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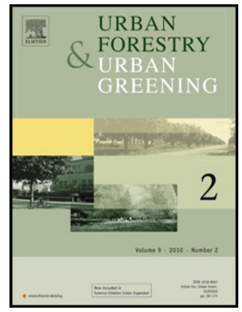

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Relations Between Cityscape-Related and Palm-Inherent Variables and the Pruning State of Urban *Arecaceae* Suggest Three Reasons for Overpruning

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Highlights

- Various factors possibly related to overpruning of palms were analysed
- Palm height and distance to closest object are related to the pruning state
- Beside cityscape-related and palm-inherent factors, human component affects pruning
- Personal taste, misinformation and economic reasons need to be considered

ABSTRACT

In warmer climates palms (*Arecaceae*) are commonly found in city environments, planted mainly for the purpose of landscape beautification. Overpruning these palms can have negative side-effects, which reduce the health and therewith the aesthetical value of the plant. Despite this, it is not uncommon to see palms in cities that had too many of their fronds removed. This study aimed to find relations between various factors, such as ‘species’ or ‘distance to the closest road’, and the pruning state of *Arecaceae* in the study city Olhão (Portugal) in order to suggest reasons for the continued existence of this practice and approaches to reduce its prevalence. Only two factors, ‘height’ and ‘distance to the closest object’, showed the same relations with the pruning state for the three most common species and should therefore be the first to address in order to reduce overpruning. Data analysis proposes three underlying reasons, personal taste in relation with misinformation, improper choice of species for available planting sites, and economic factors as most likely to be responsible for widespread overpruning. While the latter is difficult to address, implementing educative measures to inform relevant personnel about the negative side-effects and better species-site matching could show fast and cost-efficient improvements in the reduction of the practice of overpruning and therewith the danger of reduced aesthetic value of *Arecaceae*, undermining the purpose of their original planting.

Keywords: *Chamaerops humilis;* crown; leaves; *Phoenix canariensis;* removal*; Washingtonia robusta*

INTRODUCTION

Urban palms tend to be planted mainly for aesthetic purposes, as they do not provide many of the highly valued services of urban trees or at considerably lower levels (e.g. McPherson et al., 2005; Vargas et al., 2007). Their distinct appearance, however, makes them a generally suitable choice for landscape beautification, where the focus then should be on keeping them healthy, offering the best possible growing conditions and avoiding maintenance operations which could have negative side-effects.

A commonly carried out arboricultural practice is that of removing whole fronds, a practice which has some need in city environments e.g. to reduce liability issues or the danger of fire. An excessive removal of leaves, however, referred to as overpruning, is advised against in the academic literature for its many possible negative side effects. These have been reviewed by Rosenfeld (2009), mentioning e.g. the increased spread of symptoms of potassium deficiency and faster rates of plant decline where older leaves on deficient palms are removed (Broschat, 1994), thereby severely impacting the health of the plant and decreasing its aesthetical value and life span. Besides effects on the nutrient composition of the leaves, overpruning can also have negative effects on the structural integrity of the palm as older leaves support the younger, immature ones, reducing the likelihood of the crown failing in high winds (Calvez, 1976; Chan and Duckett, 1978). Further reasons against overpruning, and pruning more generally, are related to the risks of spreading diseases, such as *Fusarium oxysporum*, which is spread through the use of contaminated pruning tools (Feather et al., 1979), or palm decline due to *Rhynchophorus ferrugineus* (Oliv.) (Coleoptera: Curculionidae), the Red Palm Weevil. The latter one present in the study area, where it could be observed on or next to several palms, possibly attracted to them by chemicals emitted from remaining leaf bases or pruning wounds (Broschat, 2011). In addition to these problems, an extensive removal of fronds decreases the value of palms in a wider, landscape-related context where overpruning palms is not just questionable from an aesthetic point of view but does also reduce the amount of shadow produced by the crown while further impairing the plants' leaf area related functionalities, such as the absorption of gaseous pollutants. Recommendations are, that "no leaves with tips above the horizontal plane (9:00 to 3:00 positions on a clock face) should be removed" (Broschat, 2011). Despite this consensus in the academic world, palms in cities continue to be overpruned, sometimes severely (Fig. 1).

Insert Fig. 1 here

Information on the extent of overpruning of palms in city environments is lacking and with this, data on possible connections between the pruning state of the crown and various factors encountered in city environments related to urban green planning and management.

Besides quantifying the amount of public, overpruned *Arecaceae* in the study site, this study aimed at considering cityscape-related and palm-inherent variables and their possible relations with an increase or decrease in leaf removal. Knowledge ultimately usable to inform the development of effective strategies to reduce this practice and negative side effects, which can result in a decreased aesthetical value and premature death of the palms.

METHODS

Study Site

Olhão is a coastal city, located at around 37° 2' N and 7° 50' W, in the south of Portugal (Algarve Region), about 10 km to the east of Faro, the region's capital. The city has 14.914 inhabitants (INE, I.P, 2011), covering an area of approximately 12,25 km^2 (Eurostat, 2011).

According to the Köppen-Geiger climate classification, it is a Csa type (dry-summer subtropical or Mediterranean)(Peel et al., 2007) with mean temperatures above 10° C during the whole year and above 15° C from March/April to November. Mean monthly rainfall in the area is below 5 mm between June and August and highest from October (60.1 mm) to February (52 mm). The maximum daily amounts can reach more than 150 mm in October, but are less than 100 mm throughout the rest of the year (Instituto de Meteorologia, IP Portugal).

Data Collection

In April and May 2012 data were collected on all public, urban palms (n = 904) within the city boundaries of the study site. Individuals were determined to species level and the following additional information was collected:

Location

The palms' locations were recorded with a GPS device (eTrex H, Garmin, Schaffhausen, Switzerland).

Overall Height

Overall heights were measured using a clinometer (Pm-5/360 PC, Suunto, Vantaa, Finland) for higher palms or a measuring tape (20 m by 13 mm, Fischer-Darex, Le Chambon-Fegeurolles, France) for smaller ones. Vertically upwards growing spear leaves were excluded, however, as this could overestimate overall palm height, using the highest point on the next youngest leaf, which already moved to a more horizontal position, instead. Results were rounded to the closest 5 cm-step and only determined for the highest stem/crown of multi-stemmed individuals.

Number of Objects

The number of above-ground structures in a 4 m radius from the palm's stem was counted, the ground distance to the closest object measured and recorded to the closest 5 cm-step.

Size of Closest Object

The size of the closest object was classified in relation to the extent of the respective above-ground structure. Poles, street lights, street signs and other minor objects were considered to be 'small', more substantial objects like trees or palms to be 'medium' and houses, walls and large advertisement boards were categorized as 'large'. The categories were open, so that e.g. bigger trees could also be classified as 'large'.

Existence of Obstacles

For the three most common species in the study site, a growing space was defined based on half the crown diameter large, mature palms can reach (Riffle, Craft and Zona, 2012; Broschat, Hodel and Elliott, 2014), rounded to the closest 10 cm-step (Table 1). An above-ground structure located inside this radius can turn into an obstacle, possibly leading to a direct contact between the palm and the obstacle. The presence of such an above-ground structure was noted with ‘yes’, the absence as ‘no’.

Insert Table 1 here

Distance to the Closest Road

The distance to the closest road was measured from the corresponding side of the palm’s stem and recorded to the nearest 5 cm-step if it was less than or equal to 10 m.

State of Pruning

The crown was judged by eye as either clearly overpruned when the shape of the crown was 10 to 2 o’clock or above (Fig. 2) or as clearly not overpruned when the shape of the crown was an 8 to 4 o’clock shape or below (Fig. 3). A preliminary ‘?’ was recorded for those palms, where the leaf tips of the lowest leaves fell between the two other shapes (Fig. 4). The 9 to 3 o’clock imaginary reference line crosses the palm´s stem on the height of the lowest leaf bases. In determining the pruning state, the different sides of the crown were taken into consideration, rating a palm as overpruned if more than 1/3 of it had too many of its leaves removed, even when the leaf tips on the remaining parts of the crown were below the horizontal line, taking symmetry into account. The leaf tip of the leaflet at the end of the rachis or in the centre of the frond was used to determine the pruning state, the nearest healthy leaflet was chosen when it was damaged. In multi-stemmed individuals, the main crown was examined and the removal of whole stems excluded from the study as it is not possible to collect information, useful for the purpose of this study, on absent stems and crowns. To determine the reliability of judgement by eye, further information was collected on the

Insert Figs. 2 to 4 here

palms with a preliminary '?'-rating. First, they were rated as overpruned or not, based on the 9 to 3 o'clock scheme after which the heights of three leaflet tips and the respective leaf bases were measured. As a palm could potentially have too many of its fronds removed on only one side, e.g. those close to an object, the procedure outlined below was followed in order to take the symmetry of the crown into account when judging the pruning state. First, the lowest leaflet tip of the whole palm was visually determined and its height and that of the leaf base measured. The remaining two measurements were then taken on the lowest leaflet tips and bases on other sides of the crown, roughly dividing it into three parts. This was done directly with the measuring tape for small palms, noting the results to the closest 5 cm-step, while for taller palms the height was measured with the help of the clinometer.

In the latter case, a laser pointer (MP1000, Velleman, Gavere, Belgium) was used to project the position of the respective leaflet tip onto the ground in order to find the 10 m distance, that was needed to determine the height of the respective tip. The construction consisted of the laser pointer fixed to an extendable pole, normally used to paint walls (A70392, Serie 703, 2 m, Rulo pluma, Barberà del vallès, Spain), on which two pipe air levels (0.5 and 0.75 inches from 350 Pipe Level Set, Kapro, Lake Mills, USA) were attached in a 90° angle to each other. The pointer was focussed on the leaf tip while held straight up so that the base of the extendable stick could be used for the second measurement with the clinometer.

Palms close to roads or large obstacles, as well as those growing on noticeable slopes were excluded from these further measurements, as sufficient space and a flat ground was needed. When the differences between measured average height of the three lowest leaflet tips and leaf bases was less than or equal to 5 cm, the individuals were excluded, as this degree of error can easily be introduced by wind, inconspicuous unevenness of the ground and the clinometer itself. After elimination of the unsuitable palms, only 18 remained for the comparison of eye judgement and the determination of pruning state with the laser construction or measuring tape, which was found to be consistent in all cases. Though the sample was too small for statistical analysis, fast determination by eye of the pruning state in the field seems to produce reliable results even when the measured differences between leaf tip and leaf base were as small as 6 cm, supporting the use of data from eye judgement for further analyses.

DATA ANALYSES

Data were analysed using the statistical software 'R' (R Development Core Team, 2012), testing for significant connections between 'pruning state' and the remaining variables for the three most common species in the study site.

Non-parametric tests were used in all situations, as the visual examination of the continuous variables, i.e. 'height' and 'distance to the nearest road', led to the conclusion that the distribution deviated too much from a normal distribution to use parametric tests. Mann-Whitney U (MWU) tests were used to compare two groups (overpruned and not overpruned palms). Pearson's Chi-squared (PCS) test was used for categorical data. Fisher's Exact (FE) test for 2 x 2 tables and the Fisher-Freeman Halton (FFH) test for bigger cross tables if an observed number was zero or more than 20 % of the cells had an expected number smaller than 5. The latter one was calculated employing the Monte Carlo method, based on 1'000'000 replicates.

RESULTS and DISCUSSION

STUDY SITE SITUATION

A total of 904 public palms were found to be growing in Olhão at the time of data collection being spread throughout the whole city but found in larger numbers along the waterfront in the south and in so-called *urbanizações*, larger-scale housing developments, in the north-west and south-west corner and around the center of the urban area (Fig. 5). **Insert Fig. 5 here**

Out of eight palm species identified in Olhão only three were common enough to be considered separately for further statistical analysis, including *Phoenix canariensis* Chabaud (*Ph. canariensis*, n = 356), *Chamaerops humilis* L. (*Ch. humilis*, n = 116) and *Washingtonia robusta* H. Wendl. (*W.*

robusta, n = 393). Of those palms, eight, two and five individuals, respectively, were excluded from further testing as there crowns were caught in other trees, preventing their pruning states to be judged.

Pruning and...

<u>Species</u>

Regarding the pruning state of the three *Arecaceae,* more *Ph. canariensis* and *Ch. humilis* palms than expected were overpruned, with the opposite holding true for *W. robusta*. Examining relative numbers, about 70 percent of all *Ph. canariensis*, 80 percent of all *Ch. humilis* palms and 30 percent of *W. robusta* palms had too many of their fronds removed.

Ph. canariensis has pinnate, *Ch. humilis* palmate, and *W. robusta* costapalmate leaves so that frond type alone does not seem to be an explanatory factor. The three species also vary considerably in the possible maximum crown spread mature individuals can reach. The crowns of mature and unpruned *Ph. canariensis* palms can be as much as 8 m wide (Broschat, Hodel and Elliott, 2014) and while excessive leaf removal to reduce the spread could explain the high amount of overpruned individuals, the crowns of *Ch. humilis* palms only reach about 3 m (Riffle, Craft and Zona, 2012), not explaining why the majority of the latter species was also found to be overpruned. The small average height of only 1.1 m of individuals of this species in the study site, as compared to 5.4 m for *Ph. canariensis* and 5.6 m for *W. robusta* might partially explain excessive leaf removal, allowing uncomplicated and cheap access to the fronds to be removed.

The differences of pruning levels between *Ph. canarienis* and *W. robusta*, both with similar average heights and therefore theoretically with the same difficulties and expenses attached, could possibly be related to popular ideas about how *Ph. canariensis* palms should ideally look. One of the common names of this species is ‘pineapple palm’, referring to an individual usually with a still rather short stem and a heavily pruned crown, resembling a pineapple. If this look is proposed and accepted as the desirable one, heavier pruning on this species would result, despite the extra effort needed.

Height

Pruning higher palms is disproportionately more complex than pruning smaller palms. Equipment to reach higher leaves is needed and tools can be unhandy and might interfere with other aspects of city life. Additionally, renting or purchasing heavy equipment is a cost factor, increasing the workforce needed and the time necessary for the pruning operations. In some cases it might not just be less complicated to prune smaller individuals but also necessary, as some species, such as those found in the *Phoenix* genus, feature sharp spines on their petioles which, especially on or close to sidewalks, can be a danger to the public.

The statistical tests showed a relation between height and pruning for all three species, with higher palms being significantly less likely to be overpruned than smaller individuals. This result was not only the case for *Ph.canariensis* (MWU test, N = 348, p < 0.001) and *W. robusta* (MWU test, N = 389, p < 0.001) but also for *Ch. humilis* (MWU test, N = 114, p = 0.002) despite the small average size of this species and the highest sampled individual being only 4.4 m high. In the study site no *Ph. canariensis* palm with more than 9 m (Fig. 6), *W. robusta* with more than 7 m (Fig. 7) and *Ch. humilis* with more than 3 m of height (Fig. 8) had too many of their leaves removed.

Insert Figs. 6 to 8 here

Distance to the Nearest Road

Overpruned and not overpruned palms did not differ significantly with regards to the distance to the nearest road for *Ph. canariensis* (MWU test, N = 232, p = 0.95) and *Ch. humilis* (MWU test, N = 43, p = 0.11), while overpruned *W. robusta* palms were found to grow significantly further away from the road than their not overpruned counterparts (MWU test, N = 261, p = 0.028), including only individuals, with a distance of up to 10 metres. Analysing the geographical distribution of the individuals of the latter species, no clumped appearances of the two pruning states became apparent and neither differed significantly in average heights.

Pruning operations are possibly facilitated if palms are growing further away from the road, usually allowing more easily for the use of heavy equipment, while reducing disturbances to the public. Furthermore, a greater distance to the nearest road is often related to growing in parks or park-like environments, where the visual appearance of the plants is of primary importance. This might lead to increased pruning, if this look is considered more appealing by those responsible for deciding the removal of fronds. While it is possible that one or more of these factors are related to the excessive pruning on *W. robusta* palms further away from the road, the reasons why the other two species show no such connection remains unclear.

Number of Objects

Comparing palms with and without above-ground structures in the 4 m radius around the stem, no connection with the pruning state was found for *Ph. canariensis* (PCS test, N = 348, $X^2 = 0.93$, df = 1, p = 0.34), while significantly more *Ch. humilis* palms with at least one object were found to be overpruned than expected (FE test, N = 114, p = 0.046). This was also the case for *W. robusta*, but individuals with and without an object were differing considerably in average heights (4.85 m and 6.29 m respectively), suggesting that this confounding factor is most likely responsible for the statistically significant results.

Looking at exact numbers of objects and their relation with leaf removal, *Ch. humilis* palms were less likely to be overpruned for up to three objects around and more likely to be so when they had five or more objects in the 4 m radius around (FFH test, N = 114, p <0.001). The results for *W. robusta* were similar, with the only difference being the fact that overpruning was more extensive for four or more objects close-by (PCS test, N = 389, $X^2 = 22.637$, df = 6, p < 0.001). No relation was found for *Ph. canariensis* palms (PCS test, N = 348, X^2= 5.546, df = 6, p = 0.48).

Above-ground structures in proximity of the *Arecaceae* are possibly related to an increased likelihood of overpruning, as the objects might limit the growing space available so that leaves are being removed to protect both the structures as well as the plants from damage.

Distance to Closest Object

Ch. humilis palms up to one metre away from the closest object were overpruned in larger number than expected, and not overpruned in larger number than expected when the closest object was more than two meters away (FFH test, N = 114, p = 0.043). Mature individuals can reach a crown radius of around 1.5 m, a size reflected in the above results.

For *W. robusta* (PCS test, N = 389, $X^2 = 17.326$, df = 4, p = 0.002) a similar connection was found as well, yet lacking the continuous trend seen for *Ch. humilis*, as palms further than four metres away from the closest object were more likely to be overpruned than expected, likely related to the smaller average height of the individuals in this category.

Statistically significant results were also found for *Ph. canariensis* (PCS test, N = 348, $X^2 = 10.393$, df = 4, p = 0.034), but less palms were overpruned than expected in the first distance class to the nearest object, with no height differences possibly explaining this result.

Generally, there seems to be a connection between the extent of frond removal and the distance to the closest object, as leaves might have to be removed in increasing quantities to avoid interference between the above-ground structure and the palm as distances decreased. There are however other factors closely related to this connection, such as the vertical dimension of the crown and the growing speed of the respective individuals.

Existence of Obstacles

Ph. canariensis (PCS test, N = 348, $X^2 = 0.929$, df = 1, p = 0.34) and *W. robusta* (PCS test, N = 389, $X^2 = 0.281$, df = 1, p = 0.64) showed no relation between the presence or absence of an obstacle in the respective growing space and the pruning state. The test was significant for *Ch.*

humilis, with a higher number of palms overpruned than expected, when there was an obstacle present (FE test, N = 114, p = 0.013). The average height of palms with an obstacle however was considerably smaller (0.9 m) than that of palms without an obstacle (1.7 m) so that the statistical significance might be related to the confounding factor of 'height' again.

Distance to the Closest Obstacle

No connection was found between the pruning state and the distance to the closest obstacle for *Ch. humilis* (MWU test, N = 93, W = 382.5, p = 0.067), *Ph. canariensis* (MWU test, N = 258, W = 6016.5, p = 0.17) and *W. robusta* (MWU test, N = 140, W = 2347, p = 0.15).

Size of Object

The size of the closest object was not related to the pruning state of *Ph. canariensis* (PCS test, N = 142, X^2 = 1.9, df = 2, p = 0.39) and *W. robusta* palms (PCS test, N = 95, X^2 = 2.56, df = 2, p = 0.28). No tests could be conducted for *Ch. humilis* due to the small sample size and all objects falling into the medium category.

The Extent of Overpruning

Measuring the state of pruning at only one specific point in time might have led to an underestimation of the extent of this practice However, no repeated measurements were taken as there are no comparisons being made between different study areas, in which case the time passed since the last pruning operation would constitute a crucial factor to be considered. It was disregarded for this study based on the assumption that intra-city variations in terms of 'time since last frond removal' are likely negligible as the study area is relatively small and the persons responsible would favour having to rent heavy equipment for only one short time span. Field observations confirmed this assumption as it could be commonly seen that individuals of the same species with similar heights and growing in close proximity, and thereby comparable conditions, differed in pruning state. This suggests that in this case the one-time determination of pruning state is not problematic and does not invalidate the correlations that were found and the possible reasons that are being suggested for the continuation of this practice below.

Three Likely Reasons for Overpruning in City Environments

The analysis of the data suggests that there are three underlying reasons for palms in the study site to be overpruned. The boundaries between these reasons are not clear-cut and most likely overlap. Drawing lines between them and considering them separately however, allows for an easier and more useful consideration of their planning and management implications.

The first reason for overpruning seems to be related to personal taste in combination with misguided ideas about the state of the art on pruning palms. The individual executing the pruning or instructing others to do so, might favour a specific look of a palm's crown, which by definition is overpruned, unaware of the academic literature arguing against excessive leaf removal. If current management practices of urban palms teaches overpruning of crowns as the appropriate for *Arecaceae* in city environments, the result can be as seen in Olhão, where 54 % of individuals belonging to the three most common species were overpruned and thereby, poorly managed in arboricultural terms. The large amount of *Ph. canariensis* palms that had too many of their fronds removed, despite a large proportion of them being of considerable height and not easily pruned, is a strong indicator of personal taste leading to this practice, as the similarly high *W. robusta* palms were subjected to overpruning significantly less. In the case of *Ch. humilis*, a reason for pruning can be found in it being a multi-stemmed species that can look bushy when left unpruned, yet the prevalence of overpruned individuals hints at a lack of knowledge of the possible negative side effects and advantage being taken of its small average height, facilitating ease of access to and the removal of fronds.

The second reason can be found in the connections between pruning state and variables related to above-ground structures around the palms. Here, a necessity to overprune seems to factor into the arboricultural management. When leaves are in contact with objects, they can become damaged and unsightly, thereby inhibiting the palms ability to offer the service of landscape beautification they were planted for. In these cases, overpruning can be a preventative measure before harm is done or problems have appeared. Additionally, space tends to be a limiting factor in city environments and removing a large amount of leaves can reduce the crown spread of palms, making them fit into spaces, where individuals with full crowns are not an option. The problem with this explanation of overpruning is that the necessity to do so is a perceived one, rather than an actual one, being man-made as the result of an improper choice of species, a suboptimal planting site and the matching between these two.

Finally, economic factors play a role in the extensive overpruning of public, urban palms. Some leave removal is usually necessary in city environments from an arboricultural perspective. Dead leaves need to be removed from *Arecaceae* that are not self-cleaning, not only for aesthetical reasons but also for health and safety issues to avoid them falling in high winds, being a fire hazard or a hiding place for unwanted animals. Proper pruning in these cases would require small pruning intervals in which a very limited number of leaves are removed, being repeated possibly every year. On the first look, this appears to be much more expensive and disruptive to city life than choosing larger pruning intervals. These however often lead to crowns being overpruned with a need for further research to establish if the negative side effects of this eventually costing as much or more as proper pruning in small intervals would have cost.

Applying these results to the arboricultural management and planning of public urban palms, educating people about proper practice and raising awareness about the possible negative side effects, could already reduce the extent of overpruning considerably. This could be done through a simple workshop in a cost and time-efficient manner with prompt and almost immediate effects on the health and healthy appearance of palms.

These educative measures need to be combined with an improved species-site match, reducing the number of palms that are overpruned out of 'necessity'. To develop a framework for matching species to planting sites it will be necessary to investigate relations between their health, their appearance, and various biotic, abiotic and palm-inherent factors acting and interacting in city environments. Additionally, similar studies should be conducted in other cities for the purpose of comparison and to avoid the reliance on only one specific case study, as has been done here, in the formulation of interpretive statements.

The third proposed factor for overpruning, economic reasons, will be the most difficult one to address and change, especially in times when cities are notoriously lacking funds, making a consideration of likely costly results in the future unattractive in the light of a seemingly cost-efficient present planning and management scheme.

CONCLUSION

Some variables, such as 'height', show the same statistically significant relations with the state of pruning for all of the three most common species, while others, such as the 'distance to the nearest road' or the 'number of objects', were found to be related to only one or two of the tested *Arecaceae* species. In city environments the number of factors that can act simultaneously, resulting in a palm being overpruned is high, complicating data analysis and interpretation. In terms of pruning, an extra factor is added, the 'human component', making it necessary to consider the impact of difficult to analyse concepts like 'taste' and financial decisions, which most likely underlie decision-making processes.

The two variables 'height' and 'distance to the closest object' showed the same relations with the pruning states of all three species, appearing to be major factors related to an excessive removal of fronds. Addressing these variables first by educating the public, specifically those directly related to arboricultural practices, about proper palm pruning, consideration of above-ground growing space requirements, and matching species to appropriate planting sites will produce, comparatively, the fastest, largest and most cost-efficient decrease of the number of overpruned palms.

Whatever the specific reasons for an excessive frond removal are, there is agreement upon the fact that this practice has many undesirable side effects, primarily diminishing the health and aesthetic value of individual palms and the urban forest in total. In city environments however, where palms are planted and maintained for a purpose, negative effects of overpruning will ultimately also affect people in various ways, be it as an increased liability issue or financial expenditures on removing and replacing palms, which died or failed their purpose directly or indirectly as a result of overpruning.

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Figure 1. An overpruned *Phoenix canariensis* palm

Figure 2. Schematic depiction of a crown shape with the 10 to 2 o'clock shape or less ('clearly overpruned')

Figure 3. Schematic depiction of a crown shape with the 8 to 4 o'clock shape or more ('clearly not overpruned')

Figure 4. Schematic depiction of a crown shape with the lowest leaf tips between the 10 to 2 o'clock shape and the 8 to 4 o'clock shape ('preliminary ?')

Figure 5. Urban palms in the study site

Figure 6. Number of overpruned and not overpruned *Ph. canariensis* palms in different size classes

Figure 7. Number of overpruned and not overpruned *W. robusta* palms in different size classes

Figure 8. Number of overpruned and not overpruned *Ch. humilis* palms in different size classes

Figure 1. Lyn-Kristin Hosek and Andreas Roloff

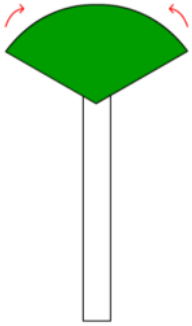

Figure 2. Lyn-Kristin Hosek and Andreas Roloff

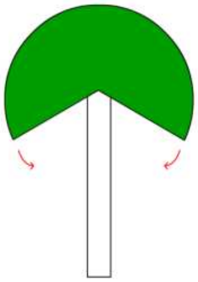

Figure 3. Lyn-Kristin Hosek and Andreas Roloff

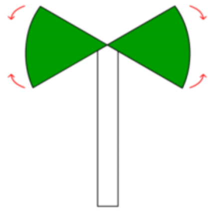

Figure 4. Lyn-Kristin Hosek and Andreas Roloff

Figure 5. Lyn-Kristin Hosek and Andreas Roloff

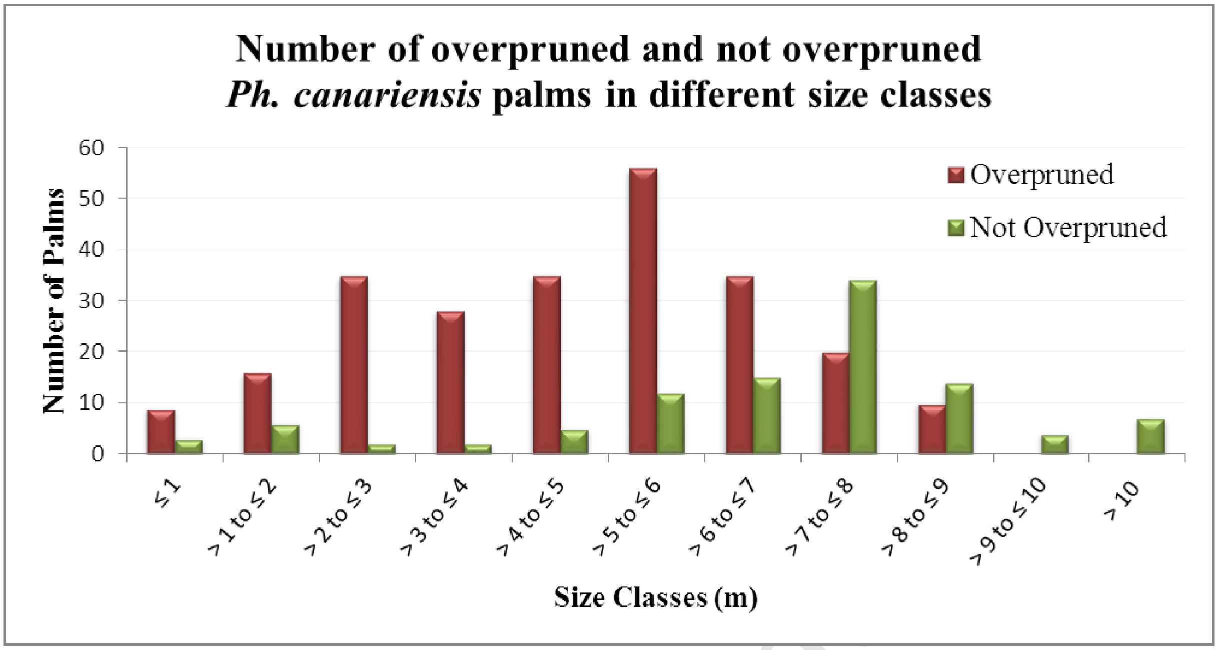

Figure 6. Lyn-Kristin Hosek and Andreas Roloff

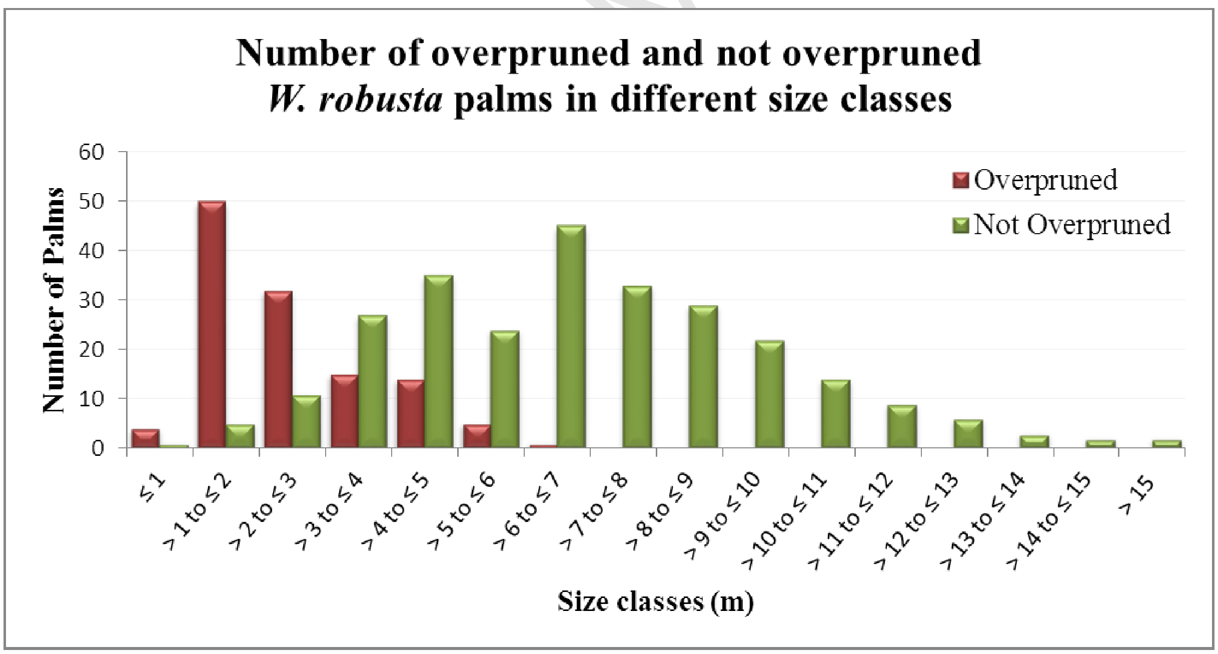

Figure 7. Lyn-Kristin Hosek and Andreas Roloff

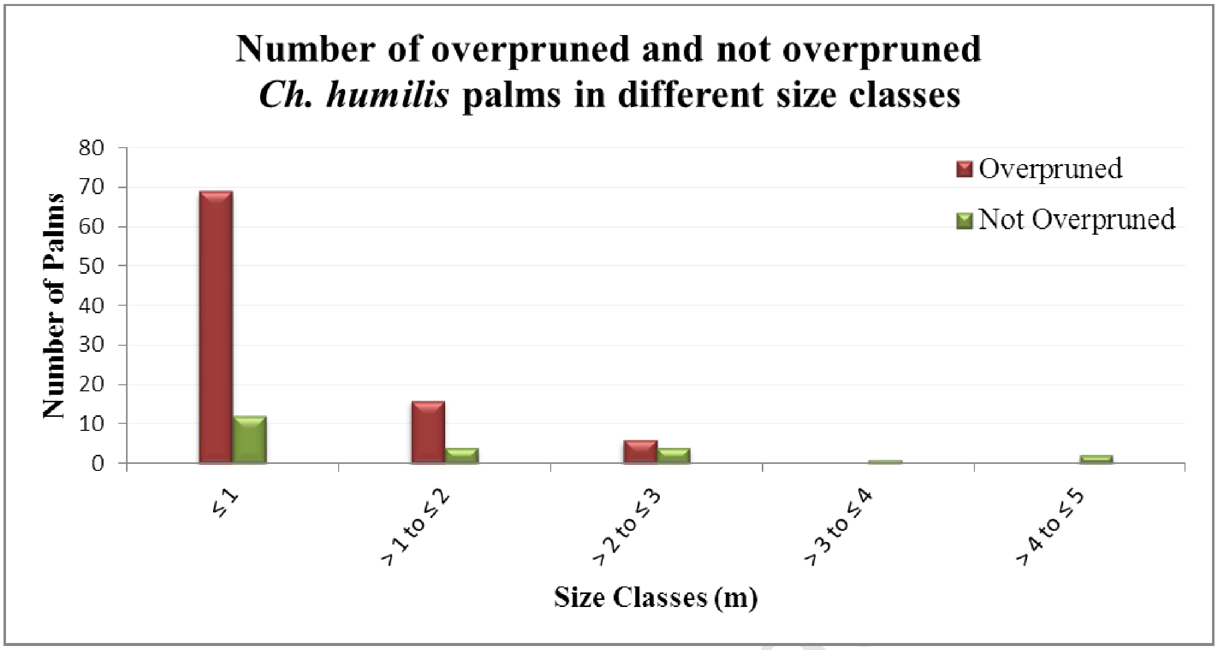

Figure 8. Lyn-Kristin Hosek and Andreas Roloff

Table 1 Lyn-Kristin Hosek and Andreas Roloff

Species	Growing Space
Chamaerops humilis	1.5 m
Washingtonia robusta	2.5 m
Phoenix canariensis	4.0 m