

## Botanic Gardens as Communicators of Plant Diversity and Conservation

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**Abstract** This paper presents a unique survey on the role of botanic gardens as educational institutions that communicate plant diversity and conservation. An online survey was created to evaluate the present strategies developed by botanic gardens from all over the world to their visiting public. Dependent on their resources, either human, financial or both, all of them look for the accomplishment of Global Strategy for Plant Conservation' target 14, promoting education on plants and awareness on human impacts in plant diversity loss. However, an educational group/department is more common in botanic gardens owned by the central government compared to the private, non-profit botanic gardens. The diversity of activities on plant diversity and conservation is influenced by the size and the number of staff in the garden. Only half of the surveyed botanic gardens have rooms exclusively assigned for educational activities and even less have garden spots for the same purpose. Online resources are particularly restricted to North America and Oceania botanic gardens. Although climate change is a brand new subject that could attract public to the garden, the most part of the gardens address biodiversity and plant identification as major themes of communication. Besides species label information and interpretation panels, self-guided visits, guided visits or activities/workshops are the common offers for public attraction. School visitors are still less than half of the total visitors and cover children from 6 to 13 years-old. These follow more guided visits and activities while general public choose self-guided visits.

**Keywords** Plant conservation · Science communication · Public awareness · Environmental education · Public education · Global Strategy for Plant Conservation

### Abbreviations

BGCI Botanic Gardens Conservation International

CBD Convention on Biological Diversity

GSPC	Global Strategy for Plant Conservation
GPPC	Global Partnership for Plant Conservation
IUCN	International Union of World Conservation Union (previously called the International Union for Conservation of Nature)
UN	United Nations

## Introduction

“If you want to learn about plants go to a botanic garden” – this is the statement that could summarise the desirable communication relationship between botanic gardens and their public, both concerning scientific knowledge and biodiversity conservation challenges.

Since the first botanic gardens were created, more than 400 years ago, the communication strategies aimed at their publics have experienced great changes throughout time. The first botanic gardens, from the 16th century (e.g., the Botanic Garden of Padua and the Botanic Garden of the University of Pisa) had a strictly practical mission, of growing and providing plants for medicinal research (Doyle, 2008; Rinker, 2002), improving the quality of teaching medical students, rather than making great communication efforts (Cappelletti & Savoia, 2006). During the 17th and 18th centuries, however, botanic gardens were already communicating with the public, as they were showcases of the colonial empire from their countries, with the new botanical species that were brought from the expeditions to the tropics (BGCI, 2014a, b, c; Heyd, 2006; Rinker, 2002). Nevertheless, this communication was restricted to the labels in the living plants in display, containing the name and geographic location of the exotic species that could not be found elsewhere in the host country. The botanic gardens that arose during the 18th and 19th centuries displayed plants showing their taxonomic relationships, with a major investment in the establishment and development of herbaria and botanical laboratories (Heyd, 2006; Rinker, 2002). Here, the communication was mainly focused on the academic public, since gardens were very much associated to universities and to the research carried out in these institutions (Rinker, 2002). During the 20th century, many of the founded botanic gardens were specialised in particular plant groups, strengthening their role as botanical research centres (BGCI, 2014a, b, c; Heyd, 2006; Rinker, 2002). Being more specialised, these gardens also attracted more specialised visitors, such as amateur gardeners, that were fond of the plants in display, such as roses or orchids. Finally, in the present days the major roles of botanic gardens include scientific research, *ex-situ* conservation (e.g., seed banks) and public education, among other roles (BGCI, 2012).

To understand the current importance of public education, one should go back to the last decade from the 20th century, where the issues concerning the worrying global loss of biodiversity became more actively debated among the United Nations (UN)’ member states. Following this, the UN Convention on Biological Diversity (CBD) adopted, in 2002, the Global Strategy for Plant Conservation (GSPC), updated in 2010 (GSPC 2011–2020) and signed by 196 countries (CBD, 1992, 2002; Sharrock, 2011). Botanic gardens responded to the challenge by forming the Botanic Gardens Conservation International (BGCI), under the auspices of the World Conservation Union (IUCN), and the Global Partnership for Plant Conservation (GPPC). Now, BGCI is a global organisation that plays an important role for the Global Strategy for Plant

Conservation (GSPC)' implementation after its adoption by 196 countries (BGCI, 2014a, b, c).

The GSPC, that includes 16 outcome-oriented global targets, aims to halt the continuing loss of plant diversity and to alert to the main threats plants are exposed to (Diversity, 2009). This largely contributed to the change of the main mission of botanic gardens, giving a strong emphasis on their responsibility to ensure the conservation of the genetic resources from plants all over the world, and to provide *ex situ* protection of threatened plant species (Secretariat of the Convention on Biological Diversity, 2009). In this way, more than 600 new botanic gardens have been set up all over the world in the past two decades to support the conservation of plant diversity (Willison, 2006).

One of the main aims of GSPC is to “Promote education and awareness about plant diversity [...] through incorporation of the knowledge [...] into communication, education and public awareness programs” (objective IV, target 14). It was agreed that more than 2500 botanic gardens, spread all over the world and visited by more than 250 million people every year (Willison, 2006), should implement these communication programs (Willison et al., 2006). Botanic gardens have an important role in what concerns strategies aiming to embed informal plant based education into their public (Hawkins et al., 2008), following the vision of BGCI. Indeed, botanic gardens have the great responsibility of providing learning experiences that promote the importance of plants, habitats and conservation, but also to influence the values, attitudes and actions of their visitors (Willison, 1997). This emphasises the importance of a well-focused communication strategy developed by botanic gardens.

In what concerns public education, botanic gardens are putting the focus on increasing the knowledge and awareness for plant diversity and conservation, as well as environmental awareness (Ballantyne et al., 2008; Miller et al., 2004). Indeed, these institutions have a great responsibility for educating the public about global environmental change and conservation issues (Mintz & Rode, 1999). While the public has become more aware of environmental issues in recent decades, most do not actively engage in environmental-sustainable behaviours (Ballantyne et al., 2008). One of the reasons is the lack of environmental literacy, which is necessary to make informed decisions and address the problems currently facing the planet (Jordan et al., 2009).

Having this important mission in mind, the question that arises is: in what way are botanic gardens currently fulfilling their mission of communicating plant diversity and conservation related themes to the public? In order to contribute to answering this question, the present work draws a picture of the communication strategies that botanic gardens from all over the world are developing to their visiting public as well as to their surrounding community.

## Methods

### Survey

An online survey of botanic gardens was conducted from October 15, 2010 to January 14, 2011, using Kwiksurveys as a tool (kwiksurveys.com). The survey was sent to 938 botanic gardens, all over the world, that were listed in the website of the Botanic

Gardens Conservation International ([www.bgci.org](http://www.bgci.org)), a global network that aims to mobilize botanic gardens in securing plant diversity and to support plant conservation (BGCI, 2014a, b, c). The survey was composed of a total of 52 questions, both open and close, which were divided into four categories: institutional details (14 questions), general features (9 questions), educational features (10 questions) and details about educational activities (19 questions). All questions that asked for the number of collaborators, number of visitors, details about visitors and activities, etc., concerned the year 2009, to assure that the majority of botanic gardens had those data already statistically treated. From the 52 questions, 30 were chosen to be included in this manuscript. See Annex 1 for the survey's list of selected questions.

## Statistical Analyses

All statistical analyses in this study were done using the software package SPSS, version 22.0. We performed nominal by nominal symmetric measurements and used the Phi correlation coefficient to measure the degree of association between two variables, considering a value from 0.0 to 0.1 a negligible association, 0.1 to 0.2 a weak association, 0.2 to 0.4 a moderate association, 0.4 to 0.6 a relative strong association, 0.6 to 0.8 a strong association, and 0.8 to 1.0 a very strong association.

## Botanic Gardens

From the 938 botanic gardens that were contacted, 206 (22% of total) answered the survey. Those botanic gardens that answered the survey but did not fill the last sections (educational features and educational activities) were not included in the 206 botanic gardens' data. On the other hand, all filled surveys with only a few questions unanswered, without compromising the whole survey, were still included.

The geographic distribution of the 206 surveyed botanic gardens is the following: 8 from Africa, 81 from America, 21 from Asia, 90 from Europe and 6 from Oceania (see Table 1 for more details).

From the surveyed botanic gardens, 69% have a public status, including those under the purview of central and local governments, as well as of universities. Only 7% of the botanic gardens have a private, profitable status, while 24% are private, non-profit organisations. The majority of the surveyed botanic gardens (75%) were founded during the 20th century or after. There is a relative strong association ( $\Phi = 0.426$ ), with statistical significance, between the botanic garden status and the foundation year, with the majority of the botanic gardens that were created before the 20th century belonging to Universities (Table 2).

In what concerns the total area of the surveyed botanic gardens, 53% have less than 10 ha and only 7% of the botanic gardens have a total area with more than 100 ha. When analysing the total number of plant species in display, 46% of the surveyed botanic gardens have 1000 to 5000 plant species, 30% have less than 1000 species and 24% have more than 5000 species. There is a significant positive correlation between the number of displayed plant species and the age of the botanic garden (Pearson correlation of 0.432 for  $p < 0.01$ ), the oldest botanic gardens having a higher number of plant species in display. There was no significant correlation between the number of displayed species and the garden area, or between the area and the age of the botanic garden.

**Table 1** Number of botanic gardens that have concluded the survey, by continent and by country, in a total of 206 surveyed botanic gardens

Continent   Countries	Number of botanic gardens
Africa	
Kenya	1
South Africa	6
Uganda	1
America	
Argentina	6
Belize	1
Brazil	2
Canada	9
Chile	1
Colombia	1
Haiti	1
Mexico	3
Nevis, West Indies	1
Puerto Rico	1
Republic of Panama	1
Saint Eustatius	1
United States of America	52
Venezuela	1
Asia	
Azerbaijan	1
China	2
Hong Kong	2
India	2
Israel	1
Japan	1
Malaysia	1
Pakistan	1
Philippines	1
Russia	3
Saudi Arabia	1
South Korea	1
Sultanate of Oman	1
Taiwan	1
Turkey	2
Europe	
Austria	1
Belgium	6
Croatia	2
Czech Republic	5
Finland	2

**Table 1** (continued)

Continent   Countries	Number of botanic gardens
France	6
Germany	10
Greece	2
Hungary	3
Iceland	1
Ireland	1
Italy	7
Latvia	1
Lithuania	1
Luxembourg	1
Norway	1
Poland	2
Portugal	2
Romania	1
Slovakia	1
Slovenia	2
Spain	5
Sweden	1
Switzerland	2
The Netherlands	5
United Kingdom	18
Ukraine	1
Oceania	
Australia	4
New Zealand	2

When analysing the number of staff working at the botanic gardens (not including the volunteers), 42% of the surveyed botanic gardens have less than 10 employees and

**Table 2** Association between the botanic gardens' foundation year and the institutional status using nominal by nomina

Independent Variable	Botanic garden status					
	Private	Private non-profit	Central government	Local government	University	
Botanic garden foundation year	Until 1900	4%	4%	17%	14%	61%
	1901–1960	2%	31%	21%	19%	27%
	1961–1990	8%	31%	6%	22%	33%
	Since 1991	14%	30%	6%	21%	29%

Phy = 0.426

Approx. Sig = 0.000

only 15% have more than 50 employees. From the surveyed botanic gardens, 72% have volunteers collaborating with the institution. Although it was difficult to assess the exact number of volunteers working throughout a year, the majority of the botanic gardens were able to present an approximated value. In this way, in the majority of the botanic gardens (58%), the number of volunteers counts for more than half of the total staff.

## Results

### Botanic Gardens' Educational Features

From the 206 surveyed botanic gardens, more than half present an organised educational group or department. There is a moderate association, between the existence of this department and the botanic garden status. An educational group/department is quite common in botanic gardens owned by the central government compared to the private, non-profit botanic gardens (Table 3). There is also a moderate association between the existence of the educational group/department and the total number of staff that work in the botanic garden. This department is present in almost all the botanic gardens with more than 10 workers (Table 3). Nevertheless, in 94% of the surveyed botanic gardens, the educational staff represents less than half of the total workers.

The great majority of botanic gardens present interpretation panels as educational features (75%) apart from the classic labels with the plants' scientific name and geographical distribution. This type of communication is associated to the oldest botanic gardens (Table 4).

**Table 3** Association between the botanic gardens' status and the presence of an educational/group department using nominal by nominal symmetric measurements

Independent Variable		Educational group/department	
		Present	Absent
Botanic garden status	Private	47%	53%
	Private non-profit	76%	24%
	Central government	84%	16%
	Local government	56%	44%
	University	64%	36%
Phy = 0.222 Approx. Sig = 0.038			
Number of staff	Up to 5	49%	51%
	6 to 10	64%	36%
	11 to 50	69%	31%
	More than 50	92%	8%
Phy = 0.262 Approx. Sig = 0.003			

The Phi correlation coefficient measures the degree of association between the two variables

**Table 4** Association between the botanic garden's foundation as well as the number of staff with the interpretation panels and educational garden spots, using nominal by nominal symmetric measurements

Independent Variable		Interpretation panels		Educational garden spots	
		Present	Absent	Present	Absent
Botanic garden foundation year	Until 1900	84%	16%	22%	78%
	1901–1960	81%	19%	21%	79%
	1961–1990	61%	39%	16%	84%
	Since 1991	73%	27%	48%	52%
Phy = 0.203 Approx. Sig = 0.038				Phy = 0.287 Approx. Sig = 0.001	
Number of staff	Up to 5	56%	44%		
	6 to 10	72%	28%		
	11 to 50	80%	20%		
	More than 50	100%	0%		
Phy = 0.304 Approx. Sig = 0.000					

The Phi correlation coefficient measures the degree of association between the two variables

Rooms exclusively assigned for educational activities are present in 47% of the surveyed botanic gardens, particularly in those with more than 10 ha size (58%). Only 27% of the surveyed botanic gardens have garden spots assigned for educational, hands-on, activities. These spots are generally available to different types of public, although the target-public referred by the majority of the botanic gardens are children up to 9 years old. This type of communication and attraction is associated to the botanic gardens built in the last 25 years (Table 4).

More than 60% of the surveyed botanic gardens make available to the public printed copies of educational resources, whilst less than 40% produce online educational resources. The great majority of gardens with online educational resources are located in North America and Oceania.

### Botanic Gardens' Educational Activities

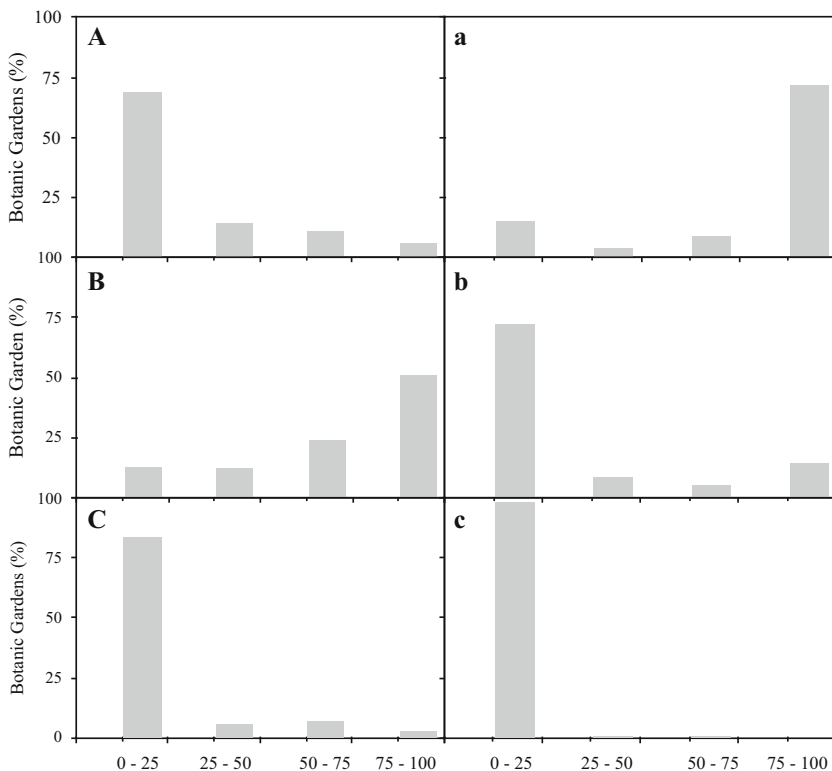
In the survey, there were several questions aiming to characterise the botanic gardens' visitors. However, 84 of the 206 surveyed botanic gardens were not able to answer those questions, mainly because they do not keep track of that kind of data. Having this in mind, this set of results comes only from the analyses of 122 botanic gardens.

When analysing the different type of visitors (school vs. non-school), it was observed that in almost all of the botanic gardens, school visitors comprise less than half of the total visitors. The next step was to analyse the type of visit that was performed by school visitors and non-school visitors: self-guided



visits, guided visits or activities/workshops. The botanic gardens' staff is responsible for the last two types of visits, whereas the first one (self-guided visit) is made autonomously by school teachers and their students or by general visitors. In the majority of the surveyed botanic gardens, more than 75% of school visitors performed guided tours (Fig. 1 A-C). Self-guided visits or attendance to activities/workshops were less common (Fig. 1 C). On the other hand, more than 75% of the general visitors (not coming from schools) performed self-guided visits (Fig. 1 a-c). This general public do rarely follow guided visits (Fig. 1 a) or attend any activities/workshops (Fig. 1c). Guided tours are the most chosen visit type by school visitors (75%) whereas non-school visitors follow self-guided visits (80%).

When analysing the education levels of school visitors that attended guided tours, it was possible to observe that they were quite spread throughout the different ISCED (International Standard Classification of Education) levels. Nevertheless, when looking only to the most represented ISCED level in each of the botanic gardens (with the highest percentage of students from that educational level), ISCED 1 and 2 were the most represented (Fig. 2 A). These



**Fig. 1** Percentage of the surveyed botanic gardens that had 0–25%, 25–50%, 50–75% or 75–100% of their school (**a,b,c**) and non-school (**a,b,c**) visitors performing self-guided visits (**a, a**), guided visits (**b,b**) and activities/workshops (**c,c**)

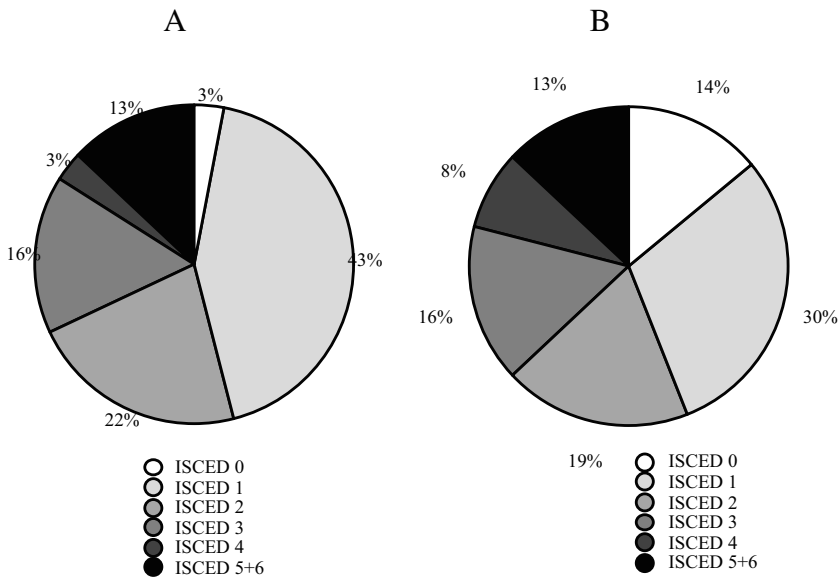
education levels represent, respectively, primary and lower secondary education, comprising students between 6 and 15 years old.

No defined pattern was found concerning the educational levels of school visitors attending activities/workshops. When looking at the most represented ISCED levels in each of the botanic gardens, ISCED 0, 1 and 2 were the most represented (Fig. 2 B).

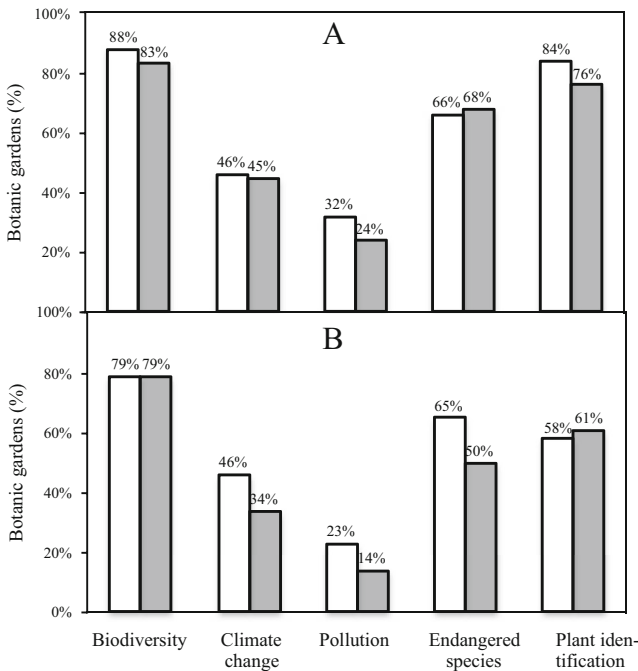
Biodiversity and plant identification were the most addressed themes, both with school visitors and with the general public (Fig. 3). Endangered species was only addressed in less than 70% of the botanic gardens and climate change and pollution were the least chosen themes to be addressed (Fig. 3).

Conferences and complementary/further education courses were only offered in a small fraction of the surveyed botanic gardens (<35%), and were found to be associated to the botanic gardens' staff number (Table 5). Conferences and courses were mainly targeted to the general public, followed by students from ISCED 5 and 6 (tertiary education and bachelor) (Fig. 4). The major topics addressed in these conferences and/or complementary/further education courses are biodiversity, endangered species and plant identification (Fig. 3).

After summing all different activities that each surveyed botanic garden referred to develop, different intervals were considered in order to define an index of educational activities: low (1 or 2 different activities), medium low (3 or 4 different activities), medium high (5 or 6 different activities) and high (7 or more different activities). This analysis was possible to be performed in 148 of the surveyed botanic gardens and reached the following distribution: 27 botanic gardens with low index, 50 with medium low index, 43 with medium high index and 28 botanic gardens with high index of educational activities. A relative strong association was found between the index of educational activities and the botanic gardens' staff number ( $\Phi = 0.430$ ) (Table 6).



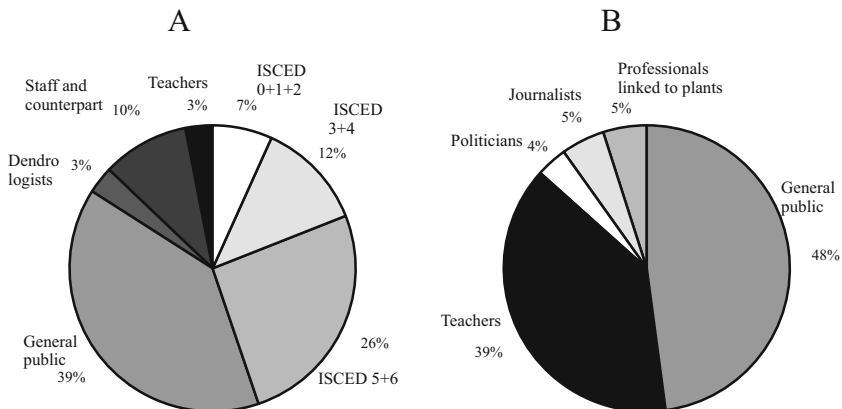
**Fig. 2** Different ISCED levels (self-guided visits, guided visits and activities/workshops) most represented by school visitors performing guided visits (a) and performing activities/workshops (b) in each of the surveyed botanic garden (in each botanic garden the ISCED levels of more than 50% of the school visitors)



**Fig. 3** Different themes developed by the surveyed botanic gardens during visits (a) both to school visitors (white columns) and non-school visitors (grey columns) or during other activities (b) both in conferences (white columns) and in complementary/further education courses (dark columns)

**Discussion**

Nowadays, and following the GSPC’ objectives spread in the mission of all botanic gardens affiliated to BGCI, an educational group or department, or at least one staff member responsible for the development of strategies aiming to communicate biodiversity and conservation issues to the general public is quite common (BGCI, 2014a, b,



**Fig. 4** Percentage of botanic gardens developing conferences (a) and/or complementary/further education courses (b) to different target audiences

**Table 5** Association between the botanic gardens' staff number and the development of conferences, complementary/further education courses and educational activities outside the gardens (SPSS nominal by nominal symmetric measurements)

Independent Variable		Conferences		Complementary/further education courses		Educational activities outside the garden	
		Yes	No	Yes	No	Yes	No
Number of staff	Up to 5	20%	80%	22%	78%	28%	72%
	6 to 10	27%	73%	29%	71%	25%	75%
	11 to 50	33%	67%	48%	52%	46%	54%
	More than 50	54%	46%	58%	42%	52%	48%
		Phy = 0.215 Approx. Sig = 0.045		Phy = 0.261 Approx. Sig = 0.016		Phy = 0.219 Approx. Sig = 0.039	

The Phi correlation coefficient measures the degree of association between two variables)

c). This statement is in agreement with the present results, as the great majority of the surveyed botanic gardens have an educational group or department. Indeed, the awareness for the importance to communicate and educate about biodiversity must be the main difference that one could find in the current services offered by botanic gardens, all over the world, when comparing with what happened some years ago (He & Chen, 2012; Sellmann & Bogner, 2013; Williams et al., 2012).

The GSPC functions as a driver for the change in botanic gardens' communication strategy, by setting these institutions as the congregators of all policies and programmes aiming to halt the loss of plant diversity (Diversity, 2009; Wyse & Kennedy, 2009). Acting as a driving force, GSPC provides a framework for grassroots actions (Blackmore et al., 2011), which results in the mobilisation of new science communication ideas to reach wider audiences (Bowker & Jasper, 2007; Gaio-Oliveira et al., 2012; Martins Loução et al., 2014; Zhai & Dillon, 2014).

Botanic gardens, members of BGCI are more likely to implement the GSPC than non-BGCI members, as this institution promotes the implementation of all targets through the distribution of information and toolkits (BGCI, 2014a, b, c). They have a

**Table 6** Association between the botanic gardens' staff number and the index of educational activities using SPSS nominal by nominal symmetric measurements

Independent Variable		Index of educational activities			
		Low	Medium low	Medium high	High
Number of staff	Up to 5	33%	37%	23%	7%
	6 to 10	22%	33%	39%	6%
	11 to 50	13%	32%	32%	23%
	More than 50	0%	33%	17%	50%

The Phi correlation coefficient measures the degree of association between two variables.

Phy = 0.430

Approx. Sig = 0.002

valuable and distinctive mix of staff skills, particularly related to systematics, ecology, horticulture or even conservation fields, they establish networks either within continents or at a trans-continental level (e.g., South African National Biodiversity Institute, SANBI; Associação IberoMacaronésica de Jardins Botânicos, AIMJB; Botanic Garden Conservation International, BGCI), creating new proactive engagement among gardens and sharing different ways of communication (Blackmore et al., 2011). All these strategies make botanic gardens a powerful force for changing public science literacy about plants, besides being important plant research centres, which is in line with the GSPC targets (Crane et al., 2009; Martins-Loução & Gaio-Oliveira, 2016).

Botanic gardens are central institutions in non-formal and formal science education, with a great responsibility of increasing science literacy on plant diversity and conservation, of engaging students in plant-related issues and also in developing continuous professional development courses to teachers about these issues (Elaine et al., 2014; Gaio-Oliveira et al., 2012; Willison et al., 2006; Willison, 2006). In spite of that great mission of awareness and education about plant diversity and conservation, school visitors are still less than half of the total visitors in 84% of the surveyed gardens. Botanic gardens should perform a greater effort in developing strategies to attract school visitors and in engaging students with science. In this process, the “out of the class” approaches have great impact and benefits on children’s learning (Dillon et al., 2006; Manifesto, 2007; Passy, 2014). Botanic gardens are great Learning Outside the Classroom (LOtC) places, engaging students with science themes related to plant diversity and the threats caused by global climate change as well as paving the way for the urgent need of plant conservation (Chang et al., 2008; Crane et al., 2009; Elaine et al., 2014; Martins-Loução et al., 2013). These subjects are very well internalised by young children, changing their attitudes towards scientific themes (Bowker & Jasper, 2007; Martins-Loução et al., 2012), which may explain why the surveyed botanic gardens mostly focus their educational activities to this public.

But the mission of botanic gardens as promoters of the awareness for plant diversity and conservation goes even further. Botanic gardens should promote the use of other green areas, such as community gardens and schoolyards, as LOtC places where the study of plant sciences and the discussion of biodiversity and conservation issues should be encouraged (Gaio-Oliveira & Garcia, 2014; Krasny & Tidball, 2009; Malone & Tranter, 2003). This can be achieved by developing courses to teachers interested in improve schoolyard gardens, or other areas beneath, to help deepening science subjects already present in the school curriculum or by developing good practice manuals that allow school communities to take the best of schoolyards as LOtC areas (Gaio-Oliveira & Garcia, 2014; Martins-Loução et al. 2013).

Dependent on their staff and financial resources, botanic gardens’ continuous professional development courses for teachers and educators, awareness programmes for all-age students, strategies for awareness and formation of police- and decision-makers and creative programmes to attract diverse audiences, are among different initiatives to accomplish the mission of these institutions (Martins-Loução & Gaio-Oliveira, 2016). However, the so much needed specialised staff to develop these strategies are becoming scarce or shrinking, a true reality in the most part of countries (Powledge, 2011). Moreover, the relative number of educational staff is still quite small, when comparing to the total staff number, being less than half in 94% of the surveyed botanic gardens. Botanic gardens, like many of society’s cultural centres, are

for the last years exposed to a serious financial crisis, which could lead to a lower investment on human resources. This makes volunteer work one of the most recent botanic garden work force, high rewarded in the prominent garden through the prestige, the knowledge and the relations it offers. Volunteer work advertisers are now very common in all botanic gardens sites, particularly, in North America as well as in the UK. But the effectiveness of the communication strategies depends very much in the creativity and skills of botanic gardens' educational staff to offer new approaches in the battle of biodiversity loss (Barata et al., 2012; Chang et al., 2008; Hwang et al., 2015; Martins-Loução et al., 2014; Maunder, 2008).

It is interesting to see that the great majority of the surveyed botanic gardens are no longer limited to have only taxonomic labels in the displayed plants but that they have invested in interpretation panels. These features give much more information about the gardens' displays, concerning taxonomic, ecological and historic knowledge, as well as any curiosities linked to the exhibited plants, which clearly increases visitors' interest by the botanical collections. This is in agreement with the observation that during the late twentieth and the beginning of the twenty-first centuries botanic gardens, in addition to the traditional types of exhibits, present new information aiming the facilitation of environmental interpretation, taking profit of new design approaches (Maunder, 2008; Villagra-Islas, 2011). The same investment was also observed in the present study when considering the printed resources, but not as such when considering the online educational resources. Moreover, about half of the botanic gardens that have online educational resources are located in North America and Oceania. The small investment in online resources is quite worrying, because through them, a botanic garden can reach a much wider audience; even people that, for some reason (geographic, financial, etc.) do not visit the botanic garden. Moreover, online resources allow teachers, as well as other public, to develop follow-up educational approaches (Barata et al., 2012) that can prepare or extend the visit to the botanic garden beyond the time this visit took place. Although digital technology is changing how people live and communicate, botanic gardens are still experiencing this fast pace digital age (see BGCI, 2014a, b, c, vol. 11). For instances, online supported guided tours have proven to offer new positive ways of exploring information and preparing visiting tours (Barata et al., 2012; Lewi et al., 2014).

The fact that less than half of the surveyed botanic gardens have rooms exclusively assigned for educational activities and even less have garden spots for the same purpose, can restrict the ability of a botanic garden to promote educational activities to the general public, others than guided tours. In a survey conducted in five botanic gardens in China, it was concluded that visitors that attended the visitor education centres gained more knowledge on botany and environment protection than visitors that did not attend those educational facilities (He & Chen, 2012). Botanic gardens with a bigger size could more easily allocate rooms and garden spot for specific activities, but these are still very dependent on the financial resources and on the educational staff that will develop the activities.

The two great aims of environmental education programmes are to increase knowledge and in this way positively influence environmental behaviour and attitudes towards nature (Stern et al., 2008). Although almost 80% of the surveyed botanic gardens address the themes of plant identification and biodiversity, the percentage of botanic gardens addressing global environmental issues, as climate change, in the

educational programmes was quite small. Still, these results were better than the ones found by Kneebone (Kneebone, 2006), which could mean that through time botanic gardens are investing in these themes. But the observed change is still very slow. Concerning that, for example, in Europe more than half of the vascular flora may become endangered by 2080 due to climate change (Thuiller et al., 2005) and that the current citizen knowledge and awareness about climate change is still very scarce and confused (Lorenzoni & Langford, 2001; Spence et al., 2010) a speeding of the integration of climate change in all educational activities is therefore of great importance (Schulman & Lehvāvirta, 2011). Botanic gardens are, thus, ideal places for addressing this and other environmental themes, such as simple conservation measures as the displayed plant collections allow the exploration of environment-related phenomena in the different small-scale ecosystems that are represented in these institutions (Crane et al., 2009; Sellmann & Bogner, 2013). But for this to happen it is very important that botanic gardens invest more in educational activities that go beyond guided-tours. Although guided tours allow approaching quite easily themes such as biodiversity and plant identification, it is not so easy to address themes such as pollution, habitat destruction or climate change. It is important to develop hands-on/minds-on activities, that promote awareness about these issues among visitors, in a more effective way (Tampoukou et al., 2015; Williams et al., 2015; Zhai & Dillon, 2014).

Besides education, social interaction and scientific literacy for the general public are key aspects for botanic gardens' attraction and visiting. Thus, botanic gardens need to design activities and spaces that cater for and encourage group interaction (Ballantyne et al., 2008). In spite of all those efforts to fulfil the success of GSPC's target 14, the majority of visitors to botanic gardens do not come to learn per se (Darwin Edwards, 2000; Ward et al., 2010). Surveys developed in Adelaide Botanic Gardens (Crilley & Price, 2005), in Brisbane Botanic Garden (Ballantyne et al., 2008), or in Crosby Arboretum, Mississippi State University (Conklin & Drackett, 2011) found out that the main reasons for visitors to go were for pleasure or to attend a special event. These findings put botanic gardens in line with public gardens. Connel and Meyer (Connel & Meyer, 2004), when studying the visitor experience in gardens in UK, concluded that the main factors that motivate people to visit were the appreciation of the aesthetic and rare qualities of plants; the interest in garden design and landscaping, the admiration of gardens' scenery and ambience and the pleasure of being outdoors.

## Conclusion

Dependent on their resources, either human, financial or both all, of the surveyed botanic gardens look for the accomplishment of GSPC' target 14, promoting education on plants and awareness on human impacts in plant diversity loss. However, defining success of public education and environmental literacy among those gardens is difficult, given the diversified features of these institutions. More than ever, botanic gardens need to be involved in real problems of the world and to assert their involvement in science, conservation and educational activities (Martins-Loução & Gaio-Oliveira, 2016; Powledge, 2011). This requires understanding of people perspectives and simplified contexts within the social setting, something that botanic gardens never had before. Thus, to fully accomplish this mission of communicate plant diversity and

conservation, a good collaboration with social and humanity sciences, and communicator professionals is needed.

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## Appendix 1

List of the selected questions used in this manuscript:

- Botanic Garden Details
- Name of the botanic garden
- Year of foundation
- What is the botanic garden status?
- Private
- Private non-profit
- Central government
- Local government
- University
- How many people were working in the botanic garden in 2009?
- Does the botanic garden have volunteers?
- Yes
- No

If you replied “yes” to the previous question, how many volunteers collaborated with the botanic garden in 2009?

Botanic Garden General Features

What is the approximate size of the botanic garden’s main features?

Total botanic garden

Class (if applied)

Arboretum (if applied)

Exhibition greenhouse(s) (if applied)

Research greenhouse(s) (if applied)

Nursery (if applied)

What is the total number of plant species present in the botanic garden?

Are all the plant species accessible to the public?

Yes

No

If not, which is the percentage of plant species not accessible to the public?

Is it possible to find throughout the botanic garden any placards/boards with educational information, other than taxonomic data?

Yes

No

Botanic Garden Educational Features

Does the botanic garden have an educational group/department?

Yes

No

If you replied “yes” to the previous question, how many people were working at the educational group/department in 2009 (excluding volunteers)?

Does the botanic garden have rooms exclusively assigned for educational activities?

Yes

No

Does the botanic garden possess any garden spots exclusively assigned for hands-on activities?

Yes

No

To which types of public are the hands-on garden spots reserved? (if applied)?

Kindergarden/Pre-primary (ISCED 0)

Elementary school (ISCED 1) (1–6 years of schooling)

Basic education (ISCED 2) (7–9 years of schooling)

Secondary education (ISCED 3) (10–12 years of schooling)

Post-secondary non tertiary education (ISCED 4)

Tertiary/higher education (ISCED 5 and 6)

General public

Senior public (over 65 years-old)

Does the botanic garden make available to the public hard copies/printed educational material?

Yes

No

Does the botanic garden make available to the public online educational material?

Yes

No

Botanic Garden Educational Activities

What was the total number of visitors of the botanic garden in 2009:

School visitors

General public

Considering the number of school visitors in 2009, how many performed:

Self-guided visits

Guided/exploration tours by garden personnel

Workshops

Considering the number of school visitors performing guided/exploration tours in 2009, how were they distributed by educational levels?

Kindergarden/Pre-primary (ISCED 0)

Elementary school (ISCED 1) (1–6 years of schooling)

Basic education (ISCED 2) (7–9 years of schooling)

Secondary education (ISCED 3) (10–12 years of schooling)

Post-secondary non tertiary education (ISCED 4)

Tertiary/higher education (ISCED 5 and 6)

Considering the number of school visitors performing workshops in 2009, how were they distributed by educational levels?

Kindergarden/Pre-primary (ISCED 0)

Elementary school (ISCED 1) (1–6 years of schooling)

Basic education (ISCED 2) (7–9 years of schooling)

Secondary education (ISCED 3) (10–12 years of schooling)

Post-secondary non tertiary education (ISCED 4)

Tertiary/higher education (ISCED 5 and 6)

Which discussion themes were made available to students during visits/activities offered by the botanic garden in 2009?

Biodiversity

Climate change

Pollution

Organic farming

Ethnobotany

Recycling

Endangered species

Plant identification

Others

Considering the general public that visited the garden in 2009, how many performed:

Self-guided visits

Guided/exploration tours by garden personnel

Workshops

Which discussion themes were made available to the general public during visits/activities offered by the botanic garden in 2009?

Biodiversity

Climate change

Pollution

Organic farming

Ethnobotany

Recycling

Endangered species

Others

Did the botanic garden organise any conferences during 2009?

Yes

No

If you replied “yes” to the previous question, which was the target audience of the conferences?

Kindergarden/Pre-primary (ISCED 0)

Elementary school (ISCED 1) (1–6 years of schooling)

Basic education (ISCED 2) (7–9 years of schooling)

Secondary education (ISCED 3) (10–12 years of schooling)

Post-secondary non tertiary education (ISCED 4)

Tertiary/higher education (ISCED 5 and 6)

General public

Which themes were discussed in the conferences? (if applied)

Biodiversity

Climate change

Pollution

Organic farming

Ethnobotany

Recycling

Endangered species

Others

Did the botanic garden perform any complementary/further education courses in 2009?

Yes

No

If you replied “yes” to the previous question, which was the target audience of the courses?

General public

Teachers/educators

Politicians

Decision makers

Journalists

Others

Which themes were discussed during the courses? (if applied)

Biodiversity

Climate change

Pollution

Organic farming

Ethnobotany

Recycling

Endangered species

Others