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A Technical Report for

PROJECT PALMS

An Assessment of the Population of Threatened Palms in Sainte Luce, Southeast Madagascar

July 2023

Contents

Summary

The littoral forest fragments of Sainte Luce, in the Anosy region of southeast Madagascar, support a large variety of endemic and threatened species, including populations of threatened palm species. Many of these palm species are important natural resources used for construction materials, firewood, and local livelihood generation within the Sainte Luce community. SEED Madagascar's Conservation and Research Programme conducted a palm census of six threatened species in five core forest fragments in Sainte Luce, aiming to expand existing knowledge of population size, distribution, health, threats, and demographic structure.

Transect-based methodology was used to assess populations of *Beccariophoenix madagascariensis*, *Chrysalidocarpus prestonianus*, *Chrysalidocarpus psammophilus*, *Chrysalidocarpus saintelucei, Dypsis brevicaulis*, and *Dypsis scottiana*. In total, 153,630 palm observations were recorded of which 2,970 were adults. *D. scottiana* (*n* = 88,129) and *C. psammophilus* (*n* = 40,423) were the most frequently observed species, whereas *B. madagascariensis* (*n* = 756) and *D. brevicaulis* (*n* = 4,215) were the least frequently observed. Forest fragments S9 (*n* = 54,555) and S7 (*n* = 49,561) contained the most palm observations, whereas S17 (*n* = 2,038) and S6 (*n* = 10,249) contained the least. These data will contribute to increasing the understanding of these palm species and enable the formation of context-specific, community-driven, and evidence-based conservation plans.

1 Introduction

1.1 Background

Madagascar is one of the world's highest conservation priorities (Myers et al., 2000). With 98% of palm species endemic to the island, it has one of the most unique and diverse palm collections in the world (Méndez et al., 2022). However, ecosystems across Madagascar are in decline, with 4.36 million hectares (25%) of Madagascar's forest cover lost to deforestation between 2001 and 2021 (Global Forest Watch, 2022). Littoral forests are one of the rarest and most threatened ecosystems in Madagascar, and considered a national conservation priority (Ganzhorn et al., 2001), with an estimated 90% loss of original forest cover (Krishnan et al., 2012).

The southeast Anosy region contains some of the few remaining viable littoral forests (Bollen & Donati, 2006). The Sainte Luce Littoral Forest (SLLF), comprising 17 fragments, is one of three larger fragmented littoral forests remaining in the region. Sainte Luce, with approximately 2,600 inhabitants, is just one of the local communities supported by the forest through the provision of natural resources for firewood, construction materials, and local livelihood generation (Bollen & Donati, 2006; Hyde Roberts et al., 2021; SEED Madagascar, 2021).

Although a critically important natural resource for the Sainte Luce community, most of the 13 species of palm supported by SLLF are threatened[1] with extinction (Bennett, 2011; Couvreur & Baker, 2013). The six target palm species for this study are all threatened and in decline locally: *Beccariophoenix madagascariensis* (VU), *Chrysalidocarpus prestonianus* (VU), *Chrysalidocarpus psammophilus* (EN), *Chrysalidocarpus saintelucei* (EN), *Dypsis brevicaulis* (CR), and *Dypsis scottiana* (VU) (Hyde Roberts et al., 2020; Rakotoarinivo & Dransfield, 2012a; 2012b; 2012c; 2012d; 2012e; 2012f). Within Sainte Luce there are several uses for these species; *Dypsis scottiana* trunks and the leaf rachises of *Beccariophoenix madagascariensis, Chrysalidocarpus prestonianus*, and *Chyrsalidocarpus saintlucei* are woven to make lobster traps, the primary source of income for many households in the region, and the trunks of *Chrysalidocarpus psammophilus* and *Dypsis scottiana* are used in the walls of houses (Hogg et al., 2013a).

Extant populations in the SLLF are threatened by habitat fragmentation and degradation, drought, increased vulnerability to fire, and proposed mining activities by QIT Madagascar Minerals (QMM) (Bollen & Donati, 2006; Vincelette et al., 2007; Krishnan et al., 2012; Ashraf et al., 2021). With 83% of endemic palm species threatened with extinction in Madagascar (Rakotoarinivo et al., 2014), it is crucial to understand the local pressures on palms, and map viable pathways for their conservation and continued availability. A previous study by SEED Madagascar (SEED) identified rapidly declining populations of *Beccariophoenix madagascariensis* and *Chrysalidocarpus saintelucei* in Sainte Luce (Hyde Roberts et al., 2020). While limited information exists on the current demography and distribution of the other four target species, it is believed that the local populations of these threatened species are in decline.

1.2 An Overview of Project Palms

Project Palms aims to improve the conservation status of six threatened palm species by expanding existing knowledge of population size, distribution, health, threats, and demographic structure in Sainte Luce's core forest fragments. Improved understanding on current distribution, abundance, and natural history of each species will enable SEED to focus future conservation and restoration efforts in Sainte Luce. Future *in-situ* planting efforts will be based on the census findings alongside microhabitat assessments, while seed collection and pollinator surveys are informed by seasonality data.

[1] Threatened is an umbrella term consisting of Vulnerable (VU), Endangered (EN) and Critically Endangered (CR) species (IUCN Standards and Petitions Committee, 2022).

2 Methods

2.1 Study Site

Research was conducted in five littoral forest fragments (S6, S7, S8, S9, and S17) within the SLLF in the Anosy region of Madagascar (24° 46′ S, 47° 10′ E) (Figure 1). S6 and S7 are designated as Community Resource Zones (CRZ), from which natural resource use is permitted. S8 and S9 are part of Madagascar's National Protected Areas network, classified as conservation zones under IUCN Category V Protected Areas regime. S8 is comprised of two fragments, S8 North (S8N) and S8 South (S8S), and five remnants (S8R1-5). Much of S17 is privately owned land, with an area designated as a CRZ.

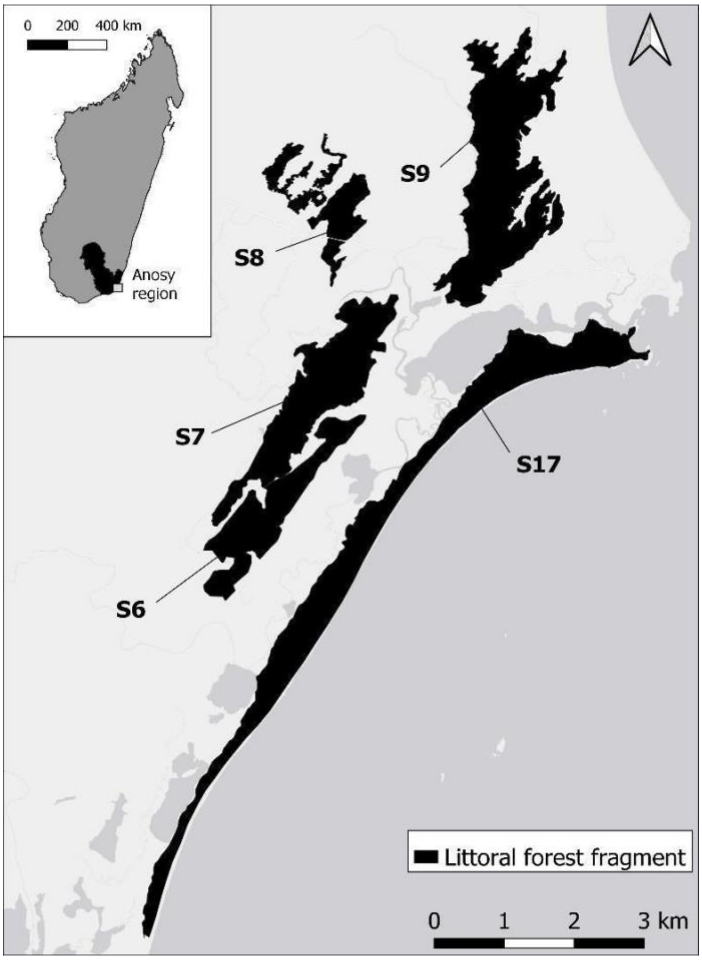


Figure 1: Study site.

2.2 Data Collection and Analysis

Data collection was conducted between October 2021 and February 2023 by SEED's Conservation Research Programme (SCRP). To assess populations of each of the six threatened species, a transect-based methodology was employed. Forest fragments were traversed by two groups of trained researchers, walking from one forest edge to the other as part of a pair of transects. Surveying groups were positioned at least 20m apart to increase coverage of the forest and prevent double-counting individuals. Once a pair of transects was completed, the next pair would begin 150m north or south of the previous until a representative area of each forest fragment was assessed. Groups oriented themselves within the forest using Global Positioning Systems (GPS) and environmental characteristics (e.g., features in the landscape and the sun's position), with GPS tracks saved and examined following each collection. A slow walking pace was adopted to ensure that all individuals in the survey area were identified and recorded.

Juvenile and sub-adult individuals of each species were counted in 30m intervals along the transect. Within each interval, the total number of juvenile and sub-adult palms for each species were recorded, along with the GPS coordinates of the interval. Individual maturity was determined following descriptions by Hogg et al. (2013b) and local expert knowledge (Table 1).

Table 1: Description of palm maturity classes used for the census. These classifications were based on descriptions of the different maturity phases for C. saintelucei by Hogg et al. (2013b) and adapted for use across all six palm species.

Maturity Phase	Description
Juvenile	No visible trunk; early juveniles possess leaves with 2 or more leaflet pairs; leaves grow up to 2m in length in older juveniles
Sub-adult	Development of a crownshaft and a short trunk; no visible signs of reproductive maturity; bark not yet established
Adult	Visible signs of reproductive maturity (flowers/fruit); trunk is greater in height; bark is established

For adult palms, a suite of variables was recorded for each individual, including GPS location, morphology (total height (m) and trunk circumference at chest height (cm)), condition, and phenology (flowering and fruiting). Additional notes were recorded when necessary, including evidence of human activity (e.g., axe marks on trunk, removal of fronds from crown, evidence of fire) and presence of mutualist species (e.g., fauna observed using the palm). Palm condition was measured on a scale of 1 to 4, with criteria to differentiate between each category (Table 2).

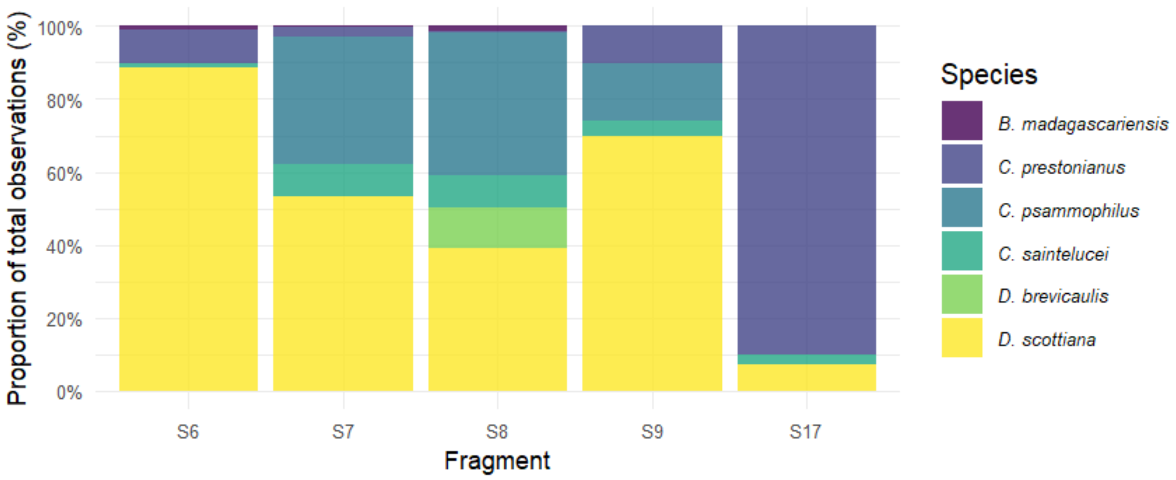
Table 2: Description of palm condition categories, developed with local guides and expert knowledge.

Condition	Description
1 - Dead	Palm has wilted, lost its leaves, and turned brown
2 - Poor	Severe signs of either: damage, pest infestation, discolouration, fungi, or abnormal growth
3 - Fair	Signs of either: damage, pest infestation, discolouration, fungi, or abnormal growth
4 - Good	Healthy palm, with green leaves showing no evidence of pests/disease, or human disturbance such as leaf removal or axe marks on trunk.

Data collection was completed using the Open Data Kit (ODK) mobile data collection platform (ODK, 2023) and uploaded to an online database for processing, cleaning where observations with insufficient data were removed, and analysis. Descriptive statistics were produced in R (R Core Team, 2022), and distributional patterns were assessed using the geographic information system (GIS) Quantum GIS (QGIS) (QGIS Development Team, 2023).

3 Results

A total of 153,630 observations were made of all six palm species across the study site. Most observations were made in S9 (n = 54,555), followed by S7 (*n* = 49,561), and S8 (*n* = 37,213). Fewest number observations were



made in S17 (*n* = 2,038) followed by S6 (*n* = 10,249). The proportions of each species found in each forest fragment differed (Figure 2) and only in S8 were all species observed (Annex 1).

Figure 2: Proportion of each palm species across all age categories observed in each forest fragment.

3.1 Distribution

B. madagascariensis was the least frequently observed species, with only 756 observations made across all forest fragments (Table 3). *B. madagascariensis* was observed in all forest fragments aside from S17 (Annex 2). Most observations were made within S8 (*n* = 593), followed by S6 (*n* = 107) and S7 (*n* = 50). There were no observations of *B. madagascariensis* made in S17, and very few individuals were observed in S9 (*n* = 6).

There was a total of 9,755 observations of *C. prestonianus* (Table 3). *C. prestonianus* was observed in all five forest fragments (Annex 3). Most observations were made in S9 (*n* = 5,618), followed by S17 (*n* = 1,833) and S7 (*n* = 1,342). *C. prestonianus* was the most frequently observed palm species in S17 and comprised 89.94% of all observations made here. The fewest observations of *C. prestonianus* were made in S8 (*n* = 33), followed by S6 (*n* = 929).

C. psammophilus was the second most frequently observed species, with 40,424 total observations made (Table 3). *C. psammophilus* was observed in S7, S8, and S9 (Annex 4). Most observations were made in S7 (*n* = 17,282), followed by S8 (*n* = 14,645), and then S9 (*n* = 8,496). *C. psammophilus* was the most frequently observed palm species in S8, with most observations made in S8N (*n* = 12,079). This species was not observed in S6 or S17.

C. saintelucei was observed 10,338 times (Table 3). *C. saintelucei* was observed in all forest fragments (Annex 5). Most observations of this species (43.64%) were made in S7 (*n* = 4,511), followed by S8 (*n* = 3,211), and S9 (*n* = 2,435). The fewest observations were made in S17 (*n* = 55), followed by S6 (*n* = 126).

D. brevicaulis was the second least abundant species, with a total of 4,215 observations made (Table 3). *D. brevicaulis* was only observed in S8 (Annex 6). Within S8, *D. brevicaulis* was observed in S8N, S8S, S8R2 and S8R4, with no observations made in S8R1 or S8R3 (Annex 1). Most observations (65.79%) were made in S8N (*n* = 2,773), followed by S8S (*n* = 1,414). The fewest observations were made in S8R2 (*n* = 5), followed by S8R4 (*n* = 23).

D. scottiana was the most frequently observed species, with a total of 88,131 observations made (Table 3), comprising 57.37% of all palm observations. *D. scottiana* was observed in all forest fragments (Annex 7). Most observations of *D. scottiana* were made in S9 (*n* = 38,000) and S7 (*n* = 26,376) where they were the most frequently observed palm species, followed by S8 (*n* = 14,516). The fewest observations of *D. scottiana* were made in S17 (*n* = 150), followed by S6 (*n* = 9,067) where it was the most observed palm species.

Table 3: Summary of total number of individuals of each species observed across study site.

Species	Age	S6	S7	S8	S9	S17	Total
B. madagascariensis	Juvenile	34	41	390	4	0	469
	Sub-adult	62	1	180	0	0	243
	Adult	11	8	23	2	0	44
	Total	**107**	**50**	**593**	**6**	**0**	**756**
C. prestonianus	Juvenile	928	1,330	29	5,414	1,807	9,508
	Sub-adult	1	11	2	137	13	164
	Adult	0	1	2	67	13	83
	Total	**929**	**1,342**	**33**	**5,618**	**1,833**	**9,755**
C. psammophilus	Juvenile	0	10,084	8,904	5,593	0	24,581
	Sub-adult	0	6,614	5,490	2,634	0	14,738
	Adult	0	584	251	269	0	1,104
	Total	**0**	**17,282**	**14,645**	**8,496**	**0**	**40,423**
C. saintelucei	Juvenile	118	4,026	3,152	2,396	55	9,747
	Sub-adult	2	463	49	37	0	551
	Adult	6	22	10	2	0	40

	Total	**126**	**4,511**	**3,211**	**2,435**	**55**	**10,338**
D. brevicaulis	Juvenile	0	0	2,381	0	0	2,381
	Sub-adult	0	0	1,452	0	0	1,452
	Adult	0	0	382	0	0	382
	Total	**0**	**0**	**4,215**	**0**	**0**	**4,215**
D. scottiana	Juvenile	5,342	15,282	8,186	22,633	101	51,581
	Sub-adult	3,640	10,716	6,174	14,655	46	35,231
	Adult	105	368	156	685	3	1,317
	Total	**9,087**	**26,376**	**14,516**	**38,000**	**150**	**88,129**
Total		**10,249**	**49,561**	**37,213**	**54,555**	**2,038**	**153,616**

3.2 Demography

For all palm species, juveniles were the most frequently observed age demographic, comprising 63.97% of observations (*n* = 98,267; Table 3). Sub-adults were the second most frequently observed age demographic across all species, accounting for 34.10% of observations (*n* = 52,379). Adults were the least observed age demographic across all species, making up 1.93% of observations (*n* = 2,970). S9 contained the most observations of adult individuals (*n* = 1,025), followed by S7 (*n* = 983) and S8 (*n* = 824). The fewest observations of adult palms were made in S6 (*n* = 122) and S17 (*n* = 16).

Adult *B. madagascariensis* made up 5.82% of observations of this species (*n* = 44; Table 3). Sub-adults comprised 32.14% of observations (*n* = 243), and juveniles 62.04% (*n* = 469*)*. 52.27% of adult *B. madagascariensis* observations were recorded within S8 (*n = 23)*.

Adult *C. prestonianus* made up 0.85% of observations (*n* = 83; Table 3). Sub-adults accounted for only 1.68% of total *C. prestonianus* observations (*n* = 164). Juvenile *C. prestonianus* individuals were relatively abundant across all five fragments (*n* = 9,508) and made up 97.47% of observations. The majority of adult *C. prestonianus* were observed in S9 (*n* = 67).

Observations of adult *C. psammophilus* across all forest fragments made up 2.73% of total observations of this palm species (*n* = 1,104; Table 3). Sub-adults comprised 36.46% of observations (*n* = 14,738) and juveniles made up 60.81% of total observations across all forest fragments (*n* = 24,581). S7 contained the greatest abundance of *C. psammophilus* individuals at all age demographics, with 10,084 juveniles, 6,614 sub-adults, and 584 adults observed. Comparatively, there were very few observations of adult *C. psammophilus* in S8 (*n* = 251) and S9 (*n* = 269).

Adult *C. saintelucei* made up 0.39% of observations for this species (*n* = 40; Table 3). Observations of sub-adults accounted for 5.32% of the total (*n* = 551), while 94.28% of all observations for *C. saintelucei* were juvenile individuals (*n* = 9,747). S7 contained the greatest number of adult and sub-adult individuals, with 55.00% of all observed adults located in this forest fragment (*n* = 22), and 84.03% of all sub-adult individuals (*n* = 463) observed here.

Observations of adult *D. brevicaulis* made up 9.06% of all observations for this species (*n* = 382; Table 3). 34.45% of observations were of sub-adult individuals (*n* = 1,452), and 56.49% were of juvenile individuals (*n* = 2,381). *D. brevicaulis* showed the highest proportion of adults to sub-adults and juveniles across all species.

Adult *D. scottiana* accounted for 1.49% of all observations of this species (*n* = 1,317; Table 3). Sub-adult and juvenile observations comprised 39.98% (*n* = 35,231) and 58.53% respectively (*n* = 51,581). The greatest number of adult *D. scottiana* were observed in S9 (*n* = 683) and S7 (*n* = 368), with the fewest observations in S17 (*n* = 3).

3.3 Morphology and Health

Morphology and health data were recorded for 2,970 adult individuals across all species. Outliers were included in the analysis, due to the small sample size for certain species. For each palm species, variation in height was found between individuals (Figure 3) as well as between forest fragments (Figure 4). Additionally, there was variation in trunk circumference between individuals for each species (Figure 5). The most frequent condition observed across all species and forest fragments was *good* (Figure 6).

B. madagascariensis height varied between individuals (Figure 3) and between forest fragments (Figure 4). The average height of *B. madagascariensis* was 9.80m, with the tallest mean height of the species found in S9 and the shortest in S8. Trunk circumference showed the largest variation between individuals of the six palm species (Figure 5), with a range of 125.00cm. Across all forest fragments, 80.00% of observed adult *B. madagascariensis* were recorded in *good* condition, with 17.14% recorded as in *fair* condition, 2.86% in *poor* condition, and no *dead* individuals observed (Figure 6).

C. prestonianus height varied between individuals (Figure 3) and showed a large variation in height between forest fragments (Figure 4). The average height of *C. prestonianus* was the largest observed at 13.53m, with the tallest mean height for the species found in S9 and the shortest in S8. The difference in height of observed individuals was the greatest of any species at 19.00m; some of this variation in height between fragments can be explained by the palm's location. Palms located within the forest were generally taller, whereas palms growing outside of the forest canopy were shorter. Trunk circumference varied greatly between individuals (Figure 5), with a range of 86.00cm. Across all forest fragments, 65.43% of observed *C. prestonianus* were recorded in *good* condition, 28.40% in *fair* condition, 3.70% in *poor* condition, and 2.47% as *dead* (Figure 6). Overall, the observed population of *C. prestonianus* were in the poorest condition with a mean condition of 3.57.

C. psammophilus height varied between individuals (Figure 3), however did not vary greatly between forest fragments (Figure 4). The average height of *C. psammophilus* was 7.02m, with the tallest mean height for the species found in S8 and the shortest in S7. The difference in observed height of individuals was 14.00m. Trunk circumference showed some variation between individuals (Figure 5), with a range of 44.00cm. Most individuals were recorded in *good* condition (86.89%), 12.56% were recorded as *fair*, 0.28% as *poor*, and 0.28% as *dead* (Figure 6). *C. psammophilus* showed the highest mean condition of 3.86.

C. saintelucei height showed large variation between individuals (Figure 3) and between forest fragments (Figure 4). The average height was 11.81m, with the tallest mean height for the species found in S6 and the shortest in S9. There was a large difference in the observed height of individuals, with a difference of 12.00m. Trunk circumference showed large variation between individuals (Figure 5), with a range of 71.00cm. Across all forest fragments there were no individuals found in *dead* or *poor* condition; 27.03% of individuals were recorded as *fair*, and 72.97% as *good* (Figure 6).

D. brevicaulis showed very little variation in height between individuals (Figure 3) and no variation in height between forest fragments, as the species was only found in S8 (Figure 4). This species was the smallest, with an average height of 1.54m and the smallest height range recorded of 2.50m. The trunk circumference for *D. brevicaulis* also showed the smallest range, of 8.00cm. Across S8, 60.48% of *D. brevicaulis* observations were of *good* condition, with 38.99% of palms recorded as *fair*. No individuals were recorded as *dead* or in *poor* condition (Figure 6). The most common condition for *D. brevicaulis* was *good*.

D. scottiana height showed some variation between individuals (Figure 3) and very little variation between forest fragments (Figure 4). The average height of *D. scottiana* was 3.28m, with a range of 9.20m. The tallest average height was seen in S8 and the shortest in S17. The trunk circumference showed very little variation (Figure 5) with a range of 12.00cm. Across all fragments, 63.56% of recorded *D. scottiana* were in *good* condition, whereas 34.31% were *fair,* 2.13% were *poor*, and there were no individuals recorded as *dead* (Figure 6).

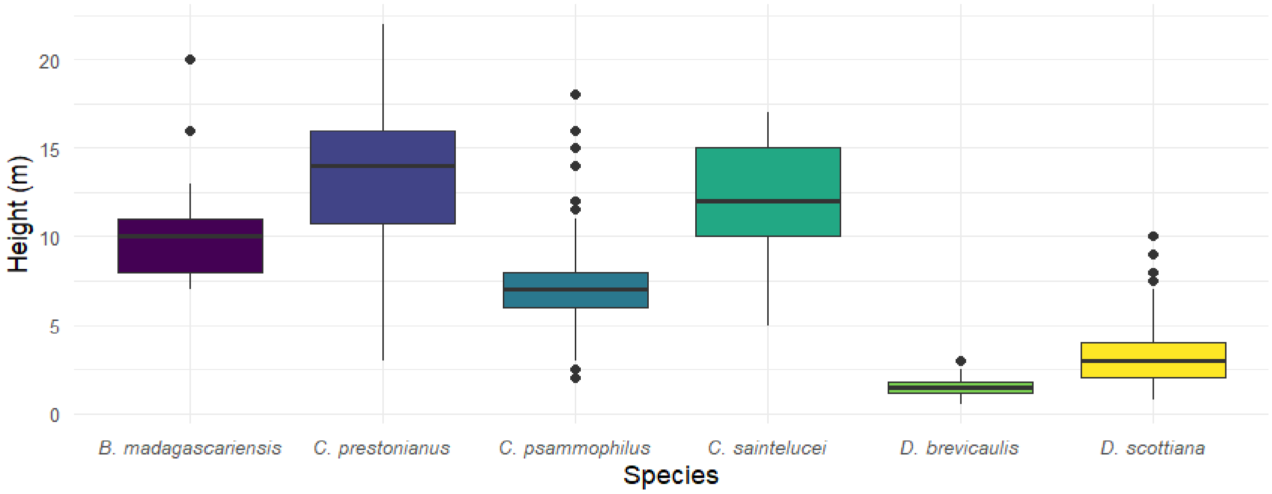


Figure 3: Estimated height (m) of all observed adult palm species. Annex 8 provides descriptive statistics on the heights of different palm species.

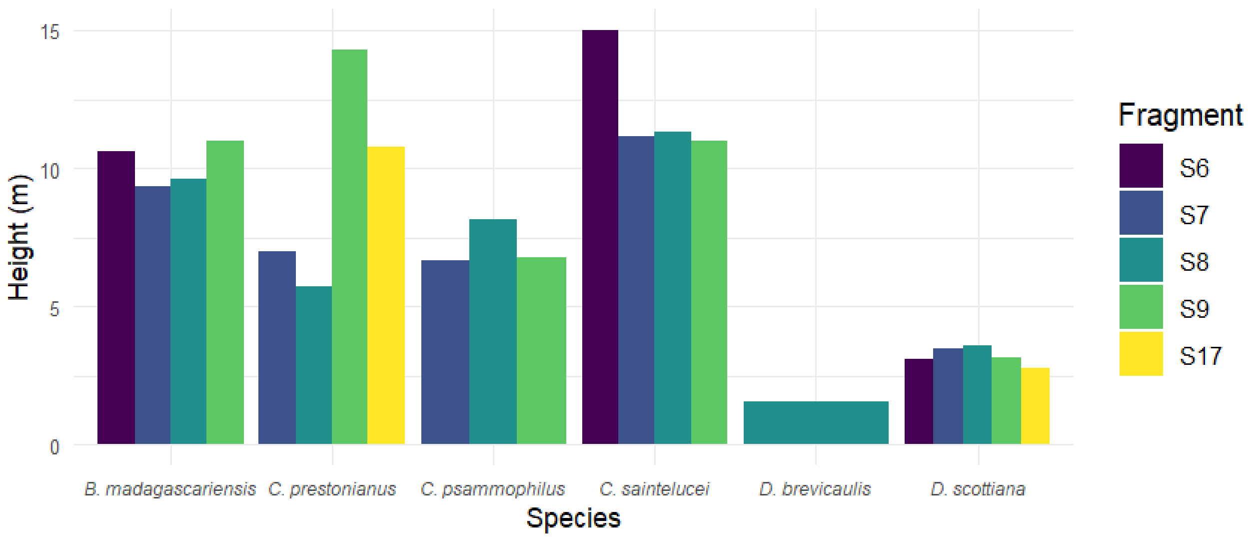


Figure 4: Mean height (m) of all observed adult palm species in each forest fragment.

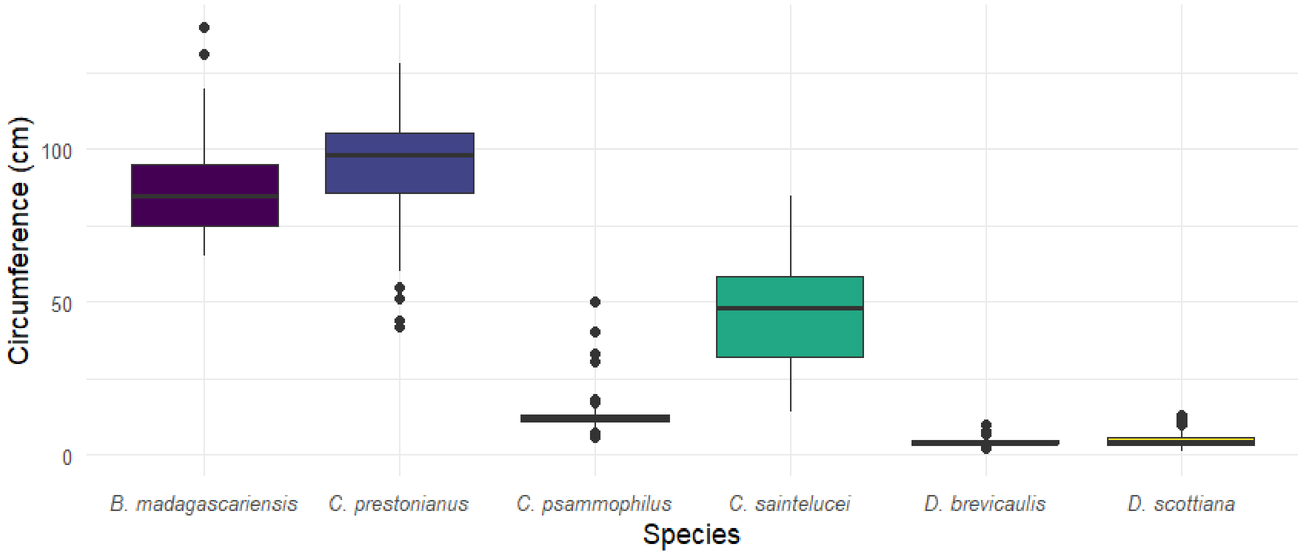


Figure 5: Circumference (cm) of all observed adult palm species. Annex 8 provides descriptive statistics on the circumferences of the different palm species.

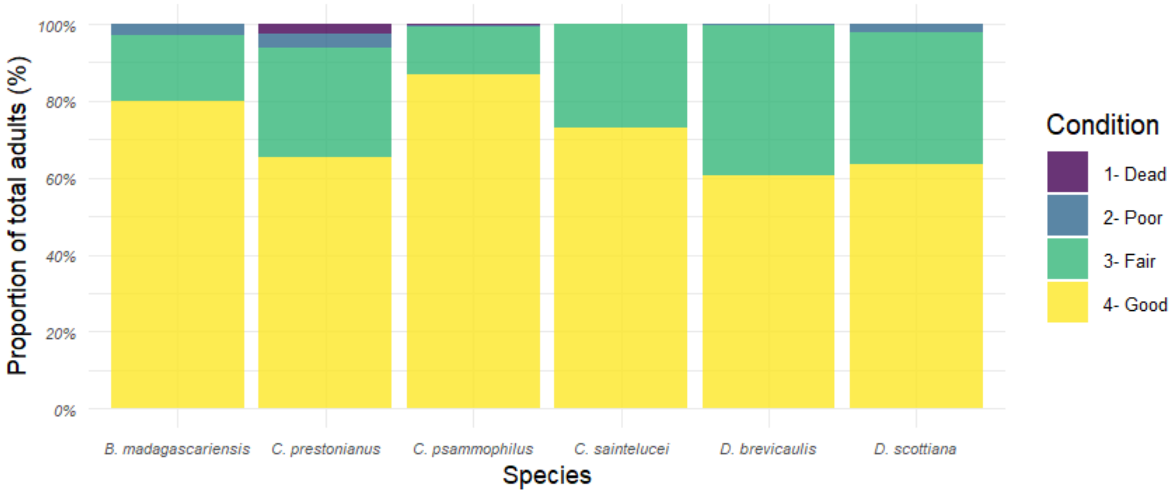


Figure 6: Proportion of adult palm condition for each species. Annex 8 provides descriptive statistics on the conditions of each of the different palm species and Annex 9 percentages of each condition of the different palm species.

4 Discussion

The palm census identified the abundance and distribution of six threatened palm species in Sainte Luce, revealing low palm frequency, interesting distribution trends, and varying demographics between species. The key findings from this census make up a population baseline for the six studied species of threatened palms in the SLLF, which can then be used for further studies.

4.1 Distribution Findings

Prominent findings from this study include a restricted distribution of *D. brevicaulis* within the SLLF. A distinct lack of palm observations in S17 has been recorded, in contrast with more palm observations recorded from S7 than typically expected within a CRZ, based on findings from CRZ S6.

One prominent finding of the census is the number of observations of adult *D. brevicaulis* individuals. The last IUCN Red List assessment of *D. brevicaulis* was made in 2010, when only 40 adult individuals were observed (Rakotoarinivo & Dransfield, 2012b). This small population size, alongside highly localised threats from habitat loss and mining, culminated in *D. brevicaulis* being classified as Critically Endangered (Rakotoarinivo & Dransfield, 2012b). During this census, a total of 4,215 *D. brevicaulis* individuals were identified, including 382 adults, all of which were observed in S8 and adjoining littoral forest remnants. At present, *D. brevicaulis* is only known to be present in two locations, of which S8 is one (Dransfield & Rakotoarinivo, 2012; Rakotoarinivo & Dransfield, 2012b). Furthermore, Rakotoarinivo and Dransfield (2012b) stated in their assessment that if more than 50 adult individuals of this species are observed, then *D. brevicaulis* could instead be reclassified as Endangered. The findings of this study may therefore provide a basis for the reclassification of this species. Despite finding more adult individuals than observed during the last IUCN Red List assessment, further research examining the principal factors driving this unique distribution is necessary and whether other, healthy populations exist within the wider Anosy region. Low population numbers are still threatened by *tavy*[2] and deforestation, despite implementation of the conservation zone in this area (Hogg et al., 2013a). With so few observations made S8, and the other known locality based on the finding of one individual (Dransfield & Rakotoarinivo, 2012), it will be important to continue to monitor population trends.

4.2 Demography Findings and Resource Use

This study identified low proportions of adult palms for *B. madagascariensis*, *C. prestonianus*, and *C. saintelucei* within the SLLF. These palms are particularly valued by local communities as natural resources, where *B. madagascariensis*, *C. prestonianus* and *C. saintelucei*, along with *C. psammophilus* and *D. scottiana*, are regularly

[2] *Tavy* is a swidden agricultural practice which involves setting intentional fires to clear land for agriculture.

used by local communities for house construction, weaving lobster traps, and *pirogue* (dugout canoe) construction (Hogg et al., 2013a).

Adult *B. madagascariensis* observations made up 5.82% of total observations for this species, across all fragments. This was the second highest proportion of adult observations for any species. In the past, *B. madagascariensis* has been used for construction materials and making lobster traps (Dransfield & Beentje, 1995; Hogg et al., 2013a). Today, with the low frequency of adults, the availability of more durable palms for house construction, and the shared common knowledge that this species needs protecting, local natural resource users no longer frequently use adult *B. madagascariensis* palms (Hogg et al., 2013a); possibly accounting for the higher-than-average proportion of adult observations compared to other target palm species in Sainte Luce.

Observations of *C. prestonianus* and *C. saintelucei* were few across all maturity stages, with particularly small proportions of adults; only 0.85% of all *C. prestonianus* and 0.39% of *C. saintelucei* observations being adult individuals. Harvested for their size and durability, adult and sub-adult *C. prestonianus and C. saintelucei* palms are favoured for making lobster traps, along with house construction once mature, leading to a localised reduction in adult populations of these species (Hogg et al., 2013a). *C. prestonianus* and *C. saintelucei* are now less commonly used within the community due to the low availability of sub-adults and adults, and local preference of using stems of more common but equally durable palms such as *C. psammophilus* and *D. scottiana* (Hogg et al., 2013a).

The census concluded *C. psammophilus* and *D. scottiana* to be the most common species in Sainte Luce. Despite larger populations, unsustainable selective harvesting, forest clearance, and *tavy* could land these species in the same position that *B. madagascariensis* and *C. saintelucei* are in today, where populations are in serious decline and few adults remain (Hyde Roberts et al., 2020). The low number of overall adult palm observations aligns with previous findings of palm decline (Hogg et al., 2013b).

D. brevicaulis adults made up 9.06% of total observations for this species, which was the highest proportion of adults across all palm species studied. Observations of adult *B. madagascariensis*, *C. prestonianus*, and *C. saintelucei* were particularly low, with all three species having fewer than 100 observations each across all fragments. There are no known uses for *D. brevicaulis* (Dransfield & Beentje, 1995) possibly contributing towards a higher proportion of adult individuals (Hogg et al., 2013a).

4.3 Palm Health, Frequency, and Decline

Many of the observed palms were in *fair* or *good* condition, despite overall low numbers of observed adults. *C. psammophilus* adult palms were in the best condition compared to other species, with the largest percentage of *good* condition palms (86.89%). *C. prestonianus* were on average the palms in the worst condition, with palms ranging from *dead* to *good* condition, which could be influenced by the frequency of their use by local communities. Many adult *C. prestonianus* were recorded with axe marks, and overall, there was a higher proportion of individuals in *poor* or *dead* condition than other palm species. It was also observed that some *C. prestonianus* adults had died upon reaching a certain age, with their crown blown off and trunk either remaining in place or collapsing to the ground.

S6 and S7's designation as CRZs is likely contributing to lower observed palm frequencies within these fragments. S6 contained the second fewest palm observations, with the majority of observations *D. scottiana* juveniles. Only 122 observations were made of the six threatened palm species throughout the whole fragment, which could be explained by selective removal of adults for resource use. Despite being a CRZ, S7 had the second largest number of palm observations of any fragment, with similar proportions of adult, sub-adult, and juvenile observations as S8 and S9. As a CRZ, this fragment would be expected to have similar palm diversity and density as that of S6, which was not the case. This could suggest that S7 can support a healthy and diverse population of palms despite degradation and has a high potential for regeneration due to the larger numbers of adults, sub-adults, and juveniles that were observed (Hogg et al., 2013a).

S8 and S9 are designated conservation zones, helping to protect threatened palm populations within these areas of Sainte Luce (Temple et al., 2012). S9 contained the most palm observations, with adults of five of the studied palm species observed within the fragment. S8 contained all six studied palm species, of which the most abundant were *D. scottiana* and *C. psammophilus*. S8 contained all observations of *D. brevicaulis*.

Much of S17 is privately owned and managed, and interestingly there were significantly fewer observations of the six studied palm species made in S17 in comparison to the other forest fragments. Overall, the vegetation comprised mostly ferns, vines, *Pandanus* species, and few trees. Combined with observations of multiple non-native species, such as *Eucalyptus sp.* groves and *Lantana sp.* patches, indicating a high level of disturbance in this area (Binggeli, 2003). As the only fragment to border a beach and geographically separated from the rest of the forest, this may result in different topographic and localised climatic conditions. Varying soil chemistry, hydrology, climate, and topography have been shown to influence palm distribution (Eiserhardt et al., 2011). These differing abiotic conditions along with disturbance are potential explanations for lack of palm abundance and diversity in the area. This population assessment provides novel insight into this fragment. Other data collected as part of Project Palms, including interviews with community members and landowners, may provide insight into why this fragment had a lower observed frequency and diversity of target palms.

Hyde Roberts et al. (2020) identified rapidly declining populations of adult and sub-adult *C. saintelucei* and *B. madagascariensis* between 2008 and 2018 in Sainte Luce. Observations of adult *C. saintelucei* declined from 147 individuals across four forest fragments (S6, S7, S8, and S9) in 2011, to 49 individuals in 2018. Whilst losses of *B. madagascariensis* were not observed to be as significant as that of *C. saintelucei*, an average decline of 1.5 adults per year was calculated, with 48 adult individuals in 2008 to 36 in 2018. The low frequencies of adult *C. saintelucei* and *B. madagascariensis* palms observed during the census could indicate that these populations are still declining rapidly. Further population assessments would enable trends in populations to be determined. Taken together, declines in the local populations of both *B. madagascariensis* and *C. saintelucei* highlight the need for a community-driven conservation action plan to manage the remaining populations.

4.4 Challenges

Due to the size of the assessed forest fragments, a transect-based methodology that evaluated palm presence from a representative area of each forest was chosen and a full, traditional census was not completed. As such, absolute populations for each species were not recorded and the values presented in this report are underestimates of the true populations. Potential future analysis could be conducted on the collected data to estimate *true* local populations that could then be used to assess the abundance and diversity of threatened palms within the forests of Sainte Luce.

Due to their similar morphologies as other species in the region, species such as *C. prestonianus* and *C. saintelucei* were occasionally misidentified. To assist accurate identification, a visual identification guide and training was provided to aid identification. Experience of local experts was also sought to improve understanding of each species. Instances of misidentification were identified and corrected in the dataset, with re-visits to any further questionable observations.

Due to the difficulty in identifying species when a palm had been cut, fallen, or died, not all dead palms were recorded to reduce misidentification of species. When identity of the dead palm was clear and could be confirmed, this was recorded on the dataset. Therefore, census data on dead palms are accurate but an underestimate of the true value within the forest. Following the completion of the census, some palms that had been identified in the census have since been cut down or died, particularly in the CRZs of S6 and S7. By collecting GPS data on every adult and the species it was identified as during this census, this gives a baseline of which palms could be found in exact locations and provides a comprehensive population baseline to be compared against in the future.

5 Conclusion

The findings of this report point to several key observations of current threatened palm populations in the SLLF. All target palms have low numbers of adult individuals, with broader concerns that local populations of each of these species may continue decreasing as a consequence of mining, habitat loss, and unsustainable natural resource use. A current understanding of the abundance and distribution of the target species in the SLLF has now been achieved. The findings of this study improve the overall understanding of these palm species, by broadening the literature about their distribution, demographics, and phenology, aiding the ability to conserve them. By informing national and international understanding of these threatened species, this report aims to contribute to the development of a community-driven conservation action plan to ensure their long-term survival.

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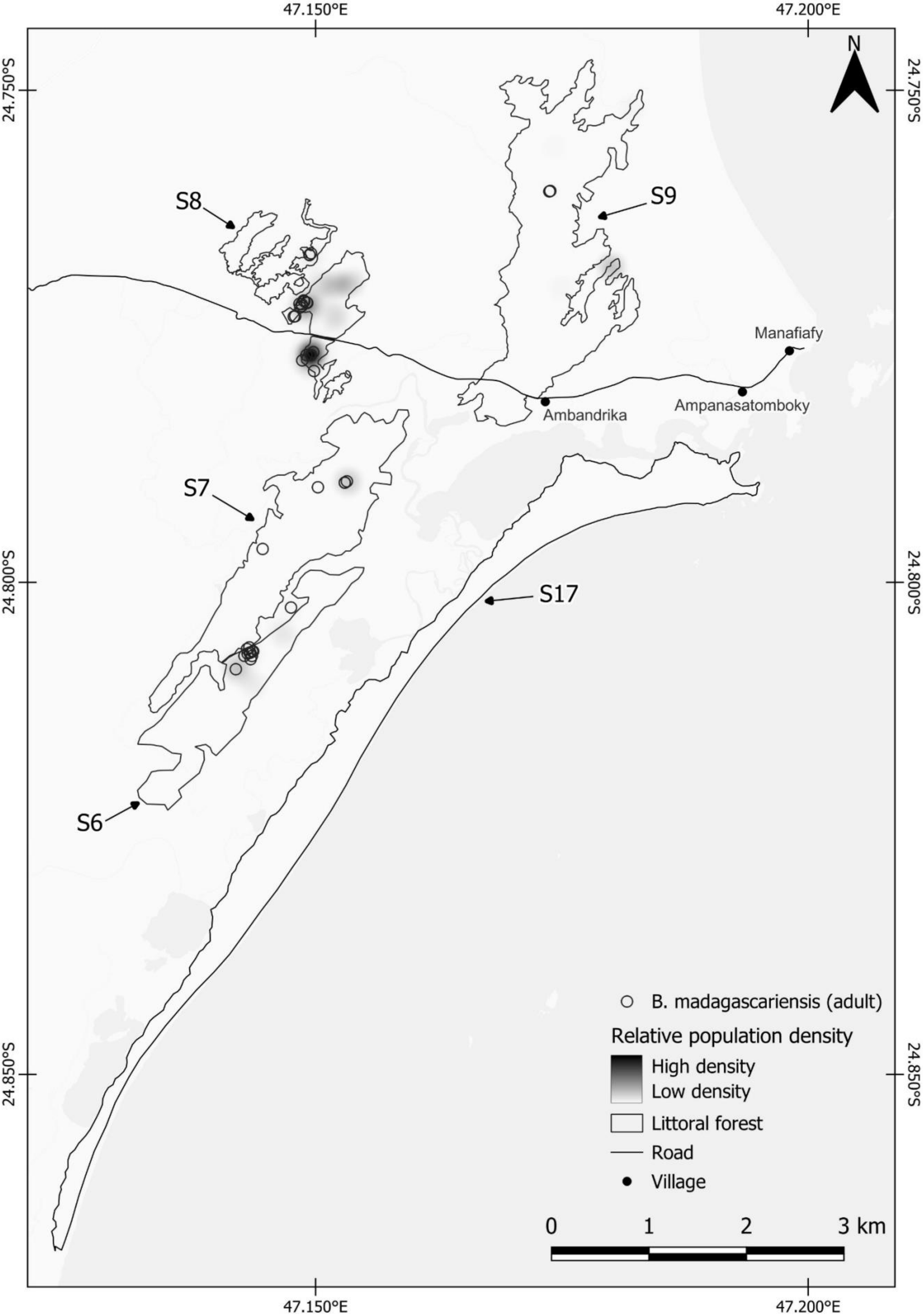
7 Annexes

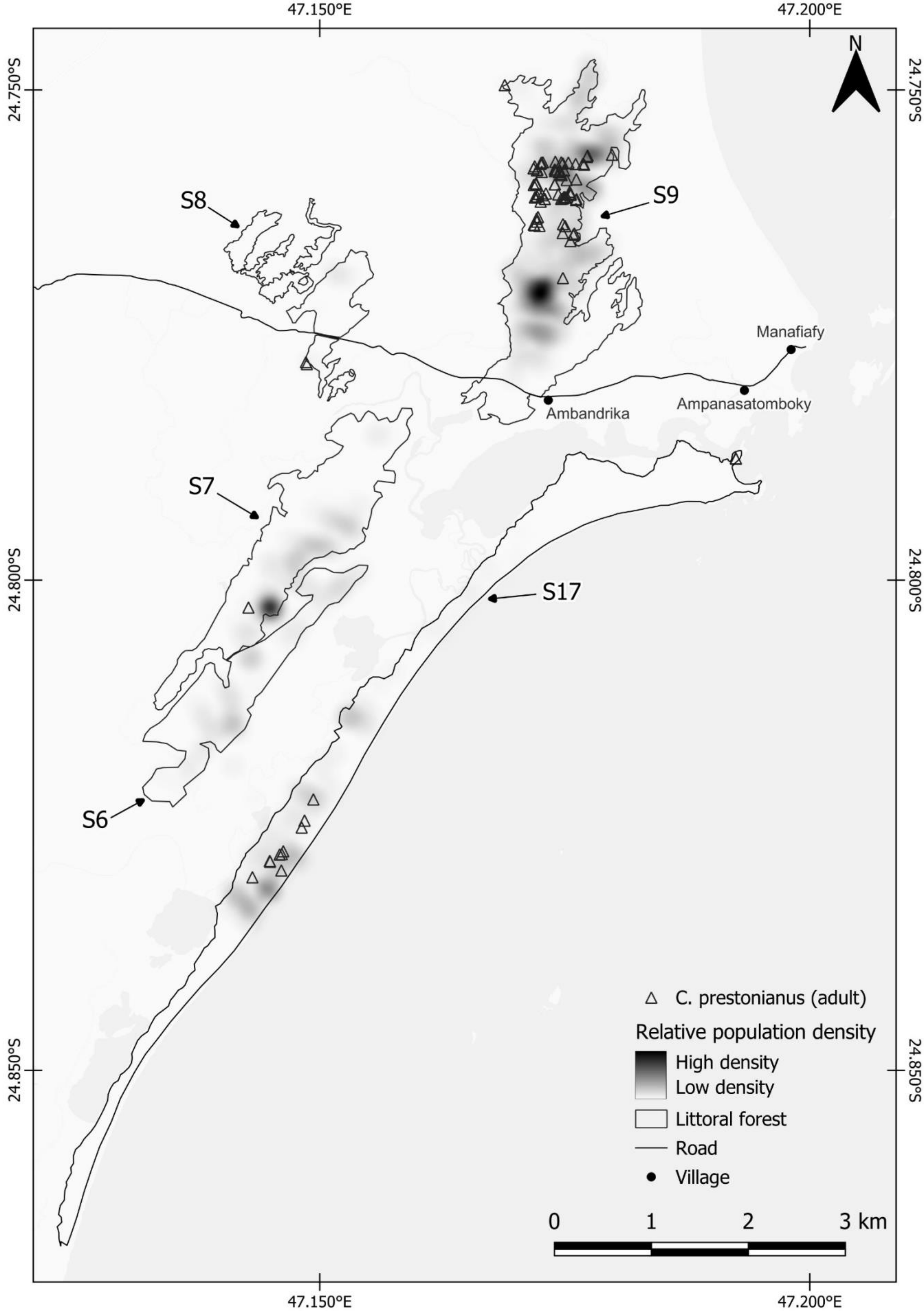
Annex 1 – Summary of observation frequencies of total palms found in S8 (S8N and S8S) and adjoining remnants (S8R1-4)

Species	Age	S8R1	S8R2	S8R3	S8R4	S8N	S8S	Total
B. madagascariensis	Juvenile	0	12	0	0	131	247	390
	Sub-adult	0	1	0	0	134	45	180
	Adult	0	3	0	0	15	5	23
	Total	**0**	**16**	**0**	**0**	**280**	**297**	**593**
C. prestonianus	Juvenile	0	1	0	0	20	8	29
	Sub-adult	0	0	1	0	1	0	2
	Adult	0	0	0	0	0	2	2
	Total	**0**	**1**	**1**	**0**	**21**	**10**	**33**
C. psammophilus	Juvenile	0	144	35	86	7,276	1,363	8,904
	Sub-adult	0	91	20	48	4,632	699	5,490
	Adult	0	3	0	9	171	67	250
	Total	**0**	**238**	**55**	**143**	**12,079**	**2,129**	**14,644**
C. saintelucei	Juvenile	142	30	191	121	1,695	973	3,152
	Sub-adult	8	0	8	4	13	16	49
	Adult	0	1	6	1	1	1	10
	Total	**150**	**31**	**205**	**126**	**1,709**	**990**	**3,211**
D. brevicaulis	Juvenile	0	0	0	6	1,535	840	2,381
	Sub-adult	0	0	0	9	966	477	1,452
	Adult	0	5	0	8	272	97	382
	Total	**0**	**5**	**0**	**23**	**2,773**	**1,414**	**4,215**
D. scottiana	Juvenile	693	163	177	302	4,964	1,887	8,186
	Sub-adult	435	102	90	208	4,152	1,187	6,174
	Adult	10	3	1	3	96	43	156
	Total	**1,138**	**268**	**268**	**513**	**9,212**	**3,117**	**14,516**
Total		**1,288**	**559**	**529**	**805**	**26,074**	**7,957**	**37,212**

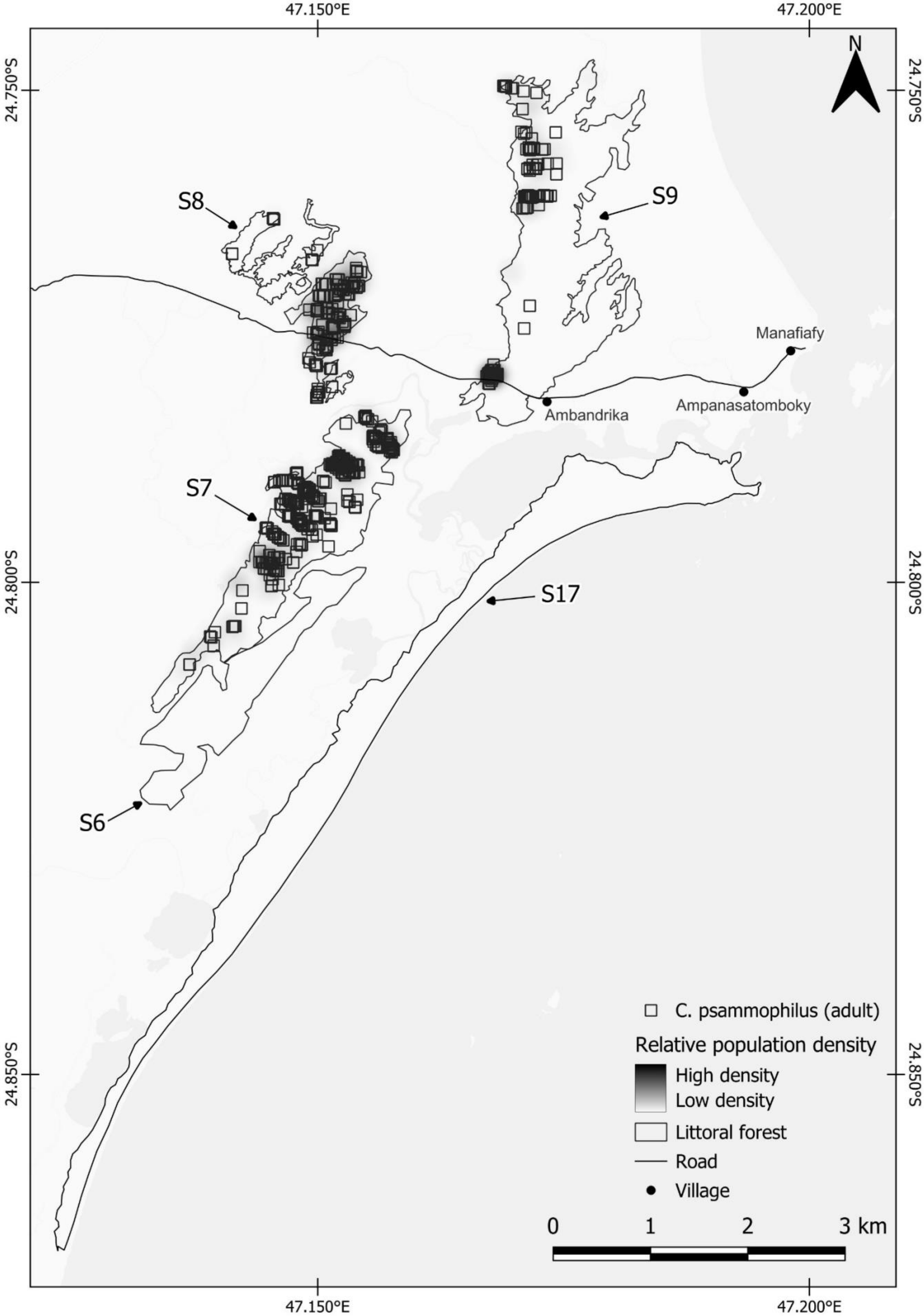
Annex 2 – Distributional map of *Beccariophoenix madagascariensis* in Sainte Luce



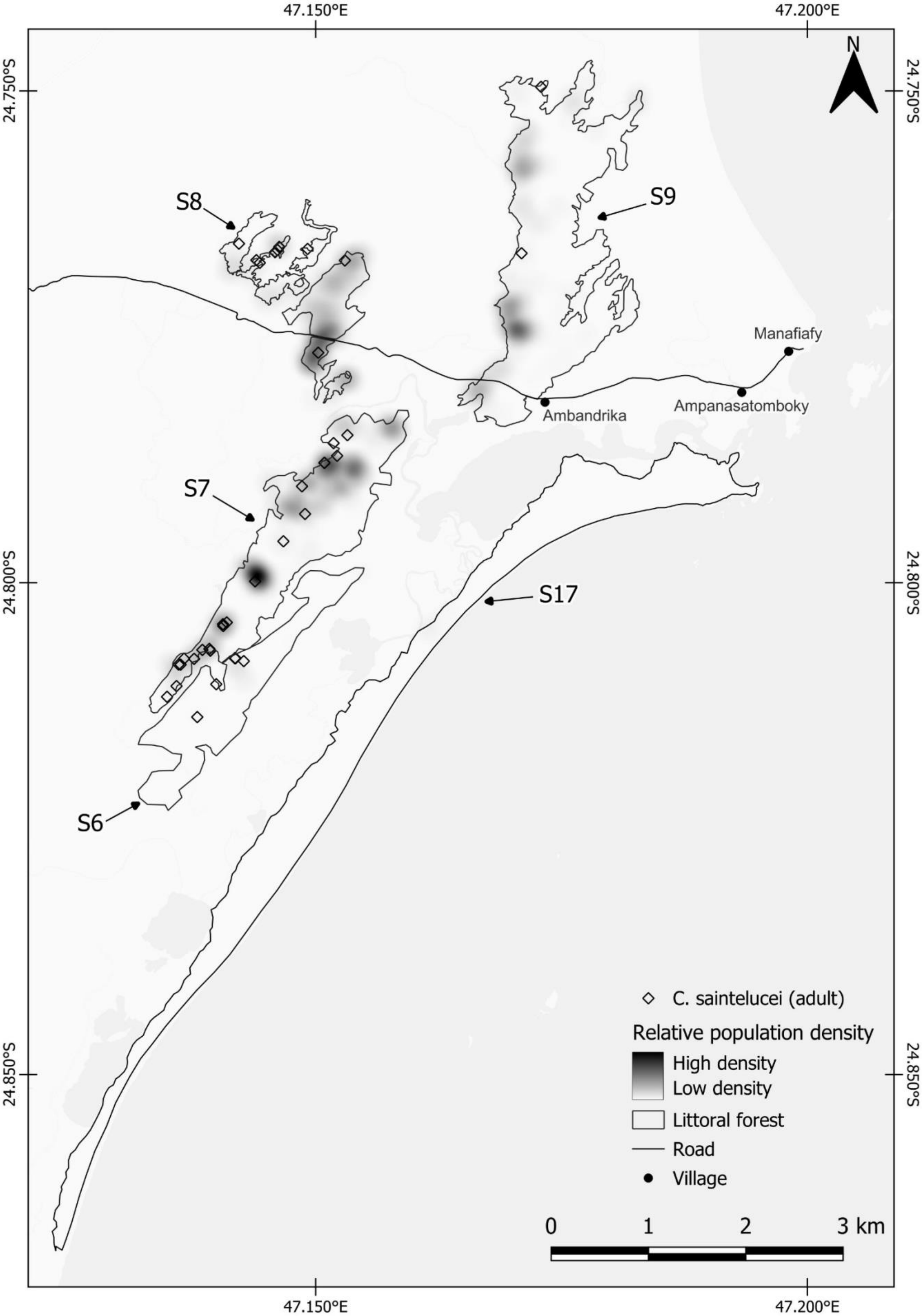
Annex 3 – Distributional map of *Chrysalidocarpus prestonianus* in Sainte Luce



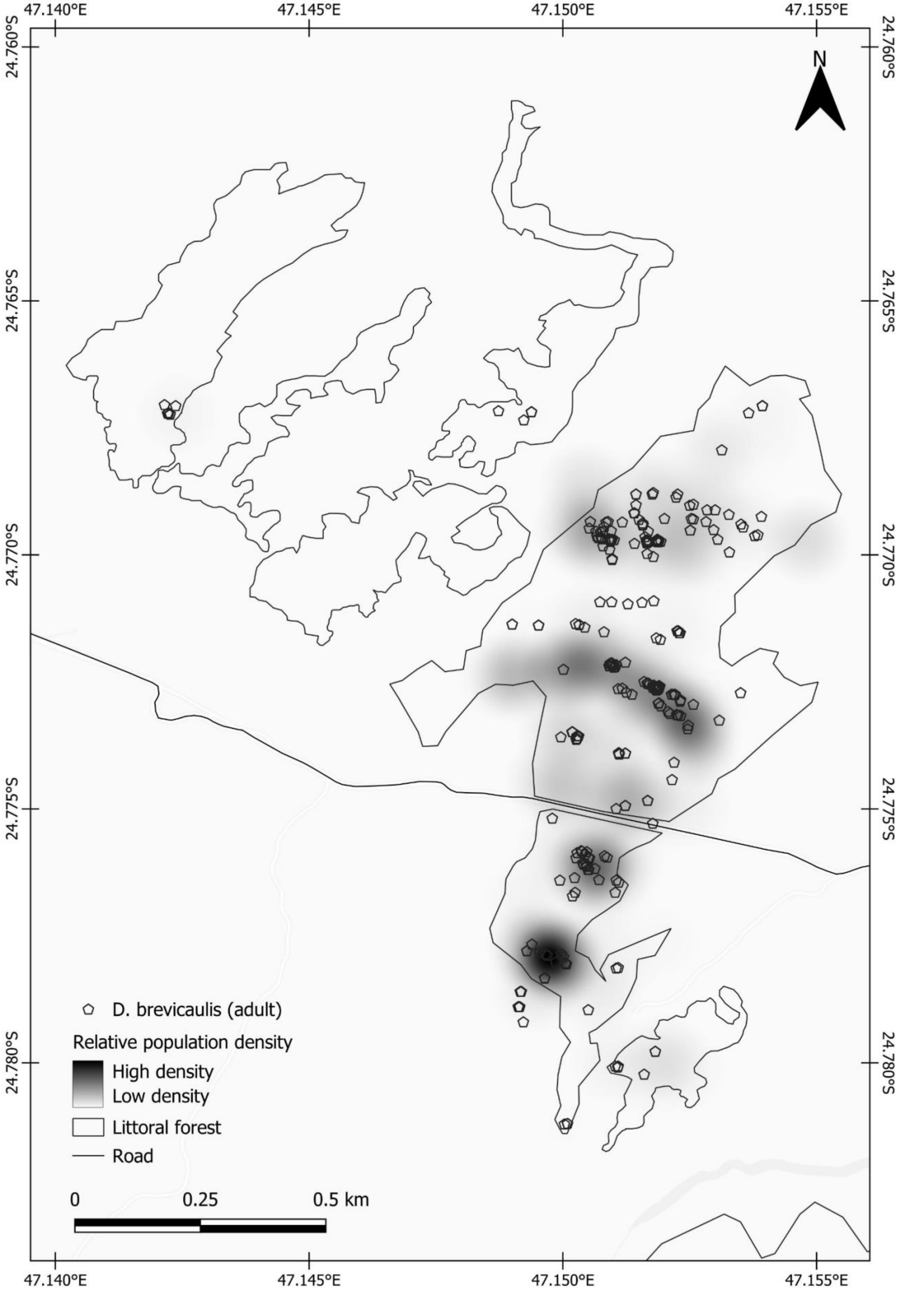
Annex 4 – Distributional map of *Chrysalidocarpus psammophilus* in Sainte Luce



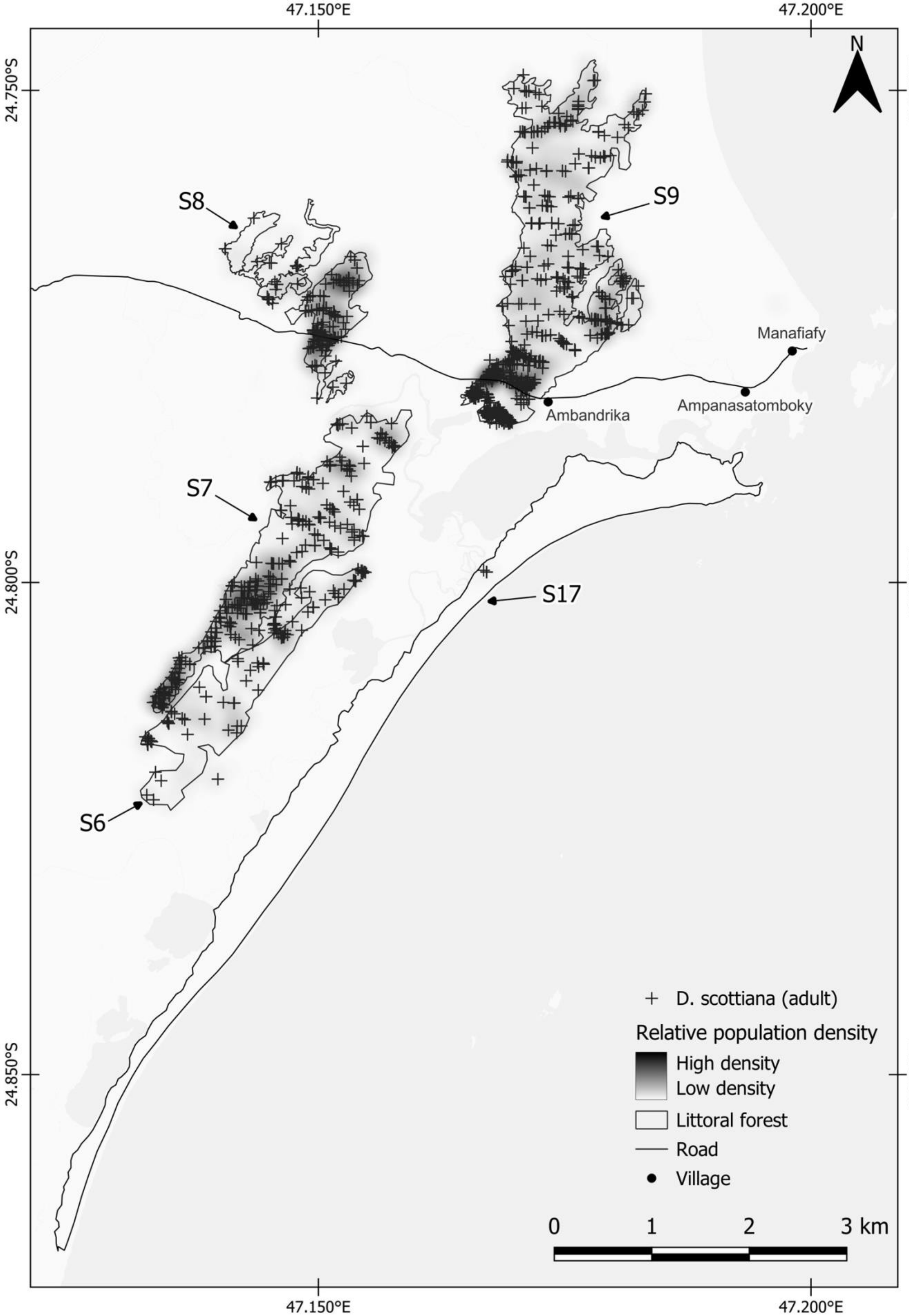
Annex 5 – Distributional map of *Chrysalidocarpus saintelucei* in Sainte Luce



Annex 6 – Distributional map of *Dypsis brevicaulis* in forest fragment S8



Annex 7 – Distributional map of *Dypsis scottiana* in Sainte Luce



Annex 8 – Summary of descriptive statistics of adult palm height, circumference, and condition

Height (m)						
Species	**N**	**Mean**	**Median**	**Mode**	**Min**	**Max**
B. madagascariensis	44	9.80	10.00	10.00	7.00	20.00
C. prestonianus	83	13.51	14.00	15.00	3.00	22.00
C. psammophilus	1,104	7.02	7.00	7.00	2.00	18.00
C. saintelucei	40	11.81	12.00	15.00	5.00	17.00
D. brevicaulis	382	1.54	1.50	1.50	0.50	3.00
D. scottiana	1,317	3.28	3.00	2.00	0.80	10.00
Circumference (cm)						
Species	**N**	**Mean**	**Median**	**Mode**	**Min**	**Max**
B. madagascariensis	44	91.47	85.00	70.00	65.00	190.00
C. prestonianus	83	94.90	97.50	100.00	42.00	128.00
C. psammophilus	1,104	12.04	12.00	12.00	6.00	50.00
C. saintelucei	40	47.68	48.00	70.00	14.00	85.00
D. brevicaulis	382	4.56	4.00	4.00	2.00	10.00
D. scottiana	1,317	4.75	4.50	4.00	1.00	13.00
Condition (1-4)						
Species	**N**	**Mean**	**Median**	**Mode**	**Min**	**Max**
B. madagascariensis	44	3.77	4	4	2	4
C. prestonianus	83	3.57	4	4	1	4
C. psammophilus	1,104	3.86	4	4	1	4
C. saintelucei	40	3.73	4	4	3	4
D. brevicaulis	382	3.60	4	4	2	4
D. scottiana	1,317	3.61	4	4	2	4

Annex 9 – Proportion of palm condition for each species

Species	1 – Dead	2 – Poor	3 – Fair	4 – Good
B. madagascariensis	0.00%	2.86%	17.14%	80.00%
C. prestonianus	2.47%	3.70%	28.40%	65.43%
C. psammophilus	0.28%	0.28%	12.56%	86.89%
C. saintelucei	0.00%	0.00%	27.03%	72.97%
D. brevicaulis	0.00%	0.53%	38.99%	60.48%
D. scottiana	0.00%	2.13%	34.31%	63.56%