BIOGEOGRAFIA

Estudo da distribuição dos organismos no presente e no passado. Ciência que busca explicar os padrões de distribuição de espécies e grupos taxonômicos superiores.

Fitogeografia – Zoogeografia

Biogeografia Histórica – Biogeografia Ecológica

Paleobiogeografia

ANÁLISE ESPACIAL

Estudo de fenômenos que se manifestam no espaço

DISTRIBUIÇÃO NO ESPAÇO - PADRÕES

PROCESSOS NO ESPAÇO-TEMPO

PREDIÇÕES OU RETRODIÇÕES

ANÁLISE ESPACIAL

PADRÃO e PROCESSO

Processos ao longo do tempo geram padrões.

Padrões observados são usados para a reconstrução (ou retrodição) de processos ocorridos.

Padrões e processos são complementares um ao outro.

ANÁLISE ESPACIAL

PROCESSOS NO ESPAÇO-TEMPO

- (sucessão ecológica)
- extinção
- dispersão
- vicariância

ANÁLISE ESPACIAL

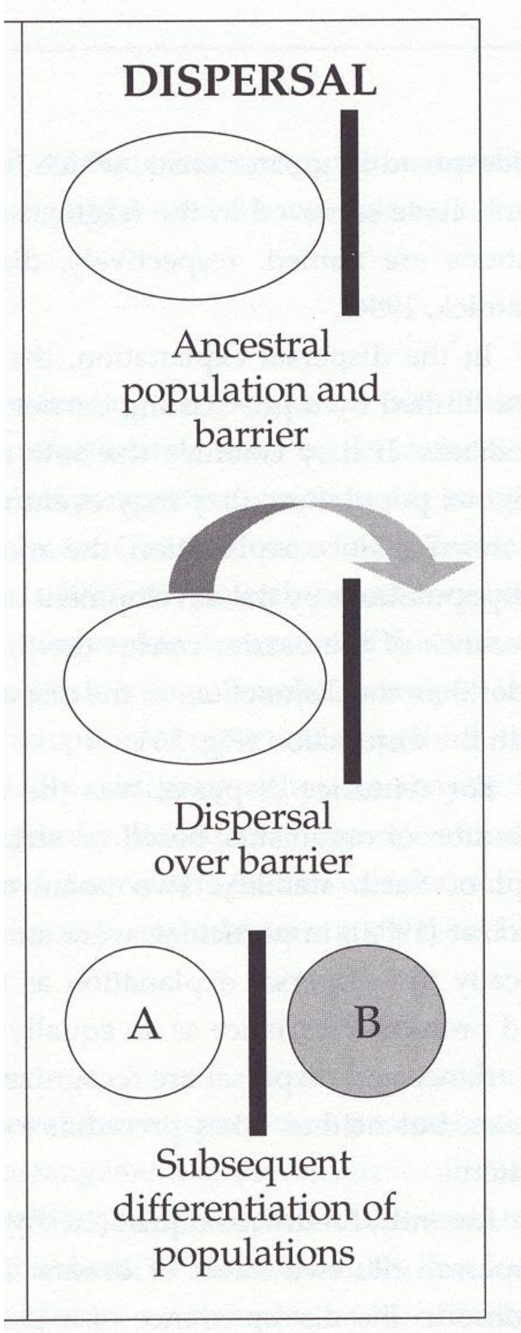
PROCESSOS NO ESPAÇO-TEMPO

- (sucessão ecológica)

- extinção

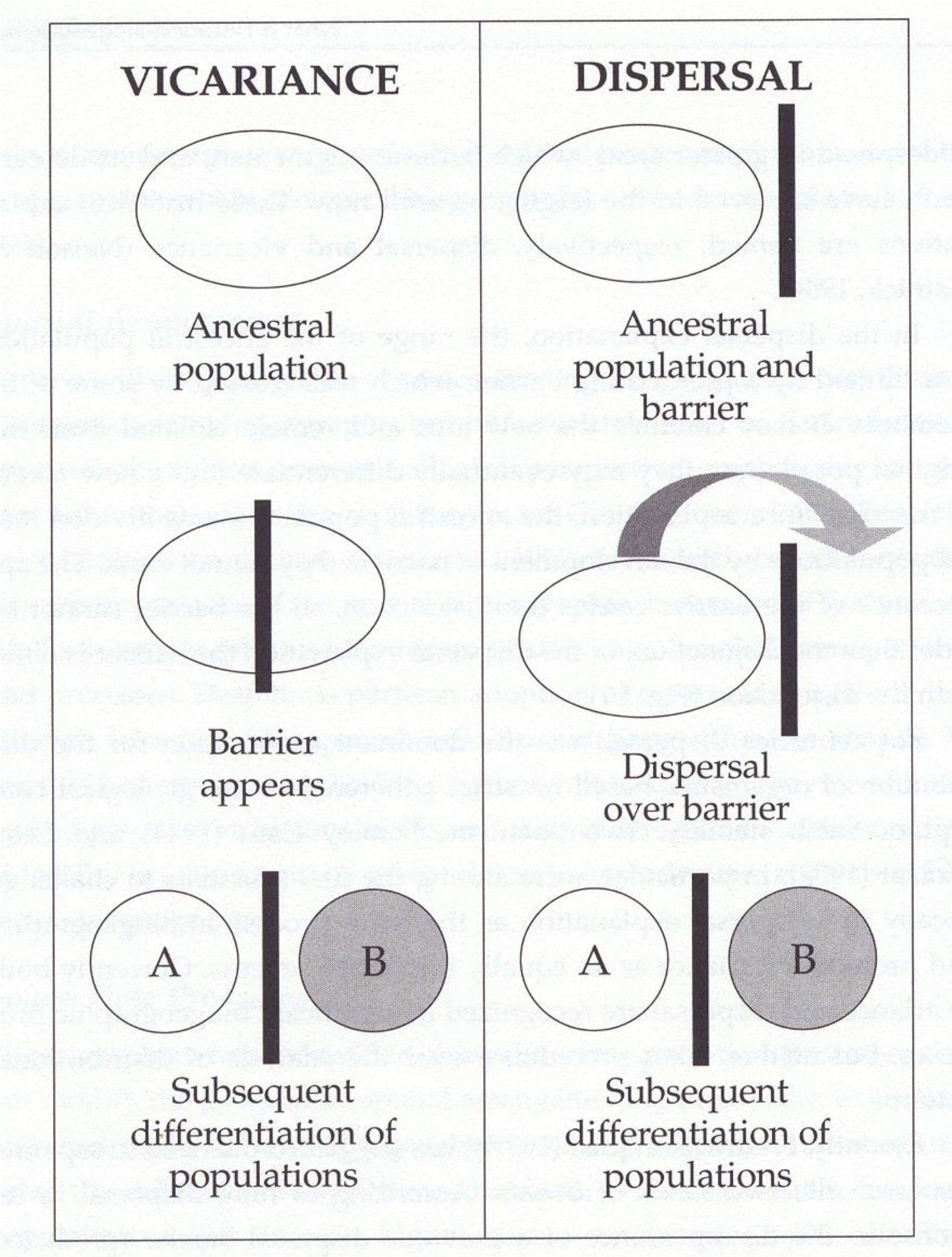
- dispersão: predizível x ao acaso (Ronquist 1997)
  difusão x ao acaso (Brown & Lomolino 1998)
  movimentos dentro da área natural do táxon x ocupação de áreas distantes (Parenti & Ebach 2009)

- vicariância



Dispersão

Crisci *et al.* 2003



Vicariância

x

Dispersão

processos históricos possíveis para 2 táxons ou clados

Crisci *et al.* 2003
baseado em
Nelson & Platnick 1981

VICARIÂNCIA

1. **Eventos de vicarância + especiação**
   = espécies-irmãs em áreas-irmãs

2.

3.

VICARIÂNCIA

1. **Eventos de vicarância + especiação**
   = espécies-irmãs em áreas-irmãs

2. Eventos de vicariância + especiação *a posteriori* de uma especiação prévia independente da vicariância
= paralogia geográfica (ou simpatria, ou redundância)

3.

VICARIÂNCIA

1. **Eventos de vicarância + especiação**
   = espécies-irmãs em áreas-irmãs

2. Eventos de vicariância + especiação *a posteriori*
de uma especiação prévia independente da vicariância
= paralogia geográfica (ou simpatria, ou redundância)

3. Eventos de vicariância sem especiação
= espécie de distribuição disjunta (descontínua)

Predições e retrodições

-Reconstrução da história da distribuição de grupos individuais
(biogeografia do táxon ou clado)

-Reconstrução da história das áreas de endemismo
(biogeografia da área)

-Reconstrução da distribuição de biotas
(busca de homologia espacial)

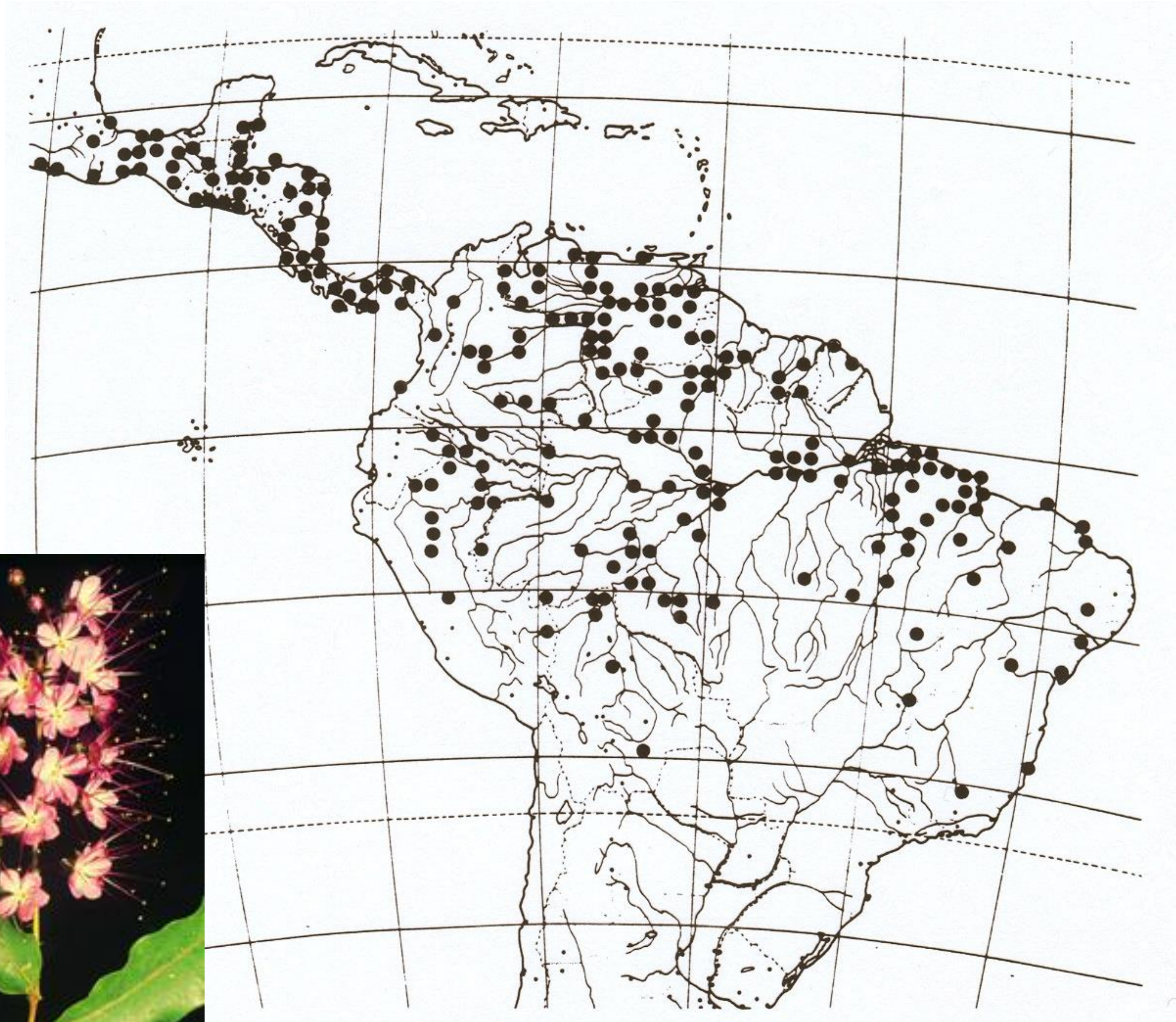
Podem ser feitas por meio de técnicas diversas
sem conhecimento prévio dos processos no espaço-tempo

ÁREA DE DISTRIBUIÇÃO

Região total dentro da qual se distribui uma unidade taxonômica qualquer (Cain 1944)

Métodos de representação: cartográficos e aerográficos (Rapoport 1975, Zunino & Zullini 1995; Morrone *et al.* 1996)

- mapa com pontos
- mapa com grade
- mapa com isolinhas ou hachuras
- mapa híbrido com pontos + isolinhas



Distribution of *Hirtella racemosa* Lam.

Prance 1994

Couepia

Licania

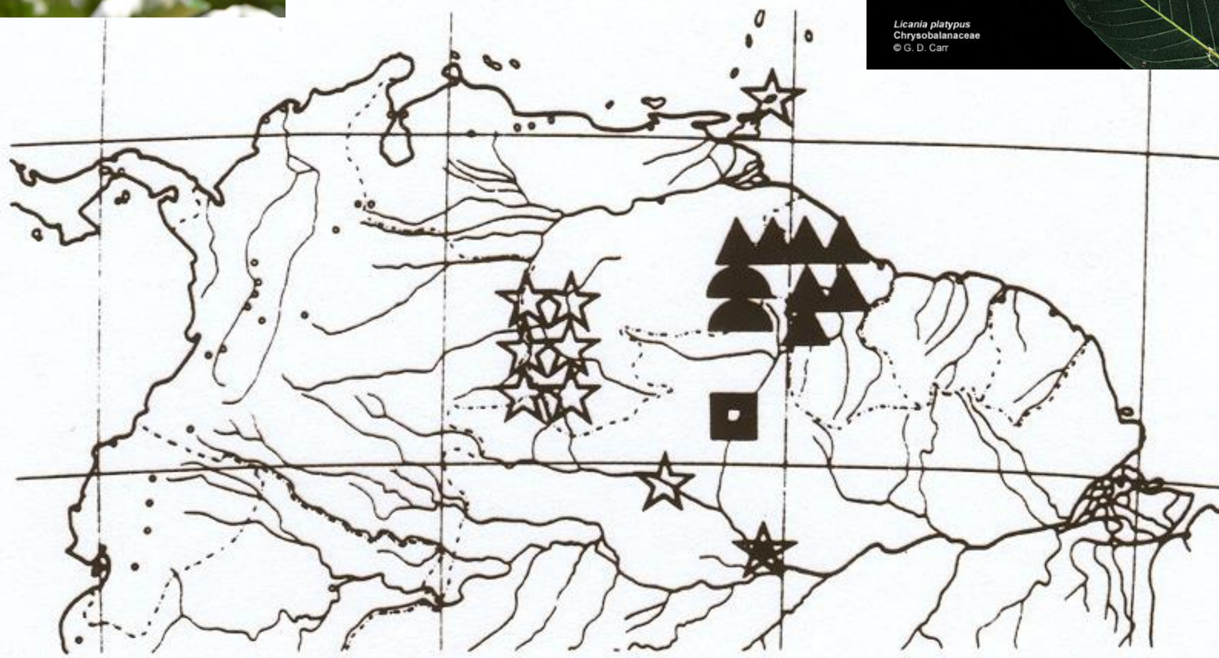


Fig. 11.2 Distribution of five locally endemic species of Chrysobalanaceae, each occurring in a different habitat: ◓ *Couepia steyermarkii* Maguire (montane forest), ▲ *Couepia comosa* Benth. (riverine forest), ◘ *Hirtella dorvalli* Prance (white sand), ★ *Couepia glabra* Prance (terra firme forest), ☆ *Licania lanceolata* Prance (savannah).

Prance 1994

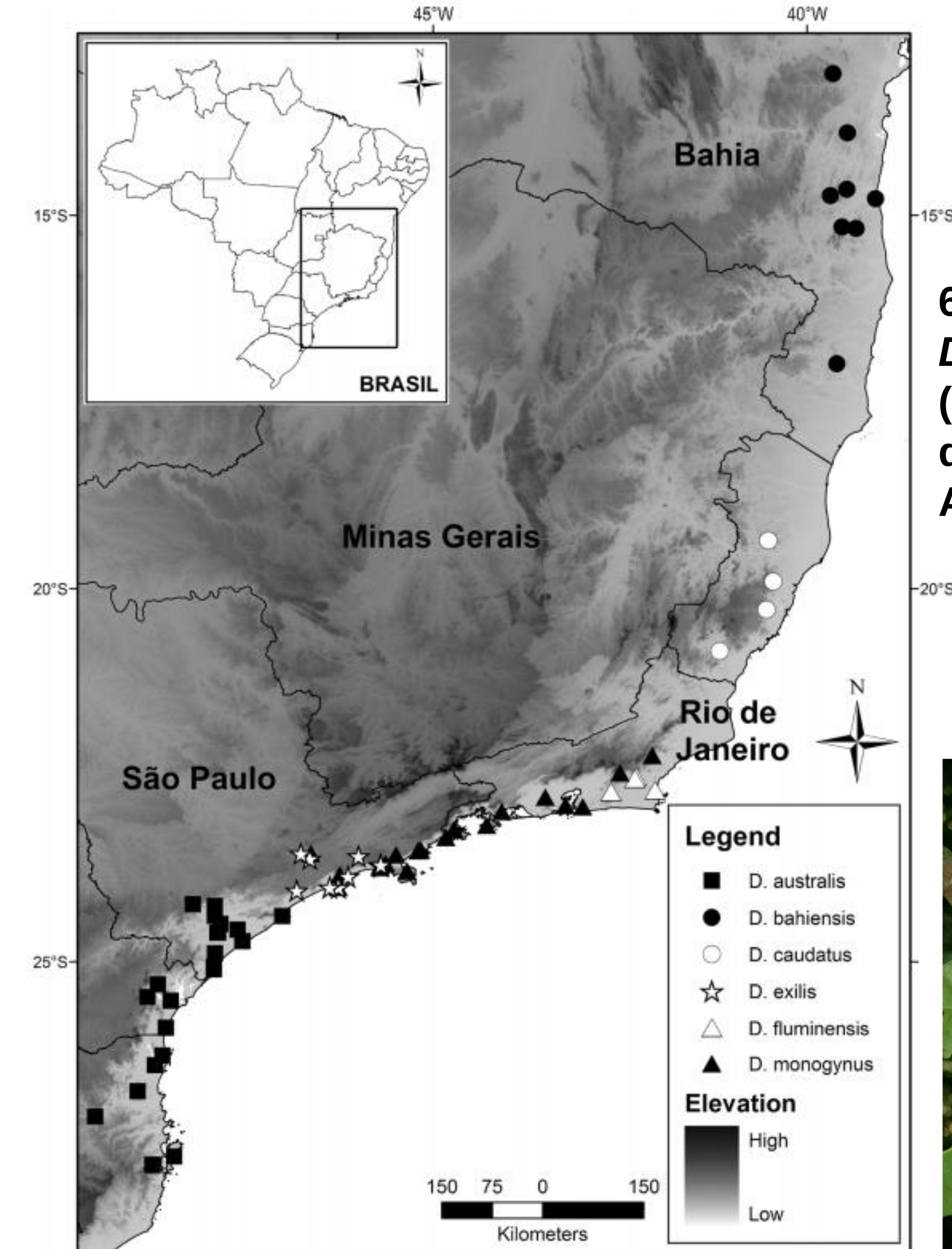


FIG. 3. Distribution map of *Dendropanax fluminensis* and similar species from the Brazilian Atlantic Forest.

6 espécies de *Dendropanax* (Araliaceae) da Mata Atlântica

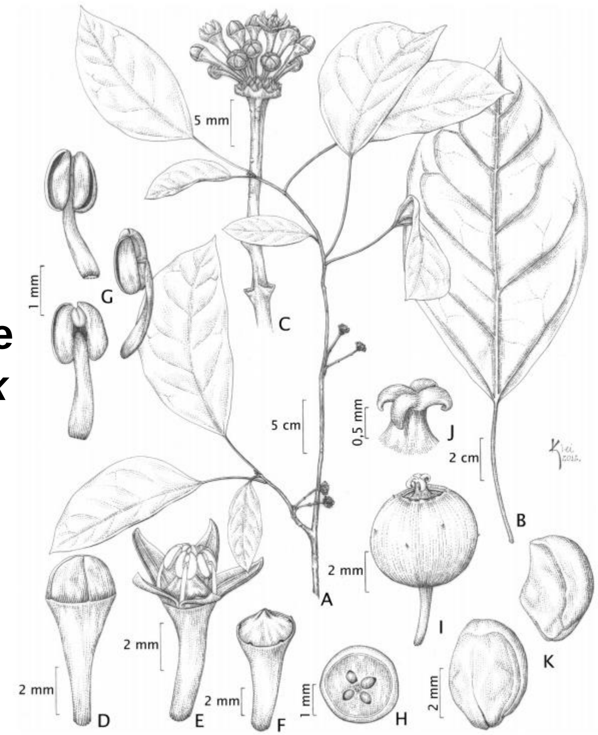
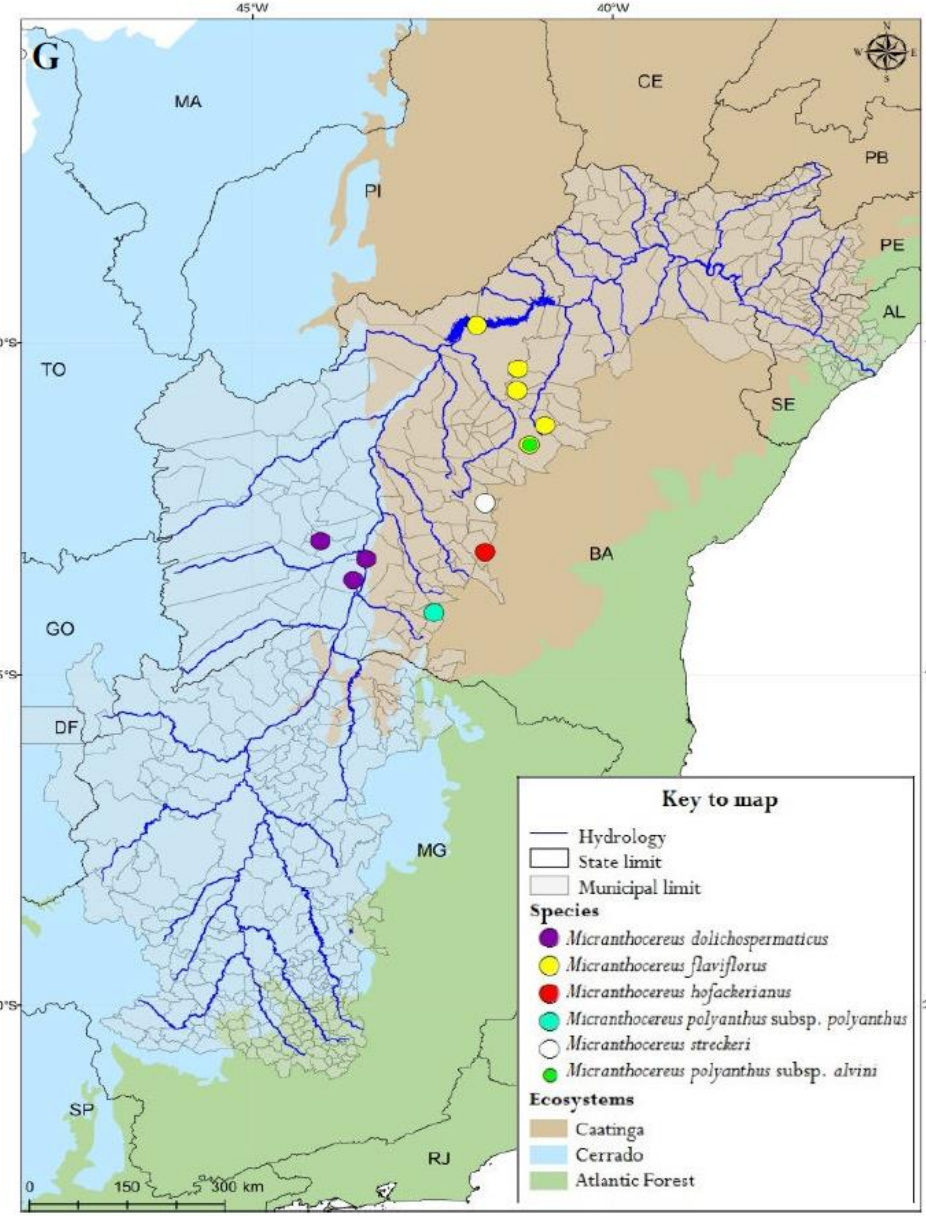
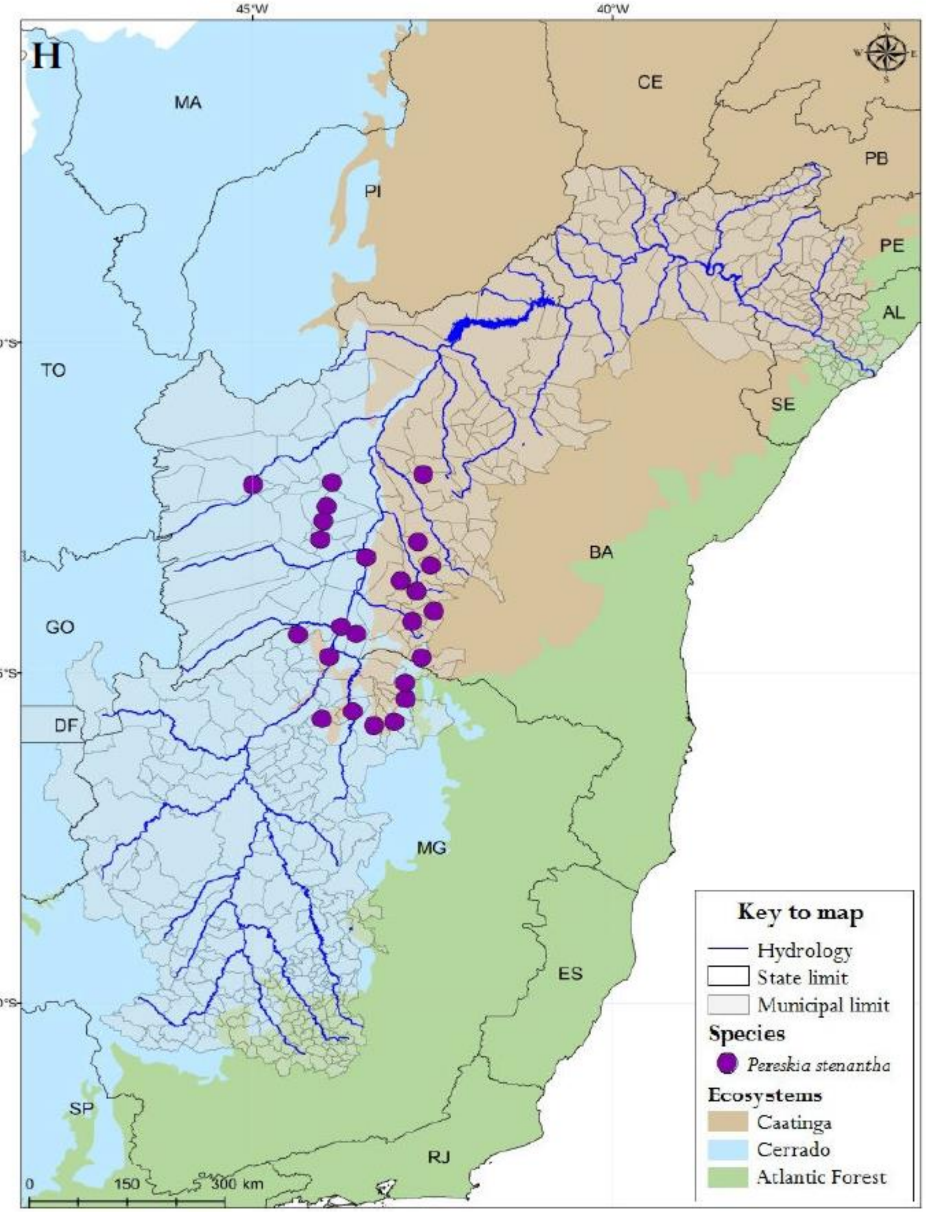


FIG. 1. *Dendropanax fluminensis*. **A.** Flowering branch. **B.** Leaf, abaxial view. **C.** Detail of an inflorescence secondary axis (peduncle). **D.** Flower bud, lateral view. **E.** Flower, lateral view. **F.** Detail of the disc (note indistinct styles). **G.** Stamen, adaxial (top), lateral (mid) and abaxial (bottom) views. **H.** Ovary, transverse section. **I.** Fruit, lateral view. **J.** Detail of the styles in fruit. **K.** Pyrene, adaxial (left) and lateral (right) views. A-H from the holotype. I-K from *Braga et al. 2684*.

Fiaschi 2016



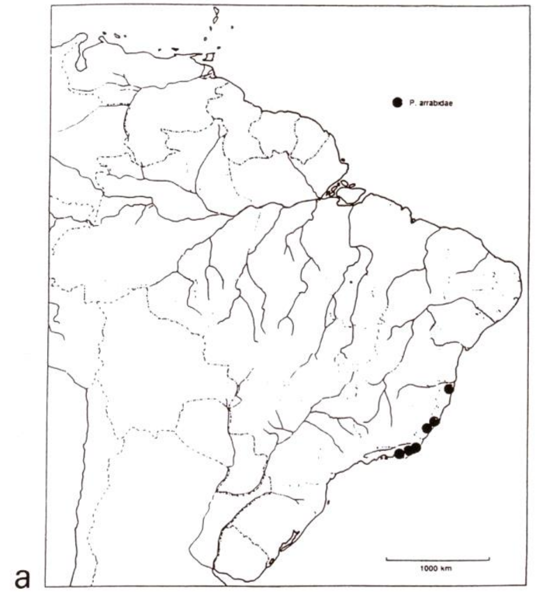


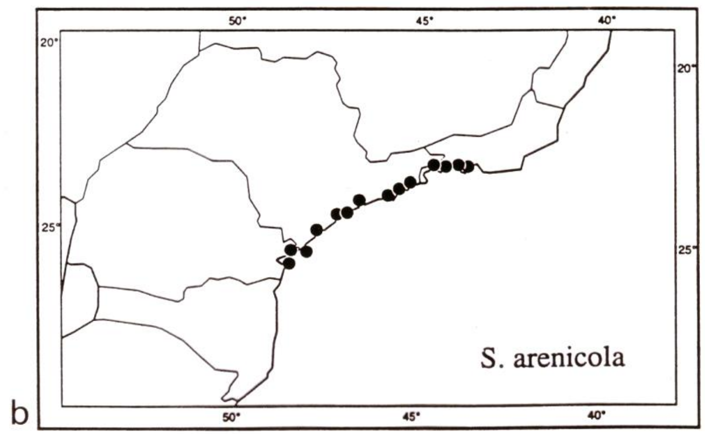
ECOLOGICAL ATTRIBUTES, GEOGRAPHIC DISTRIBUTION
AND ENDEMISM OF CACTI FROM THE SÃO FRANCISCO WATERSHED

Meiado et al. 2015

Fig. 11.3 Two examples of common patterns of species disjunction: ✪ *Licania affinis* Fritsch (Guianas-Amazonia), ▲ *Couratari macrosperma* A. C. Smith (Amazonia-Eastern Brazil).

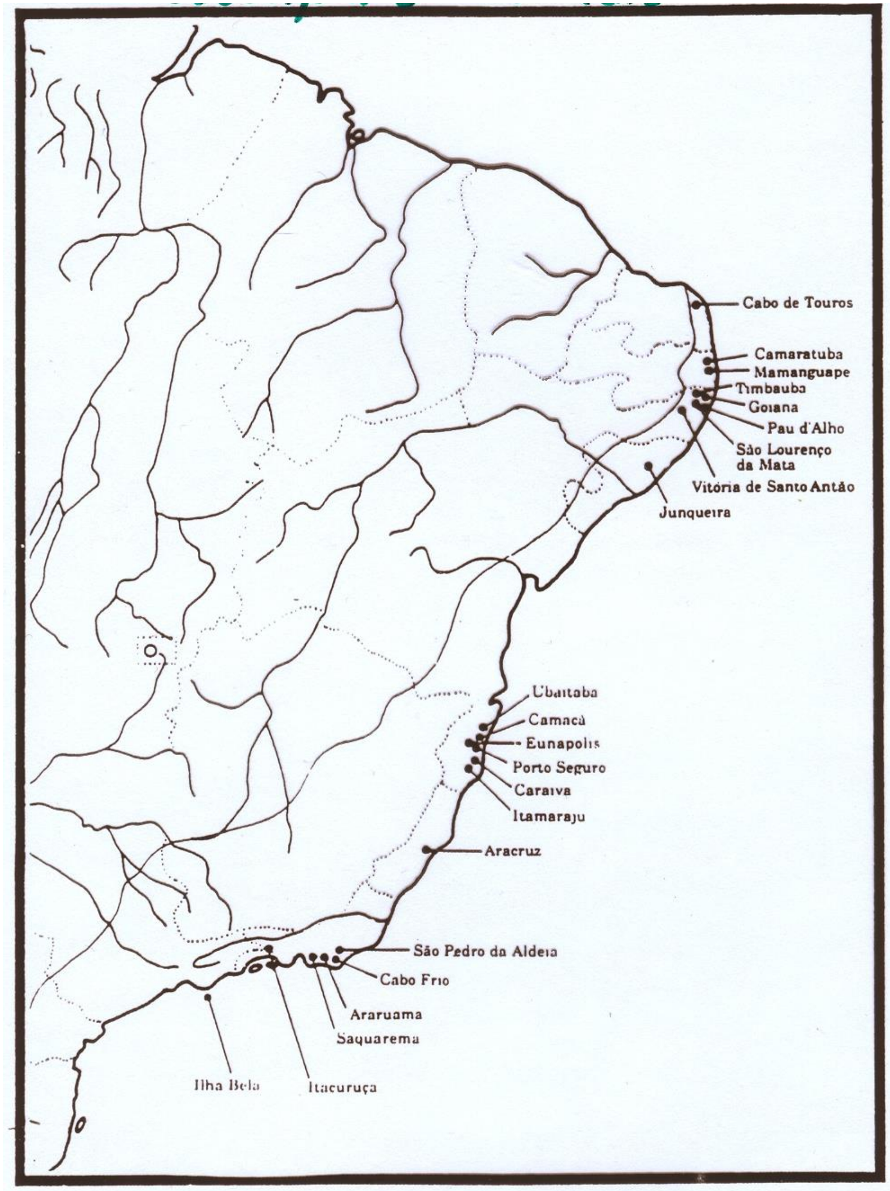
Prance 1994, in Forey *et al*.





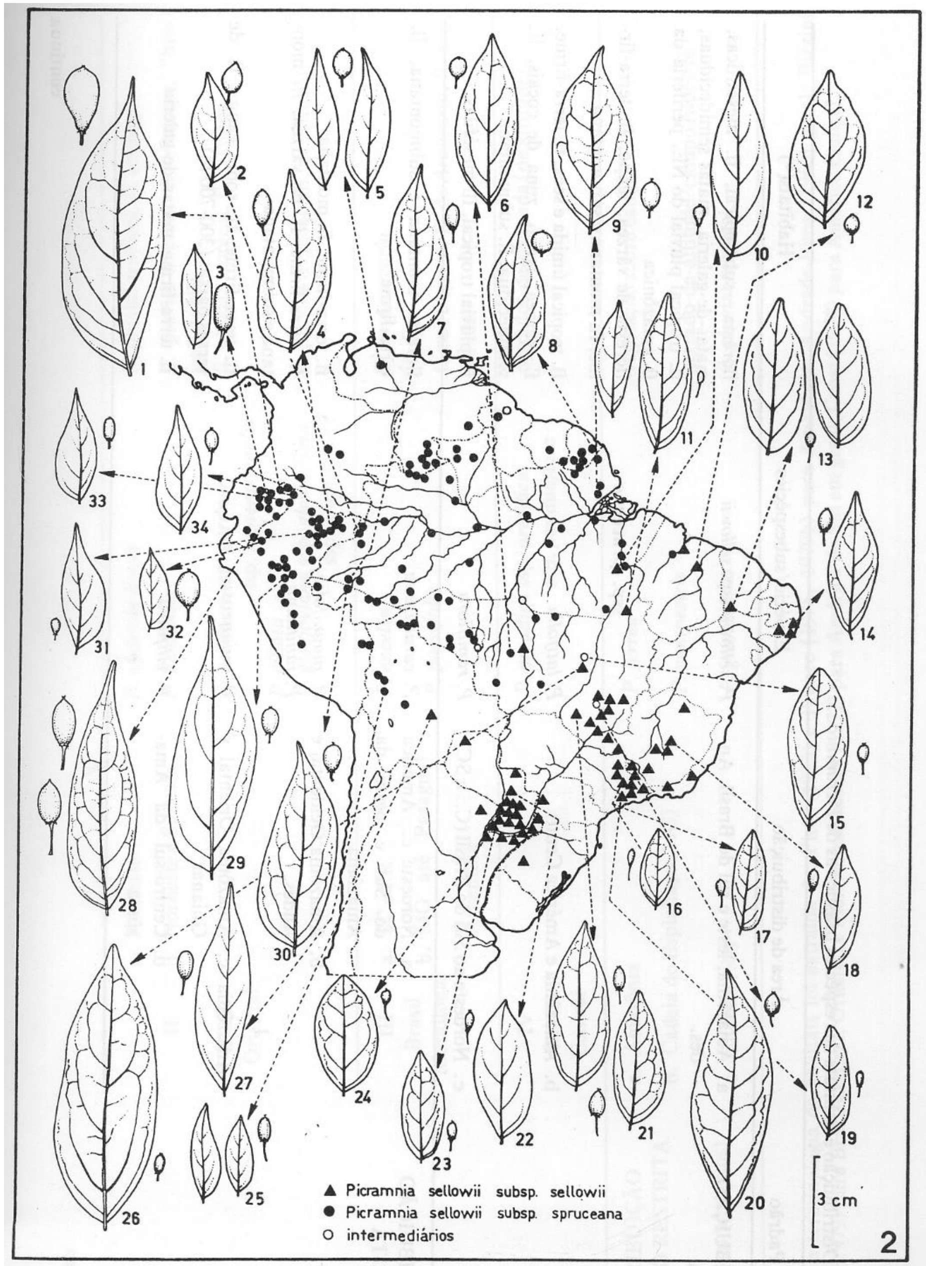
Padrão de distribuição Costa Atlântica Sudeste/Sul. (a) ***Pilosocerus arrabideae*** (Cactaceae) ocorre nas restingas e morros litorâneos do Estado do Rio de Janeiro para o norte até o sul da Bahia (Fonte: Zappi, 1994) (b) ***Stigmaphyllon arenicola*** (Malpighiaceae) ocorre na Mata Atlântica e nas restingas do Estado do Rio de Janeiro, para o sul (Fonte: Anderson, 1997)

(Araújo, 2000)



Padrão de distribuição Costa Atlântica Ampla, mostrado por ***Caesalpinia echinata*** (Leguminosae)

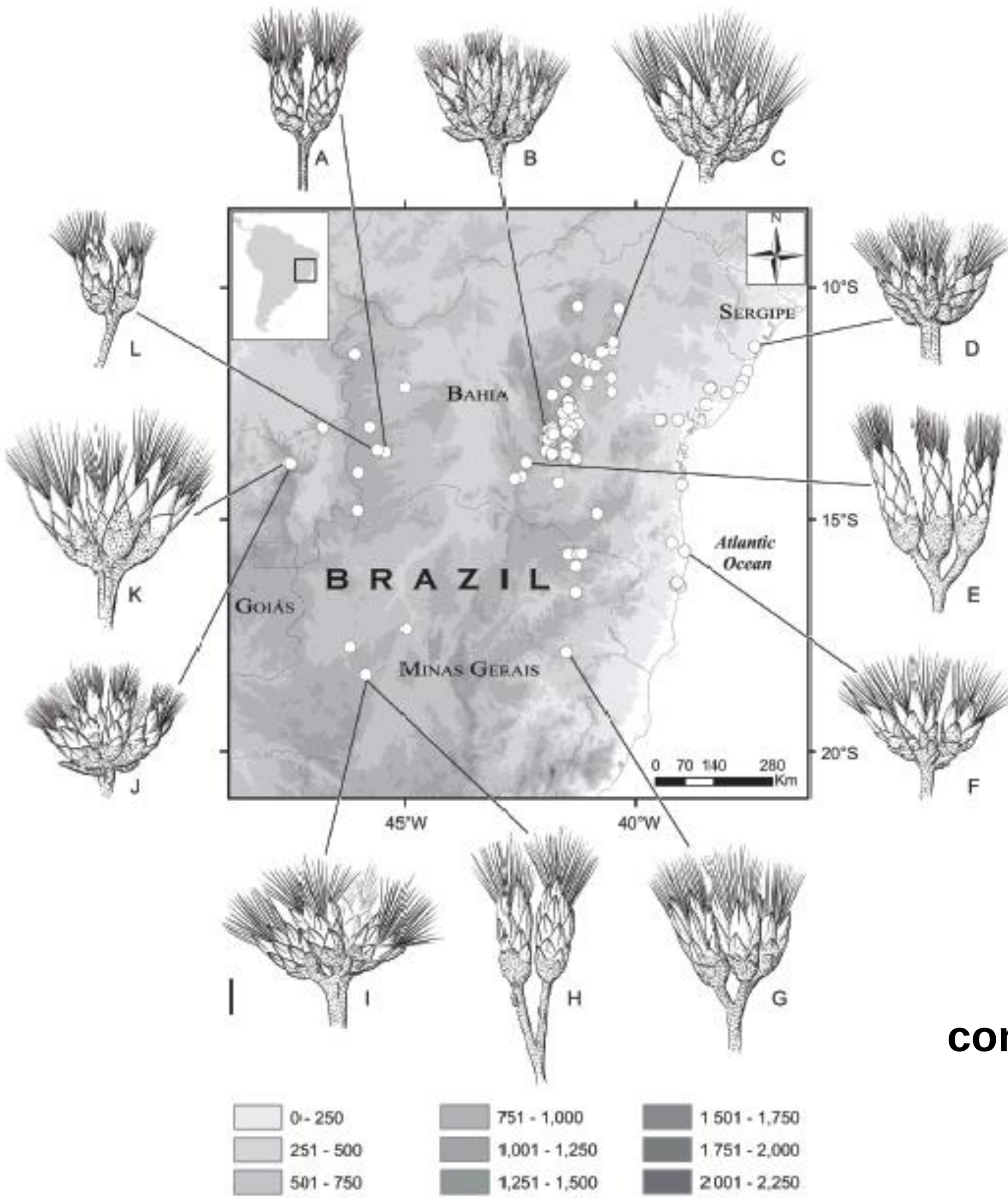
Araújo 2000



Mapa 2 — Distribuição geográfica de *Picramnia sellowii* Planch., discriminando as 2 subespécies, espécimes intermediários entre elas, e variação morfológica de folíolos laterais distais e frutos.

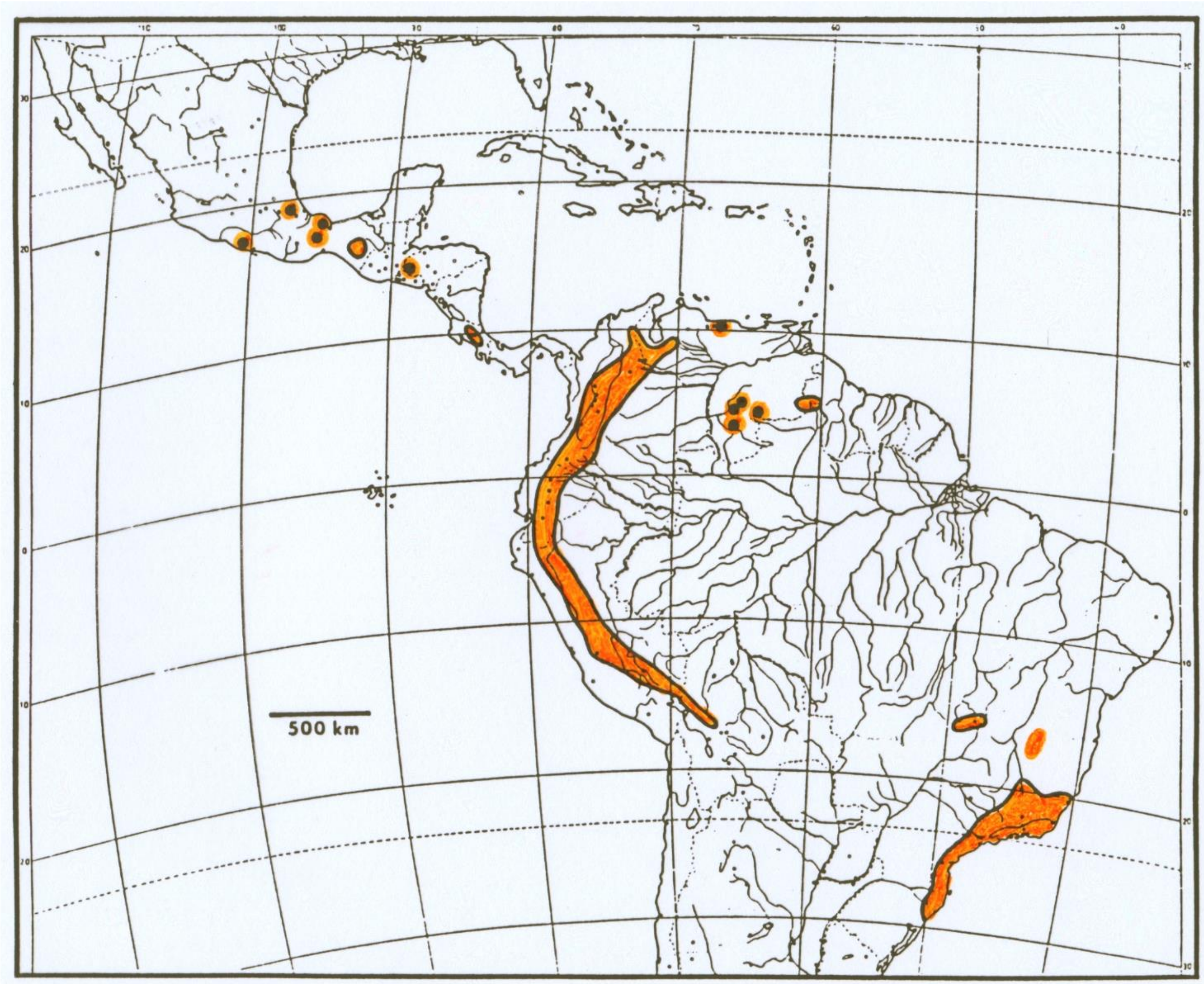
Picramnia sellowii

Pirani 1988



Distribuição de *Eremanthus capitatus* (Compositae)
com variações de glomérulos e invólucros de capítulos.

Loeuille et al. 2011



Distribution of ***Aulonemia,*** Gramineae

Clark 1995

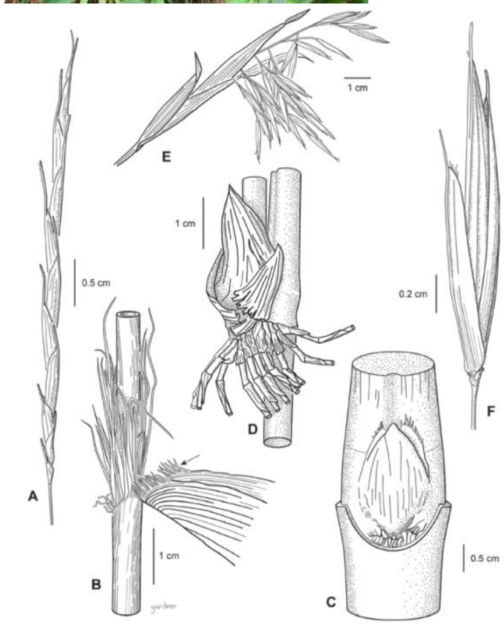
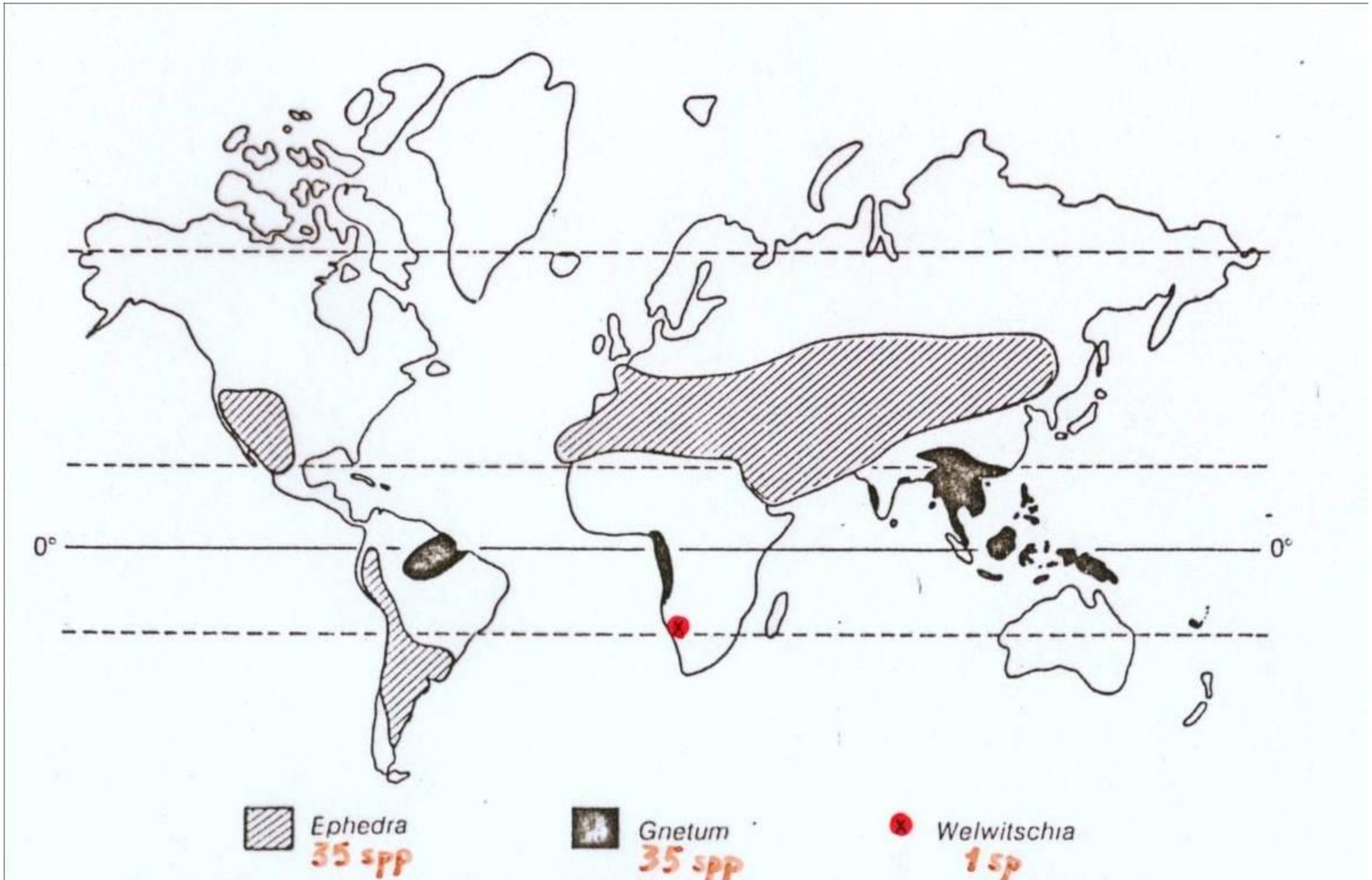


Figure 1. A-B. *Aulonemia fimbriatifolia*. A. Spikelet. B. Ligular area of the foliage leaf, showing well developed fimbriae on the sheath summit and the fimbriate base (arrow) of the blade. C-F. *Chusquea longispiculata*. C. Bud complement. D. Branch complement. E. Inflorescence with three subtending spatheate bracts. F. Spikelet (A: *Hoehne & Gehrt s.n.*, US2926655; B: *Clark & Windisch 1060*; C: *Clark & Windisch 645*; D: *Sarahyba et al. 1064*; E: *Vital s.n.*, SP217610, and *Kuhlmann s.n.*, US1255438; F: *Vital s.n.*, SP217610).

Clark 2004



Present distribution of three genera

of the gnetophytes

Hutchinson 1924

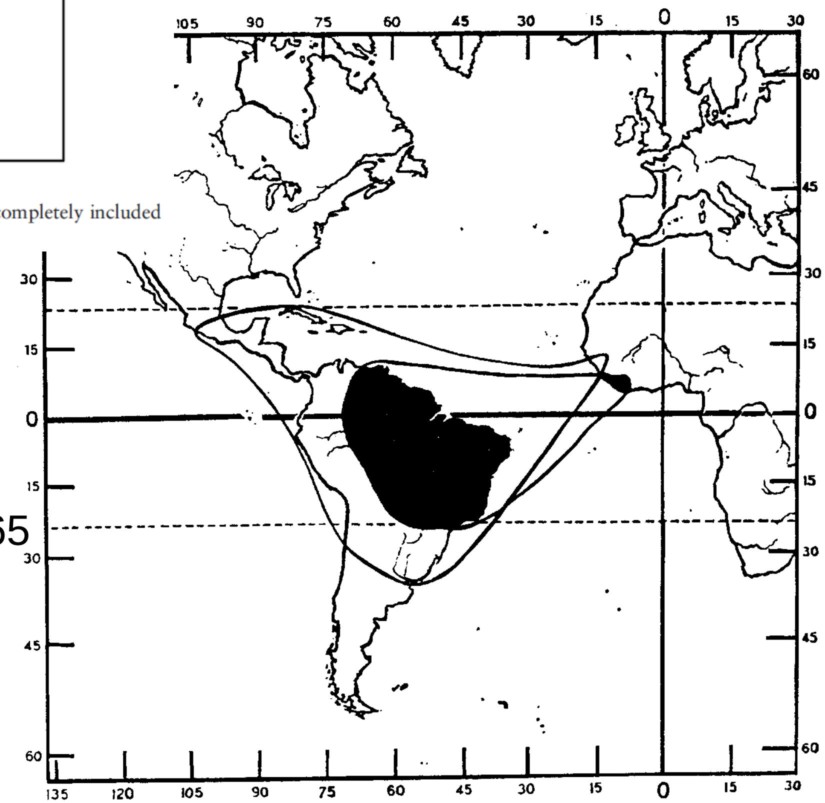
Fig. 1 Amphiatlantic distributions of Bromeliaceae and Rapateaceae. The distribution of rapateads in the New World is completely included within that of bromeliads.

Givnish et al. 2004

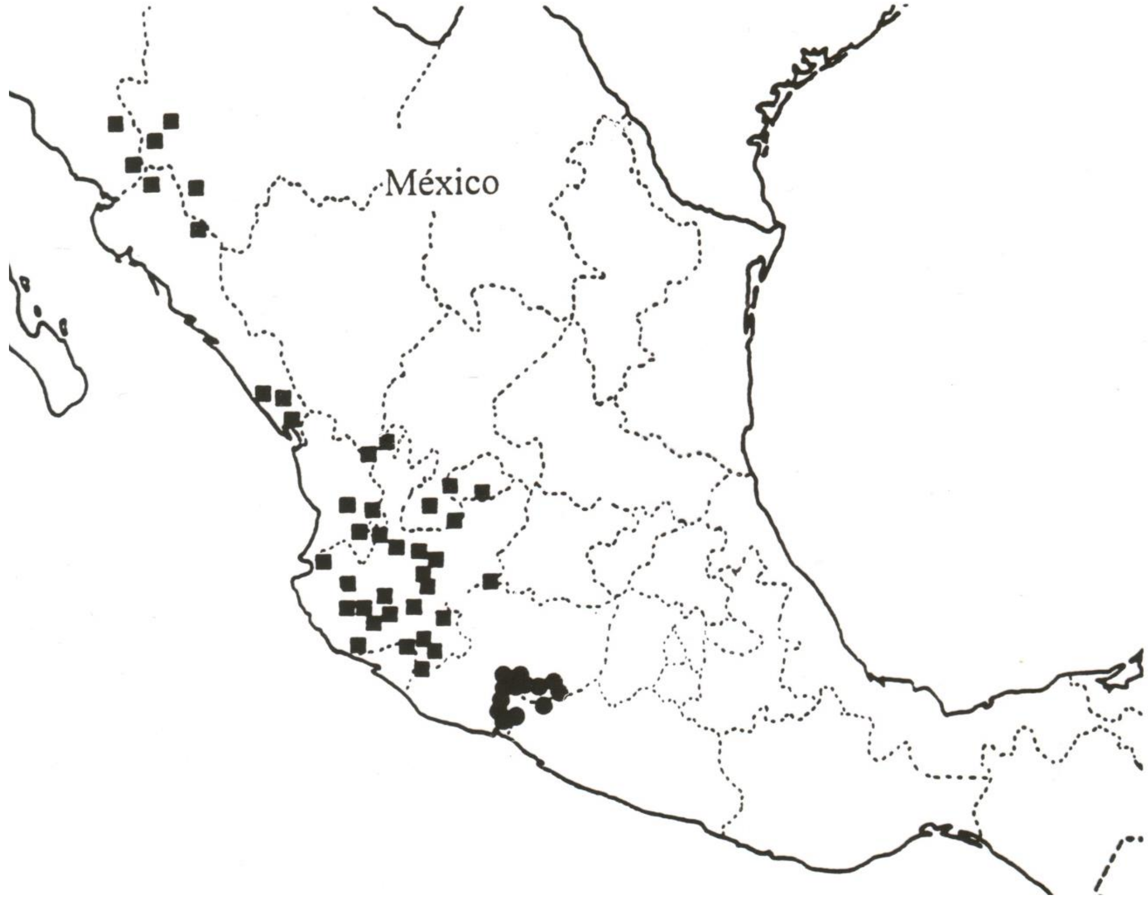
Duas representações da distribuição anfiatlântica de duas famílias (disjunção Afro-Americana):

Bromeliaceae
(hachura cinza ou isolinha não hachurada)

Rapateaceae
(hachuras negras)



Mter Hepper 1965



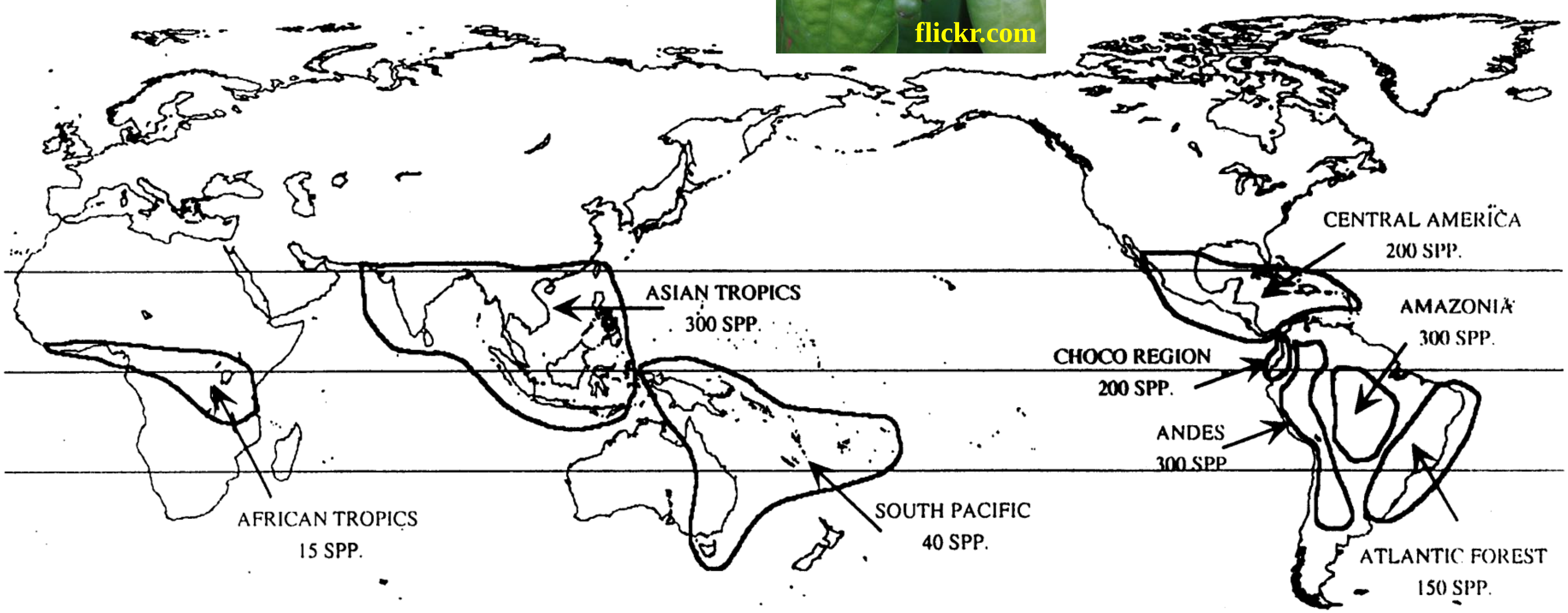
● *Bursera paradoxa*

Burseraceae

■ *Bursera penicillata*

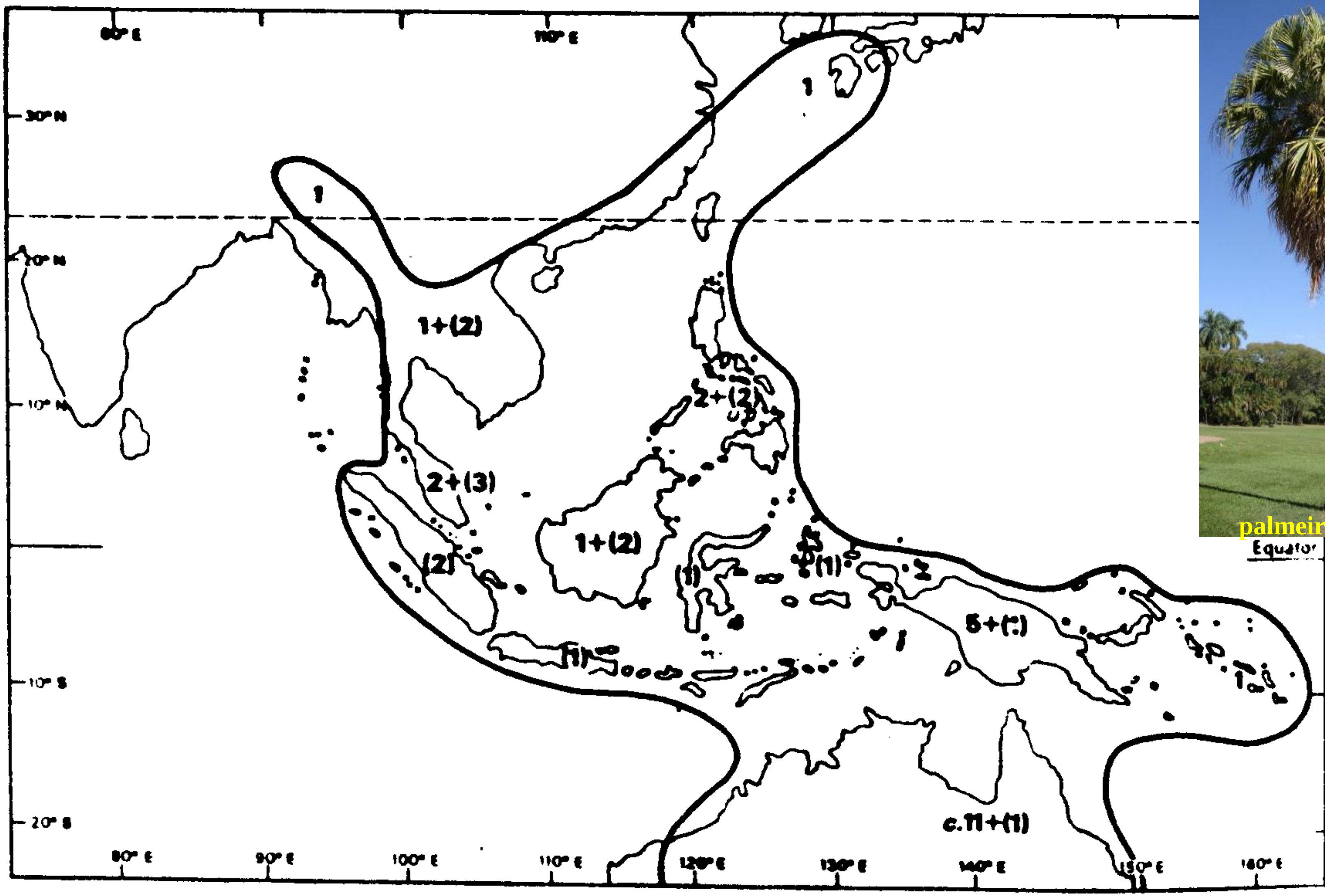
Kohlman & Sánchez 1984

Piper nigrum



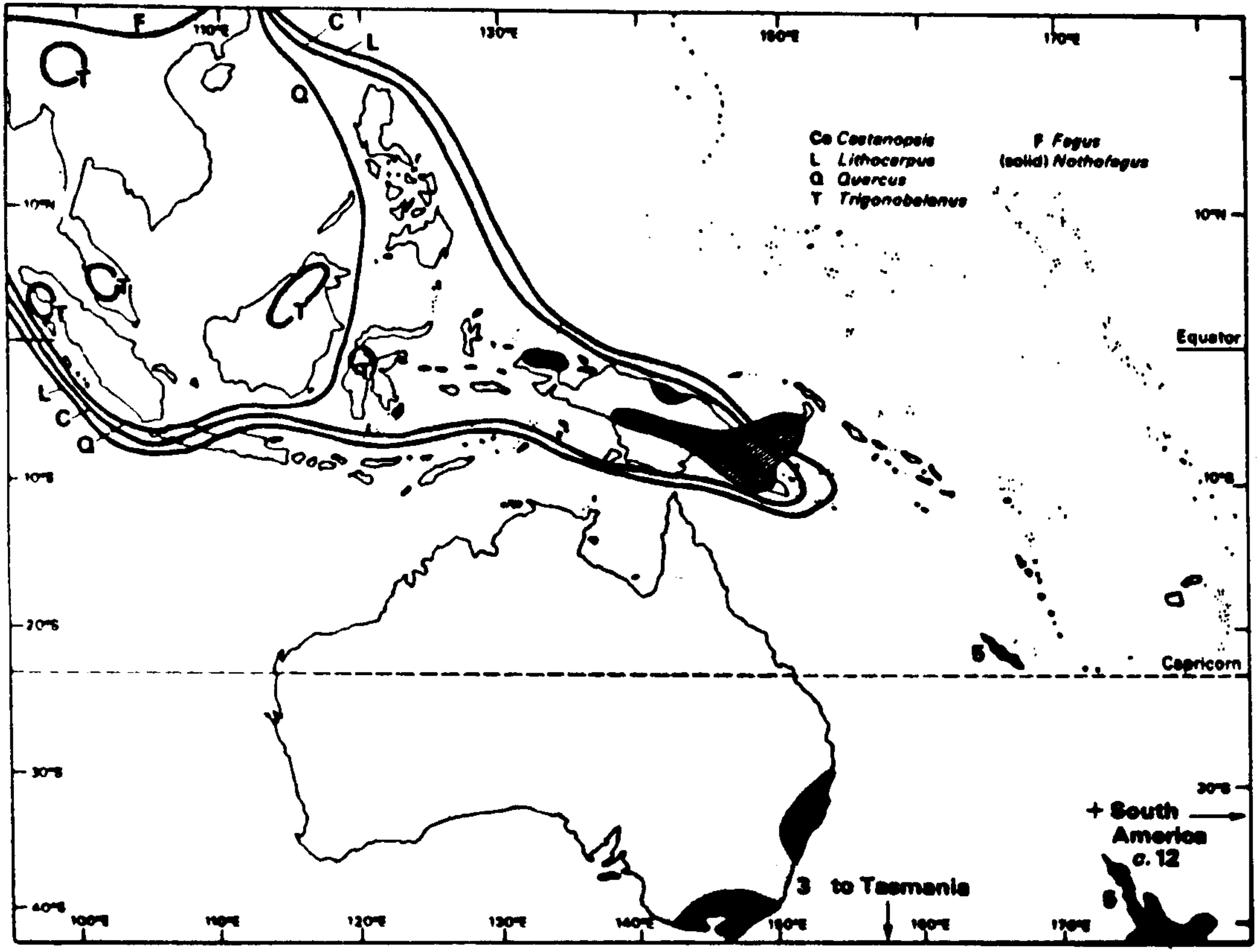
Geographic distribution of the genus ***Piper.*** Species numbers are estimates for each of the centers of diversity of the group, thus regionally widespread taxa may be represented more than once.

Jaramillo & Manos 2001



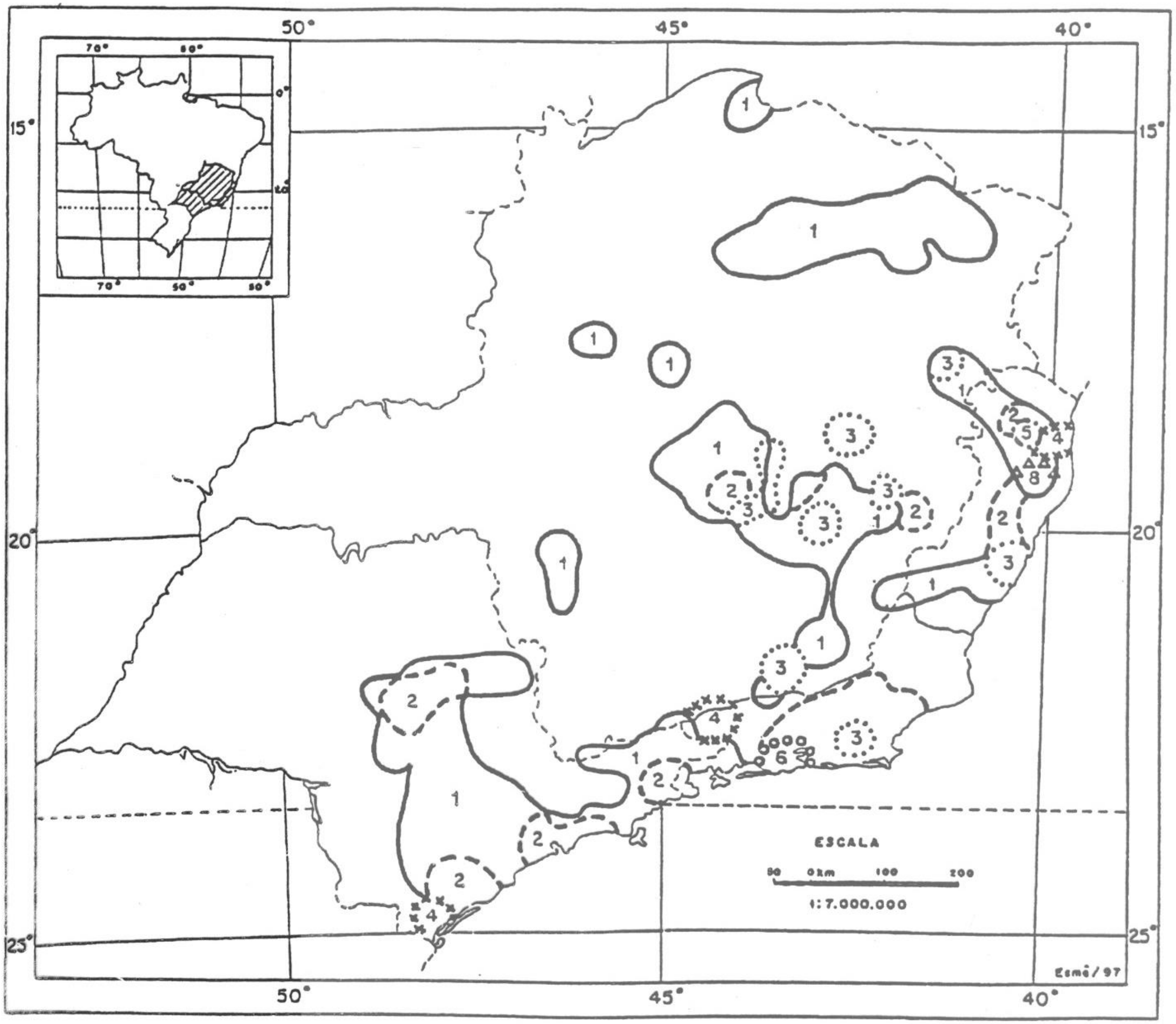
The distribution of the species of ***Livistona*,** Palmae.
Numbers of endemic and in parentheses non-endemic species shown.

Dransfield 1981



The ranges of the genera of Fagaceae in southeast Asia, Malesia and the southeast Pacific.

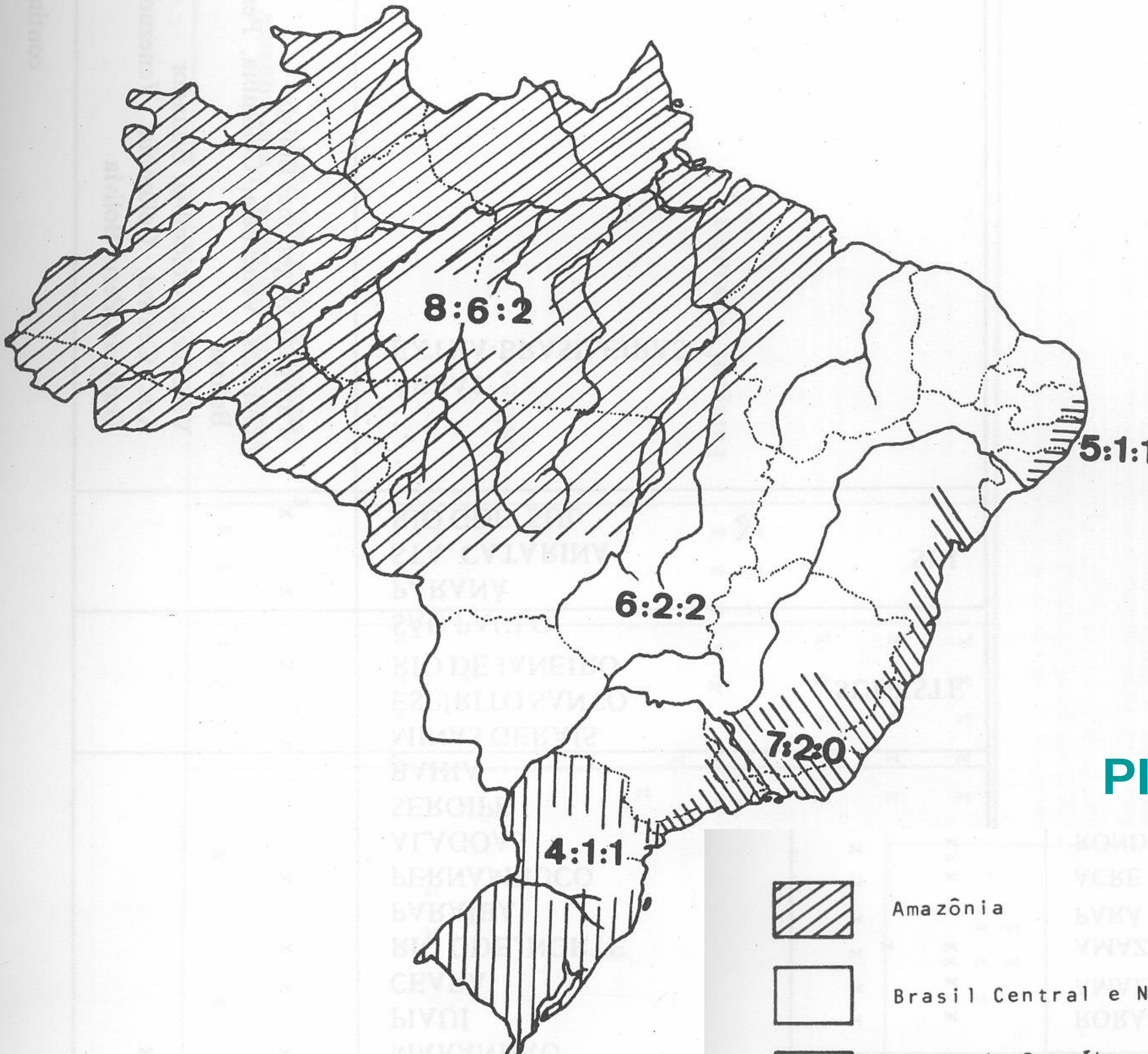
Whitmore 1981



Mansano &

Tozzi 1999

Distribuição geográfica do gênero ***Swartzia*** Schreb. (Leguminosae-Pap.), com diversas isolinhas das espécies que ocorrem na região sudeste do Brasil, plotadas a partir dos mapas de distribuição do material examinado (os números indicam a quantidade de espécies registradas na área delimitada)



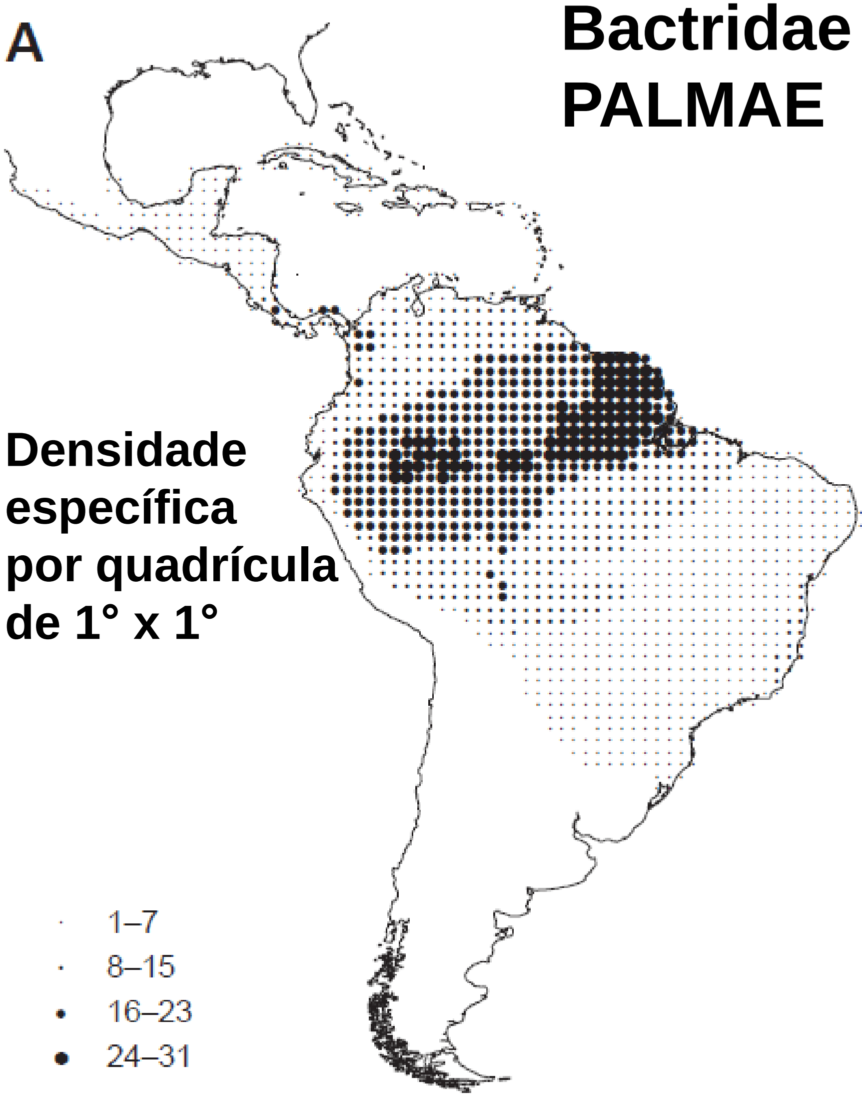
Pirani 1988

Picramnia

PICRAMNIACEAE

Mapa 9 — Distribuição geral das espécies de *Picramnia* no Brasil. As áreas hachudas representam "regiões" com diferentes conjuntos de espécies. Em cada área, a série numérica indica: total de spp. na área: spp. restritas, no Brasil, à área: spp. novas ou recentemente descritas.

Bactridae
PALMAE



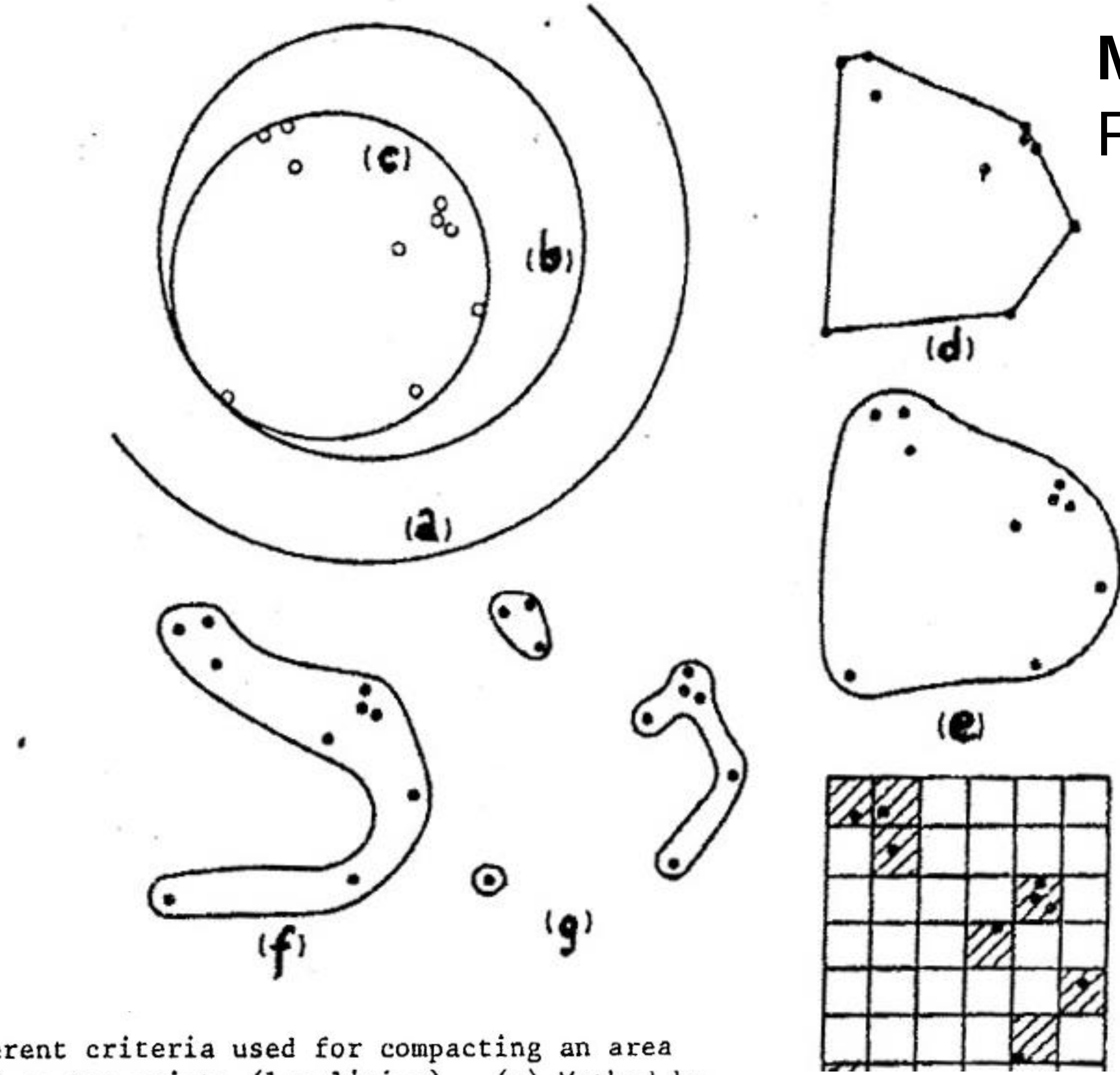
Densidade específica por quadrícula de 1° x 1°

Proporção de spp. em floras regionais

Fig. 1. A, Species richness of subtribe Bactridinae in the Americas based on the range maps provided by Henderson & al. (1995) and digitized by Bjorholm & al. (2005). Circle size corresponds to the number of spp. in the 1° × 1° grid cell the circle is centred on. **B,** Proportion of Bactridinae species within regional palm floras. Circle size corresponds to the number of Bactridinae species/number of palm species in the 1° × 1° grid cell the circle is centred on.

Eiserhardt *et al.* 2011

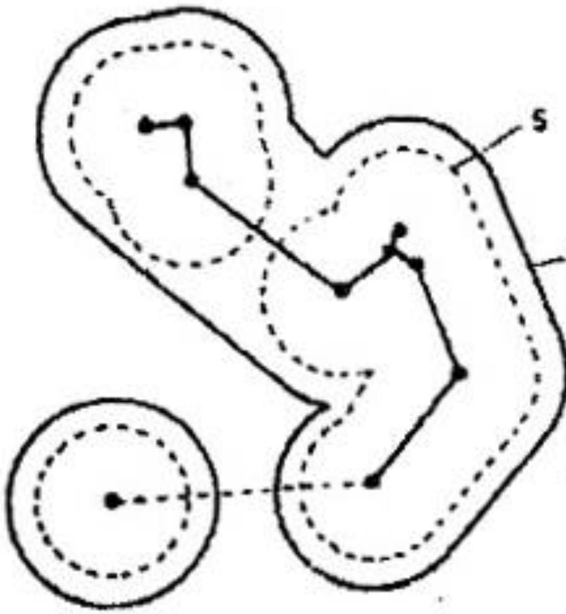
Métodos
Rapoport 1982



Different criteria used for compacting an area based on ten points (localities). (a) Method by Calhoun and Casby; (b) method of the mean radius between points and the geometric centre; (c) minimum circle; (d) minimum convex polygon; (e, f, g) three adjustments by eye; (h, i) quadrangular grid using two mesh sizes; (j) mean propin-

Método de propinqüidade média

(Rapoport 1975, 1982)



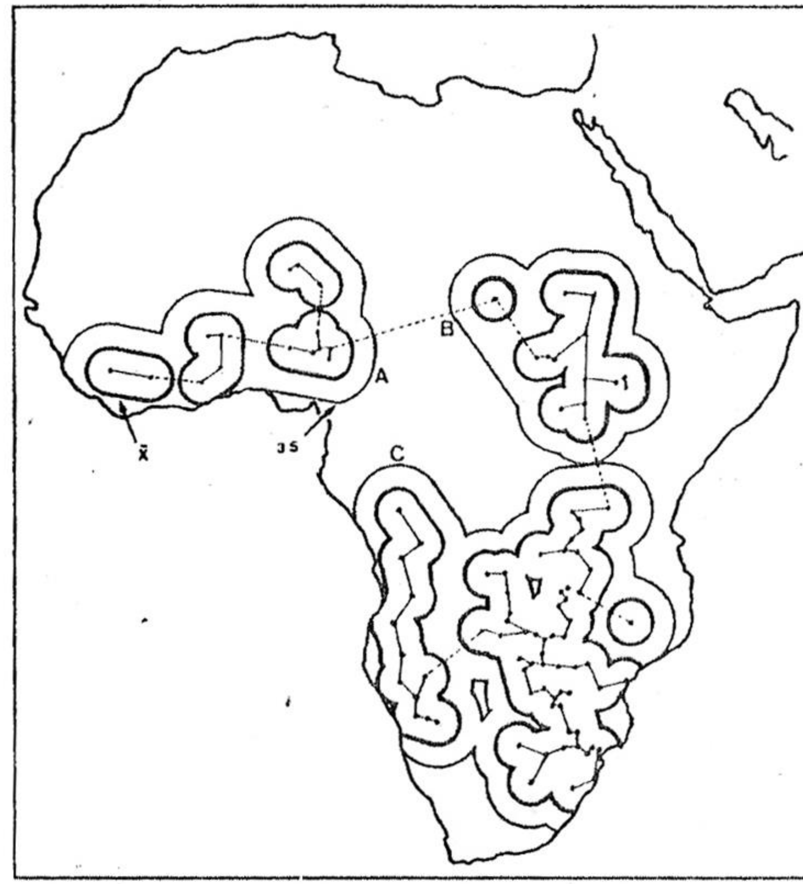


Fig. 3.2. Compactation of the range of *Mirafra nigricans* based on the maximum propinquity tree. Mean distance ($\bar{x}$ – thick line) and three standard deviations (3s – outer line) criteria were used. Dotted lines join segregated areas.

Versieux & Wendt 2007

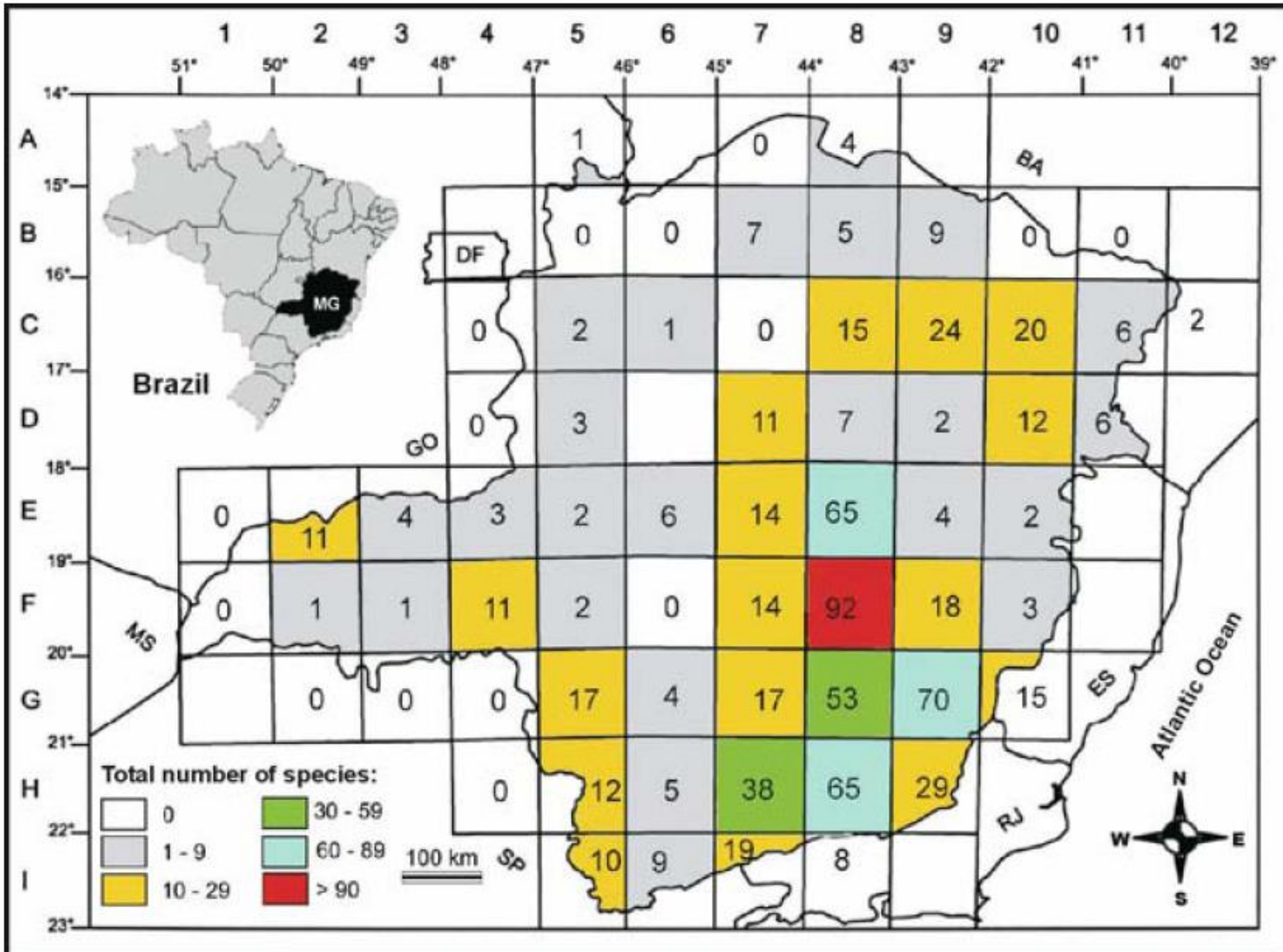


Fig. 2 Species richness within 1° × 1° grid cells for Bromeliaceae of Minas Gerais, Brazil

Versieux & Wendt 2007

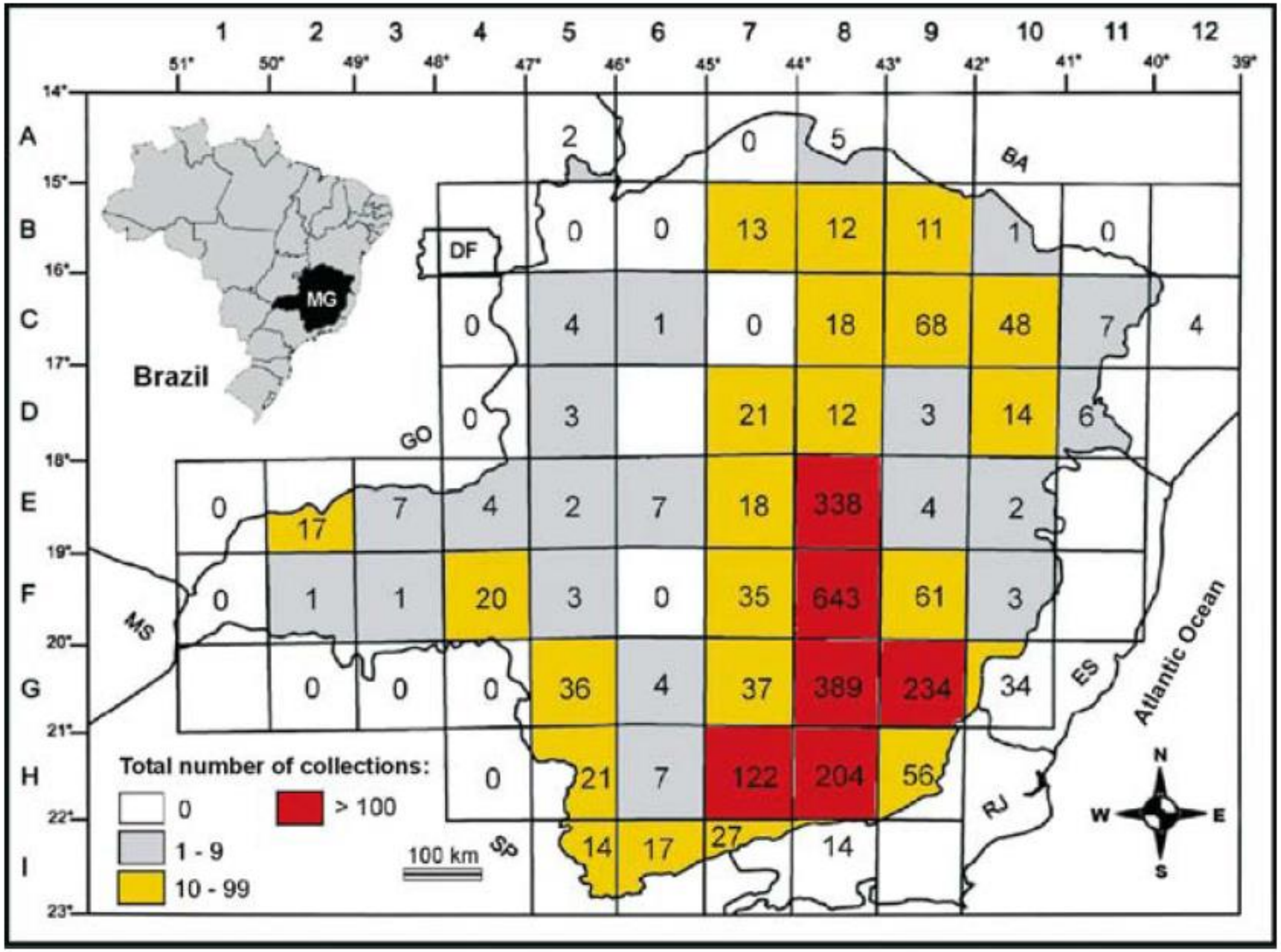


Fig. 3 Total number of Bromeliaceae taxa collections within 1° × 1° grid cells, in Minas Gerais, Brazil

Trabalho de campo e estudo de herbários (2686 registros) de 283 táxons (265 espécies e 18 infra-específicos) de Bromeliaceae, MG

Table 1. Number of studies of broad-scale species richness patterns utilizing range maps (extent > 800 km) by time period and the proportion of those studies examining richness at a resolution of 1° or finer

Time period	Number of studies	Proportion ≤ 1°
1960–1989	7	0.14
1990–1994	5	0.20
1995–1999	12	0.42
2000–2004	23	0.57
2004–2007	26	0.96

Studies were identified from Table 1 of Hawkins *et al*. (4) by searching the terms "richness pattern*" or "diversity pattern*" in the ISI Web of Science database and from a handful of other studies with which we were familiar. A complete list of studies is available in supporting information (SI) Table 3.

Hurlbert & Jetz 2007

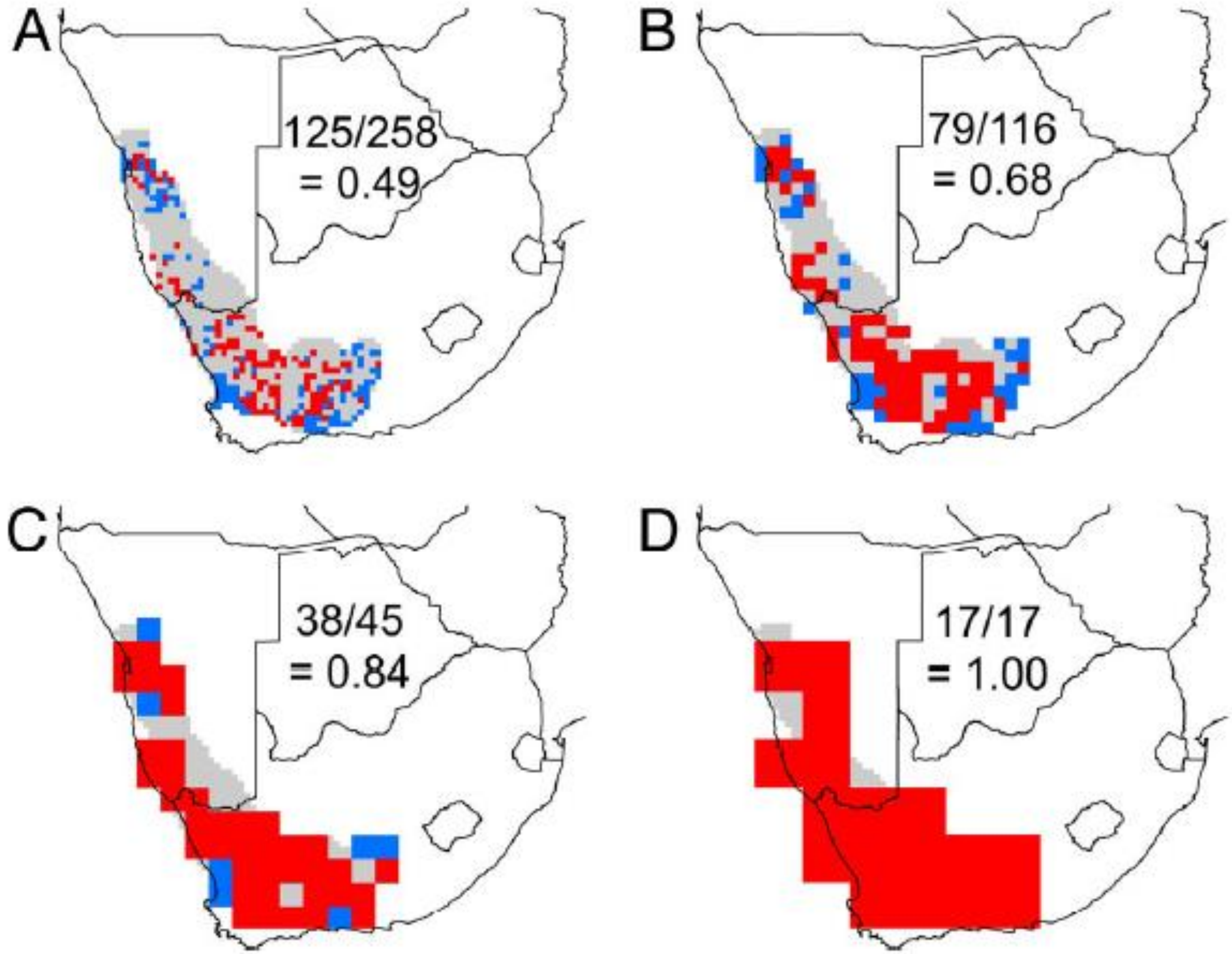


Fig. 1. The range map of *E. gregalis* (gray) in southern Africa, atlas cells in which the species was observed (red), and well surveyed atlas cells in which it was not observed (blue) at 0.25° (*A*), 0.5° (*B*), 1° (*C*), and 2° (*D*). Values reflect the range occupancy of the species (atlas cell occurrences/total number of well surveyed atlas cells falling within the species' geographic range) at each scale.

***Eremomela* (Aves)**

Hurlbert & Jetz 2007

Riqueza específica (Aves)

Hurlbert & Jetz 2007

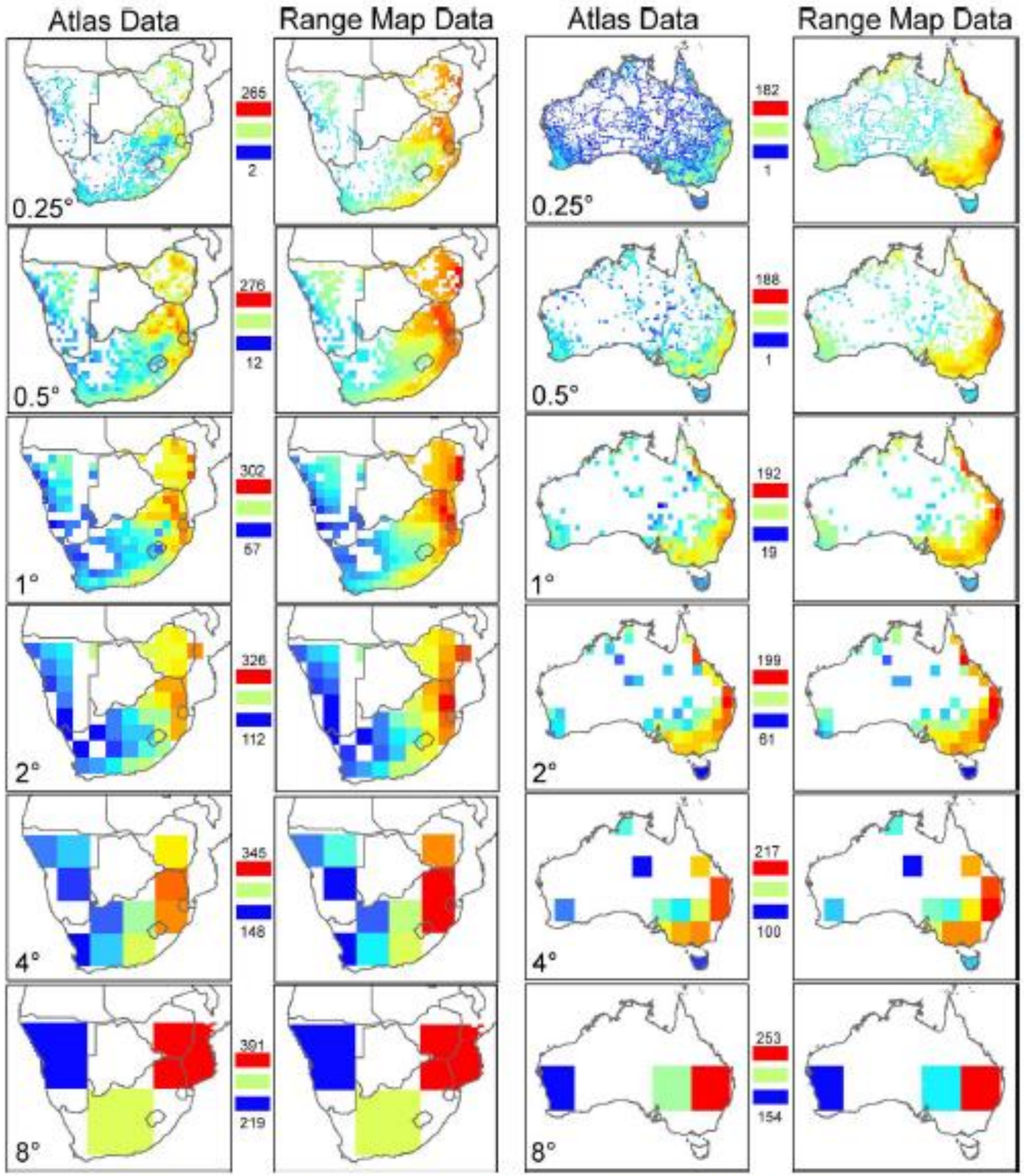
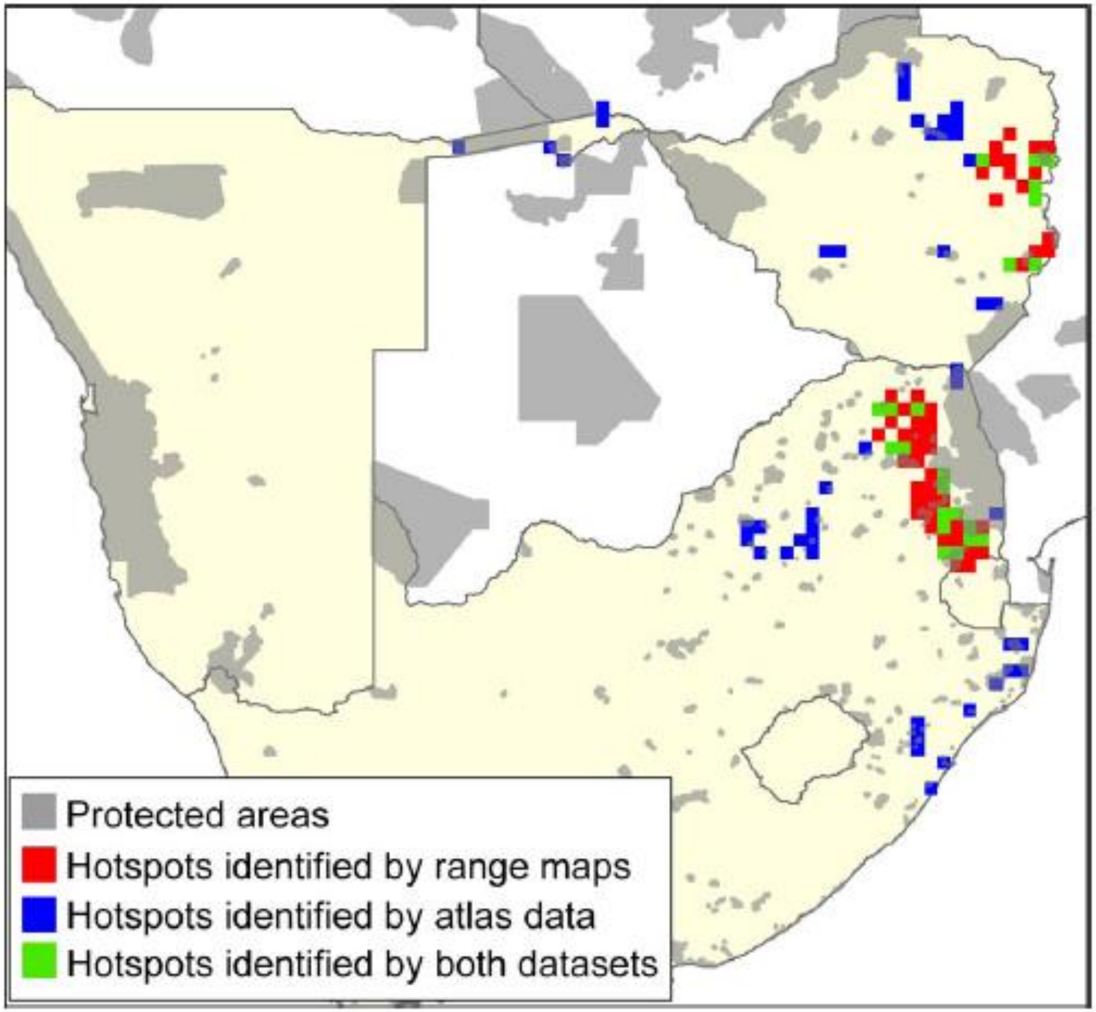


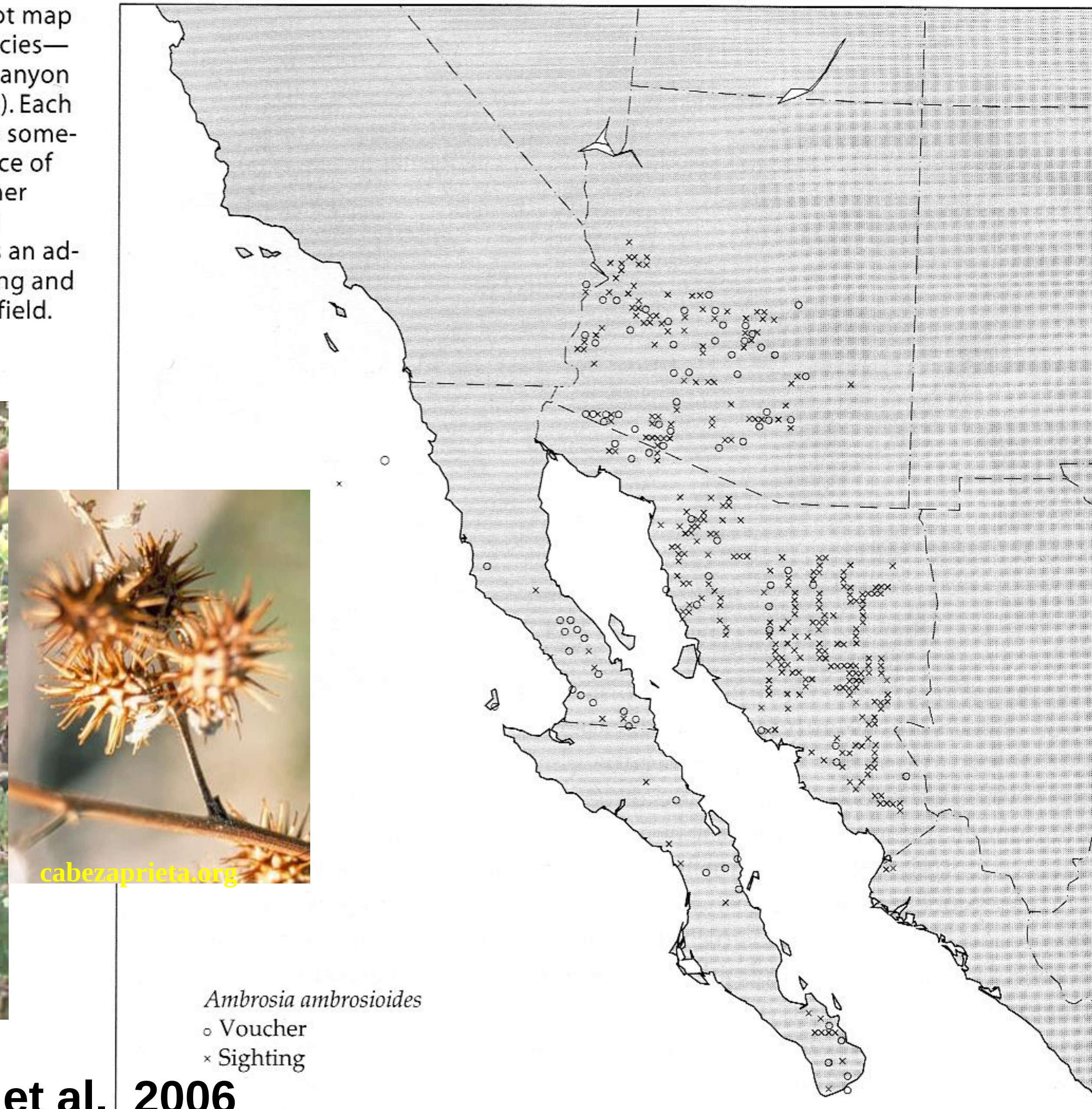
Fig. 3. Spatial patterns of species richness in southern Africa (left two columns) and Australia (right two columns) across six levels of spatia ≈0.25° grid cells to 8° grid cells. For each region, the column on the left reflects species richness based on atlas data, whereas the column on richness based on the overlaying of range maps. Only grid cells with sufficient sampling effort are shown.



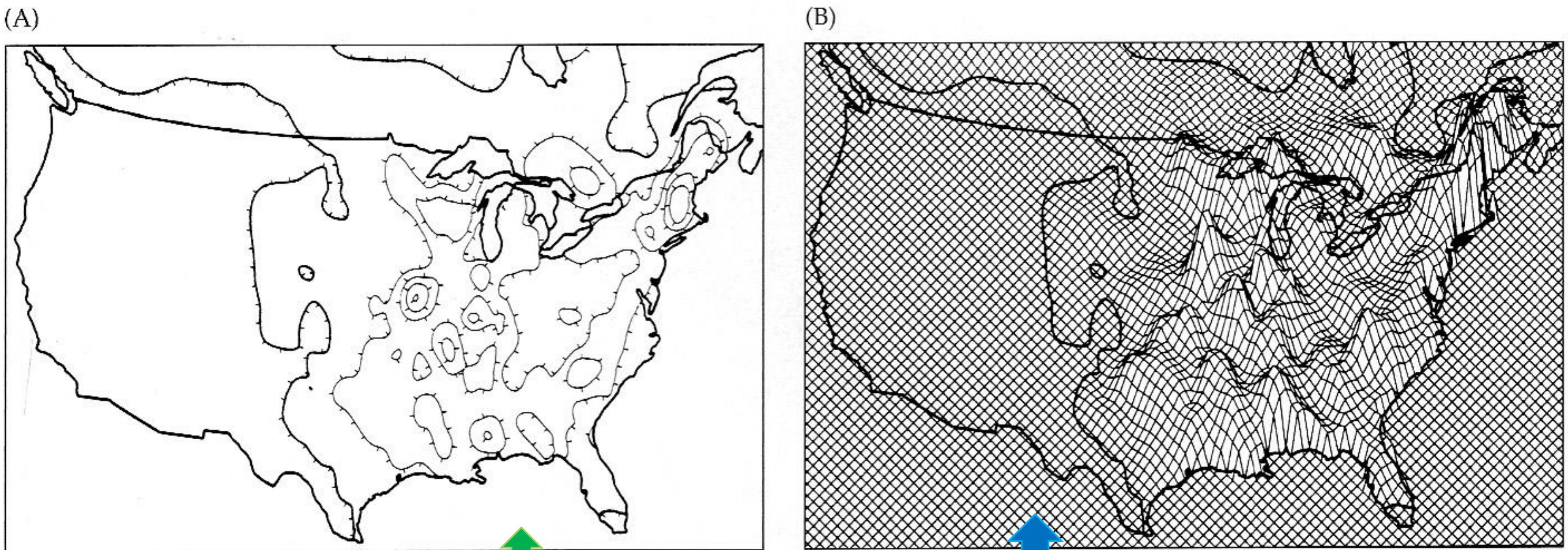
Hurlbert & Jetz 2007

Fig. 6. Lack of congruence between atlas (blue) and range-map (red) hotspots (the 5% most species-rich grid cells) in southern Africa using 0.25° grid cells. Gray areas indicate IUCN-designated protected areas, and green grid cells represent hotspots identified by both types of data. At this resolution, only 31% of the range-map-based hotspots are also identified as hotspots by atlas data. No data were available for countries in white.

FIGURE 4.3 An example of a dot map of the geographic range of a species—in this case the Sonoran Desert canyon ragweed (*Ambrosia ambrosioides*). Each circle represents a locality where someone has documented the presence of the species by collecting a voucher specimen and depositing it in an herbarium. Each cross represents an additional record based on a sighting and identification of the plant in the field. (After Turner et al. 1995.)



Lomolino et al. 2006



isoclinas de 20% de abundância relativa

abundância relativa em 3 dimensões

FIGURE 4.5 An example of a contour map of the geographic range of a species—in this case the winter range of the blue jay (*Cyanocitta cristata*), showing geographic variation in abundance. (A) Each contour line (or isocline) indicates a 20th-percentile class of relative abundance. (B) A three-dimensional landscape depicting relative abundance. Data on abundance come from North America Christmas Bird Counts. Raw data from these census counts (number of birds seen per hour per field party) were entered into a computer program that averaged and smoothed them to estimate abundance between actual census localities in order to draw the maps. (From Root 1988a.)

Lomolino et al. 2006

GIS ou SIG = Sistema de Informação Geográfica

= sistema computacional para armazenamento, representação e análise de dados espaciais digitalizados.

- grande quantidade de dados
- gera mapas com rapidez

-permite sobreposição de mapas de táxons sobre camadas com outras informações (solo, clima) = modelagem ambiental, modelagem de nicho, distribuição potencial de espécies.

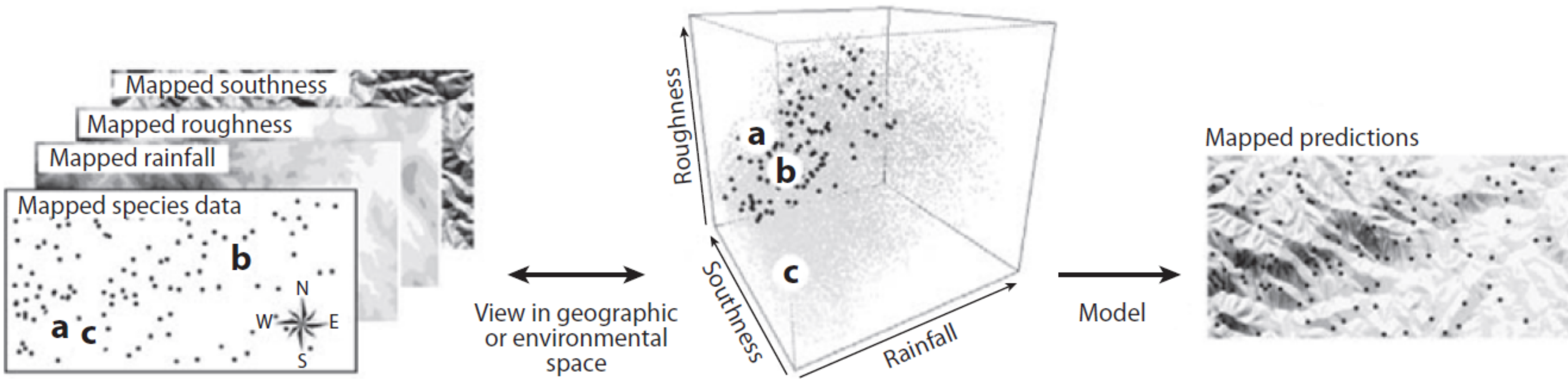


Figure 1

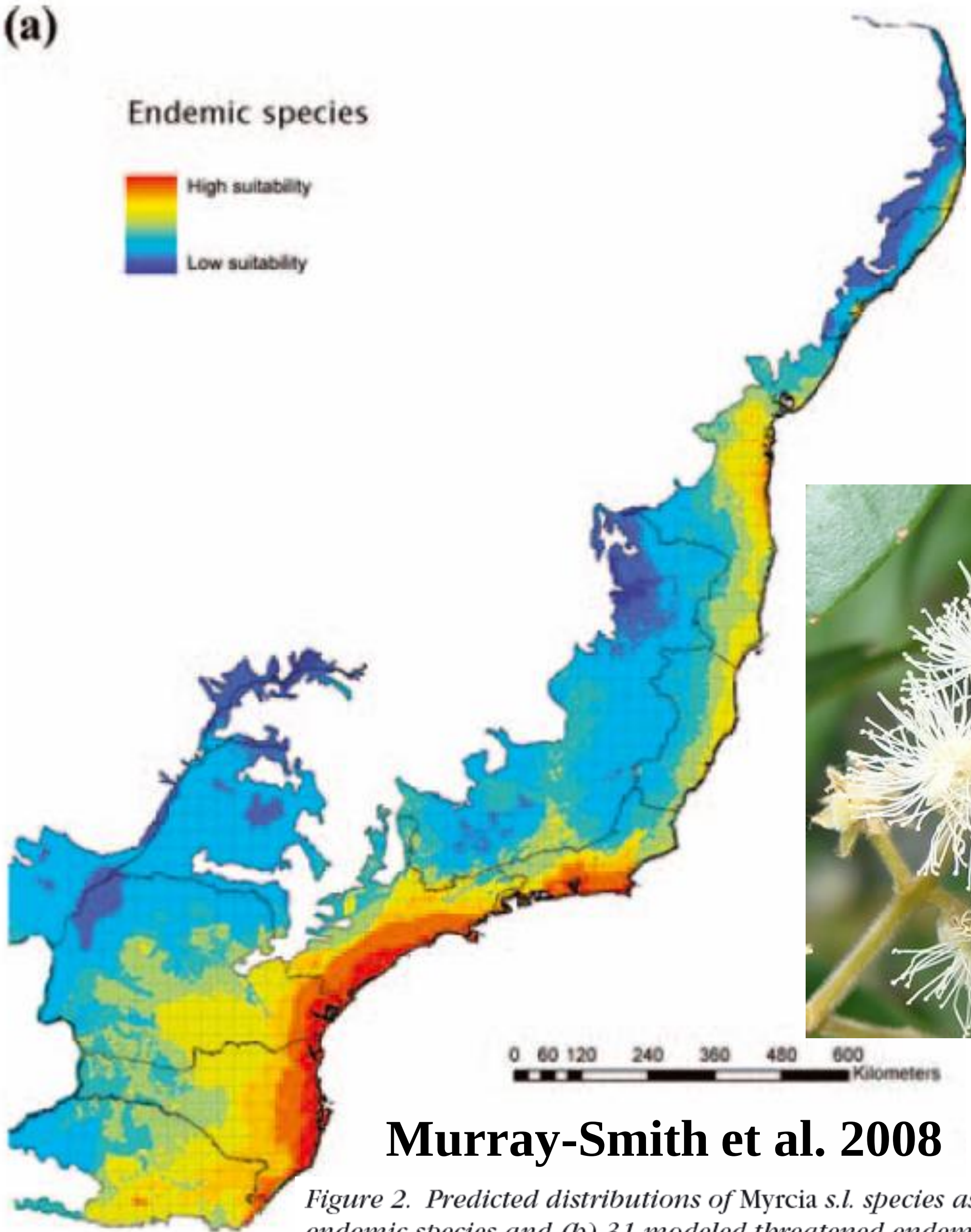
The relationship between mapped species and environmental data (*left*), environmental space (*center*), and mapped predictions from a model only using environmental predictors (*right*). Note that inter-site distances in geographic space might be quite different from those in environmental space—*a* and *c* are close geographically, but not environmentally. The patterning in the predictions reflects the spatial autocorrelation of the environmental predictors.

Species Distribution Models:

Ecological Explanation and Prediction Across Space and Time

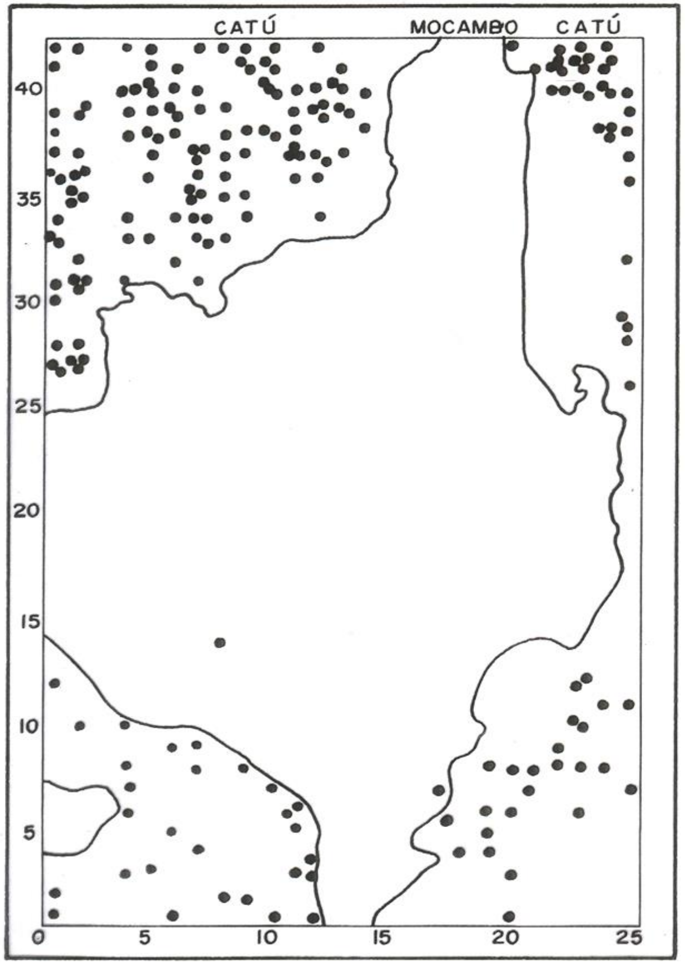
Elith & Leathwick 2009

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

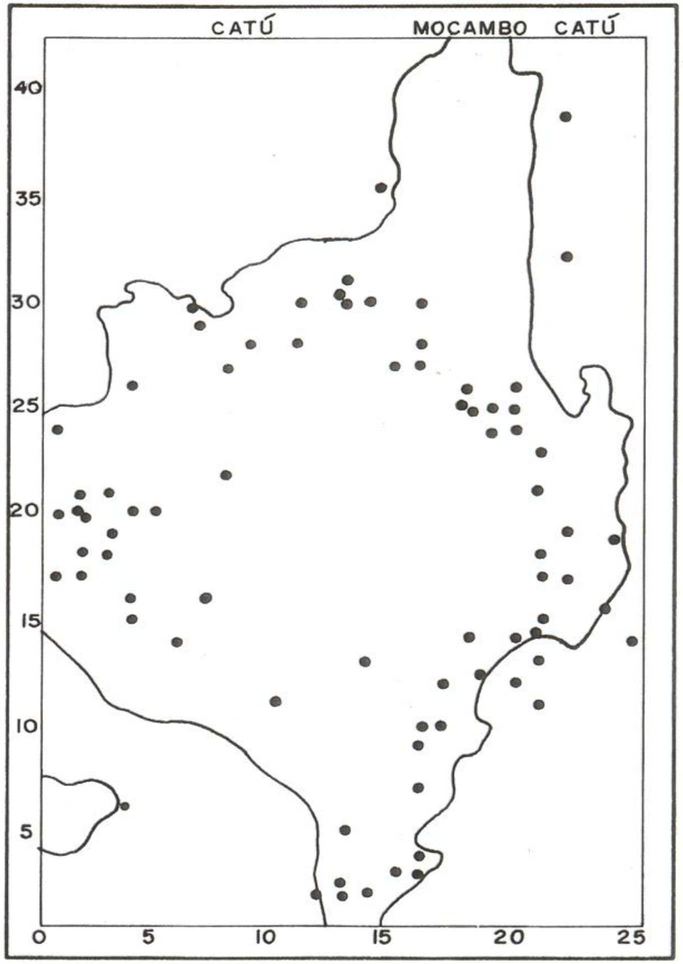


Murray-Smith et al. 2008

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]).*



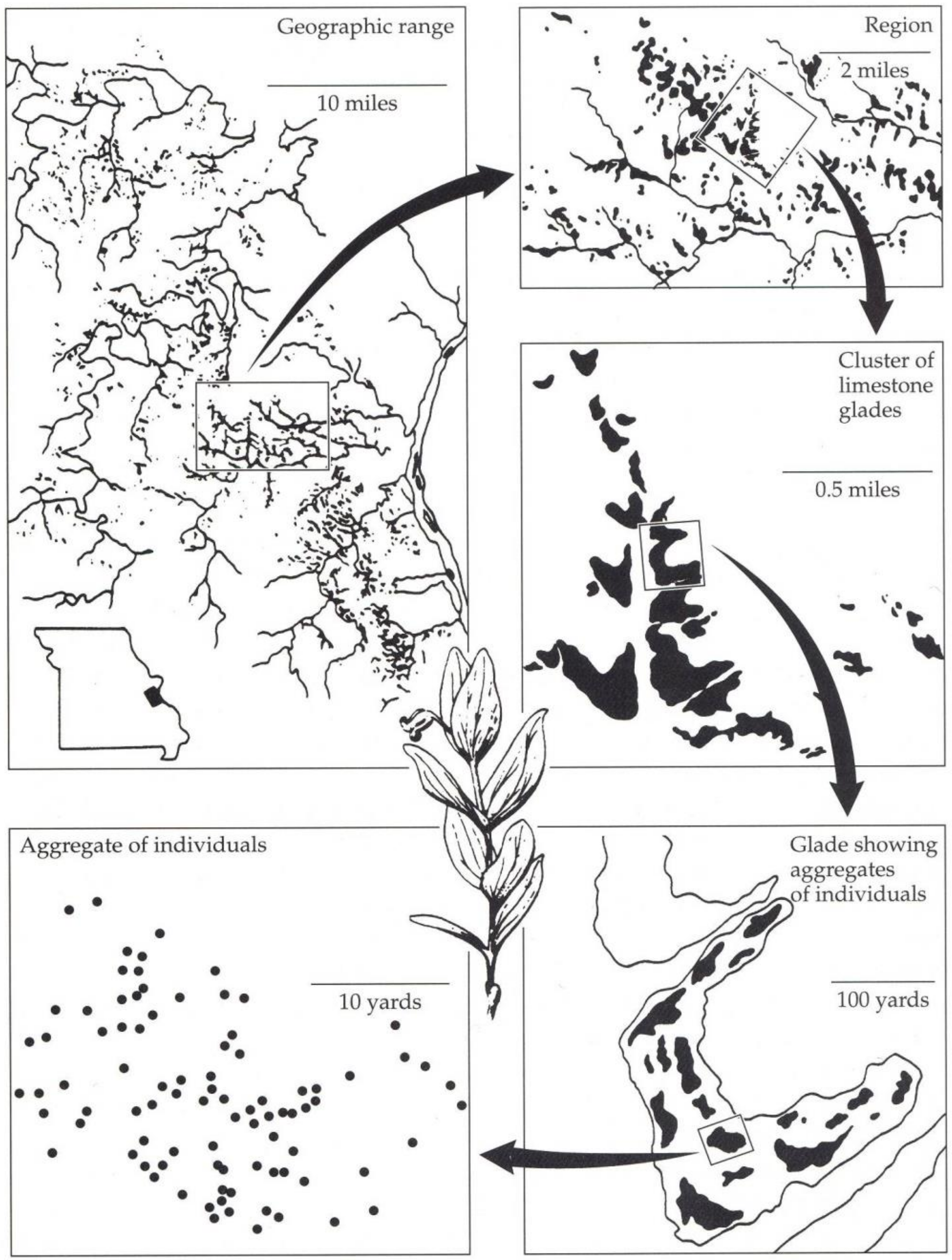
A



B

Distribution of two species in the Mocambo reserve in Belém, Brazil. The central area is non-flooded terra firme, and the area around the four corners is tidally flooded várzea. **(A) *Virola surinamensis***, a species of inundated forest; **(B) *Goupia glabra***, a species of terra firme. (Adapted from Pires and Prance, 1977)

Prance in Lieth & Werger 1989



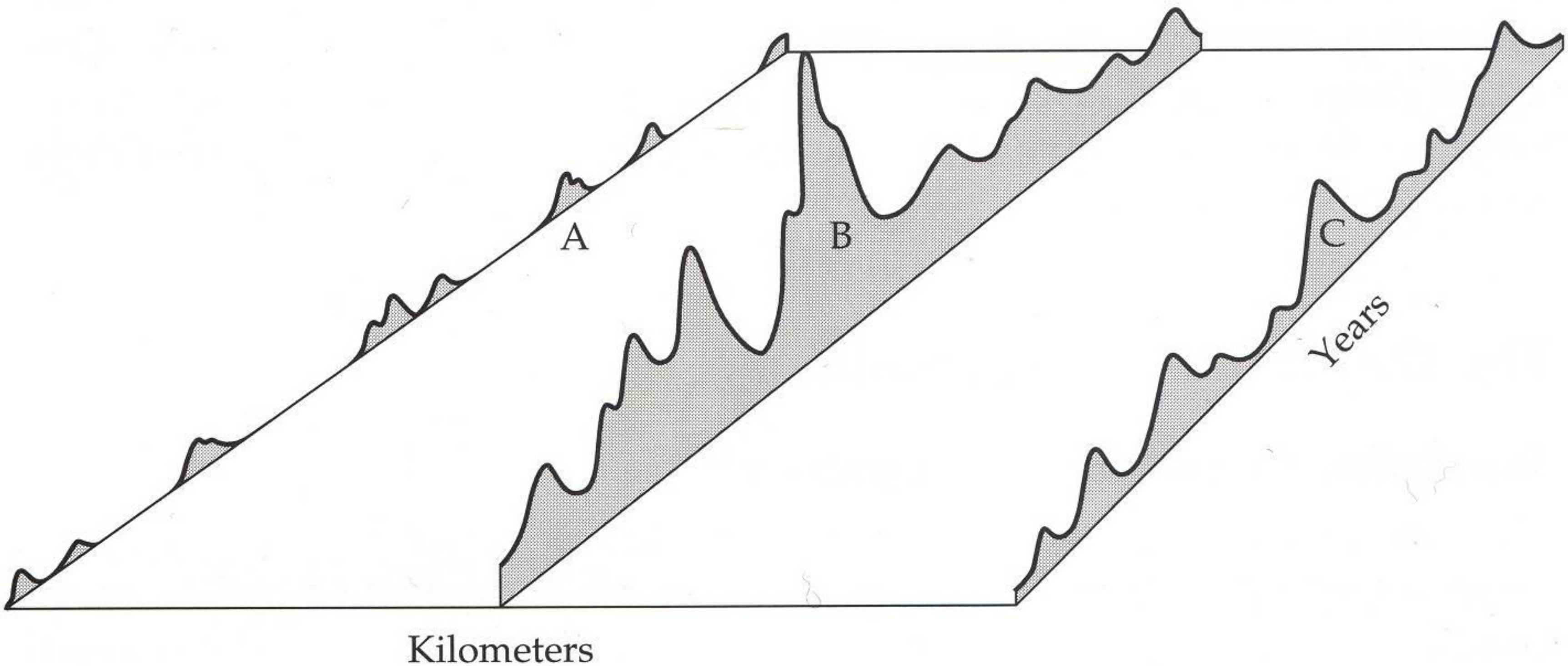
Erickson's classic depiction of the distribution of the shrub ***Clematís fremontíí***, within the state of Missouri in the central United States, on different spatial scales. The largest scale shows the geographic range based on known collecting localities. Successively smaller scales show the distribution of populations. The smallest scale shows the dispersion of individual plants within a single local population. Note that at all scales the distribution is patchy, and that areas where plants are found are separated by uninhabited areas.

Erickson 1945.

FIGURE 4.6 An aerial photograph near the edge of the local distribution of the juniper tree (*Juniperous 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.

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

Lomolino et al. 2006



A schematic diagram showing how the abundance and distribution of a hypothetical organism might vary in time and space. Shown are fluctuations in abundance over many years at three different localities (A-C) separated by distances of several kilometers. Note that all three populations fluctuate. At locality A, which is presumably at the margin of the local or geographic range of the species, only a few individuals are intermittently present, indicating repeated episodes of local extinction and recolonization. (From Andrewartha and Birch 1954.)

Lomolino *et al.* 2006

Biodiverse: ferramenta para análise espacial e biológica relacionadas a diversidade

www.purl.org/biodiverse

Laffan et al. 2010

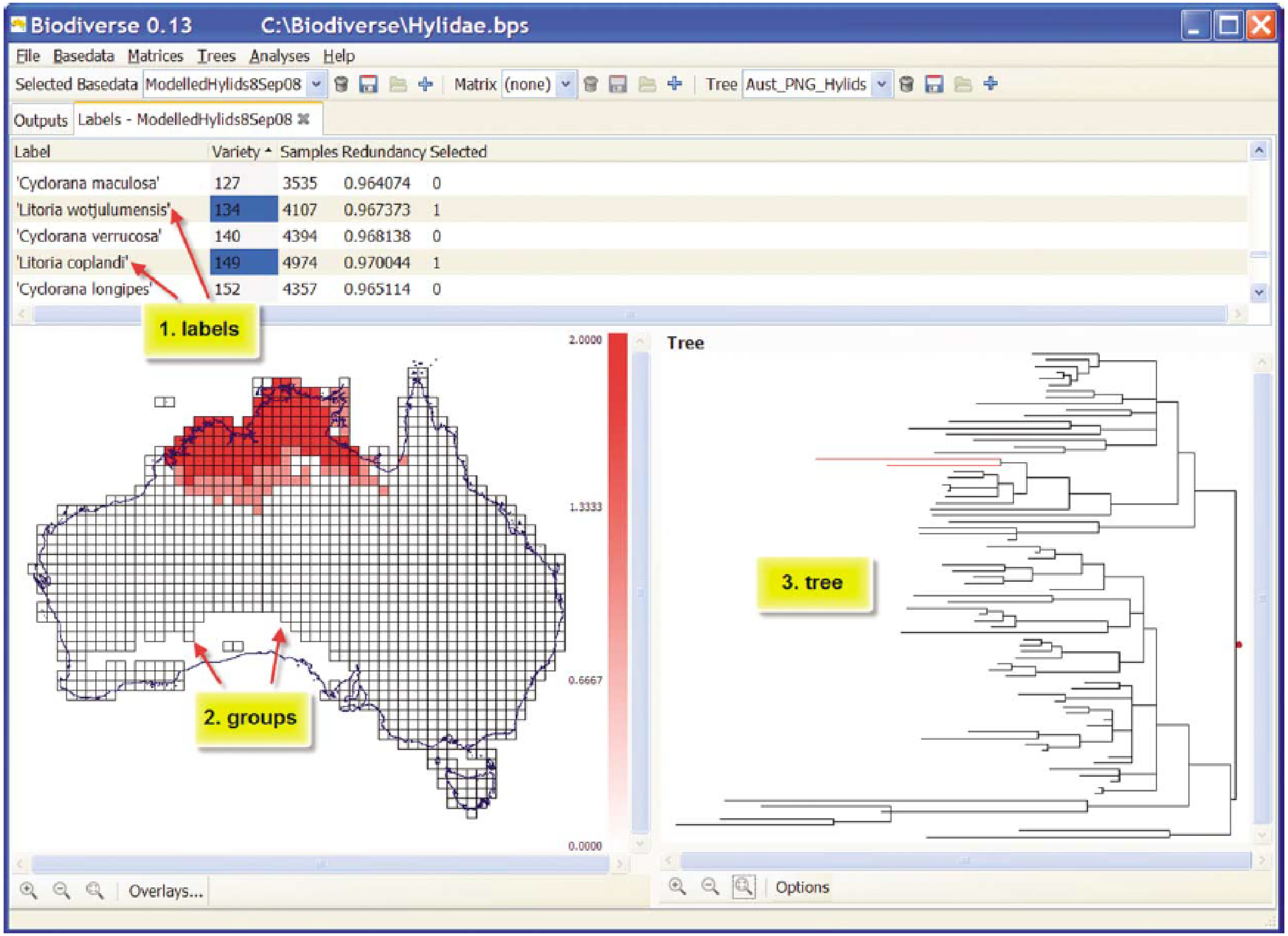


Figure 1. The Biodiverse data visualisation window displaying three linked views of a dataset. In each pane, the same two taxa are highlighted: 1) the labels, where the species or other entities are listed by name; 2) a map showing groups for which data were loaded. In this case the groups are 0.75 degree grid cells. The red shading indicates the relative number of the selected species (labels) recorded in each cell (group); 3) a tree showing a phylogeny for these taxa, with a clade of two species selected. Selecting an element in any pane highlights the corresponding elements in the other panes. The data shown are for Australian hylid frogs, as described in Rosauer et al. (2009). A GIS layer of a coastline is displayed for context.

Biodiverse:

Laffan et al. 2010

www.purl.org/biodiverse

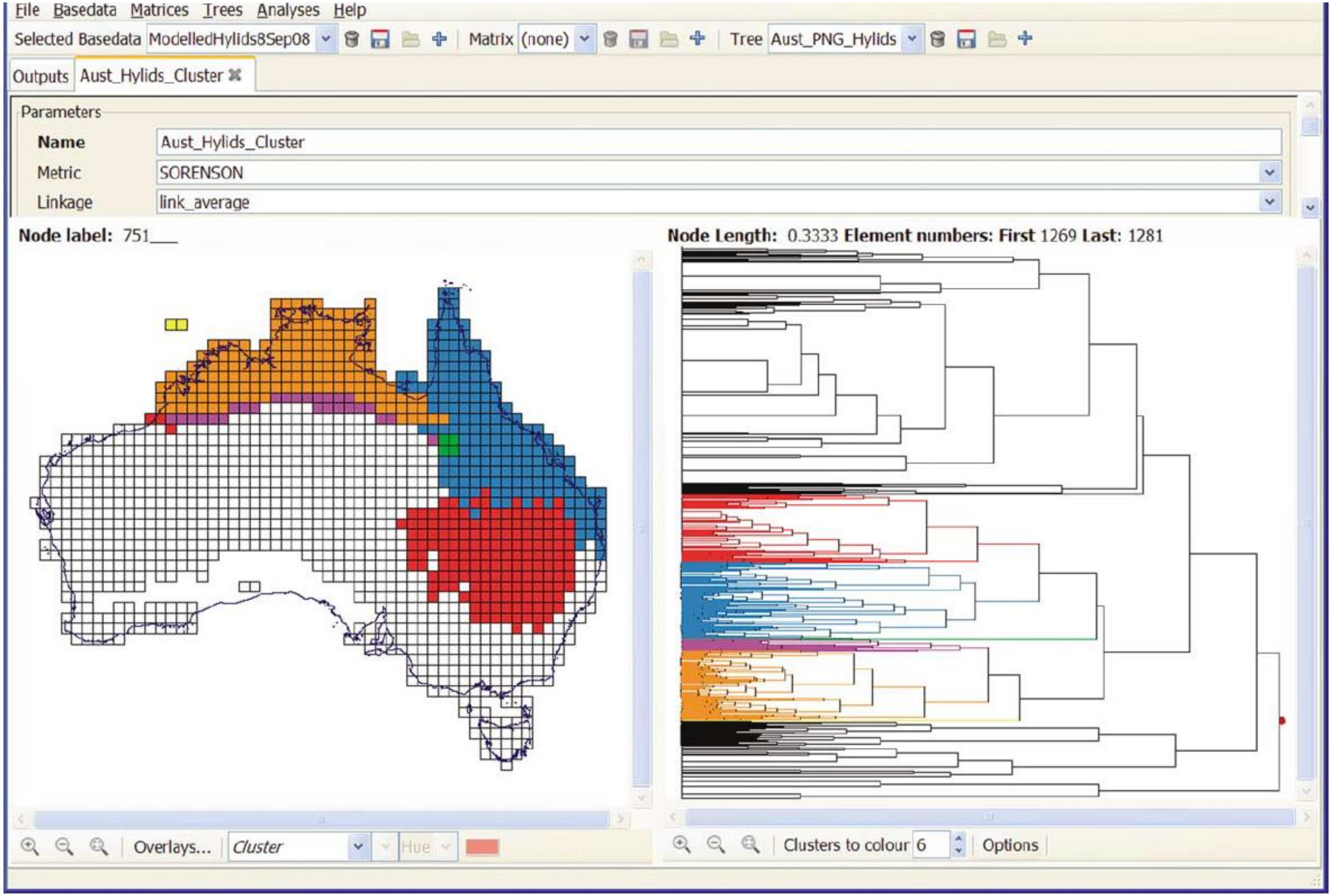


Figure 3. The cells (groups) on the map have been clustered based on a Sorenson distance. The tree on the right represents similarity between clusters of cells on the map (not between taxa). The user has clicked on a branch of the tree to highlight the branches beneath it, and the corresponding areas on the map. These are coloured after being divided into six sub-clusters based on their node lengths.

Todos os métodos para delimitar áreas de distribuição são simplificações da distribuição real:

- fonte dos dados: literatura

herbário

inventário

estratigrafia

dados digitalizados

- representações bidimensionais

(raramente tridimensionais).

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Perspectives in Plant Ecology, Evolution and Systematics

journal homepage: www.elsevier.com/locate/ppees

Review

Biological collections in an ever changing world: Herbaria as tools for biogeographical and environmental studies

Claude Lavoie*

Lavoie 2013

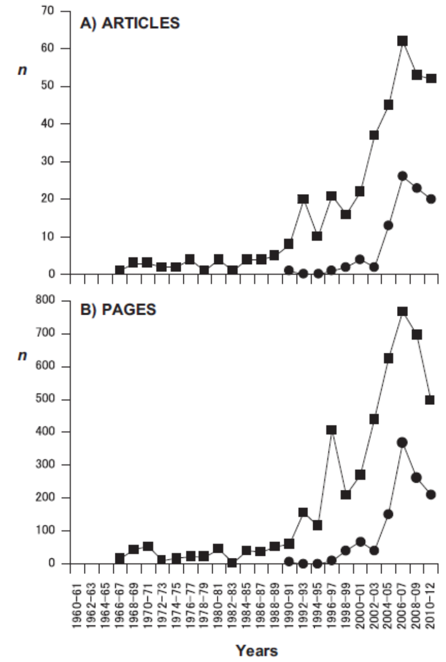

Fig. 1. Peer-reviewed articles with original data that used herbarium specimens for documenting biogeographical patterns or environmental changes and published from 1966 to February 2012. (A) Published articles per two-year period (January and February 2012 included in 2010–2011 data); (B) published pages per two-year period; squares: all articles (or pages); circles: only articles (or pages) with computerized collection(s) as information source(s) for herbarium specimens.

Table 1
Summary of peer-reviewed studies (per topic) with original data that used herbarium specimens for documenting biogeographical patterns or environmental changes from 1933 to February 2012. A study could have more than one topic.

Topic	Articles (*n*)	Pages (*n*)	Earliest article (year)	Articles (% of the total) published since		Median number of herbarium specimens used per article
				2000	2005	
Plant invasions	98	1156	1966	60	45	277
Biogeographical patterns	71	1085	1990	86	59	3335
Biases associated with herbarium specimens	67	807	1985	87	72	4316
Pollution (including carbon dioxide)	65	588	1968	49	31	50
Rare or declining plant species	58	941	1985	78	55	351
Plant phenology	21	362	1991	86	76	1256
Historical floristic assessments	20	368	1989	70	45	2000
Plant diseases	18	146	1933	72	33	391
Conservation priorities	14	180	1998	93	64	2858
Climate change and distribution range of plants	11	120	1999	91	73	1075
Other topics	29	312	1976	79	66	926
All topics	382	4620	1933	71	51	486