



Alien Bamboos in South Africa: a Socio-Historical Perspective

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Published online: 29 November 2018

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Abstract

Changes in fashions and economic imperatives underlying plant introductions have a profound influence on the movement of species around the world. Using bamboo introductions into South Africa as a case-study, we explore these issues by assessing historical trends through a literature review and determining current human perceptions based on a questionnaire distributed via social media. We identify five main phases of introduction and distribution of bamboos in South Africa associated with: (1) the intra-African migration of people; (2) the arrival of Europeans; (3) growth of the agricultural and forestry sectors; (4) small-scale domestic use by landowners; and (5) the rise of the “green economy.” Our narrative is built around 27 alien bamboo species (taxa mentioned in the literature that could be linked to currently accepted nomenclature). Bamboos were among the first plants introduced to South Africa by European settlers, and they are still used and valued by many landowners, although on a small-scale. Bamboos now create conflicts of interest because they are both valued and perceived to be weeds (the latter particularly by people who do not utilise them).

Keywords Alien species · Biological invasions · Conflicts of interest · Human usage · Perceptions · South Africa

Introduction

The domestication of plants and animals and their transfer around the world have been instrumental in the development of complex societies (Crosby 1972; Diamond 1997). The expansion of agriculture, including the cultivation of food crops and commercial forestry, has allowed humans to expand and thrive in new regions (Gupta 2004). Examining the historical context of intentional plant introductions can reveal how changes in social ethos and economic imperatives have influenced which species have been moved around the world by humans (Carruthers *et al.* 2011). Perceptions and attitudes

relating to the value of species is dynamic, often changing over time, and many intentionally introduced plant species ultimately lose their value (Udo *et al.* 2018). This is especially the case when these species spread beyond sites of introduction and cultivation to become invasive (Starfinger *et al.* 2003; van Wilgen and Richardson 2014).

The values attached to alien plants by people strongly influence the likelihood of preventing introductions of species that pose a high risk of becoming invasive. Values also shape the options for management interventions (Lindemann-Matthies 2016; Bennett and van Sittert 2019). For example, species viewed as desirable are more likely to be propagated and disseminated by people whereas those that are viewed negatively or with indifference are less likely to be distributed intentionally; there is also usually greater support for management of species in the latter categories (Zengeya *et al.* 2017; Shackleton *et al.* 2019). Perceptions also determine the level of stakeholder engagement that is needed to manage “conflict of interest species,” i.e., those species perceived to have benefits and costs by different groups of people (Novoa *et al.* 2018; Shackleton *et al.* 2019). For example, Lindemann-Matthies (2016) found that when alien plants are viewed as beautiful by the public in Switzerland there is less willingness to support the management of those species, even when people are informed of their negative environmental and economic impacts. Other influences on people’s perceptions of non-

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s10745-018-0041-8>) contains supplementary material, which is available to authorized users.

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native plants include the historic context surrounding the introduction of species and the time since their introduction, as many species become integrated into culture and livelihoods, e.g., prickly pear in South Africa (Beinart and Middleton 2004; Shackleton *et al.* 2007).

Bamboos are a large group of grasses (c. 1600 species) that are particularly important culturally and economically in Asia, where there is the highest diversity of native bamboo species resides (Canavan *et al.* 2017). Bamboos have been cultivated and widely used for millennia in China (Li and Kobayashi 2004). There is a growing demand for bamboo products globally, and the commercial cultivation of Asian bamboo species has been expanding to new regions. In South Africa, for example, the commercialization of bamboo species (mostly Asian taxa) has been proposed as a contribution to the ‘green development’ of the economy by providing a potential source of renewable bioenergy, among other uses. Scheba *et al.* (2017) identified various emerging stakeholders in South Africa involved in the widespread cultivation of bamboo and promoting the introduction of new species.

The introduction of bamboos to South Africa has a long history, bamboos being one of the earliest plant groups to be introduced by European settlers (c. 1653) (Claassens and Pretorius 2004). Bamboos are now naturalized across the country, growing around rural homesteads and as screens in urban gardens. However, several species of bamboo are known to be invasive in other parts of the world, and some cause considerable environmental impacts, especially in forest habitats (Canavan *et al.* 2017, 2019). The growing interest in bamboo has increased the area under bamboo cultivation and has incentivised the introduction of new species to the country. Given that there are species that pose a risk of becoming invasive and causing environmental and economic impacts, there might be unforeseen consequences associated with the current popularisation of bamboos in South Africa.

In several parts of the world the perceived value of bamboos has changed over time. For example, *Phyllostachys edulis*, a temperate bamboo from China, was introduced to Japan in 1736 as a non-timber forestry plant (Suzuki 1978). A change in land-use and the decline of the domestic bamboo industry led to the abandonment of plantations and the subsequent spread of this bamboo into neighbouring forests. This species (and another, *P. bambusoides*) are now perceived as problematic to the area (Fukushima *et al.* 2014; Takano *et al.* 2017; Wu *et al.* 2018).

Although bamboos have had a long history of introduction around the world, have high usage potential, and are increasingly considered as potential invaders (Canavan *et al.* 2017, 2019), few reports exist on the importance of the socio-historical aspects of bamboos and the links between such factors and invasions. Due to the long history and rapid increase in interest in growing bamboos in South Africa, conflicts of interest are likely to emerge in the future. Such conflicts of

interest have thwarted effective management in other plant groups in South Africa (e.g., van Wilgen and Richardson (2012); Novoa *et al.* (2016)) and timeous interventions are needed to prevent similar problems with bamboos. Therefore, in this study we: (1) present a historical narrative of the introduction of bamboos to South Africa; and (2) assess the current human perceptions of bamboos in South Africa as both a useful and a weedy plant.

Methods

Literature Search of Historical Records

An online search was done to gather historical literature addressing bamboos introductions in South Africa with the aims of: (1) compiling a list of introduced species; (2) documenting original localities of plantings; (3) assessing reasons for introduction; and (4) documenting the dates of introduction. We used the Sabinet database (<https://www.sabinet.co.za>), an online resource for southern African publications (including almost 500 African journals) that includes an extensive collection of digitised historical archive material. Google Scholar and Google were also used, although these search engines yielded few results. We searched the general terms *bamboo* or *bamboes* [Afrikaans] and the names of common genera (e.g., *Bambusa*, *Dendrocalamus*, and *Phyllostachys*) in combination with “*South Africa*”. Additional publications were located through snowballing of reference lists.

Questionnaire

We compiled an online questionnaire (using Google Forms) directed at landowners or residents in South Africa with bamboos on their property. The questionnaire was developed to understand the perceptions and the current uses, if any, of bamboos. It was circulated by intermittent posting during May 2017 on online South African groups (see Table S1) on social media (Facebook), where users could access a link to the survey and complete it voluntarily. We posted the questionnaire to a total of 50 Facebook groups and the questionnaire was further shared independently by Facebook users 32 times on personal accounts and groups. Some users shared the questionnaire via email and through conservancy newsletters. In this study we present the results of the following questions: When was the bamboo planted? How much space does the bamboo occupy currently? Would you consider the bamboo a weed? How often do you use the bamboo? Have you attempted to remove the bamboo population? Has the bamboo spread more than 2 m in a year? Respondents were also asked to list the ways in which they use the bamboos, and the ways in which they have had problems with it (See Table S2).

Bamboos are commonly classified into two groups: (1) temperate species with leptomorph rhizomes (“running” species); and (2) tropical species with pachymorph rhizomes (“clumping” species) (Makita 1998). As both running and clumping species disperse infrequently via seeds, rhizome expansion is the main mode of spread. Lieurance *et al.* (2018) reported that running species scored higher than clumping species in risk assessments for their invasive potential in the continental United States. We therefore expected that the growth form (running or clumping) would influence the perceptions of landowners on the weediness of bamboos. We asked respondents to identify whether they had running or clumping species by providing photographs of examples of the most common species found in South Africa (the features of the two groups are easily distinguishable). Some respondents had more than one type of bamboo and some did not specify the type (we grouped these as “unspecified”). It would have been preferable to identify plants to the species level, but this was not possible due to limitations of an online survey and our inability to verify all identifications provided by respondents.

We used a two-way chi-square test to compare responses with categorical answers between the three types of bamboo (running, clumping and unspecified), for six questions. We used a Wilcoxon signed-rank test to compare the mean scores of whether bamboo is perceived as useful or problematic according to respondents. All analyses and data visualization were done using R 3.4.3 (R Core Team 2017).

Results and Discussion

Historical Narrative of the Introduction and Use of Bamboos in South Africa

Our literature search found 40 papers that referenced bamboos in South Africa in line with our criteria (see Table S3). Twenty-four papers referred to the usage of bamboo, seven mentioned aspects of cultivation, five discussed the history of introduction, and four more recent papers provided inventories of naturalised and invasive species. Most references (75%) used the general term ‘bamboo’ (or *bamboes* [Afrikaans]) and only 10 papers identified the species. Of those that did mention a species, 28% were synonyms or unknown species (Table 1). In total, we found evidence of 34 species, primarily Asian taxa, having been introduced to South Africa (Table 1). The list includes 27 taxa that could be linked to currently accepted bamboo species (7 additional species names used in the literature could not be linked to currently accepted names, including known synonyms). Of the 27 species, 18 species were included in Visser *et al.* (2017)'s list of alien grasses in South Africa. The use of

bamboo by foresters has provided the best records on the importation of species, whereas references to bamboos from other periods were less clear regarding the species that were introduced.

Most global plant introductions are associated with particular sectors of society e.g., *Acacia*, *Eucalyptus* and *Pinus* species with foresters (van Wilgen and Richardson 2014), and *Prosopis* with rural farmers (Shackleton *et al.* 2015). In India, where many bamboos are native, they are commonly referred to as “poor man’s timber” due to their use among subsistence farmers (Singh 2008). The historical literature shows that this was not the case in South Africa, where bamboos have been valued across economic sectors, social classes, and demographic groups (Figs 1 and 2). There have been multiple surges of bamboo introductions, each associated with different species and different groups of people. These include: (1) the early intracontinental migration of people; (2) the arrival of the first European settlers; (3) the growth of the agricultural and forestry sector; (4) general domestic use on farms and homesteads; and, most recently (5) the rise of the green economy. We discuss each of these periods of introduction and distribution that are related to major events in South African history (Fig. 1).

Early Intra-Continental Migration of People

The earliest introduction of bamboos to South Africa is thought to have been made by the ancestors of the Venda people. The Venda migrated from Zimbabwe and the East African Rift Valley during the last of the Bantu expansions (c. 1000 BC to c. AD 500) when they settled in the far north-eastern corner of South Africa, now the Limpopo province. They are thought to have introduced the East African bamboo *Oxytenanthera abyssinica* (A. Rich.), regionally known as ‘holy Venda bamboo’ or ‘musununu’, to South Africa. As the name suggests, the bamboo is valued for traditional holy ceremonies and is also used to make musical instruments such as flutes (Stayt and Hoernle 1931; Blacking 1962; Netshlungani *et al.* 1981). The bamboo has been reported to grow in only one sacred grove at Tshuaulu, and it is highly revered among the Venda, the remaining populations are protected (Blacking 1969; Harris *et al.* 2015). This has led to the traditional flutes being replaced with modern materials (e.g., hosepipes, metal tubing, etc.). Native reeds are also used to make flutes but unlike the musununu bamboo flutes, which are heptatonic, they are pentatonic, and therefore not interchangeable (Blacking 1962). In the early twentieth century, the bamboo was also reported to be used for arrow shafts for hunting, and to provide splints for bone fractures (Stayt and Hoernle 1931).

Although *O. abyssinica* is the earliest confirmed introduction of bamboo, another herbaceous bamboo species, *Olyra latifolia*, is thought to have been introduced from further north

Table 1 Bamboo species recorded as introduced to South Africa based on a literature review. The earliest record of introduction (ERO) is indicated for each species (as determined by Visser *et al.* (2017)) with references to the introduction, presence or use of each species within the

country. Synonyms have been corrected according to The Plant List (www.theplantlist.org, accessed March 2018), with the original names as per the source shown in brackets. Where the authority was not given we used the one given in The Plant List for the accepted species

Species	ERO	Reference
<i>Bambusa balcooa</i> Roxb.	1866	(Glen 2002, Visser <i>et al.</i> 2017)
<i>Bambusa bambos</i> (L.) Voss (= <i>Bambusa arundinacea</i> ; <i>Bambusa spinosa</i>)	1823	(Legat 1905, Glen 2002, Visser <i>et al.</i> 2017)
<i>Bambusa flexuosa</i> Munro	1910	(Reid 1910)
* <i>Bambusa guilioe</i>	1910	(Reid 1910)
<i>Bambusa multiplex</i> (Lour.) Raeusch. ex Schult. (= <i>Bambusa nana</i>)	1972	(Legat 1905, Glen 2002, Visser <i>et al.</i> 2017)
<i>Bambusa oldhamii</i> Munro	1945	(Glen 2002, Visser <i>et al.</i> 2017)
<i>Bambusa polymorpha</i> Munro (= <i>Arundarbor polymorpha</i>)	1992	(Glen 2002, Visser <i>et al.</i> 2017)
* <i>Bambusa simoin</i>	–	(Reid 1910)
* <i>Bambusa swochiki</i>	–	(Reid 1910)
<i>Bambusa textilis</i> McClure	–	(Glen 2002)
<i>Bambusa vulgaris</i> Schrad. (= <i>Bambusa mitis</i>)	1905	(Legat 1905, Reid 1910, Glen 2002, Visser <i>et al.</i> 2017)
* <i>Bambusa variegata</i>	–	
<i>Dendrocalamus asper</i> (Schult.) Backer (= <i>Gigantochloa aspera</i>)	1905	(Legat 1905)
<i>Dendrocalamus giganteus</i> Munro	1878	(Legat 1905, Glen 2002, Visser <i>et al.</i> 2017)
<i>Dendrocalamus latiflorus</i> Munro	–	(Glen 2002)
<i>Dendrocalamus membranaceus</i> Munro	1910	(Reid 1910)
* <i>Dendrocalamus siamensis</i>	–	(Legat 1905)
<i>Dendrocalamus strictus</i> (Roxb.) Nees	1905	(Legat 1905, Reid 1910, Glen 2002, Visser <i>et al.</i> 2017)
<i>Drepanostachyum falcatum</i> (Nees) Keng f.	–	(Glen 2002)
<i>Himalayacalamus hookerianus</i> (Munro) Stapleton (= <i>Arundinaria hookeriana</i>)	1905	(Legat 1905)
<i>Melocanna baccifera</i> (Roxb.) Kurz (= <i>Melocanna bambusoides</i>)	1905	(Legat 1905)
* <i>Ochlandra rumphiana</i>	–	(Legat 1905)
<i>Ochlandra scriptoria</i> (Dennst.) C.E.C.Fisch (= <i>Ochlandra rheedii</i>)	1905	(Legat 1905)
* <i>Ochlandra spinosa</i>	–	(Legat 1905)
† <i>Olyra latifolia</i> L.	1895	(Glen 2002, Visser <i>et al.</i> 2017)
<i>Oxytenanthera abyssinica</i> (A.Rich.) Munro	1952	(Glen 2002, Visser <i>et al.</i> 2017)
<i>Phyllostachys aurea</i> Rivièrè & C.Rivièrè	1927	(Glen 2002, Visser <i>et al.</i> 2017)
<i>Phyllostachys nigra</i> (Lodd. ex Lindl.) Munro	1932	(Visser <i>et al.</i> 2017)
<i>Phyllostachys viridiglaucescens</i> (Carrière) Rivièrè & C.Rivièrè (= <i>Bambusa viridiglaucens</i>)	1910	(Reid 1910)
<i>Pleioblastus fortunei</i> (Van Houtte) Nakai (= <i>Bambusa fortunei</i>)	1910	(Reid 1910)
<i>Pleioblastus simonii</i> (Carrière) Nakai (= <i>Bambusa simonii</i> & <i>Bambusa mitake</i>)	1910	(Reid 1910, Glen 2002)
<i>Pseudosasa hindsii</i> (Munro) Nakai	–	(Glen 2002)
<i>Schizostachyum dullooa</i> (Gamble) R.B.Majumdar (= <i>Teinostachyum dullooa</i>)	1905	(Legat 1905)
<i>Thyrsostachys siamensis</i> Gamble	1905	(Legat 1905)

*Unknown species

† The native range of this species in Africa is not clear; we follow Visser *et al.* (2017) in considering it to be alien to South Africa

of the continent (Clayton and Renvoize 1986; Soderstrom and Zuloaga 1989; Henderson 2007). It is not known when and how *O. latifolia* was introduced to South Africa. It is possible that its introduction pre-dated the arrival of *O. abyssinica* with early migrations. The herbaceous culms of *O. latifolia* are thin and flexible and cannot be used like other bamboos making

them less valuable. However, the plant is used in other parts of Africa. For example, the hollow stems are used to make straws and tools for spinning in Ethiopia (Bekele-Tesemma 2007), in Central and West Africa the leaves are used in various medicines, and in the Central African Republic culms are used for arrow shafts (Burkhill 1994).

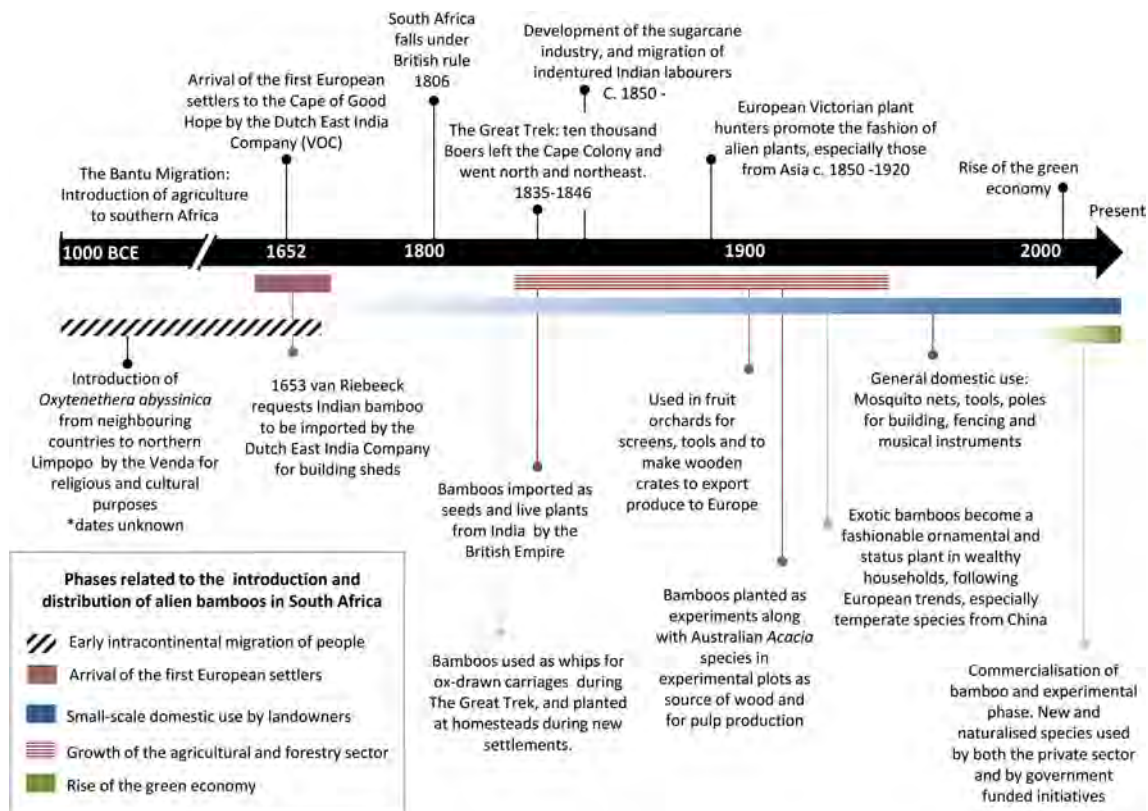


Fig. 1 Timeline of important historical events (above) related to the introduction, distribution, and use of bamboo species in South Africa (below). *Timeline is not to scale

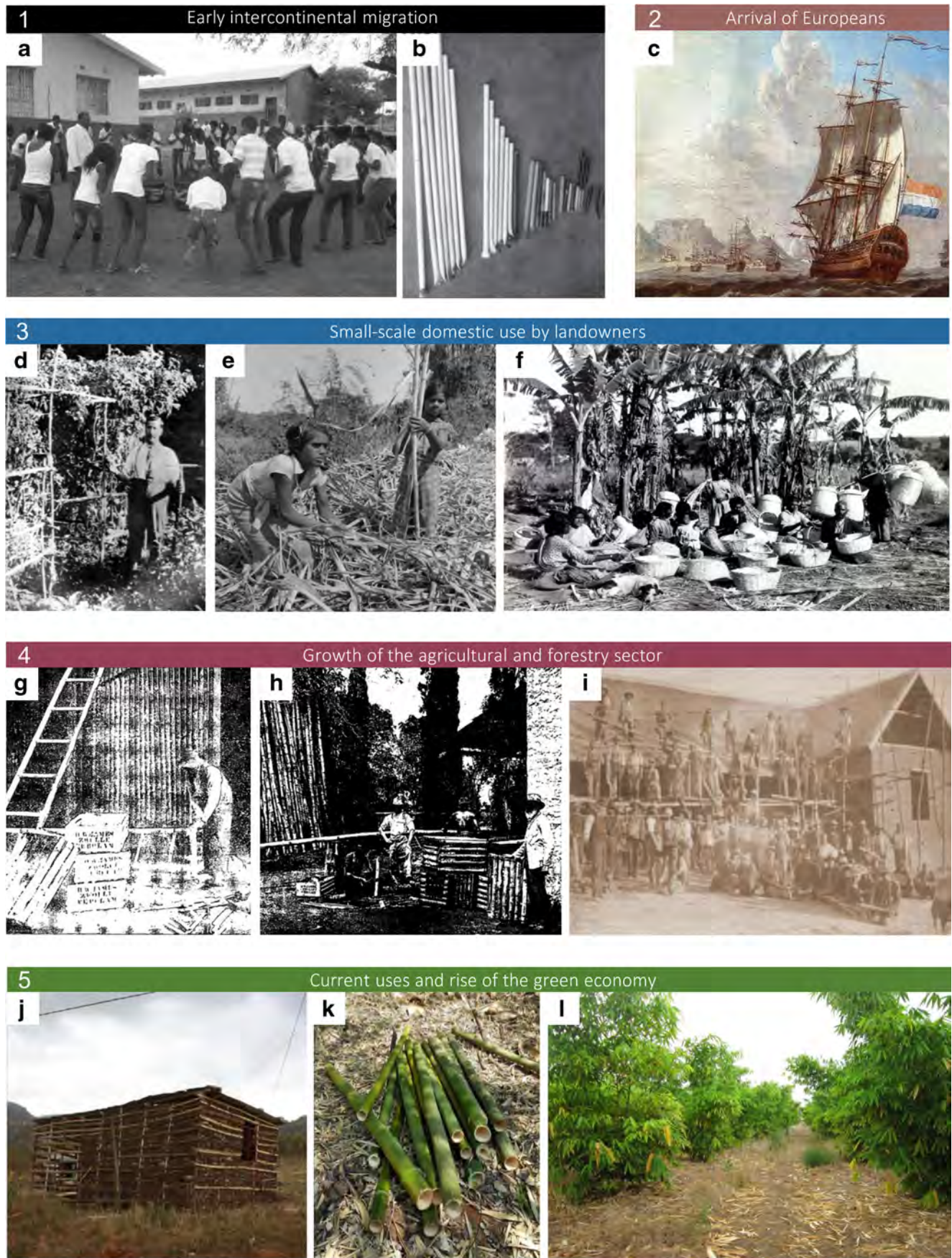
The Arrival of the First Europeans

When the Dutch East India Company (VOC) started the first European settlement at the Cape of Good Hope they brought a consignment of plants for cultivation (Pooley 2009). Bamboos were some of the first plants introduced in 1653 by the VOC (Spilhaus 1966). Jan van Riebeeck, the Dutch colonial administrator, requested seeds and plants imported from India for growing as a building material for garden sheds: “Bamboo plants and seeds will be useful in many ways as there is no suitable forest here to make anything ... Would like to have some old bamboos to be used for little *pondoks* [=basic hut or shelter] on the land” (Leibbrandt 1900; Spilhaus 1966). Letters from van Riebeeck indicated that not all tropical plants (such as pineapple and coconuts) fared well in the Mediterranean-climate conditions of the Cape, but he remarked on how well bamboos grew in gardens (Claassens and Pretorius 2004). Bamboo provided building material, but was also used for food (Claassens and Pretorius 2004). One of the first references in South Africa for *atjar* (or *achaar*), a spiced pickle condiment introduced by Malay slaves, mentions that bamboo shoots were used (Kolb 1726). *Atjar* is still popular in South African cuisine, although bamboo shoots are now rarely used as an ingredient.

The general usefulness of bamboo continued in the Cape in the following century. During the travels of Thunberg (1795) bamboos were categorised as “useful for the purpose of domestic and rural-economy” for various tools and utensils. Unfortunately, early records mention no particular species, but only note that the bamboos were of Indian origin. In fact, it was during this time that the word ‘bamboo’ was born, originating from the Dutch word which was adapted from Malay ‘mambu’ (where bamboos were likely sourced by the VOC). The influence of the early Dutch traders in disseminating bamboos to other regions extends beyond the Cape; there is a legacy of naturalised populations (most commonly *Bambusa vulgaris*) that still exist on tropical islands along early trade routes (Canavan *et al.* 2017).

The Growth of the Agricultural and Forestry Sector

During the mid-nineteenth to the early twentieth century the British, who now occupied much of South Africa, were expanding the agricultural sector considerably to supply other colonies. To meet the high labour demands, particularly to develop the sugarcane industry (1860 onwards) in what is now the KwaZulu-Natal Province, indentured labourers were brought from India. Bamboos were also imported from India during this time and propagated by Indian labourers. On



◀ **Fig. 2** Historical photographs showing the cultivation and use of alien bamboos in South Africa grouped by the five phases of introduction and distribution (See Fig. 1). **a & b** Venda school children practice the *Tshikona* dance, which traditionally includes music played with flutes made from introduced *Oxytenethera* bamboo (**b**) (source: Tracey and Gumboreshumba (2013)). **c** The arrival of the Dutch East India Company at the Cape of Good Hope brought a consignment of plants for cultivation including tropical bamboos from India (Source: <http://www.voc-kaap.org>). **d** Tomatoes trellised with bamboo poles for the “tallest tomato plant” contest in Ficksburg, Free State, circa 1920s (Source: Felix Sorour, personal archive). **e** Children harvesting sugarcane on the KwaZulu-Natal’s North Coast in 1957; bamboo windbreak in the background (Photo: Ranjith Kally). **f** Basket making from split bamboos by Indian labourers in c. 1909 in Umzinto, KwaZulu-Natal (source: Collection of The 1860 Heritage Centre). **g & h** The construction of bamboo boxes for transporting fruit to Europe, KwaZulu-Natal (Ergates 1902, 1906). **i** the building of an early mission near Modjadjiskloof, Limpopo province, using bamboo and *Eucalyptus* poles as scaffolding c. 1890s (Source: Felix Sorour, personal archive). **j** A house built with bamboo and daub in rural Zululand, KwaZulu-Natal (Photo: Susan Canavan). **k** Harvested bamboo culms from a naturalised roadside population, Limpopo (Photo: Susan Canavan). **l** An experimental plantation of multiple species of bamboo in Vredendal, Western Cape (Source: Susan Canavan)

farms, bamboos were planted as wind breaks and screens to provide protection for sugarcane crops (Legat 1905). Similar to the sugarcane industry, bamboo became a useful resource for the fruit-growing industry and was often planted in the vicinity of fruit orchards. There was a shortage of timber, and packing fruit in wooden crates for export was costly. Eventually, fast-growing bamboos were used; culms were processed to construct crates for not only fruit but also other crops and for packing harvested tobacco (Ergates 1906; Davies 1910; Fletcher 1925). These were expertly constructed by Indian labourers experienced in using bamboo (Fig. 2g) (Ergates 1902, 1906). Bamboos were also used to make basic tools such as axe handles and ladders on agricultural properties (Ergates 1902; du Plessis 1939).

In the early twentieth century, foresters became interested in the commercial cultivation of bamboo as a potential source of woody biomass (Bennett 2011). Bamboo plantations were established alongside Australian acacias in the Zululand district (Davies 1908). Bamboos were also planted in Emakhazeni in the Mpumalanga Province for use in hut building and as a general construction material in rural areas (Sawer 1909). In Barberton, seeds of *Dendrocalamus strictus* from India were successfully grown in the government nursery (Davies 1910). Cuttings were raised by the Forestry Division and were distributed around the country. Bamboo proved to be well-adapted to the climate of the sub-tropical Lowveld region, which includes much of the Mpumalanga and KwaZulu-Natal provinces and parts of Swaziland (Taylor 1910). During this time there was also experimental paper manufacturing using bamboo (Exchange Reviews 1908). Although how extensively bamboo was planted during this time remains unknown.

Small-scale Domestic Use of Bamboos

Bamboo has also been an important resource on farms and homesteads across South Africa for small-scale uses. Clementz (1931) proposed that it be planted along streams and river ways to fight erosion on farms, but also to provide poles for hut building and as food for cattle (Cleghome 1931). Bamboo culms were used to construct mosquito nets (Simpson 1904), tools (Ergates 1902; Olivier 1938; du Plessis 1939), poles for building and fencing (Ergates 1906), garden trellises (Terry 1927; Esselen 1930), and musical instruments (Liengme 1983).

Following the use of bamboo in the sugarcane industry in KwaZulu-Natal, Indian labourers often planted bamboo around their homes. Bamboo has continued to be an important resource and material among the Indian community for building houses and tools, and for religious ceremonies. In Muslim communities, bamboos were used to build miniature mausoleums called *tazzias* for the Muharram festival as early as the 1900s (Vahed 2009). Among the Hindu population, prayer-flags (“Jhandi”) were constructed using bamboo poles to send messages to a Hindu god (Kearney 1999). It is suggested that the infamous “Bamboo Square” (1873–1903), the first settlement of marginalised people in the city of Durban that had a prevalence of Indian, Chinese, and Malay inhabitants, received its name from the bamboo prayer flags that would have been erected by the community (Kearney 2002). Prayer flags are still made today using bamboo poles, especially in the Tongaat region of KwaZulu-Natal. The highest density of bamboo populations (*Bambusa balcooa* and *B. vulgaris*) in South Africa occurs in KwaZulu-Natal.

Zulu communities still use bamboos to stabilise raised graves and to decorate pottery (S. Canavan, pers. obs.). In some areas of rural KwaZulu-Natal, the traditional wattle and daub huts are built with bamboos instead of wattles (*Accacia* spp.) as there are many naturalised bamboo populations (S. Canavan, pers. obs.). This type of building construction has also been noted among the Venda (Magwede *et al.* 2018).

Bamboos have been, and still are, widely used as ornamental horticultural plants in gardens. They became particularly fashionable as garden subjects in the nineteenth century through the influence of European plant collectors during the Victorian era. During this time The Royal Botanic Gardens at Kew, UK, received and cultivated many temperate bamboo varieties from Asia (Townsend 2013). For example, William Keit, a German botanist with close connections to Kew, traded and distributed alien species for horticulture in South Africa (McCracken 1986). He planted bamboo along roadsides and in the Durban Botanical Gardens as part of his efforts to beautify the city.

The Rise of the Green Economy

The most recent chapter of the bamboo story has been spurred by a trend towards improved sustainability in industry and agriculture over the past decade. Specifically there has been the rise of the green economy concept which promotes economic activity with lower environmental impacts (Department of Environmental Affairs 2007). This has led to exploration of alternative plant species that are suited for modern uses such as biofuels, bioenergy, phytoremediation, and the rehabilitation of mines (see Mothapo 2017). Bamboos have been in the limelight for meeting such criteria.

Scheba *et al.* (2017) reviewed the potential use of bamboo for ‘green development’ in South Africa and identified numerous stakeholder groups who were experimenting and distributing bamboos for these purposes: (1) nursery and tissue-culture sellers; (2) commercial growers; (3) specialised retailers; (4) government; and (5) consultants. This has led to the importation of many new undocumented species for experimentation, including taxa from regions outside Asia, such as the Neotropics. New plantations, however, are predominantly planted with species that have already naturalised in South Africa such as *Bambusa balcooa* and *B. vulgaris*. The further development of the bamboo industry faces multiple challenges, including land conflicts, complex governance arrangements, and limitations in the technology available for processing raw bamboo into value-added products (Scheba *et al.* 2017). It is therefore still unclear what impact (positive or negative) this trend may have, and whether the bamboo market in South Africa will become the burgeoning industry suggested in some reports.

Current Perceptions

Similar to historical uses in gardening and agriculture, the results of the questionnaire indicate that the small-scale use of bamboo in a domestic setting is ongoing. In total, 83 respondents completed the questionnaire (3 of which were excluded as 2 were incomplete or incorrectly completed, and one misclassified reeds as bamboos). Most respondents were connected with the survey via Facebook ($n = 51$), eleven people responded by local email newsletters, and fewer than ten from unspecified sources, word-of-mouth referrals, or from their local conservancy. As such, there was likely a bias in the pool of respondents to those who are regular internet users. Although responses were received from across the country a higher than expected number of respondents were from the major cities of Johannesburg, Durban, and Cape Town (see Fig. S1). Despite this, there was an equal representation of respondents in urban/peri-urban areas and rural/semi-rural areas (See Note S1).

More than a third (35%; $n = 28$) of the respondents (or a relative) had actively planted the bamboo, showing that there

is still a desire to propagate and distribute bamboos. Eighty-six percent ($n = 69$) of questionnaires were completed by the owner, tenant, or neighbour of properties of private land whereas 10% ($n = 8$) of respondents were related to commercial, business, or public works land, with the questionnaires completed by either the owner, an employee, volunteer, or local resident. The majority of respondents had ‘inherited’ bamboo on their land, and 36% ($n = 29$) did not know who had planted the bamboo or whether it had been planted by previous landowners or tenants. A surprisingly high number of respondents (26%; $n = 21$) reported that the presence of bamboo on their land was the result of invasion from a neighbouring property.

The historical literature was dominated by references to clumping tropical species from Asia, but only 49% ($n = 39$) of questionnaire respondents had this type. Nearly a third 31% ($n = 25$) of respondents reported having temperate running bamboo on their land, with the remaining 20% ($n = 16$) being unspecified or reporting both types. This gives credence to the notion that there is a preference for running species for ornamental horticulture and thus there may be bias for running species found in urban and peri-urban areas. This is certainly true in the Northern Hemisphere where in Europe and the United States, perhaps due to the climatic similarity to Asia, running species native to temperate Asia have traditionally been preferred over tropical clumping species in the ornamental horticultural trade (Canavan *et al.* 2017). For example, Kew Botanical Gardens, which was the epicentre for Victorian plant collections, has a bamboo garden that still maintains a historical collection of almost entirely temperate species (S. Canavan, pers. obs.).

Given that temperate running species tend to be more invasive (Lieurance *et al.* 2018), we expected that growth form would be an important factor explaining how respondents value bamboo. We also expected that the pathways of introduction would differ for running and clumping species. This was true for three questions, where the type of bamboo (running, clumping, or unspecified) was significantly associated with (1) the period when the bamboo was planted ($X^2 = 22.01$; $df = 10$; $p = 0.015$; Fig. 3a); (2) whether respondents had attempted to remove or manage the bamboo ($X^2 = 23.12$; $df = 8$, $p < 0.01$; Fig. 3e); and (3) whether the bamboo had spread more than two meters in a year ($X^2 = 17.83$; $df = 8$, $p < 0.01$; Fig. 3f). We interpreted these results to mean that: (1) the preference for planting clumping or running bamboos has changed over time; (2) landowners with clumping species were less likely to remove or manage the bamboo; (3) if control was attempted, it was more likely to have failed for running species; and, perhaps unsurprisingly, (4) respondents reported that the running species spread more often than clumping species, although there were reports of spreading clumping species.

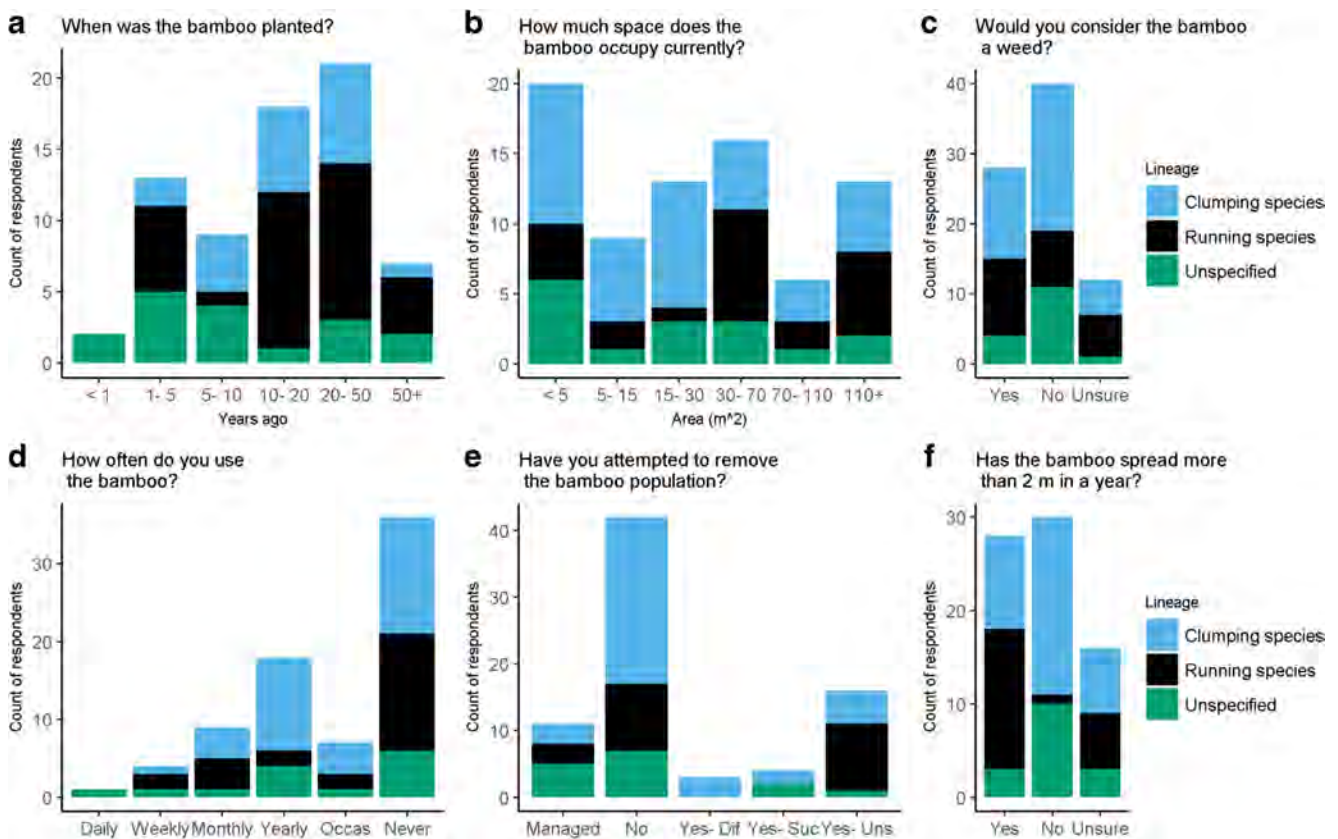


Fig. 3 Respondent answers for six questions regarding the uses and perception of bamboos in South Africa. Answers are grouped by bamboo lineage/ type (clumping, running, and unspecified species). In panel **d**, Occas is occasionally; in panel **e** Managed means that the bamboos are controlled but there was not an attempt to remove them entirely;

Yes-Dif means an attempt was made to entirely remove the bamboos, it was successful but with difficulty; Yes-Suc means the bamboo was successfully removed with little difficulty; and Yes-Uns means yes an attempt was made to remove the bamboos but it was unsuccessful

The type of bamboo, however, did not influence (1) the size of the area that the bamboo occupied (Fig. 3b); (2) whether respondents considered the bamboo a weed (Fig. 3c); and (3) the frequency of use (Fig. 3d). We would have expected running bamboos more likely to be considered weedy given their more invasive nature, but this was not the case. A fairly high proportion of respondents (35%, $n = 28$) did, however, consider bamboo (both running and clumping species) to be a weed in general. Whether respondents considered bamboo a weed was not related to the type of bamboo but might be related to whether they used the bamboo. For example, of the 42% ($n = 32$) of respondents who indicated that they never use the bamboo on their property, 50% ($n = 18$) viewed it as a weed. Only 23% of the 24 respondents that do use bamboo considered it to be a weed.

For many respondents, bamboo was a useful plant to some degree, but also a problematic one. Respondents were asked to score the usefulness of bamboo to them on a scale from 0 (no use) to 5 (very useful), and also how problematic they found the bamboo to be on a scale of 0 (no problems) to 5 (very problematic); these scores were not influenced by the type of bamboo. When we compared the average score given for

“usefulness” ($m = 2.28$, $s.d. = 1.94$) and “problematic” ($m = 2.22$; $sd = 1.94$) there was no significant difference ($W = 3172$, p value = 0.85; Fig. 4) between the two groups. We take this to mean that respondents found bamboos both useful and problematic.

Respondents were asked to list how they used bamboo by selecting from a list of predefined uses or providing a use that was not listed. We grouped the final answers into six categories (respondents could have given answers for multiple categories); planted screens ($n = 39$; e.g., garden screens, wind breaks, perimeter plantings); ornamental purposes ($n = 36$); tools and utensils ($n = 16$; e.g., garden and kitchen tools, fishing rods); poles ($n = 36$; e.g., poles for constructions, trellises, fencing); no use ($n = 10$); and other ($n = 14$; e.g., food, animal fodder, toys, wind chimes, leaf litter). Again, the type of bamboo did not influence how the bamboo was used ($\chi^2 = 7.99$; $df = 14$; $p = 0.63$) and neither did whether it was temperate or tropical (Fig. 5a).

Similarly, when respondents listed the ways in which they find bamboo to be problematic, the type of bamboo did not influence the type of problem ($\chi^2 = 16.73$; $df = 14$; $p = 0.27$) (Fig. 5b). We grouped the final answers into eight categories:

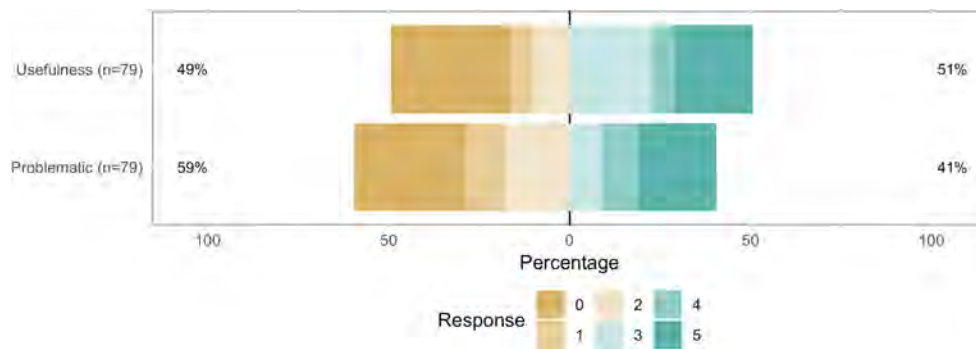


Fig. 4 Respondents were asked to score the extent to which bamboos are useful (Is the bamboo a useful plant today?) and problematic (Does the bamboo cause any problems? e.g., excessive spreading, difficult to control, fire hazard etc.), on a scale from 0 (no use/ no problem) to 5 (very useful/ very problematic). Colours and sizes in the bar plot indicate

the percentage of respondents that answered for each level for usefulness and problematic. Being perceived having both uses and problematic at times indicates that bamboos may be a “conflict of interest” species in some instances

no response/no issue ($n = 32$); out-competes other plants ($n = 25$); property and infrastructure damage ($n = 12$); impedes access ($n = 11$); other reasons ($n = 11$; e.g., labour intensive to maintain, emerging spikes (shoots) are dangerous to children, noisy in wind); aesthetic eyesore ($n = 8$); and excessive water use ($n = 5$). The most common issue that respondents reported in terms of negative impacts were that bamboo out-competes plants, causes damage to property and infrastructure, and requires excessive use of water. We did note that when respondents indicated that the bamboo impedes access a high proportion were running species (Fig. 5b). Some respondents also remarked on the financial cost of managing the bamboo. Currently, there are no government-led actions towards managing or removing naturalised bamboo populations. Although with the growing concerns identified in this study by landowners, it is possible that certain taxa may continue to spread

beyond planted sites to be become problematic in urban and natural areas.

The questionnaire revealed that current perceptions towards bamboos vary widely, making bamboo a potential “conflict of interest group” – species that are both valued and considered to be weeds. The mixed value placed on bamboo taxa might be explained by: (1) the cultural integration during the long history of introduction and use, resulting in certain people now having a strong affinity towards bamboos; and (2) the recent realization by and personal experiences of landowners that bamboos can have negative impacts, leading to negative perceptions among some groups. The difference in opinions may manifest itself more in places like South Africa due to the stark socio-economic contrasts, both historical and current, which shape perceptions regarding plants in different

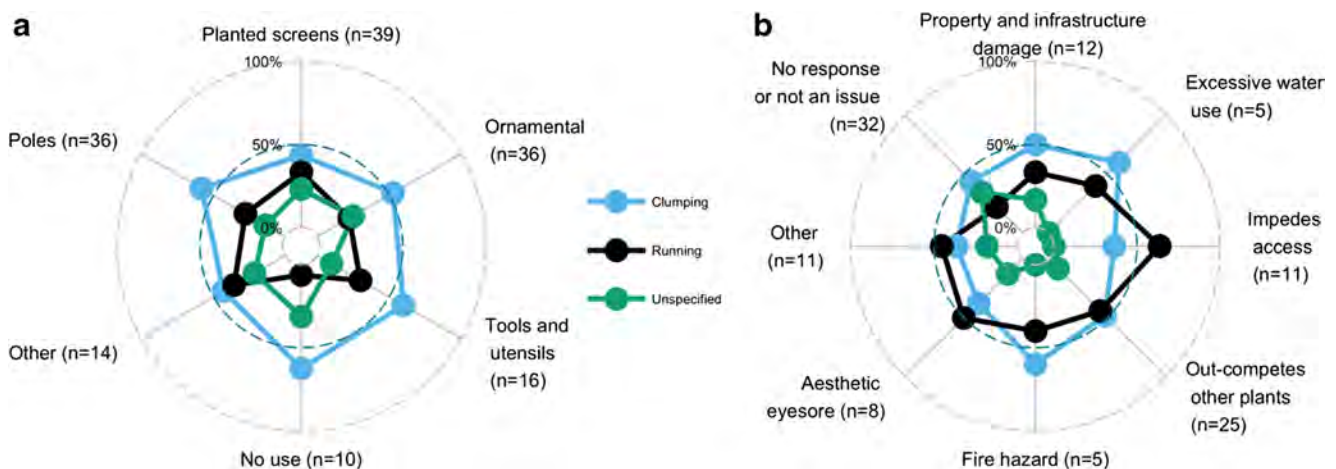


Fig. 5 Respondents ($n = 77$) were asked to list: (a) all the ways in which they use bamboo; and (b) problems associated with invasive bamboo populations. Uses were classified into six categories and problems into eight categories. Respondents could answer multiple ways for how the bamboo is used or found to be problematic. The radar chart shows the

proportion of respondents with running, clumping or unspecified species for each use or problem category, e.g., for the 36 respondents who indicated that the bamboo is used for ‘poles,’ 58% had clumping species, 28% had running species and 14% were unspecified

contexts (Kull *et al.* 2011; Bennett and van Sittert 2019). For example, high water usage for bamboos might be important to rural farmers but less so for city-dwellers, whereas concerns relating to spreading of bamboos in tended gardens are of more concern to city-dwellers than farmers. Although we had a good representation of land-owners in both rural and urban settings, we suspect that more traditional communities are under-represented in the study, as only those with access to the internet and who use social media were targeted. There are likely additional uses and practices as well as perceptions towards bamboos that were not accounted for (e.g., from some Venda and Zulu communities). Further work to quantify how such perceptions differ across distinct demographic groups and communities might shed light on how valuations of bamboos differ across South Africa.

Conclusions

Bamboos have had a long history in South Africa based on multiple phases of introduction with multiple pathways and incentives for these events. Each phase has been closely aligned with socio-historical events in the region. Bamboos have been used by different demographic groups and across socioeconomic classes, with introductions driven by different groups, e.g., Venda people and European settlers. The range of reasons for introduction and groups involved in the introductions is perhaps unusual compared to other plant introductions. The story of bamboo in South Africa is thus an excellent example of how initial motivations for introductions, the process of cultural integration, and the emergence of polarized attitudes as the species spread and become weedy over time have combined to create a complex tapestry of perceptions. Such perceptions must be considered when formulating national and regional strategies for sustainable environmental management.

Acknowledgements SC thanks the following people for their help and guidance: Joubert Roux, Adrian Sutton, Felix Sorour, Brett Bennett, Selvan Naidoo, Ingrid Nanni, Reshnee Lalla, Nolwethu Jubase. We would also like to thank all the questionnaire participants for taking the time to contribute to the study, and two anonymous reviewers for valuable comments on an earlier version of the manuscript. This work was supported by the National Research Foundation of South Africa (grants 85412 to JRW, 626 85417 to DMR, 91117 to JLR); and the South African National Department of Environment Affairs through its funding of the South African National Biodiversity Institute and the DST-NRF Centre of Excellence for Invasion Biology.

Compliance with Ethical Standards

Ethical Approval and Informed Consent Ethical clearance to conduct the research was obtained from the National Health Research Ethics Committee (NHREC: REC-050411-032) at Stellenbosch University

(SU-HSD-004196). All ethical standards were adhered to. The relevant local authorities were approached for permission to conduct the research and formal, free, prior and informed consent was obtained from all participants. Anonymity was assured.

Conflict of Interest The authors declare that they have no conflict of interest.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

References

- Atkinson, D. (2014). Rural-urban linkages: South Africa case study. Territorial Cohesion for Development Program, Rimisp, Santiago.
- Beinart, W., and Middleton, K. (2004). Plant transfers in historical perspective: A review article. *Environment and History* 10: 3–29.
- Bekele-Tesemma, A. (2007). Useful Trees and Shrubs for Ethiopia: Identification, Propagation and Management for 17 Agroclimatic Zones, RELMA in ICRAF Project, Nairobi.
- Bennett, B. M. (2011). Naturalising Australian trees in South Africa: Climate, exotics and experimentation. *Journal of Southern African Studies* 37: 265–280.
- Bennett, B. M., and van Sittert L. (2019). Historicising perceptions and the national management framework for invasive alien plants in South Africa. *Journal of Environmental Management* 229: 174–181.
- Blacking, J. (1962). Musical expeditions of the Venda. *African Music* 3: 54–78.
- Blacking, J. (1969). Songs, dances, mimes and symbolism of Venda girls' initiation schools. *African Studies* 28: 215–266.
- Burkhill, H. M. (1994). The useful plants of west tropical Africa. Royal Botanical Gardens, Kew, UK.
- Canavan, S., Richardson, D. M., Visser, V., Roux, J. J. L., Vorontsova, M. S., and Wilson, J. R. U. (2017). The global distribution of bamboos: assessing correlates of introduction and invasion. *AoB PLANTS*: plw078.
- Canavan, S., Kumschick, S., Le Roux, J. J., Richardson, D. M., and Wilson, J. R. U. (2019). Does origin determine environmental impacts? Not for bamboos. *Plants, People, Planet*. <https://doi.org/10.1002/ppp3.5>.
- Carruthers, J., Robin, L., Hattingh, J. P., Kull, C. A., Rangan, H., and van Wilgen, B. W. (2011). A native at home and abroad: The history, politics, ethics and aesthetics of acacias. *Diversity and Distributions* 17: 810–821.
- Claassens, H., and Pretorius, F. (2004). Die geskiedenis van Boerekos 1652–1806. *South African Journal of Cultural History* 18: 110–126.
- Clayton, W. D., and Renvoize, S. A. (1986). *Genera graminum. Grasses of the World*. 13. Kew bulletin additional series.
- Cleghome, W. S. H. (1931). Soil erosion and reclamation. *Farming in South Africa* 6: 379–381.
- Clementz, C. (1931). Farmers who are overcoming soil Erosion. *Farming in South Africa* 6: 164–181.
- Crosby, A. W. (1972). *The Columbian exchange: Biological and cultural consequences of 1492*, Greenwood Publishing Group, Westport.
- Davies, G. H. (1908). Afforestation. *Natal Agricultural Journal* 11: 623–626.
- Davies, R. A. (1910). The horticultural section: South African show of maize and citrus fruits. *Transvaal Agricultural Journal* 8: 641–644.
- Department of Environmental Affairs. (2007). *South Africa's Green Economy Strategy*. Department of Environmental Affairs, Enviropedia.
- Diamond, J. (1997). *Guns, germs, and steel: The fates of human societies*, W. W. Norton, New York.

- du Plessis, S. J. (1939). Bacterial blight in vines. *Farming in South Africa* 14.
- Ergates (1902). The bamboo and its uses. *The Natal Agricultural Journal* 5: 179–189.
- Ergates (1906). Coast fruit: The bamboo and its uses. *Natal Agricultural Journal* 9: 1171–1177.
- Esselen, D. J. (1930). The litchi. *Farming in south. Africa* 5: 543–544.
- Exchange Reviews (1908). Exchange reviews. *Natal Agricultural Journal* 11: 210–215.
- Fletcher, T. (1925). Fire-cured Tobacco. *The Sun & Agricultural Journal of S.A.* 16: 1082–1090.
- Fukushima, K., Usui, N., Ogawa, R., and Tokuchi, N. (2014). Impacts of moso bamboo (*Phyllostachys pubescens*) invasion on dry matter and carbon and nitrogen stocks in a broad-leaved secondary forest located in Kyoto, western Japan. *Plant Species Biology* 30: 81–95.
- Glen, H. F. (2002). Cultivated plants of southern Africa: Botanical names, common names, origins, literature. Jacana Media.
- Gupta, A. K. (2004). Origin of agriculture and domestication of plants and animals linked to early Holocene climate amelioration. *Current Science* 87: 54–59.
- Harris, A., Thieberger, N., and Barwick, L. (2015). *Research, records and responsibility: Ten years of PARADISEC*, University Press, Sydney.
- Henderson, L. (2007). Invasive, naturalized and casual alien plants in southern Africa: A summary based on the southern African plant invaders atlas (SAPIA). *Bothalia* 37: 215–248.
- Kearney, J. A. 1999. Indians and whites in the multicultural world of Rooke's Ratoons. *English in Africa* 26: 89–112.
- Kearney, B. 2002. Bamboo Square: A documentary narrative of the 'Indian and Native Cantonment' at the the Point, 1873 to 1903. *Journal of Natal and Zulu History* 20: 29–64.
- Kolb, P. (1726). Naaukeurige en uitvoerige beschrijving van kaap de Goede Hoop; behelzende een zeer omstandig verhaal van den tegenwoordigen toestand van dat vermaarde gewest, B. Lakemann, Amsterdam.
- Kull, C. A., Shackleton, C. M., Cunningham, P. J., Ducatillon, C., Dufour-Dror, J. M., Esler Karen, J., Friday, J. B., Gouveia, A. C., Griffin, A. R., Marchante, E., Midgley, S. J., Pauchard, A., Rangan, H., Richardson, D. M., Rinaudo, T., Tassin, J., Urgenson, L. S., von Maltitz, G. P., Zenni Rafael, D., and Zylstra, M. J. (2011). Adoption, use and perception of Australian acacias around the world. *Diversity and Distributions* 17: 822–836.
- Legat, C. E. (1905). On Bamboos. *Transvaal Agricultural Journal: The Forestry Section* 4: 97–100.
- Leibbrandt, H. C. V. (1900). *Precis of the archives of the Cape of Good Hope, letters Despatched from the cape, 1652–1662, to which are added land grants, attestations journal of voyage to Tristan da Cunha, names of freemen etc.*
- Li, Z.-h., and Kobayashi, M. (2004). Plantation future of bamboo in China. *Journal of Forestry Research* 15: 233–242.
- Liengme, C. A. (1983). A survey of ethnobotanical research in southern Africa. *Bothalia* 14: 621–629.
- Lieurance, D., Cooper, A., Young, A. L., Gordon, D. R., and Flory, L. S. (2018). Running bamboo species pose a greater invasion risk than clumping bamboo species in the continental United States. *Journal for Nature Conservation* 43: 39–45.
- Lindemann-Matthies, P. (2016). Beasts or beauties? Laypersons' perception of invasive alien plant species in Switzerland and attitudes towards their management. *NeoBiota* 29: 15–33.
- Magwede, K., van Wyk B. E., and van Wyk A. E. (2018). An inventory of Vhavenda useful plants. *South African Journal of Botany*. doi: 10.1016/j.sajb.2017.12.013
- Makita, A. (1998). The significance of the mode of clonal growth in the life history of bamboos. *Plant Species Biology* 13: 85–92.
- McCracken, D. P. (1986). William Keit and the Durban botanic garden. *Bothalia* 16: 71–75.
- Mothapo, M. G. (2017). Economic evaluation of bamboo cultivation and potential yield on rehabilitated mine sites. University of the Witwatersrand, Johannesburg, South Africa.
- Nelson, A. (2004). Population Density for Africa in 2000. *in* U. G. S. Falls, editor., UNEP/GRID Sioux Falls, SD, USA.
- Netshlungani, M. T., van Wyk, E. N., and Linger, A. E. (1981). That the holy forest of the Vhavenda. *Veld & Flora* 67: 51.
- Novoa, A., Kaplan, H., Wilson, J. R., and Richardson, D. M. (2016). Resolving a prickly situation: Involving stakeholders in invasive cactus management in South Africa. *Environmental Management* 57: 998–1008.
- Novoa, A., Shackleton, R., Canavan, S., Cybele, C., Davies, S. J., Dehnen-Schmutz, K., Fried, J., Gaertner, M., Geerts, S., and Griffiths, C. L. (2018). A framework for engaging stakeholders on the management of alien species. *Journal of Environmental Management* 205: 286–297.
- Olivier, H. J. A. (1938). Manipulation of ostrich feathers. *Farming in South Africa* 13: 121.
- Pooley, S. (2009). Jan van Riebeeck as pioneering explorer and conservator of natural resources at the Cape of Good Hope (1652-62). *Environment and History* 15: 3–33.
- R Core Team (2017). *R: A language and environment for statistical computing*, R- Foundation for Statistical Computing, Vienna.
- Reid, A. (1910). Experiment farm reports : central experiment farm. *Natal Agricultural Journal* 14: 327–333.
- Sawer (1909). Division of agriculture and forestry notices: Report for October, 1909. *Natal Agricultural Journal* 13: 140–141.
- Scheba, A., Blanchard R., and Mayeki S. (2017). Bamboo for green development? The opportunities and challenges of commercialising bamboo in South Africa. Human Sciences Research Council (HSRC).
- Shackleton, C. M., McGarry, D., Fourie, S., Gambiza, J., Shackleton, S. E., and Fabricius, C. (2007). Assessing the effects of invasive alien species on rural livelihoods: Case examples and a framework from South Africa. *Human Ecology* 35: 113–127.
- Shackleton, R. T., Le Maitre, D. C., and Richardson, D. M. (2015). Stakeholder perceptions and practices regarding *Prosopis* (mesquite) invasions and management in South Africa. *Ambio* 44: 569–581.
- Shackleton, R. T., Richardson, D. M., Shackleton, C. M., Bennett, B., Crowley, S. L., Dehnen-Schmutz, K., Estévez, R. A., Fischer, A., Kueffer, C., Kull, C. A., Marchante, E., Novoa, A., Potgieter, L. J., Vaas, J., Vaz, A. S., and Larson, B. M. H. (2018). Explaining people's perceptions of invasive alien species: A conceptual framework. *Journal of Environmental Management* 229:88–101.
- Shackleton, R. T., Shackleton, C. M., and Kull, C. A. (2019). The role of invasive alien species in shaping local livelihoods and human well-being: A review. *Journal of Environmental Management* 229:145–157.
- Simpson, C. B. (1904). Preventive and remedial measures against mosquitoes. *Transvaal Agricultural Journal* 2: 354–357.
- Singh, O. (2008). Bamboo for sustainable livelihood in India. *Indian Forester* 134: 1193–1198.
- Soderstrom, T. R., and Zuloaga, F. O. (1989). A revision of the genus *Olyra* and the new segregate genus *Parodiolyra* (Poaceae: Bambusoideae: Olyreae). *Smithsonian Contributions to Botany* (69): 1–79.
- Spilhaus, M. W. (1966). They Planted the Cape. *Historia* 11.
- Starfinger, U., Kowarik, I., Rode, M., and Schepker, H. (2003). From desirable ornamental plant to pest to accepted addition to the flora? – The perception of an alien tree species through the centuries. *Biological Invasions* 5: 323–335.
- Statistics South Africa (2003). *Census 2001: Investigation into appropriate definitions of urban and rural areas for South Africa: Discussion document*, Statistics South Africa, Pretoria.

- Stayt, H. A., and Hoernle, A. W. (1931). *The Bavenda*, Oxford University Press, London.
- Suzuki, S. (1978). *Index to Japanese Bambusaceae*, Gakken, Tokyo.
- Takano, K. T., Hibino, K., Numata, A., Oguro, M., Aiba, M., Shiogama, H., Takayabu, I., and Nakashizuka, T. (2017). Detecting latitudinal and altitudinal expansion of invasive bamboo *Phyllostachys edulis* and *Phyllostachys bambusoides* (Poaceae) in Japan to project potential habitats under 1.5 C–4.0 C global warming. *Ecology and Evolution* 7: 9848–9859.
- Taylor, L. E. (1910). Forestry section: *Dendrocalamus strictus*- the male bamboo. *Transvaal Agricultural Journal* 8: 633–634.
- Terry, G. (1927). Winter rhubarb. *Farming in South Africa* 2: 115.
- Thunberg, C. P. (1795). *Travels in Europe, Africa and Asia*, London.
- Townsend, R. (2013). Bamboos at Kew. Pages 51-53 in I international symposium on genetic resources of bamboos and palms and III international symposium on ornamental palms. ISHS. *Acta Horticulturae* 1003.
- Tracey, A., and Gumboreshumba, L. (2013). Transcribing the Venda tshikona reedpipe dance. *African Music: Journal of the International Library of African Music* 9:25–39.
- Udo, N., Darrot, C., and Atlan, A. (2018). From useful to invasive, the status of gorse on Reunion Island. *Journal of Environmental Management* 229:166–173.
- Vahed, G. (2009). *Indian Muslims in South Africa: continuity, change and disjuncture. Africa's Islamic Experience*. Sterling Publishers Pvt, UK.
- van Wilgen, B. W., and Richardson, D. M. (2012). Three centuries of managing introduced conifers in South Africa: Benefits, impacts, changing perceptions and conflict resolution. *Journal of Environmental Management* 106: 56–68.
- van Wilgen, B. W., and Richardson, D. M. (2014). Challenges and trade-offs in the management of invasive alien trees. *Biological Invasions* 16: 721–734.
- Visser, V., Wilson, J. R. U., Canavan, K., Canavan, S., Fish, L., Le Maitre, D., Nanni, I., Mashau, C., O'Connor, T. G., Ivey, P., Kumschick, S., and Richardson, D. M. (2017). Grasses as invasive plants in South Africa revisited: Patterns, pathways and management. *Bothalia* 47(2): a2169. <https://doi.org/10.4102/abc.v47i2.2169>.
- Wu, C., Mo, Q., Wang, H., Zhang, Z., Huang, G., Ye, Q., Zou, Q., Kong, F., Liu, Y., and Wang, G. G. (2018). Moso bamboo (*Phyllostachys edulis* (Carriere) J. Houzeau) invasion affects soil phosphorus dynamics in adjacent coniferous forests in subtropical China. *Annals of Forest Science* 75.
- Zengeya, T., Ivey, I., Woodford, D. J., Weyl, O., Novoa, A., Shackleton, R. D., and van Wilgen, B. (2017). Managing conflict-generating invasive species in South Africa: Challenges and trade-offs. *Bothalia* a2160: 47.

1 **Table S1.** Facebook groups where the questionnaire was posted on, and the number of members of the group or
 2 likes associated with the group. The numbers are as recorded on the day the post was made between the 5th and
 3 10th of May 2017.

4

Group name		Link
ADS LIMPOPO	9299 members	https://www.facebook.com/groups/JOBSSHERENOW/
AGFO Expo - Agriculture & Forestry	3612 likes	https://www.facebook.com/AGFOExpo/
Alien Plant Identification Services	275 likes	https://www.facebook.com/Alien-Plant-Identification-Services-369800736547050/
Ariston Elemental Organic Garden	573 likes	https://www.facebook.com/aristonelementalorganicgarden/
Bromeliads in South Africa	1626 members	https://www.facebook.com/groups/bromeliadsocietysa/
BUY AND SELL SOUTH AFRICA	16530 members	https://www.facebook.com/groups/831935736829559/
Cape Environmental Assessment Practitioners	91 likes	https://www.facebook.com/cape.eaprac/
Cape Town Invasive Species	2328 likes	https://www.facebook.com/ctinvasives/
Carnivorous Plant Growers South Africa	520 members	https://www.facebook.com/groups/745661525507236/
Cycadfriends Community	3124 members	https://www.facebook.com/groups/CycadForumPetition/?ref=br_rs
Dam & River Angling in South Africa	14152 members	https://www.facebook.com/groups/Heenent/?ref=br_rs
Department of Botany, Rhodes University	347 likes	https://www.facebook.com/BotanyRhodesUniversity/
Farmers Network South Africa (FNSA)	15149 members	https://www.facebook.com/groups/FarmersNetworkSouthAfrica/
Flora of southern Africa	3515 members	https://www.facebook.com/groups/Floraofsouthafrica/
Garden Technics SA	180 likes	https://www.facebook.com/gardentechnicsa/
Gauteng Conservancy and Stewardship Association	102 members	https://www.facebook.com/groups/630179793790090/about/
Hout Bay Organised	923 likes	https://www.facebook.com/groups/houtbay/
Howick (KZN South Africa)	1581 members	https://www.facebook.com/groups/663062110384807/
Indigenous Flowers of South Africa	2741 members	https://www.facebook.com/groups/IBSAGroup/about/
Invasive/Exotic Plant Species in South Africa	496 members	https://www.facebook.com/groups/219604578373033/
Invasive Species South Africa (ISSA)	6651 likes	https://www.facebook.com/invasivespeciesouthafrica/
Joburg Online	6426 members	https://www.facebook.com/groups/joburgonline/

Group name			Link
Klein Karoo Sustainable Drylands Permaculture Project	1511	members	https://www.facebook.com/groups/228236642394/
KZN Midlands seed savers	61	members	https://www.facebook.com/groups/222812881156285/?ref=br_rs
LETS TALK PLANTS, TREES AND SHRUBS	864	members	https://www.facebook.com/groups/treesandplants/
Limpopo Classifieds	12956	members	https://www.facebook.com/groups/325338070893306/
Livingseeds Veggie Gardeners	3824	members	https://www.facebook.com/groups/114911155205206/
MAMAHOOD FREE STATE	3282	members	https://www.facebook.com/groups/MamahoodFreeState/
Mbombela Invasives	190	likes	https://www.facebook.com/Mbombelainvasives/
MDMB Landscapes	269	likes	https://www.facebook.com/mdmblandscapes/
NACSSA National Association of Conservancies/ Stewardship South Africa	NA		https://www.facebook.com/NACSSA-National-Association-of-ConservanciesStewardship-South-Africa-134435801056/
Orchid growers South Africa	4864	members	https://www.facebook.com/groups/132655120270019/
Organic farmers of South Africa	5152	members	https://www.facebook.com/groups/OrganicFarmersZA/
Passionate about gardening South Africa	317	members	Passionate about gardening South Africa
Permaculture Network South Africa	812	members	https://www.facebook.com/groups/308946355788009/
Permaculture Research Centre Cape Town	3964	likes	https://www.facebook.com/PRCCapetown/
PETS and FARMERSGALORE [South Africa]	7016	members	https://www.facebook.com/groups/petsandfarmersgalore/
Plant People South Africa	4046	members	https://www.facebook.com/groups/plantpeople/
Poultry Farming South Africa/ Africa	11911	members	https://www.facebook.com/groups/167059293177361/about/
S.A. Butterflies, Bugs, Bees and other small things	21077	members	https://www.facebook.com/groups/Butterfliesandbugs/
Seed and Plant Exchange/ For Sale South Africa	3327	members	https://www.facebook.com/groups/836314193121949/
SOLVE- Save Our Limpopo Valley Environment	3321	members	https://www.facebook.com/groups/274439892602335/about/
SANA- South African Nursery Association	2935	followers	https://www.facebook.com/sanurseryassociation/?ref=br_rs
Sylvia Pass Garden Centre	145	likes	https://www.facebook.com/Sylvia-Pass-Garden-Centre-667658326717416/
The Botanical Society of South Africa	4473	members	https://www.facebook.com/BotSocSA/
The Sappi Nature Journal	1069	likes	https://www.facebook.com/The-Sappi-Nature-Journal-139925246217214/

Group name		Link
Trade Board: Exotic, Rare and unusual plants	958 members	https://www.facebook.com/groups/795879563824370/
Urban Farmers	2392 likes	NA
URBAN FARMING- South Africa	471 members	https://www.facebook.com/groups/1042453599175549/
Vegetable, Fruit & Herb Gardening South Africa	123 members	https://www.facebook.com/groups/1156813641054679/
Veld/ vegetation of South Africa	443 members	https://www.facebook.com/groups/443110699189777/?ref=br_rs

6 **Table S2.** Questionnaire targeting landowners in South Africa with bamboo on their property.

7

1	Name
2	Contact number
3	Contact email
4	Where did you hear about this research?
5	Age
6	What is your occupation?
7	In which province is the property located that has bamboo present on it?
8	How many types/ species of bamboo do you think are on the property?
9	What is the address or locality of the property with bamboo/s population? (GPS coordinates if possible)
10	What is the nearest town or city to your property?
11	What kind of property is the bamboo located on?
12	What is the primary use for the property?
13	What is your connection with the property?
14	Did you initially plant the bamboo? If not, do you know who did?
15	Do you know when the bamboo was first planted on the property? if you know the specific year, please write it in other
16	Where was the bamboo planted?
17	Do you know what the original purpose for the bamboo was? (please click all relevant uses, if there are other specific uses, such as for candlesticks, write in 'other')
18	Is the bamboo a useful plant on the farm today?
19	How is the bamboo used today? (please click all relevant uses, and add specific uses in 'other')
20	How much space does the bamboo occupy currently? If you know the exact measurement, please write in 'other'
21	How many clumps or populations of bamboo are there?
22	How often do you use the bamboo on the property?
23	Do you have any interesting stories about the bamboo and/ or its history on the property or in South Africa, in general, that you would like to share?
24	Does the bamboo cause any problems?
25	If the bamboo is spreading, has it spread a distance of 2 meters or more per year from the original plant?
26	If problematic, please select and explain some of the ways it is a nuisance?
27	Would you consider the bamboo a weed (an undesirable plant)?
28	Have you tried to remove the population? if yes, what was the outcome?
29	How tall is the bamboo stand? If you can be specific, please answer under 'other'
30	How thick are the bamboo culms (or stalks)? Please give a specific answer if possible
31	Have you ever observed the population flowering or producing seeds?
32	What colour are the culms or stalks of the bamboo?
33	What is the growth form of the bamboo?
34	Can you identify which species of bamboo are on the property from the pictures below?
35	If there is any other information you would like to share?
36	Would you like to be informed of any outputs (articles etc.)?

8

9 **Table S3.** Literature referencing bamboo in South Africa, including the language of the literature
10 (Afr=Afrikaans, Eng= English, Dut=Dutch), and the province (WC= Western Cape, KZN=KwaZulu-
11 Natal, M= Mpumalanga, L=Limpopo) in which the bamboo is being used or cultivated. Ordered by
12 earliest mention to the most recent.

Reference	Relevance	Species	Lang	Notes	Date used/ date planted (dp)	Province
Leibbrandt 1900	Introduction history	General	Afr/ Eng	Introduction from India for building	1652-1662	WC
Spilhaus 1966	Introduction history	General	Eng	Import of bamboos by the VOC, and planting by Jan Van Riebeeck	1653 (dp)	WC
Kolb 1726	Usage	General	Dut	Atjar	1727	WC
Thunberg 1795	Usage	General	Eng	Tools and utensils	1779	WC
Claassens and Pretorius 2004	Usage	General	Afr	Atchar pickled young bamboo shoots for food	c. 1800s	WC
Ferreira 1990	Usage	General	Afr	Garden ornamental	< 1816 (dp)	WC
Vahed 2009	Usage	General	Eng	Religious ornaments	1860-1910	-
McCracken 1886	Usage	General	Eng	Horticultural planting along roads	1870s	KZN
Ergates 1902	Usage	General	Eng	Fruit boxes, ladders, tools, wind break, poles	c. 1880 (dp)	KZN
Ergates 1906b	Usage	General (20 m high tropical type)	Eng	Walls, doors, ladders, water troughs, handles of tools,	c. 1880 (dp)	KZN
Kearney 1999	Usage	General	Eng	Religion flag poles	20 th Century	KZN
Botes 2003	Usage	General	Afr	Furniture	Late 1900s- early 20 th century	FS
Simpson 1904	Usage	General	Eng	Nets/ mosquito nets	1904	-
Legat 1905	Introduction history	12 species	Eng	Import of seeds and live plants from India	c. 1905 (dp)	-
Taylor 1910	Introduction history	<i>Dendrocalamus strictus</i>	Eng	Experimental plantation in nursery	1905 (dp)	M
Ergates 1906a	Usage	General	Eng	Cattle dipping tanks	1906	-

Reference	Relevance	Species	Lang	Notes	Date used/ date planted (dp)	Province
Braine 1907	Usage	General	Eng	Drainage in orchards	1907	-
Exchange Reviews 1908	Usage	General	Eng	Paper pulp	1908	-
Davies 1908	Cultivation	General	Eng	Experimental plantations	1908	KZN
Sawer 1909	Cultivation	General	Eng	Experimental plantations	1909	M
Davis 1910	Cultivation	<i>Dendrocalamus strictus</i>	Eng	Experimental plantation in nursery	1909 (dp)	M
Reid 1910	Cultivation	13 species listed	Eng	Experimental plantations	1910	KZN
Fletcher 1925	Usage	General	Eng	Crates for harvesting tobacco	1925	-
Terry 1927	Usage	General	Eng	Garden trellis	1927	KZN
Esselen 1930	Usage	General	Eng	Garden trellis	1930	-
Cleghorne 1931	Cultivation	General	Eng	Soil reclamation	1931	-
Clementz 1931	Cultivation	General	Eng	Building, vegetation for river ways, feed stock	1931	NC
Olivier 1938	Usage	General	Eng	Ostrich feather dusters	1938	-
du Plessis 1939	Usage	General	Eng	Wine making tools	1939	WC
Liengme 1983	Usage	General	Eng	Venda flutes	c. 1980s	L
van der Waal 1982	Usage	General	Afr	Hut building	1982	
Milton 2004	Species list	-	Eng	Status of invasive and naturalised grasses	2004	-
Foxcroft et al. 2008	Species list	-	Eng	Status of invasive and naturalised grasses	2008	M
Visser et al. 2017	Species list	-	Eng	Status of invasive and naturalised grasses	2017	-
Glen 2002	Species list	16 species	Eng	-	-	-
Fowler 2008	Usage	General	Eng	Pottery tools	Current	KZN

Reference	Relevance	Species	Lang	Notes	Date used/ date planted (dp)	Province
Magwede 2018	Usage	<i>B. balcooa</i> ; <i>Bambusa</i> <i>vulgaris</i>	Eng	Construction by the Venda	Current	L
Tangye 1896	Usage	Swiepstock bamboes	Afr	Whips	1900s	-

14 **References for Table S3.**

- 15 Botes, S. M. 2003. Laat-Victoriaanse invloed op die interieurinrigting van twee van Bloemfontein se
16 bekendste wonings, 1880-1900. *South African Journal of Cultural History* 17:115-140.
- 17 Braine, C. D. H. 1907. Farm irrigation in the Transvaal. *Transvaal Agricultural Journal* 5:354-361.
- 18 Claassens, H., and F. Pretorius. 2004. Die geskiedenis van Boerekos 1652-1806. *South African*
19 *Journal of Cultural History* 18:110-126.
- 20 Cleghorne, W. S. H. 1931. Soil erosion and reclamation. *Farming in South Africa* 6:379-381.
- 21 Clementz, C. 1931. Farmers who are Overcoming Soil Erosion. *Farming in South Africa* 6:164-181.
- 22 Davies, G. H. 1908. Afforestation. *Natal Agricultural Journal* 11:623-626.
- 23 Davies, R. A. 1910. The Horticultural Section: South African show of maize and citrus fruits.
24 *Transvaal Agricultural Journal* 8:641-644.
- 25 du Plessis, S. J. 1939. Bacterial blight in vines. *Farming in South Africa* 14.
- 26 Ergates. 1902. The Bamboo and its Uses. *The Natal Agricultural Journal* 5:179-189.
- 27 Ergates. 1906a. A Chat with an Old Colonist. *Natal Agricultural Journal* 9:885-890.
- 28 Ergates. 1906b. Coast Fruit: The Bamboo and its USes. *Natal Agricultural Journal* 9:1171-1177.
- 29 Esselen, D. J. 1930. The litchi. *Farming in South Africa* 5:543-544.
- 30 Exchange Reviews. 1908. Exchange Reviews. *Natal Agricultural Journal* 11:210-215.
- 31 Ferreira, O. J. O. 1990. Thomas Ignatius Ferreira (c. 1743-c.1814), Oosgrenspionier en "Britse"
32 Bevelvoerder Van Fort Frederick. *Historia* 35:20-38.
- 33 Fletcher, T. 1925. Fire-cured Tabacco. *The Sun & Agricultural Journal of S.A.* 16:1082-1090.
- 34 Fowler, K. D. 2008. Zulu pottery production in the Lower Thukela Basin, KwaZulu-Natal, South
35 Africa. *Southern African Humanities* 20:477-511.
- 36 Foxcroft, L. C., D. M. Richardson, and J. R. U. Wilson. 2008. Ornamental plants as invasive aliens:
37 Problems and solutions in Kruger National Park, South Africa. *Environmental Management* 41:32-51.
- 38 Glen, H. F. 2002. Cultivated plants of Southern Africa: botanical names, common names, origins,
39 literature. Jacana Media.
- 40 Kearney, J. A. 1999. Indians and whites in the multicultural world of Rooke's Ratoons. *English in*
41 *Africa* 26:89-112.
- 42 Kolb, P. 1726. Naaukeurige en uitvoerige beschryving van kaap de Goede Hoop; behelzende een zeer
43 omstandig verhaal van den tegenwoordigen toestand van dat vermaarde gewest. B. Lakemann,
44 Amsterdam.
- 45 Legat, C. E. 1905. On Bamboos. *Transvaal Agricultural Journal: The Forestry Section* 4:97-100.

- 46 Leibbrandt, H. C. V. 1900. *Precis of the Archives of the Cape of Good Hope, Letters Despatched*
47 *from the Cape, 1652-1662, to which are added land grants, attestations journal of voyage to Tristan da*
48 *Cunha, names of freemen etc.*
- 49 Liengme, C. A. 1983. A survey of ethnobotanical research in southern Africa. *Bothalia* 14:621-629.
- 50 Magwede, K., B. E. van Wyk, and A. E. van Wyk. 2018. An inventory of Vhavenḁa useful plants.
51 *South African Journal of Botany*.
- 52 McCracken, D. P. 1986. William Keit and the Durban Botanic Garden. *Bothalia* 16:71-75.
- 53 Milton, S. J. 2004. Grasses as invasive alien plants in South Africa. *South African Journal of Science*
54 100:69-75.
- 55 Olivier, H. J. A. 1938. Manipulation of ostrich feathers. *Farming in South Africa* 13:121.
- 56 Reid, A. 1910. Experiment farm reports : central experiment farm. *Natal Agricultural Journal* 14:327-
57 333.
- 58 Sawyer. 1909. Division of agriculture and forestry notices: Report for October, 1909. *Natal*
59 *Agricultural Journal* 13:140-141.
- 60 Simpson, C. B. 1904. Preventive and remedial measures against mosquitoes. *Transvaal Agricultural*
61 *Journal* 2:354-357.
- 62 Spilhaus, M. W. 1966. They Planted the Cape. *Historia* 11.
- 63 Tangye, H. L. 1896. In *New South Africa: Travels in the Transvaal and Rhodesia*. H. Cox.
- 64 Taylor, L. E. 1910. Forestry Section: *Dendrocalamus strictus*- the male Bamboo. *Transvaal*
65 *Agricultural Journal* 8:633-634.
- 66 Terry, G. 1927. Winter rhubarb. *Farming in South Africa* 2:115.
- 67 Thunberg, C. P. 1795. *Travels in Europe, Africa and Asia*, London, UK.
- 68 Vahed, G. 2009. *Indian Muslims in South Africa: continuity, change and disjuncture*. Africa's Islamic
69 Experience. Sterling Publishers Pvt, UK.
- 70 van der Waal, C. S. 1982. Hutbou in Venda. *South African Journal of Ethnology* 5:1-14.
- 71 Visser, V., J. R. U. Wilson, K. Canavan, S. Canavan, L. Fish, D. Le Maitre, I. Nanni, C. Mashau, T.
72 G. O'Connor, P. Ivey, S. Kumschick, and D. M. Richardson. 2017. Grasses as invasive plants in South
73 Africa revisited: Patterns, pathways and management. *Bothalia* 47.
- 74
- 75
- 76

77 **Note S1. Socioeconomic factors of questionnaire respondents**

78

79 **1. Age range (n=81):**

80 18-30: 6.1%

81 31-45: 32.1%

82 46-65: 51.9%

83 65+: 9.9%

84

85

86 **2. Land area classification of where respondents are located (n=76):**

87 *Land area classification was determined by overlaying the coordinates given by the*
88 *respondents with the population density map for Africa in 2000 (Nelson 2004). The*
89 *population density per square kilometre data was extracted for each coordinate using*
90 *ArcGIS maps. If the respondents were located in areas with a population greater than 400*
91 *people per km² the area was classified as urban or peri-urban, and less than 400 was*
92 *classified as rural or semi-rural. The classification boundaries are based on the definitions*
93 *from Statistics South Africa (2003) and Atkinson (2014).*

94

95 Urban/ peri-urban: 51.3%

96 Rural/ semi-rural : 48.7%

97

98

99

100 **References for Note S1**

101

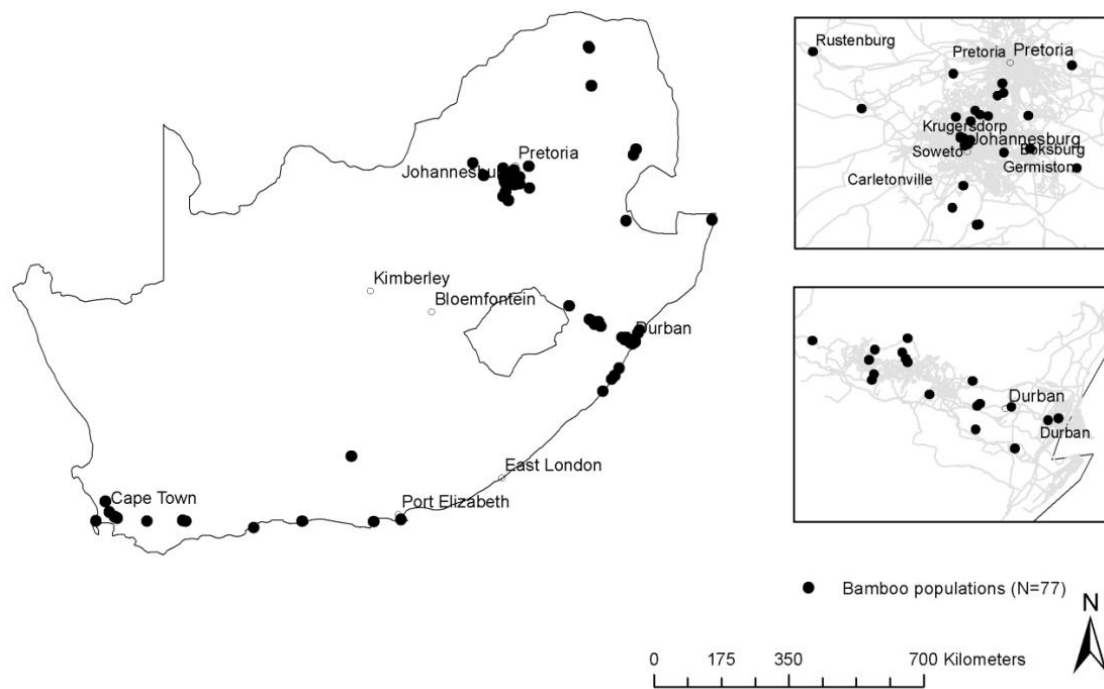
102 Atkinson, D. 2014. Rural-urban linkages: South Africa case study. Territorial Cohesion for
103 Development Program. Rimisp, Santiago, Chile.

104 Nelson, A. 2004. Population Density for Africa in 2000.in U. G. S. Falls, editor., UNEP/GRID Sioux
105 Falls, SD, USA.

106 Statistics South Africa. 2003. Census 2001: Investigation into appropriate definitions of urban and
107 rural areas for South Africa: Discussion document. Pretoria: Statistics South Africa.

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111

112 **Fig S1.** Localities of questionnaire respondents with bamboo on their property (n=77) were received
 113 for all South African provinces except the Northern Cape (three sites were excluded as locality
 114 information was not provided). Many responses were received from urban areas, especially Durban
 115 and Johannesburg.

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