Chapter 1
The Atlantic Forest: An Introduction to the Megadiverse Forest of South America

Marcia C. M. Marques, Weverton Trindade, Amabily Bohn, and Carlos E. V. Grelle

Abstract The Atlantic Forest, the second largest forest in South America and one of the most biodiverse biomes in the world, is also one of the most threatened and important for conservation. In this chapter, we introduce the Atlantic Forest focusing on describing the evolution of knowledge, the geographical limits, and the current proposals of sectorization in ecological units. The knowledge of the Atlantic Forest can be explained by three successive phases: (1) the science of naturalists (the late eighteenth century to the late nineteenth century), where the flora and fauna were described by European travelers; (2) the rise of science in Brazil, characterized by the organization of Atlantic Forest biodiversity in collections (1890–1985); and (3) the contemporary era (1985–2020), characterized by the publication of 8226 studies focused on 4 main topics – biogeography and systematics, conservation and biodiversity, plant-animal interaction, and populations and community. The understanding of the distribution limits of the Atlantic Forest biome (11 different proposals), as well as sectorization (4 different proposals), has been the subject of several studies and legislations, which are presented and discussed. Additionally, we present terminologies usually used to designate the Atlantic Forest as a whole, as well as its sectors, to facilitate understanding in future studies. We conclude that understanding the Atlantic Forest remains a long and endless exercise, given its complexity, increased knowledge, and continuous threats.

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1.1 Introduction

Since Brazilian territory was discovered by Europeans, the Atlantic Forest has been the object of admiration and curiosity. This exuberant forest, with fauna and flora of impressive diversity, inhabited by human beings never before seen by the colonizers, was gradually being explored by the five senses of curious members of the Portuguese court charged with describing the New World. The same enchantment that motivated rapporteurs and artists to record the diversity of plants and animals persisted for generations of naturalists and scientific researchers, who for over 500 years have sought to describe, know, and explain the exuberance of this South American megadiverse forest.

The Atlantic Forest is the second largest tropical forest in South America. With an original total area of 1.6 million ha (according to the integrative limits of Muylaert et al. 2018; see below), it was previously distributed mainly in the Brazilian territory (93% of biome total area), but also entering the borders with Paraguay (5.3%) and Argentina (1.7%). Several palynological and phylogeographic evidence show that there were connections between the Atlantic Forest and the Amazon Forest in the Quaternary, 33,000 to 25,000 years BP (Bigarella et al. 1975; Costa 2003). During the last glaciation, a xeric and shrubby vegetation developed in central Brazil, separating the two forests that are still connected by riparian forests (Prado and Gibbs 1993). Therefore, the Atlantic Forest can be understood as a landscape of the geological dynamics of tropical forests in South America, whose identity and specificity have been defined especially in the last 20,000 years.

The Atlantic Forest is one of the most biodiverse and unique regions on Earth (Myers et al. 2000), which is a result of a complex evolutionary history. The mechanisms of flora and fauna diversification have been explained by several, non-exclusive theories along the time: (1) the Pleistocene refuges, which are isolated forest sites formed during the glaciations where organisms could have diverged and originated new lineages (Ab'Saber 1979) and, consequently, resulted in centers of endemism (Carnaval and Moritz 2008); (2) the neotectonic hypothesis, in which the uplift of mountain ranges at about 5.6 Ma, especially the Serra do Mar in the southeastern region, would have modified the climate (Simpson 1979) and created new conditions and landscapes for the local diversification; (3) the riverine barriers, especially the São Francisco, Jequitinhonha, Doce, and Paranapanema systems, that would have caused important differentiation of lineages and species (see examples in Dantas et al. 2011); and (4) the ecological gradient hypothesis, where the gradual transition from humid forests, in the core area of Atlantic Forest, toward those drier biomes surrounding the biome (e.g., Cerrado and Caatinga), would have created differential selective regimes leading to a divergence of organisms between regions (for instance, Cabanne et al. 2011). Most of the hypotheses (except no. 4, explained by parapatric speciation) are based on reductions of gene flow among populations by geographical isolation, which promoted divergence and allopatric speciation, resulting in a cumulative biological diversity (Dantas et al. 2011).

Although these hypotheses are usually used to explain diversification in large scales, the current knowledge about lineage diversification suggests that some differences across taxa do exist (Peres et al. 2020). In general, higher species richness is found on the topographically complex coasts of the states of São Paulo and Rio de Janeiro, despite other regions may have favorable conditions for differentiating niches and accumulating species. Some specific locations are important for the turnover of species, especially the Rio Doce river (Espírito Santo state), the border between São Paulo and Rio de Janeiro, and the state of Bahia, resulting in five main centers of endemism: Pernambuco, coastal Bahia, central Bahia, Serra do Mar, and Paraná/Araucaria (Peres et al. 2020). Altogether, these regions contribute to making the Atlantic Forest a megadiverse biome.

In this chapter, we introduce the Atlantic Forest focusing on describing the evolution of the knowledge about its biodiversity, its geographical limits, and the current proposals of sectorization into smaller ecological units. As opposed to establishing rigid classifications and delimitations, our goal is to show different views of a complex and unique biome that can be useful for future studies.

1.2 The Paths of Scientific Knowledge

The discovery and knowledge of the Atlantic Forest are intrinsically related to Brazil's colonization history. This is because it is located in the easternmost portion of the continent, the lands first occupied by European colonists. It is not uncommon bibliometric studies and systematic reviews to point out the Atlantic Forest as the most studied biome in Brazil. This status has been achieved by a long way of scientific exploration and the institutionalization of science in the country. We propose that knowledge of the biodiversity of the Atlantic Forest can be characterized by different phases, as described below: (1) the science of naturalists; (2) the rising of science in Brazil; and (3) the contemporary period.

1.2.1 The Science of Naturalists (Late Eighteenth Century to Late Nineteenth Century)

Almost 300 years after the discovery of Brazil and the Portuguese's indifference for the knowledge of the indigenous peoples who lived there, the colonizers finally began to look at the Atlantic Forest with scientific interest. According to Dean (1995), this look of curiosity arises after a good part of the forests have already been cut down and the demand for new natural products by the European market instigates the crown to a search for economic diversification and efficiency. One of the first investigations was stimulated by Marquês de Pombal, who helped to train generations of naturalists, Portuguese and Brazilian, at the University of Coimbra.

The investigations carried out in the late eighteenth and early nineteenth centuries were financially supported by more visionary crown managers, which were aligned to the scientific advances in France and England. Two important collections and research centers were installed in Rio de Janeiro – the Botanical Garden in 1808 and the Royal Museum (later the National Museum) in 1818 – which were then responsible to search for useful native species and to promote agricultural diversification. With the arrival of the royal family to Brazil, mainly by the encouragement of the Archduchess D. Leopoldina, a group of brilliant European naturalists were invited to Brazil. These included Karl Friedrich Philipp von Martius, Johann Emanuel Pohl, Johann Baptist von Spix, and August Glaziou, the most important naturalists to describe Brazilian flora and fauna. The transfer of the royal family to the colony also favored the arrival of innumerable young naturalists, who were sent by museums, botanical gardens, and European scientific societies to collect in Brazil. It is worth mentioning the French botanist Auguste de Saint-Hilaire, who in 1816 landed in Brazil and, for 6 years, collected 15,000 species of plants and animals that would result in the publication of 14 volumes when he returned to France (Dean 1995). Charles Darwin, while passing with H.M.S. Beagle through Rio de Janeiro in 1832, would have recorded in his logbook the admiration for the grandeur of the Atlantic Forest (Dean 1995). Despite being one of the most exciting periods of discovery about the flora and fauna of the Atlantic Forest, as well as about the first times of Brazil's formation, most of the specimens and data collected by these naturalists were taken to European institutions, and just a few specimens were left to the still-scarce Brazilian infrastructure of museums and researchers.

Accompanying the activities of collecting and describing nature carried out by naturalists, several artistic missions from Europe promoted the encounter between art (the sensitivity) and science (the reason) of the Atlantic Forest. The Atlantic Forest was then portrayed and known through the brushes of artists such as Jean-Baptiste Debret, Nicolas-Antoine Taunay, and Johann Moritz Rugendas, among others (Belluzzo 1996).

1.2.2 The Rising of Science in Brazil: The Organization of Atlantic Forest Biodiversity (1890–1985)

After the emergence of the Brazilian scientific institutions, in the nineteenth century during the reign of D. Pedro II, the sciences started to figure among the government policies, with the state being its main supporter. With the establishment of the Republic (1889), the provinces had the opportunity to develop their science independently of federal power, which resulted in the proliferation of natural history museums, such as the Museum of Zoology of the University of São Paulo (launched in 1895) and, later, the São Paulo Botanical Gardens (1928), the Mello Leitão Biology Museum (1949, Espírito Santo), and the Zoobotanic Foundation (1972, Rio Grande do Sul). The Brazilian Research Council (CNPq) was created in 1951, and the organization of scientists in societies occurred in the 1940s and 1970s, with the creation of the Brazilian Society for the Advancement of Science (1948), the Botanical Society of Brazil (1950), and the Brazilian Society of Zoology (1978). Some of the main Brazilian teaching and research centers were established in the Atlantic Forest region, such as the University of São Paulo (1934), the Federal University of Rio de Janeiro (1920), the Federal University of Pernambuco (1946), the Federal University of Minas Gerais (1927), the Federal University of Paraná (1912), and the Pontifical Catholic Universities of Rio de Janeiro (1940) and São Paulo (1946). These universities created their own collections of fauna and flora or incorporated pre-existing museums, in addition to being the training site for the first generations of scientists in postgraduate courses on natural sciences. In the 1970s and 1980s, other important universities and research centers were consolidated, such as the State University of São Paulo (1976), the State University of Campinas (1962), the Cocoa Research Centre (1957), and the Brazilian Agricultural Research Corporation (1972). The latter two were responsible for the development of researches related to the Brazilian agricultural production and, thus, with direct impacts on the economic development and knowledge of the areas within the Atlantic Forest.

1.2.3 The Contemporary Era (1985–2019): A Bibliometric Analysis

With the facility of current search tools, contemporary Atlantic Forest research can be described through bibliometric research. We performed a bibliometric analysis to describe the evolution of the knowledge about the Atlantic Forest by searching documents on the Web of Science using the topics "Atlantic Forest" and "Mata Atlântica," from 1985 to December 2019 (see Supplementary Material). A total of 8288 documents have been published in the period; the first article "The Vanishing Brazilian Atlantic Forest" was published in the journal *Biological Conservation* in 1985 (note that obviously other studies were published before this year, but they are not cataloged in Web of Science, a contemporary tool). In this article, Da Fonseca (1985) examined the Atlantic Forest deforestation in the state of Minas Gerais and claimed to urgent efforts to protect the remaining forest remnants, which were few, small, isolated, and unprotected. Until the late 1980s, other three articles were published, but a clear interest on the Atlantic Forest emerged only in the 1990s, especially in 1993, when more than ten articles were published in a single year (Fig. 1.1).

The Rise and Establishment of Conservation Science (1985–2015)

Analyzing the keywords used by authors from 1992 to 2019, Atlantic Forest research can be divided into four clusters (Fig. 1.2): conservation and biodiversity (green), biogeography and systematics (red), plant-animal ecology (blue), and ecology of population and communities (yellow).

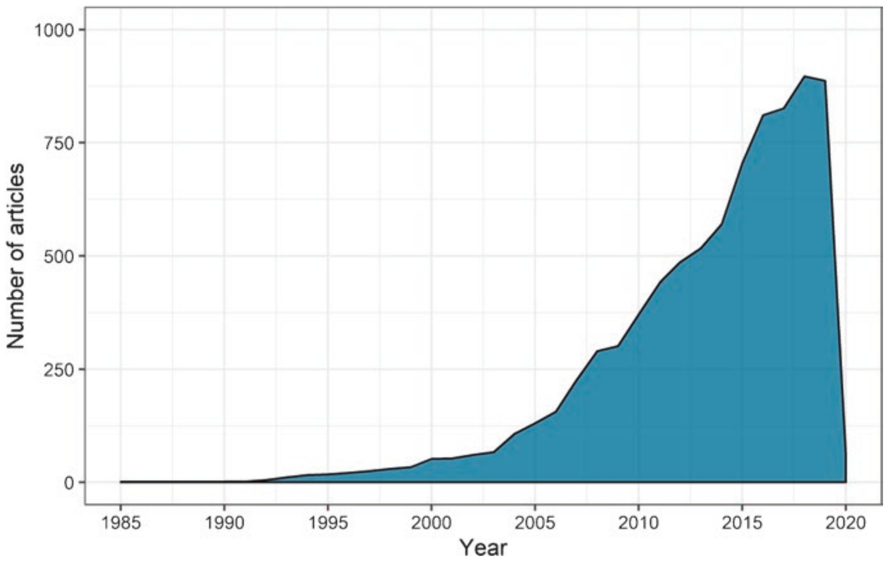

Fig. 1.1 Number of articles published from 1985 to December 2019 on the topic "Atlantic Forest" (n = 8288). Data downloaded from Web of Science and analyzed using Bibliometrix R package (Aria and Cuccurullo 2017)

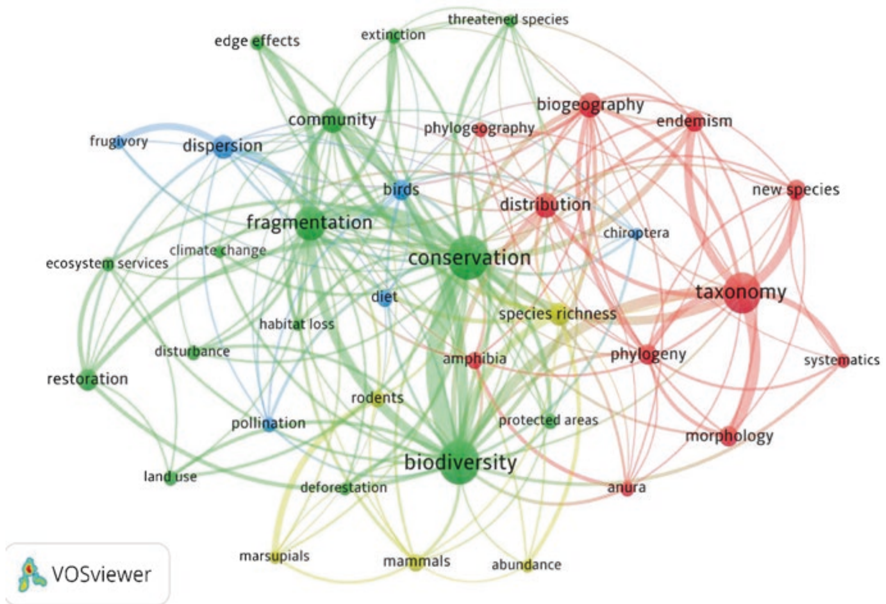

Fig. 1.2 Bibliometric network based on keywords mentioned in articles on the Atlantic Forest. Size of keyword labels and circles are determined by number of occurrences. Keywords are connected by number of co-occurrence. Network map created in VOSviewer 1.6.14

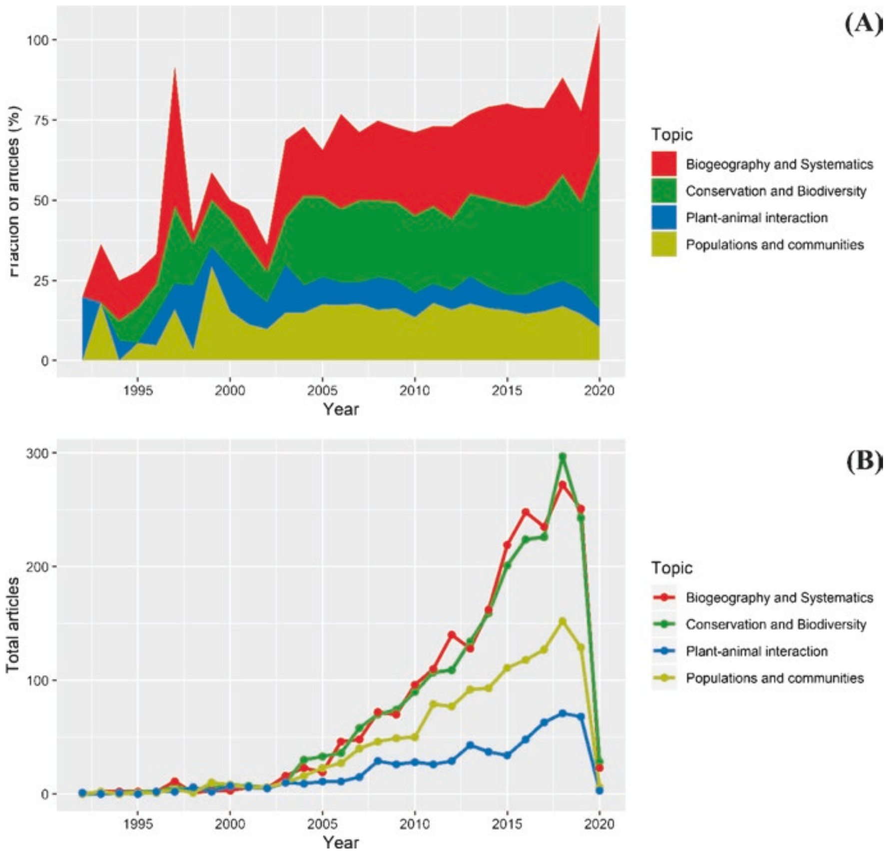

Fig. 1.3 Number (**a**) and proportion of total articles (**b**), by topic, according to words from title and keywords. Articles were selected and clustered according to keywords and clusters from bibliometric network map (Fig. 1.2)

In the early 1990s, there was a predominance of descriptive studies on plant-animal interaction and ecology of population and communities comprising mammals (rodents, primates, bats, and marsupials) and birds (Fig. 1.3a, b). Since then, especially after Rio 92, concerns in the environment and biodiversity conservation have grown in Brazil. The main factors that contributed to this growth were (1) the promulgation of the Brazilian Constitution in 1988, which placed the environment as a citizen's right and state responsibility, and (2) the rupture of the 30-year military dictatorship regime in 1989, where the number of species and ecosystem losses was still unknown.

In the early 2000s, the information about the Atlantic Forest, still fragmented, begins to be compiled in special numbers of scientific journals and books. In the early 2000, Morellato and Haddad (2000) edited a special issue of the journal *Biotropica*, with 14 articles that dealt mainly on vertebrate distribution, plant-animal interactions, and ecology and plant distribution. It is worth mentioning the work of

Oliveira-Filho and Fontes (2000), who proposed a comprehensive definition of the Atlantic Forest, including humid and semideciduous forests as a great continuum. Also, in this year, the Atlantic Forest has been confirmed as a hotspot for global conservation actions (Myers et al. 2000). In 2003 (and in 2004, the Portuguese version), the Conservation International published a book entirely dedicated to the Atlantic Forest as part of a series dedicated to the world's conservation hotspots (Galindo-Leão and Câmara 2003). In its 31 chapters, the book reported the history of the threats in the different territories and showed the conservation status, with examples focused mainly on vertebrates in the 3 countries where the Atlantic Forest occurs (Brazil, Paraguay, and Argentina).

In parallel, in the early 2000s, the number of articles on biogeography and systematics also increased considerably (Fig. 1.3a, b). This exponential growth is likely due to the beginning of the "big data era" on biodiversity, which has as starting point the establishment of the Global Biodiversity Information Facility (GBIF), in 2001. The massive availability of biodiversity data, together with the rapid emergence of new techniques and tools to analyze such information, provides an invaluable resource to document biodiversity and its distribution through time and space (Maldonado et al. 2015; Smith and Blagoderov 2012). Thanks to that, both conservation and biogeography became consistent research fields in Atlantic Forest, which explains, in part, them being the main research topics currently studied (Fig. 1.3b). Conservation has been the most used keyword (765 occurrences), and it is linked to all 38 keywords on the map (Fig. 1.2). This finding suggests that conservation is the main focus of the research conducted on the Atlantic Forest.

In 2009, a special issue of the *Biological Conservation* journal was also dedicated to the Atlantic Forest (Metzger and Sodhi 2009). In this issue, the 11 articles suggest the high degree of fragmentation of Atlantic Forest and its effects on different groups of organisms and regions of Brazil. In the estimates of that time, only 11% of the biome original area remained (Ribeiro et al. 2009), which motivated several later studies. In 2015, a special issue of the *Biodiversity and Conservation* journal explored, in 14 articles, the flora and vegetation of the Atlantic Forest (Eisenlohr et al. 2015). One of the most impressive results shows that in 70 years of studies in the Atlantic Forest, only 0.01% of the total Atlantic Forest was actually surveyed. This demonstrates how limited our knowledge is on the Atlantic Forest (Lima et al. 2015).

This period definitively marked the fruitful "marriage" between science and the environmental movement in Brazil, which brought quality and greater argumentative capacity to the implementation of legal regulation of several Brazilian environmental laws, including the Atlantic Forest Law (Law 11428/2006; see below).

Biodiversity Collections and Big Data

The accumulation of scientific work over time has generated a huge collection of data. Recently, some data repository initiatives have been published for the biodiversity of organisms, such as bats (Muylaert et al. 2017), small mammals (Figueiredo et al. 2017), amphibians (Vancine et al. 2018), butterflies (dos Santos et al. 2018), mammals (Souza et al. 2019), primates (Culot et al. 2019), epiphytic plants (Ramos et al. 2019), and trees (Oliveira-Filho 2017; Bergamin et al. 2015; Zwiener et al. 2017, 2019). Databases of attributes of tree plants (Rodrigues et al. 2018) and wood densities (Oliveira et al. 2019), mammals (Gonçalves et al. 2018), and birds (Rodrigues et al. 2019) also proliferated. In this period, all topics considered here reached their peak of publications (Fig. 1.3b), especially conservation and biogeography. Altogether, these data collections have been important for the increase of studies using geospatial tools, allowing a broader understanding of diversity patterns and influencing public policies.

1.3 The Limits of the Atlantic Forest

Defining a geographical space with ecological, biological, and environmental significance is one of the most complex tasks for a nature scientist. While there is a lot of controversy regarding the use of terms (see Box 1.1), it is known that the physiognomy of vegetation is one of the most important characteristics to define a biome. The understanding that the Atlantic Forest is a distinct ecological unit within Brazilian territory dates back to the middle of the nineteenth century with the work of von Martius, who contributed greatly to the knowledge of Brazilian flora and vegetation. In his seminal proposal for the floristic division of Brazil, in 1858, Martius named Dryades, the Greek deity, to refer to the forests of the Atlantic coast, located in the southeast and part of the northeast of Brazil (IBGE 2012).

Several other proposals for phytogeographic divisions were suggested (Fig. 1.4). Hueck (1972) identified the Brazil coastal vegetation as an extension of Amazon rainforest (Fig. 1.4b). Ab'Saber (1977) identified "landscape units" based on relief, drainage, climate, soils, and vegetation patterns and called them "morphoclimatic domains." According to this proposal, the Atlantic Forest is considered the hilly areas of *Mares de Morro* (Seas of Hills), with origin in the Tertiary (Fig. 1.4c). Rizzini's proposal of 1966 and 1979 deserves to be highlighted. For him, the Atlantic Forest is closely related to the *Restingas* and the *Pinheiral* (Araucaria Forest) complexes (Fig. 1.4d). The Atlantic Forest, considered by Myers et al. (2000) as a biodiversity hotspot, had an extension similar to the morphoclimatic domain designated by Ab'Saber (Fig. 1.4e). Currently, the Atlantic Forest is considered by the Critical Ecosystem Partnership Fund as a biodiversity hotspot (Fig. 1.4f) and has a similar dimension to "WWF ecoregions" proposed by Olson et al. (2001) (Fig. 1.4g). Silva and Casteleti (2003) also considered a broader extension of Atlantic Forest using areas of endemism of birds, butterflies, and primates (Fig. 1.4h).

From the 1960s onward, a national project (Radambrasil project) led by phytogeographers and geographers proposed an official classification for Brazilian vegetation. A first version was published in 1991 launched by IBGE and updated in 2004 (IBGE 2004; Fig. 1.4i). In the IBGE's classification, the Atlantic Forest does not constitute an isolated unit. Instead, it is composed of a complex of various vegeta-

Box 1.1 Terms Usually Applied to Refer to the Entire or Parts of the Atlantic Forest and Used in This Book

Atlantic Forest Complex: The mosaic of vegetation types or vegetation physiognomies present in the Atlantic Forest as a whole. The Atlantic Forest complex would include both vegetation formations that are typically forestry and the shrub and grassland, the aquatic ecosystems, and the ecotonal areas in all their extension.

Atlantic Forest Domain: From a phytogeographic point of view, it refers to a specific area characterized by the presence of endemic species (IBGE 2012). The domain of the Atlantic Forest refers to a region characterized by its specific flora.

Biome: This is, certainly, one of the most controversial terms in ecology. Walter (1986) used this term to mention an area of geographical space, with dimensions up to more than one million square kilometers, represented by a uniform type of environment, identified and classified according to the macroclimate, phytophysiognomy (formation), and also the ground and altitude (main elements that characterize the different continental environments). According to the Brazilian Vegetation Classification, a biome can be defined as a set of life (plant and animal) constituted by the grouping of contiguous and identifiable vegetation types on a regional scale, with similar geoclimatic conditions and a shared history of changes, which results in its own biological diversity (IBGE 2012). In this book, the term was used by authors to refer to one of these definitions.

Ecoregion: Relatively large units of land or water containing distinct assemblages of natural communities and species, with boundaries that approximate the original extent of natural communities prior to major land-use change (Olson et al. 2001). The ecoregions have been used by the World Wildlife Fund (WWF) as a tool to establish important areas for conservation.

Ecosystem: The complex of living organisms, their physical environment, and all their interrelationships in a particular unit of space.

Endemism Centers: The Atlantic Forest's areas of endemism served as the basis for a conservation proposal that accounted three biodiversity centers (Conservation International Brazil et al. 2000; Silva and Casteleti 2003; Da Fonseca et al. 2004; Ayres et al. 2005; Tabarelli et al. 2005, 2010).

Phytophysiognomy: The aspect of vegetation, defined by its structure, based on characteristics such as the predominant life form (or habitus), plant architecture, density of vegetation, seasonality, and deciduousness.

Vegetation Formation: Term used to designate a defined vegetation type, a set of forms of higher-order plant life, which makes up a homogeneous physiognomy, despite its complex structure (IBGE 2012). The sub-formation is used as a subdivision of formation – or part of it – and is differentiating itself by presenting specific facies that alter the physiognomy of formation (IBGE 2012).

Vegetation Types: The same as vegetation formation.

tion types, from forest to non-forest physiognomies, more or less close to the Atlantic coast, and differentiated in terms of terrain, age, location, climate, and flora origin (tropical or temperate) (IBGE 2012).

During the 1990s, environmentalists and scientists organized conservation actions that culminated in the recognition of the Atlantic Forest as a member of the World Biosphere Reserve Network, in 1992 – a title granted by UNESCO. This created a demand for internal legal instruments in Brazil, to guarantee the maintenance of this title by UNESCO. In 1993, a federal decree (Decree 750) defined the IBGE map as the official limit of Atlantic Forest. The following 13 years were marked by the tentative of transform the protection of the Atlantic Forest in law. On December 22, 2006, it was finally approved the project proposed by Deputy Fabio Feldman, becoming the first law specifically created for the Atlantic Forest biome (Law 11.428). It was then promulgated by the Minister of Environment Marina Silva and President Luiz Inácio Lula da Silva. This law had strong impacts on the understanding of what the Atlantic Forest is, as well as on disciplining the use of natural resources within the limits of the biome. Subsequently, other legal instruments complemented details of the law (e.g., CONAMA Resolution 388/2007). Although the effectiveness of this law has sometimes been questioned (Varjabedian 2010), the Atlantic Forest remains the only Brazilian biome with a specific law for its protection.

In Article 2 of the Atlantic Forest Law, the limits of the biome are defined. In this definition, the Atlantic Forest includes several of its local variants, such as the Atlantic Dense Forest, Mixed Forest (Araucaria Forest), Open Forest, Seasonal Semideciduous Forest, and Seasonal Deciduous Forest. These are all part of the Atlantic Forest biome, as well as the associated ecosystems, named as mangroves, *restingas* (scrubs), altitude grasslands, and the inland swamps and mountain forest (Brejos de altitude) in the northeast region. With this more comprehensive delimitation, the Atlantic Forest is distributed in 17 Brazilian states, with a total of 3401 municipalities and housing about 70% of Brazilian population.

After the enactment of the law, a decree (Decree 6.660/2008) established the map of the law enforcement area (Fig. 1.4j), as well as the regulating devices for determining the use and protection of the Atlantic Forest. The application of the law would apply to remnants of native vegetation in the primary stage and in the initial, medium, and advanced secondary stages of regeneration.

Given the differences between the limits established by different studies and maps, Muylaert et al. (2018) compared the similarities and differences of four previously proposed and widely used limits (Atlantic Forest Law, WWF limits, Silva and Casteleti 2003, and MMA-IBGE) and proposed two new limits: the “consensual limit” of the Atlantic Forest (Fig. 1.4k), which consists of the intersection of four other limits, and the “integrating limit” (Fig. 1.4l), which refers to the union of previously defined limits. Together, all these proposals for the limits of the Atlantic Forest (Fig. 1.4) are still used, and some of them are mentioned in the chapters of this book.

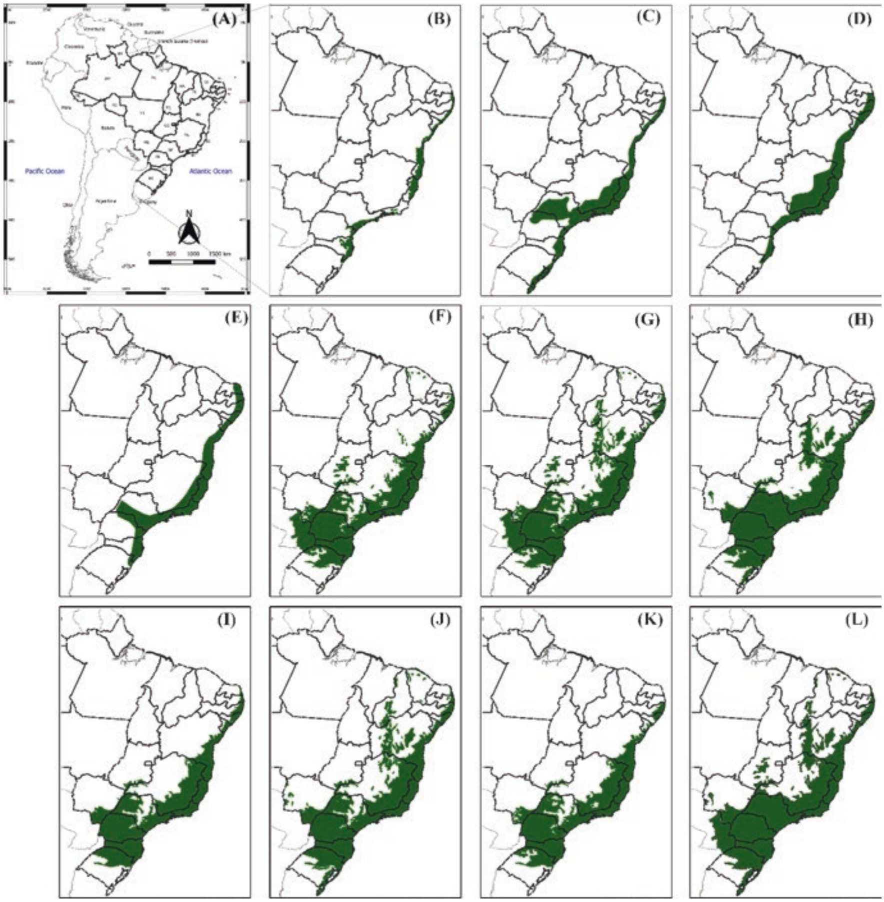

Fig. 1.4 Different proposals for Atlantic Forest limits: (**a**) South American map overview and Brazilian states limits; (**b**) Coastal Tropical forests identified by Hueck (1972), shapefile digitalized by Hasenack et al. (2017); (**c**) *Mares de Morro* proposed by Ab'Saber (1977), shapefile digitalized by IBGE (2019); (**d**) Atlantic Forest proposed by Rizzini (1979); (**e**) Atlantic Forest identified as a biodiversity hotspot by Myers et al. (2000) and (**f**) updated by Hoffman et al. (2016); (**g**) Atlantic Forests proposed by Olson et al. (2001), WWF ecoregions; (**h**) Atlantic Forest considered by Ribeiro et al. (2009), similar to the one proposed by Silva and Casteleti (2003); (**i**) Atlantic Forest considered by IBGE (2004); (**j**) Atlantic Forest Law application map, digitalized by IBGE (2008); (**k**) consensual and (**l**) integrative limits proposed by Muylaert et al. (2018)

1.4 The Atlantic Forest Sectorization

Along its length, which comprises 31° in latitude and 22.9° in longitude (according to the limits of Atlantic Forest Law), the Atlantic Forest presents a great diversity of physiognomies and ecosystems. The altitudes vary from the sea level to 2891 m in elevation, in Serra do Caparaó, between Minas Gerais and Espírito Santo states. The relief includes mountains, plateaus, plains, boards, and depressions (IBGE 2008). The climate, according to the Köppen-Geiger climate classification (Peel et al. 2007), includes the types Af, Am, Aw, BSh, Cfa, Cfb, Cwa, and Cwb. The soils are extremely varied and include types of eutrophic and dystrophic soils, on flat terrain and elevations, floodplains, *restingas*, and mangroves, frosted and thiomorphic soils, humic soils, and rock outcrops (Resende et al. 2002). In addition, 8 of the 12 Brazilian hydrographic regions are located in the Atlantic Forest: South Atlantic, Uruguay, Paraná, Southeast Atlantic, East Atlantic, São Francisco, East Northeast Atlantic, and Parnaíba (CNRH 2003, but see Padial et al. 2021).

With all this variation in space and environment throughout the Atlantic Forest, there is a strong structuring of biodiversity, which is known for various groups of organisms (e.g., Oliveira-Filho and Fontes 2000; Marcilio-Silva et al. 2017; and Zwiener et al. 2019 for plants; Da Silva et al. 2004; Carnaval et al. 2014; Loyola et al. 2014; and De La Sancha et al. 2020, for animals). Based on the combination of different drivers on the biota, and using different criteria and methods, several proposals for sectorization of the Atlantic Forest have historically followed (Fig. 1.5).

Based on global and regional distribution of plants and animals, Olson et al. (2001) subdivided the terrestrial ecosystems into 14 biomes, 8 biogeographic realms, and 867 ecoregions. In the Atlantic Forest, 11 ecoregions were recognized (Fig. 1.5a), which are based mainly on the Brazilian vegetation map from IBGE (1993). Silva and Casteleti (2003) used data on bird, butterfly, and primate distributions to propose the division of Atlantic Forest into eight biogeographical sub-regions (Fig. 1.5b), five as centers of endemism (Bahia, Brejos Nordestinos, Pernambuco, Diamantina, and Serra do Mar) and three as transition zones (São Francisco, Araucaria Forests, and Interior Forests). Ribeiro et al. (2011) refined the biogeographical sub-regions proposed by Silva and Casteleti (2003), using climatic and elevation data, identifying 55 internal divisions. The map of application of the Atlantic Forest Law (IBGE 2008) divided Atlantic Forest into ten vegetation types (Fig. 1.5c). These vegetation types were based on Brazilian vegetation map from IBGE (2004), which divided the vegetation of Brazil according to the dominant plant life forms. More recently, Cantidio and Souza (2019) identified 21 spatially cohesive occurrence ecoregions (Fig. 1.5d) using a data set on the distribution of 4378 shrub and tree species across 711 localities.

In the proposition of sectorizations above (Fig. 1.5), the authors apply terms to identify each sector based on some broader international system (e.g., IBGE 2008; Olson et al. 2001), adopting some regional terminologies (e.g., Silva and Casteleti 2003), or still do not propose any specific term (Cantidio and Souza 2019). In addition, at the infra-sector scale, there are a multitude of terms used to characterize types of vegetation or ecosystems in the Atlantic Forest. Given its wide uses and constant references, including in the chapters of this book, the main terms and their correspondents are presented in Table 1.1.

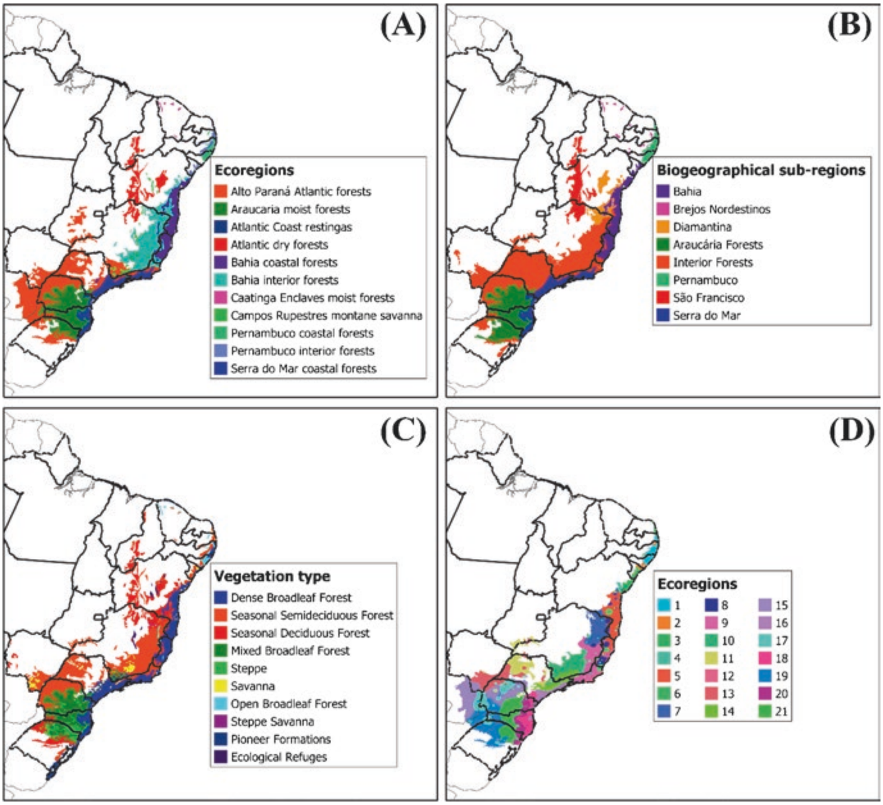

Fig. 1.5 Different proposals of Atlantic Forest sectorization: (**a**) Atlantic Forest ecoregions defined by Olson et al. (2001), "WWF ecoregions," (**b**) biogeographical sub-regions proposed by Silva and Casteleti (2003), (**c**) Atlantic Forest vegetation types defined by IBGE (2008) (see correspondent Portuguese names in Table 1.1), (**d**) ecoregions based on woody plant occurrence proposed by Cantidio and Souza (2019)

The limits between the sectors of the Atlantic Forest are defined by specific geographic and geological conditions, which change environmental conditions and biota either gradually or abruptly. Examples of these variations can be seen in the representative vegetation profiles of three regions of the Atlantic Forest (Fig. 1.6): the Northeastern Atlantic Forest, the Central Corridor, and the Southern Atlantic Forest. These regions, which were treated in detail in Chaps. 3 (Lins-e-Silva et al. 2021), 4 (Faria et al. 2021), and 5 (Carlucci et al. 2021), illustrate the diversity of physiognomies and landscapes of the Brazilian Atlantic Forest.

Table 1.1 Terms and its correspondents used to design different vegetation types in Atlantic Forest (AF) domain and applied in present book

English terms and correspondents	Portuguese terms and correspondents	General characteristics
Atlantic Forest; Atlantic Forest *latu sensu*	Floresta Atlântica, Floresta Atlântica *latu sensu*, Mata Atlântica	Used to refer to the vegetation or biome more generically
Atlantic Dense Forest, Atlantic Rain Forest, Coastal Dense Forest, Atlantic Pluvial Forest	Floresta Ombrófila Densa Atlântica[a], Floresta Pluvial Atlântica	Wet (or rainy) forest, characterized by precipitation well distributed throughout the year and dense canopy
Atlantic Open Forest	Floresta Ombrófila Aberta[a]	Moist to wet forest, characterized by precipitation distributed throughout the year and opened canopy
Semidecidual Seasonal Forest, Interior Semidecidual Seasonal Forest	Floresta Estacional Semidecidual[a], Floresta Tropical Subcaducifólia, Floresta Estacional Mesófila Semidecídua, Floresta Latifoliada Tropical	Forest characterized by seasonality (alternation of rainy and dry periods), and deciduous trees (20–50% of individuals) lose their leaves in winter
Tabuleiro Forest	Floresta de Tabuleiro, Tabuleiros Costeiros, Floresta Estacional Semidecidual[a]	Forests occurring in lowland area or coastal board, of origin Tertiary, with its species distributed along a climatic gradient in states of Rio de Janeiro to Pernambuco
Seasonal Decidual Forest, Seasonal Dry Forest	Floresta Estacional Decidual[a]; Floresta Decídua; Floresta Seca	Forest characterized by strong seasonality (alternation of rainy and long dry periods), and deciduous trees (>50% of individuals) lose their leaves in winter
Araucaria Forest, Araucaria Mixed Forest, Mixed Forest	Floresta Ombrófila Mista[a]; Floresta com Araucária, Mata de Araucária, Pinheiral	Wet forest, occurring in cold climates of southern Brazil, dominated by ancient genera from temperate regions (*Drimys*, *Araucaria, Podocarpus*)
Restinga, coastal scrub, coastal thicket, coastal plain forest, dunes	Vegetação Pioneira com Influência Marinha[a]; Restinga; vegetação (ou floresta) de restinga, vegetação de dunas	Herbaceous, shrub, or tree vegetation that grows on coastal sandy plains formed during the Holocene. All are also referred to as Atlantic Forest-associated ecosystems
Salt marsh	Vegetação Pioneira com influência Flúvio-Marinha[a]; marisma, apicum	Herbaceous vegetation flooded by seawater and freshwater. Also referred to as Atlantic Forest-associated ecosystems
Mangrove	Vegetação Pioneira com Influência Flúvio-Marinha[a], manguezal	Young tropical vegetation occurring in lowlands in estuary regions and in marginal areas of river deltas, lagoons, bays, and river mouths, affected by tides and not exposed to sea waves. Also referred to as Atlantic Forest-associated ecosystems

(continued)

Table 1.1 (continued)

English terms and correspondents	Portuguese terms and correspondents	General characteristics
Grasslands; altitude grasslands	Estepes[a], Savanas-Estépicas[a]; Campos; Campos de Altitude	Relatively extensive plateaus, composed of mosaics of grass clumps, sparse herbs, shrubs, and small trees, limited by low temperatures, in mountain ridges over 900 m (e.g., in Serra da Bocaina, Serra da Mantiqueira, Serra do Caparaó)
Rupestrian fields, *campo rupestre*	Estepes[a], Savanas-Estépicas[a]; campo rupestre	Graminoid and diverse vegetation, limited by the depth of the substrate, in mountain ridges over 900 m (e.g., in Cadeia do Espinhaço, Chapada Diamantina)
Brejos Nordestinos, altitude swamps	Brejos nordestinos, brejos de altitude, florestas serranas	Enclaves of dense forests in the semi-arid northeast (in the Caatinga domain), in regions of high altitude and humidity (due to the exposure of wet masses from the coast), forming true vegetation islands

[a]Term used in the official Brazilian Vegetation Classification (IBGE 2012)

1.5 Conclusion

In this chapter, we introduced the Atlantic Forest in terms of the evolutionary history, evolution of scientific knowledge, and subdivision along its distribution. We show that the current identity of the Atlantic Forest biome is the result of (1) an intrinsic interest of biologists who saw this as an ideal case to understand how evolution processes; (2) a continuous exercise in understanding the drivers that determine their unique identity, as well as the variations between their sectors; and (3) the notion that this is a place of intrinsic biological, ecological, and cultural values, of relevance to humanity. This identity is, therefore, complex, which challenges us to immerse ourselves both in deepening the knowledge of its parts (a physicalist view of science, sensu Mayr 2008) and in the interpretation of the functioning of the whole (an organicist and mechanist scientific view). The chapters in this book will enable a trip to these two worlds.

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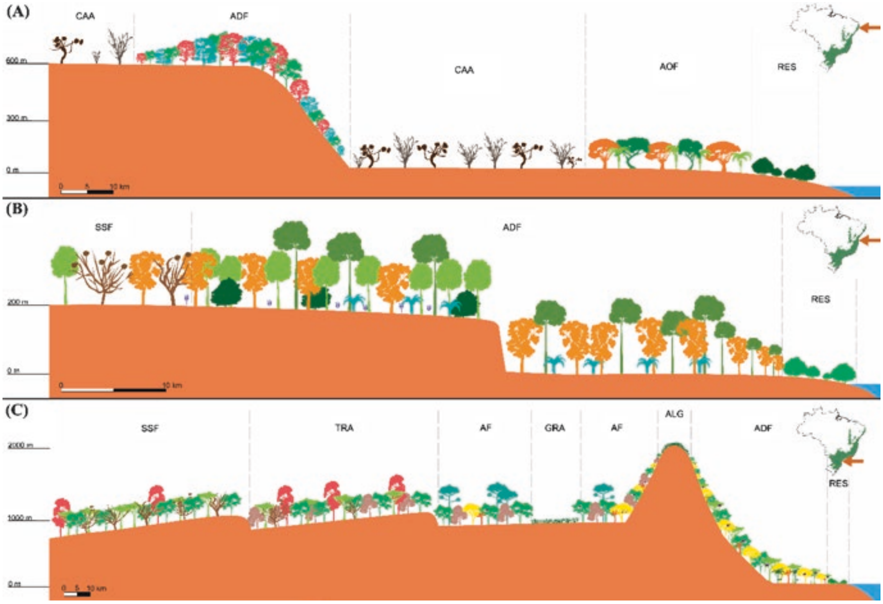

Fig. 1.6 Profiles of three Atlantic Forest phytophysiognomies in three different regions in Brazil: (**a**) *the Northeastern Atlantic Forest* in Pernambuco state – the *Restinga* is a narrow band followed by Atlantic Open Forest; after a strip of *Caatinga* vegetation, the Dense Forest occurs in the slopes of Serra da Borborema, characterizing the *Brejos Nordestinos* (based on Pôrto et al. 2004 and Lima 2007). (**b**) *The Central Corridor* – Hileia Baiana: in South Bahia, the *Restinga* is followed by Atlantic Dense Forest in the coastal plain; in the interior, the Barreiras Formation establishes a climatic and edaphic transition where the Seasonal Semideciduous Forest (Tabuleiro Forest) occurs (based on Jardim 2003). (**c**) *The Southern Atlantic Forest*: in Paraná state, the coastal plain is narrow, and the *Restinga* is followed by Atlantic Dense Forest in the lowlands and in the Serra do Mar mountains; at higher elevations, outcrops and altitude grasslands occur. In the interior, the first plateau is covered by Araucaria Forest and grasslands, the second by a transitional vegetation, and the third plateau by Seasonal Semideciduous Forest (based on Roderjan 1994, 2001). AF Araucaria Forest, ADF Atlantic Dense Forest, AOF Atlantic Open Forest, ALG altitude grasslands, CAA *Caatinga*, GRA grasslands, SSF Seasonal Semideciduous Forest, RES *Restinga*, TRA transitional vegetation between SSF and AF. The left/vertical scale refers to the altitude; the horizontal scale refers to the ocean distance. All scales are estimates

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