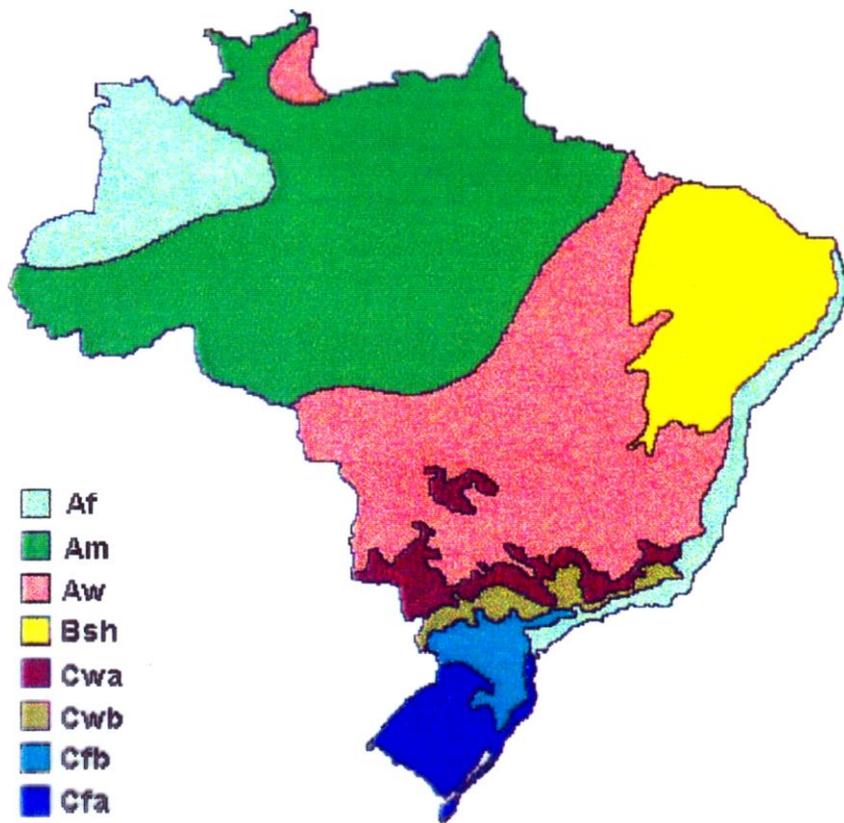
Domínios	I – Amazônico		Terras baixas florestadas equatoriais
	II – Cerrado		Chapadões tropicais interiores com cerrados e florestas-galeria
	III – Mares de morros		Áreas mamelonares tropical-atlânticas florestadas
	IV – Caatingas		Depressões intermontanas e interplanálticas semi-áridas
	V – Araucárias		Planaltos subtropicais com araucárias
	VI – Pradarias		Coxilhas subtropicais com pradarias mistas
	Faixas de transição		(Não diferenciadas)



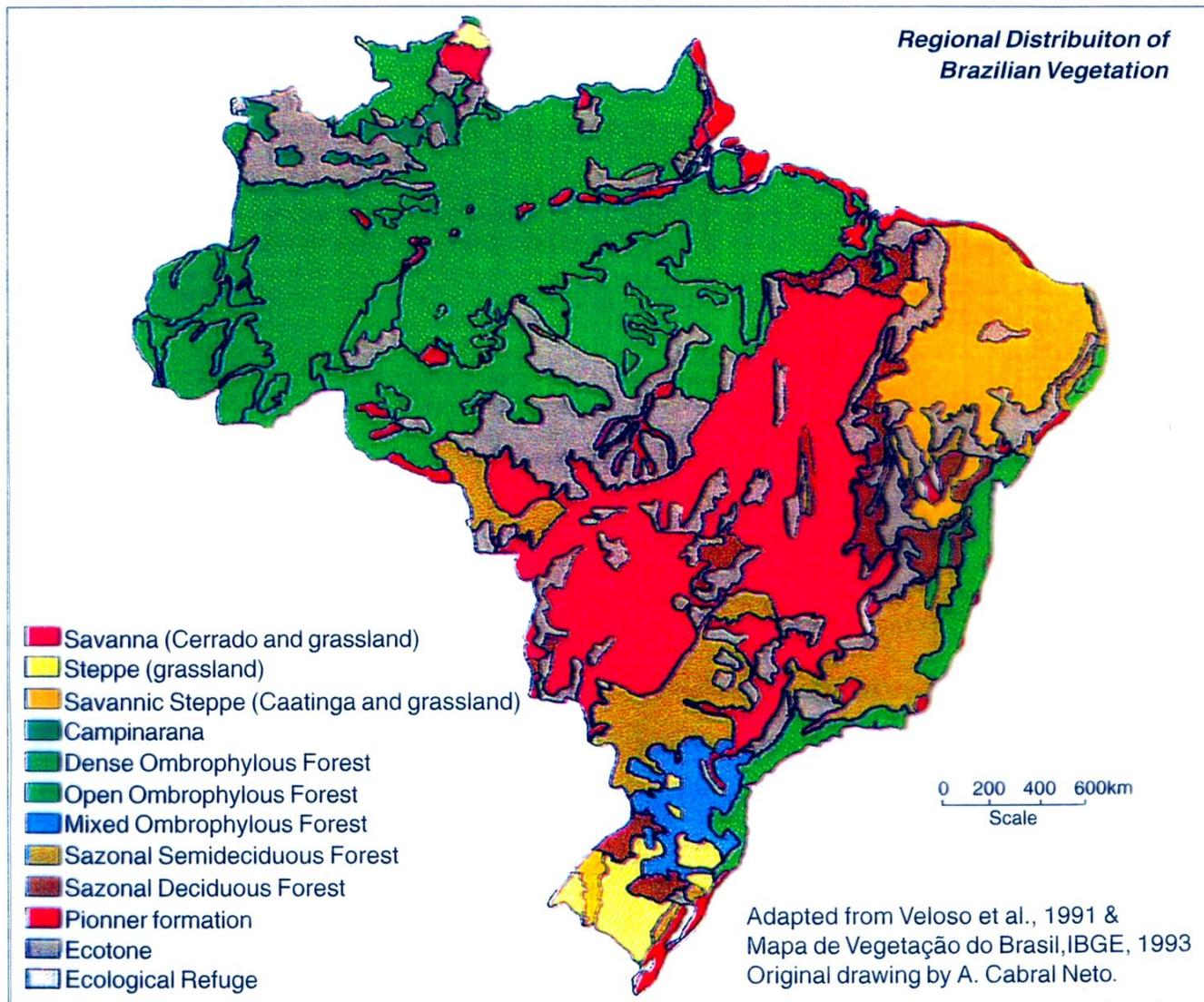
Tipos de clima no Brasil de acordo com Köppen (1948)



Formações vegetacionais do Brasil



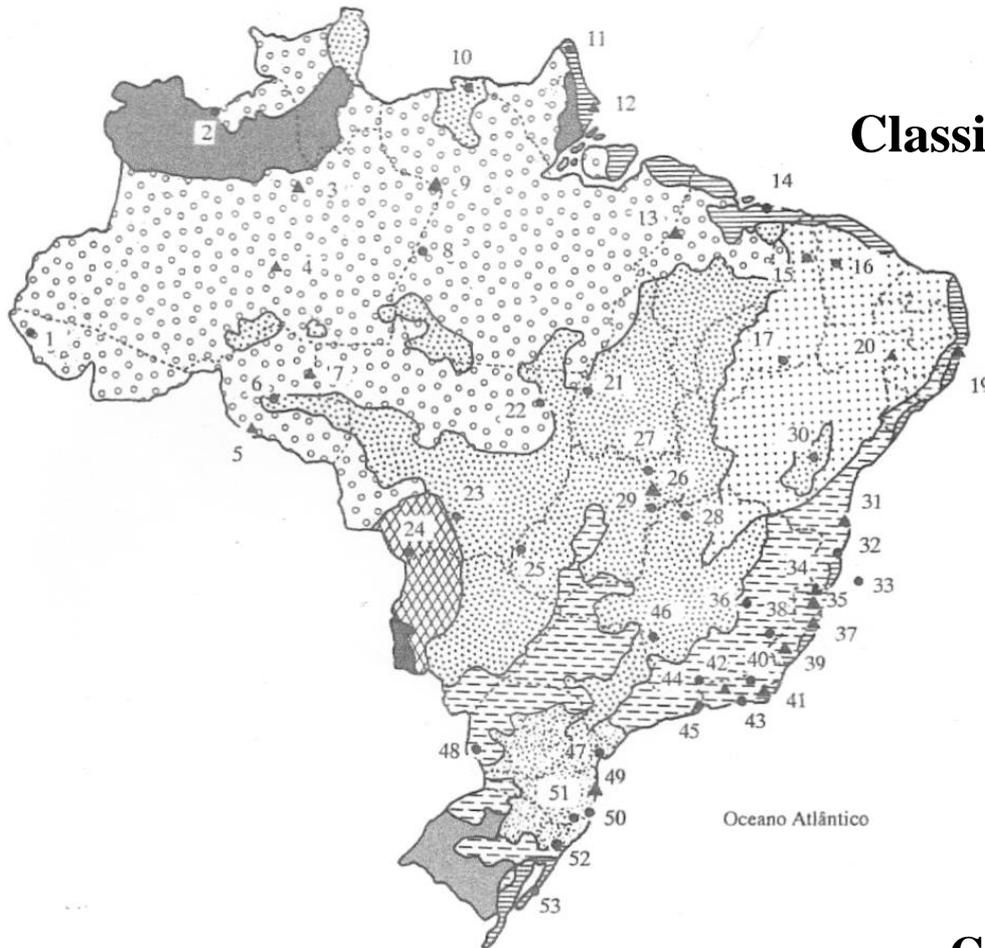
Clima e vegetação do Brasil



Classificação da vegetação brasileira segundo o IBGE, adaptado de Veloso *et al.* (1991).

Joly *et al.* 1999

Classificação da vegetação brasileira no livro *Geografia do Brasil* de Ross (1998)



- Parques
- ▲ Reservas

Classificação da vegetação natural

	Florestas amazônicas		Mata de araucárias (pinheiral)
	Campos amazônicos ou campinaranas		Cerrados do Pantanal
	Matas atlânticas		Pantanal (campos inundáveis)
	Cerrado		Campo limpo
	Caatinga		Mangues, restingas, jundus

Conti & Furlan 1998
fonte: Sampaio & Furlan 1993

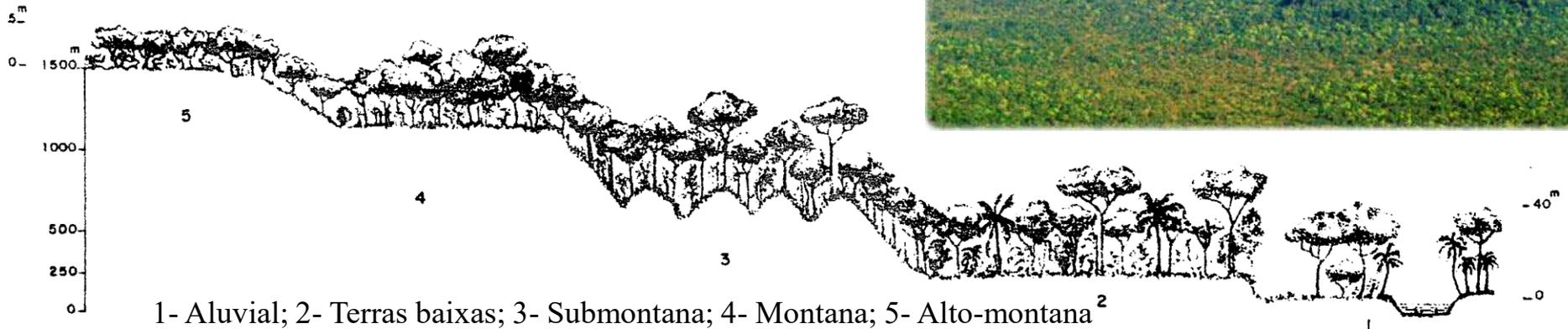
Floresta ombrófila densa



Amazônia

***Ceiba pentandra* - sumaúma**

Perfil esquemático da **Floresta Ombrófila Densa**



Perfil esquemático dos “facies” da **Floresta Ombrófila Aberta**

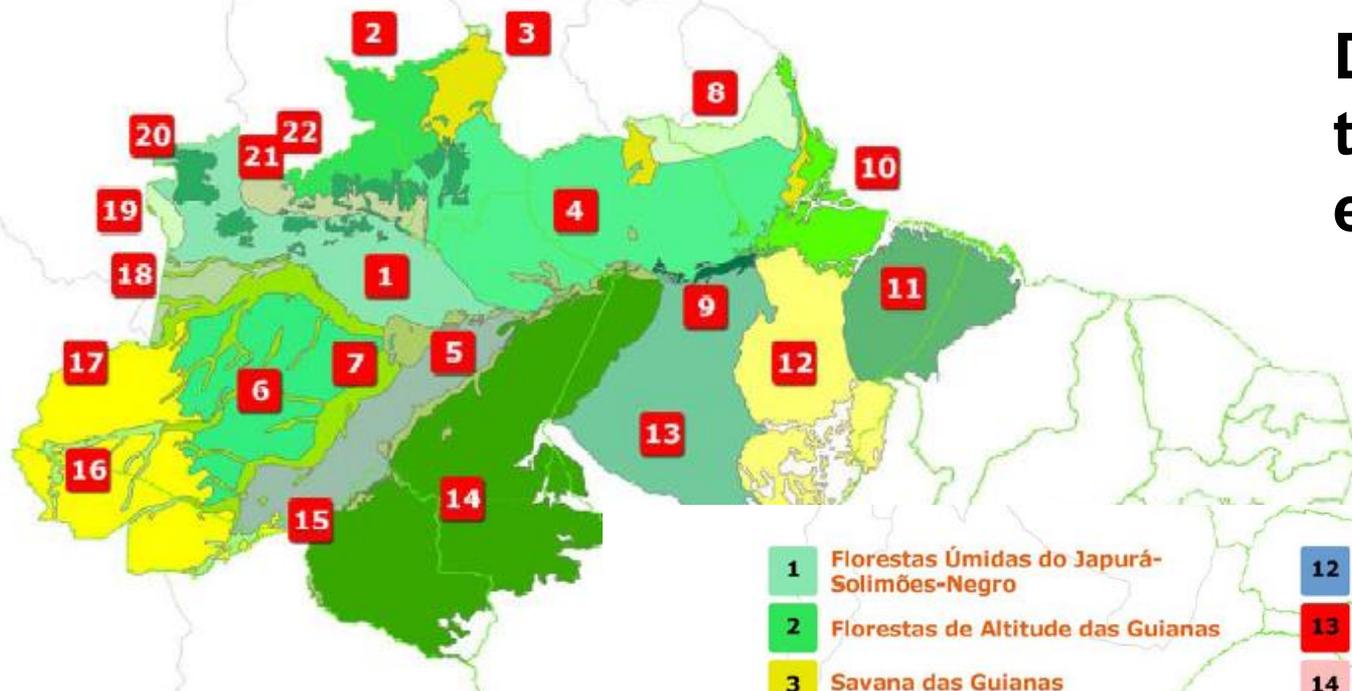


1- Com cipó; 2- Com palmeira; 3- Com Bambu; 4- Com Sororoca



Biomos do Brasil Amazônia

Domínio das
terras baixas
equatoriais



- | | | | |
|----|---|----|--|
| 1 | Florestas Úmidas do Japurá-Solimões-Negro | 12 | Florestas Úmidas do Tocantins-Xingu-Araguaia |
| 2 | Florestas de Altitude das Guianas | 13 | Florestas Úmidas do Tapajós-Xingu |
| 3 | Savana das Guianas | 14 | Florestas Úmidas do Madeira-Tapajós |
| 4 | Florestas Úmidas do Uatumã-Trombetas | 15 | Florestas Úmidas Do Purus-Madeira |
| 5 | Várzea de Monte Alegre | 16 | Várzea de Iquitos |
| 6 | Florestas Úmidas do Juruá-Purus | 17 | Sudoeste da Amazônia |
| 7 | Várzea do Purus | 18 | Florestas Úmidas do Solimões-Japurá |
| 8 | Floresta das Guianas | 19 | Florestas Úmidas de Caquetá |
| 9 | Várzea de Gurupá | 20 | Campinarana do Alto Rio Negro |
| 10 | Várzea de Marajó | 21 | Florestas Úmidas do negro-Branco |
| 11 | Florestas Úmidas do Tocantins-Araguaia | 22 | Tepuis |

Fonte: www.wwf.org.br



Vegetações abertas no Domínio Amazônico

destaque para os ecossistemas sobre solos arenosos brancos: campinas e campinaranas

Manchas menores evidenciadas por registros de espécies de *Pagamea* (Rubiaceae), indicador ecológico

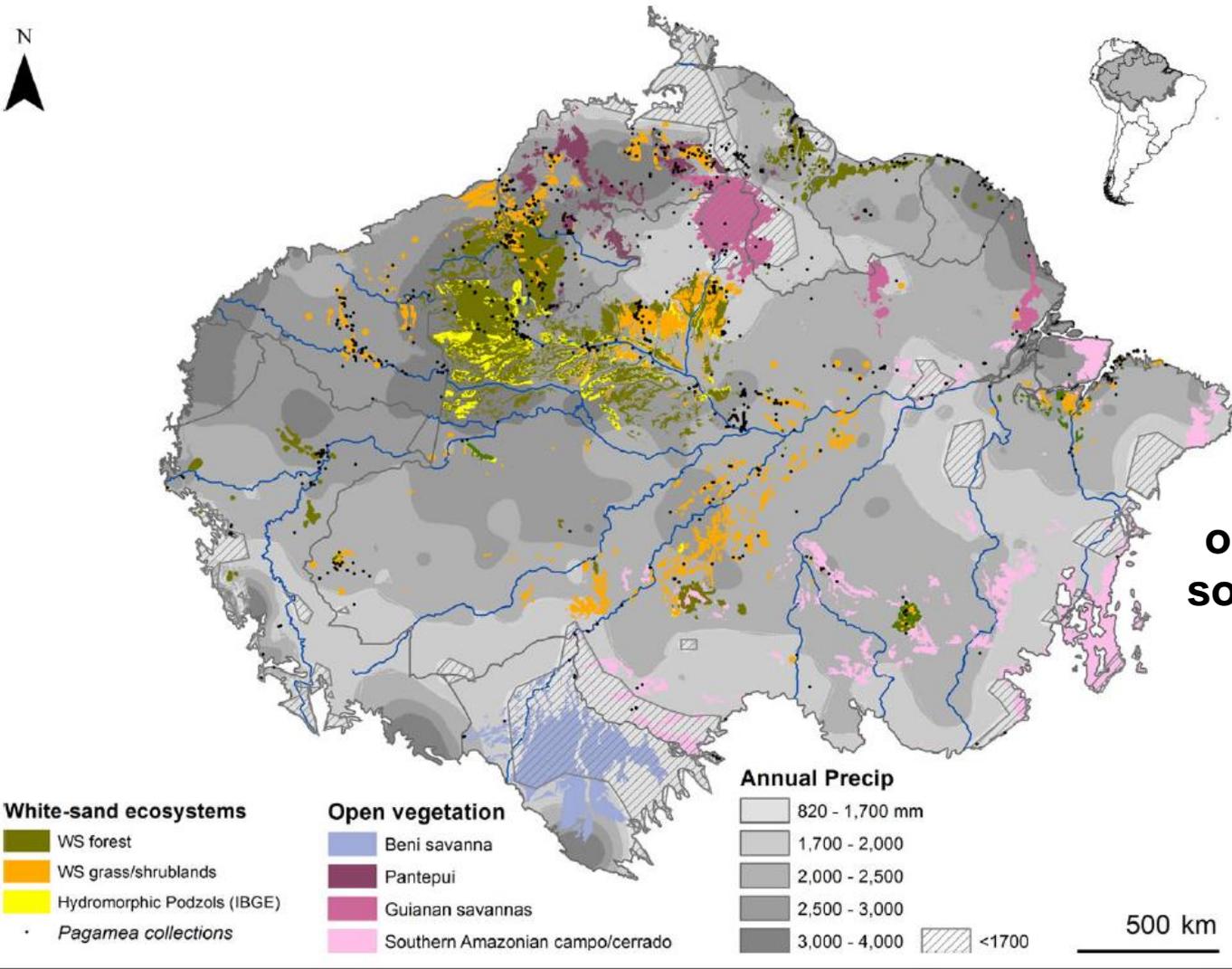
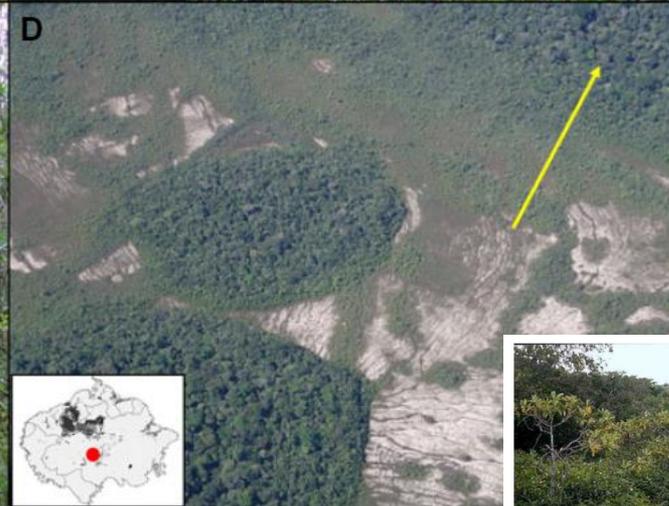


FIGURE 1. White-sand ecosystems and open vegetation in the Amazon ecoregion generated from composite sources and overlaid on annual precipitation. Areas receiving <1700 mm of annual rainfall (cross-hatch) contain savannas (open vegetation) distinct from WSE and are shown for context. Because small WSE patches may be missed, mixed with savanna patches, or misclassified, we include collection points for the genus *Pagamea* (Rubiaceae) to indicate where other WSE patches might occur. (Note that the map displays very small WSE patches larger than actual scale for visibility.) Data sources: precipitation, WorldClim; rivers, ESRI; Amazon boundary, Beni savanna, and pantepui, Olson *et al.* (2001); Brazilian WS grass/shrublands, Guianan savannas, and Southern Amazonian campos/cerrado, M Alencar & A. Carneiro, INPA GIS Lab; hydromorphic podzols, IBGE (ftp://geofip.ibge.gov.br/mapas_tematicos/mapas_murais/shapes/); accessed

Adeney et al. 2016

Vegetações abertas no Domínio Amazônico

ecossistemas sobre solos arenosos brancos: campinas e campinaranas



- A. Campina aberta no interflúvio Madeira-Purus, Amazonas
- B. Parque Nacional do Viruá, Roraima
- C. Campinarana (floresta) Catunama, sul do Amazonas
- D. Foto aérea do gradiente vegetação aberta-fechada, Lábrea, Amazonas

Adeney et al. 2016

Campina na Serra do Aracá, AM
Cid Ferreira 2009

Fig. 8. Fisionomia arbustiva com a dominância de *Humiria floribunda* Aubl., e as áreas arenosas onde ocorrem as espécies de *Lagenocarpus rigidus* (Kunth) Nees, associadas com o líquen *Cladonia confusa* f. *confusa* (R. Sant.) Follmann & Ahti. Parque Nacional da Serra do Aracá, (AM).

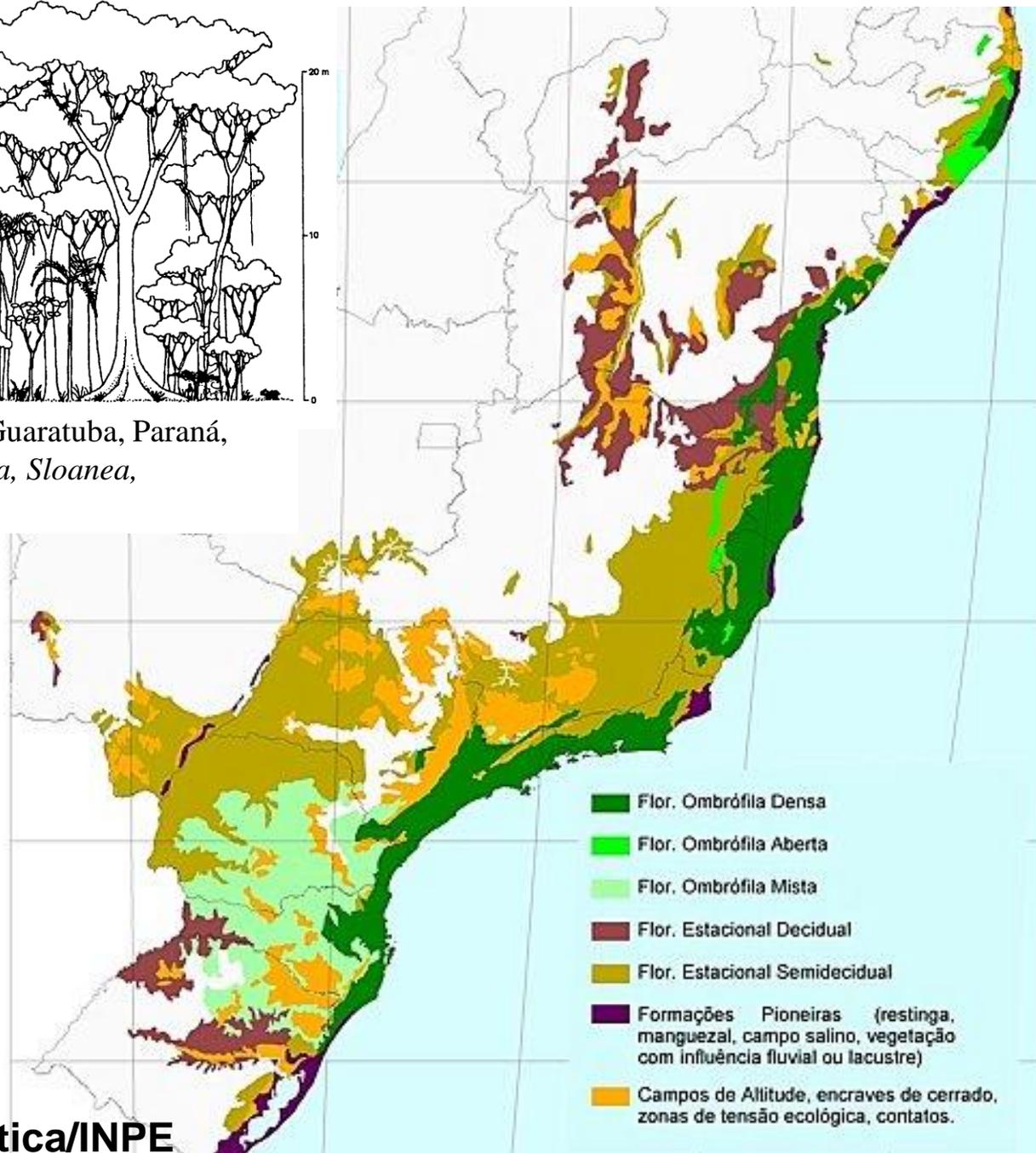
Floresta ombrófila densa

Serra do Mar





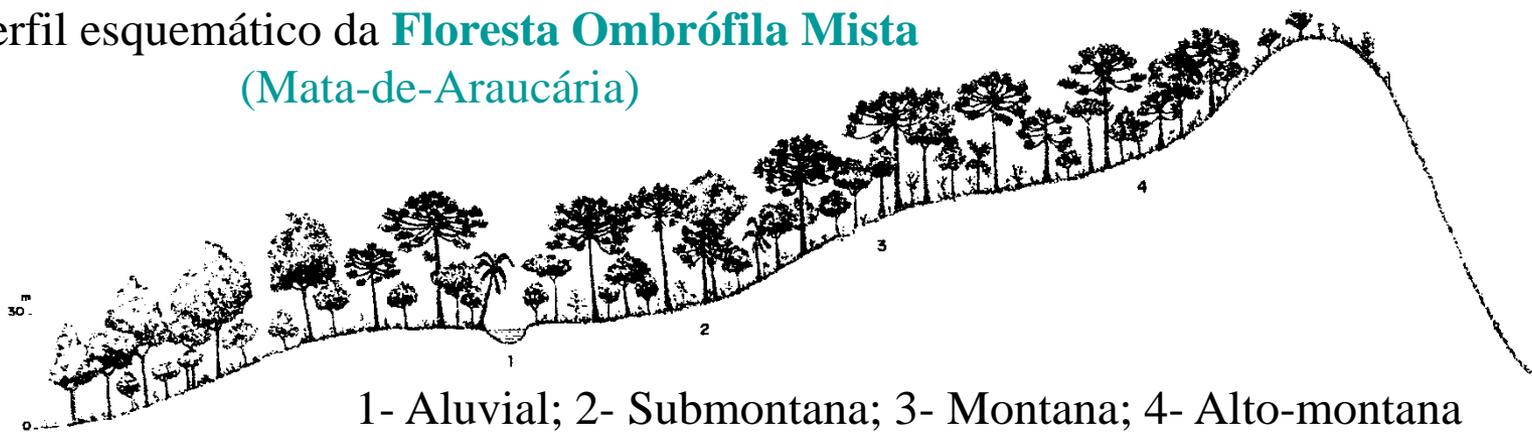
Perfil de **Floresta Ombrófila Densa** - Guaratuba, Paraná, com *Ficus*, *Schizolobium*, *Virola*, *Ocotea*, *Sloanea*, *Hyeronima* e *Alchornea*.





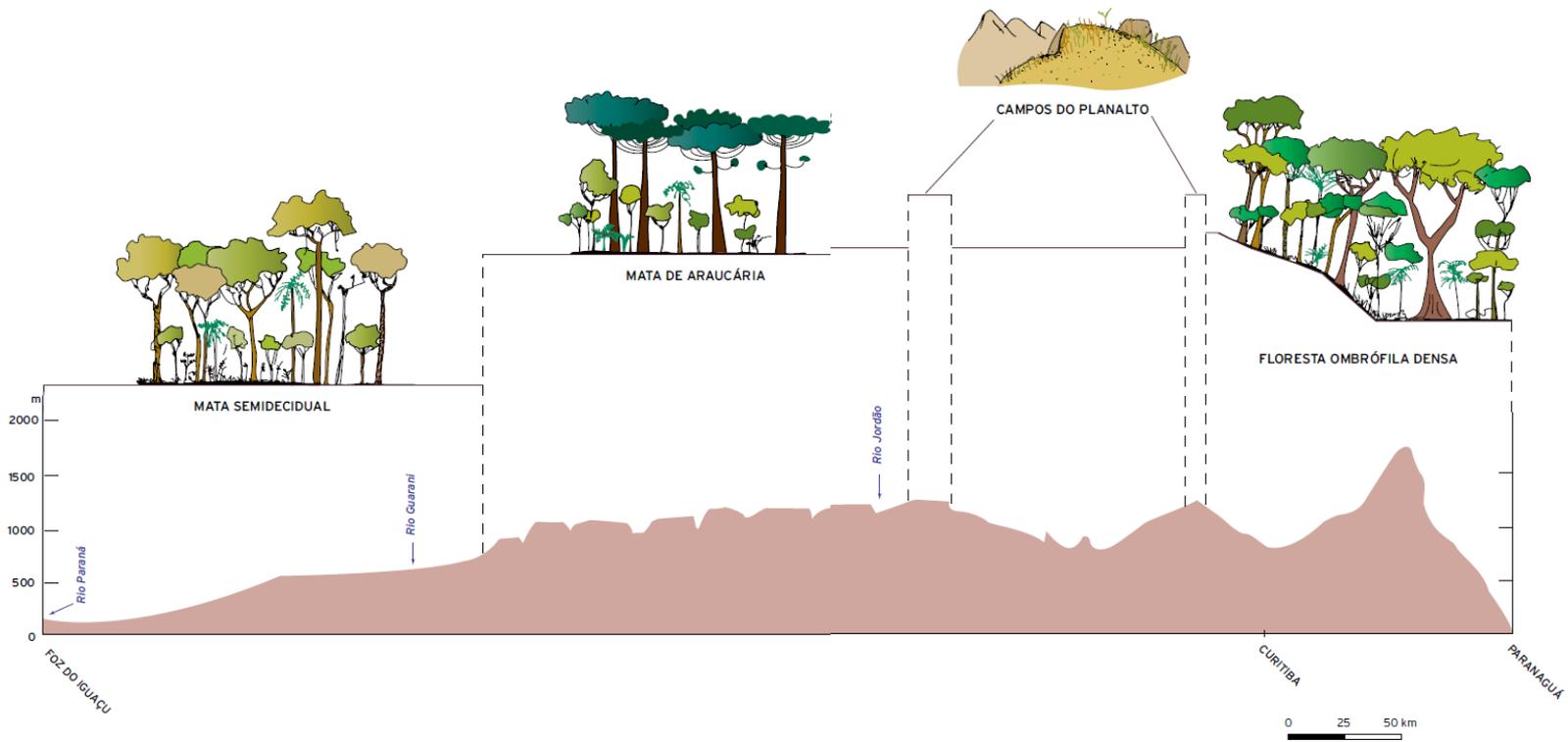
Perfil esquemático - estrutura de um segmento de **Floresta Ombrófila Mista** em Irati, Paraná, com predominância de *Araucaria*, *Ocotea*, *Cedrela*, *Casearia*, *Sloanea*, *Podocarpus*, *Campomanesia*, *Ilex* e *Capsicodendron*. **Roderjan et al. 2002**

Perfil esquemático da **Floresta Ombrófila Mista**
(Mata-de-Araucária)



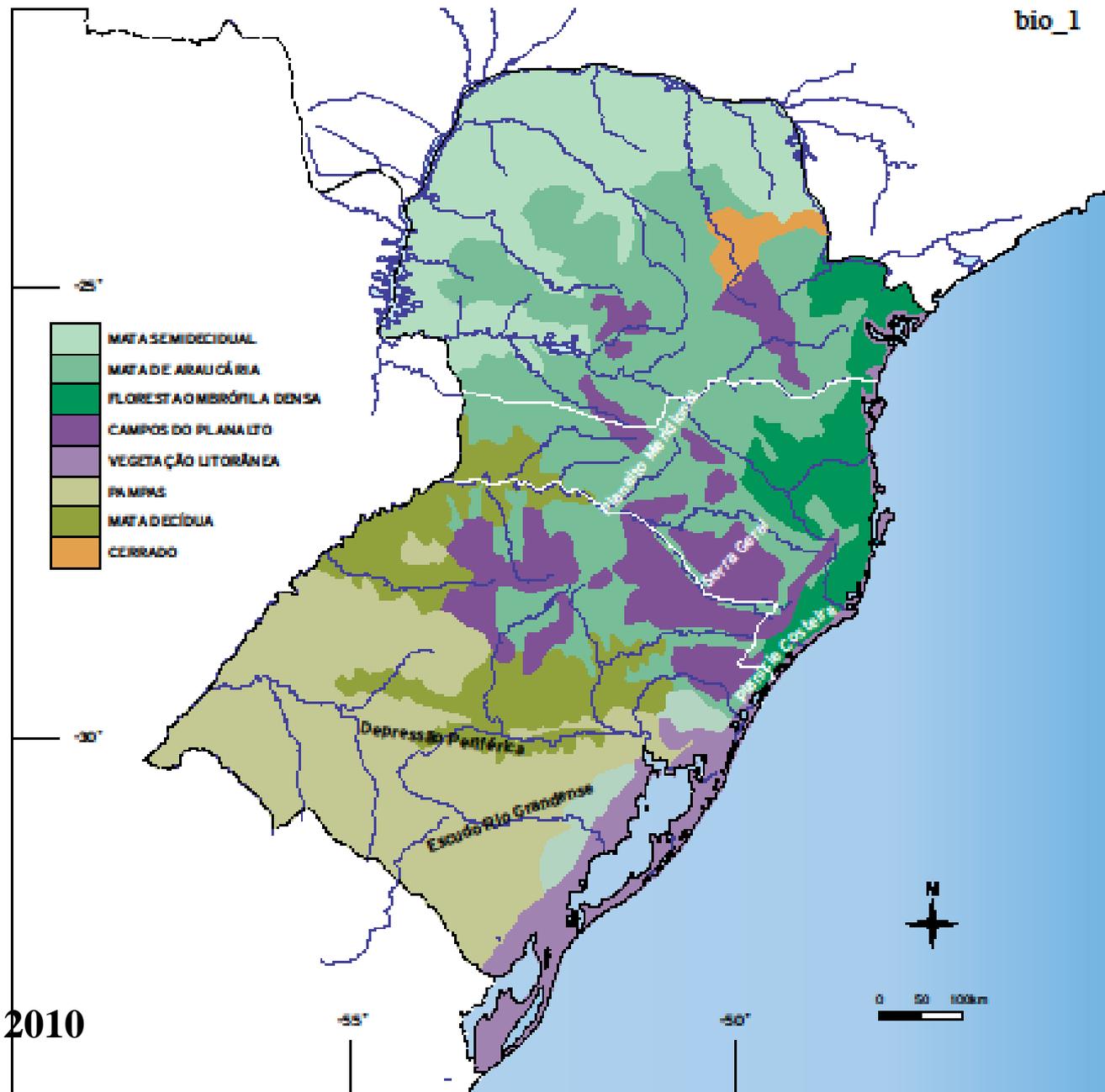
1- Aluvial; 2- Submontana; 3- Montana; 4- Alto-montana

Veloso et al. 1991



Perfil topográfico com vegetação PARANÁ

Pirani 2010



Campos do Planalto Meridional (Fortaleza, SC)





Perfil esquemático destacando a estrutura de um segmento de Floresta Estacional Semidecidual no município de Maringá, Paraná, com predominância de *Aspidosperma*, *Peltophorum*, *Enterolobium*, *Parapiptadenia*, *Cordia*, *Gallesia*, *Balfourodendron*, *Holocalyx* e *Cedrela*.

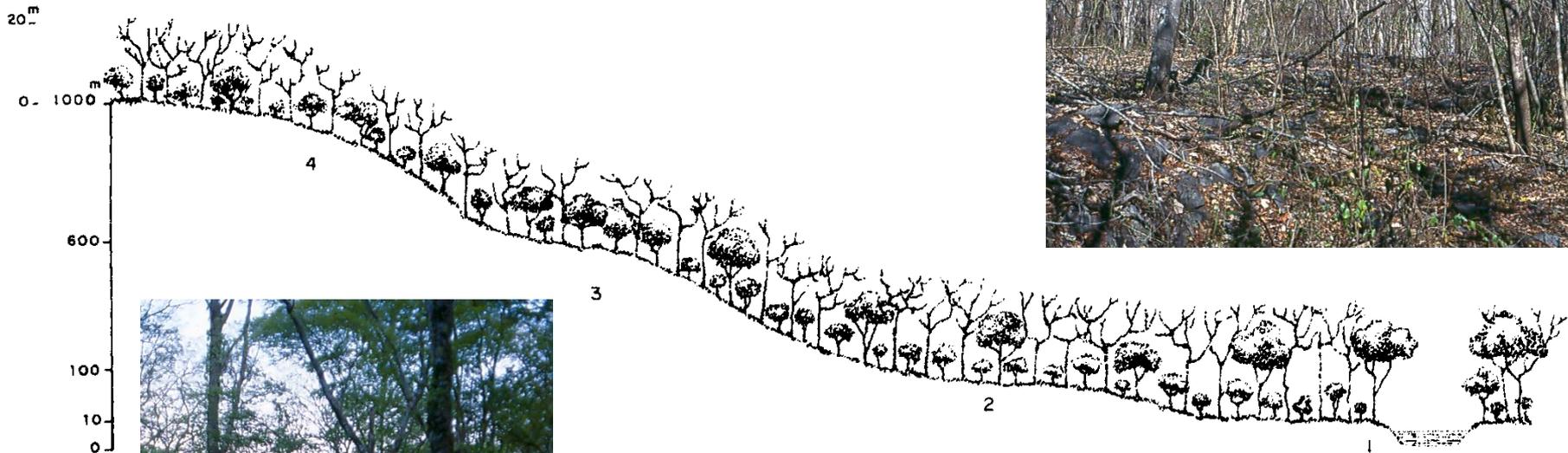
Roderjan et al. 2002



Perfil Esquemático da **Floresta Estacional Semidecidual**

1- Aluvial; 2- Terras Baixas; 3- Submontana; 4- Montana

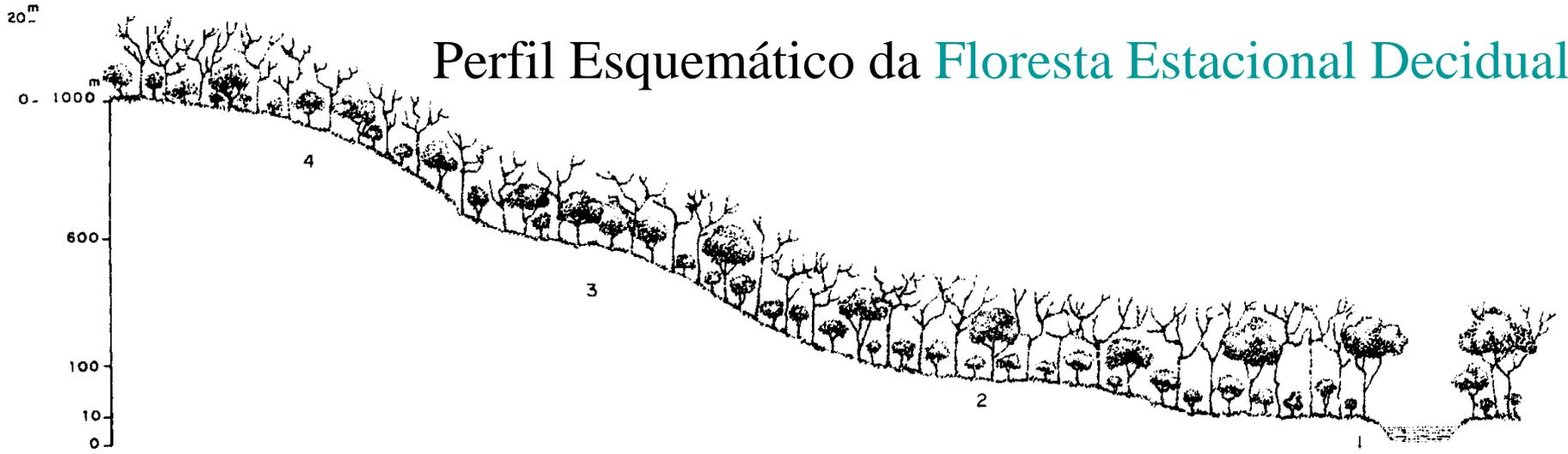
Perfil Esquemático da Floresta Estacional Decidual



Monjolos, MG

1- Aluvial; 2- Terras Baixas; 3- Submontana; 4- Montana
Veloso et al. 1991

Perfil Esquemático da Floresta Estacional Decidual

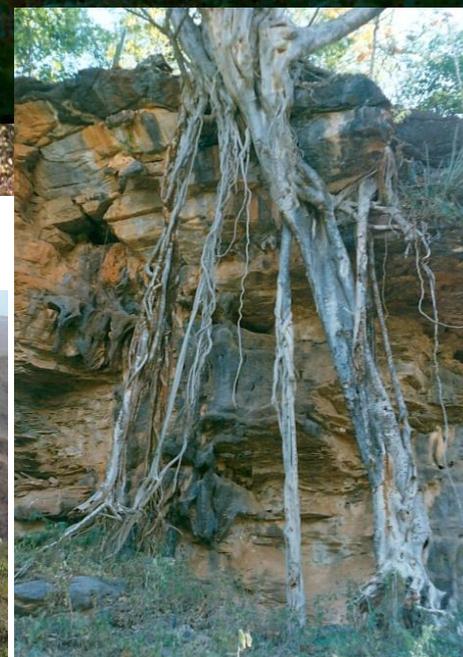


1- Aluvial; 2- Terras Baixas; 3- Submontana; 4- Montana

Veloso et al. 1991



Cardeal Mota, MG

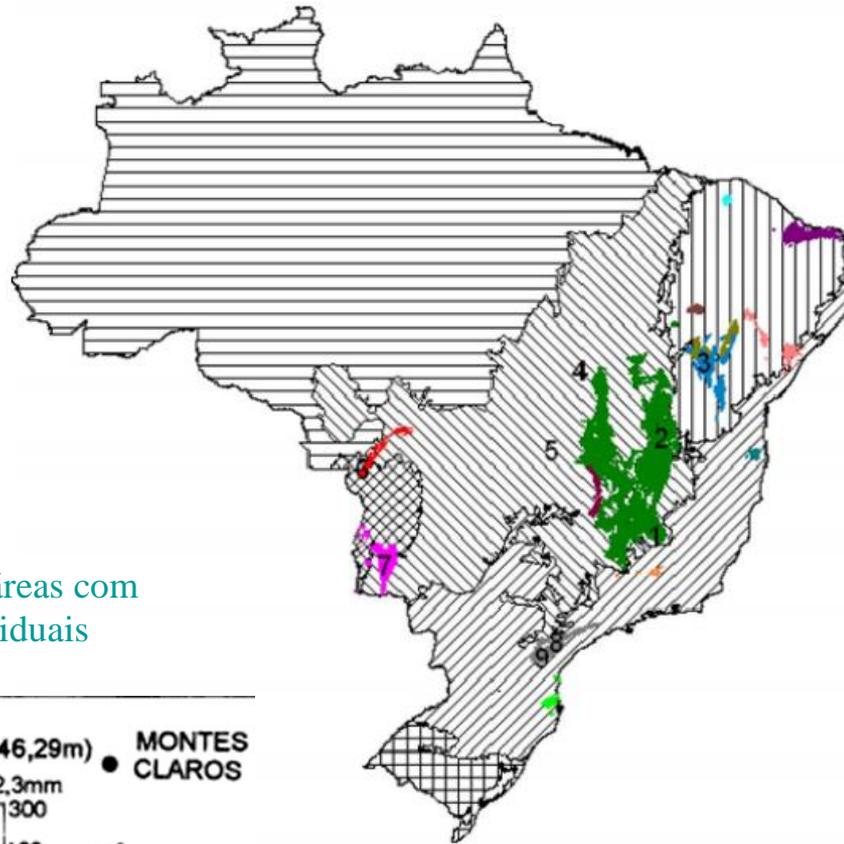


Monjolos, MG
Floresta Estacional Decidual

Meguro et al. 2007

Regiões cársticas carbonáticas do Brasil (CECAV 2009)

Floresta Estacional Decidual:
geralmente associada a regiões
com calcário



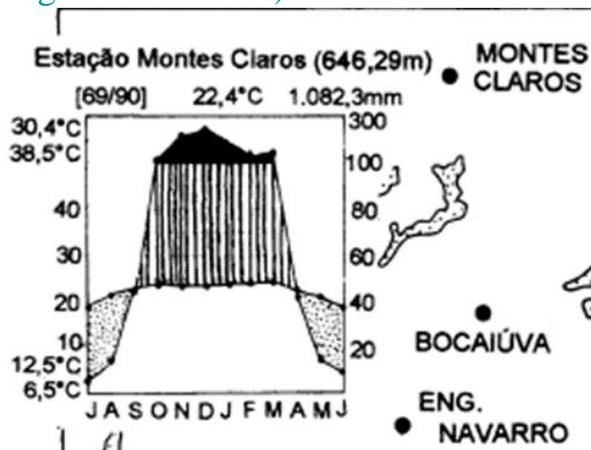
Dominios Fitogeográficos



R. Cársticas Carbonáticas

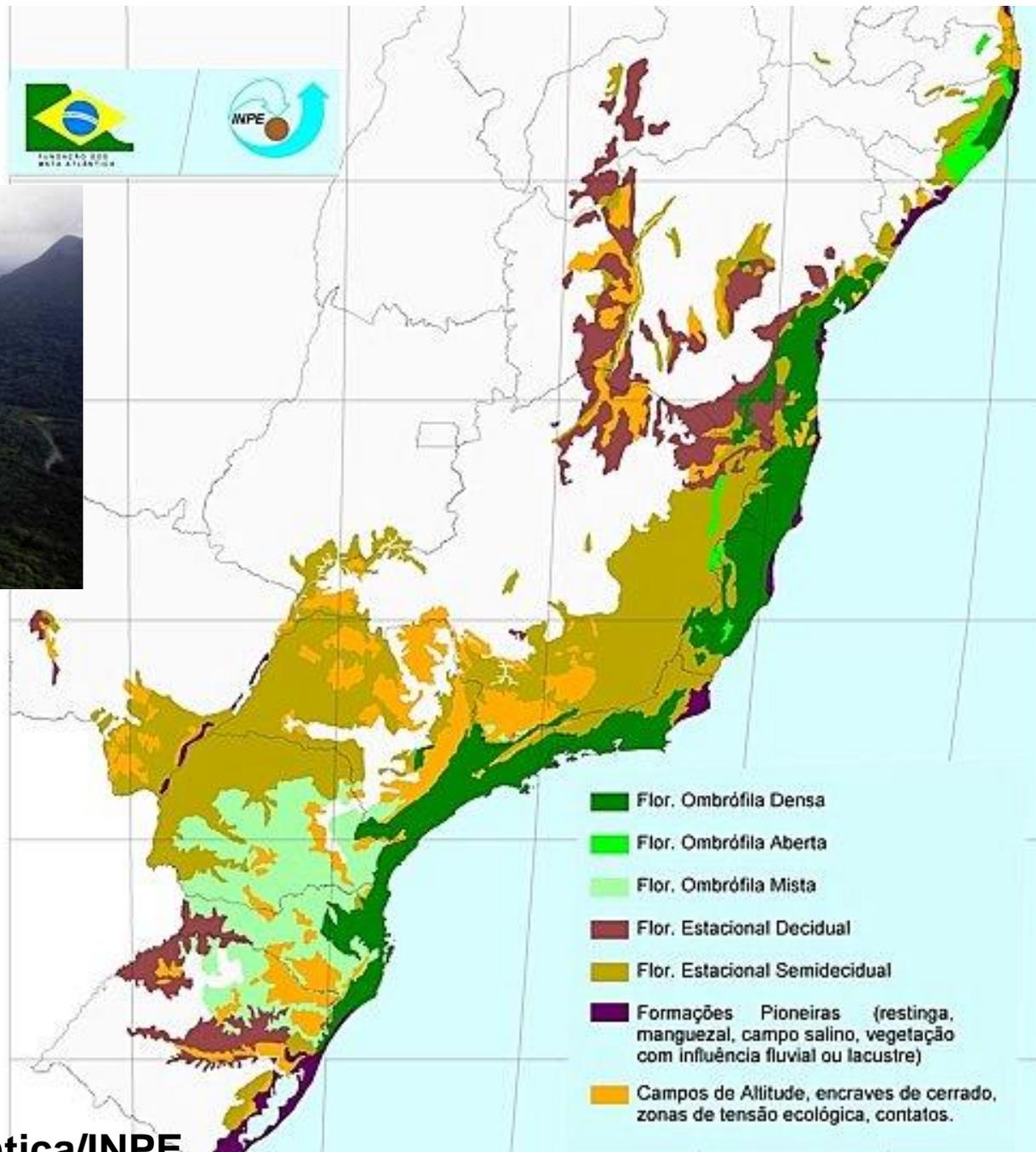


Diagrama climático de áreas com
florestas estacionais deciduais
(Meguro et al. 2007)



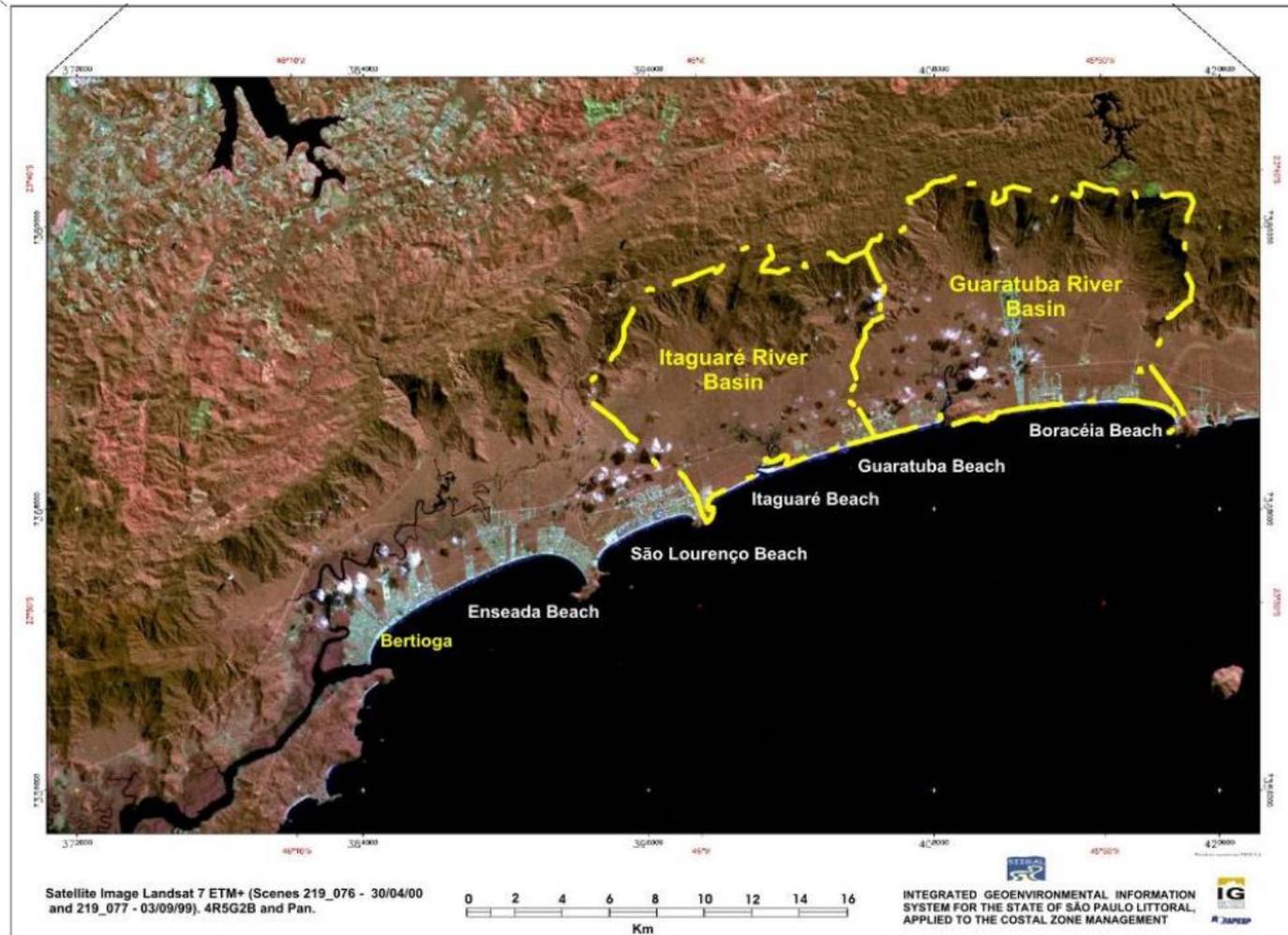
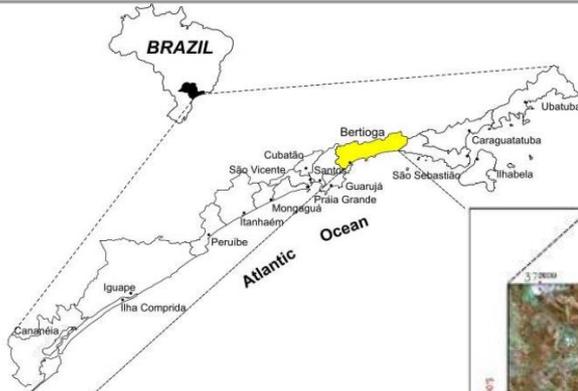
Áreas com inventários florísticos:

1. Funilândia, MG;
2. Matias Cardoso, MG;
3. Irecê, BA;
4. Natividade, GO;
5. Vila Propício;
6. Cáceres, MT;
7. Bonito, MS;
8. Apiaí, SP;
9. Rio Branco do Sul, PR.



Domínio da Mata Atlântica: Trecho da Serra do Mar em São Paulo

Souza et al. 2009



Domínio da Mata Atlântica:

Transecção mostrando a heterogeneidade da cobertura vegetal ao longo da encosta da Serra do Mar Souza et al. 2009

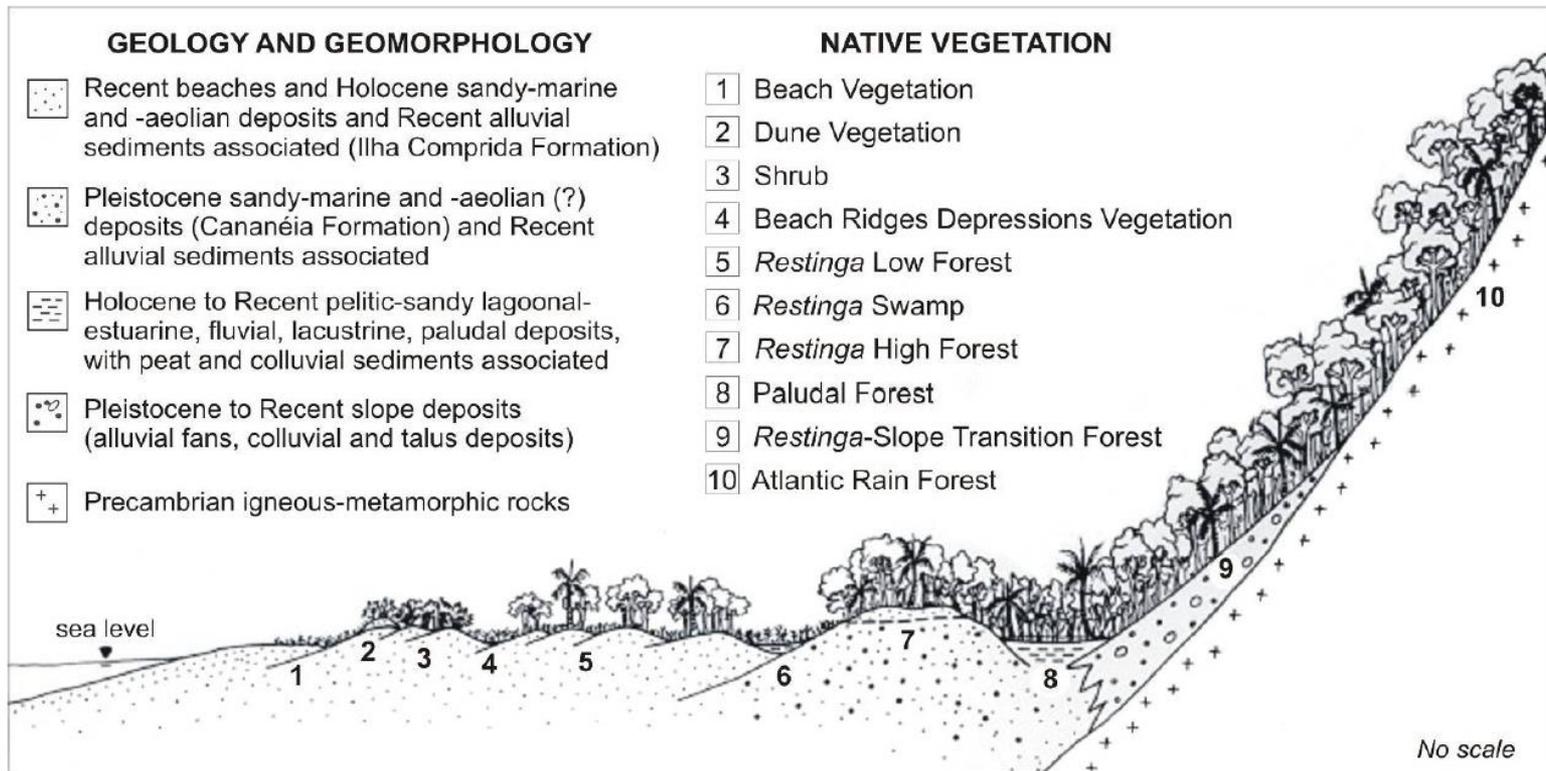


Figure 1. A cross-section profile of the São Paulo coastal plain and Serra do Mar coastal range slopes showing the most common association between Quaternary geological units and native vegetation (according to the Conama Resolution n° 07/1996) (29 modified).

Mata Atlântica *sensu lato*

Eisenlohr & Oliveira-Filho 2015

483 sítios; 3546 espécies de árvores;
33 variáveis geoclimáticas

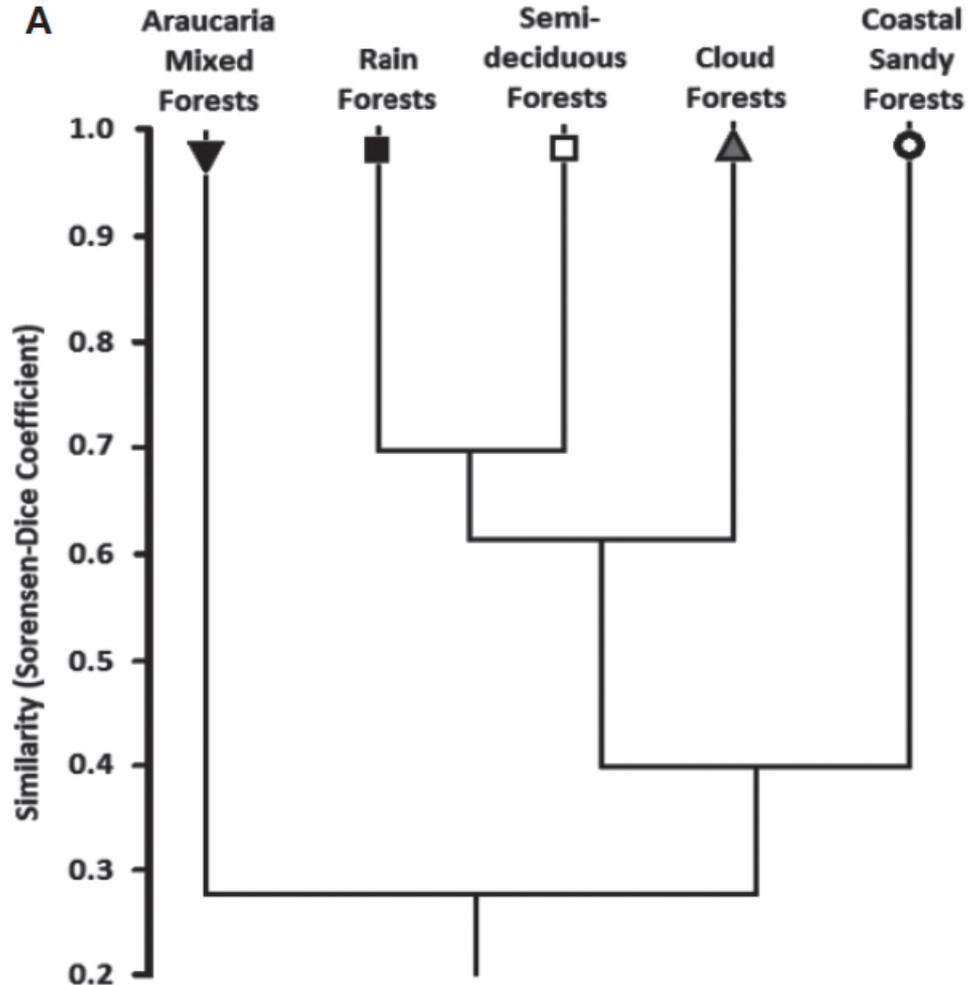
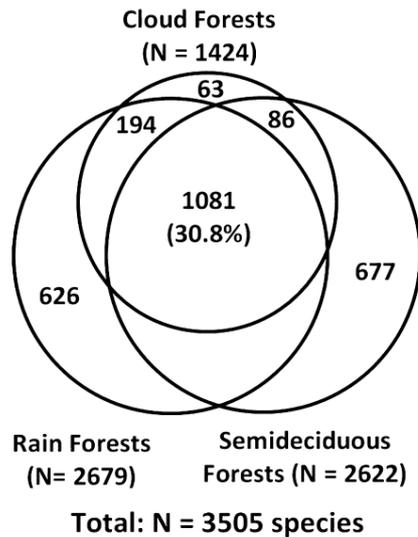
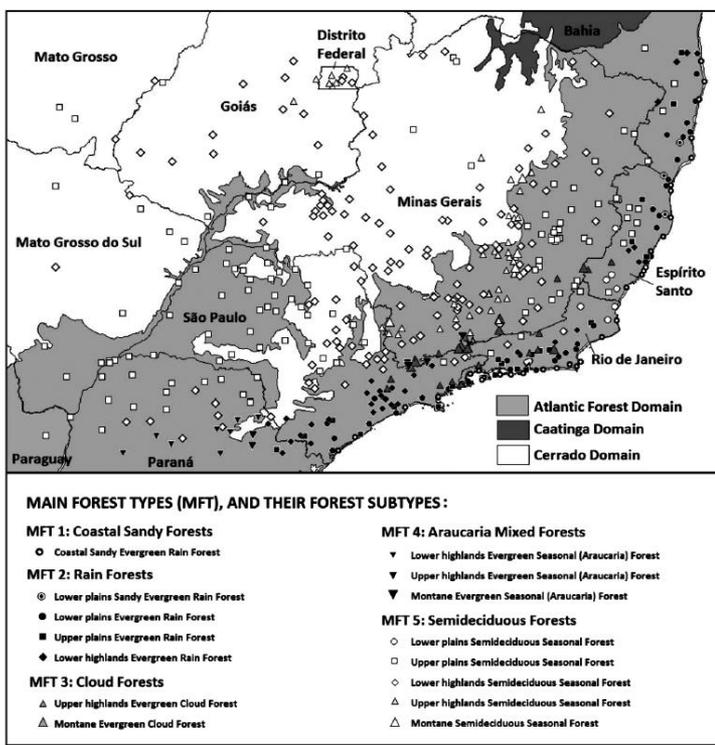


FIGURE 2. Venn diagram illustrating the unique and shared species among the main forest types (MFTs) in the Atlantic Forest of southeastern Brazil.

Ivanauskas et al. 2008 Acta Amaz. 38(3).

Floresta Estacional Perenifólia

Borda sul da Amazônia,
com maior amplitude geográfica
na região do Alto Rio Xingu



Figura 2 - Domínio amazônico, com destaque para a ecorregião das florestas secas de Mato Grosso (em cinza). Adaptado de Ferreira *et al.* (2001).

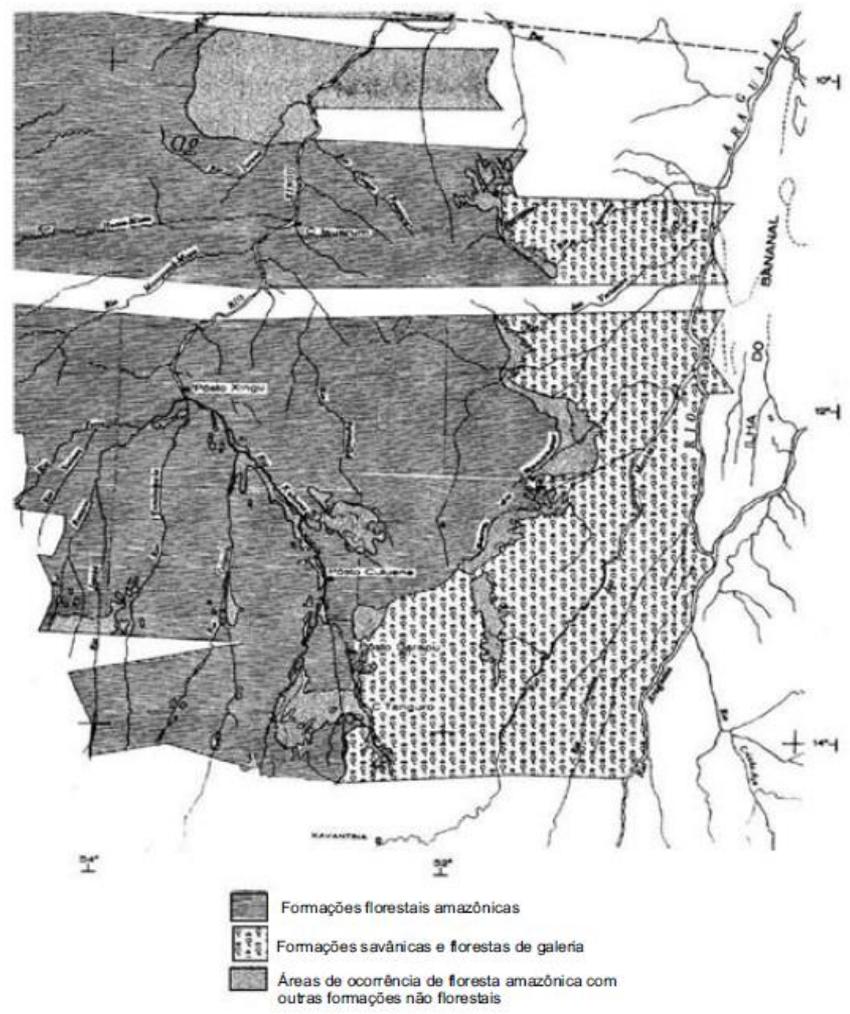


Figura 1 - Mapa fitofisionômico da região nordeste do Mato Grosso, com destaque para as formações florestais da Bacia do Alto Rio Xingu e para as formações savânicas da Bacia do Araguaia. Escala 1:2.000.000. Adaptado de Soares (1953). As faixas em branco representam áreas não cobertas pelas fotografias aéreas Trimetrogon (1942).

Floresta Estacional Perenifólia

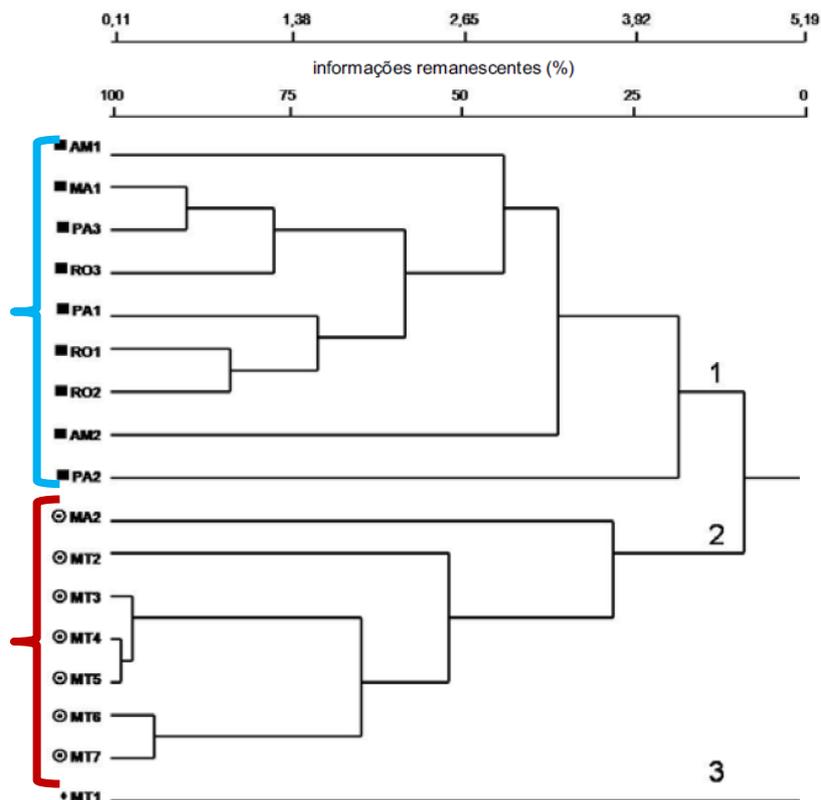
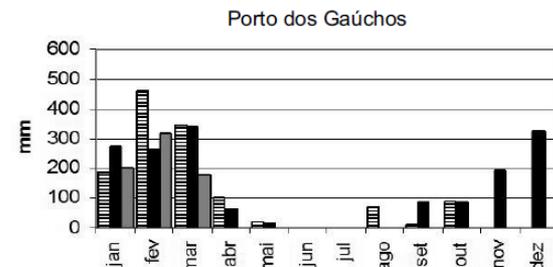


Figura 6 - Dendrograma de similaridade florística entre os levantamentos fitossociológicos realizados em áreas de Floresta Ombrófila e Floresta Estacional nos Estados do Amazonas (AM), Maranhão (MA), Pará (PA), Rondônia (RO) e Mato Grosso (MT), utilizando como coeficiente o índice de Sorensen e agrupando as localidades pelo método de média de grupo (UPGMA). ■ - Grupo 1, ⊙ - Grupo 2, ◆ - Trabalho isolado 3. As localidades



Totais pluviométricos mensais em 3 municípios - MT

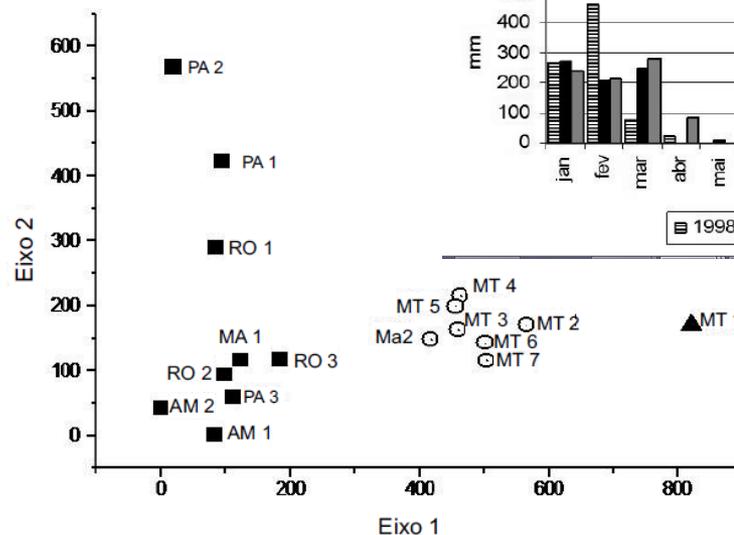
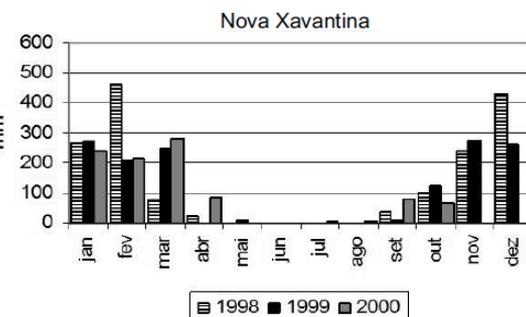
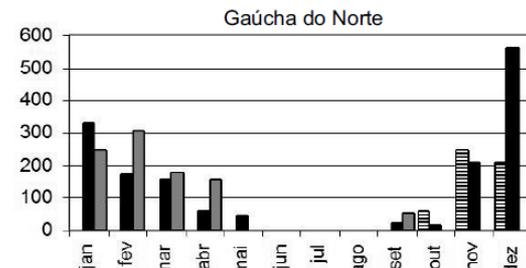


Figura 7 - Ordenação por análise de correspondência retificada (DCA) de áreas de Floresta Ombrófila e Floresta Estacional nos Estados do Amazonas (AM), Maranhão (MA), Pará (PA), Rondônia (RO) e Mato Grosso (MT). ■ - Grupo 1, ⊙ - Grupo 2, ▲ - Trabalho isolado. As localidades seguem o mesmo código

Diagonal de formações secas

Distribuição disjunta de vegetações tropicais secas na América do Sul

(Ecorregiões de Olson et al. 2001)

Moro et al. 2016



Fig. 1 Distribution of the disjunct seasonally dry tropical plant formations of South America (also called Seasonally Dry Tropical Forests - SDTF). The map shows the ecoregions of South America (as mapped by Olson et al., 2001) which are classified by Pennington et al. (2000) as SDTF. Cerrado and Chaco are also shown because enclaves of SDTF (Cerro Leon in Paraguay and “Matas Secas” in the Brazilian Cerrado) are reported to occur within their boundaries. The Bahia interior forests and Alto Paraná forests are usually considered part of the Atlantic Forest Domain, but they have more seasonal climates than the coastal, ombrophilous Atlantic forests and are considered by Pennington et al. (2000) as part of the SDTF biome. Map design: M.F. Moro



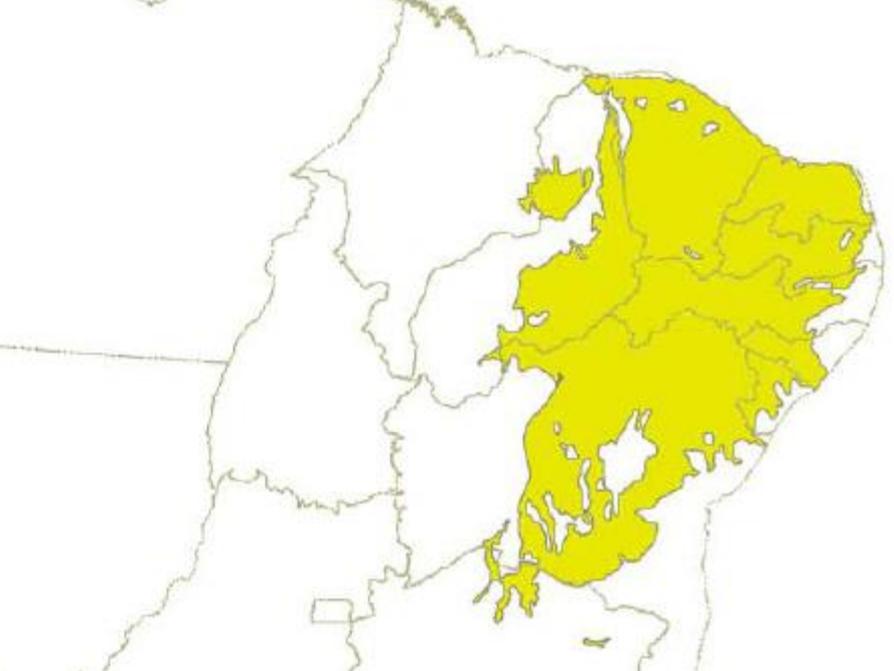
Biomas do Brasil

Caatinga

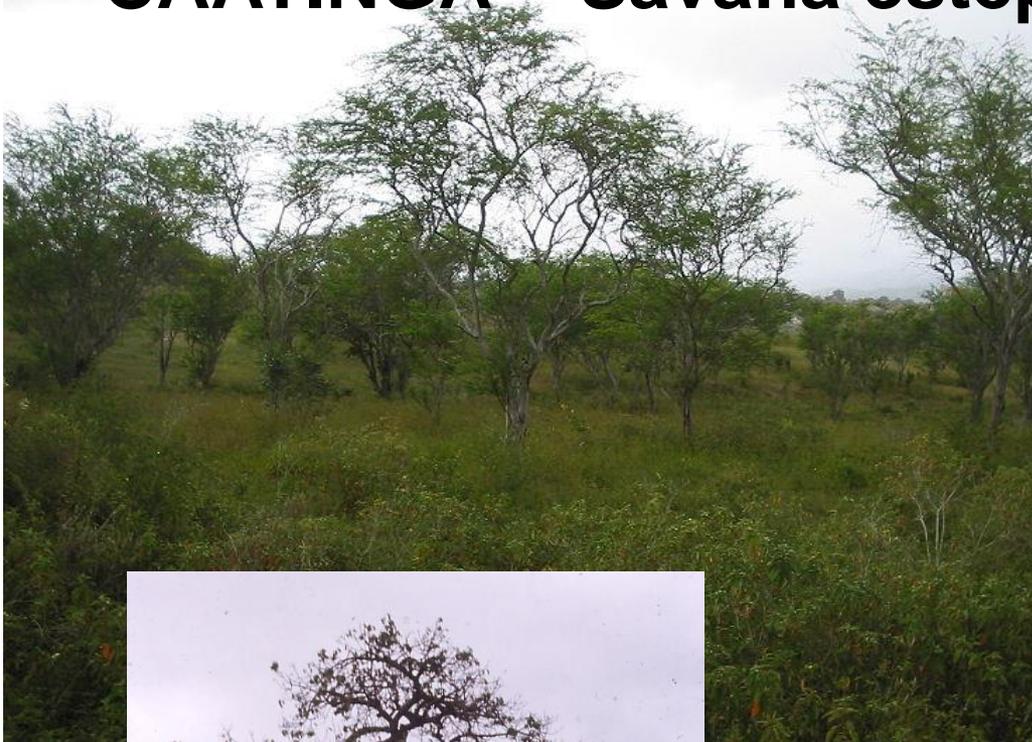
Savana estépica



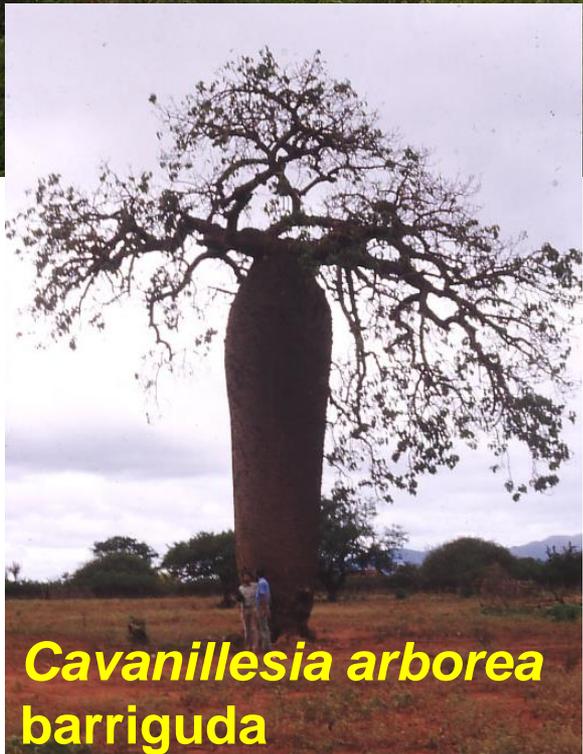
Pilosocereus gounellei
xique-xique



CAATINGA - Savana estépica



Copernicia cerifera
carnaúba

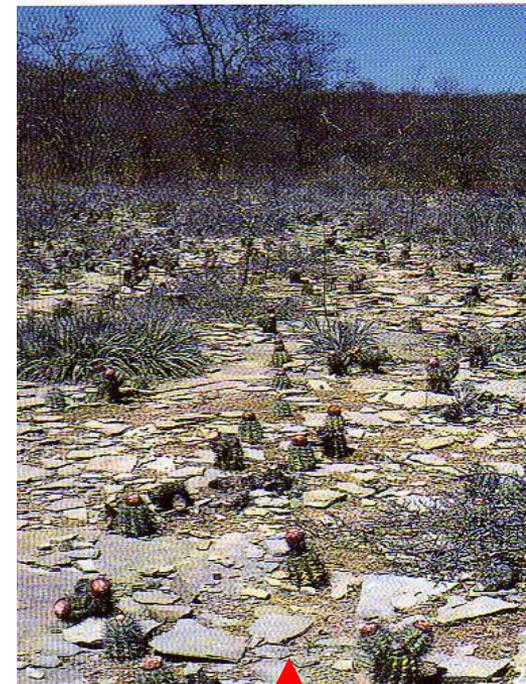


Cavanillesia arborea
barriguda



Pilosocereus

Perfil esquemático da Savana-Estépica



“Core” da Savana-Estépica (Caatinga)

1- Florestada; 2- Arborizada; 3- Parque, 4- Gramíneo-Lenhosa

Veloso et al. 1991

Caatinga cristalina (caatinga s.s.) no CEARÁ:

Estação chuvosa A e C (General Sampaio)



Estação seca: B e D (B - General Sampaio,
D - Pentecoste)



Moro et al. 2016

Habitats sedimentares na Caatinga:

B, C: P.N. Serra da Capivara (PIAUÍ): B chapadões; C. habitat rupestre



D, E - Dunas continentais do São Francisco (BAHIA)



Domínio fitogeográfico da Caatinga

Mostrando os terrenos predominantemente **cristalinos**, terrenos predominantemente **sedimentares** (destacando os terrenos **cársticos**).

Hachurado: áreas ecotonais com domínios adjacentes (Cerrado e Mata Atlântica) e a Chapada Diamantina (com caatinga, cerrado, campo rupestre e manchas de floresta).

Moro et al. 2016

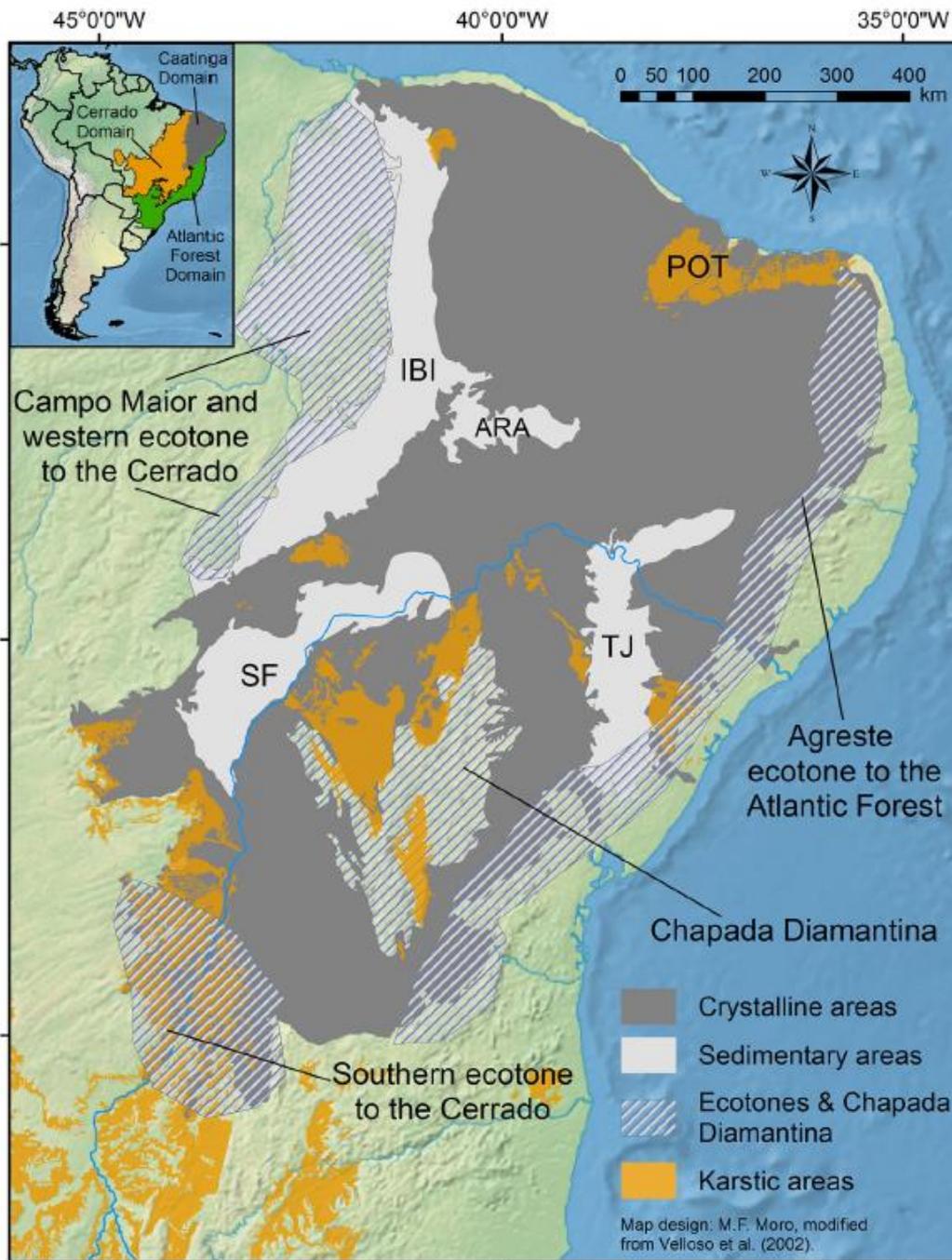
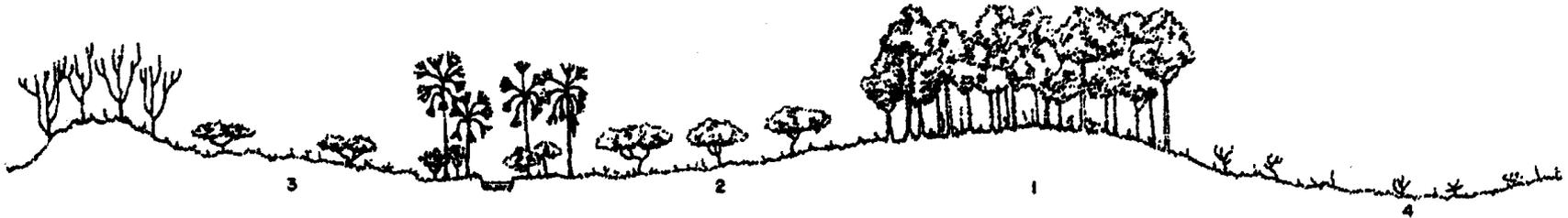


Fig. 2 Geographical location of the Caatinga Phytogeographical Domain (CPD) in northeastern Brazil. The CPD is surrounded by the Atlantic Forest Domain to the east and the Cerrado Domain to the west. The areas within the CPD with predominantly crystalline geology are represented in dark gray, whereas areas where the predominant geology is sedimentary are represented in light gray. The enclaves of karstic terrains (brown areas) within and around the CPD are also shown. The main ecotonal areas of the CPD are hatched, as is the Chapada Diamantina highland in the middle of the CPD, where caatinga, cerrado and campos rupestre (rocky grasslands) vegetation mix. The main sedimentary areas within the CPD are: *TJ* Tucano-Jatobá sedimentary basin; *IBI* Ibiapaba sedimentary basin; *ARA* Araípe sedimentary basin; *SF* São Francisco Continental Dunes; *POT* Potiguar sedimentary basin, a basin with abundance of karstic deposits. The CPD map is modified from Velloso et al. (2002). Map design: M.F. Moro

Perfis Esquemáticos da Savana-Estépica



“Core” da Savana-Estépica (Caatinga)



Disjunção da Savana-Estépica (Campos de Roraima) - Embasamento arenítico litólico com derrame basáltico



Disjunção da Savana-Estépica (Chaco) - Áreas aluviais (Depressão Quaternária)

1- Florestada; 2- Arborizada; 3- Parque, 4- Gramíneo-Lenhosa

Distribuição dos “brejos” nordestinos

Andrade-Lima 1982

- encaves de floresta úmida no domínio da Caatinga

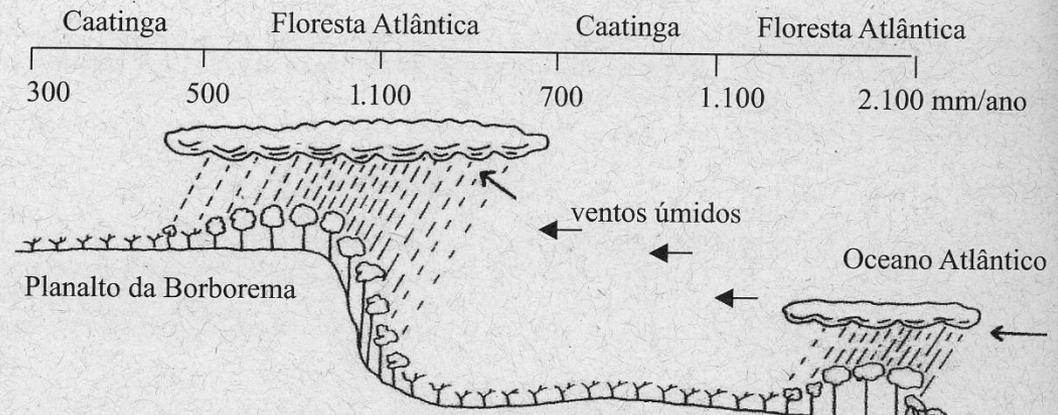
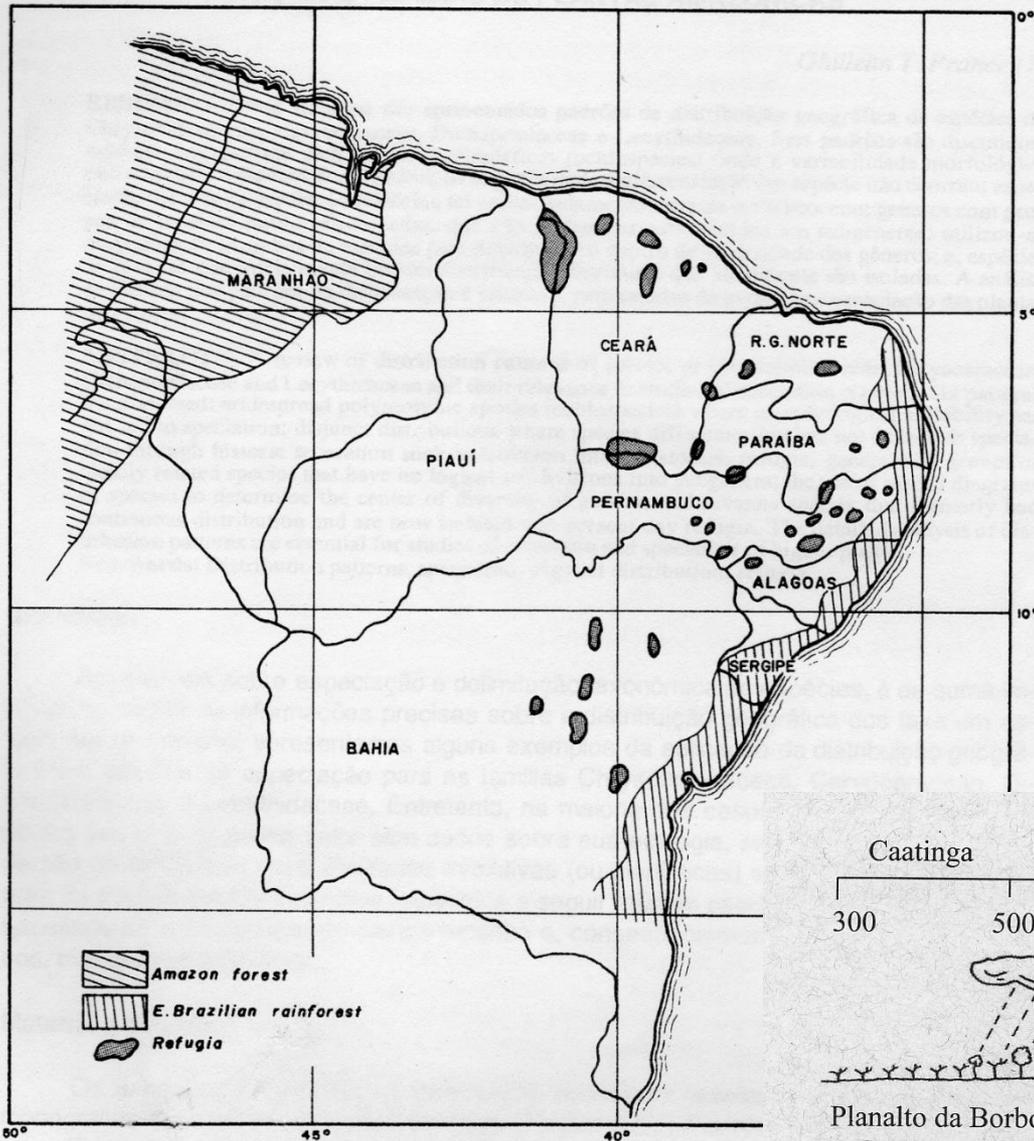


Figura 2. Perfil esquemático dos brejos de altitude no Nordeste do Brasil.

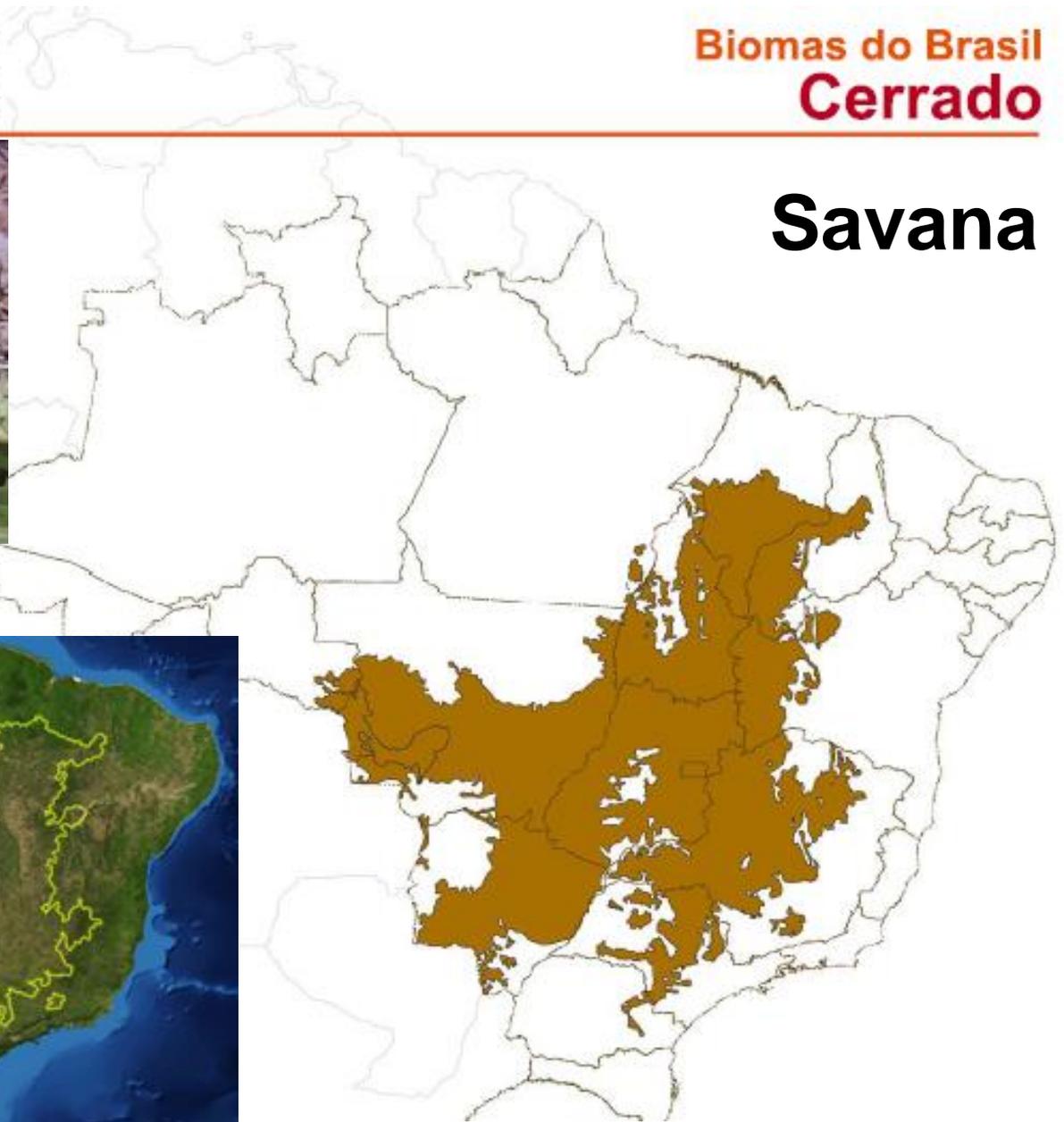
(Fonte: Adaptado de Mayo & Fevereiro 1982)



Savana

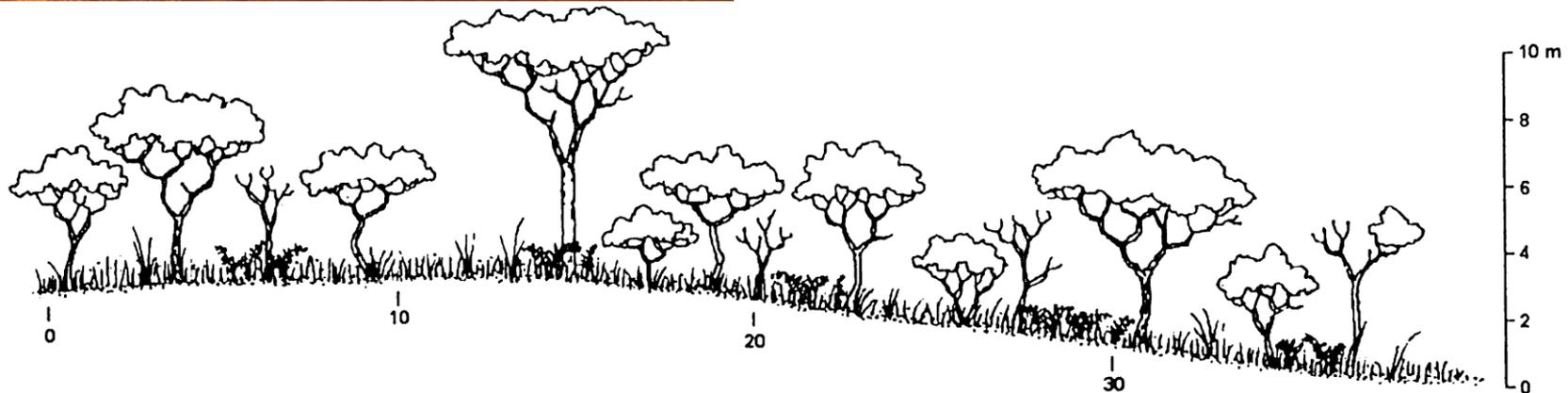


Caryocar brasiliense pequi



Savana cerrado

Distrito Federal

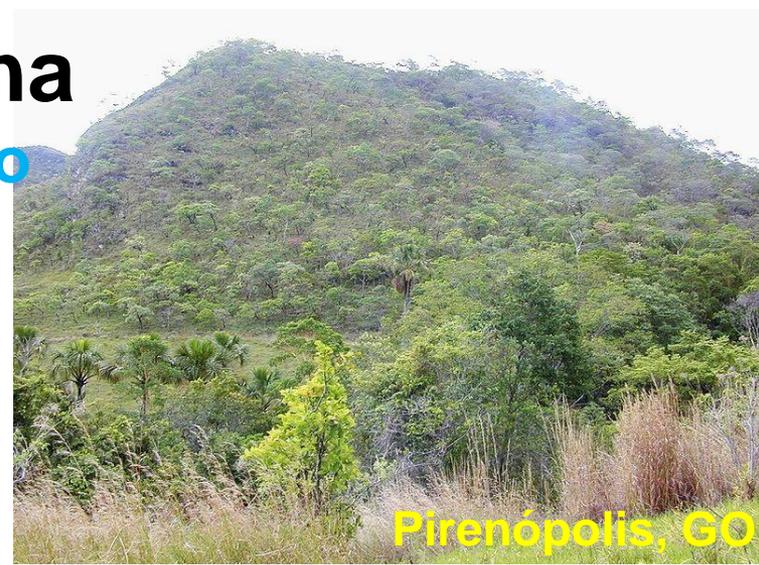


Perfil esquemático destacando a estrutura de um segmento de **Savana** no município de Jaguariaíva, Paraná, com predominância de *Stryphnodendron*, *Anadenanthera*, *Couepia*, *Tabebuia*, *Annona*, *Caryocar* e *Qualea*.
Roderjan *et al.* 2002

Fig 16 - PERFIL ESQUEMÁTICO DA SAVANA (Cerrado)

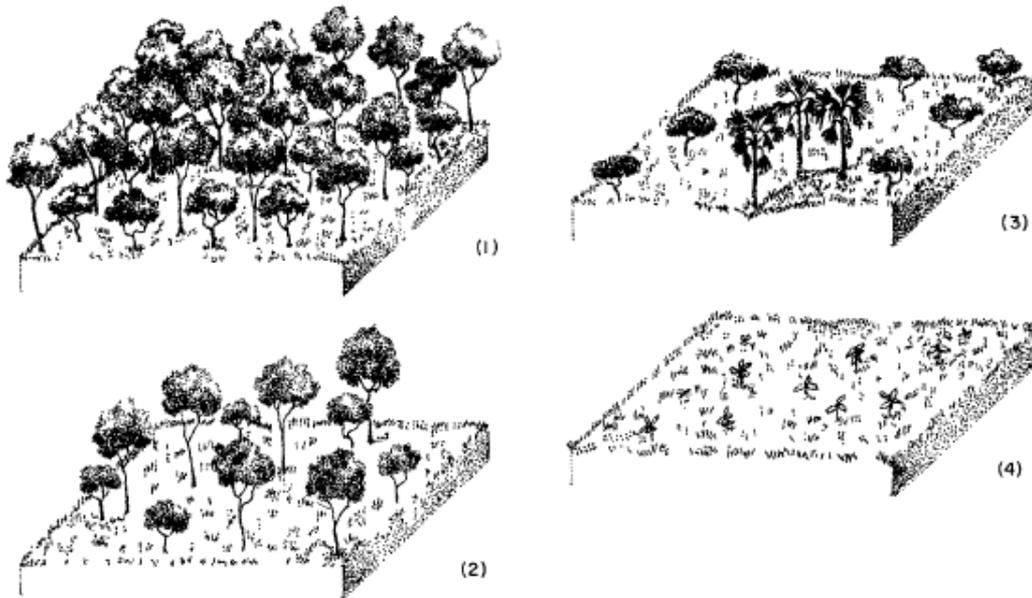


Savana cerrado



Pirenópolis, GO

Fig 17 - BLOCOS-DIAGRAMAS DAS FISIONOMIAS ECOLÓGICAS DA SAVANA (Cerrado)



1- Florestada- 2- Arborizada- 3- Parque- 4- Gramíneo- Lenhosa

ILUSTRAÇÃO DE REGINA JULIANELE



Handroanthus



Veloso et al. 1991

Savana cerrado



Figura 1. Representação gráfica, através de perfis de vegetação, do conceito "floresta-ecotono-campo" de cerrado.

“floresta-ecotono-campo”

Coutinho 1978
O conceito de cerrado

Pirenópolis, Goiás



Savana

cerrado

Jalapão, Tocantins



Annona warmingiana



Gomphrena macrocephala

APA do Lajeado, Campo Grande, MS

VEREDA



Savana cerrado

Serra das Flores, CE



SAVANAS do mundo: recentes (ca. 3 a 10 milhões de anos)

Diferem em fenologia, resistência ao fogo,
crescimento e arquitetura das lenhosas.

Savanas africanas: dominância de leguminosas;
megafauna expressiva.

Savanas australianas: dominância de mirtáceas;
megafauna pouco expressiva.

Cerrados: flora bem mais diversificada, sem uma família dominante;
megafauna pouco expressiva.

Estação seca
muito mais pronunciada



SAVANAS:

Diferenças funcionais:

Relação mais fraca de temperatura e chuvas com a vegetação nas savanas neotropicais

África e Austrália: chuvas e temp. têm efeito forte em aumentar a frequência do fogo (propiciando aumento da biomassa de herbáceas).

Solo: equilíbrio da fração argilosa mais variável entre subáreas do cerrado do que nas savanas africanas e australianas.

Relações variáveis

Fatores ambientais têm atuação distinta conforme o continente

Um modelo que mapeia o efeito das chuvas, do solo e da temperatura sobre a frequência de incêndios e a biomassa das árvores mostra o peso dos fatores ambientais na savana de cada continente. Traços mais grossos indicam influência mais forte. O fogo tem um leve impacto direto, negativo, diminuindo a biomassa

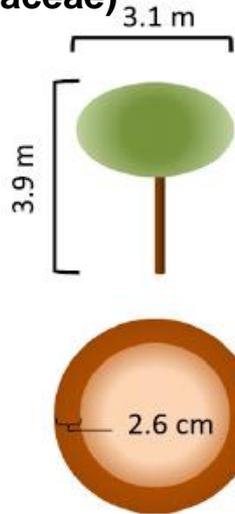


FONTE SCIENCE



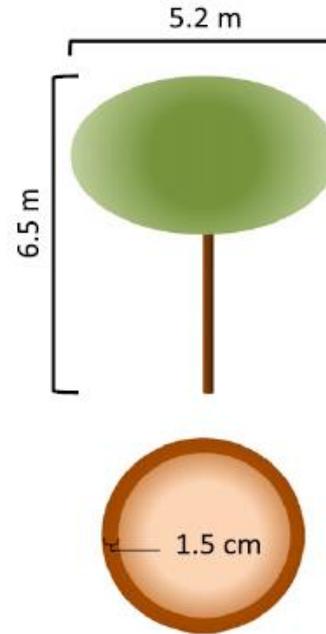
Lehmann et al. 2014

Malpighiaceae,
Melastomataceae,
Mimosoideae,
Qualea (Vochysiaceae)

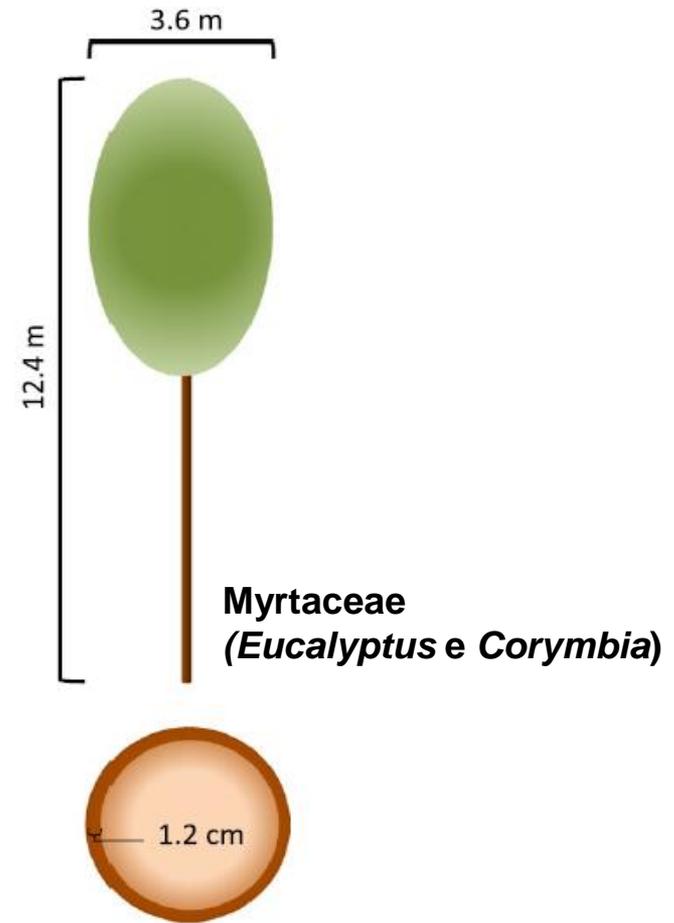


South America

Caesalpinioideae,
Mimosoideae,
Combretaceae



Africa



Myrtaceae
(*Eucalyptus* e *Corymbia*)

Australia

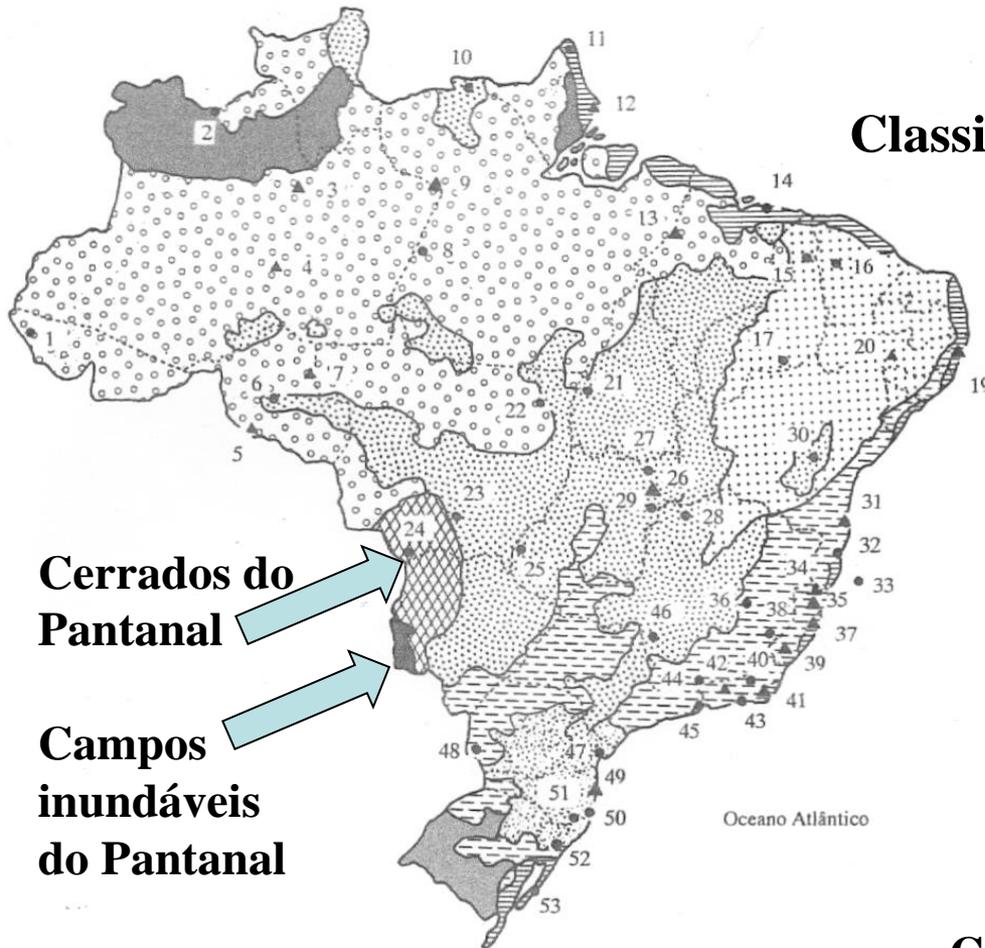
Figure 1 Comparative architecture of savanna trees from three continents. Canopy diameter, tree height and bark thickness are shown at 20 cm stem diameter summarizing data from Moncrieff *et al.* (2014a), Dantas & Pausas (2013) and Lawes *et al.* (2011). Allometries are drawn to scale except bark thickness, which is exaggerated by a factor of 2 relative to stem diameter in the diagram. The extensive savannas now found in South America, Africa and Australia evolved in the late Miocene (c. 5–8 Ma, Beerling & Osborne, 2006) long after Gondwana began to break-up; circa 184 Ma. The tree flora of each continent has thus been independently assembled. Savanna trees evolved in situ on each continent from ancestors in closed-canopy forests and sclerophyll biomes (Simon *et al.*, 2009; Bouchenak-Khelladi *et al.*, 2010; Crisp *et al.*, 2011; Maurin *et al.*, 2014). Thus, different clades characterize different continents, with Mimosoideae, Melastomataceae and Malpighiaceae and the genus *Qualea* common in South American Cerrado, Myrtaceae (particularly *Eucalyptus* and *Corymbia*) often dominant in Australian savannas and Mimosoideae, Caesalpinioideae and Combretaceae common throughout African savannas.

PANTANAL

complexo inundável no domínio dos cerrados



Classificação da vegetação brasileira no livro *Geografia do Brasil* de Ross (1998)



**Cerrados do
Pantanal**

**Campos
inundáveis
do Pantanal**

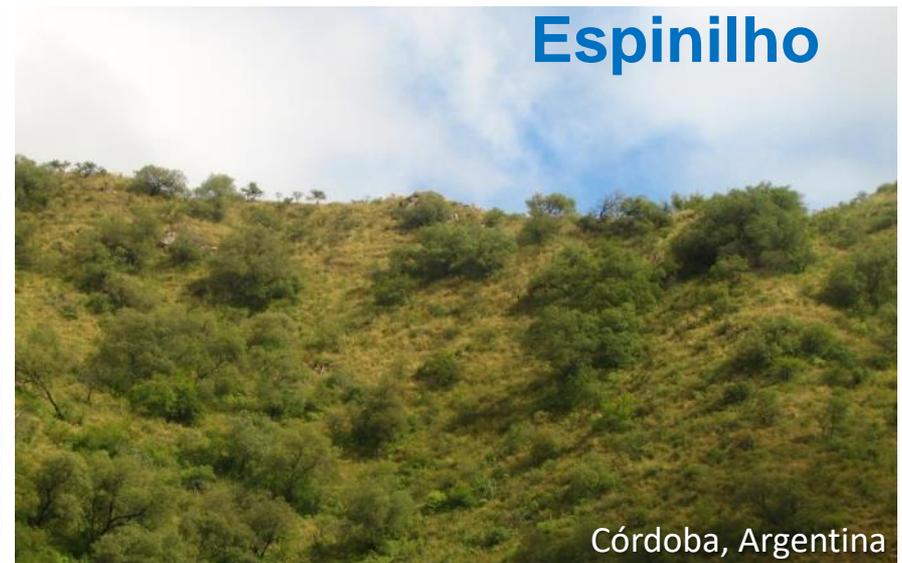
- Parques
- ▲ Reservas

Classificação da vegetação natural

	Florestas amazônicas		Mata de araucárias (pinheiral)
	Campos amazônicos ou campinaranas		Cerrados do Pantanal
	Matas atlânticas		Pantanal (campos inundáveis)
	Cerrado		Campo limpo
	Caatinga		Mangues, restingas, jundus

Conti & Furlan 1998
fonte: Sampaio & Furlan 1993

Savanas na América do Sul: tropicais até subtropicais (espinilho)





Estepe



Aristida jubata



Fig 20 - PERFIS ESQUEMÁTICOS DA ESTEPE

Veloso et al. 1991

Estepe

Campanha gaúcha
Pampas



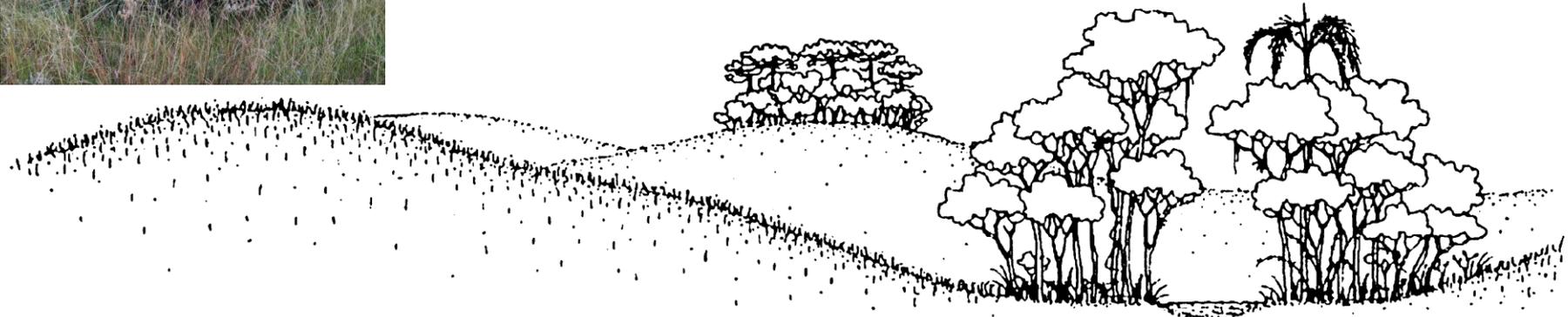
Core da Estepe (Campanha Gaúcha):
1 Arborizada 2 Parque 3 Gramíneo Lenhoso



Disjunção da Estepe (Uruguiana) Embasamento arenítico litólico:
1 Parque 2 Gramíneo Lenhoso



Emb. arenítico litólico

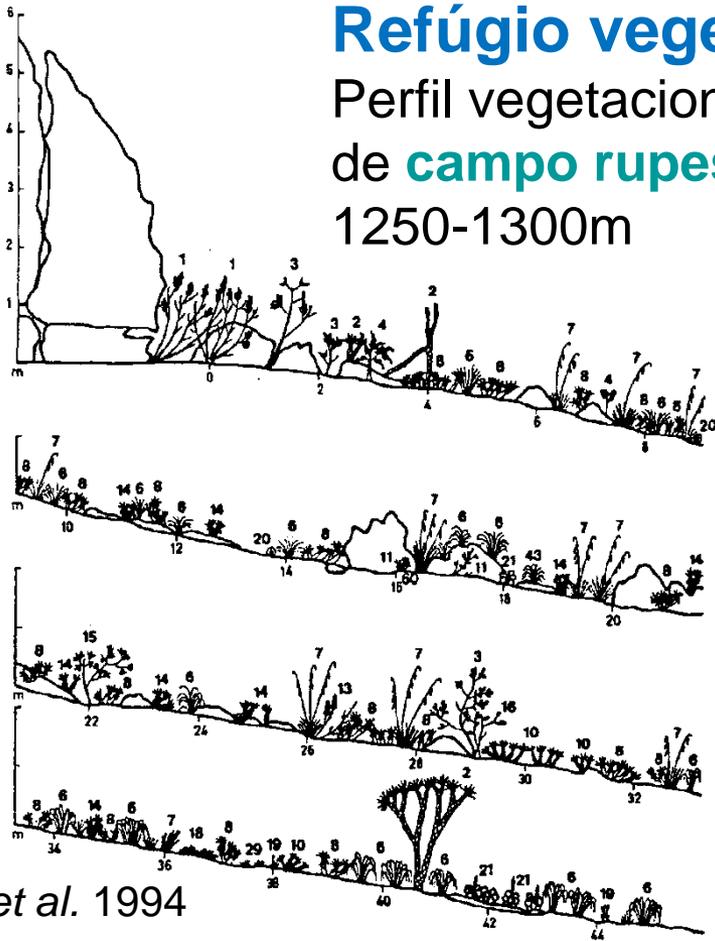


Perfil esquemático representativo da **Estepe**, onde predominam formações herbáceas entremeadas por vegetação ripária (à direita) e agrupamentos arbóreos isolados (os capões, ao fundo).

Roderjan et al. 2002

Refúgio vegetacional

Perfil vegetacional
de **campo rupestre, MG**
1250-1300m



Meguro *et al.* 1994



Classificação da vegetação: polêmica

Vegetação dominante sobre os substratos arenosos e pedregosos de serras do Brasil Central:

campo rupestre

Magalhães 1966, Joly 1970, Eiten 1983, Giulietti *et al.* 1987, 1997, Meguro *et al.* 1994, Pirani *et al.* 1994, 2014; Harley 1995, Rapini *et al.* 2009, Vasconcelos 2011

campo quartzítico

Rizzini 1979, Semir 2000

refúgio ecológico montano

Veloso *et al.* 1991



Vegetação em montanhas ou relevo acidentado: grande heterogeneidade ambiental, mosaico de fitofionomias: campestres no topo, mais densas nas encostas (matas montanas e nebulares)



Rio Grande do Sul, Brasil



Santa Catarina, Brasil



La Paz, Bolivia

montanhas e afloramentos rochosos...



Bahia, Brasil



Rio de Janeiro, Brasil



Espírito Santo, Brasil



Rio Grande do Sul, Brasil

Combining climatic and soil properties better predicts covers of Brazilian biomes

Arruda et al. 2017

500 quadrículas de 100 km² em 10 biomas do mapa da vegetação (IBGE 2004).
38 (climatic and soil-related) predictors

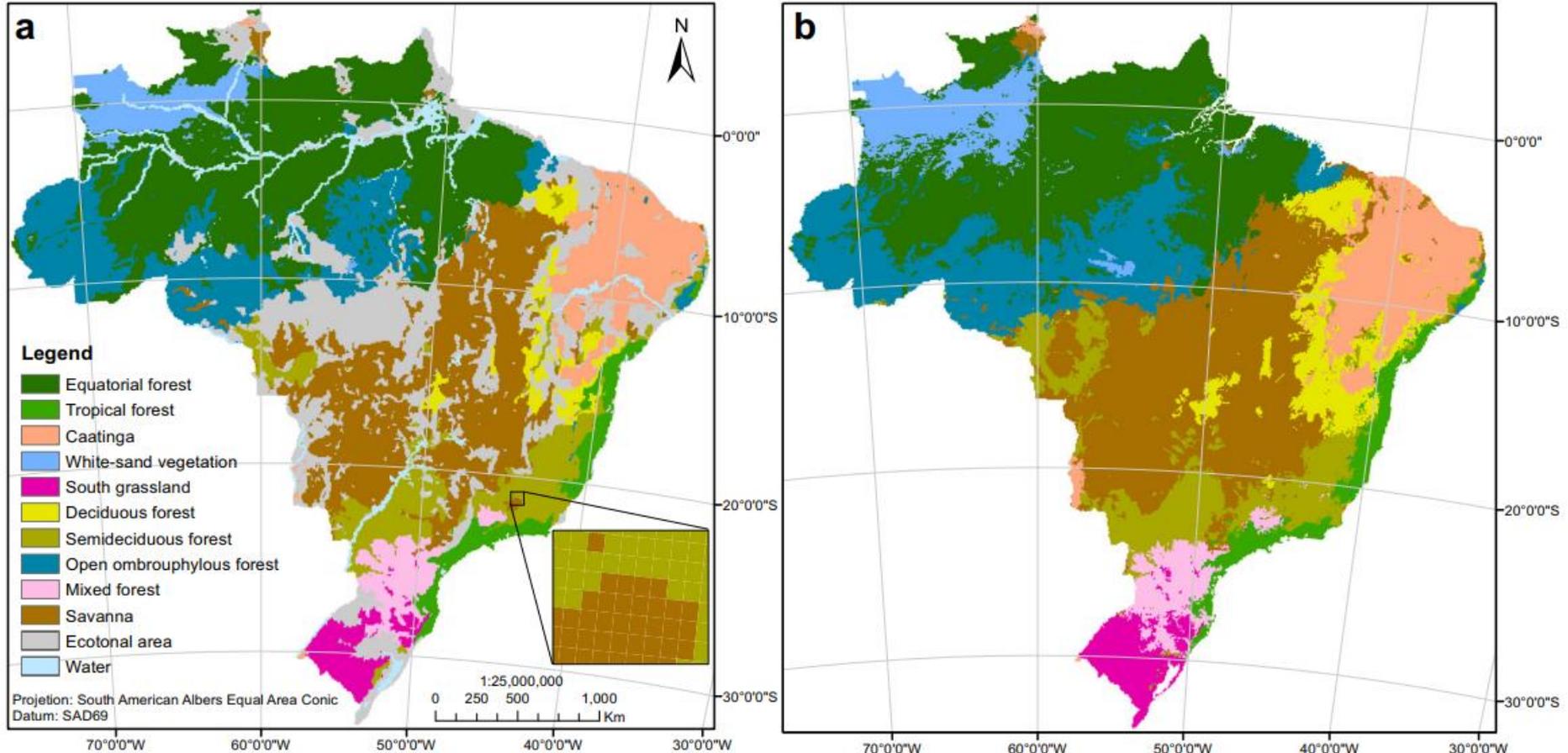


Fig. 1 a Grid map (10-km grid squares) of Brazilian biomes, derived from the Vegetation Map of Brazil (IBGE 2004). b Distribution of the Brazilian biomes based on predictions of the soil-climate model

The climate and soil predictors are complementary, for covering different parts of the multidimensional niche. Thus, a single biome can cover a wide range of climatic space, versus a narrow range of soil types, so that its prediction is best adjusted by soil-related variables, or vice versa.

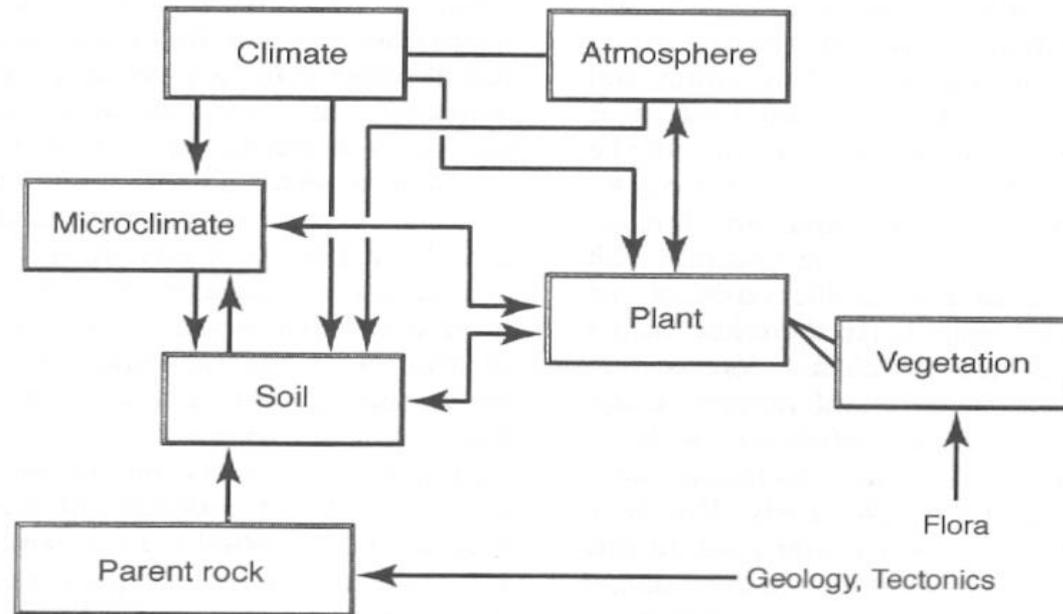
Millington *et al.* 2011

Figure 8.7 Simplified sketch of interrelationships between vegetation and site factors (after Walter, 1986; Walter and Breckle, 1999, modified)

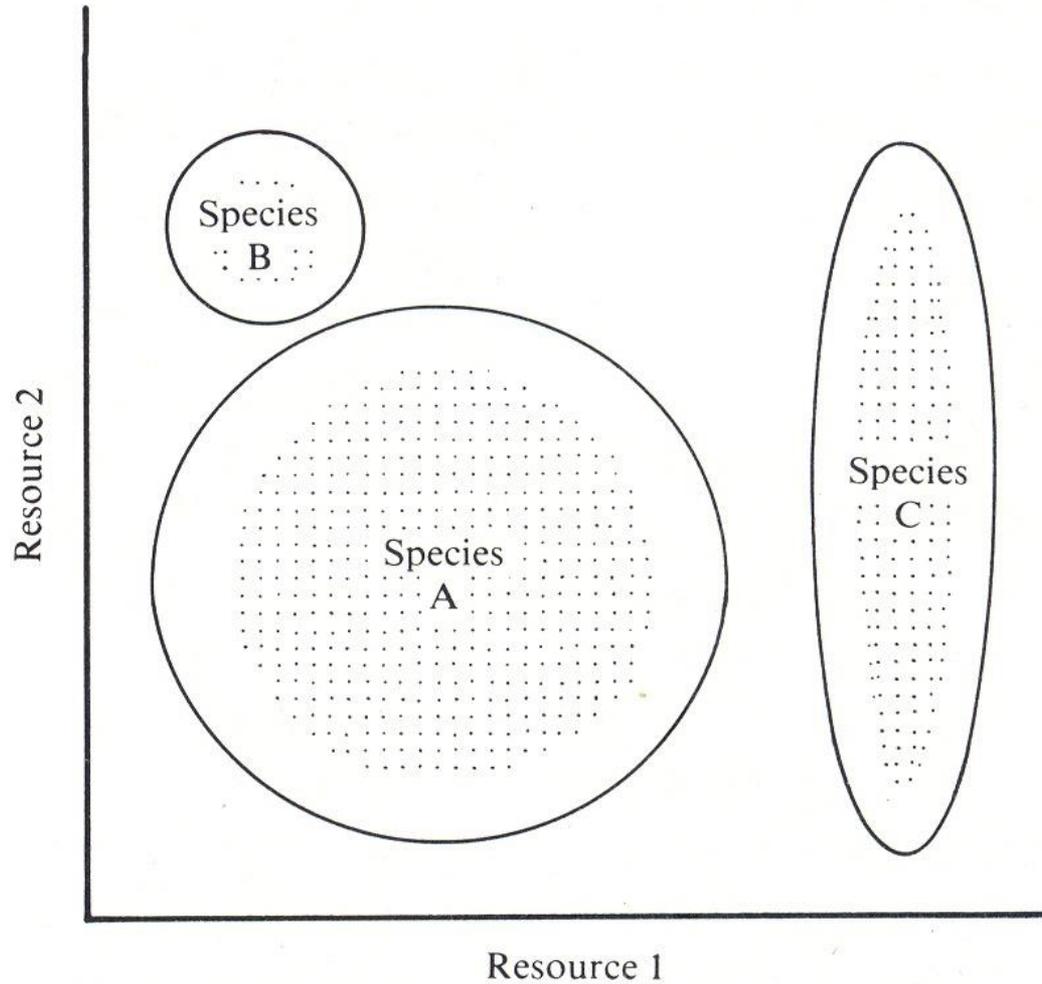
- Fatores limitantes da distribuição geográfica de espécies ?

BIOGEOGRAFIA ECOLÓGICA

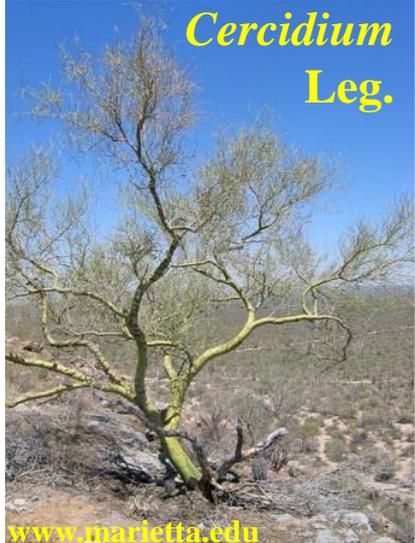
Limites da distribuição de espécies:

- **incapacidade de dispersão**
- **limites locais são determinados por fatores ecológicos que impedem a expansão das populações**
- **limites locais por interações bióticas**

Maioria dos modelos explicativos carece de evidência empírica!



Diagrams of two dimensions of the niches of three hypothetical species. Circles indicate the extreme ranges of the two resources used by each species, and stippled areas show that the central parts of the niche spaces provide the most favorable environment.



www.maricopa.edu

Cercidium
Leg.

● *Cercidium microphyllum*



● *Opuntia fulgida*

○ *O. cholla*

Distributions of endemic Sonoran Desert plants: the green-stemmed tree (*Cercidium microphyllum*), and the related cholla cacti (*Opuntia fulgida* and *O. cholla*). Note that the northern and eastern limits of the ranges correspond closely to the margin of the Sonoran Desert vegetation as a whole (*hatching*), which in turn is highly correlated with low temperatures owing to increasing latitude and elevation. (Redrawn from Hastings et al., 1972.) **Brown & Gibson 1983**

(A)



(B)

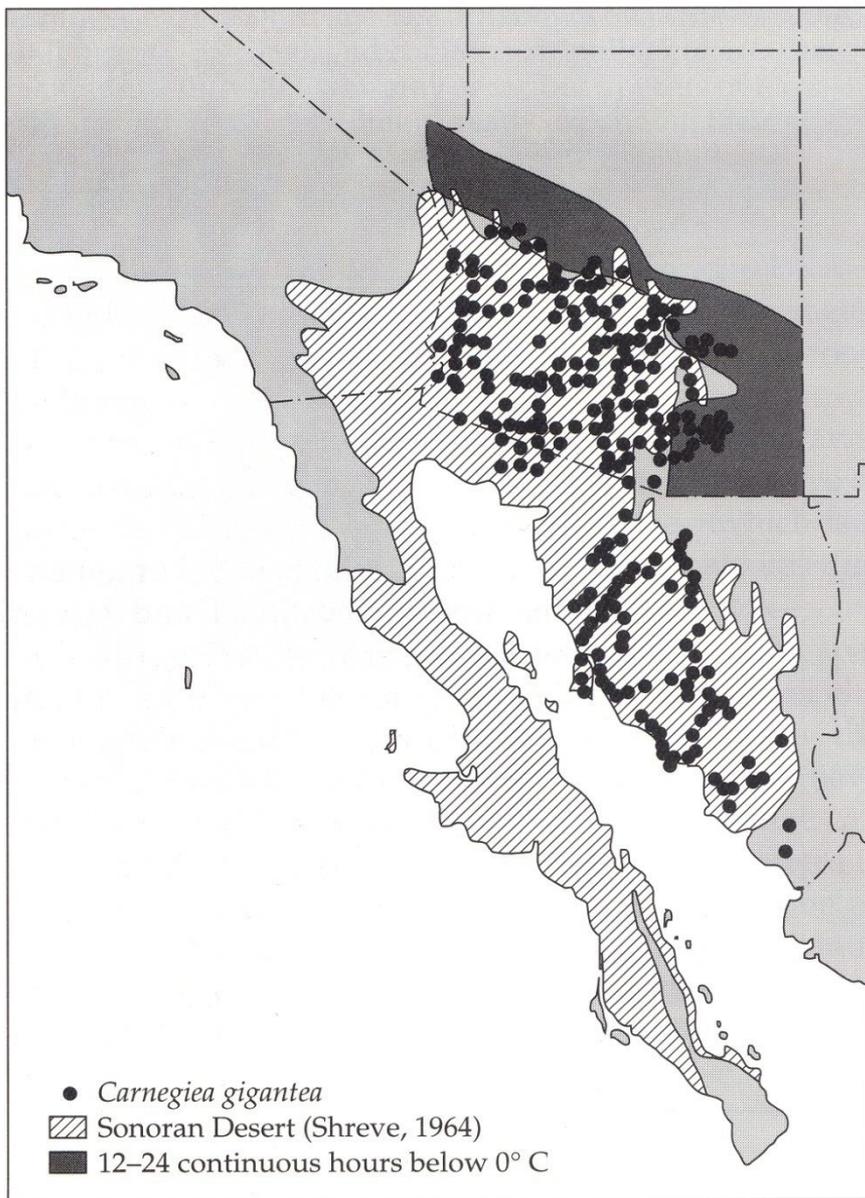


(C)



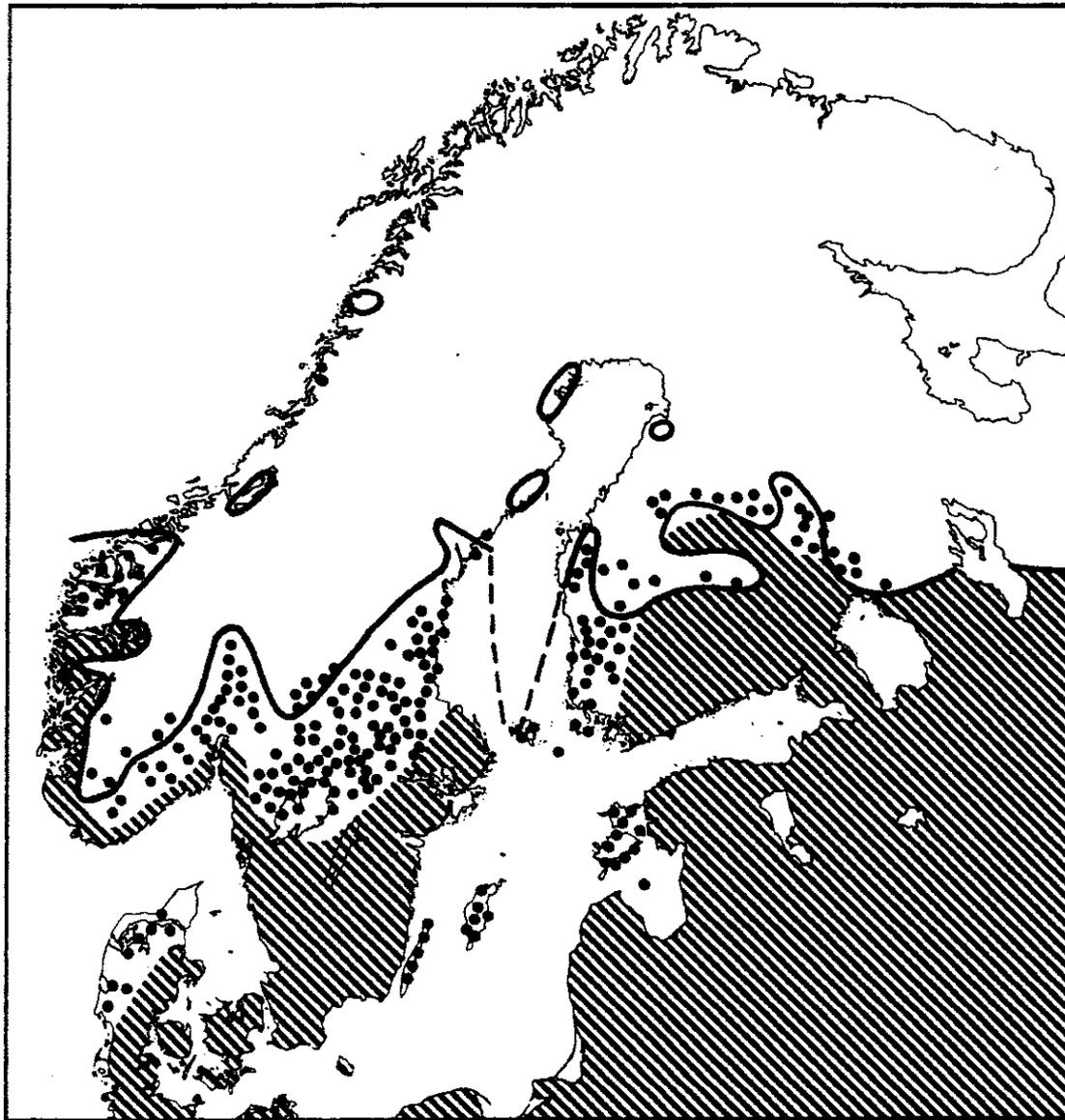
Matched photographs of a stand of saguaro cacti near Redington, Arizona, near the upper elevational and northern edge of the species range. (A) In 1961. (B) In 1966, showing the loss of one large individual (center foreground) and scars (white patches near tips of arms) on several others as a result of severe frost in 1962. (C) In 1979, showing much additional mortality due to severe frosts in 1971 and 1978; several of the individuals still standing are dead or dying. (A and B courtesy of J. R. Hastings; C courtesy of R. M. Turner.)

Brown & Gibson 1983



The distribution of the **saguaro cactus** (*Carnegiea gigantea*) in relation to winter temperature regime. This cactus, like many other Sonoran Desert plants, is intolerant of prolonged freezing. Note the close correspondence between the northern limit of the saguaro, the northern boundary of the Sonoran Desert, and the region where temperatures remain below 0° C for more than 12 hours. (Data from Hastings and Turner 1965; Hastings et al. 1972).

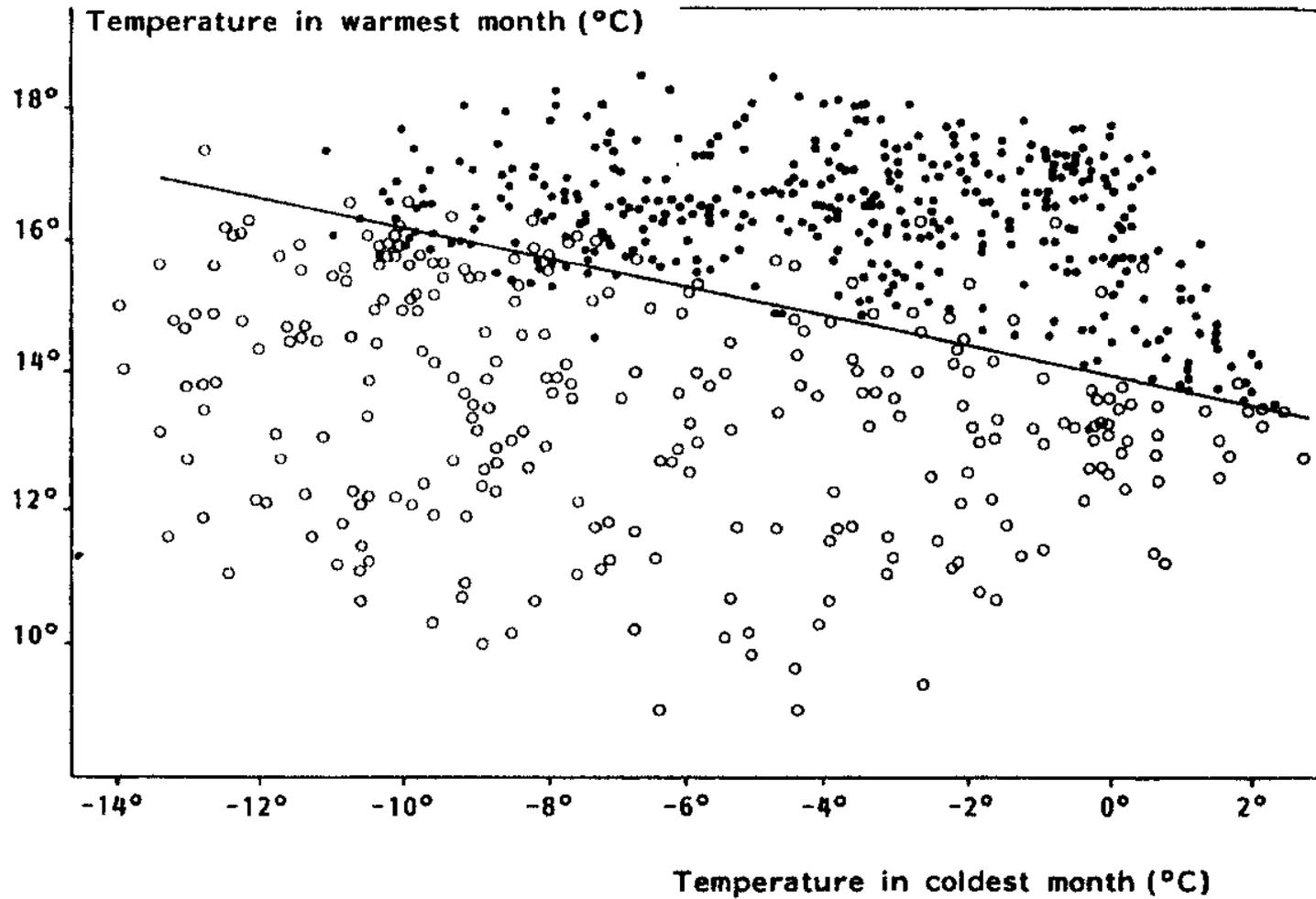
Brown & Gibson 1983



Geographical range margin of *Tilia cordata* translated from the straight line in Figure 42 (after Hintikka, 1963).

Hengeveld 1990

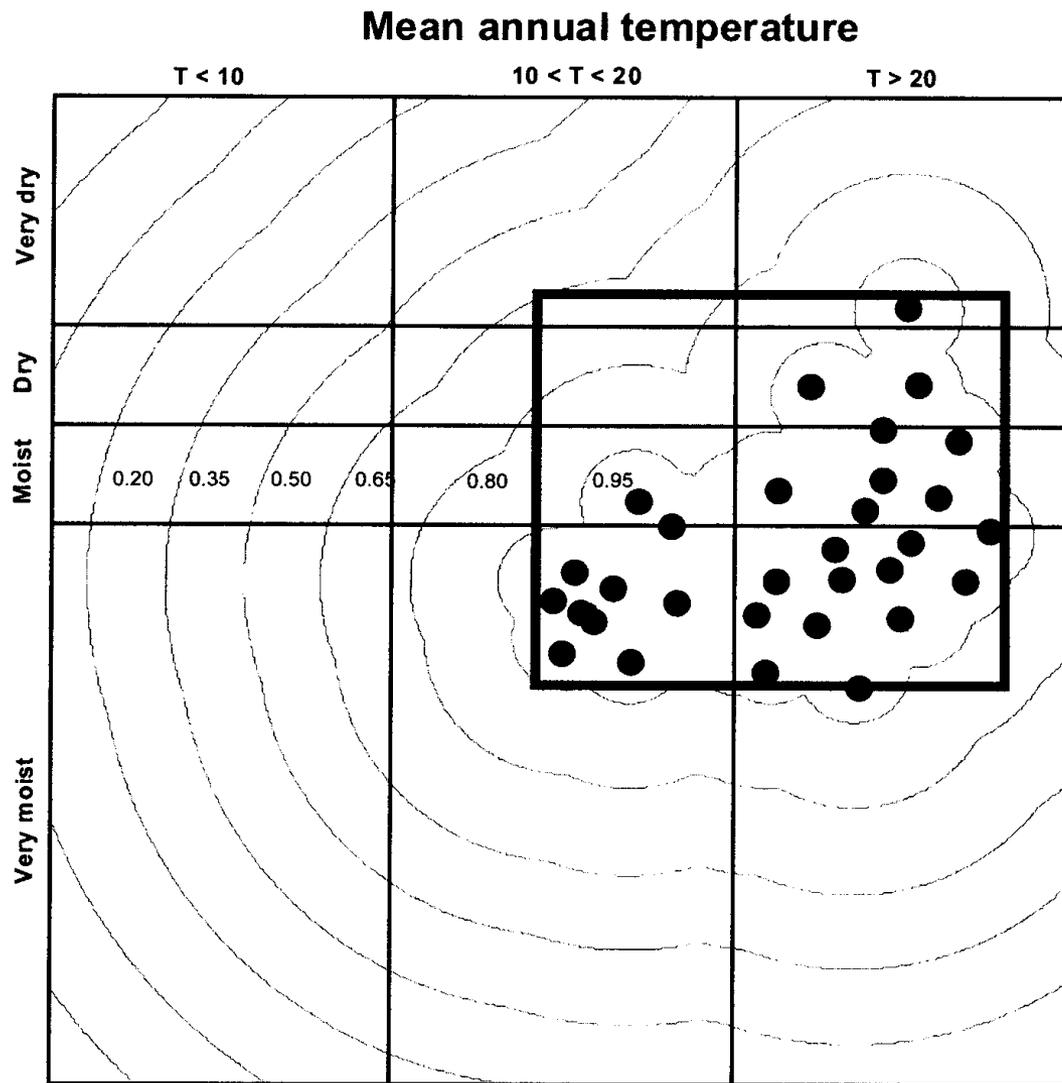
Areography: the analysis of species ranges



The same as Figure 41 for *Tilia cordata* in Fennoscandia. Dots indicate locations within the range, circles those outside (after Hintikka, 1963).

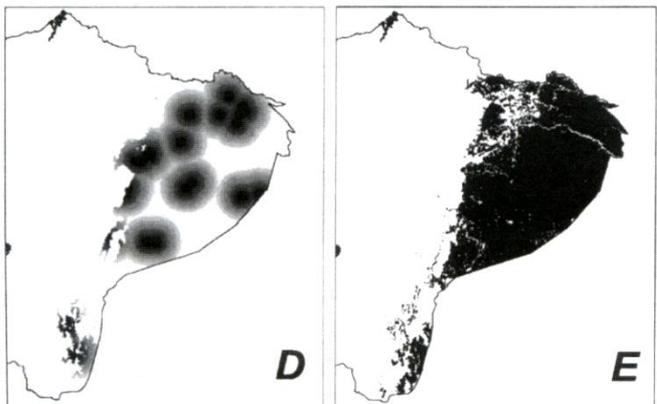
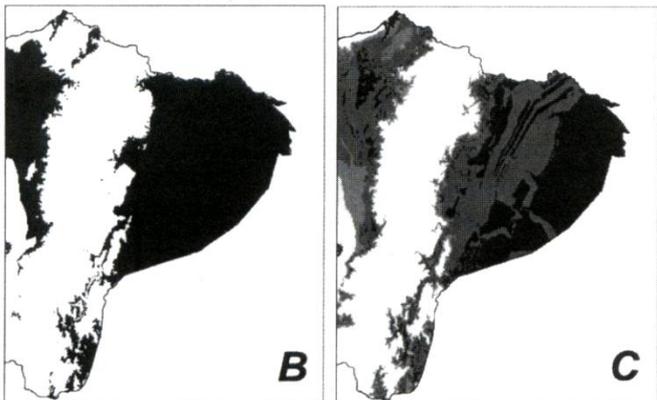
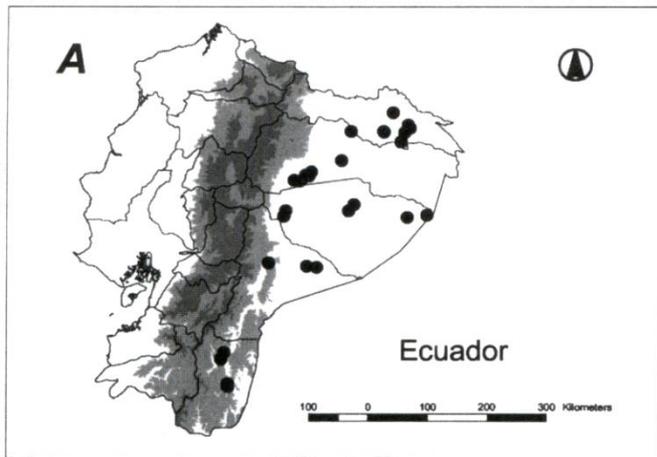


Humidity



The distribution of the palm species *Chamaedorea linearis* in a two-dimensional environmental space (y-axis corresponds to humidity and x-axis to mean annual temperature). Dots represent individual collections. The climatic envelope model is represented by the rectangle that encloses all dots. Isolines indicate how close a given combination of humidity and temperature is to known localities using the point-to-point similarity model (numbers indicate distance).

Skov 2000



A series of potential distribution maps of *Chamaedorea pauciflora*.

A, distribution of known records from Ecuador, altitudes above 1,200 (light grey) and 3,000 meters (dark grey) are shaded to indicate the outline of the Andes;

B, potential distribution based on the climatic envelope model;

C, potential distribution based on point-to-point similarities;

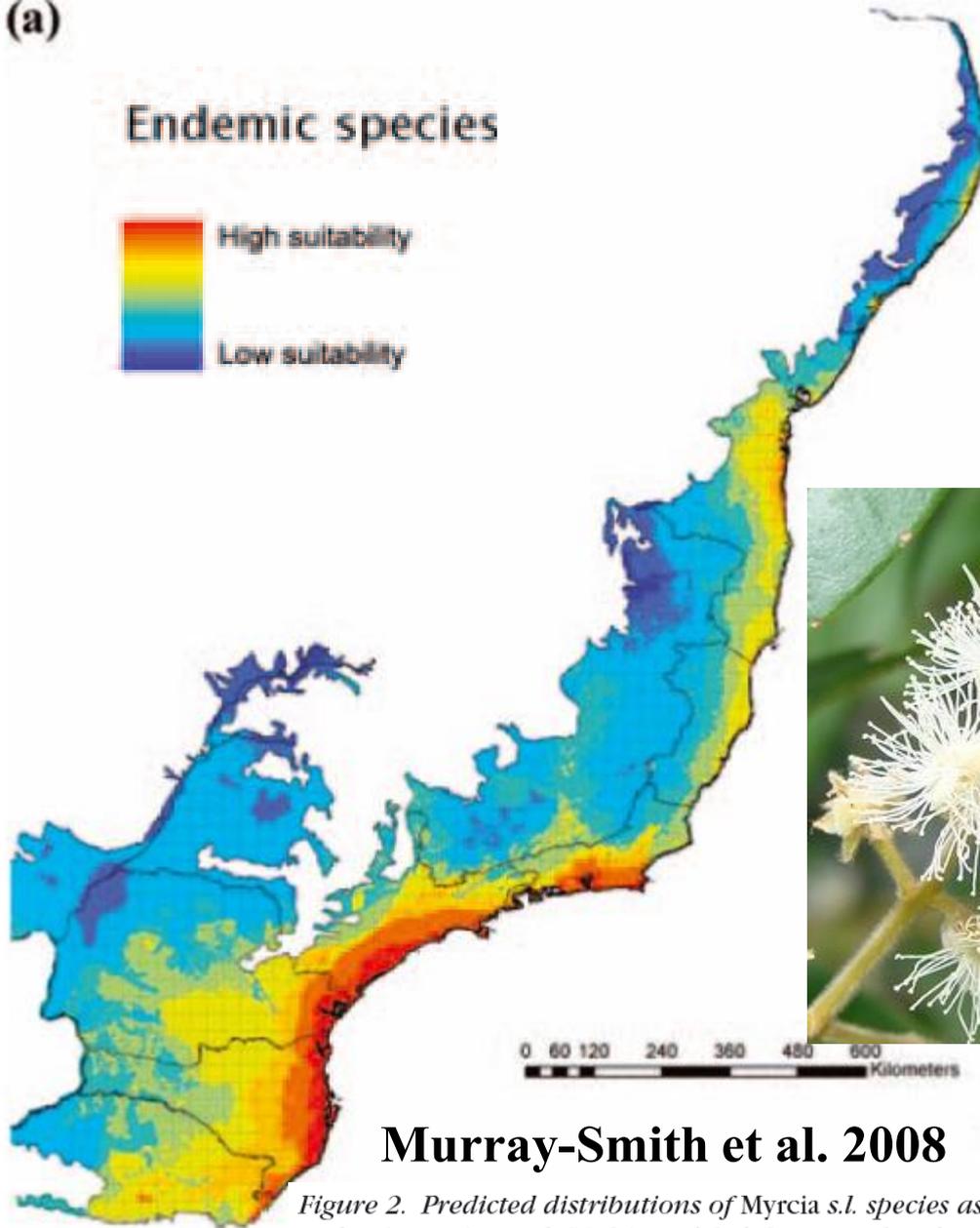
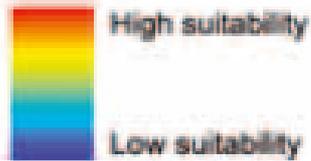
D, potential distribution map based on the climatic envelope model with distance weighting;

E, potential distribution map based on the climatic envelope model where areas with unsuitable habitats have been removed.

Skov 2000

(a)

Endemic species



Distribuição potencial
de 57 espécies endêmicas
modeladas de *Myrcia*
(Myrtaceae)



Murray-Smith et al. 2008

Figure 2. Predicted distributions of *Myrcia* s.l. species as portrayed in summed suitability maps of (a) 57 modeled endemic species and (b) 31 modeled threatened endemic species (each pixel within the grid has a probability value on an arbitrary suitability scale from blue [very unsuitable conditions] to red [highly suitable conditions]).

TABLE 2. Average index of frost damage of species in decreasing order.

Species	Index	% species in area	% individuals in plot	
<i>Miconia albicans</i>	98.5			
<i>Xylopia aromatica</i>	71.0	4%	1%	totally damaged
<i>Casearia silvestris</i>	30.5			
<i>Davilla elliptica</i>	25.0			
<i>Connarus suberosus</i>	22.6			
<i>Guapira noxia</i>	19.5			
<i>Tocoyena brasiliensis</i>	19.0			
<i>Piptocarpha rotundifolia</i>	15.6			
<i>Aegiphila paraguariensis</i>	14.2	26%	16%	substantially damaged
<i>Plathymenia reticulata</i>	11.9			
<i>Kielmeyera rosea</i>	11.0			
<i>Hancornia speciosa</i>	10.9			
<i>Caryocar brasiliense</i>	9.8			
<i>Byrsonima coccolobifolia</i>	9.6			
<i>Annona crassiflora</i>	8.3			
<i>Licania humilis</i>	5.9			
<i>Eriotheca gracilipes</i>	5.6			
<i>Diospyros hispida</i>	4.8			
<i>Styrax ferruginea</i>	3.8			
<i>Tabebuia caraiba</i>	3.7			
<i>Annona coriacea</i>	3.6			
<i>Myrcia lasiantha</i>	3.4			
<i>Dimorphandrea mollis</i>	3.0			
<i>Byrsonima</i> sp.	3.0	34%	24%	moderately damaged
<i>Stryphnodendron barbadetimum</i>	3.0			
<i>Guapira graciliflora</i>	2.7			
<i>Eugenia aurata</i>	2.6			
<i>Qualea grandiflora</i>	2.5			
<i>Psidium</i> sp.	1.8			
<i>Byrsonima verbascifolia</i>	1.7			
<i>Qualea multiflora</i>	1.3			
<i>Couepia grandiflora</i>	1.1			
<i>Boucdichia virgilitoides</i> H.B.K.	0.5			
<i>Stychnos pseudo-quina</i>	0.4			
<i>Machaerium acutifolium</i>	0.3			
<i>Sclerolobium aureum</i>	0.3			
<i>Erythroxylum tortuosum</i>	0.3			
<i>Tocoyena formosa</i>	0.2	18%	15%	slightly damaged
<i>Ouatea spectabilis</i>	0.2			
<i>Roupala montana</i>	0.1			
<i>Peritasta campestris</i>	0.1			
<i>Bauhinia rufa</i>	0.0			
<i>Erythroxylum suberosum</i>	0.0			
<i>Anadenanthera falcata</i>	0.0			
<i>Tabebuia ochracea</i>	0.0			
<i>Plenckia populnea</i>	0.0	18%	44%	not damaged
<i>Acotium subelegans</i>	0.0			
<i>Byrsonima intermedia</i>	0.0			
<i>Kielmeyera coriacea</i>	0.0			
<i>Aspidosperma tomentosum</i>	0.0			

Cerrado de Botucatu, SP



MELASTOMATACEAE

Miconia albicans



ANNONACEAE

Xylopia aromatica

Cerrado – Botucatu, SP

Average index of frost damage of species in decreasing order

Species	Index	% species in area	% individuals in plot	
<i>Miconia albicans</i>	98,5	4	1	totally damaged
<i>Xylopia aromatica</i>	71,0			
<i>Casearia silvestris</i>	30,5	26	16	substantially damaged
<i>Davilla elliptica</i>	25,0			
<i>Connarus suberosus</i>	22,6			
<i>Guapira noxia</i>	19,5			
<i>Tocoyena brasiliensis</i>	19,0			
<i>Piptocarpha rotundifolia</i>	15,6			
<i>Aegiphila paraguariensis</i>	14,2			
<i>Plathymenia reticulata</i>	11,9			
<i>Kielmeyera rosea</i>	11,0			
<i>Hancornia speciosa</i>	10,9			
<i>Caryocar brasiliense</i>	9,8			
<i>Byrsonima coccolobifolia</i>	9,6			
<i>Annona crassiflora</i>	8,3			

Silbebauer-Gottsberger *et al.* 1977



en.wikipedia.org



Foto aérea dos limites da distribuição local de *Juniperus osteosperma* (Cupressaceae) Nevada, E.U.A.

Lomolino et al. 2006

FIGURE 4.6 An aerial photograph near the edge of the local distribution of the juniper tree (*Juniperus osteosperma*) in eastern Nevada. Individual trees, which are recognizable as dark spots, generally decrease in both size and abundance as elevation decreases from left to right. Note three things: (1) the overall complexity of the pattern of abundance and the difficulty of defining a precise range boundary; (2) the relatively uniform distribution of plants along an alluvial outwash plain at the top of the photograph; and (3) the patchy distribution of plants on southeast-facing slopes of small hills toward the bottom of the photograph.

Filogenia de breus (Burseraceae) e solos amazônicos: especiação dirigida por fatores edáficos

Fine *et al.* 2004



Fig. 1. Phylogenetic relationships of the species in the transplant experiment with their family, genus, species, and soil type (origin). The phylogenetic tree is adapted from (37), and the Burseraceae phylogeny is adapted from (38). *Tetragastris panamensis* has been found to be imbedded within *Protium* sensu lato (38), therefore we are considering *Tetragastris panamensis* as a *Protium* clay specialist species. Soil type (origin) was determined by extensive tree and seedling inventories that we conducted in more than 25 sites throughout the 57,600-ha Allpahuayo-Mishana Reserve. Our designation of white-sand specialists is consistent with other inventories and a published flora from the area (19, 22, 38, 39). Our designation of clay specialists

Family	Genus and species	Soil type (origin)
Annonaceae	<i>Oxandra xylopioides</i> Diels	Clay
Annonaceae	<i>Oxandra euneura</i> Diels	White sand
Burseraceae	<i>Tetragastris* panamensis</i> (Engler) Kuntze	Clay
Burseraceae	<i>Protium subserratum</i> (Engler) Engler	White sand
Burseraceae	<i>Protium nodulosum</i> Swart	Clay
Burseraceae	<i>Protium paniculatum</i> Engler	White sand
Burseraceae	<i>Protium opacum</i> Swart	Clay
Burseraceae	<i>Protium calanense</i> Cuatrec.	White sand
Burseraceae	<i>Protium trifoliolatum</i> Engler	Clay
Burseraceae	<i>Protium kruckhoffii</i> Swart	Clay
Burseraceae	<i>Protium heptaphyllum</i> subsp. <i>ulei</i> (Swart) Daly	White sand
Burseraceae	<i>Protium hebetatum</i> Daly	Clay
Malvaceae (Bombacoid)	<i>Pachira insignis</i> (Swartz) Swartz ex Savigny	Clay
Malvaceae (Bombacoid)	<i>Pachira brevipes</i> (Robyns) Alverson	White sand
Euphorbiaceae	<i>Mabea pulcherrima</i> Müll. Arg.	Clay
Euphorbiaceae	<i>Mabea subsessilis</i> Pax & Hoffmann	White sand
Fabaceae (Faboid)	<i>Swartzia arborescens</i> (Aublet) Pittier	Clay
Fabaceae (Faboid)	<i>Swartzia cardiosperma</i> Spruce ex Benth.	White sand
Fabaceae (Mimosoid)	<i>Parkia multijuga</i> Benth.	Clay
Fabaceae (Mimosoid)	<i>Parkia igneiflora</i> Ducke	White sand

conforms to other species lists on clay soils in the area (19, 22, 38) as well as with lists from the Ecuadorian Amazon, which is almost entirely composed of clay soils and where white-sand forests are unknown (40).

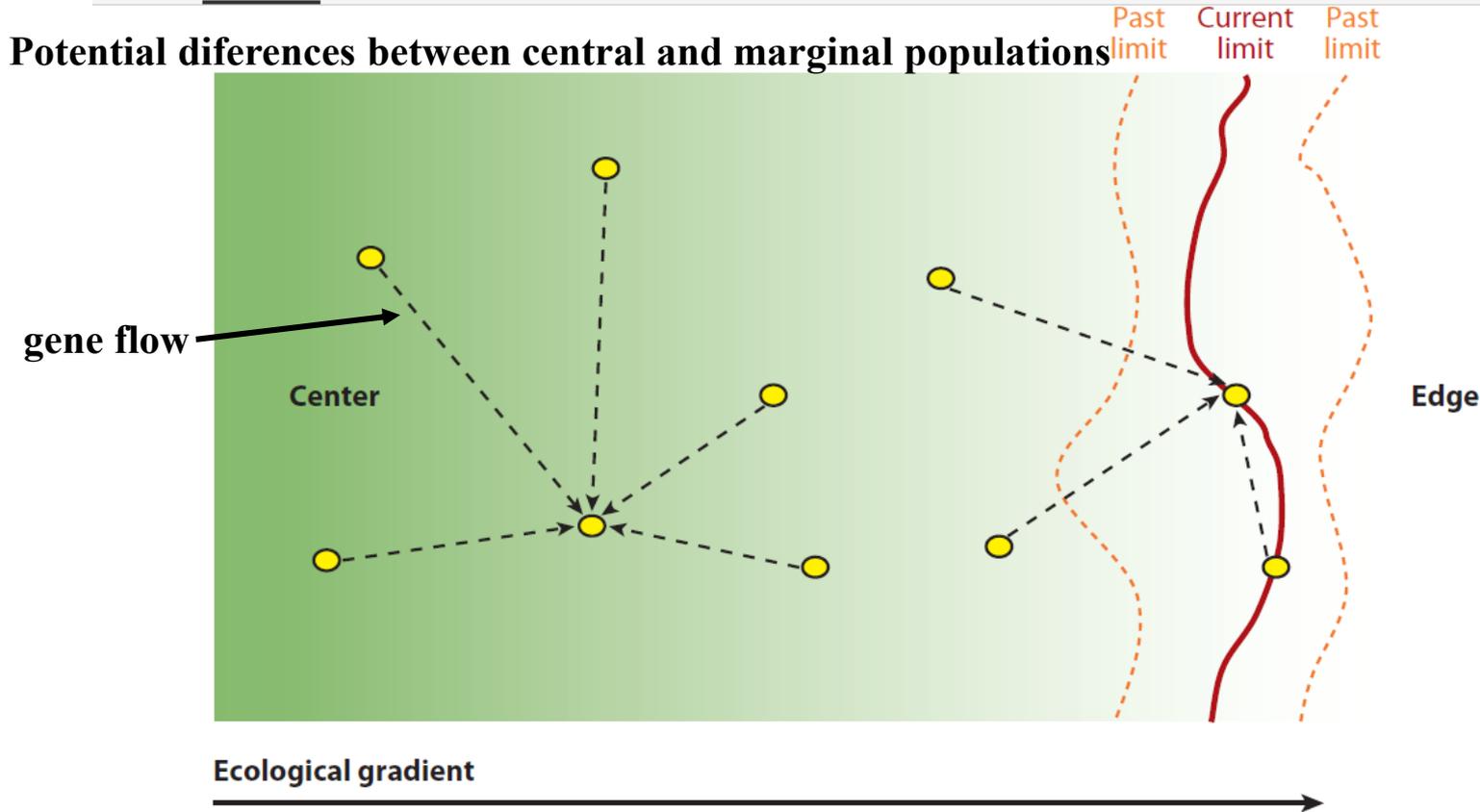


Figure 1

Potential differences between central and marginal populations. Populations are shown equally distributed among selection regimes produced by an ecologically important gradient (e.g., temperature, precipitation, competitor density, or symbiont density) across the species range. Example populations from central and edge areas are shown with potential sources of gene flow (*arrows*) and illustrate how gene flow to edge populations can be limited by the number and diversity (that is, from fewer selection regimes) of source populations. Central populations are more likely to receive immigrants from opposite ends of their selection gradient, whereas edge populations are more likely to receive immigrants from only one end. The spatial position of the range limit may vary through time, caused by increased temporal variance in critical habitat quality near the range limit.

Evolution and Ecology of Species Range Limits

Sexton *et al.* 2009

Table 1 Summary of major theoretical models addressing geographic range limits, with key findings

MODELS OF RANGE LIMITS ^a		
No evolution and without underlying environmental heterogeneity		
Framework	Key findings	References
Random dispersal (diffusion) with an Allee effect	Negative growth at low density can prevent a population from dispersing beyond its current range	Keitt et al. 2001, Lewis & Kareiva 1993
Spatially explicit competition	Parapatric ranges form owing to competitive exclusion (e.g., colonization patterns maintained by priority effects)	Case et al. 2005, Fowler & Levin 1984, Yodzis 1978
Random dispersal of hybridizing species	Parapatric ranges form owing to reduced hybrid fitness limiting population expansion	Case et al. 2005, Goldberg & Lande 2006
No evolution and with environmental heterogeneity		
Framework	Key findings	References
Demographic parameters vary along gradients (single- or multispecies models)	Limits to population growth along an environmental gradient result in a range limit. Corresponds to fundamental (single species) or realized niche limitation (multispecies)	Case et al. 2005, Hochberg & Ives 1999, Holt & Barfield 2009, Pulliam 2000, Roughgarden 1979
Environmental gradients in metapopulation models	Variation in colonization and extinction along gradients can result in range limits. Sharp range limits are possible even over shallow gradients owing to patch extinction-colonization dynamics	Carter & Prince 1981, Case et al. 2005, Holt & Keitt 2000, Lennon et al. 1997
Temporal or spatial heterogeneity in dispersal	Range limits result from environmentally determined patterns of dispersal (ocean or air currents)	Gaylord & Gaines 2000
	Spatial or temporal variation in dispersal can stall population expansion and create temporary range limits	Holt et al. 2005b, Shigesada et al. 1986
	Dispersal barriers can "attract" parapatric range limits owing to competition or hybridization over otherwise homogenous space	Goldberg & Lande 2007
With evolution and environmental heterogeneity		
Framework	Key findings	References
Gene flow (dispersal), selection, and adaptation along an environmental gradient	Gene flow from large, well-adapted populations may prevent adaptation in marginal populations. Depends on the rate of adaptation (genetic variance, selection) and steepness of the gradient. Assumes constant genetic variance	Kirkpatrick & Barton 1997
	Range limits are harder to achieve if genetic variation is not constant, because migration can increase variation in peripheral populations and facilitate adaptation	Alleaume-Benharira et al. 2006, Barton 2001
	Incorporation of competitive interactions among species makes range limits easier to achieve, as presence of a better-adapted competitor along a gradient can reduce peripheral populations and increase asymmetry in gene flow	Case & Taper 2000
	Dispersal barriers limit gene flow and allow for local adaptation and spread. If gene flow is restricting a species range, species borders should not be associated with dispersal barriers	Goldberg & Lande 2007
	The strength and form of density-dependent population regulation can influence the likelihood that a species adapts to peripheral populations by influencing demographic asymmetries in peripheral and central populations	Barton 2001, Filin et al. 2008
Selection and gene flow in a source sink scenario	Gene flow can provide a demographic and genetic "rescue effect" in sink populations, facilitating adaptation. Niche expansion may proceed in a punctuated fashion	Holt 2003, Holt & Gomulkiewicz 1997, Gomulkiewicz et al. 1999

Evolution and Ecology of Species Range Limits

Sexton *et al.* 2009

Estudios empíricos:

Table 2 Summary of empirical studies addressing geographic range limits^a

EMPIRICAL STUDIES OF RANGE LIMITS			
Association of range limit with environmental parameter(s)			
Hypothesis/Prediction	Support	Partial support	No support
Limiting abiotic variable(s)	112	17	17
<i>Response variable:</i>			
Presence(/absence)	41	6	2
Abundance	16	2	0
Fitness component(s)	34	4	5
Physiological response	21	5	10
Limiting biotic variable(s)	31	8	12
<i>Explanatory variable:</i>			
Competition	17	6	3
Predation	6	1	3
Disease or Parasitism	4	0	3
Host	4	1	3
Limiting abiotic × biotic interaction(s)	7	0	1
Variation in individual and population fitness			
Hypothesis/Prediction	Support	Partial support	No support
Fitness declines	56	8	48
<i>Response variable:</i>			
Recruitment	7	0	5
Survival	8	3	10
Size, growth or development	19	1	14
Fecundity	15	1	15
Lifetime fitness (or lambda)	7	3	4
Abundance declines	31	17	24
<i>Response variable:</i>			
Population size	5	1	3
Density within populations	20	13	17
Frequency of populations	6	3	4
Population dynamics more variable	16	2	8
<i>Response variable:</i>			
CV(lambda)	1	0	2
CV(abundance)	6	2	3
Recruitment more irregular	4	0	0
Extinction more likely	5	0	3

Do Ecological Niche Models Accurately Identify Climatic Determinants of Species Ranges?

Christopher A. Searcy^{1,*} and H. Bradley Shaffer²

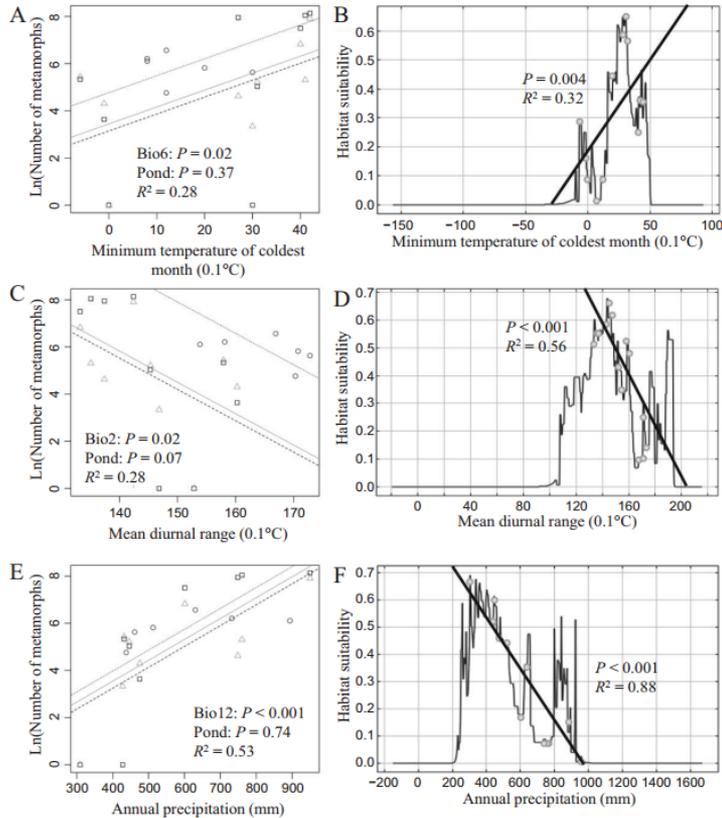


Figure 2: Linear responses of metamorph recruitment and habitat suitability scores to the three most important independent climatic variables. Responses are in agreement for minimum temperature of the coldest quarter (both positive) and mean diurnal range (both negative) but disagree for annual precipitation (one positive, one negative). A, C, E, Correlations between number of metamorphs recruited in a given year and three different Bioclim variables. Each panel illustrates the results of an ANCOVA model with pond as the categorical term (circles, dotted line = Blomquist Pond; squares, dashed line = Olcott Lake; triangles, solid line = Round Pond). B, D, F, Correlations between predicted habitat suitability based on the informed model and three different Bioclim variables. Correlations are based on the particular number for that variable in the informed model. Dotted lines represent the informed model, solid lines represent the basic model.

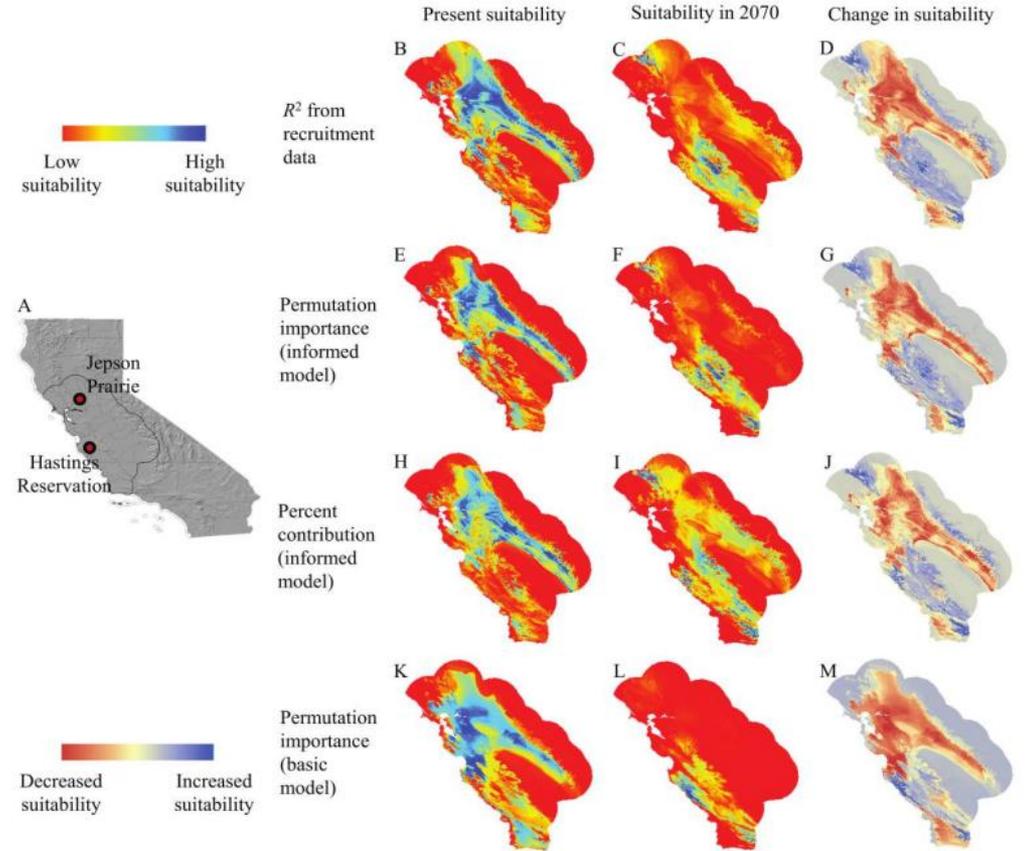


Figure 3: Changing climatic suitability for California tiger salamander (CTS). A, Hillshade map of California illustrating the region modeled using the informed approach (black outline) relative to county boundaries (gray lines). Red circles show locations of study sites where recruitment data were collected. Each niche model was built using six environmental layers that are ranked highest by a different metric (see table A1): R^2 from recruitment data (B–D); permutation importance from informed model (E–G); percent contribution from informed model (H–J); permutation importance from basic model (K–M); logistic suitability scores, which can be interpreted as probability of finding the focal species (Phillips and Dudik 2008; but see Royle et al. 2012) in the present (B, E, H, K) and projected suitability scores in 2070 (C, F, I, L), where for both, blue and red values represent high and low suitability, respectively (see upper color bar); and projected change in suitability between current climate and 2070 (D, G, J, M), where blue values represent areas where suitability is predicted to increase, and red values represent areas where suitability is predicted to decrease (lower color bar). Generally, climatic suitability is projected to increase in high-elevation areas and decrease in low-elevation areas. Pairwise comparisons of all maps in the same column based on Schoener's D are given in table A2 (Schoener 1968; Warren et al. 2008).

Limites da distribuição de espécies:

- por interações bióticas: ?

Limites da distribuição de espécies:

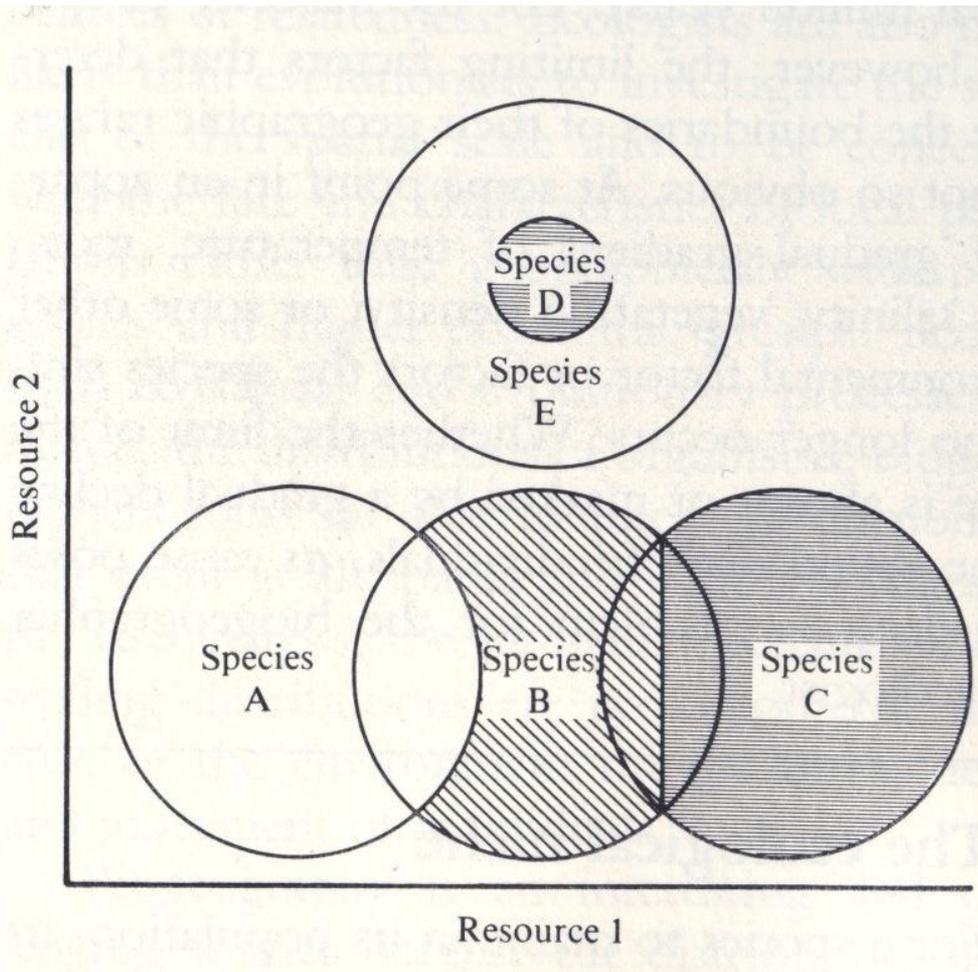
- por interações bióticas:

competição

predação

mutualismo

interações complexas



Diagrams of two dimensions of the niches of five hypothetical species, showing fundamental, realized, and included niches. Circles indicate the limits of the fundamental niches of the species, whereas shaded portions show the realized niches. For species A the fundamental and realized niches are identical, but the realized niches of species B and C include only part of their fundamental niches because they are excluded from the remaining niche space by other species. Species D, a specialist, occupies a niche included entirely within the fundamental niche of the more generalized species E.

Modelagem de nicho

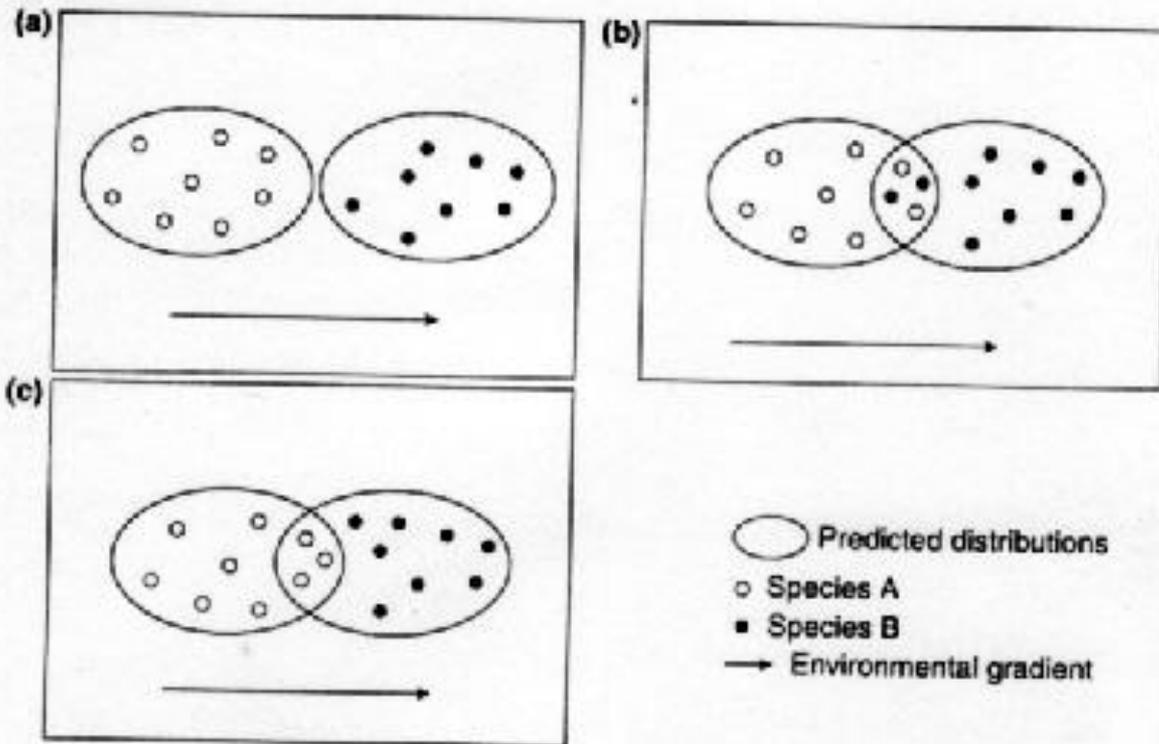


Figure 1 Predicted results of using niche modelling to investigate factors that may affect distributions of closely related species along an environmental gradient. (a) Species do not overlap in their predicted distributions. (b) Both species occur in the predicted overlap zone. (c) Only one species occupies the predicted overlap zone.

Costa et al. 2008 J. Biogeogr. 35: 637-646.

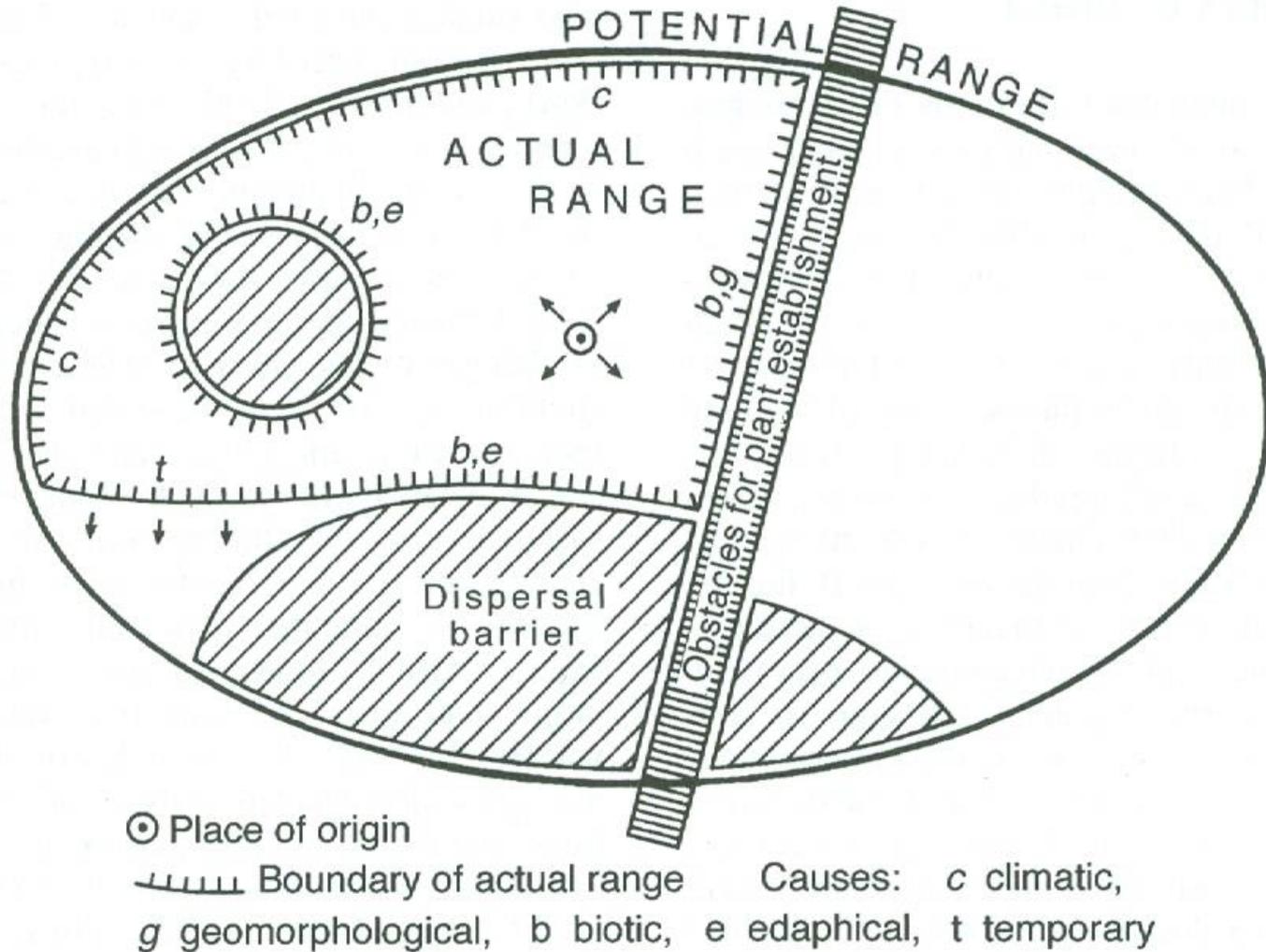


Figure 8.1 Potential range, dispersal, and range boundaries of a newly evolved plant species (after Schroeder, 1998, modified)

Modelagem de nicho em 6 pares de espécies

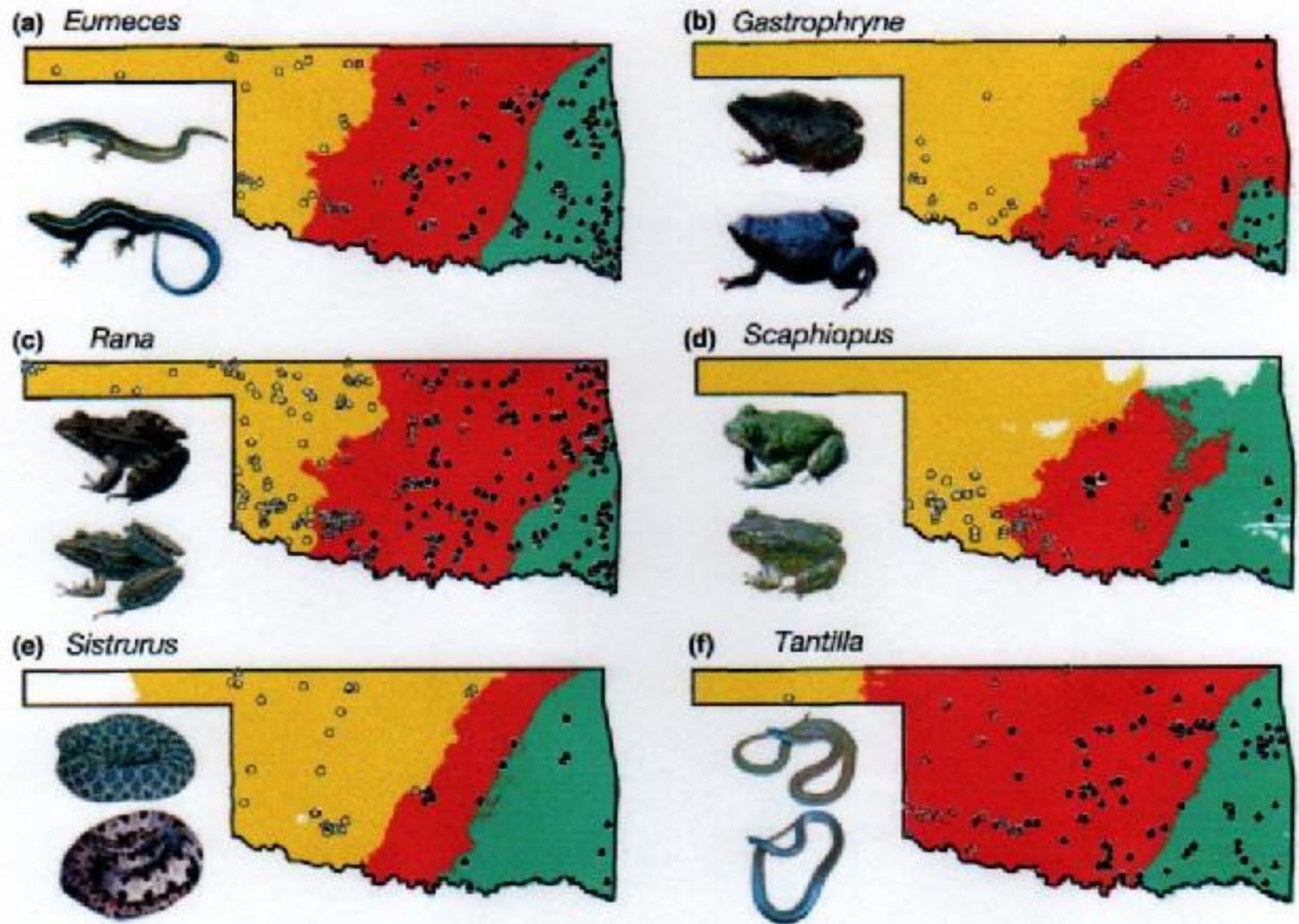
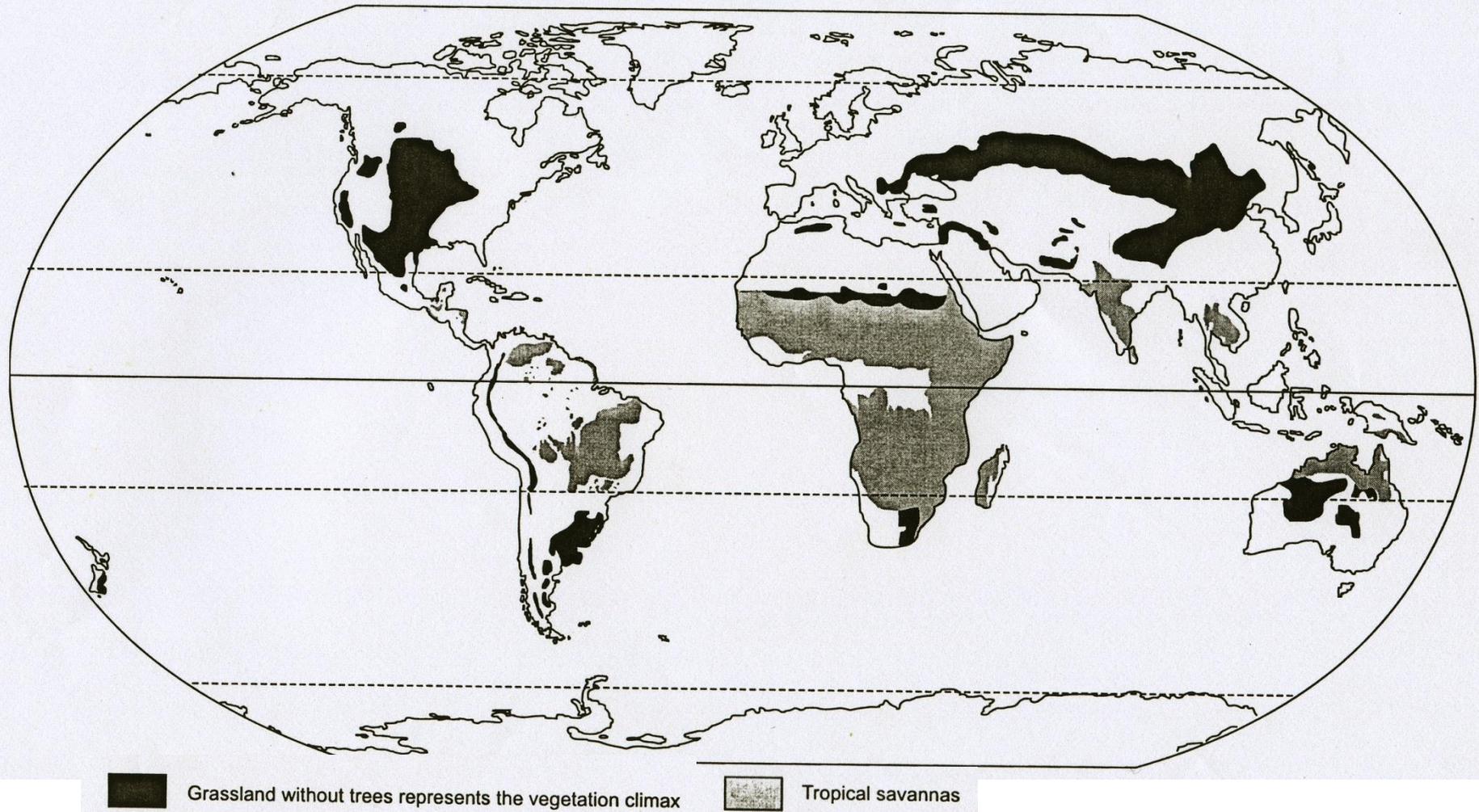


Figure 5 Niche-modelling maps for the six species pairs. For each species pair, open circles on each map represent known localities for the species generally restricted to the western part of the state, whereas closed circles represent localities for the eastern species. Yellow represents the predicted distribution of the western species, blue represents the predicted distribution of the eastern species, and red is the predicted overlap zone based on the models. Photographs next to each map correspond to the western species (above) and the eastern species (below). (a) *Eumeces obsoletus*–*E. fasciatus*. (b) *Gastrophryne olivacea*–*G. carolinensis*. (c) *Rana blairi*–*R. sphenocphala*. (d) *Scaphiopus couchii*–*S. hurterii*. (e) *Sistrurus catenatus*–*S. miliarius*. (f) *Tantilla nigriceps*–*T. gracilis*.

Bond 2008: **What limits trees in C4 grasslands and savannas?**

Climate mismatch: Biomas dominados por gramíneas C4 cobrem vastas áreas que são quentes e úmidas o suficiente para suportar florestas densas.



Modern distribution of grass-dominated ecosystems. Redrawn from Boulière & Hadley (1983) and Coupland (1992)

Jacobs *et al.* 1999

What limits trees in C4 grasslands and savannas?

Climate mismatch:

Biomass dominados por gramíneas C4 cobrem vastas áreas que são quentes e úmidas o suficiente para suportar florestas densas.

bottom-up (resources) x top-down (fire, herbivory) ?

Bond 2008

Ann. Rev. Ecol. Evol. Syst. 39: 641-659.

Limites da distribuição de espécies:

- por interações bióticas:

competição

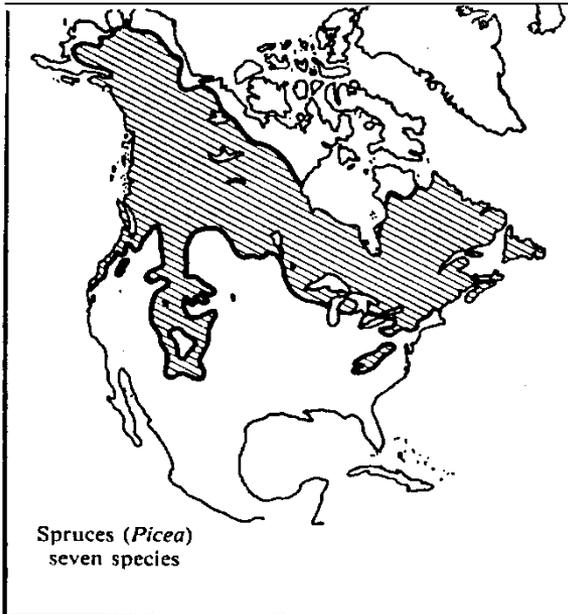
predação

Mutualismo:

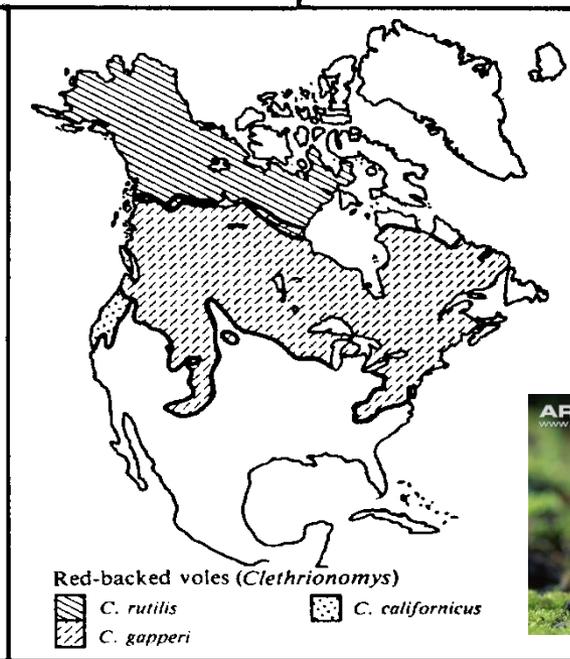
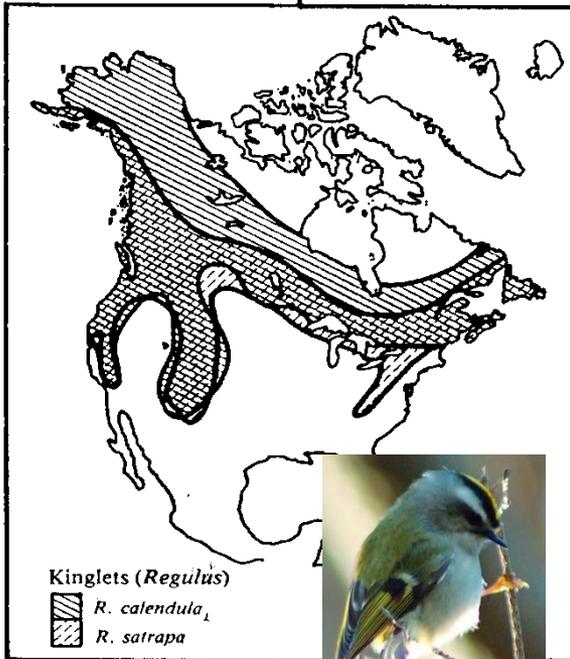
Trifolium pratense na Nova Zelândia + *Bombus* spp.

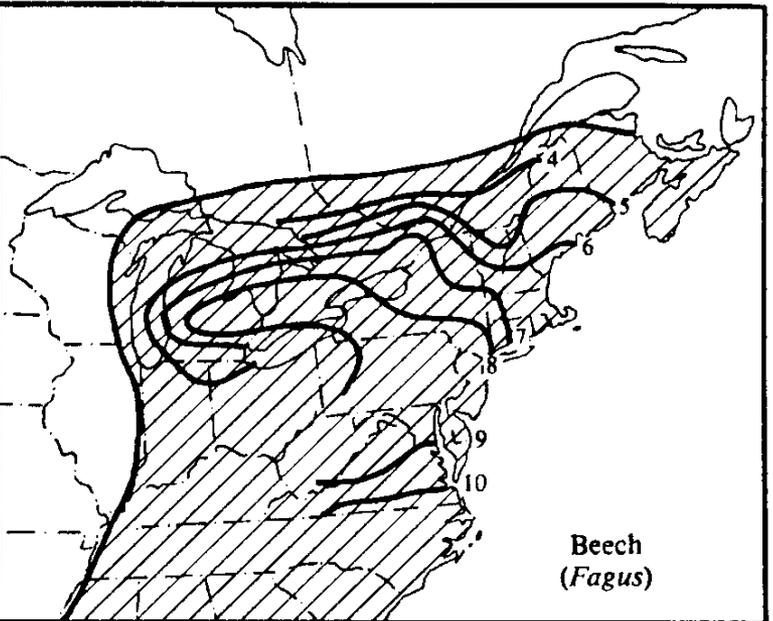
Acacia + *Pseudomirmex* na região neotropical (Janzen 1966)

interações complexas

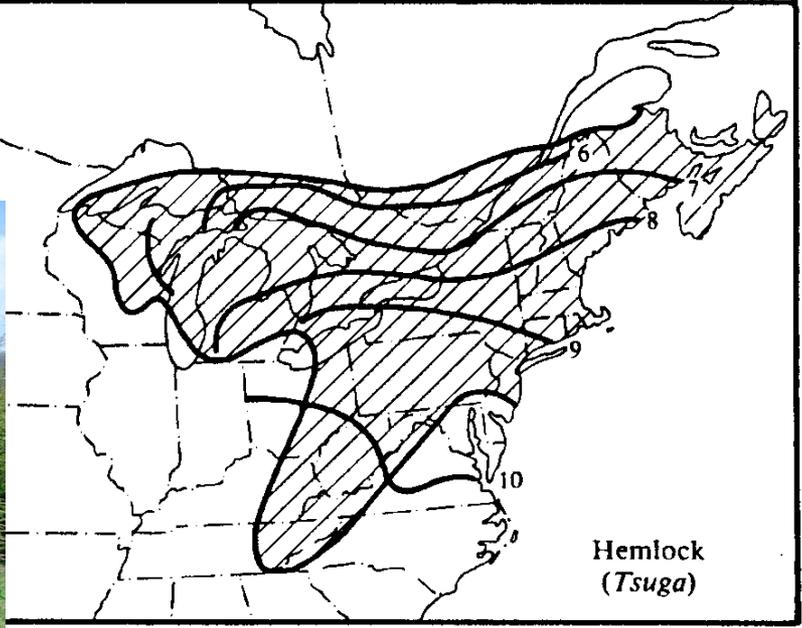


Picea Pinaceae





Beech
(*Fagus*)



Hemlock
(*Tsuga*)

Reconstruction from fossil pollen records of the recolonization of North America by two species of trees, beech (*Fagus*) and hemlock (*Tsuga*), since the last Pleistocene glaciation. Numbered lines indicate the fronts of each species at 1000-year intervals BP, showing the progressive northern migration of each species. Note that the migration of these trees was quite different, although the northern borders of their present ranges (*shaded areas*) are virtually identical. (After Bernabo and Webb, 1977.)

Brown & Gibson 1983



BIOGEOGRAFIA ECOLÓGICA

Padrões geográficos definidos em bases ecológicas

DIVERSIDADE FLORÍSTICA:

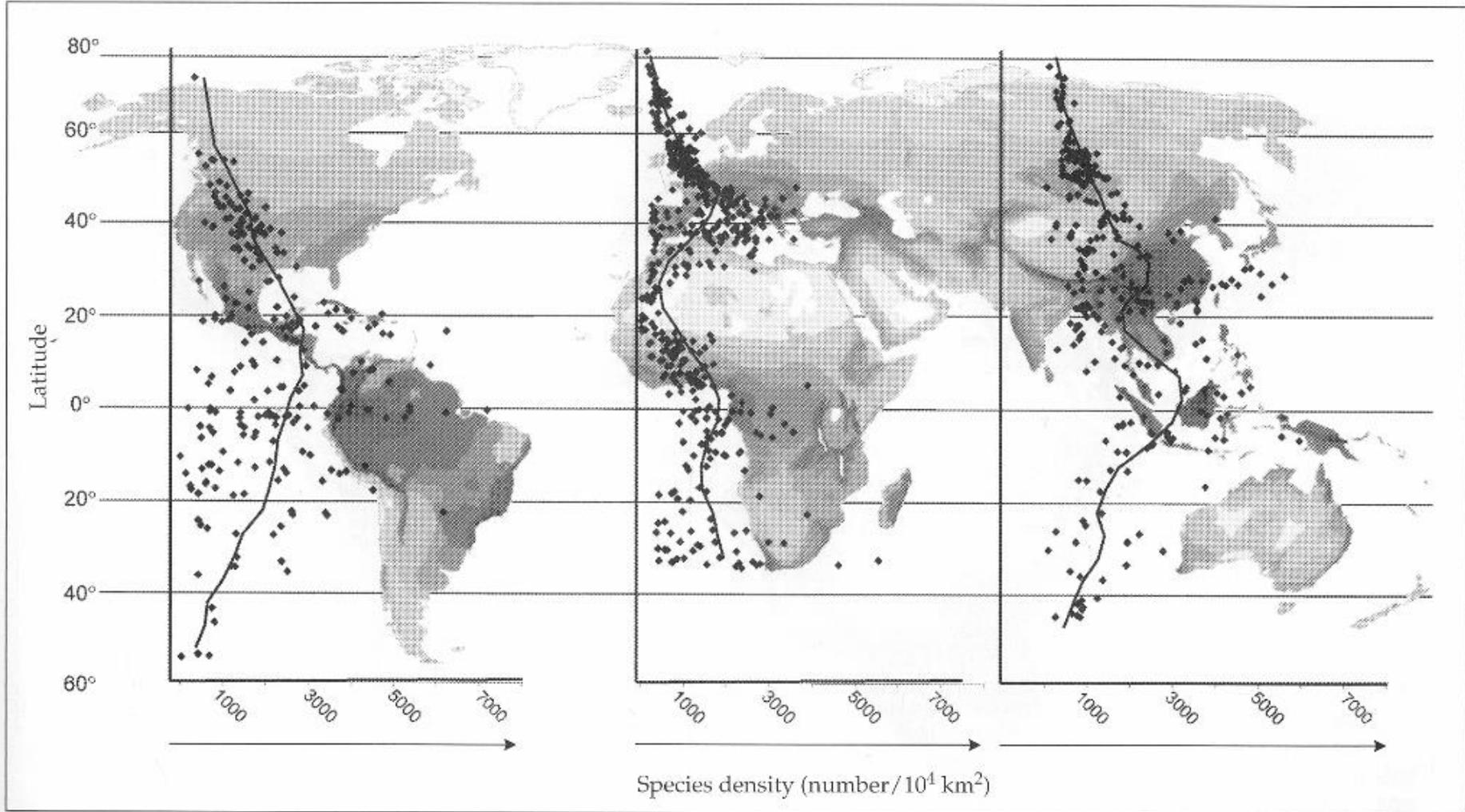
- riqueza em espécies**
- abundância relativa das espécies**

Odum 1985: padrão 1 ou poucas spp. dominantes com grande n° de indivíduos, associadas com muitas spp. raras é típico da estrutura de comunidades de latitudes setentrionais e nos trópicos de sazonalidade marcante.

Tendências geográficas em riqueza específica

Latitude

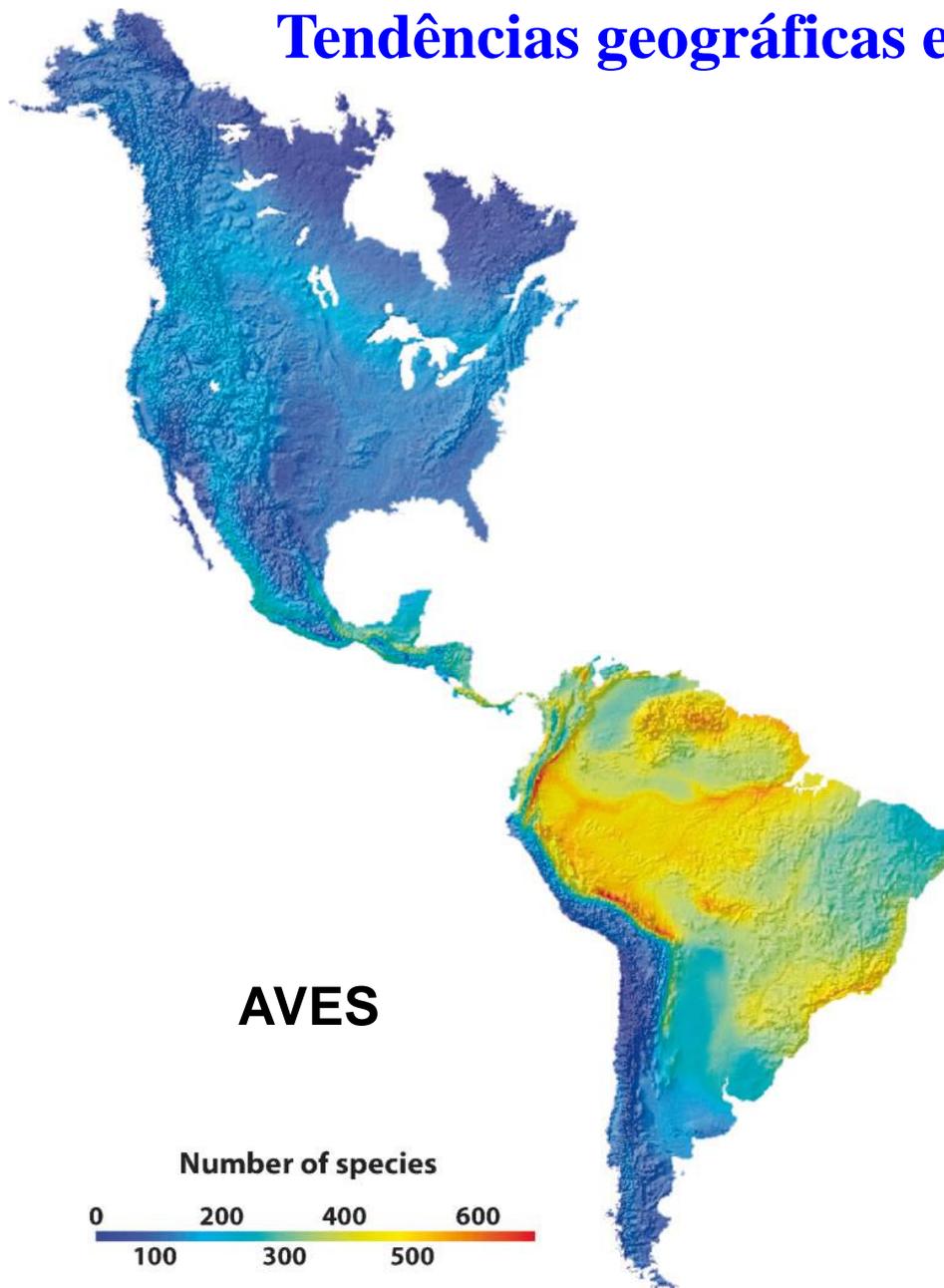
(A) All vascular plants



Lomolino et al. 2006

Tendências geográficas em riqueza específica

Latitude



AVES

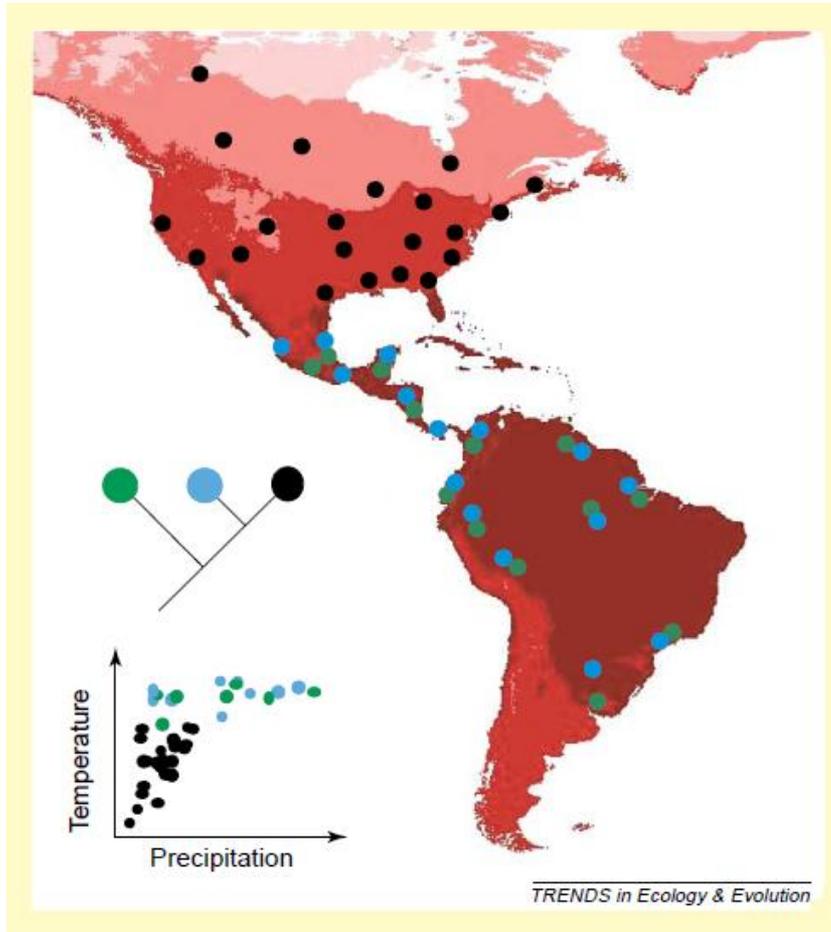
Number of species



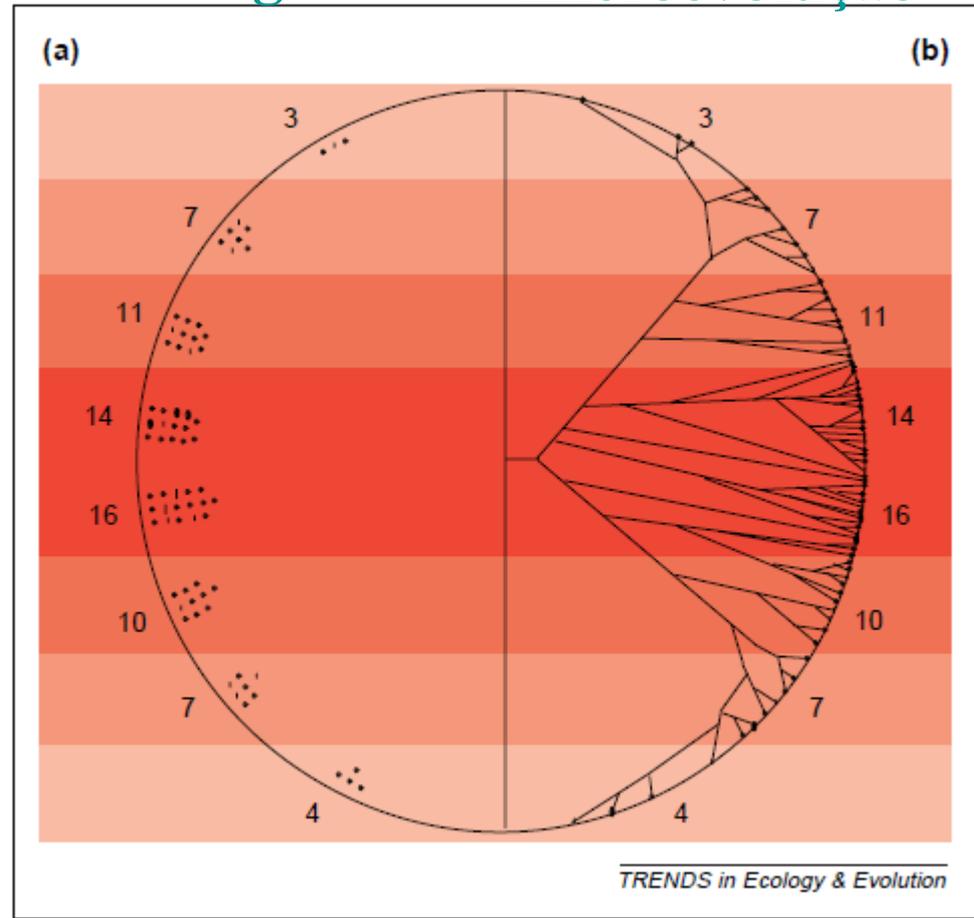
Hawkins 2006

Historical biogeography, ecology and species richness

John J. Wiens¹ and Michael J. Donoghue²



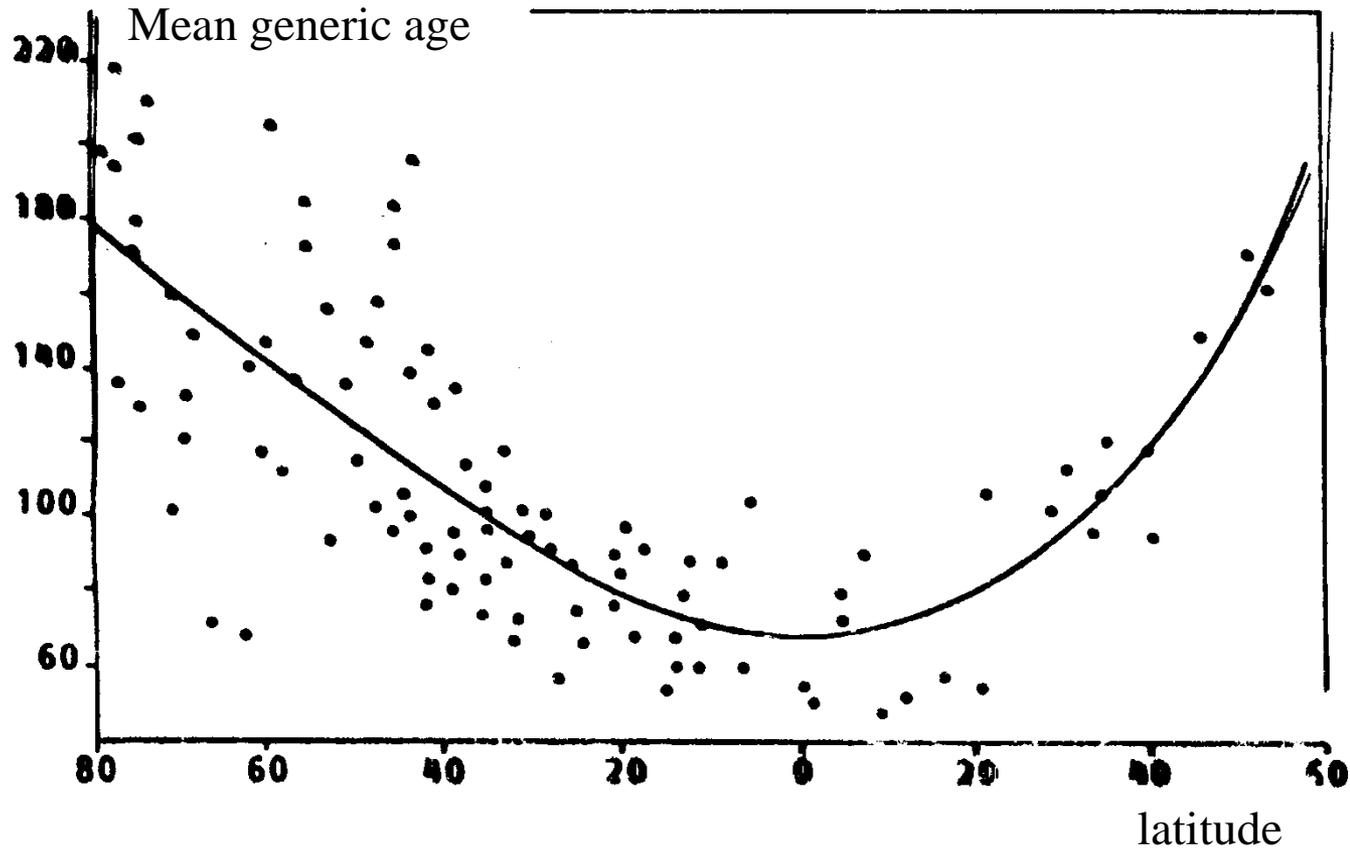
ecologia +
filogenia +
microevolução



Wiens & Donoghue 2004

Tendências geográficas em riqueza específica

Latitude



Mean generic age of benthic foraminiferal genera plotted against latitude
(after Durazzi & Stehli, 1972)

Hengeveld 1990

Tendências geográficas em riqueza específica

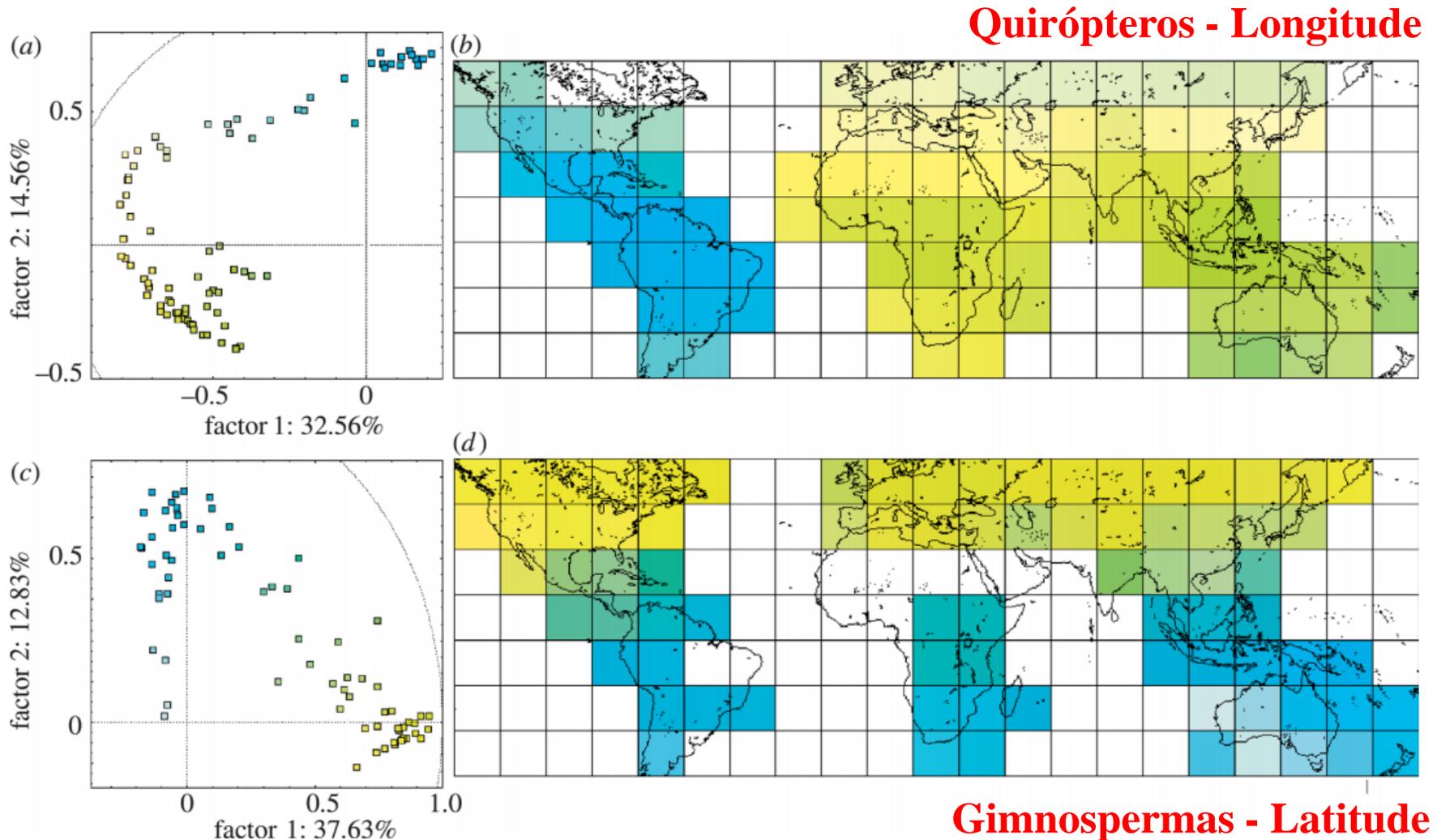
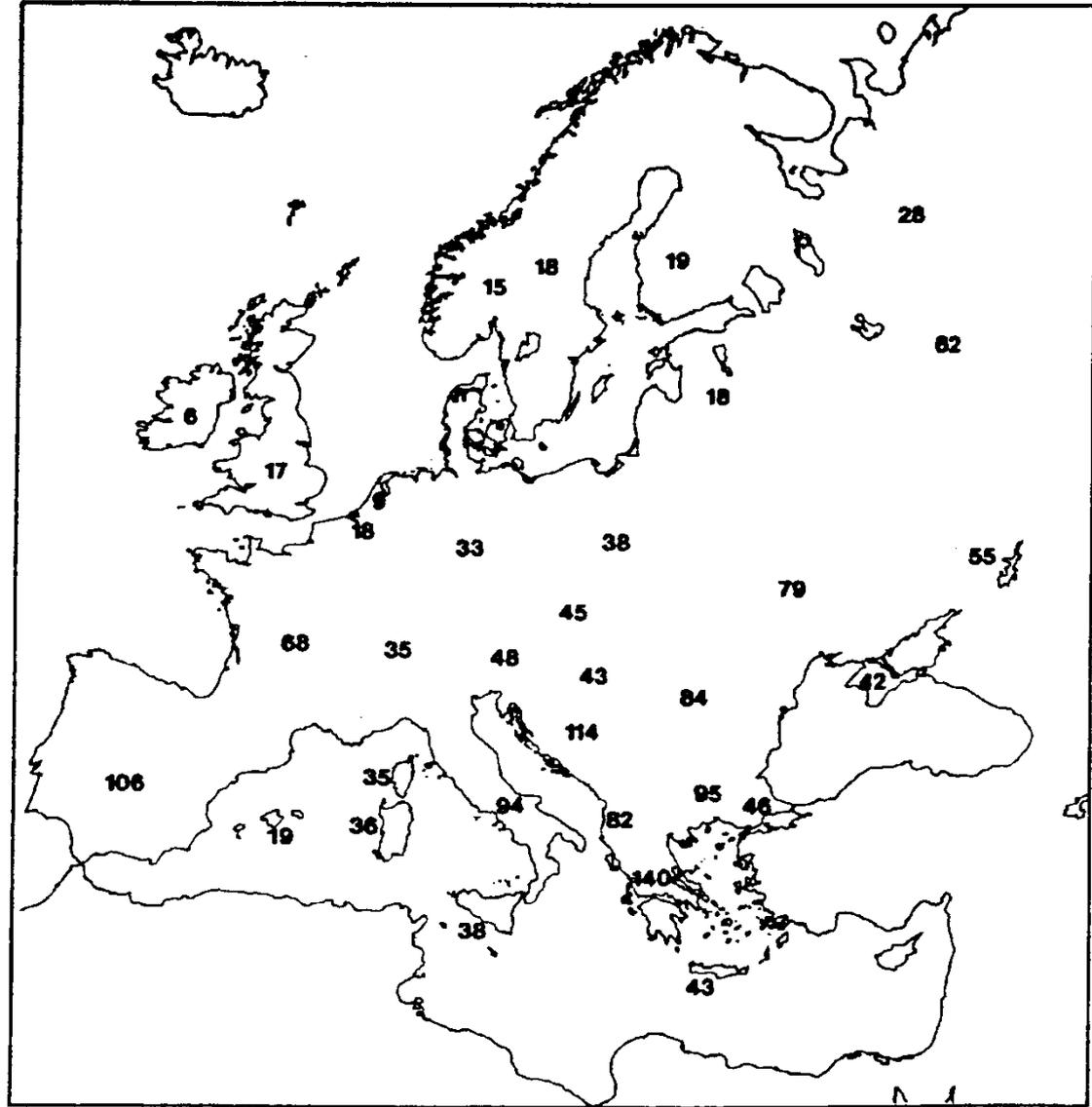


Figure 1. Principal component analyses (a, c) and maps showing global variation in assemblage composition (b, d) for bats (a, b) and gymnosperms (c, d). Only $15 \times 15^\circ$ cells with more than five species in either group were included in the analyses.

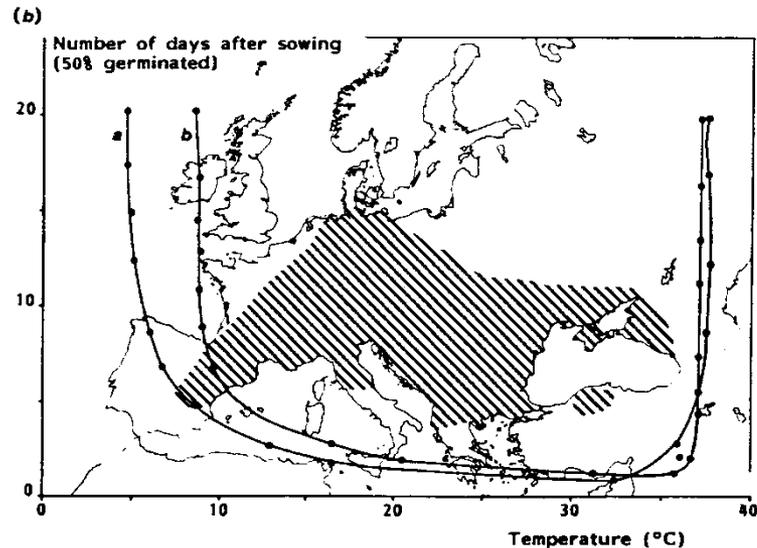
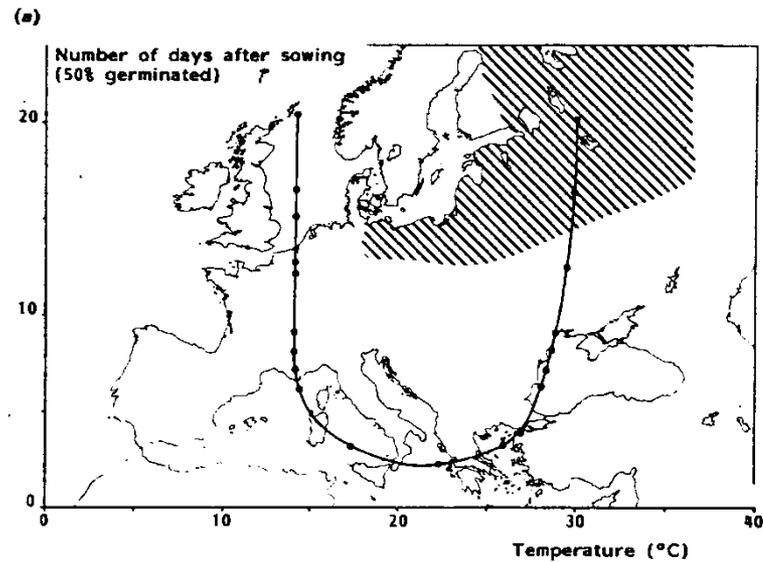
Tendências geográficas em riqueza específica

Centros
de
diversidade



Regional number of silenoid species across Europe (after Thompson, 1973

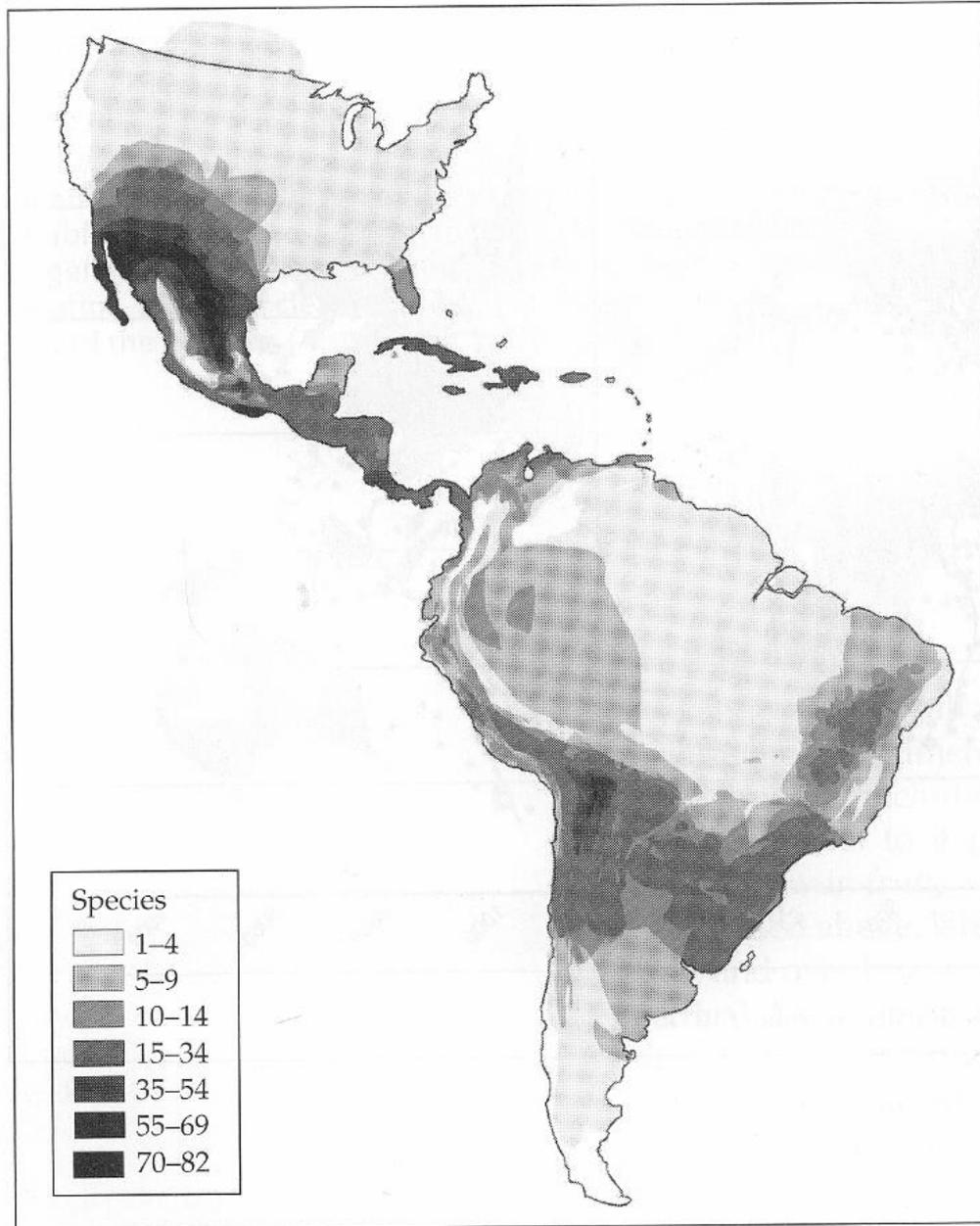
Hengeveld, 1990



Geographical range in Europe and temperature range of germination for *Silene larlarica* (a) and *Pelrorhagia proifera* (b) (after Thompson, 1970). The two temperature response curves in (b) refer to seeds originating from France (line a) and from Hungary (line b).

Hengeveld 1990

(C) Cacti



**Tendências geográficas
em riqueza específica**

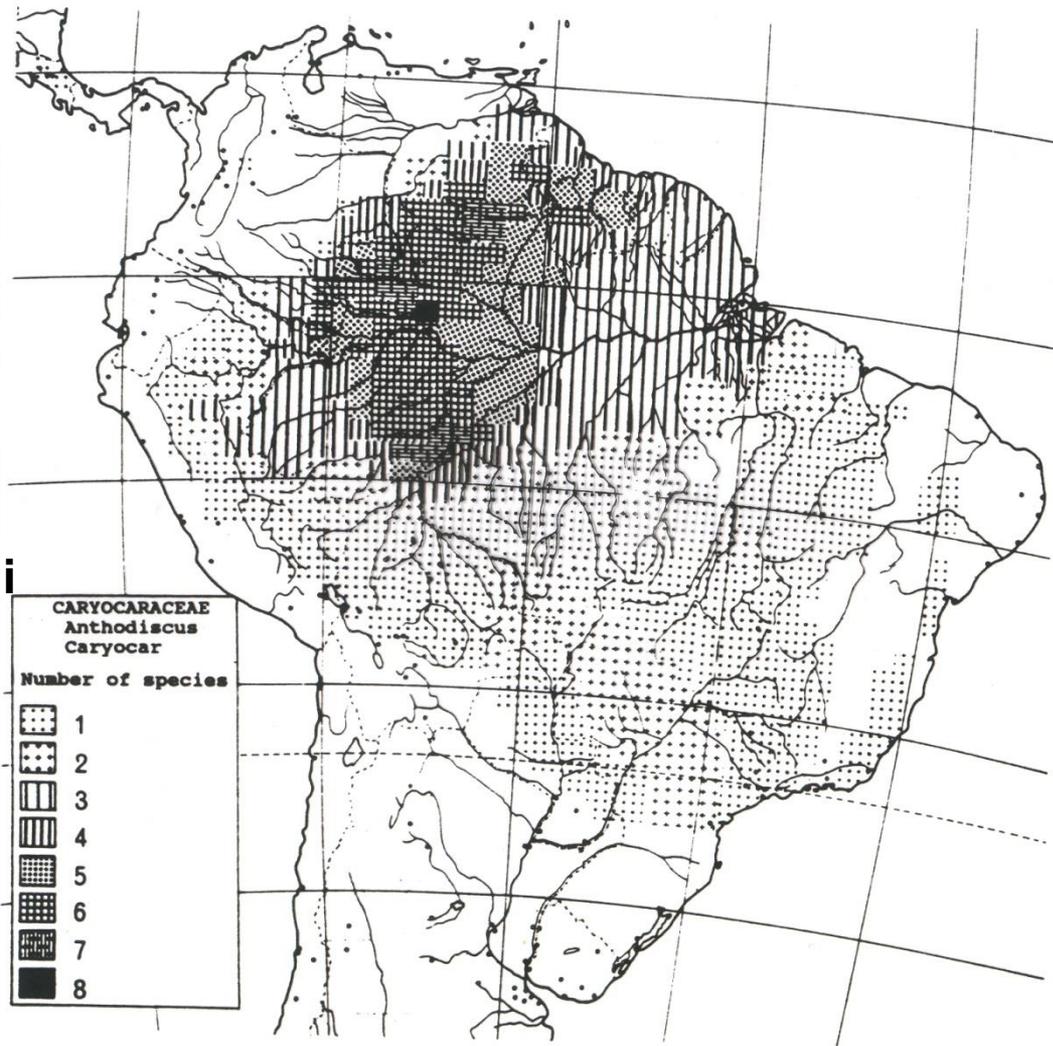
**Centros
de
diversidade**

**Densidade específica
de CACTACEAE**

Lomolino *et al.* 2006



Caryocar brasiliense - pequi



Distribution density map of species of CARYOCARACEAE

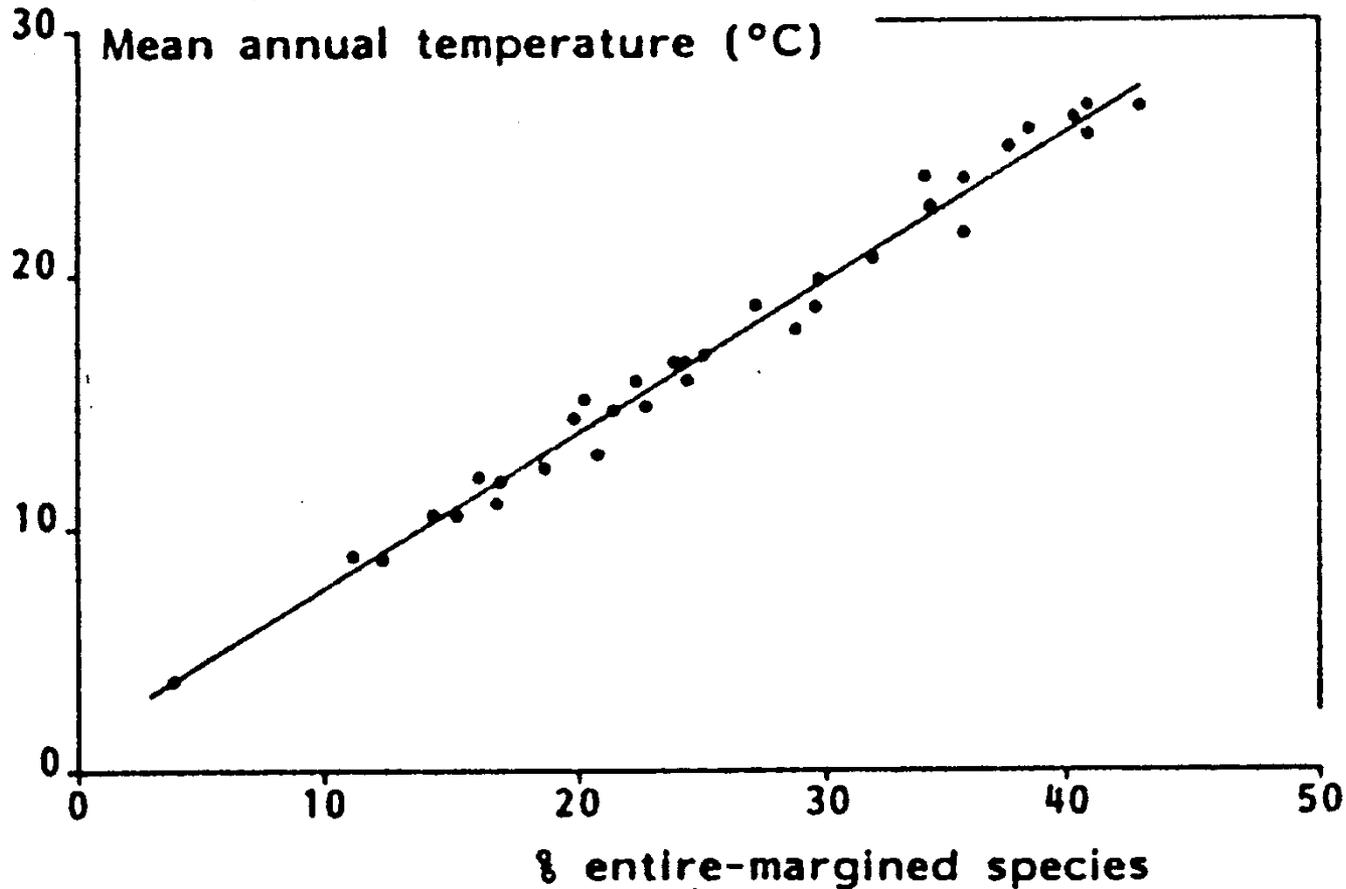
Prance 1994 in Forey *et al.*

Some examples of diversity index in Brazilian ecosystems: Species richness (number of species/number of individuals), Alpha diversity (H' nats/ individuals), and Equitability O'). Bibliogr. = Bibliography.

	Species richness	H'	J'	Bibliogr.
Amazonian Tropical Rain Forest	1: 4.86	3.83	0.86	1
	1: 2.89	3.98	0.89	2
	1: 3.73	4.19	0.89	3
	1: 4.24	4.44	0.86	4
Atlantic Tropical Rain Forest	1: 5.35	4.31	0.86	5
	1: 3.77	4.08	0.87	6
	1: 5.20	4.07	0.85	7
Temperate Warm Forest	1: 6.94	4.13	0.83	8
	1: 7.01	3.52	0.86	9
Estacional Semidecidual Forest	1:10.62	3.56	0.75	10
	1: 7.63	4.29	0.85	11
	1: 9.78	3.94	0.81	12
Riparian Forest	1:11.001	3.84	0.84	13
	1: 5.71	2.85	0.80	14
	1:11.90	3.06	0.69	15
	1:13.29	3.60	0.77	16
Brazilian Savannah	1:33.66	3.64	0.79	17
	1:11.06	3.11	0.76	18
	1:19.39	3.62	0.84	18
	1:19.24	2.60	0.73	19
Tropical Forest on Sand Plain	1:13.46	3.48	0.81	20
	1:29.19	3.22	0.81	21
	1:27.97	2.44	0.71	22
Swampy and Foodplain Forests	1:19.04	3.01	0.75	23
	1:28.18	2.45	0.70	24
	1:18.26	1.08	0.34	25
Tropical Forest on Lithosoil	1:25.00	1.95	0.70	26

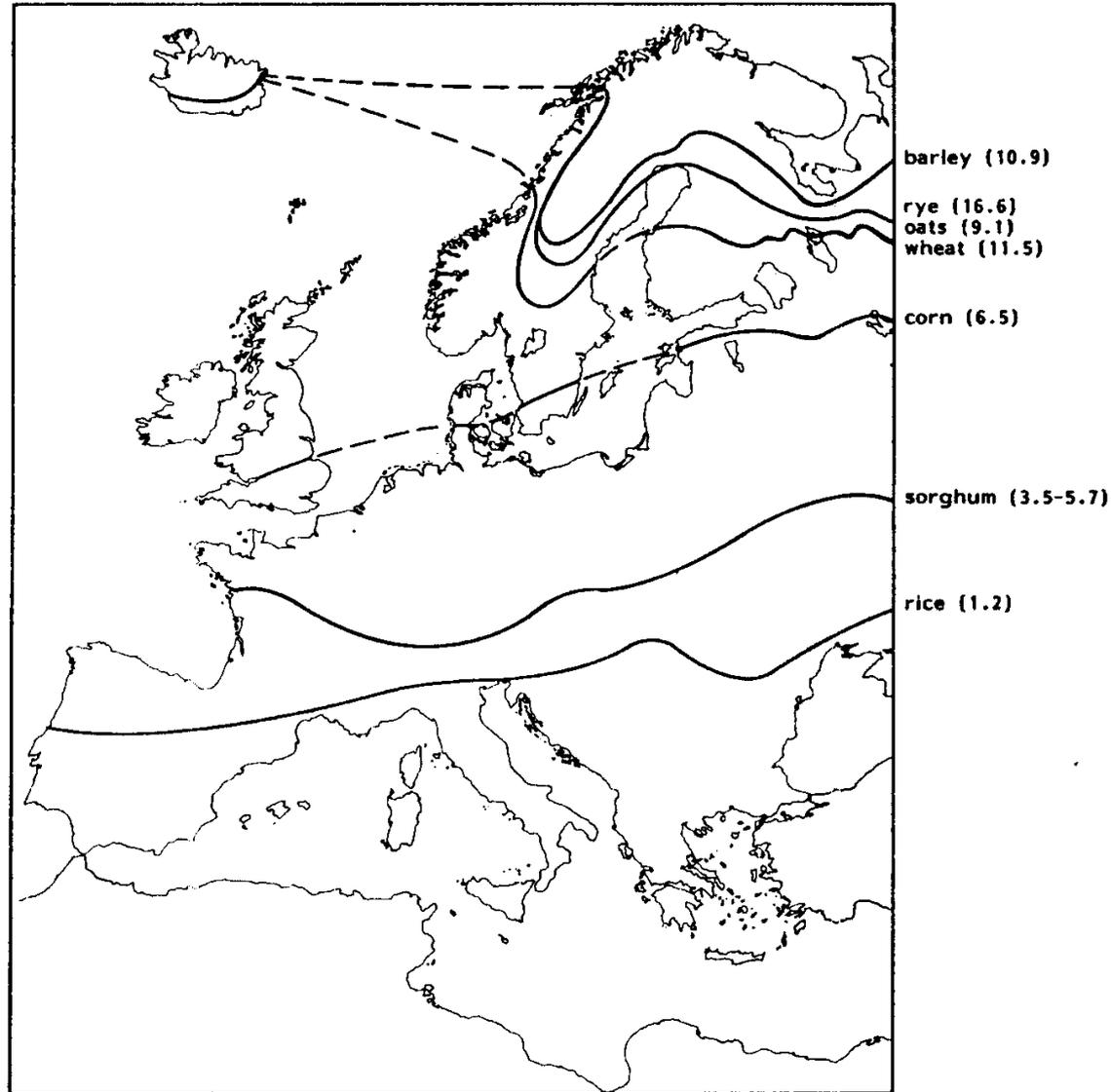
Bibliography: (01) Black *et al.*, 1950; (02) Morellato & Rosa, 1991; (03) Muniz *et al.*, 1994; (4) Salomão & Lisboa, 1988; (05) Leitão-Filho, 1993; (06) Mantovani *et al.*, 1990; (07) Silva & Leitão-Filho, 1982; (08) Baltello *et al.*, 1992; (09) Vasconcelos *et al.*, 1992; (10) Cesar & Leitão-Filho, 1990; (11) Pagano & Leitão-Filho, 1987b; (12) Rodrigues *et al.*, 1989; (13) Felfini, 1994; (14) Menacci & Schlichter, 1992; (15) Salis *et al.*, 1994; (16) Soares-Silva *et al.*, 1992; (17) Cesar *et al.*, 1988; (18) Felfini *et al.*, 1993; (19) Nascimento & Saggi, 1992; (20) Cesar & Nlonteiro, 1995; (21). Silva *et al.*, 1993; (22) Sugiyama & Mantovani, 1993; (23) Keci & Prance, 1979; (24) Torres *et al.*, 1994; (25) Nascimento & Cunha, 1989; (26) Silva *et al.*, 1988.

Tendências geográficas em traços biológicos



Proportion of the number of plant species with **entire margins** plotted against mean temperature (after Wolfe, 1978).

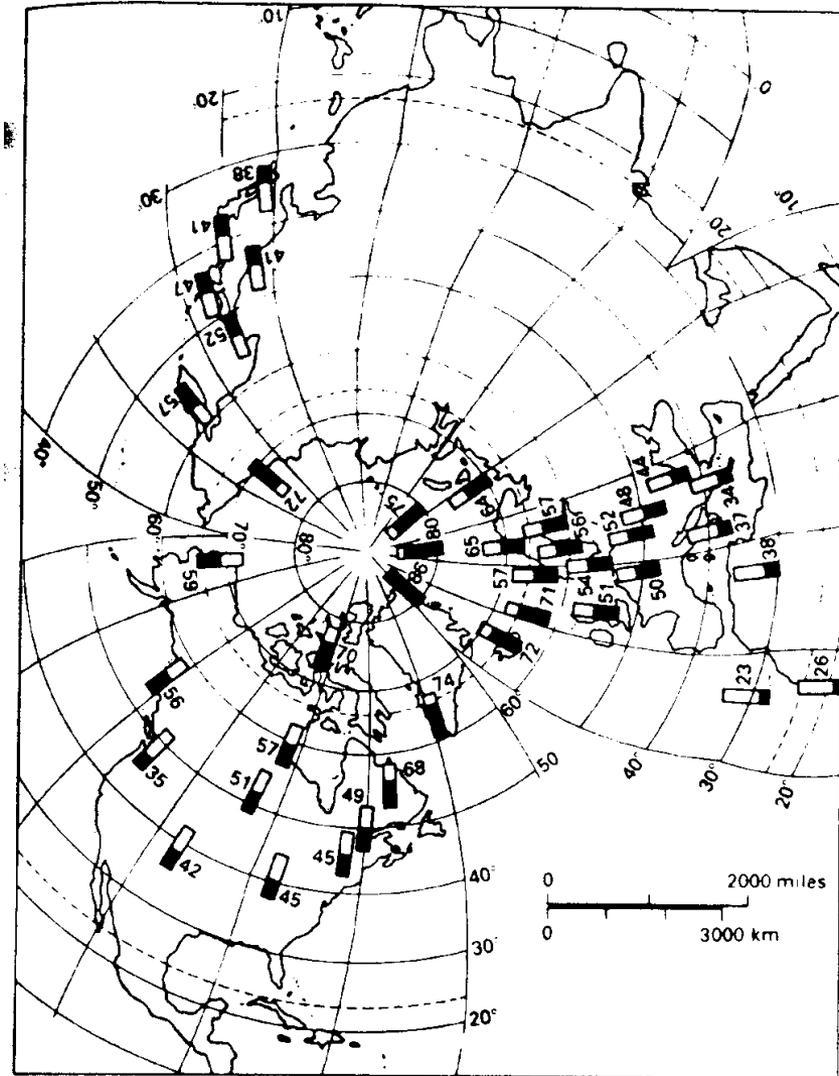
Tendências geográficas em traços biológicos



Relationship between **genome size and latitude** as expressed by northern range limits of various crops in Europe (after Bennet, 1976)

Hengeveld 1990

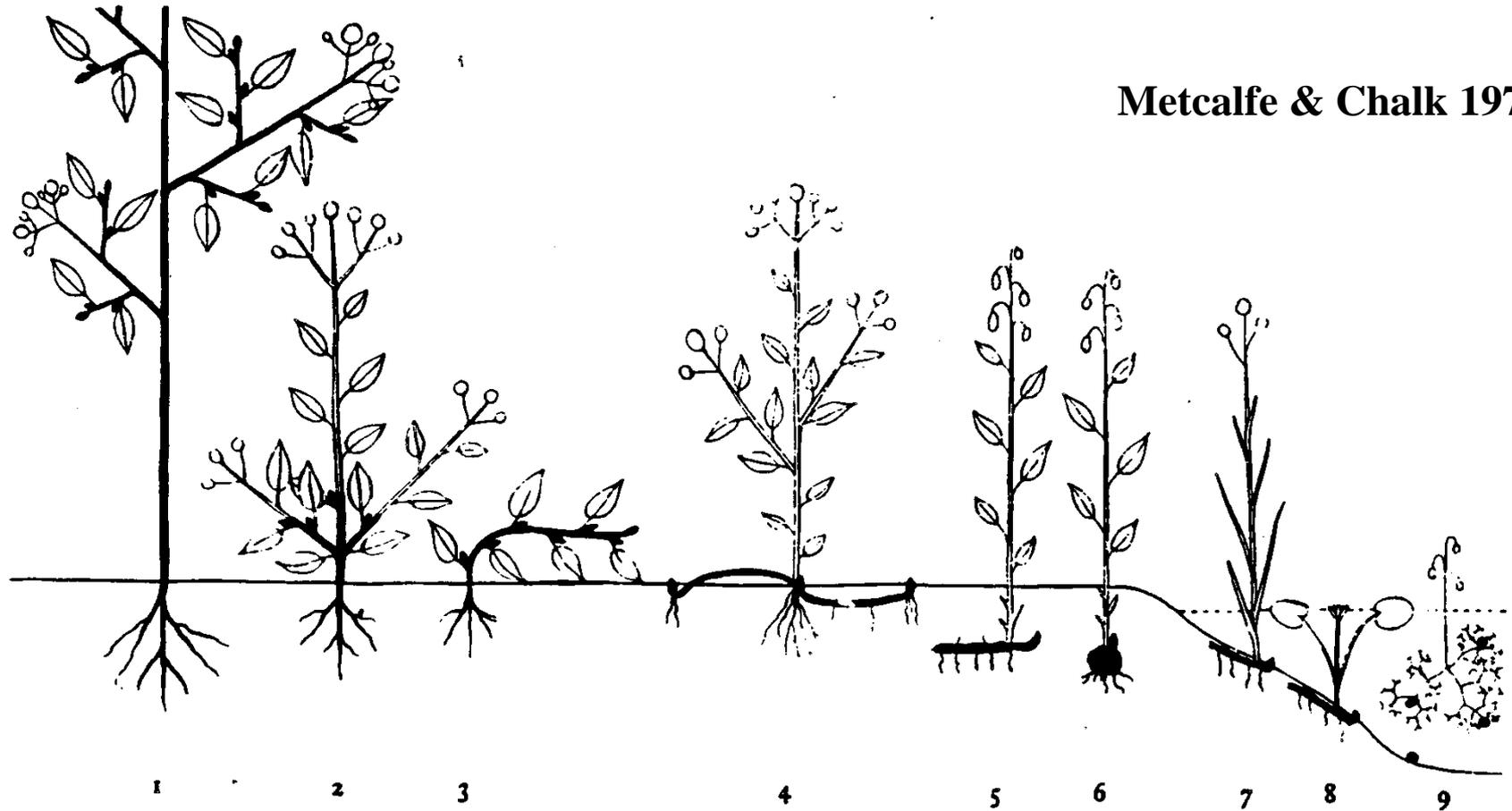
Tendências geográficas em traços biológicos



Frequency of polyploids (given as percentage figures and indicated as black portion of column) in the floras of various territories in the northern Hemisphere. (from Löve & Löve, 1974)

Briggs & Walters 1990

Tendências geográficas em traços biológicos



Formas de vida: fanerófitas (1), caméfitas (2-3), hemicriptófitas (4), criptófitas (5-9): helófitas (7), hidrófitas (8-9). (Raunkiaer, C. 1934. *The life forms of plants and statistical plant geography*, Clarendon Press, Oxford.)

Tendências geográficas em traços biológicos

CLASSIFICATION OF BIOGEOGRAPHICAL AND ECOLOGICAL PHENOMENA

79

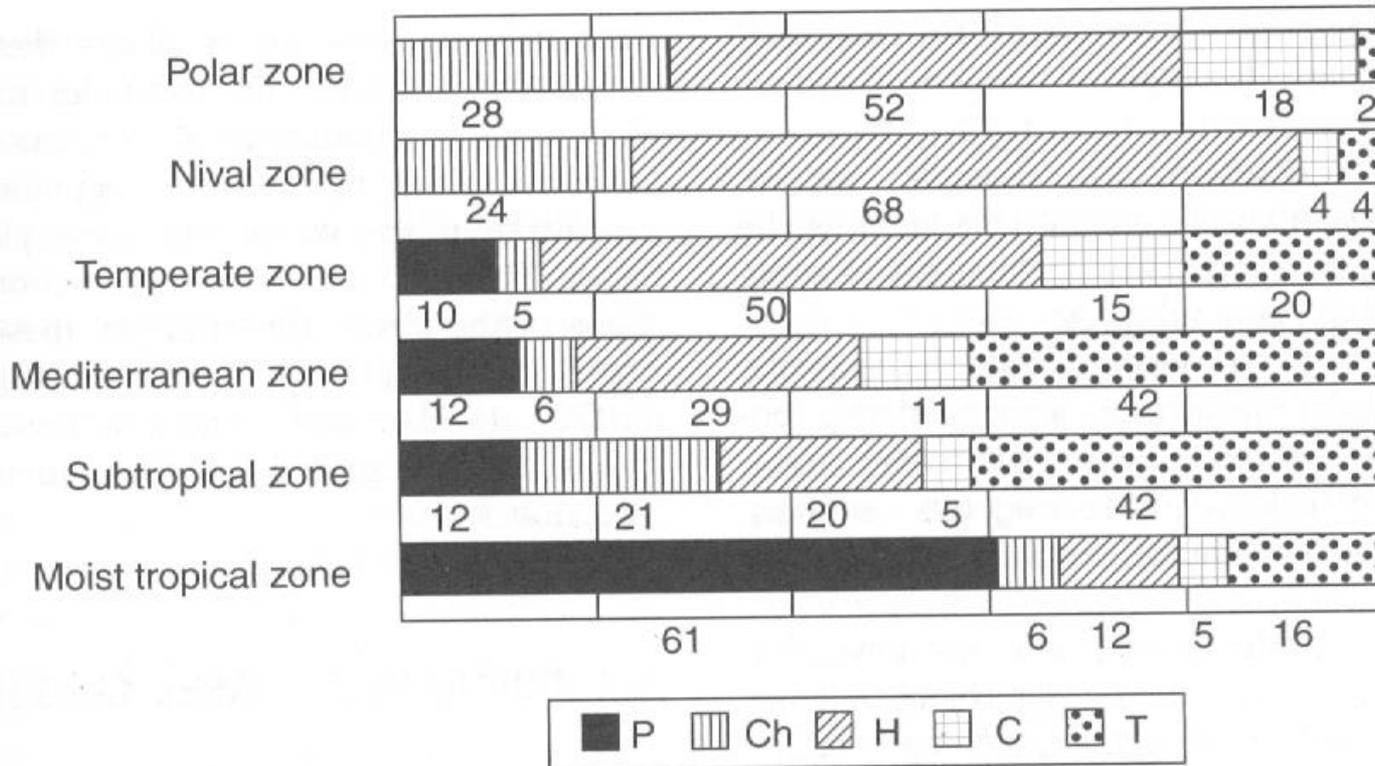


Figure 5.2 Raunkiaer's plant life-form spectra from different regions of the world (from Kratochwil and Schwabe, 2001). P, Phanerophytes; Ch, Chamaephytes; H, Hemicryptophytes; C, Cryptophytes; T, Therophytes.

Millington et al. 2011

Tendências geográficas em traços biológicos

- Mecanismos fotossintéticos: C3 e C4 e CAM

**n° de spp C4 decresce com a latitude e com a altitude;
spp CAM correlacionam negativamente com umidade**

- Alcalóides

- Galhas

- Tamanho de sementes

- Tipos de polinização

- Duração de floração

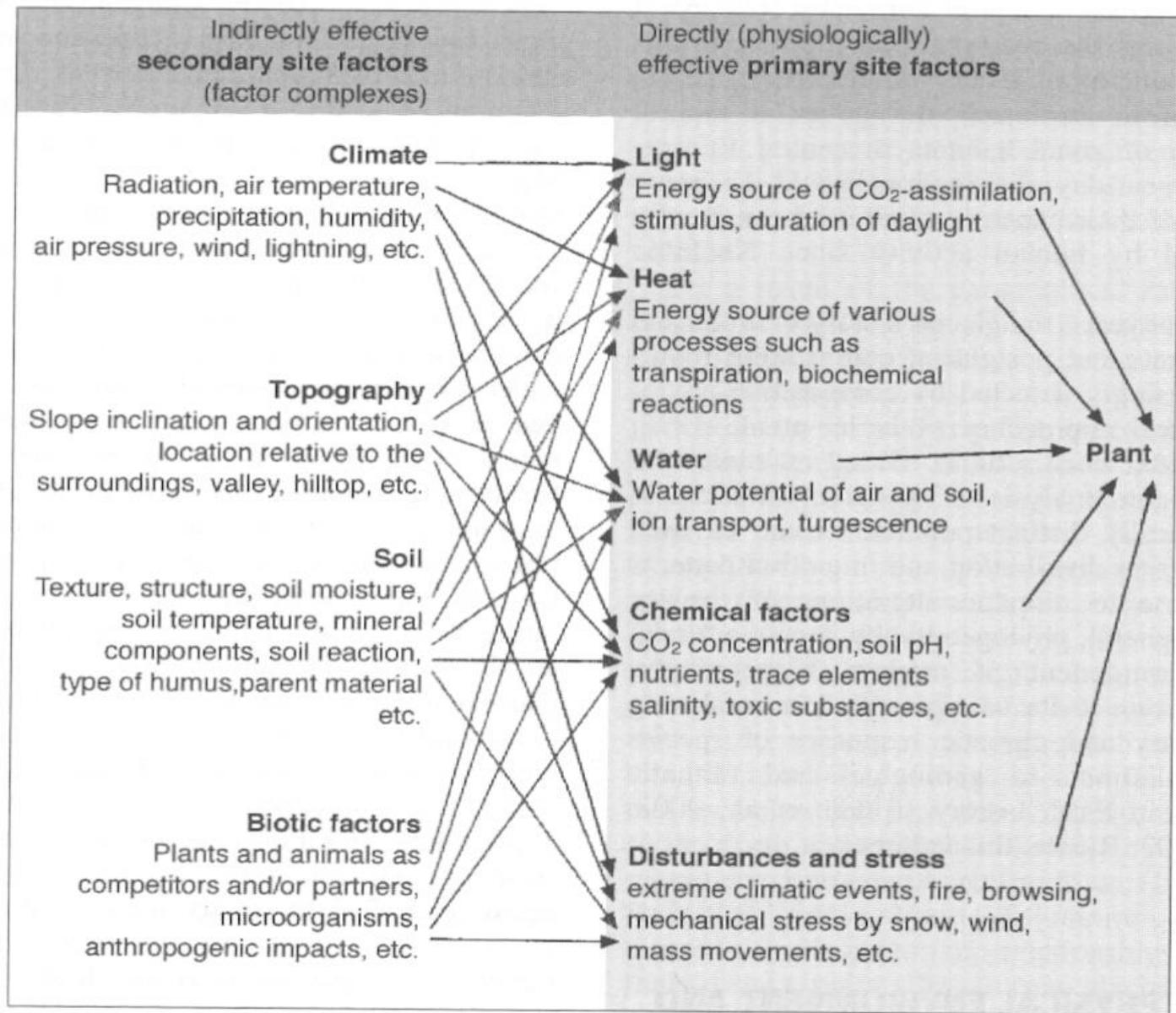


Figure 8.8 Indirectly (secondary) and directly (primary) effective site factors (after Walter, 1960; Ellenberg, 1968; Klink, 1996, modified)

BASES DA BIOGEOGRAFIA ECOLÓGICA

Explicar a distribuição geográfica de um organismo envolve:

- Ecologia da dispersão da espécie**
 - Variações do ambiente físico**
- Interações ecológicas com outros organismos**