Urban Forest Fragments as a Living Laboratory for Teaching Botany: An Example from Federal University of Rio Grande do Norte, Brazil

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Abstract—"Plant blindness" is affecting humans’ relationships with plants, which has negative consequences for both science and conservation. It is, therefore, important to find new ways to promote societal interest in botany and plants. One possibility is encouraging the use of informal settings to promote curiosity and provide education to students. Forest fragments can be regarded as open air labs for teaching botany, especially on university campuses. We aimed to formally document the angiosperm diversity in the Mata dos Saguis (MS), a fragment of Atlantic forest under restoration belonging to the central campus of the Federal University of Rio Grande do Norte (UFRN), Brazil. We recorded 140 species, 113 genera in 52 families, and 24 orders of angiosperms. The MS has nearly 10% of the species and one third of all the families occurring in the entire state of Rio Grande do Norte, representing the main evolutionary groups of angiosperms, and we also recorded two new species occurrences for the state. Here we provide a checklist of the MS, a location that has been used as an open-air laboratory by many UFRN undergraduate courses in biosciences. We also share examples that can be replicated in other institutions and discuss the process of learning systematic botany in floristically rich countries by means of alternative and hands-on experiences.

Keywords—Atlantic forest, botany classes, fragmentation, problem-based learning, systematics.

Teaching plant systematics can be a difficult task, even for biology courses in universities, because we live in a world with many distractions and diminishing time spent on contemplation and observation of nature. “Plant blindness,” or lack of appreciation for plants as a vital component of the biosphere, is widespread in our society and common even among students of life sciences (Wandersee and Schussler 2001; Drea 2011). Plant-blind students are less motivated to learn about plants than other organisms or aspects of biology because they perceive plants as less valuable or distant from everyday life (Salatino and Buckeridge 2016). Based on our personal observations from living and teaching in Brazil, plant blindness can lead to a cascade effect, where undergraduate students lacking motivation to learn about plants become teachers with poor knowledge of botany and lack a passion for teaching others about plants. In this case, a teacher will most likely produce a new generation of plant-blind students. Lack of interest in learning and applying science is a deep problem that extends beyond the education system and requires both scientific and social education at all levels of society, and requires an effort from scientists to explain, without jargon, the importance of their work to the general public. However, we expect that universities would be a natural place to cultivate motivated and enlightened future teachers.

It is much easier to motivate students to study animals or disciplines that focus on human life than to motivate students to learn botany or, in the case we will discuss here, plant morphology and systematics. Some explanations offered for plant blindness include zoocentric or zoochauvinistic perspectives, which means a lack of interest in plants when compared to animals (Hershey 1996; Wandersee and Schussler 2001; Allen 2003) and fundamental differences in how the human visual system processes plants (Balas and Mønsen 2014).

Traditional courses in plant systematics (in Brazil, typically totaling 60 hr) are included in the basic graduation requirements for biological sciences and form the core of botanical knowledge for undergraduate students. The overwhelming lexicon of technical terminology describing the classification and morphology of plants is one of the biggest challenges in teaching botany. Students typically find it hard to rapidly learn and apply such a volume of specific terms. Failure to obtain the necessary vocabulary hinders communication and discourages students from immersing themselves in the topic.

Little has been written on how plant systematics is taught in Brazil or South America, but we assume that most courses in plant systematics have a similar structure worldwide: theoretical lectures followed by practical activities. Instructors typically focus on flowering plants (angiosperms) and use species of the most common plant families in their geographical regions, plus some economically important species to which they have access. In general, classes focus on morphology and family-level diagnostic characters, the use of identification keys, and phylogenetic relationships and classification. It is also common to include the origin of terrestrial plants and basic principles of evolution, systematics, and cladistics as initial topics, before introducing families, in a one-semester course. In some countries it is common to take field trips or visits to botanical gardens where one can see many taxa in a short period of time. According to Silva et al. (2016) students in Brazil and Portugal would prefer more practical teaching of botany and, if allowed, they would prefer field activities instead of only theoretical lessons.

The high diversity of plants observed in Brazil (Myers et al. 2000; BFG 2015) can be an impediment to the assimilation of the corresponding large number of scientific names and morphological variation. It is not uncommon (and potentially frustrating!) for a student finishing a course on plant systematics in Brazil to go into the field and recognize only a fraction of what they have seen in class. On the other hand, this high biodiversity may serve to aid in the teaching and learning process, facilitating interaction with a diversity of plant forms and species.

University campuses usually harbor large green areas and open spaces, and most university campuses have their own
herbaceous successional species with their diversity and documentation about composition of native and alien species (Carneiro and Irgang 2005).

A growing field of research involving ecologists, biologists, urbanists, and architects is concerned with the resilience of the landscape increased by small native urban vegetation fragments (Schlee 2015), how human activities influence diversity between urban and periurban forest (Blood et al. 2016), how urban forests can promote and preserve biodiversity (Alvey 2006), and how to deal with the new, usually cosmopolitan flora (but still having importance and providing ecological services) that is typical of the urban space (Tredici 2017).

In response to concerns about the fragmentation of natural green areas with increased urbanization, and to satisfy the need for alternative settings in which to teach botany at universities, we aim to take advantage of urban green areas and fragments by using them as educational laboratories. We aimed to formally document the angiosperm diversity in Mata dos Saguis (MS), a fragment of Atlantic forest belonging to the Federal University of Rio Grande do Norte (UFRN) campus, Centre for Biosciences. This area has been used for sporadic educational activities for the last 15 yr, although it has the convenience of being located only 50 m walk from botany labs and classes and offers the potential for new floristic findings. Furthermore, there are conservation issues affecting the area, as it is typically used as a recreational space and not as an open laboratory. Our goals were: 1) to generate a formal floristic checklist of MS, 2) to determine the prevalence of native and exotic species, and 3) to explore the potential of a forest fragment for teaching systematic botany and share some case studies as potential activities to be applied elsewhere.

Materials and Methods

Study Area—The Mata dos Saguis (MS) is a forest fragment zoned as a “non-constructible/developed area” by an internal resolution (0028/2007-CONSAF of UFRN Campus plan), with 1.5 ha next to the Centre for Biosciences on the campus of the Federal University of Rio Grande do Norte (Fig. 1). The fragment of forest is surrounded by streets or by buildings (Fig. 1), and in its original shape could be classified as an interdune depression. Currently, all the area is delimited by a fence and contains approximately 450 m of trails (“Trilha dos Saguis”). The entrance to the MS trail (5° 50′ 33.32″ S, 35° 12′ 5.58″ W) is a smooth slope, while the core of the forested area is flat and around 45 m above sea level. Natal has a humid coastal tropical climate with moderate deficit of rains during the summer. Rains are concentrated from the autumn to the winter, varying from 800 mm to 1555 mm annually (Nunes 2006; Espírito-Santo and Silva 2016). The soil is soft, well-drained, composed of dystrophic quartz sands and tending to have a thick layer of litter. Besides the rain, other important climatic factors are the predominant southeast winds, reaching up to 8 m/s in August and September, and a monthly mean temperature about 26°C (Nunes 2006; Espírito-Santo and Silva 2016).

The original vegetation of the whole UFRN campus, which was developed on an inter-dune area, was likely a mix of scrub-shrubby vegetation, dominated by Fabaceae, Myrtaceae, Rubiaceae, and xerophytic taxa (cacti and bromeliads), open fields and herbaceous vegetation, and small patches of forest with scattered trees not forming a dense and continuous canopy, dominated by Anacardium occidentale (Anacardiaceae), Hancornia speciosa (Apocynaceae), and many arboreal species of legumes and Myrtaceae.

The northern limit of the Atlantic forest corresponds to the city of Natal area, in Rio Grande do Norte state (RN), which is quite distinct from the core area of the Atlantic forest in southern Brazil. The Atlantic forest in RN includes an up to 10 m tall forest, restricted to the valleys placed among the dunes, where soils are more stable, humid, and nutrient rich (Rizzini 1997), while other areas, particularly the windy escarpments of the dunes, are dominated by a shrubby sandplain vegetation (restinga).

The MS has a mix of all these habitat types and the original forest suffered disturbance, as it was partially burned in 2005 and 2011 (A.
Carvalho and M. Pichorim pers. comm.). Young trees (native to other Brazilian biomes) were transplanted to the area prior to 2014. Also, a fraction of this area was used to implement a xerophyte garden, mainly cacti, which were later transplanted to another area. Despite being limited by a fence, the MS suffered with accumulation of garbage and abandoned cats. In addition, students and people from the community use the area for recreational purposes.

Floristic Diversity in the Mata dos Saguis—In order to have a formal list of all angiosperms occurring in the area, the authors of this study performed an exhaustive collection effort from April to November 2016. In addition, we analyzed all vouchers available in the UFRN herbarium as well as dissertations and undergraduate monographs produced by students. All specimens collected were deposited in UFRN herbarium (images available at http://ufrn.jbrj.gov.br). The identifications were made using specific taxonomic literature or local checklists and field guides (Trindade and Jardim 2013; Medeiros et al. 2016; Diesel 2018) and herbarium comparison, or by taxonomists (listed in the acknowledgments). We followed the classification system proposed by the Angiosperm Phylogeny Group IV (APG 2016). The APG IV phylogenetic tree (Fig. 2) was edited using the software Mesquite (Maddison and Maddison 2016) to generate a graphic representation of the phylogenetic composition in the MS.

As the UFRN campus is adjacent to the Natal Dunes State Park, a large area (about 1000 ha) of Atlantic forest, we compared our inventory to a previous list from that reserve (Freire 1990) to see how many species are shared by both and how many were restricted to our area. We used the Lista de Espécies da Flora do Brasil (BFG 2015) to record the phytogeographical domain where each species is found and the status of each species as native, exotic, or naturalized (an exotic that has adapted itself to reproduce and disperse in the new habitat). After the compilation of the biomes in which each species occurs (Appendix 1), we prepared charts to visualize if the species occurring in MS tend to be widespread in Brazil, occurring in several biomes, or if they are more restricted to the Atlantic forest or caatinga, the predominant biomes in Northeast Brazil (Figs. 3, 4).

The Mata dos Saguis as an Open Air Laboratory—Since 2010, professors A. Calvente, L. M. Versieux, and for a limited time F. A. Carvalho (2016–2019) have used different techniques and approaches to teaching morphology, taxonomy, and systematics to courses in the undergraduate program. Three basic botany courses have been offered by these professors: field botany, for undergraduate students of Ecology; botany III, focused on the systematic botany of angiosperms for students of Biology; and plant morphology and systematics, a course offered to Forestry and Animal Husbandry.

Each course usually has a mean number of 35 students per semester and teachers usually ask as one assignment a group (of 10 students) activity that is based on a project. Some examples of the outcomes of such activities are presented in the Supplemental Material (Versieux and Calvente 2021) and in most of them the idea is to ask students to present a product, resolving a specific problem through a project working group, after an initial theoretical introduction. Students have been assigned to create different field guides as a class project, taking up to 1/3 of the total grade. Similarly, it is common for professors to assign the collection and mounting of at least 10 specimens, which must be identified to the family level. This last task is usually done in groups of students, who can visit different areas at different times, but must use the lab to identify the samples and to press and mount the specimens. This approach has been important to intensify our own knowledge of the overall flora of RN, since students are free to collect wherever they want; some students have collected in MS. Assistance to identify families is provided during lab classes, where students bring the material they are collecting (either dried plants or liquid preserved flowers).

Our focus is to teach how to use the taxonomic keys, familiarize the students with the family morphology, field work, importance of different...
sources of evidence for systematics, and importance of the scientific collections. Student activities and assessments in the MS included preparing different field guides (e.g., of flowers, of vegetative structures, of habits, of seeds, of plantlets germinated from birds’ droppings). Not all these projects were excellent, but by regular meetings with the groups, it is easy to evaluate the progress of each group. Besides field guides, we have used technology such as for creating a blog about MS’s flora, and now there is work in progress to have a complete e-flora for the area. In this case, the e-flora was not done by students in general classes but as a senior thesis project (Moreira 2017, see https://efloramatadossaguis.wixsite.com/chave).

We have also used the area for graduate courses, including exercises to select native plants of ornamental potential or to have a field guide focused on the trees and their barks. By using the same area over the years for the different activities listed above, the professors become more familiar with the local flora and gain different experiences and insights on how to explore and use the selected area.

**Sampling**—We have focused only on angiosperms, since the three courses that we taught are focused on this taxon. There are no native gymnosperms in RN, and the ferns, lycophytes, and “bryophytes” are...

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**Fig. 2.** Adapted cladogram based on APG IV orders (APG 2016) highlighting the clades with representatives in Mata dos Saguis, UFRN Campus. (Photos taken in loco by N. Dávila when not identified, or EM = E. Moura).

**Fig. 3.** Number of the species of Mata dos Saguis, UFRN Campus, according to their occurrence in Brazilian biomes (or phytogeographical domains). Missing data category includes cultivated species and undetermined taxa (12 taxa in total), and is not represented. See Appendix 1 for details on the distribution of each taxon.

**Fig. 4.** Number of species of Mata dos Saguis UFRN Campus, with occurrence in each individual Brazilian biome (or phytogeographical domains). Missing data category includes cultivated species and undetermined taxa (12 taxa in total).
studied in other courses. We do plan to include these taxa in the future in new projects in other courses or to suggest other teachers do so. If we observe the most complete field guide produced so far, the flowers field guide (60 species, near 43% of the number we report now), we notice that the proportion of biodiversity documented by students alone is high considering that they still perform other individual assignments and collect during a limited time frame during a single season.

RESULTS

Floristic Diversity in the Mata dos Saguis—We recorded 140 species, 113 genera in 52 families (Appendix 1). The richest genera were Chamaecrista and Mimosa (four species each). The families with higher numbers of species were Fabaceae (24 species), Malvaceae (nine species), Rubiaceae (nine species), and Bignoniaceae (seven species). The fragment harbors species from all main clades of the angiosperm phylogeny (APG 2016), including Magnoliids, Monocots (Commelinids), and Eudicots (Superrosids and Superasterids) (Fig. 2). Twenty-four orders were recorded, with Fabales (29 species), Malpighiales (17 species), and Gentianales (12 species) being the most species-rich. Only the three basal angiosperm lineages (i.e. Amborellales, Nymphaeales, and Austrobaileyales) are not represented in the study area (Fig. 2).

The species composition of Mata dos Saguis includes taxa that are found across a broad geographic distribution with 30% of species occurring in four phytogeographical domains (biomes), 64.2% occurring from three to five domains, and 8.6% of species occurring in only one domain (Fig. 3). The Atlantic forest (114 species), caatinga dry woodland (111 species), and cerrado savanna (103 species) are domains where most of the species occur (Fig. 4). Species that occur in domains Pampa (11 species) and Pantanal wetland (11 species) were less frequent among the species occurring in MS. Even though the MS has suffered continuing disturbance (e.g. trash, cats, and foot traffic), 86.4% (121 species) of the species are natives from Brazil and only 7.9% (11 species) are exotics (cultivated or naturalized). We could not define the distribution of 12 species (8.6%) that were identified only to the generic level or were cultivated taxa (Appendix 1).

The Mata dos Saguis as an Open Air Laboratory—The MS has helped professors and students not only by providing plant material to be dissected in the lab, but also by providing an open air laboratory. Several student activities that had particularly positive outcomes included the development of field guides during a one-semester course, which incorporated technology such as digital cameras or cell phones into the learning process. Examples are the guide to flowers of the MS (produced when the second author of this paper was a student), guide to fruit and seeds, guide to leaves, creation of blogs with data of the MS, and keys for particular groups and taxa (Supplemental Material, Versieux and Calvente 2021). Another highlight was to move outdoors the traditional practical activities such as the demonstrations of collection techniques for preparing herbarium specimens. In addition, many other activities can be developed in the MS such as demonstration on how to establish plots for floristics inventories, observation of different plant life forms, observations and comparisons among parasitic plants, field observations of plants with a focus on ornamental potential, floral visitors, and phenology.

Discussion

Floristic Diversity in the Mata dos Saguis—This is the first time that a comprehensive and formal species list has been published for the MS. Our sampling in MS almost tripled the 50 species previously recorded from this area by Fernandes-Neto (2012). The diversity recorded in this fragment represent 9.8% of plant species in the RN state flora (BFG 2015). Also, most herbaceous plants found in the area are cited in the UFRN campus herbaceous flora guide (Trindade and Jardim 2013), but some species that prefer open habitats (e.g. Stachytarpheta angustifolia or S. microphylla (Verbenaceae), Aspilia procumbens (Asteraceae), and a few Poaceae, like Pappophorum mucronulatum), were not found in the MS area, possibly due to the limited sunny areas in MS, while these taxa may be found easily in adjacent areas of the campus.

Due to the proximity of MS and Natal Dunes State Park (600 m straight line, border to border) a high similarity between their flora might be expected but we only recorded 33 species (approximately 24% of MS species) that also occur in Natal Dunes State Park. However, such comparisons are only preliminary, since the checklist of Natal Dunes State Park is taxonomically and numerically outdated (Freire 1990; Diesel 2018), and this reserve has a much larger area, nearly 1000 ha, while MS has a much smaller area and a history of disturbance, with a fence just installed in 2016 to limit unauthorized access and accumulation of garbage. All these factors could affect the assemblage of each area’s plant community. Considering only the richest genus in MS, Chamaecrista, all four species are cited in a recent inventory for the Dunes State Park area (Queiroz and Loiola 2010).

We compared our floristic list with those from Natal Dunes State Park and the Parque da Cidade (Medeiros et al. 2016). We could observe that bioindicator species, such as epiphytes, are lacking in the MS. Bromeliads, orchids, and epiphytic Araceae are more sensitive to human impacts and prefer mature forests (Barthlott et al. 2001) and are nearly absent in MS. The rare and endangered terrestrial species Cryptanthus zonatus (Bromeliaceae), abundant on the litter of closed forest patches in those parks (Versieux et al. 2013), is absent in MS. Also, Myrtaceae, one of the richest families in the Atlantic forest (BFG 2015), with many slow-growing trees and shrubs, are less frequent in MS. Myrtaceae totaled four species in MS, a small number when compared to the 14 taxa of this family listed in the Natal Dunes State Park (Diesel 2018). Comparing our list with the Parque da Cidade field guide (Medeiros et al. 2016), a similar pattern is observed. The MS lacks such sensitive groups, like epiphytes, particularly orchids, represented in Parque da Cidade by five species, including the highly ornamental Cattleya granulosa. The same is valid for the globose Melocactus violaceus, usually found in well preserved restinga in Natal. We believe that the impact over the area of MS is responsible for the local extirpation of these species, although only a fraction of the area would be suitable and sunny enough to allow such restinga species to thrive there.

Most species we recorded in MS were somehow associated with Atlantic forest domain. Ninety species (64% of the total) have a broad distribution, occurring in three to five Brazilian biomes or domains (Fig. 3), and only 9 species (about 6%) are endemic to the Atlantic forest. Additionally, the human impact on the area also allows typical urban plants to grow side by side with other nonnatives introduced for cultivation (e.g. Sansevieria trifasciata) and natives.
The species composition of MS is also likely influenced by poorly-planned attempts at reforestation using species from other Brazilian biomes, such as the Amazonian *Pachira aquatica*, as well as recruitment of broadly distributed and pioneering plants that tolerate a wide range of conditions. The typical vegetation of Natal includes some shrubs with pioneering generalist species, that can reach and colonize sand dunes or poor sandy soils, the predominant conditions found in this city (Diesel 2018). Some planted coconut palm-trees (*Cocos nucifera*) may be observed in adjacent areas but are not in the core area of MS and thus were not listed here. Although 90% of the flora in this fragment are native to Brazil, we found some exotic plants. These are considered to be ornamentals (e.g. *Sansevieria trifasciata* (Asparagaceae), and *Oecocellades maculata* (Orchidaceae)), species used to restore degraded areas that may also be invasive (e.g. *Delonix regia*, *Crotalaria retusa*, *Leucaena leucocephala*, and *Pithecellobium dulce* (Fabaceae)), and invasive species (e.g. *Ricinus communis* (Euphorbiaceae), and *Melinis repens* (Poaceae)), which are frequently reported in disturbed areas (Leão et al. 2011; Castillo et al. 2014). This cosmopolitan array of plants of distinct origins, adapted to the urban space, are the product of interacting forces of urbanization, globalization, and climate change that have become the “native” urban vegetation (Tredici 2017) and that constitutes an excellent model to be studied in botany classes, as well as to discuss evolution, adaptations, selective pressures, and ecological services provided by this new kind of flora.

Similar evidences of urban and invasive species are found in the fauna of MS. Besides the domestic cats, the large land snail *Achatina fullica* and cockroaches *Periplaneta americana* are frequently captured by zoologists in the area (B. Bellini and R. Gondim pers. comm. 2020). Among the species of lizards of the family Gekkonidae that occur in area of MS, the tropical house gecko *Hemidactylus mabouia* stands out as an exotic species that has been gaining the status of invader in the natural environments of Brazil, also occurring in areas of closed forest in Rio Grande do Norte (Freire 1996; Rocha et al. 2011). Despite being categorized as “low risk of invasion” in the List of Invasive Alien Species, *H. mabouia* has increasingly occupied the habitats of native species, including areas of the MS (Sales et al. 2009; Leão et al. 2011; Rocha et al. 2011).

On the other hand, this fragment supports conservation of species that are native and nationally threatened such as *Pradosia restingae* (Sapotaceae), which is known only from sandplain areas in Rio Grande do Norte and categorized as an endangered species (Terra-Araujo et al. 2013). Additional examples of native and threatened species found in MS are the vulnerable *Aplelea leicarca* (Varty 1998; Gagnon et al. 2016) and *Paubrasilia echinata* (Fabaceae), popularly known as “Pau-Brasil,” which is a tree endemic (Pernambuco, Bahia, Espirito Santo, and Rio de Janeiro) and categorized as endangered in Brazil. Besides the two new records for the RN state flora (see below), we found two species that were only recently recorded in the Atlantic forest of Rio Grande do Norte: *Cenchris echinatus* (Poaceae) (Versieux et al. 2017) and *Amphilophium scabrissculum* (Bignoniaceae) (Colombo et al. 2016).

Our work in MS resulted in two additions to the flora of Rio Grande do Norte: a subshrub, *Conoclinopsis psiosfolia* (Asteraceae), which has previously been reported from only three states in northeastern Brazil (Alagoas, Bahia, and Pernambuco) (Ferreira 2015), and the grass *Dichanthelium scirrotoides* (Poaceae), which occurs in northeastern and southeastern Brazil (Viana and Rodrigues 2015). Our new records for RN, plus two new species of springtails (Collembola) recently described for the MS (Bellini et al. 2019), and records of birds, reptiles, and bats emphasize the importance of formally documenting the biodiversity of urban forest fragments because they may harbor notable species of interest for conservation. Also, as alerted by some authors, the urban flora is important and provides services despite its cosmopolitan origins (Carneiro and Frigang 2005; Tredici 2017), and even if botanists prefer pristine habitats, we must research and teach about such new plant communities.

**The Mata dos Saguis as an Open Air Laboratory**—Teaching botany in one of the most biodiverse countries in the world, with 32,086 angiosperms (BFG 2015), can be a challenge and a big responsibility for several reasons. First, instructors want students to learn (and we believe students want to learn, as well) about their own native flora, avoiding as much as possible the exotic plant species commonly observed in the imported and translated textbooks. Second, instructors want to engage students with plant science and attract potential future botanists. Finally, students will inherit the responsibility to document local flora in the face of rapid loss of habitat. Teaching and learning botany are more interesting and engaging with practical activities and strategies that promote active learning (e.g. doing research projects or practical activities).

The MS allowed students to have intimate and personalized experiences with plants. By using the MS as a living laboratory, students can learn about 10% of the species that occur in RN flora. In addition, students can learn about the classification and phylogenetic relationships of 24 (37.5%) of the angiosperm orders, representing the main clades of the APG IV (2016) classification system. This suggests that when a thorough collection effort is done, even in a small urban area in the tropics, plenty of material becomes available to students or instructors.

As a result of active learning, students developed field guides of the biodiversity of the MS, learned technical procedures to evaluate biodiversity, and performed ecological observation of plants and animals. These exercises boost the level of engagement of students and stimulate their passion for observing and relating to plants and nature. These exercises can be employed easily by any botanists teaching taxonomy or morphology.

To have enough time to finish the project and present a final “product” we reduced our focus on taxa, sometimes making difficult choices about which content (orders or plant families) should be excluded, so that some classes could be devoted exclusively to work on the projects. At the same time, not all of the student groups are highly successful or present excellent works; however, as different individuals have different abilities and preferences, by working in groups students find more easily their ways to engage with each other and how to meet their personal interests and exchange knowledge.

Other examples of academic activities that have been using this area include class projects such as “florestinha viva” and “L.A.N.A.MATA dos saguis” ([https://florestinhaufm.wixsite.com/lamatadossaguis](https://florestinhaufm.wixsite.com/lamatadossaguis)), final term papers (e.g. Fernandes-Neto 2012; Moreira 2017), the inventory of squamate reptiles that listed six species (Sales et al. 2009), inventory of the 21 species of birds (Sousa-Júnior et al. 2008), and two recently described new species of springtails (Collembo) (Bellini et al. 2019). Furthermore, field classes from disciplines such as restoration ecology, environmental education, zoology, and outreach
activities for the community take place in MS each semester. Despite the value of MS, part of the UFRN community remains unaware of its existence, and it is still under-utilized (Macedo 2011).

An important aspect of using the same area over many years, especially if associated with the herbarium, is the possibility to multiply collection effort. Different students go through the same area over many years, and a complete collection from the area eventually becomes available. We have used the MS as a collecting area but not in a standardized way. Although most vouchers cited here (N = 159) were collected by the authors, former students have also collected specimens and today the herbarium UFRN includes near 200 specimens from MS.

Preparing herbarium samples is a common task in Brazilian plant systematics courses. At UFRN, we encourage students to collect and present 10 herbarium samples by the end of their courses, identified at least to family level, but also ask them to try collecting while traveling inland to other areas of RN. This has helped us to increase sampling effort in a state considered to have the lowest species richness in Brazil, probably due to lack of sampling effort in the past (BFG 2015).

At this point it is worthwhile to consider some weaknesses of our approaches and share some experiences with professors aiming to do similar activities. If you look to the number of specimens collected by the authors (159) and the total of specimens available in our herbarium (200), you may notice that only 41 specimens were collected by students, what could be considered a small number. Possible reasons for that are that when we started, we did not realize that activities conducted during classes could contribute to a floristic project in the future. Many of the specimens collected by students in different years were returned to them, because there was a constant repetition of plant species that we already had for other areas of our campus in our herbarium. An important first step is selecting a good site to conduct the inventory and keeping as many specimens as possible from this area, considering that the list as a long-term achievement.

We noticed that students avoid collecting grasses or other small-flowered species, or large trees, either as part of larger projects or when they were free to choose plants for their herbarium. On the other hand, abundant species found along the trails of MS or those more common and easy to identify, such as edible fruit, were frequently collected (e.g., *Anacardium occidentale*, *Hancornia speciosa*, *Friederia chica*, *Richardia grandiflora*), and were not included in UFRN herbarium. Despite being taught about how to collect different taxa, the students didn’t submit any specimens of the columnar cacti *Pilosocereus* or of the large-leaved tree *Cecropia*. Possible ways to overcome these difficulties may include the separation of taxa to be collected by specific groups of students (e.g. monocots, Malpighiales) or of life-forms (trees, vines, herbs) in order to cover all the taxonomic groups with more focus. Another issue is that students working with digital photos of living plants for field guides may avoid vouchering their images. One solution to this problem could be for instructors to organize the project so that different groups are working in parallel, one presenting the specimens, while another group could work more freely on the images and guides.

Places outside the campus can be used as outdoor laboratories with similar results. In 2016, Prof. A. Calvente, after a demand from the extra-campus community, conducted a complete inventory of trees in an abandoned public square outside the UFRN campus using the same approach of experiential and problem-based learning, asking students to work on projects that should conclude with a product for their community. Positive learning outcomes have been achieved using open air laboratories combined with formal taxonomic keys or games to teach plant identification (Stagg and Donkin 2013) and by using informal spaces like botanical gardens and museums to teach botany (Faria et al. 2011). Feedback from students indicates that they prefer teaching with theoretical lessons followed by practical exercises, classes that are more practical and dynamic, and increased use of field lessons and informal spaces in teaching (Silva et al. 2016). One potential concern with using field lessons is that off-campus activities may involve transportation costs. However, an advantage of using urban forests for field classes is that they may be easily and independently accessed by students using local and public transportation in a cost-effective manner.

Finally, the information provided here, particularly the checklist (Appendix I), can be used by students of botany, ecology, plant morphology, plant systematics, field botany, and dendrology, all of which are courses offered by the Centre for Biosciences at UFRN to undergraduate and graduate students. Knowledge of plants on campus can also assist management and conservation policies within the university and the city of Natal. New platforms such as apps and online flora including interactive keys could be useful tools to develop for the Flora of UFRN campus, as an incentive for students to become familiar with, and curious about, plants.

**Conclusions**

Offering an area in which to inventory and study plants is a way to involve students in practical and problem-based education in systematic botany. Similar results in undergraduate plant science teaching are reported by Beckmann et al. (2015) who termed this new kind of students as “plant detectives.” Here we show how a small, on-campus fragment of urban forest may help the process of learning botany, and suggest that the same approach can be applied in public parks, green spaces, or squares, to which students have easy access, which also facilitate the approximation of scientific teaching/learning to the general extra-campus community. Ideally, courses in plant systematics should be taught as condensed field courses but this is not always feasible because of mixed schedules typical of undergraduate programs, as well as the cost of travel. We have observed that it is becoming more difficult to capture students’ attention using the traditional formula of teaching taxonomy using theoretical lectures followed by lab exercises based on dichotomous keys and drawing morphology in reports. By collecting interannually in the same place, it is possible to document species succession, cover distinct phenology, and increase the size and quality of herbarium collections. In addition, the diverse community of plants coexisting in even small fragments makes an excellent laboratory for teaching botany, where students can learn and see many different morphologies and adaptations and generate their own questions in the field. With fragmentation pressuring many habitats throughout the world (Liu et al. 2016), urban forest fragments will gain importance, not only for ecosystem services, but also to facilitate connections between humans and nature and provide space for learning and for conveying the importance of plants to the general public, especially where botanical gardens and other well-curated collections of living plants are absent (a very common
situation in developing countries). The results obtained here and in previous inventories highlight how the importance of the MS as an educational resource makes it even more significant to manage this area to conserve the site’s biodiversity.

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Author Contributions

AC, LMV, and FC designed the project and compiled all information regarding their personal experiences in teaching botany over the last years in Brazil. ND, EM, and LMV collected the floristic data and identified the species, ND and EM provided the photographs. All the authors analyzed the data and wrote the text. LMV provided all the additional information requested by reviewers and made substantial revisions to the original text.

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| Family               | Species                                      | Voucher       | Freire (1990) | Origin | Ama. | Atl. | Caa. | Cor. | Pam. | Pan. |
|---------------------|---------------------------------------------|---------------|---------------|--------|------|------|------|------|------|------|
| Acanthaceae         | Erythrina imbricata (Vahl) Pers.            | Queiroz 545   | native        | X      | X    | X    |      |      |      |      |
| Amaranthaceae       | Froelchia humboldtiana (Roem. & Schult.) Seub. | Moreira 46    | native        | X      |      |      |      |      |      |      |
| Anacardiaceae       | Anacardium occidentale L.                   | Versieux 530  | native        | X      |      |      |      |      |      |      |
| Spindas sp.         | Dávila 6646                                 | native        | X              |        |      |      |      |      |      |      |
| Apocynaceae         | Tapirira guanensis AUBL.                    | Moreira 43    | native        | X      | X    | X    | X    |      |      |      |
| Hancornia speciosa Gomes | Versieux 534     | native        | X              |        |      |      |      |      |      |      |
| Mattea gangulosa (Vell.) Rapini | Nascimento 50 | native        | X              |        |      |      |      |      |      |      |
| Araceae             | Anthurium affine                            | Dávila 6564   | X              | native |      |      |      |      |      |      |
| Asparagaceae        | Sansevieria trifasciata Prain               | Ribeiro 27    | cultivated    | X      |      |      |      |      |      |      |
| Asteraceae          | Conocliniopsis prasifolia (DC.) R.M.King & H.Rob. | Dávila 6600; | native        | X      | X    |      |      |      |      |      |
|                     | Elephantopus hirtifloras DC.                | Dávila 6587   | native        | X      |      |      |      |      |      |      |
|                     | Emilia soucifolia (L.) DC. ex Wight         | Moreira 41    | native        | X      | X    | X    |      |      |      |      |
|                     | Tilia buccata (L.) Pruski                   | Nascimento 4  | naturalized   | X      |      |      |      |      |      |      |
| Bignoniaceae        | Ampelopsis brevipedunculata (L.) L.Olms     | Dávila 6579   | native        | X      |      |      |      |      |      |      |
|                     | Fridericia chica (Bonpl.) L.G. Mohanan     | Queiroz 560; Versieux 567 | native | X | X | X | X | X |      |      |
|                     | Fridericia dispar (Bureau ex K. Schum.) L.G. Mohanan | Lacerda UFHRN4050 | native | X |      |      |      |      |      |      |
|                     | Handroanthus impetiginosus (Mart. ex DC.) Standl. | Dávila 6618; Versieux 528 | native | X | X | X | X | X |      |      |
| Capparaceae         | Cynophalla flexuosa (L.) J.Presl           | Dávila 6570 A | native        | X      |      |      |      |      |      |      |
| Celastraceae        | Magnesium urceolatus (Benth.) Prance       | Dávila 6569, 6570 | native | X | X |      |      |      |      |      |
| Chrysobalanaceae    | Licania apetala (Benth.) Prance            | Dávila 6563   | native        | X      |      |      |      |      |      |      |
|                     | Licania tomentosa (Benth.) Frisch          | Dávila 6640   | native        | X      |      |      |      |      |      |      |
| Commelinaceae       | Commelina erecta (L.) Benth.               | Adalberto 1   | native        | X      |      |      |      |      |      |      |
|                     | Commelina obtusa Vahl.                     | Nascimento 51 | native        | X      |      |      |      |      |      |      |
| Burseraceae         | Protium heptaphyllum (Aubl.) Marchand      | Dávila 6634   | native        | X      |      |      |      |      |      |      |
| Cactaceae           | Pilosocereus catingicola subsp. salvadorensis | Moreira 24    | native        | X      |      |      |      |      |      |      |
|                     | Tradescantia spathacea Sw.                 | Dávila 6635   | cultivated    | X      |      |      |      |      |      |      |
| Convolvulaceae      | Dusistinia montana (Moric.) Buril & A.R. Simões | Dávila 6578   | native        | X      |      |      |      |      |      |      |
| Erythroxylaceae     | Ipomoea incisa (Desr.) Roem. & Schult.     | Vénia UFHRN4119 | native | X | X | X |      |      |      |      |
| Euphorbiaceae       | Bixa orellana (L.) L.                      | Queiroz 530   | native        | X      |      |      |      |      |      |      |
|                     | Euphorbia characias (Vell.)                | Dávila 6629   | native        | X      |      |      |      |      |      |      |
|                     | Euphorbia comosa Vell.                     | Dávila 6595   | native        | X      |      |      |      |      |      |      |
| Fabaceae            | Aeschynomene L.                            | Dávila 6615   | cultivated    | X      |      |      |      |      |      |      |
|                     | Adenanthera pavonina L.                    | Dávila 6592   | native        | X      |      |      |      |      |      |      |
|                     | Anadenanthera colubrina (Vell.) Brenan      | Nascimento 70 | native        | X      |      |      |      |      |      |      |
|                     | Apuleia leucarpia (Vogel) J.F.Macbr.        | Moreira 22    | native        | X      |      |      |      |      |      |      |
|                     | Bignoniaceae                               | Dávila 6627   | native        | X      |      |      |      |      |      |      |
|                     | Canellodium papyrifera (Hook. & Am.) Spec. | Nascimento 71 | native        | X      |      |      |      |      |      |      |
|                     | Centrosema pinnatum (L) L.                  | Dávila 6614   | native        | X      |      |      |      |      |      |      |
|                     | Chamaecrista ensiformis (Vell.) H.S. Irwin & Barneby | Dávila 6604, Queiroz 572 | native | X | X | X |      |      |      |      |
|                     | Chamaecrista flexuosa L.                   | Dávila 6579A  | native        | X      |      |      |      |      |      |      |
|                     | Chamaecrista hispida (Vahl) H.S. Irwin & Barneby | Dávila 6576 | native        | X      |      |      |      |      |      |      |
|                     | Chamaecrista ramosa (Vell) H.S. Irwin & Barneby | Dávila 6589, Versieux 568 | native | X | X | X |      |      |      |      |
|                     | Delonix regia (Bojer ex Hook.) Raf.         | Dávila 6562   | cultivated    | X      |      |      |      |      |      |      |
|                     | Erythrina velutina Wild.                   | Dávila 6642   | native        | X      |      |      |      |      |      |      |
|                     | Indigofera hirsuta L.                      | Dávila 6590   | native        | X      |      |      |      |      |      |      |
|                     | Leucaena leucocephala (Lam.) de Wit        | Dávila 6636   | naturalized   | X      |      |      |      |      |      |      |
|                     | Mimosa caesalpiniifolia Benth.             | Dávila 6619   | native        | X      |      |      |      |      |      |      |
|                     | Mimosa invisa Mart. ex Colla               | Dávila 6596   | native        | X      |      |      |      |      |      |      |

(Continued)
| Family          | Species                              | Voucher                        | Freyre (1990) | Origin | Ama. | Atl. | Caa. | Cor. | Pam. | Pan. |
|----------------|--------------------------------------|--------------------------------|---------------|--------|------|------|------|------|------|------|
| Malvaceae      | Mimosa misera Benth.                 | Dâvila 6525, Silva 02          | native        | X      | X    | X    | X    |      |      |      |
|                | Pachira aquatica Aubl.               | UFRN 4129                      | native        | X      |      |      |      |      |      |      |
|                | Pachira endeaphyta (Vell.) Carv.-Sobr. | Moreira 50                           | native        |       |      |      |      |      |      |      |
|                | Pavonia cancellata (L.) Cav.         | Dâvila 6806                      | native        | x      |      |      |      |      |      |      |
|                | Sida angustissima A.St.-Hil.         | Dâvila 6591                      | native        |      |      |      |      |      |      |      |
|                | Sida linifolia Cav.                  | Dâvila 6537                      | native        |      |      |      |      |      |      |      |
|                | Waltheria indica L.                  | Versieux 573                    | native        |      |      |      |      |      |      |      |
|                | Molugo verticillata L.               | Versieux 573                    | native        |      |      |      |      |      |      |      |
|                | Myristaceae                          |                                |               |        |      |      |      |      |      |      |
|                | Campanoeasias dichotoma (O.Berg) Mattos | Dâvila 6568                      | native        |      |      |      |      |      |      |      |
|                | Eugenia luschnathiana (0.Berg) Klotzsch ex B.D.Jacks. | Dâvila 6568 | native |      |      |      |      |      |      |      |
|                | Eugenia punicifolia (Kunth) DC.      | Dâvila 6588, 6613                | native        | x      |      |      |      |      |      |      |
|                | Psidium guajava L.                   | Trindade s.n. (UFRN503)         | naturalized   | X      |      |      |      |      |      |      |
| Nyctaginaceae  | Bougainvillea spectabilis Willd.     | Ingrid s.n. (UFRN4236)          | native        | X      |      |      |      |      |      |      |
| Ochnaceae      | Ouratea sp.                          | Dâvila 6645                      | native        |      |      |      |      |      |      |      |
|                | Orchideae                            |                                |               |        |      |      |      |      |      |      |
|                | Oececodaeles maculata (Lindl.) Lindl. | Dâvila 6562                      | naturalized   | X      |      |      |      |      |      |      |
| Passifloraceae | Paspalum cincinatus Mast.            | Dâvila 46                        | native        | x      |      |      |      |      |      |      |
|                | Passiflora edulis Sims               | Moreira 29                       | native        | x      |      |      |      |      |      |      |
|                | Pinqueta guianensis N.E.Br.          | Moreira 18                       | native        |      |      |      |      |      |      |      |
|                | Turnera meloechioides Cambess.       | Moreira 57                       | native        | x      |      |      |      |      |      |      |
|                | Turnera subulata Sm.                 | Moreira 68                       | native        | x      |      |      |      |      |      |      |
| Phytolaccaceae | Microtoca paniculata Moq.            | Dâvila 6599                      | native        | x      |      |      |      |      |      |      |
| Poaceae        | Aristida setifolia kunth.           | Dâvila 6598                      | native        |      |      |      |      |      |      |      |
|                | Axonopus polycocactus (Steud.) Dedeecca | Dâvila 6855                      | naturalized   | x      |      |      |      |      |      |      |
|                | Cenchrus echinatus L.                | Dâvila 680, Dâvila 6699          | native        | x      |      |      |      |      |      |      |

(Continued)
### Appendix 1. (Continued)

| Family              | Species                                      | Voucher               | Freire (1990) | Origin | Ama. | Atl. | Caa. | Cor. | Pam. | Pan. |
|---------------------|----------------------------------------------|-----------------------|---------------|--------|------|------|------|------|------|------|
| Santalaceae         | *Phoradendron bathyoryctum* Eichler          | Dávila 6607, 6598;    | native        | X      | X    | X    | X    | X    | X    | X    |
|                     |                                               | Versieux 570          |               |        |      |      |      |      |      |      |
| Sapindaceae         | *Cupania impressinervia* Acev.-Roder.         | Dávila 6644           | native        | X      |      |      |      |      |      |      |
|                     | *Sapindus sapotaria* L.                      | Dávila 6616           | native        | X      | X    | X    | X    |      |      |      |
|                     | *Talisia esculenta* (Cambess.) Radlk.         | Dávila 6647           | native        | X      | X    | X    | X    |      |      |      |
| Sapotaceae          | *Manilkara salzmannii* (A.DC.) H.J.Lam       | Nascimento 56         | X             | native | X    |      |      |      |      |      |
|                     | *Pradosia restingae* Terra-Araujo            | Dávila 6610; Moura 207| native        | X      |      |      |      |      |      |      |
|                     |                                               |                       |               |        |      |      |      |      |      |      |
| Simaroubaceae       | *Simaba ferruginea* A. St.-Hil.              | Moura 50              | native        | X      | X    | X    | X    |      |      |      |
| Smilacaceae         | *Smilax sp.*                                 | Dávila 6638           |               |        |      |      |      |      |      |      |
| Solanaceae          | *Schwenckia americana* Rooyen ex L.          | Moreira 47            | native        | X      | X    | X    | X    |      |      |      |
|                     | *Solanum paludosum* Moric.                   | Versieux 526          | native        | X      | X    |      |      |      |      |      |
|                     | *Solanum paniculatum* L.                     | Roque 1566            | X             | native | X    | X    | X    |      |      |      |
| Talinaceae          | *Talinum triangulare* (Jacq.) Willd.sp.      | Pierre 1              | native        | X      |      |      |      |      |      |      |
| Trigonaceae         | *Trigonia utica* Cambess.                    | Dávila 6593           | X             | native | X    | X    | X    |      |      |      |
| Urticaceae          | *Cecropia pachystachya* Trécul               | Dávila 6626           | native        | X      | X    | X    | X    |      |      |      |
| Verbenaceae         | *Lantana sp.*                                | Dávila 6639           |               |        |      |      |      |      |      |      |
| Violaceae           | *Pombala calceolaria* (L.) Paula-Souza       | Dávila 6581           | native        | X      | X    | X    | X    |      |      |      |
| Zygophyllaceae      | *Kallstroemia tribuloides* (Mart.) Steud.    | Dávila 6565           | native        | X      |      |      |      |      |      |      |