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People's knowledge and perceptions of *Trachycarpus fortunei* (Chinese windmill palm) invasions and their management in Ticino, Switzerland

Micol Genazzi[1,2], **Antoine Guisan**[1,3], **and Ross T. Shackleton**[2,4,5]

[1]Institute of Earth Surface Dynamics (IDYST), University of Lausanne, Geopolis, CH-1015 Lausanne, Switzerland
[2]Institute of Geography and Sustainability, University of Lausanne, 1015 Lausanne, Switzerland
[3]Department of Ecology and Evolution (DEE), University of Lausanne, Biophore, CH-1015 Lausanne, Switzerland
[4]Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Stellenbosch, South Africa
[5]Swiss Federal Institute for Forest, Snow and Landscape Research, WSL, Zürcherstrasse 111, CH-8903 Birmensdorf, Switzerland

Correspondence: Ross Shackleton (rtshackleton@gmail.com)

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Abstract. The introduction of alien plant species can lead to biological invasions, which have major impacts on people and the environment. *Trachycarpus fortunei* (Hook.) H. Wendl. (Arecaceae) is an alien plant (palm tree) that has been introduced as an ornamental into urban areas across the world, but in many regions, it has started invading forests and other natural environments leading to negative impacts. To improve understanding and guide management, this study sought to assess people's knowledge and perceptions of *T. fortunei* in Ticino, the region in Switzerland where invasions of the species are most common. To achieve this goal, an online survey was conducted, and a total of 487 responses were received. The formal name(s) (scientific or common names) of *T. fortunei* were unknown to almost all participants (89 %), and people mostly just called them "palm". Most respondents were familiar with the term invasive alien species (IAS) (88 %) and were aware of the invasiveness (spread) of *T. fortunei* (73 %). The study showed that although people like to see the palm in the region (51 %) and enjoyed the related sense of place it provides, respondents have become aware of the challenges associated with invasions and the majority (65 %) would like to see more done to control the spread of *T. fortunei* invasions within natural areas, particularly forests. To improve management, a large number of respondents (63 %) mentioned that education and awareness programmes should be implemented to provide people with knowledge on how to deal with invasive alien plants and thus prevent further spread. Almost a third of respondents supported (32 %) the regulated sale of *T. fortunei* in an effort to reduce invasions. Educational level, gender, and age affected response patterns, and this needs to be accounted for within strategic management planning, in particular, within education and awareness-raising initiatives. Tailored and targeted educational campaigns and management plans need to be established to prioritise and improve control of this invasive palm in Switzerland in the long term.

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1 Introduction

Biological invasions arise through the human-mediated movement of species beyond their natural biogeographic areas (Richardson et al., 2000). There are several different pathways of introduction and they can be intentional and/or accidental (Hulme, 2009). A key pathway for the introduction of IAS, particularly plants, has been through ornamental trade centred around the world's urban areas (van Kleunen et al., 2018). Globally, a small proportion of introduced alien species naturalise (reproduce in their new location unassisted by humans) and a subset of these naturalised alien species become invasive (spread uncontrollably over large areas in their introduced range) (Richardson et al., 2000). Invasive alien species (IAS) can cause a wide range of negative environmental and socioeconomic impacts (Jeschke et al., 2014; Blackburn et al., 2014; Bacher et al., 2018), such as altering biodiversity and ecosystem processes, and harming human livelihoods and wellbeing (Pejchar and Mooney, 2009; Vilà et al., 2011).

Social–ecological information about biological invasions is critical for improving understanding and management-related decision-making to reduce their long-term impacts (Barney et al., 2013; García-Díaz et al., 2021). Although many studies have been carried out to assess the effects of IAS, there are still issues with data deficiency for most species (Evans et al., 2016; Volery et al., 2021). Additionally, invasion science research has traditionally focused on categorising and quantifying ecological impacts and processes, and focussed less on the social dimensions of invasion science (Vaz et al., 2017; Abrahams et al., 2019; Shackleton et al., 2019a, b). However, increasingly research approaches that assess local knowledge, attitudes, perceptions, behaviours, and the broader social–ecological dimensions of IAS are being used to gather evidence to guide decision-making and improve understanding (Marshall et al., 2011; Lindemann-Matthies, 2016; Kapitza et al., 2019; Potgieter et al., 2019; Shackleton et al., 2019a, b). For example, past research has shown that knowledge and perceptions can vary greatly among stakeholder groups and people with different social–demographic backgrounds (e.g. differences according to gender (Lindemann-Matthies, 2016), income levels (Shackleton and Shackleton, 2016), across people living on rural to urban gradients (Novoa et al., 2017), educational levels (Eiswerth et al., 2011, Jubase et al., 2021), cultural and linguistic backgrounds (Tonellotto et al., 2022)), and understanding of this could help to develop targeted awareness campaigns to help reduce the spread or impacts of invasive species.

Social–ecological research is especially pertinent for IAS that have both benefits and costs leading to potential conflicts between different stakeholder groups (Dickie et al., 2014; Zengeya et al., 2017; Novoa et al., 2018). This is true for the popular invasive ornamental palm *Trachycarpus fortunei* (Hook.) H. Wendl. (Arecaceae) which provides both benefits and costs where it is invasive (Fehr and Burga, 2016; Tonelletto et al., 2022). The fact that the exotic beauty of *T. fortunei* is appreciated by some but its invasiveness and associated impacts are disliked by others might lead to conflicting perceptions of the palm. This makes quantifying knowledge, perceptions, and potential conflicts important for guiding decision-making and management of this invasive plant in the future.

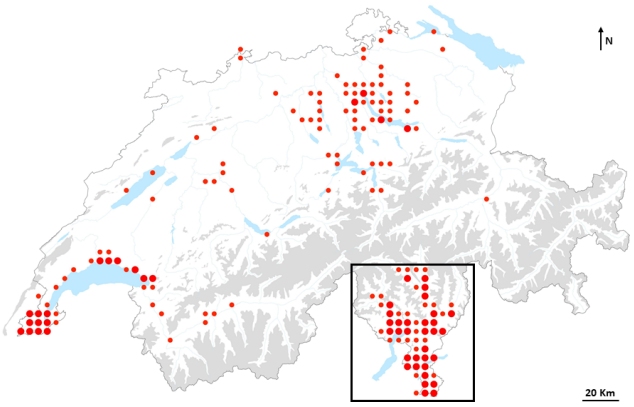

Figure 1. The occurrence of *Trachycarpus fortunei* in Switzerland, and within the study area Ticino (the black box). Red circles represent number of *T. fortunei* observations recorded in Infoflora. Larger circles represent sites with more than 10 occurrences within a 5 × 5 km Alas layer grid, and smaller circles are areas with fewer than 10 observations. Source: infoflora.ch (Info Flora/GEOSTAT/Swisstopo produced on 26 July 22; https://www.infoflora.ch/en/flora/trachycarpus-fortunei.html, last access: 26 July 2022).

Therefore, this paper aimed to better understand and quantify people's knowledge and perceptions of *T. fortunei* in Ticino, the region in Switzerland where invasions of the palm are the most prevalent. More specifically, we aimed to (1) understand if people in Ticino are aware of *T. fortunei's* invasiveness, (2) assess their perceptions of the impact of this invasive palm, (3) evaluate support for the management of *T. fortunei*, and (4) assess whether people's social–demographic backgrounds affect their knowledge and perceptions of this IAS.

2 Methods

2.1 Study site and species

The study was conducted in Ticino, the Italian-speaking region of Switzerland, located in the south of the country (Fig. 1). The primary climate of Ticino (southern side of the Swiss Alps), is different from the north of the Swiss Alps, and has hotter summers and milder winters, although there is high variability in temperatures between seasons and altitudes (Fehr and Burga, 2016). Mean annual precipitation (1600–2600 mm) and temperature (3–12 °C) have large ranges based on altitude (Pezzatti et al., 2009). The

warm climates in the lower lands of Ticino can facilitate the growth of alien subtropical plant species, and this is the case for *T. fortunei*, which is native to southeast Asia (Fehr and Burga, 2016). *Trachycarpus fortunei* is increasingly becoming common in lower land forests of Ticino which are dominated by the broadleaf trees *Castanea sativa* and *Qercus* species, followed by *Fagus decidua* at mid-elevations (900–1400 m a.s.l.) (Pezzatti et al., 2009).

In Switzerland, Ticino is often described as a land of contrasts, where you can find snow and palm trees in the same place (Fig. 2) making it a very popular region for tourism. In summer, introduced palm trees provide the ideal atmosphere for an exotic, "Mediterranean type" feeling within Switzerland (https://www.ticino.ch/en/travel-inspirations/winter-walks.html, last access: 5 March 2022), and during the building and tourist boom of the 1960s and 1970s, *T. fortunei's* exotic feel was exploited to the full where it was planted as an ornamental in many areas. As a result, the palm became closely associated with Ticino and now *T. fortunei* is often called the "Ticinese" or "Ticino" palm even though it is not indigenous to the region (Dipartimento del territorio, 2020).

Trachycarpus fortunei, commonly known as Chinese windmill palm, grows in moist woodlands in the transition zone between deciduous woodlands and warm temperate forests in its native range in southeast Asia (Riffle et al., 2012). The palm is named after the Scottish botanist and explorer Robert Fortune, who in 1844 was the first person to introduce the palm into Europe, bringing hundreds of plants from China to England. From England, *T. fortunei* was spread throughout Europe where it remains a popular and exotic ornamental plant to this day (Fehr and Burga, 2016). In its native range, *Trachycarpus fortunei* grows easily at high altitudes, up to 2400 m a.s.l., tolerates large temperature ranges, and thus grows well in regions with warm and wet summers and cold winters. *Trachycarpus fortunei* also tolerates a large range of soil types (Feng et al., 2020). Being a perennial and evergreen plant, *T. fortunei* can make the most of all growing seasons, allowing it to outcompete native deciduous understory forest species in Switzerland and in other temperate regions where it has been introduced (Fehr and Burga, 2016). Female *T. fortunei* palms can produce up to 10 000 seeds per year, which can either be dispersed by gravity or by birds and mammals. Many of these traits promote the establishment, spread, and invasiveness of this palm.

In addition to Switzerland, *T. fortunei* has also become naturalised in several regions of the world where it has been introduced, including Canada, Chile, Ecuador, England, Spain, Italy, Turkey, and the United States. In addition, it is considered as an IAS in Australia, France, Japan, and New Zealand. The first specimens of *T. fortunei* were likely imported to Switzerland in the 17th century, but this remains speculative. More detailed records discuss that it was promoted in Ticino in the second-half of the 19th century when the Russian baroness Antoinette de Saint Leger added it to her collection of exotic plants on the Brissago islands (Fehr and Burga, 2016; Tonellotto et al., 2022). In the 1960s, self-seeding in parks and gardens in the nearby semi-natural areas (naturalisation) was observed (Conedera et al., 2018). Since the 1980s, naturalised adult plants have been recorded in forest margins away from planted palms, and the first invasions within forests were recorded in the 2000s (https://www.infoflora.ch/en/, last access: 1 May 2021) (Fig. 2). This suggests substantial invasion lag times for this palm species (Cooks et al., 1999; Rouget et al., 2016), like many other invasive species, but also that climate change may be speeding up invasions of *T. fortunei* in Ticino (Conedera, et al., 2002; Aguilar et al., 2017; Dipartimento del territorio, 2020; InfoFlora, 2020).

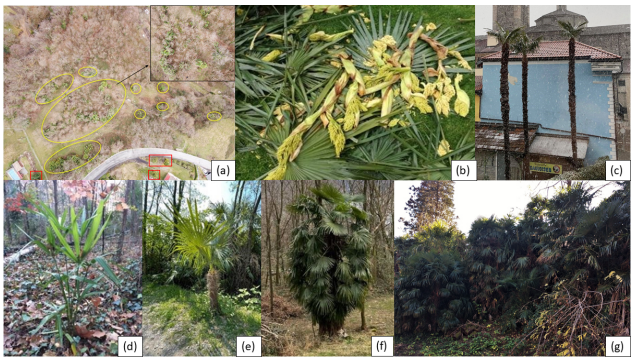

Figure 2. **(a)** A drone photo of *Trachycarpus fortunei* spreading from gardens (red squares) to forest margins (yellow circles) into forests (black box); **(b)** management of *Trachycarpus fortunei* for aesthetic reasons but also for preventing spread; **(c)** *Trachycarpus fortunei* in the snow in Locarno; **(d–f)** different aged, naturalised palms; **(g)** a large invasion near the bank of the Maggia river, Losone (Photos: **(a)** by R. Schira, the rest are by M. Genazzi).

In the last 30 years, *T. fortunei* has spread considerably into natural areas of Ticino and is it now considered as a major IAS in the region (Fehr and Burga, 2016) (Figs. 1 and 2). In Ticino, from 1971 to 2020, a total of 2 362 reports of *T. fortunei* were recorded on Infoflora, probably accounting for over 22 000 individuals (Fig. 1) (see https://www.infoflora.ch/en, last access: 1 May 2021). Of these reports, 66 are classified as sub-spontaneous individuals (i.e. non-cultivated populations), while 185 reports are categorised as cultivated plants confined to gardens. The remaining observations were not classified. Elsewhere in Switzerland, the dispersal and naturalisation of the species outside of gardens has also been recorded, especially in locations with a favourable climate such as lakeshores, riverbanks, and vineyards (e.g. around Lake Geneva/Leman, Lake Lucerne, Lake Zurich, and Lake Zug, and in the Basel region) (Fig. 1) (see https://www.infoflora.ch/en, last access: 1 May 2021).

The impacts of *T. fortunei* invasions in Ticino and globally are not yet fully known and are at times speculative due to limited research on the plant, but dense invasions of this

palm have been found to alter and reduce local biodiversity through competing with native vegetation (Ishii and Iwasaki, 2008; Ishii et al., 2016; Dipartimento del territorio, 2020) (Fig. 2). In addition, it is speculated that *T. fortunei* invasions can reduce the protective function of forests and enhance soil erosion, particularly as a result of the palms reduction herbaceous plant cover and its shallow roots, which can reduce soil stabilisation (Dipartimento del territorio, 2020; Fehr et al., 2020). The highly flammable fibres covering the palm stem pose a fire risk and this could become a major future challenge in the context of climate change (Conedera, et al., 2002; Aguilar et al., 2017; Dipartimento del territorio, 2020; InfoFlora, 2020). The palm, however, remains an excellent source of income through horticulture and tourism, and people greatly appreciate the "tropical" touch that the plant brings to temperate regions (InfoFlroa, 2020). There is also anecdotal information on ecological merits, for example, being a source of food for birds in the winter (InfoFlora, 2020).

2.2 Survey

To investigate people's knowledge and perceptions of *T. fortunei* invasions in Ticino, an online questionnaire survey (Google Forms) was used. The survey was conducted in Italian, the local language of the region (see the Supplement for a translated English version). To reach the widest possible range of people, the survey was shared on popular social media platforms such as Instagram, Facebook, and WhatsApp. The general popular mass media was targeted, rather than dedicated environmentally-related societies or groups, to try and limit a bias of those interested in environmental or botanical issues and to get a sample of the more "general" public (Potgieter et al., 2019). A snowballing approach was used where respondents were asked to share the survey among their peers. The survey ran for just over 2 months, starting in March and ending at the beginning of May 2020 when response rates became saturated. The questionnaire comprised of a mix of 28 open-ended and closed-ended questions with seven key sections. This covered questions relating to (1) information on the respondent; (2 and 3) respondents' knowledge of palms, if they have *T. fortunei* in their gardens, and common practices towards these palms in their gardens; (4) respondents' observations and perceptions about the invasiveness of *T. fortunei*; (5) respondents' perceptions and feelings towards the palm; (6) broader questions surrounding respondents' knowledge of IAS; and (7) respondents' opinions on *T. fortunei* management (see the Supplementary material for the full questionnaire). A total of 487 survey responses were collected from people living in different parts of Ticino. The survey took an average time of 7 min for completion. Ethical considerations relating to informed consent and anonymity were adhered to.

2.3 Data analysis

To assess if people's social–demographic background affects their knowledge, perceptions, and attitudes towards *T. fortunei*, Pearson chi-squared tests were conducted after checking that the core requirements and assumptions were met. This includes that the data are independent and categorical, has mutually exclusive variables, and that value of all cells have expected frequencies of five or greater. When the expected frequency was less than five for any cells, likelihood ratios (LRs) were used for assessment. Chi-squared/LR tests were run to assess the effects of the categorical variables gender (male, female) (analysis using the category "other" was excluded as the sample size was too small), age (18–24, 25–34, 35–44, 45–54, 55–65, >65), and educational level (school, technical/apprenticeship training, bachelor's degree, postgraduate degree) on responses to the following questions which had closed answers of "yes", "no" or "I don't know", and "n/a": *do you like the Fortune/Ticinese palms that you see around you?*; *do you know what an invasive species is?*; *do you think the "Ticino" palm is an invasive plant?*; and *do you think more should be done to combat the spread of palm trees in Ticino?* Please see the Supplement for contingency tables for all significant tests. Responses to other questions were categorised and assessed using simple descriptive statistics. In addition, we draw on qualitative information provided by respondents (a few selected direct comments and quotes (translated form Italian to English)) to provide context and anecdotal evidence.

3 Results

3.1 Demographic profile of the survey respondents

There were more female (66 %) respondents than males. There was a good age representation of respondents: 26 % of respondents were between 18–24, followed by people between 55–65 years old (21 %), 45–54 years old (18 %), 25–34 (13 %), 35–44 (13 %), and >65 years old (9 %). Just over half of people had a technical/apprenticeship training (51 %), followed by respondents with a bachelor's degree (23 %), postgraduate degree (MSc or PhD) (13 %), and 14 % had a school certificate.

3.2 Knowledge, perceptions, and practices associated with *Trachycarpus fortunei*

Almost all participants knew what a palm tree is (99 %). However, most respondents (89 %) were not aware of the real name (scientific or common) of *T. fortunei*, the most common and invasive palm in the region, and simply called it "palm tree". A few people (11 %) knew the scientific and international common names (Chinese windmill palm, Fortune palm or Japanese palm tree) for *T. fortunei*, and a further 6 % replied with "Ticinese" palm, which is the local name of this plant.

Table 1. Respondents' perceptions of the presence of *Trachycarpus fortunei* in their neighbourhood.

Presence of *T. fortunei*	Percentage of respondents (%)
Very common	13
Common	29
Moderate	31
Rare	22
Very rare	5

Under half of people (40 %) had *T. fortunei* in their gardens, and of those that did, the majority had 2–5 palm trees in their garden (61 %). Over half of people (57 %) responded that there were already palms in their gardens when they moved in, while 24 % said that they purposefully planted them. Interestingly, 17 % said that the *T. fortunei* arrived in their garden naturally.

The majority of respondents (90 %) mentioned that there are palm trees in their neighbourhood. Linking to this, people viewed *T. fortunei* as being common (29 %), or moderately common (31 %), with very few perceiving them as being very rare (5 %) (Table 1) in their neighbourhood. Responses highlighted that *T. fortunei* is mostly seen in private gardens (90 %). Furthermore, 58 % of respondents claimed to have seen *T. fortunei* in public parks and urban lakeside areas, while just over half of respondents (54 %) reported having seen naturalised palms in forests. Fewer people (35 %) reported having seen the *T. fortunei* invading along rivers and roadsides in their neighbourhood.

People liked seeing *T. fortunei* in Ticino, with 51 % of the surveyed population indicating a positive attitude towards this question (Table 2). Just over a third (36 %) of survey participants did not like seeing *T. fortunei* in Ticino while 13 % did not express any opinion about it. There were significant differences in opinion among different age groups with people between 45 and 65 years old responding more negatively than other age groups ($\chi^2 = 30.947$; df = 9; $p = 0.009$). People with just a school certificate were also significantly more likely to respond positively to seeing *T. fortunei* in Ticino (LR = 41.173; df = 9; $p < 0.001$) than those with further education. Gender did not have any significant effect on responses.

Table 2. Respondents' perceptions of seeing *Trachycarpus fortunei* in Ticino.

Do you like seeing *T. fortunei* around you?	Percentage of respondents (%)
Yes	51
No	36
Don't know	13

Trachycarpus fortunei induces feelings of "exoticism" in over half of people (60 %), and 20 %–25 % of respondents have a sense of well-being, tranquillity, and peace associated with these palms (Table 3). Fewer people (13 %) associated *T. fortunei* with happiness. For example, in the extra comments, one respondent wrote, "In general, I think they are plants that induce good feelings. From my point of view, they create a feeling of 'lightness' and 'vacation' since they are exotic plants and remind us of the sea." Negative senses and feelings relating to "anger", "unease", and "invasion" were felt by between 6 %–10 % of respondents (Table 3).

The majority (88 %) of survey participants think they know what an IAS is, and 73 % are aware of the invasiveness of *T. fortunei* (Fig. 3). In general, men were more likely to know what an IAS is ($\chi^2 = 4.324$; df = 1; $p = 0.038$) and that *T. fortunei* is invasive ($\chi^2 = 11.04$; df = 2; $p = 0.004$). Age also had significant influence on people's knowledge of IAS ($\chi^2 = 15.936$; df = 5; $p = 0.007$) and on knowledge that *T. fortunei* is invasive (LR = 36.044; df = 10; $p < 0.001$). Middle-aged and older respondents were more aware of the concept of IAS and that *T. fortunei* is invasive. There were no significant differences between education and awareness of the concept of IAS, however education level did affect knowledge on whether *T. fortunei* is invasive ($\chi^2 = 23.136$; df = 6; $p = 0.001$). Respondents with just a school certificate were less aware than those with further education. Interestingly, most respondents associated "invasiveness" with spread in their definitions and less commonly mentioned words to do with impact. When asked more specifically about what impacts IAS cause, most respondents associated impact with biodiversity and ecosystems, and less so impacts on economies, agriculture, and infrastructure.

The negative effects related to *T. fortunei* mentioned by some participants include the fact that "the plant is now found everywhere, and that it is ugly to see it growing in place of local trees and chestnuts". One forester who responded to the survey ladled *T. fortunei* invasions as "a very

Table 3. Respondents' senses and emotional responses towards *Trachycarpus fortunei*.

T. fortunei gives me a sense of	Percentage of respondents (%)*
Exoticism	60
Tranquillity	25
Wellbeing	20
Peace	20
Not sure/don't know	15
Happiness	13
Anger	10
Unease	8
Invasion	6

* Some respondents gave multiple answers. Only terms reported by 5 % or more respondents are included in the table.

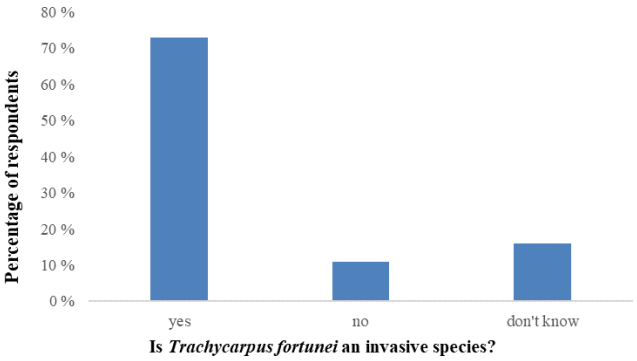

Figure 3. Respondents' knowledge on whether *Trachycarpus fortunei* is an invasive plant?

serious problem". He mentioned seeing invasions daily and discussed that the palm continues to increase in cover within low and medium altitude forests, and was particularly upset to see palm trees growing spontaneously even at altitudes of 800 m. This person was also annoyed by the carelessness with which the problem is perceived and dealt with. Another participant discussed that while clearing his vineyard, he had to uproot more than a hundred *T. fortunei* seedlings and despite this, there are still some palms present and they continue to germinate. A few respondents are angry at the lightness with which the problem is perceived by people, and one person complained about the association of Ticino with the non-native *T. fortunei*, and they would like to put an end to this association. Others have a general distaste towards the plant with one respondent saying, "Besides being invasive, they are also insignificant, I know it's not nice to say it but I call it stupid plant!" A few respondents also specifically mentioned that they preferred native biodiversity; "Better to have other 'more local' plants", and, "Here in the woods above Ronchini, it is really painful to see all these palms growing in place of the chestnuts and other local trees, and it makes me angry every time I walk around the woods behind the house." Others were concerned with the impact of invasive *T. fortunei* palms on local biodiversity; the "problem is underestimated a bit at all levels, and the consequence is that we will gradually change woodlands up to now formed by native species that are unable to compete with the strength with which the palm tree expands." One respondent was even concerned about the effects the palm can have on agriculture and ecosystem services; "serious problem for humans due to the changes in the soil composition which puts agriculture in difficulty, and the loss of other types of plants that help maintain the structural integrity of hills which helps in preventing landslides and various floods".

Some survey participants also mentioned direct and indirect ecological benefits of *T. fortunei*, such as providing useful filaments for birds; "birds use the 'threads' of the trunk to make nests". Quite a few respondents also liked the omental nature of the palm and the sense it brings to Ticino: "Beautiful, decorative, and typical of the area"; "Sorry but I still love them"; "There is in the communal garden and I like it so much", "I like them and it's wonderful to photograph them, especially with the lake behind"; and "I am sorry that it is an invasive plant, but I personally like them and they are part of the Ticino image. However, it is important to keep their spread under control".

3.3 Attitudes toward management of *Trachycarpus fortunei*

Of the people who responded that they have at least one *T. fortunei* in their garden, most said they managed them (84 %), while a small proportion (16 %) responded they are not managed at all. People who managed their palms commonly did so 1–2 times a year (89 %) mainly for aesthetic reasons but also to control spread, while very few respondents reported that they managed them 3–4 times a year or more (11 %). *Trachycarpus fortunei* is most commonly managed in gardens by cutting off old leaves (87 %) (for aesthetic reasons), and removing fruits and inflorescences (68 %) (Fig. 2b for a visual illustration), while less than half of people (45 %) removed seedlings.

More than half (65 %) of respondents thought that more should be done to manage *T. fortunei* invasions (Figs. 2 and 4) with one respondent noting, "Something really needs to be done … there are too many". In particular, men were significantly more likely to support management than women ($\chi^2 = 6.538$; df $= 2$; $p = 0.038$), with no significant differences for age or education level. Most respondents supported better prevention and management campaigns by the Ticino canton (63 %), and one respondent specifically noted, "Municipalities should do more to prevent the spread of invasive plants". Respondents (61 %) also supported the need for campaigns to inform and educate the Swiss population about *T. fortunei* invasions with a respondent saying, "Personally, I was not aware of all this, certainly information is one of the simplest methods to avoid the presence of these invasive plants and make the population aware of the important risks it can cause." Fewer people supported forcing people to manage *T. fortunei* in their gardens (40 %); "Those who do not remove the seeds of the palm trees must be fined". Another control option supported by about a third of respondents (32 %) was to prevent the sale of *T. fortunei* palms or regulate their sale under precise management conditions (Table 4). A couple of participants specifically suggested that it would be better to promote the planting of other non-invasive palm species instead of *T. fortunei*. Some respondents accepted that they were okay to have in human-modified areas but need to be managed in natural areas; "They are acceptable in gardens but should be eradicated from the forest".

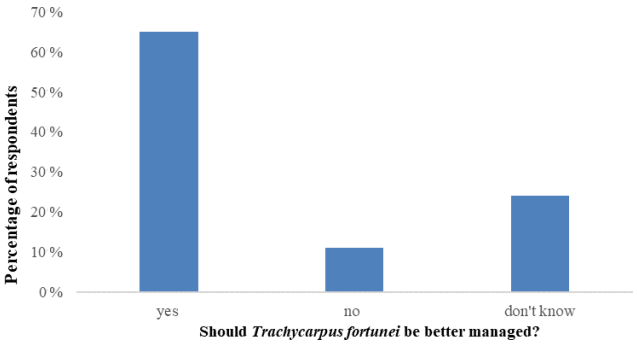

Figure 4. Respondents' perceptions relating to whether *Trachycarpus fortunei* should be better managed in Ticino.

Table 4. Respondents' perceptions and attitudes on how *Trachycarpus fortunei* should be managed.

Respondents' attitudes to different management options	Percentage of respondents (%)*
The canton should develop an appropriate prevention and management strategy	63 %
Better inform people on the threats and management of *T. fortunei*	61 %
Oblige people to manage *T. fortunei* in their gardens to prevent spread into the wild	40 %
Ban the sale of *T. fortunei*	32 %
There is no need to manage *T. fortunei* in any way	7 %
Other responses	6 %

* Some respondents gave multiple answers.

4 Discussion

In Ticino and other parts of Switzerland, *T. fortunei* is considered invasive with the potential to induce high negative threats; despite this, it is still liked for aesthetic reasons by some people (Tonellotto et al., 2022). Climate change is likely to exacerbate *T. fortunei* invasions into the future (Walther et al., 2007; Fehr and Burga, 2016; Petitpierre et al., 2016), and this could pose great challenges for people and the environment moving forward. Better understanding people's knowledge and perceptions of IAS, especially charismatic species that have the potential to create conflicts between actors, is important to guide decision-making with regard to IAS policy and management (Dickie et al., 2014; Novoa et al., 2018; Jarić et al., 2020).

Our results surprisingly highlight that despite people's positive attitudes and feeling toward *T. fortunei* in Ticino (Table 3), people want to see a decrease in the abundance of this invasive palm, and support management in natural and semi-natural areas where it is invading, and regulations and campaigns to help mitigate future invasions. As compared to other regions of the world, in this case, people in Ticino seem to be slightly more aware of the concept of IAS, in particular men and those with higher levels of education (Shackleton and Shackleton, 2016; Novoa et al., 2017; Clusa et al., 2018; Jubase et al., 2021). Interestingly in this case, people associated invasiveness with spread and less so with impact, which is quite different from other studies (e.g. Nguyen et al., 2020). The results of this study build on previous research and show how IAS can have nuanced perspectives, but in this case the potential conflicts around management may be less of an issue as compared to charismatic plant species elsewhere in the world (Dickie et al., 2014; Zengeya et al., 2017). It also builds a growing body of literature whereby people's perceptions are being quantified to better understand invasion dynamics, impacts, and guide management initiatives of IAS (Kapitza et al., 2019; Shackleton et al., 2019a). There were strong opinions on what local people thought was the best way to control the invasive palm (Table 4), and these opinions should be considered in future management strategies, especially to build trust with the public (Wald et al., 2019). Similar to other findings across the globe (e.g. Lindemann-Matthies, 2016; Eiswerth et al., 2011, Jubase et al., 2021), we also highlight that socio-demographic factors can influence people's knowledge and perceptions, and this is important to consider in awareness raising and management campaigns.

Moving forward, ornamental plant species like *T. fortunei* and others need to be better regulated in Switzerland and elsewhere in the world. Ornamental trade is a common pathway for the introduction of invasive plants (Hulme et al., 2018; Beaury et al., 2020), and better regulations and codes of conduct could help to mitigate the impacts of these species in the long term. Rules and regulations should be backed up by scientific evidence and risk assessments (Gordon et al., 2008; Conser et al., 2015), and public support for management as shown in this study. In the case of *T. fortunei* in Switzerland, a simple solution to this would be to focus on selling and replacing existing *T. fortunei* with other non-invasive palms after conducting reliable risk assessments (Conser et al., 2015). Awareness campaigns about buying and planting non-invasive palms would be needed to promote behaviour changes (Verbrugge et al., 2014; Sharp et al., 2017; Cole et al, 2019). With regards to *T. fortunei* in Ticino, Tonellotto et al. (2022) show that simple awareness raising strategies related to providing information on the negative impacts of the invasive palm is enough to change the attitudes and perceptions of most people to be more negative towards them. The same authors also show that people were highly accepting of many potential substitute species that could replace *T. fortune* for ornamental planting. For ex-

isting palms in gardens, regular maintenance, for example the correct removal of the yellow panicle inflorescences or young seeds during May before mature fruits are produced (Dipartimento del territorio, 2020), should be conducted along with meticulous disposal of the seeds once they have been cut. This will help to reduce propagule pressure and spread from gardens into natural and semi-natural areas. Economic incentives could be instituted and may also lead to better bottom-up enforcement and greater public support (Pejchar and Mooney, 2009).

For invasive populations in semi-natural and natural areas, different methods should be adopted to promote the control of *T. fortunei*. People from Switzerland generally prefer seeing *T. fortunei* less in natural areas as compared to gardens which should increasing acceptability of control in more natural settings (Tonellotto et al., 2022). It is important to start this as soon as possible to mitigate social–ecological impacts in the long term, which could become more prominent with climate change (Walther et al., 2007; Aguilar et al., 2017). Monitoring programmes are needed to understand spread and occurrence, and to set up early detection rapid response management for new invasions (Wilson et al., 2013). Research, monitoring, and awareness-building of IAS distributions to relevant local authorities has helped to promote effective management of IAS in Switzerland in the past, as seen in the case of *Heracleum mantegazzianum* in Vaud (Shackleton et al., 2020). Species distribution models (SDMs) (Guisan et al., 2013) have already been carried out for *T. fortunei* on a coarse scale (Walther et al., 2007), and more detailed models would be a powerful tool to prioritise sites for monitoring and eradication in Switzerland (Descombes et al., 2016; Petitpierre et al., 2016). Strategies to remove larger invasive patches across Switzerland are needed, and sites should be prioritised to make the most of limited time and resources (Forsyth et al., 2012). In particular, areas where erosion is high should be a key focus for management (Fehr et al., 2020). As illustrated in Japan, replanting native species where invasive *T. fortunei* have been removed in natural sites could also promote long-term restoration and the success of management initiatives (Ishii and Iwasaki, 2008; Ishii et al., 2016). Further restoration trials and research could help to identify best practices moving forward.

Data availability. Anonymous data can be provided. Please contact the corresponding author for this.

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