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1 **Relations Between Cityscape-Related and Palm-Inherent Variables**

2 **and the Pruning State of Urban *Arecaceae* Suggest Three Reasons for**

3 **Overpruning**

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8

9 Highlights

10 • Various factors possibly related to overpruning of palms were analysed

11 • Palm height and distance to closest object are related to the pruning state

12 • Beside cityscape-related and palm-inherent factors, human component affects pruning

13 • Personal taste, misinformation and economic reasons need to be considered

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ABSTRACT

22 In warmer climates palms (*Arecaceae*) are commonly found in city environments, planted mainly

23 for the purpose of landscape beautification. Overpruning these palms can have negative side-effects,

24 which reduce the health and therewith the aesthetical value of the plant. Despite this, it is not

25 uncommon to see palms in cities that had too many of their fronds removed. This study aimed to

1

26 find relations between various factors, such as 'species' or 'distance to the closest road', and the

27 pruning state of *Arecaceae* in the study city Olhão (Portugal) in order to suggest reasons for the

28 continued existence of this practice and approaches to reduce its prevalence. Only two factors,

29 'height' and 'distance to the closest object', showed the same relations with the pruning state for the

30 three most common species and should therefore be the first to address in order to reduce

31 overpruning. Data analysis proposes three underlying reasons, personal taste in relation with

32 misinformation, improper choice of species for available planting sites, and economic factors as

33 most likely to be responsible for widespread overpruning. While the latter is difficult to address,

34 implementing educative measures to inform relevant personnel about the negative side-effects and

35 better species-site matching could show fast and cost-efficient improvements in the reduction of the

36 practice of overpruning and therewith the danger of reduced aesthetic value of *Arecaceae,*

37 undermining the purpose of their original planting.

38

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

40 *robusta*

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45 **INTRODUCTION**

46 Urban palms tend to be planted mainly for aesthetic purposes, as they do not provide many of the

47 highly valued services of urban trees or at considerably lower levels (e.g. McPherson et al., 2005;

48 Vargas et al., 2007). Their distinct appearance, however, makes them a generally suitable choice for

49 landscape beautification, where the focus then should be on keeping them healthy, offering the best

2

50 possible growing conditions and avoiding maintenance operations which could have negative side-

51 effects.

52 A commonly carried out arboricultural practice is that of removing whole fronds, a practice which

53 has some need in city environments e.g. to reduce liability issues or the danger of fire. An excessive

54 removal of leaves, however, referred to as overpruning, is advised against in the academic literature

55 for its many possible negative side effects. These have been reviewed by Rosenfeld (2009),

56 mentioning e.g. the increased spread of symptoms of potassium deficiency and faster rates of plant

57 decline where older leaves on deficient palms are removed (Broschat, 1994), thereby severely

58 impacting the health of the plant and decreasing its aesthetical value and life span. Besides effects

59 on the nutrient composition of the leaves, overpruning can also have negative effects on the

60 structural integrity of the palm as older leaves support the younger, immature ones, reducing the

61 likelihood of the crown failing in high winds (Calvez, 1976; Chan and Duckett, 1978). Further

62 reasons against overpruning, and pruning more generally, are related to the risks of spreading

63 diseases, such as *Fusarium oxysporum*, which is spread through the use of contaminated pruning

64 tools (Feather et al., 1979), or palm decline due to *Rhynchophorus ferrugineus* (Oliv.) (Coleoptera:

65 Curculionidae), the Red Palm Weevil. The latter one present in the study area, where it could be

66 observed on or next to several palms, possibly attracted to them by chemicals emitted from

67 remaining leaf bases or pruning wounds (Broschat, 2011). In addition to these problems, an

68 extensive removal of fronds decreases the value of palms in a wider, landscape-related context

69 where overpruning palms is not just questionable from an aesthetic point of view but does also

70 reduce the amount of shadow produced by the crown while further impairing the plants' leaf area

71 related functionalities, such as the absorption of gaseous pollutants. Recommendations are, that "no

72 leaves with tips above the horizontal plane (9:00 to 3:00 positions on a clock face) should be

73 removed" (Broschat, 2011). Despite this consensus in the academic world, palms in cities continue

74 to be overpruned, sometimes severely (Fig. 1).

3

75 Information on the extent of overpruning of palms in city environments is lacking and with this,

76 data on possible connections between the pruning state of the crown and various factors

77 encountered in city environments related to urban green planning and management.

78 Besides quantifying the amount of public, overpruned *Arecaceae* in the study site, this study aimed

79 at considering cityscape-related and palm-inherent variables and their possible relations with an

80 increase or decrease in leaf removal. Knowledge ultimately usable to inform the development of

81 effective strategies to reduce this practice and negative side effects, which can result in a decreased

82 aesthetical value and premature death of the palms.

83

84 **METHODS**

85 *Study Site*

86 Olhão is a coastal city, located at around 37° 2' N and 7° 50' W, in the south of Portugal (Algarve

87 Region), about 10 km to the east of Faro, the region's capital. The city has 14.914 inhabitants (INE,

88 I.P, 2011), covering an area of approximately 12,25 km^2 (Eurostat, 2011).

89 According to the Köppen-Geiger climate classification, it is a Csa type (dry-summer subtropical or

90 Mediterranean)(Peel et al., 2007) with mean temperatures above 10° C during the whole year and

91 above 15° C from March/April to November. Mean monthly rainfall in the area is below 5 mm

92 between June and August and highest from October (60.1 mm) to February (52 mm). The

93 maximum daily amounts can reach more than 150 mm in October, but are less than 100 mm

94 throughout the rest of the year (Instituto de Meteorologia, IP Portugal).

95

96

97 *Data Collection*

98 In April and May 2012 data were collected on all public, urban palms (n = 904) within the city

99 boundaries of the study site. Individuals were determined to species level and the following

100 additional information was collected:

4

101

102 <u>Location</u>

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

104 Switzerland).

105

106 <u>Overall Height</u>

107 Overall heights were measured using a clinometer (Pm-5/360 PC, Suunto, Vantaa, Finland) for

108 higher palms or a measuring tape (20 m by 13 mm, Fischer-Darex, Le Chambon-Fegeurolles,

109 France) for smaller ones. Vertically upwards growing spear leaves were excluded, however, as this

110 could overestimate overall palm height, using the highest point on the next youngest leaf, which

111 already moved to a more horizontal position, instead. Results were rounded to the closest 5 cm-step

112 and only determined for the highest stem/crown of multi-stemmed individuals.

113

114 <u>Number of Objects</u>

115 The number of above-ground structures in a 4 m radius from the palm's stem was counted, the

116 ground distance to the closest object measured and recorded to the closest 5 cm-step.

117

118 <u>Size of Closest Object</u>

119 The size of the closest object was classified in relation to the extent of the respective above-ground

120 structure. Poles, street lights, street signs and other minor objects were considered to be 'small',

121 more substantial objects like trees or palms to be 'medium' and houses, walls and large

122 advertisement boards were categorized as 'large'. The categories were open, so that e.g. bigger trees

123 could also be classified as 'large'.

124

5

125 <u>Existence of Obstacles</u>

126 For the three most common species in the study site, a growing space was defined based on half the

127 crown diameter large, mature palms can reach (Riffle, Craft and Zona, 2012; Broschat, Hodel and

128 Elliott, 2014), rounded to the closest 10 cm-step (Table 1). An above-ground structure located

129 inside this radius can turn into an obstacle, possibly leading to a direct contact between the palm

130 and the obstacle. The presence of such an above-ground structure was noted with 'yes', the absence

131 as 'no'.

Insert Table 1 here

132

133 <u>Distance to the Closest Road</u>

134 The distance to the closest road was measured from the corresponding side of the palm's stem and

135 recorded to the nearest 5 cm-step if it was less than or equal to 10 m.

136

137 <u>State of Pruning</u>

138 The crown was judged by eye as either clearly overpruned when the shape of the crown was 10 to 2

139 o'clock or above (Fig. 2) or as clearly not overpruned when the shape of the crown was an 8 to 4

140 o'clock shape or below (Fig. 3). A preliminary '?' was recorded for those palms, where the leaf tips

Insert Figs. 2 to 4 here

141 of the lowest leaves fell between the two other shapes (Fig. 4). The 9 to 3 o'clock imaginary

142 reference line crosses the palm´s stem on the height of the lowest leaf bases. In determining the

143 pruning state, the different sides of the crown were taken into consideration, rating a palm as

144 overpruned if more than 1/3 of it had too many of its leaves removed, even when the leaf tips on the

145 remaining parts of the crown were below the horizontal line, taking symmetry into account. The

146 leaf tip of the leaflet at the end of the rachis or in the centre of the frond was used to determine the

147 pruning state, the nearest healthy leaflet was chosen when it was damaged. In multi-stemmed

148 individuals, the main crown was examined and the removal of whole stems excluded from the study

149 as it is not possible to collect information, useful for the purpose of this study, on absent stems and

150 crowns. To determine the reliability of judgement by eye, further information was collected on the

6

151 palms with a preliminary '?'-rating. First, they were rated as overpruned or not, based on the 9 to 3

152 o'clock scheme after which the heights of three leaflet tips and the respective leaf bases were

153 measured. As a palm could potentially have too many of its fronds removed on only one side, e.g.

154 those close to an object, the procedure outlined below was followed in order to take the symmetry

155 of the crown into account when judging the pruning state. First, the lowest leaflet tip of the whole

156 palm was visually determined and its height and that of the leaf base measured. The remaining two

157 measurements were then taken on the lowest leaflet tips and bases on other sides of the crown,

158 roughly dividing it into three parts. This was done directly with the measuring tape for small palms,

159 noting the results to the closest 5 cm-step, while for taller palms the height was measured with the

160 help of the clinometer.

161 In the latter case, a laser pointer (MP1000, Velleman, Gavere, Belgium) was used to project the

162 position of the respective leaflet tip onto the ground in order to find the 10 m distance, that was

163 needed to determine the height of the respective tip. The construction consisted of the laser pointer

164 fixed to an extendable pole, normally used to paint walls (A70392, Serie 703, 2 m, Rulo pluma,

165 Barberà del vallès, Spain), on which two pipe air levels (0.5 and 0.75 inches from 350 Pipe Level

166 Set, Kapro, Lake Mills, USA) were attached in a 90° angle to each other. The pointer was focussed

167 on the leaf tip while held straight up so that the base of the extendable stick could be used for the

168 second measurement with the clinometer.

169 Palms close to roads or large obstacles, as well as those growing on noticeable slopes were

170 excluded from these further measurements, as sufficient space and a flat ground was needed. When

171 the differences between measured average height of the three lowest leaflet tips and leaf bases was

172 less than or equal to 5 cm, the individuals were excluded, as this degree of error can easily be

173 introduced by wind, inconspicuous unevenness of the ground and the clinometer itself. After

174 elimination of the unsuitable palms, only 18 remained for the comparison of eye judgement and the

175 determination of pruning state with the laser construction or measuring tape, which was found to be

176 consistent in all cases. Though the sample was too small for statistical analysis, fast determination

7

177 by eye of the pruning state in the field seems to produce reliable results even when the measured

178 differences between leaf tip and leaf base were as small as 6 cm, supporting the use of data from

179 eye judgement for further analyses.

180

181 *DATA ANALYSES*

182 Data were analysed using the statistical software 'R' (R Development Core Team, 2012), testing for

183 significant connections between 'pruning state' and the remaining variables for the three most

184 common species in the study site.

185 Non-parametric tests were used in all situations, as the visual examination of the continuous

186 variables, i.e. 'height' and 'distance to the nearest road', led to the conclusion that the distribution

187 deviated too much from a normal distribution to use parametric tests. Mann-Whitney U (MWU)

188 tests were used to compare two groups (overpruned and not overpruned palms). Pearson's Chi-

189 squared (PCS) test was used for categorical data. Fisher's Exact (FE) test for 2 x 2 tables and the

190 Fisher-Freeman Halton (FFH) test for bigger cross tables if an observed number was zero or more

191 than 20 % of the cells had an expected number smaller than 5. The latter one was calculated

192 employing the Monte Carlo method, based on 1'000'000 replicates.

193

RESULTS and DISCUSSION

195 *STUDY SITE SITUATION*

196 A total of 904 public palms were found to be growing in Olhão at the time of data collection being

197 spread throughout the whole city but found in larger numbers along the waterfront in the south and

198 in so-called *urbanizações*, larger-scale housing developments, in the north-west and south-west

199 corner and around the center of the urban area (Fig. 5).   **Insert Fig. 5 here**

200 Out of eight palm species identified in Olhão only three were common enough to be considered

201 separately for further statistical analysis, including *Phoenix canariensis* Chabaud (*Ph. canariensis*,

202 n = 356), *Chamaerops humilis* L. (*Ch. humilis*, n = 116) and *Washingtonia robusta* H. Wendl. (*W.*

8

203 *robusta*, n = 393). Of those palms, eight, two and five individuals, respectively, were excluded from

204 further testing as there crowns were caught in other trees, preventing their pruning states to be

205 judged.

206

207 *Pruning and...*
208 <u>Species</u>

209 Regarding the pruning state of the three *Arecaceae*, more *Ph. canariensis* and *Ch. humilis* palms

210 than expected were overpruned, with the opposite holding true for *W. robusta*. Examining relative

211 numbers, about 70 percent of all *Ph. canariensis*, 80 percent of all *Ch. humilis* palms and 30 percent

212 of *W. robusta* palms had too many of their fronds removed.

213 *Ph. canariensis* has pinnate, *Ch. humilis* palmate, and *W. robusta* costapalmate leaves so that frond

214 type alone does not seem to be an explanatory factor. The three species also vary considerably in

215 the possible maximum crown spread mature individuals can reach. The crowns of mature and

216 unpruned *Ph. canariensis* palms can be as much as 8 m wide (Broschat, Hodel and Elliott, 2014)

217 and while excessive leaf removal to reduce the spread could explain the high amount of overpruned

218 individuals, the crowns of *Ch. humilis* palms only reach about 3 m (Riffle, Craft and Zona, 2012),

219 not explaining why the majority of the latter species was also found to be overpruned. The small

220 average height of only 1.1 m of individuals of this species in the study site, as compared to 5.4 m

221 for *Ph. canariensis* and 5.6 m for *W. robusta* might partially explain excessive leaf removal,

222 allowing uncomplicated and cheap access to the fronds to be removed.

223 The differences of pruning levels between *Ph. canarienis* and *W. robusta*, both with similar average

224 heights and therefore theoretically with the same difficulties and expenses attached, could possibly

225 be related to popular ideas about how *Ph. canariensis* palms should ideally look. One of the

226 common names of this species is 'pineapple palm', referring to an individual usually with a still

227 rather short stem and a heavily pruned crown, resembling a pineapple. If this look is proposed and

9

228 accepted as the desirable one, heavier pruning on this species would result, despite the extra effort

229 needed.

230

231 <u>Height</u>

232 Pruning higher palms is disproportionately more complex than pruning smaller palms. Equipment

233 to reach higher leaves is needed and tools can be unhandy and might interfere with other aspects of

234 city life. Additionally, renting or purchasing heavy equipment is a cost factor, increasing the

235 workforce needed and the time necessary for the pruning operations. In some cases it might not just

236 be less complicated to prune smaller individuals but also necessary, as some species, such as those

237 found in the *Phoenix* genus, feature sharp spines on their petioles which, especially on or close to

238 sidewalks, can be a danger to the public.

239 The statistical tests showed a relation between height and pruning for all three species, with higher

240 palms being significantly less likely to be overpruned than smaller individuals. This result was not

241 only the case for *Ph.canariensis* (MWU test, N = 348, $p < 0.001$) and *W. robusta* (MWU test, N =

242 389, $p < 0.001$) but also for *Ch. humilis* (MWU test, N = 114, $p = 0.002$) despite the small average

243 size of this species and the highest sampled individual being only 4.4 m high. In the study site no

244 *Ph. canariensis* palm with more than 9 m (Fig. 6), *W. robusta* with more than 7 m (Fig. 7) and *Ch.*

245 *humilis* with more than 3 m of height (Fig. 8) had too many of their leaves removed.

Insert Figs. 6 to 8 here

246

247 <u>Distance to the Nearest Road</u>

248 Overpruned and not overpruned palms did not differ significantly with regards to the distance to the

249 nearest road for *Ph. canariensis* (MWU test, N = 232, $p = 0.95$) and *Ch. humilis* (MWU test, N =

250 43, $p = 0.11$), while overpruned *W. robusta* palms were found to grow significantly further away

251 from the road than their not overpruned counterparts (MWU test, N = 261, $p = 0.028$), including

252 only individuals, with a distance of up to 10 metres. Analysing the geographical distribution of the

10

253   individuals of the latter species, no clumped appearances of the two pruning states became apparent

254   and neither differed significantly in average heights.

255   Pruning operations are possibly facilitated if palms are growing further away from the road, usually

256   allowing more easily for the use of heavy equipment, while reducing disturbances to the public.

257   Furthermore, a greater distance to the nearest road is often related to growing in parks or park-like

258   environments, where the visual appearance of the plants is of primary importance. This might lead

259   to increased pruning, if this look is considered more appealing by those responsible for deciding the

260   removal of fronds. While it is possible that one or more of these factors are related to the excessive

261   pruning on *W. robusta* palms further away from the road, the reasons why the other two species

262   show no such connection remains unclear.

263

264   <u>Number of Objects</u>

265   Comparing palms with and without above-ground structures in the 4 m radius around the stem, no

266   connection with the pruning state was found for *Ph. canariensis* (PCS test, $N = 348$, $X^2 = 0.93$, df

267     $= 1$, $p = 0.34$), while significantly more *Ch. humilis* palms with at least one object were found to be

268   overpruned than expected (FE test, $N = 114$, $p = 0.046$). This was also the case for *W. robusta*, but

269   individuals with and without an object were differing considerably in average heights (4.85 m and

270   6.29 m respectively), suggesting that this confounding factor is most likely responsible for the

271   statistically significant results.

272   Looking at exact numbers of objects and their relation with leaf removal, *Ch. humilis* palms were

273   less likely to be overpruned for up to three objects around and more likely to be so when they had

274   five or more objects in the 4 m radius around (FFH test, $N = 114$, $p < 0.001$). The results for *W.*

275   *robusta* were similar, with the only difference being the fact that overpruning was more extensive

276   for four or more objects close-by (PCS test, $N = 389$, $X^2 = 22.637$, df $= 6$, $p < 0.001$). No relation

277   was found for *Ph. canariensis* palms (PCS test, $N = 348$, $X^2 = 5.546$, df $= 6$, $p = 0.48$).

11

278 Above-ground structures in proximity of the *Arecaceae* are possibly related to an increased

279 likelihood of overpruning, as the objects might limit the growing space available so that leaves are

280 being removed to protect both the structures as well as the plants from damage.

281

282 <u>Distance to Closest Object</u>

283 *Ch. humilis* palms up to one metre away from the closest object were overpruned in larger number

284 than expected, and not overpruned in larger number than expected when the closest object was more

285 than two meters away (FFH test, N = 114, p = 0.043). Mature individuals can reach a crown radius

286 of around 1.5 m, a size reflected in the above results.

287 For *W. robusta* (PCS test, N = 389, X^2 = 17.326, df = 4, p = 0.002) a similar connection was found

288 as well, yet lacking the continuous trend seen for *Ch. humilis,* as palms further than four metres

289 away from the closest object were more likely to be overpruned than expected, likely related to the

290 smaller average height of the individuals in this category.

291 Statistically significant results were also found for *Ph. canariensis* (PCS test, N = 348, X^2= 10.393,

292 df = 4, p = 0.034), but less palms were overpruned than expected in the first distance class to the

293 nearest object, with no height differences possibly explaining this result.

294 Generally, there seems to be a connection between the extent of frond removal and the distance to

295 the closest object, as leaves might have to be removed in increasing quantities to avoid interference

296 between the above-ground structure and the palm as distances decreased. There are however other

297 factors closely related to this connection, such as the vertical dimension of the crown and the

298 growing speed of the respective individuals.

299

300 <u>Existence of Obstacles</u>

301 *Ph. canariensis* (PCS test, N = 348, X^2 = 0.929, df = 1, p = 0.34) and *W. robusta* (PCS test, N =

302 389, X^2 = 0.281, df = 1, p = 0.64) showed no relation between the presence or absence of an

303 obstacle in the respective growing space and the pruning state. The test was significant for *Ch.*

12

304 *humilis*, with a higher number of palms overpruned than expected, when there was an obstacle

305 present (FE test, N = 114, p = 0.013). The average height of palms with an obstacle however was

306 considerably smaller (0.9 m) than that of palms without an obstacle (1.7 m) so that the statistical

307 significance might be related to the confounding factor of 'height' again.

308

309 Distance to the Closest Obstacle

310 No connection was found between the pruning state and the distance to the closest obstacle for *Ch.*

311 *humilis* (MWU test, N = 93, W = 382.5, p = 0.067), *Ph. canariensis* (MWU test, N = 258, W =

312 6016.5, p = 0.17) and *W. robusta* (MWU test, N = 140, W = 2347, p = 0.15).

313

314 Size of Object

315 The size of the closest object was not related to the pruning state of *Ph. canariensis* (PCS test, N =

316 142, X^2 = 1.9, df = 2, p = 0.39) and *W. robusta* palms (PCS test, N = 95, X^2 = 2.56, df = 2, p =

317 0.28). No tests could be conducted for *Ch. humilis* due to the small sample size and all objects

318 falling into the medium category.

319

320 *The Extent of Overpruning*
321 Measuring the state of pruning at only one specific point in time might have led to an

322 underestimation of the extent of this practice However, no repeated measurements were taken as

323 there are no comparisons being made between different study areas, in which case the time passed

324 since the last pruning operation would constitute a crucial factor to be considered. It was

325 disregarded for this study based on the assumption that intra-city variations in terms of 'time since

326 last frond removal' are likely negligible as the study area is relatively small and the persons

327 responsible would favour having to rent heavy equipment for only one short time span. Field

328 observations confirmed this assumption as it could be commonly seen that individuals of the same

329 species with similar heights and growing in close proximity, and thereby comparable conditions,

13

330 differed in pruning state. This suggests that in this case the one-time determination of pruning state

331 is not problematic and does not invalidate the correlations that were found and the possible reasons

332 that are being suggested for the continuation of this practice below.

333

334 *Three Likely Reasons for Overpruning in City Environments*

335 The analysis of the data suggests that there are three underlying reasons for palms in the study site

336 to be overpruned. The boundaries between these reasons are not clear-cut and most likely overlap.

337 Drawing lines between them and considering them separately however, allows for an easier and

338 more useful consideration of their planning and management implications.

339 The first reason for overpruning seems to be related to personal taste in combination with

340 misguided ideas about the state of the art on pruning palms. The individual executing the pruning or

341 instructing others to do so, might favour a specific look of a palm's crown, which by definition is

342 overpruned, unaware of the academic literature arguing against excessive leaf removal. If current

343 management practices of urban palms teaches overpruning of crowns as the appropriate for

344 *Arecaceae* in city environments, the result can be as seen in Olhão, where 54 % of individuals

345 belonging to the three most common species were overpruned and thereby, poorly managed in

346 arboricultural terms. The large amount of *Ph. canariensis* palms that had too many of their fronds

347 removed, despite a large proportion of them being of considerable height and not easily pruned, is a

348 strong indicator of personal taste leading to this practice, as the similarly high *W. robusta* palms

349 were subjected to overpruning significantly less. In the case of *Ch. humilis*, a reason for pruning can

350 be found in it being a multi-stemmed species that can look bushy when left unpruned, yet the

351 prevalence of overpruned individuals hints at a lack of knowledge of the possible negative side

352 effects and advantage being taken of its small average height, facilitating ease of access to and the

353 removal of fronds.

354 The second reason can be found in the connections between pruning state and variables related to

355 above-ground structures around the palms. Here, a necessity to overprune seems to factor into the

14

356 arboricultural management. When leaves are in contact with objects, they can become damaged and

357 unsightly, thereby inhibiting the palms ability to offer the service of landscape beautification they

358 were planted for. In these cases, overpruning can be a preventative measure before harm is done or

359 problems have appeared. Additionally, space tends to be a limiting factor in city environments and

360 removing a large amount of leaves can reduce the crown spread of palms, making them fit into

361 spaces, where individuals with full crowns are not an option. The problem with this explanation of

362 overpruning is that the necessity to do so is a perceived one, rather than an actual one, being man-

363 made as the result of an improper choice of species, a suboptimal planting site and the matching

364 between these two.

365 Finally, economic factors play a role in the extensive overpruning of public, urban palms. Some

366 leave removal is usually necessary in city environments from an arboricultural perspective. Dead

367 leaves need to be removed from *Arecaceae* that are not self-cleaning, not only for aesthetical

368 reasons but also for health and safety issues to avoid them falling in high winds, being a fire hazard

369 or a hiding place for unwanted animals. Proper pruning in these cases would require small pruning

370 intervals in which a very limited number of leaves are removed, being repeated possibly every year.

371 On the first look, this appears to be much more expensive and disruptive to city life than choosing

372 larger pruning intervals. These however often lead to crowns being overpruned with a need for

373 further research to establish if the negative side effects of this eventually costing as much or more

374 as proper pruning in small intervals would have cost.

375 Applying these results to the arboricultural management and planning of public urban palms,

376 educating people about proper practice and raising awareness about the possible negative side

377 effects, could already reduce the extent of overpruning considerably. This could be done through a

378 simple workshop in a cost and time-efficient manner with prompt and almost immediate effects on

379 the health and healthy appearance of palms.

380 These educative measures need to be combined with an improved species-site match, reducing the

381 number of palms that are overpruned out of 'necessity'. To develop a framework for matching

15

382 species to planting sites it will be necessary to investigate relations between their health, their

383 appearance, and various biotic, abiotic and palm-inherent factors acting and interacting in city

384 environments. Additionally, similar studies should be conducted in other cities for the purpose of

385 comparison and to avoid the reliance on only one specific case study, as has been done here, in the

386 formulation of interpretive statements.

387 The third proposed factor for overpruning, economic reasons, will be the most difficult one to

388 address and change, especially in times when cities are notoriously lacking funds, making a

389 consideration of likely costly results in the future unattractive in the light of a seemingly cost-

390 efficient present planning and management scheme.

391

392 **CONCLUSION**

393 Some variables, such as 'height', show the same statistically significant relations with the state of

394 pruning for all of the three most common species, while others, such as the 'distance to the nearest

395 road' or the 'number of objects', were found to be related to only one or two of the tested

396 *Arecaceae* species. In city environments the number of factors that can act simultaneously, resulting

397 in a palm being overpruned is high, complicating data analysis and interpretation. In terms of

398 pruning, an extra factor is added, the 'human component', making it necessary to consider the

399 impact of difficult to analyse concepts like 'taste' and financial decisions, which most likely

400 underlie decision-making processes.

401 The two variables 'height' and 'distance to the closest object' showed the same relations with the

402 pruning states of all three species, appearing to be major factors related to an excessive removal of

403 fronds. Addressing these variables first by educating the public, specifically those directly related to

404 arboricultural practices, about proper palm pruning, consideration of above-ground growing space

405 requirements, and matching species to appropriate planting sites will produce, comparatively, the

406 fastest, largest and most cost-efficient decrease of the number of overpruned palms.

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407 Whatever the specific reasons for an excessive frond removal are, there is agreement upon the fact

408 that this practice has many undesirable side effects, primarily diminishing the health and aesthetic

409 value of individual palms and the urban forest in total. In city environments however, where palms

410 are planted and maintained for a purpose, negative effects of overpruning will ultimately also affect

411 people in various ways, be it as an increased liability issue or financial expenditures on removing

412 and replacing palms, which died or failed their purpose directly or indirectly as a result of

413 overpruning.

414

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455   Figure 1. An overpruned *Phoenix canariensis* palm

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

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

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458   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

459   4 o'clock shape ('preliminary ?')

460   Figure 5. Urban palms in the study site

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

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

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

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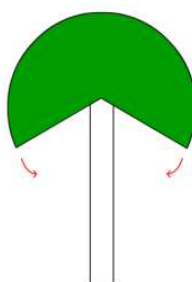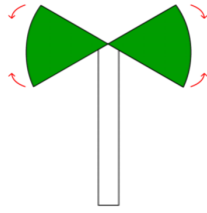
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Figure 1. Lyn-Kristin Hosek and Andreas Roloff

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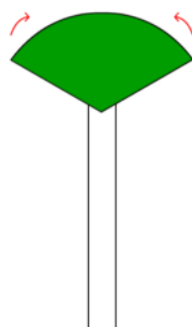
Figure 2. Lyn-Kristin Hosek and Andreas Roloff

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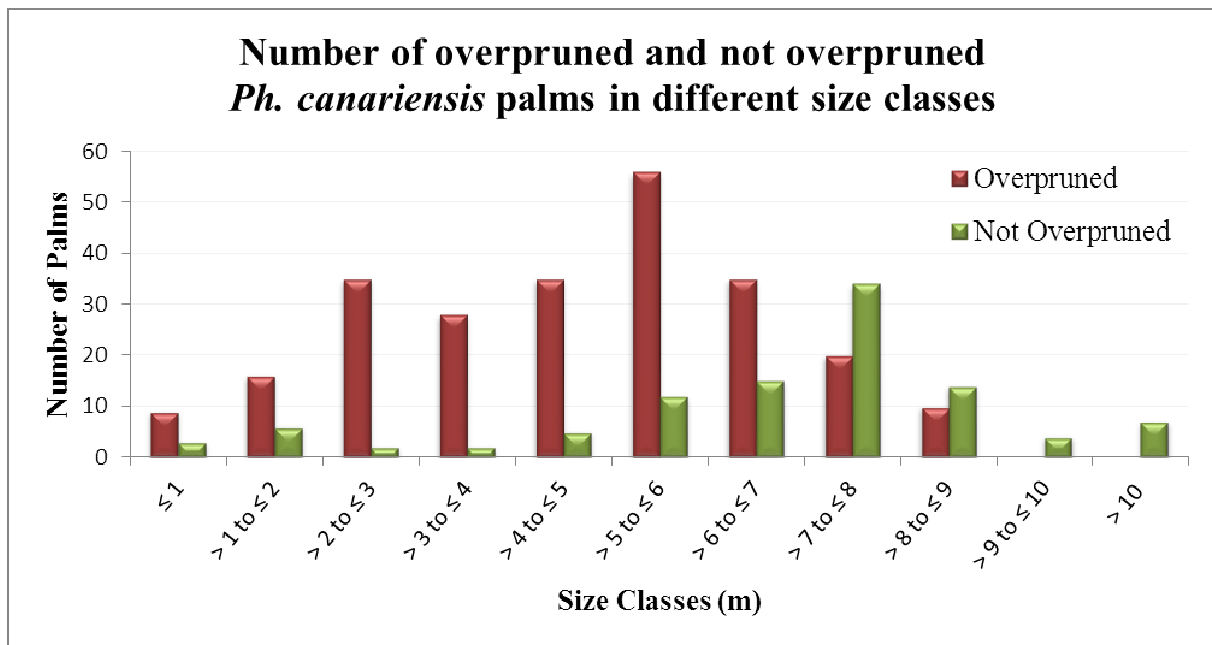**Figure 3. Lyn-Kristin Hosek and Andreas Roloff**

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Figure 4. Lyn-Kristin Hosek and Andreas Roloff

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Figure 5. Lyn-Kristin Hosek and Andreas Roloff

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Figure 6. Lyn-Kristin Hosek and Andreas Roloff

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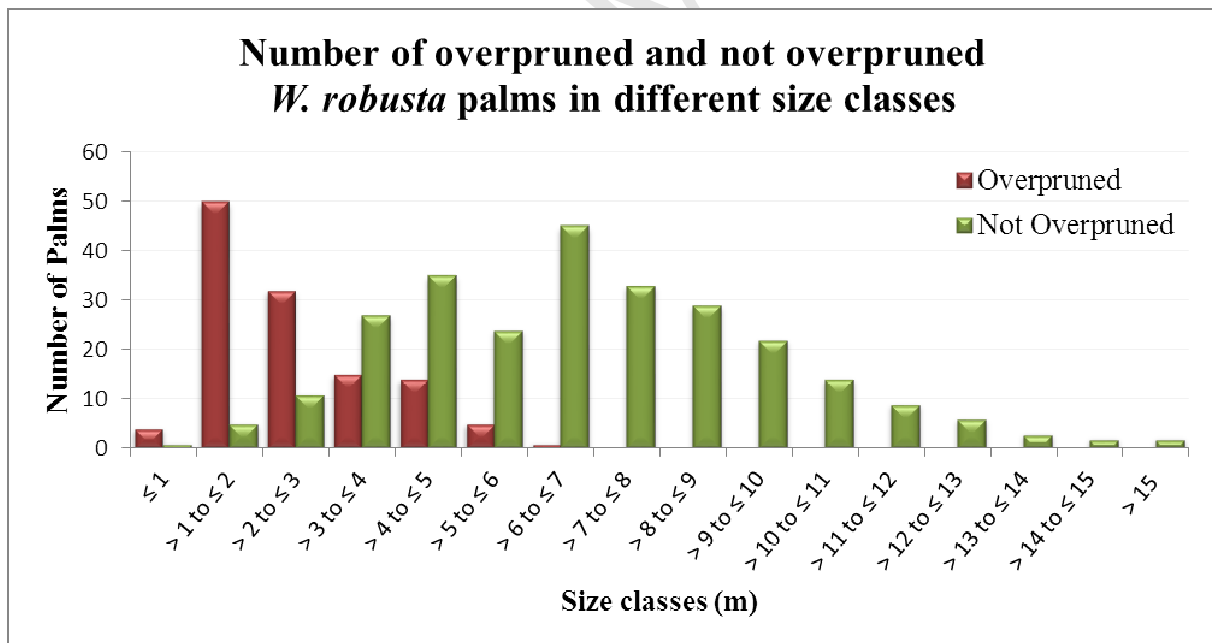
Figure 7. Lyn-Kristin Hosek and Andreas Roloff

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

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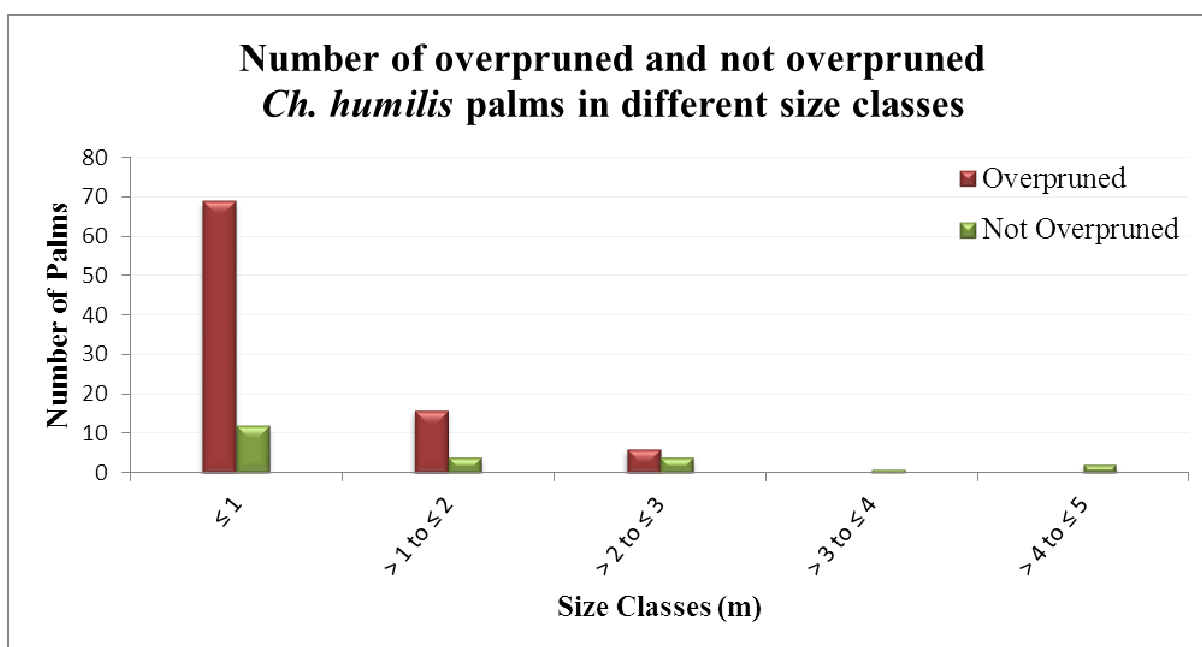
507 **Figure 8. Lyn-Kristin Hosek and Andreas Roloff**

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510 **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

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