The Biology, Ecology and Conservation of an Endangered Palm, *Dypsis saintelucei* (Arecaceae), in the Littoral Forest of Sainte Luce, Southeast Madagascar

ONG Azafady

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Abstract

Sainte Luce represents one of four locations for the endemic, Endangered and economically important palm species, *Dypsis saintelucei* (Rakotoarinivo & Dransfield 2012). *Dypsis saintelucei* provides the people of Sainte Luce with a range of useful plant materials, however overexploitation and mining threaten the extant population. Extirpation from Sainte Luce would not only place the species at greater risk of extinction, but could also threaten the future of local livelihoods. Based on extensive research into the biology, ecology, use and cultivation of the species, we propose an *in situ* conservation strategy for *Dypsis saintelucei* at Sainte Luce.

Key words: *Dypsis saintelucei*, Sainte Luce, *in situ* conservation, population reinforcement

Introduction

Madagascar's floral diversity is exceptionally high - 82% of 11,220 species of vascular plant recorded are considered endemic to the island (Callmander et al. 2011). Of the 243 plant families found on the island, it could be argued that the palm family (Arecaceae) deserves particular attention. Currently inventoried at over 200 species (over three times the species richness than mainland Africa), 97% of Malagasy palms are endemic to the island (J. Dransfield pers. comm. Oct 2011). In addition, the vast majority of these palms are seriously threatened; the IUCN Species Survival Commission (SSC) Palm Specialist Group recently reported that 83% of all native palm species are at risk of extinction and that the loss of these plants would place traditional Malagasy livelihoods at risk too (IUCN 2012).

Palms are important species in subsistence and small-scale commercial livelihood strategies across the Island. However, it is widely recognised that many palm populations are being harvested unsustainably (Dransfield & Beentje 1995, Johnson 1996, Byg & Baslev 2001, Ratirison et al. 2002, Hogg et al. 2013). This overexploitation is further exacerbated by high rates of habitat loss island wide - shifting cultivation (*tavy*), cattle grazing and mining operations continue to fragment and reduce habitat extent for many native palm species.

The genus *Dypsis* is easily the most diverse of all Madagascar's endemic palm genera, accounting for over 140 species. Occupying almost all of the Island's bioclimatic zones (Cornet 1974), *Dypsis* species vary dramatically in size, form and habit. *Dypsis saintelucei* is a medium-sized, solitary, arboreal palm restricted to the Islands eastern escarpments and lowlands (Fig 2.). Prior to 2012, *D. saintelucei's* conservation status was Critically Endangered according to the IUCN's Red List of

Figure 1. The national distribution of *D. saintelucei*; Ampasimanolotra[1], Vondrozo[2], Tsitongambarika[3] and Sainte Luce[4] (distribution map from Kew Madagascar Conservation Centre)

Threatened Species and thought to exist only in Sainte Luce (IUCN 1998). However recent explorations have revealed the existence of three other populations and subsequently its conservation status changed to Endangered (Rakotoarinivo & Dransfield 2012). In addition to Sainte Luce, the species distribution now includes populations at Ampasimanolotra, Vondrozo and Tsitongambarika (Fig. 1), with an estimated total area of occupancy at 210km^2 and a total population consensus of approximately 300 adult plants (Rakotoarinivo & Dransfield 2012).

Although none of the four sites containing *D. saintelucei* are within the protective boundaries of National Parks, the lowland humid rainforest of Tsitongambarika and the littoral forest of Sainte were two of many *nouvelles aires protégées* (newly protected areas or NAPs) included in the government's 2003 expansion of the *Système d'Aires Protégées* de Madagascar (Madagascar's protected areas network, or SAPM). Despite the NAP status, these forests continue to face unabated rates of deforestation and degradation,

and in the case of Sainte Luce, mining operations pose an added threat to the area's biodiversity. QIT Madagascar Minerals (QMM), a subsidiary of Rio Tinto, has targeted 57% of Sainte Luce's littoral forest to be cleared for the extraction of ilmenite (Vincelette et al. 2007), a titanium-iron oxide mineral that is used as a whitening agent in a wide variety of products. In 2008, mineral extraction at the pilot site of Mandena began, and by 2012, prefeasibility studies in Sainte Luce were underway. However, due to management decisions based on external factors, these operations have been recently suspended (1st Feb, 2013).

Figure 2. A mature *D. saintelucei* in forest fragment S8, Sainte Luce

The Non-Governmental Organization Azafady has been focusing conservation efforts (biodiversity research, direct species interventions, natural resource management) in the littoral forest of Sainte Luce for over a decade. Azafady has identified *D. saintelucei* as a priority plant species for *in situ* conservation – indeed the Endangered palm is used for a wide range of local applications including lobster traps (lobster fishing is a primary source of income in Sainte Luce) (Hogg et al. 2013). Since 2003, Azafady has conducted a range of population, ecological and ethnobotanical studies into *D. saintelucei* in Sainte Luce, and has developed and part-implemented a conservation strategy for the population. This report is a synopsis of the research conducted, results attained and practical experience gathered.

Methods & Results

Study Area - the Littoral Forest of Sainte Luce

The *fokontany* (the smallest unit in Madagascar's administrative system) of Sainte Luce (E047° 11' 06.67", S24° 46' 46.06") is a collection of three hamlets - Ambandrika, Apanasantomboky and Manafiafy – located approximately 40km north of Fort Dauphin (Tolagnaro) along the southeast coast of Madagascar (Fig. 3). Sainte Luce is of particular interest as it is home to the one of three remaining stands of intact littoral forest within the Tolagnaro region (as defined by Vincelette et al. 2007), with exceptional levels of biodiversity and endemism. At Sainte Luce, fifteen littoral forests fragments remain, ranging from 1ha to 340 ha, with a total area of approximately 1500 ha of forest cover (Vincelette et al. 2007). This study focussed on the largest, most *intact* fragments of forest, which represent both the largest *D. saintelucei* subpopulations and the main source of terrestrial natural resources supporting livelihoods for the local communities in Sainte Luce. These are forest fragments S6, S7, S8 and S9 as shown in Figure 2. S6 and S7 are 190 ha and 207 ha respectively and are "open access" community-use zones; S8 is 91 ha and a NAP and has also been targeted as a biodiversity offset for the mining development; and S9 is 340 ha and the mine's primary conservation zone.

Botanical Description

Classification
Order: Arecales
Family: Arecaceae
Subfamily: Arecoideae
Tribe: Areceae
Genus: *Dypsis*
Species: *saintelucei*
Author: Beentje
Local Name: *Telopoloambilany*

Dypsis saintelucei can reach a height of 12m with an average DBH of 21cm (some individuals possess a DBH exceeding 30cm). Although juveniles can cluster, adult trees have only been seen exhibiting a solitary growth habit in Sainte Luce. The trunk is very hard and possesses internodes up to 5cm long, whitish nodal scars (lateral 'rings' representing old leaf scars), and it is greener towards the crownshaft. The crownshaft is a waxy pale green and the leaves are arranged in three distinct ranks (tristichous). Up to 10 leaves can be found in the crown, arching distally (towards the end of the leaf). The petiole (section of leaf

stem between leaf attachment and first basal leaflet) is either absent or <13cm in length. Inflorescences (flowering parts) are interfoliar (within the crown) and branched to three orders; flowers are yellow and slightly scented. Fruit is ellipsoid shaped; 15mm x 8mm, yellow and the endocarp ('seed coating') is fibrous. Seed is also ellipsoid with endosperm deeply ruminate. More detailed descriptions can be found in Dransfield & Beentje (1995).

Distribution and Population Size

The perimeters of all five major Sainte Luce forest fragments (S6, S7, S8, S9 & S17) were mapped using a Garmin 60 Csx handheld GPS unit. In 2003, an entire forest cover search was conducted to count the number of mature *Dypsis saintelucei* in forest fragment S8. Later, in 2008, the distribution and population size of adult *D. saintelucei* was determined in forest fragment S8 and S9 by entire forest cover searches with the aid of local guides. Using a handheld GPS unit (Garmin 60 Csx), search teams swept east to west throughout the entire length of the forests fragments to locate adult trees. Upon discovery, the individual was tagged, using flagging tape, and its position of was recorded and mapped (GPS). In 2010, the S8 population was monitored to update the population consensus and in 2011 mapping searches expanded to forest fragments S6 and S7 employing the same extensive mapping methodology fore mentioned. In 2012, the S7 adult population was revisited and monitored. Local traditional experts and forest users reported that the palm was absent from the beachfront forest, S17.

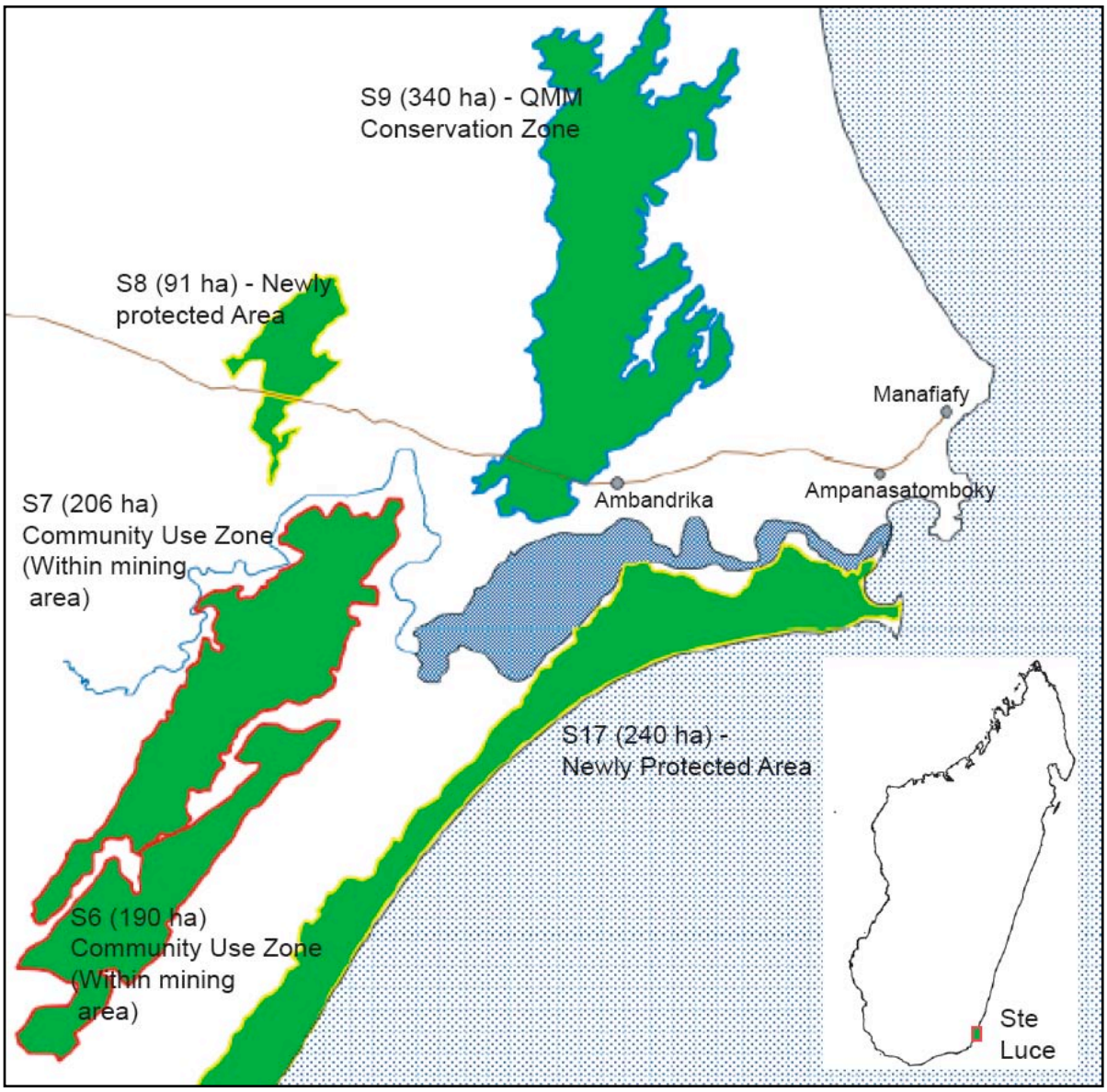

Figure 3. The three villages of Sainte Luce (Ambandrika, Ampanasatamboky and Manafiafy) and the five major forest fragments and their respective statuses

Nevertheless, Azafady researchers and local guides made several explorations to S17 to confirm these reports. The survey noted the presence of juvenile trees (see Fig. 4) too, but empirical sampling for a population census for this cohort has yet to be completed (see table 1 for cohort classifications).

Figure 4. A juvenile *D. saintelucei* growing on the edge of forest fragment S8

Table 1. Classification criteria for different age cohorts

Cohort	Description
Seedling	Seedling leaves (<4) possess a single leaflet pair (<15cm in length)
Juvenile	Early juveniles possess leaves with 2 or more leaflet pairs; leaves grow to 2m+ in length in older juvenile stages (but no visible trunk)
Subadult	Development of the crownshaft and a short trunk, but no visible signs of reproductive maturity
Adult	Visible signs of reproductive maturity; trunk usually >4m in length

As a result of expanding the mapping methodology to S6 and S7, three subpopulations were discovered. In forest fragment S7 with a total population of 113 adults for the fragment (Table 2). The most recent counts from 2011 and 2012 show that S8 and S7 represent the largest subpopulations of adult *D. saintelucei* in Sainte Luce, with 26 and 113 adult individuals respectively. Far fewer individuals are represented in S6 and S9 – four in S6 and a single solitary adult in S9. No subadults were found in either S9 or S6; the largest numbers of subadults were found in S7 and S8 with 14 and 19 individuals respectively. The total population numbers for the four fragments surveyed were 33 subadults and 144 adults. In S7, there were three distinct subpopulations discovered, the largest clusters found at the centre and in the south of the fragment (Fig. 4). It is likely that that the adults from S6 are highly related to the southern most population in S7 as only a narrow swamp divides these two forest fragments. The distribution of *D. saintelucei* throughout S8 was found to be less clumped than S7, with some individuals located in the more degraded western sub-fragments of S8.

Habitat Description

The sessile nature of plant-life ensures that the interactions of plants and their environment are local, and therefore the place where a seed lands has a significant impact on its likelihood to germinate and mature (Lehman & Tilman 1997). Intrinsic factors such as soil quality or light availability are further modified by the neighbouring plant species, either negatively (e.g. increased competition for certain nutrients) or positively (e.g. by increased litter and improved microclimate), and thus can impact on the suitability of a location for a given species (Barot & Gignoux 2003). In 2008, it was investigated whether *D. saintelucei* had any soil pH, soil moisture, canopy cover preferences, and if there are interspecific floral associations between *D. saintelucei* and other littoral flora that may be a determining factor behind growth, survival and reproduction. In order to determine whether there are any significant interactions with neighbouring plant species, a $10m^2$ quadrat was erected with an adult *D. saintelucei* at the centre point. All individual trees with a DBH of over 10cm were identified within the quadrat. This was repeated for 12 randomly selected adult individuals and 6 random control plots in the forest fragment S8. A Principal Components Analysis (PCA) Covariance was used to test for patterns in tree species composition at adult *D. saintelucei* and control sample plots. Soil pH and moisture preferences were determined using standard soil probes (supp. Tenax©) by testing at 36 strategic points within the same 10m2 quadrat used for the neighbourhood analysis. Canopy cover preferences were tested for using a densiometer at 15 *D. saintelucei* plots and 6 control plots.

Table 2. A historical record of consensus efforts by Azafady for adult *D. saintelucei* in Sainte Luce

Year	Methodology	S9 consensus (adults)	S8 consensus (adults)	S7 consensus (adults)	S6 consensus (adults)
2003	Visual encounter survey	_	130	_	_
2008	Entire forest cover searches	2	42	_	_
2010	Entire forest cover searches	2	33	_	_
2011	Entire forest cover searches (S6 & S7), relocation by GPS (S8 & S9)	1	26	116	4
2012	Relocation by GPS	1	_	113	_

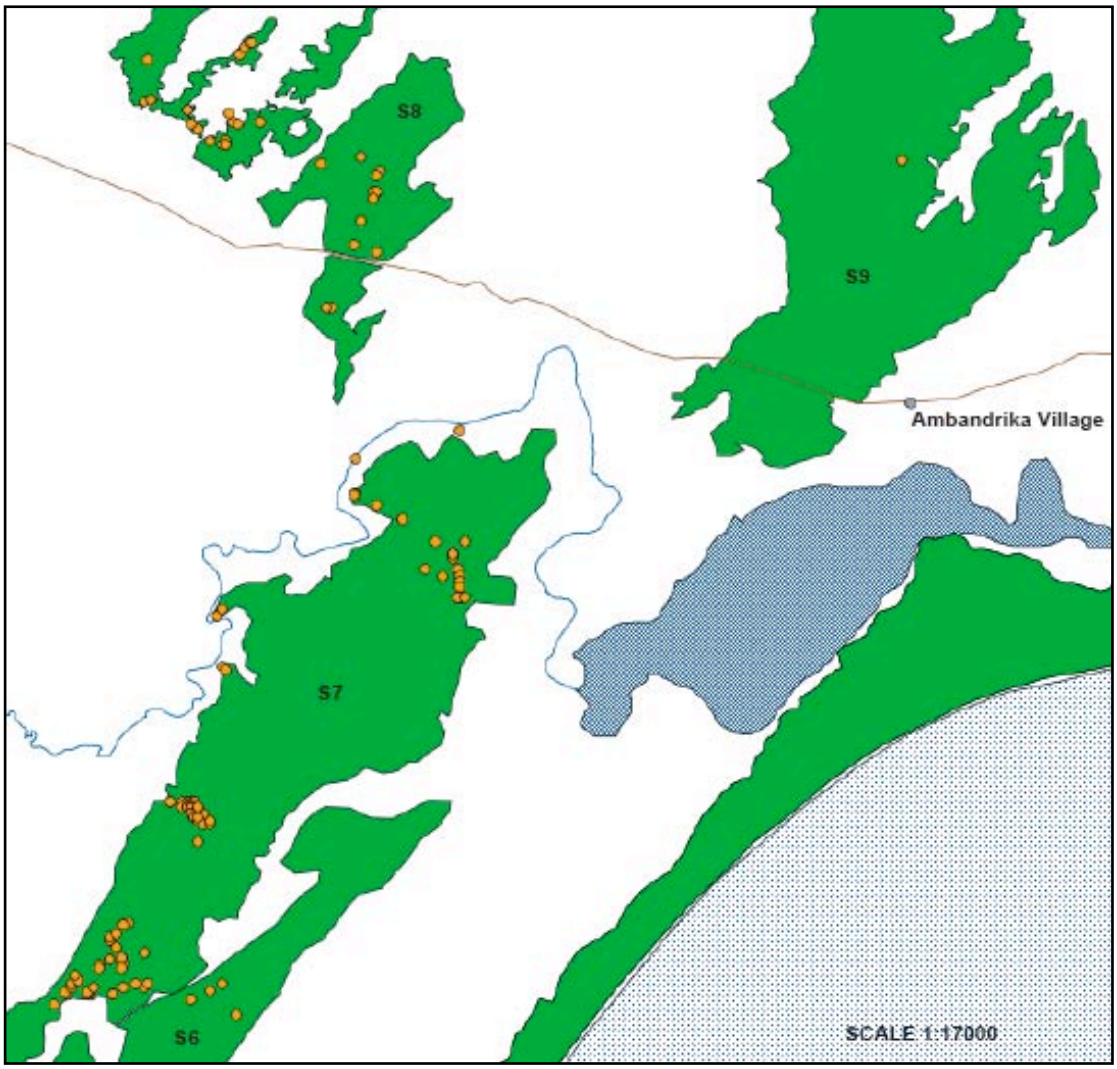

Figure 5. The distribution of adult *Dypsis saintelucei*

Floral species interactions

The PCA Covariance aimed to reveal patterns in tree species composition at adult *D. saintelucei* locations. With very limited visual separation between plots containing *D. saintelucei* and control plots not containing *D. saintelucei*, this ordination failed to delineate differences in tree species composition from these sites (see Fig. 4). *Dypsis saintelucei* distribution does not appear to be related to any of the tree species recorded in these surveys in particular. All 18 quadrats appear to represent a homogenous landscape of tree species with a few anomalies (see Fig. 6). Detrended Correspondence Analysis (DECORANA) further illustrates the homogeneity of tree species within the forest fragments sampled, regardless of *D. saintelucei* presence or absence (see Fig. 7).

Soil moisture

Soil moisture was rated from 0 to 10 (0 being the driest and 10 the wettest) and subdivided into 20 classes. *Dypsis saintelucei* sample sites had a total mean of 2.76 (±2.985452) and control group sites had a total mean of 1.675 (±1.650391). The relationship between soil moisture and *D. saintelucei* sites is statistically significant showing that *D. saintelucei* occurred in wetter soils (p = 0.0003) than would be expected by chance. This may suggest *D. saintelucei* prefers soil with a moisture value of around 2.7.

Soil acidity

Soil pH results ranged from 4.9 to 8.0, with the mean pH for *D. saintelucei* sites at 6.75 (±0.395209) and 6.88 (±0.102697) for control sites. With the total mean of *D. saintelucei* sites having a lower pH value than the mean value for the control sites, statistical analysis was used to test the significance of the data. A student *t*-test revealed that the data was statistically significant (p = 0.0009) - *D. saintelucei* occurred in more acidic soils than expected by chance.

Canopy cover

Canopy cover was recorded from the centre of each quadrat and taken as an approximate percentage. Canopy cover varied significantly throughout the sample sites; the highest recorded canopy cover for the *D. saintelucei* sample was 88% and the lowest was 5%. The mean canopy cover for all of the 21 trees sampled was 63.5 (±17.76687662) %. Comparison of the *D. saintelucei* sites (n=15) with the control sites (n=6) showed mean canopy cover to be higher in the control sites, 66.5 (±8.408329) % than the *D. saintelucei* sites, 62.3 (±20.50319) %. However, statistical analysis has described this relationship as insignificant (p = 0.64) - the sampled adult *D. saintelucei* population does not appear to relate to approximated canopy cover.

Reproduction

Dypsis saintelucei flower characteristics (shape, size, colour and the presence of nectar) suggests that the plant is pollinated by insects. On multiple occasions bees were observed visiting the flowers, however, the interfoliar (amidst the crown) positioning of the inflorescence made identifying the bee species very difficult. In the same way, the interfoliar positioning of the developing fruits made estimating of fruit development time a challenge. Surprisingly, no animals were observed predating *D. saintelucei* fruit during the mapping and monitoring phases between 2009 and 2012. However, in 2004, E.R. Ellis observed the greater vasa parrot (*Corracopsis vasa*) predating on the fruit of *D. saintelucei* on four separate occasions in S8. On closer inspection however, the parrot had cracked open the endocarp with its beak and had eaten the nutritious endosperm, destroying the seed.

According to our observations, the seed dispersal mechanism of *D. saintelucei* appears to be barochorous (gravity), resulting in a high level of intraspecific competition between the 'clumped' seedlings, which may limit recruitment. Indeed, it was common to find more than 300 recently germinated seedlings within two metres of the adult palm. Only a small percentage of these seedlings would survive to maturity - signs of stress (chlorosis) were visible soon after germination. Successful seed collections in both the S7 and S8 populations were made in August 2011, October 2011 and March 2012, suggests that fruit production is year-round (it is not known however whether fruit production is higher in a certain season). Further research is required to determine a more concrete understanding of the species reproductive biology – in particular flowering times, fruit development time and pollinator identification.

Cultivation

The Azafady tree nursery manager in Sainte Luce has been carrying out cultivation trials since 2005 to determine the most successful pre-treatment for germination and growing conditions for the young seedlings:

The ripe, fallen fruits are collected and the pericarp removed, the seeds are then left in the shade for 2-3 days before being planted out in pots in the nursery. Sandy topsoil is collected from the edge of the nearby littoral forest and is used to fill the growing pots. Leaves of the ubiquitous travellers palm, *Ravenala madagascariensis* (Strelitziaceae)

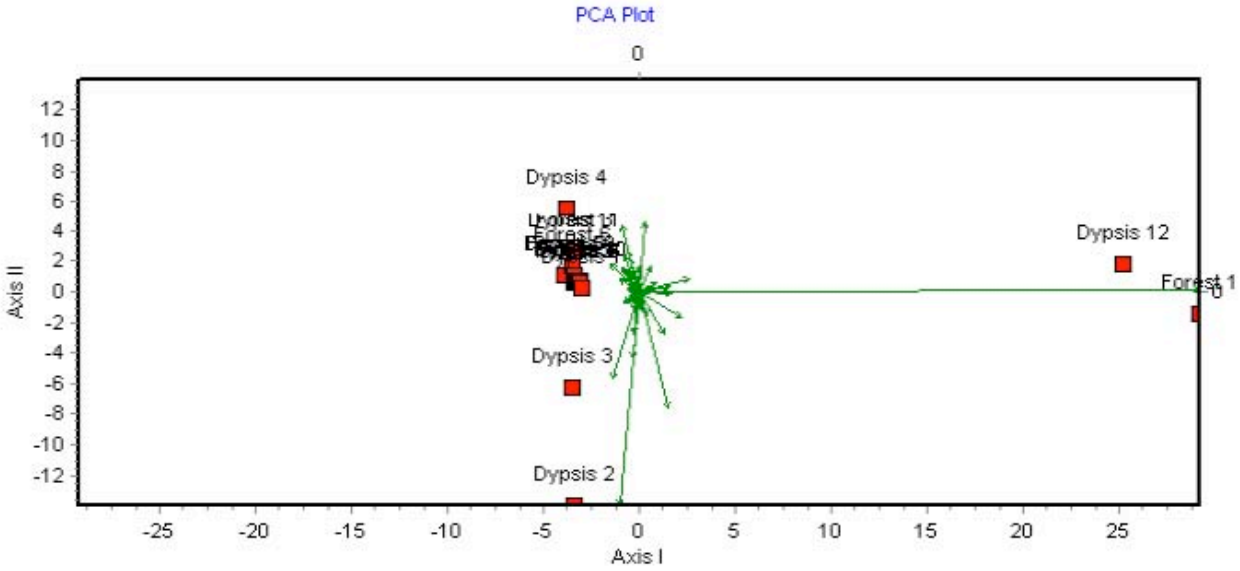

Figure 6. PCA Covarience showing species vector data against *D. saintelucei* and control sampling sites on two axes. 'Dypsis' (1 – 12) and 'Forest (control)' (1 – 6) in this ordination represent all quadrats where species data was collected.

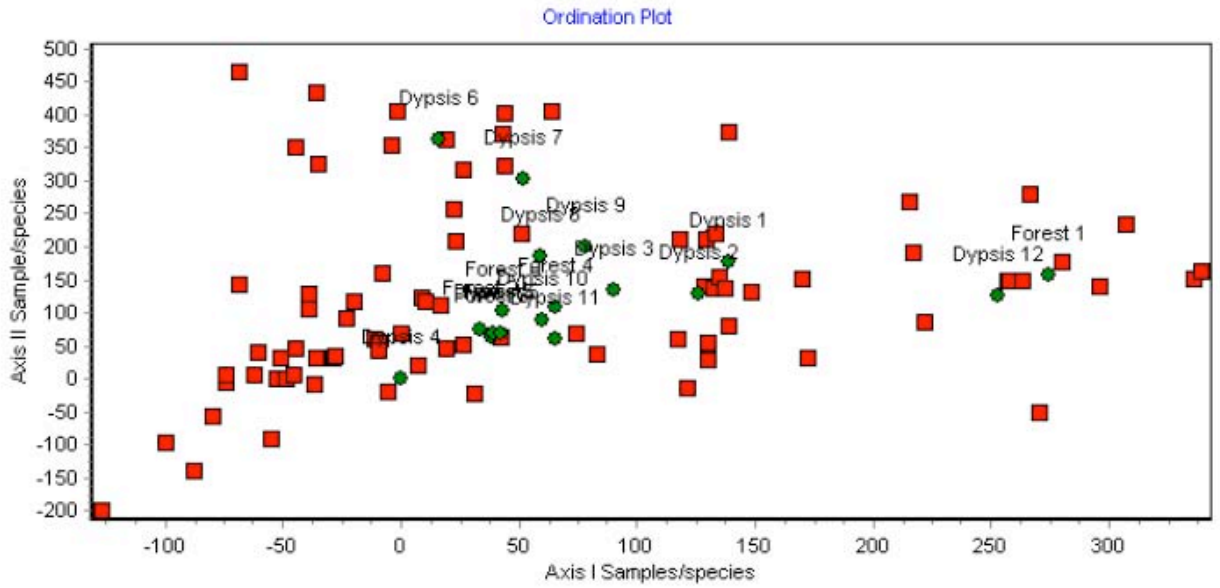

Figure 7. Detrended Correspondence Analysis (DECORANA) showing *D. saintelucei* and Forest control sample sites against tree species on two axes.

are used to shade the developing seedlings, offering approximately 60-70% cover. The germination time (from ripening to eophyll emergence) is approximately 3 weeks and within 4 weeks the second seedling leaf is usually visible. To date, the tree nursery in Sainte Luce has had a germination rate of >90%, with a similar percentage of seedlings surviving the first year.

Figure 8. (Opposite) Richard, tree nurseries volunteer, filling the pots with topsoil

Figure 9. Sosony, tree nursery manager, and *Dypsis saintelucei* seedlings growing in the Sainte Luce Tree Nursery

Local Uses

Hogg et al. (2013) investigated the relationship between *D. saintelucei* and the local community in 2012. 54 semi-structured interviews were undertaken to collect information on utilisation of the different palm species present in Sainte Luce. The survey also aimed to document the harvesting practises, the vernacular names and any perceived changes in abundances over the last 20 years. Observations of harvesting in the field were also used to reveal the local applications of *D. saintelucei* and other palms. The results highlighted from the survey in 2012, revealed that *D. saintelucei* had been a very important resource for the local people in the past. At present, the palm is still used for weaving lobster traps and felled occasionally for flooring and other construction purposes.

All interviewees agreed that the number of *D. saintelucei* individuals had decreased over the last 10-20 years (Hogg et al. 2013). Several interviewees noted that harvesting for palm hearts was largely discontinued, as few households possessed the skill to extract the cabbage (Hogg et al. 2013). The fact that these threats are ongoing, even with such low population numbers, emphasizes the need for community education in tandem with conservation action if any project is to be effective.

Dypsis saintelucei and Phelsuma antanosy

Dypsis saintelucei is an emblematic species for Sainte Luce, valued by the local human population for its many applications. There is also evidence to suggest that *D. saintelucei* is an important microhabitat for littoral fauna too. *Phelsuma antanosy* (see Fig. 10), a Critically Endangered day gecko, found only in Sainte Luce and a small parcel of transitional forest to the southwest of Fort Dauphin (Ambatorongongo), has been found to require *Dypsis spp*. and in particular *D. saintelucei* as a habitat (Ramanamanjato et al. 2002, Jenkins et al. 2011). Although *P. antanosy* was found on and in the vicinity of several adults during the mapping phase, further research is currently being conducted to test the significance of these observations.

Risk of extirpation from Sainte Luce

Exploitation, habitat loss and regeneration rates can be used to predict the rate of decline of a species (Randriatafika et al. 2007). Determining the

rate of exploitation was relatively simple – annual monitoring of the Sainte Luce population and the usage surveys provided good indicators. Using aerial photographs and satellite imagery taken between 1950 and 2005, Vincette et al. (2007) were able to estimate rate of forest cover loss (habitat loss) at Sainte Luce over the last 50 years and provided solid evidence for the reduction of *D. saintelucei* habitat. The QMM/Rio Tinto mining concession and other factors affecting habitat cover and quality were also considered. Regeneration rate is more difficult to determine, especially if rates are poor, however observations of seedling germination during the population monitoring phases were recorded and experienced local tree nursery technicians, who have been cultivating the palm in Sainte Luce, were consulted.

Exploitation

In 2003, E.R. Ellis completed a consensus of *D. saintelucei* in S8 and found the total adult population size to be 130 adults (see Table 1). Mapping in 2008 found that the S8 subpopulation had reduced to 42 adults. The declining trend continued when monitoring conducted in 2010 and 2011 found 33 and 26 respectively. Of the 7 adults lost between 2010 and 2011 four had been felled by axe, two had lost theirs crowns to strong winds and the cause of death for one remains unknown. Monitoring of the southern-most *D. saintelucei* population in S7 was conducted in 2012, a year after its discovery. Three of the 49 adults represented there had died - one from natural causes and two had been felled for construction and lobster trap materials. The rate of decline of the S8 subpopulation is on average 12/year (adults) since 2003, a significant decrease per annum.

Habitat loss

By analysing past records of satellite and aerial imagery, Vincelette et al (2007) found that 56% (4022 ha) of the littoral forests within the Tolagnaro region were lost between 1950 and 2005. The study looked at the littoral forests within the Tolagnaro region, which accounts for three main stands of littoral forest – Petriky, Mandena and Sainte Luce. It stated that the level of habitat loss at Sainte Luce is less pronounced than the other two areas. Despite this assertion, alarming levels of deforestation has been observed since 2007 in Sainte Luce. For example, an uncontrolled fire swept through the northern edge of forest fragment S8 in 2008 and extensive (unpermitted) logging in the northern reaches of S9 was observed in late 2011. Until the recent (2012 onwards) developments in institutional support and capacity building by Azafady and QMM/Rio Tinto, forest governance has failed to address the ongoing deforestation in Sainte Luce.

Regeneration

Despite poor seed dispersal, there is an apparent abundance of juveniles in S8 and S7 (pers. obs.). However, the low prevalence of subadults (n=33) encountered in the mapping phases indicates a demographic imbalance. Juveniles reaching two metres in height have been, and to a lesser degree still are, targeted by local people to construct lobster traps. The leaf rachis are cut at the crown and are stripped and woven in temporary traps. The loss of the leaves at this stage of development severely stunts growth and may be leaving the vast-majority of the population in a quasi-juvenile state – the implications of this process are yet to be realised.

In light of these factors, we consider the risk of extirpation in Sainte Luce to be high. The continued loss of 12 adults per year would see eradication of the reproductive cohort in less than 15 years. Furthermore, the potential loss of S6 and S7 to the mining concession greatly reduces this estimate, to less than 5 years.

Figure 10. A male *Phelsuma antanosy* found basking on a *Pandanus sp*. in S8

In Situ Conservation Strategy

Much of the research presented in this synopsis led to the development of *Project Telopoloambilany* (2012) – a conservation strategy for the species. The aims of the project were threefold: (1) to safeguard the species in Sainte Luce from extirpation, (2) to raise environmental and conservation awareness amongst the local community and (3) to build the capacity, through skills training, of local institutions to contribute towards future conservation and natural resource management efforts. Community consultations and regular meetings with the *Chef de Fokontany* (local political leader) and other local stakeholders ensured that decision-making was collaborative throughout the planning and implementation of the project. The conservation strategy and progress to date is presented in Table 3.

Table 3. Log frame presenting Project Telopoloambilany - a conservation action plan for *Dypsis saintelucei*

Conservation actions			**Target**	**Progress to date**
Reduction of threats to existing populations	Promoting public awareness	General public	Increase awareness among people of Sainte Luce about importance of *D. saintelucei*	• Project Telopoloambilany implemented over 15 education sessions in Sainte Luce and 3 sessions at the school in Emagnevy - typically attended by 100 children. • Education through displays of *D. saintelucei* during World Environment Day (2011 & 2012). • Transfer of responsibility to local COBA & Miaro committee is well underway. • Presence of a community tree nursery has fostered local involvement in the project.
		Business	Develop and distribute of the Field Guide to the Palms of Sainte Luce Strengthen argument for QMM/Rio Tinto to avoid mining in S7	The field guide is in draft Ongoing communication with the QMM/Rio Tinto Biodiversity Department ACP biodiversity research has begun in S7
	Direct control of threats	Fire control	No fires to spread to the forest fragments containing *D. saintelucei*	Annual firebreak maintenance around forest fragment S8 carried out by the COBA and members of local community
		Control of exploitation	No more *D. saintelucei* trees to be felled in Sainte Luce	• Usage of *D. saintelucei* for construction and lobster traps is still occurring, but percentage of adults felled has been reduced than in previous years • Investigation of alternative lobster pot materials is underway - tree nursery trials of *Dypsis scottiana* (plus investigate the success of QMM's *Bambusa multplex* trials in Mandena)
		Establish-ment of new conservation areas	Advocate and support the protection of fragments S8 and S9 from all threats	• ACP's constant presence next to S9/S8 has decreased the community's usage of this forest fragment • Azafady is working closely with the COBA and Polis'n'ala in all conservation initiatives
Reinforcement of existing population			Reinforce population of *D. saintelucei* in forest fragment in S8 by 1,500 individuals	• 5,000 seedlings have been cultivated in the nursery • 1,500 seedlings successfully planted into S8 • Ongoing support to monitor introduced seedlings
Location of new populations			Increase mapping efforts to other forest fragments in Sainte Luce	In 2011, following the same extensive mapping methodology fore mentioned, the ACP discovered large sub-population of 113 adults in S7.

Table 4. A brief summary of the reinforcement assessment conducted by Project Telopoloambilany prior to the population reinforcement of *Dypsis saintelucei*

Reinforcement Assessment: *Dypsis saintelucei*	
Previous reintroductions/ reinforcements in Ste Luce	None to the authors' knowledge
Choice of release site	Forest fragment S8
Evaluation of reinforcement site	S8 is a NAP, under management of the COBA which are currently undergoing capacity building by Azafady and QMM/Rio Tinto, S8 (north) is also a biodiversity offset zone designated by QMM/Rio Tinto
Availability of suitable habitat	Within current known range, interior sections identified with suitable biotic and abiotic features
Availability of suitable release stock	Wild population at S7, good vigor/health (comparatively), added benefit of conserving genetic material from mining area
Release of nursery-reared stock	Follow planting reinforcement guidelines outlined in the literature: staggered release of seedlings at different development stages, optimal spacing
Socio-economic and Legal requirements	
Costs and benefits of reinforcement programme to local human populations	Costs: Community time (mainly COBA engagement) Benefits: Reinforcing S8 population will bolster future local resource supply (if ongoing CBNRM initiatives (COBA) are sustainable). Added value to ecotourism. Ecological benefits.
Assessment of local attitudes to the proposed project	Supported by *Chef de Fokontany*, COBA and wider community. Local perceptions are that *Telopoloambilany* is a valuable resource and is in need of conservation.
National and Regional Legislation	Seed collection permits authorised by DREF (Regional Ministry for Water and Forests)
Planning, Preparation and Release Stages	
- Community consultation and approval - Identification of short and long-term success indicators - Design pre- and post- release monitoring programme - COBA training - Preparation of release stock; seed collection, cultivation	

Safeguarding the species primarily focused on reinforcing the *D. saintelucei* subpopulation in forest fragment S8, a Newly Protected Area (see Table 4, Fig. 11 and Fig. 13). Working alongside the Azafady Conservation Programme (ACP) the *Communatés de bases* or COBA was involved in each step of this process - seed collection, preparation for reinforcement activities and seedling translocation. Alongside *D. saintelucei* specific activities, the COBA was supported with training in firebreak and plantation management and the enforcement of the *dina* (local law), prohibiting the misuse of the Newly Protected Areas. Project Telopoloambilany also provided resources to members of the COBA to enable them to fulfill their function of reporting to the FIMPIA (the association of the protectors of the forest) and DREF, each trimester, on the status of the forest.

Conclusion

Dypsis saintelucei is an Endangered palm species at risk of extirpation from Sainte Luce, placing significant pressure on the future of the species as a result. Much progress has been made to further understanding of the biology, ecology and community use of *D. saintelucei* and the implementation of Project Telopoloambilany has taken some significant steps in conserving the species in Sainte Luce. The success of the population reinforcement in S8 will rely upon the protection and the monitoring of the introduced seedlings. Short-term success indicators will include seedling survivorship and seedling growth and development. Long-term success indicators will include the eventual maturation of reintroduced individuals such as visual evidence of flowering and

Figure 11. Planting seedlings in S8 was conducted in November 2011 and December 2012 by the ACP volunteers, Pioneer volunteers and the COBA

fruiting. As commented on previously, better knowledge is required on the species demography and reproductive biology (e.g. pollination & seed dispersal).

Azafady's work with community-level institutions, like the *Miaro* committee (a community group in Sainte Luce promoting sustainable natural resource management) and the COBA, aims to foster better governance of forest resources and encourage improved habitat protection for the protected areas (see Fig. 12). Major headway has been made since the beginning of 2012; the development of the Sainte Luce Community Action Plan and the establishment of the forest stakeholder platform to engage all management bodies and resource users in issues of sustainability and forest management. Indeed, the wider success of Project Telopoloambilany will depend upon the commitment and capacity of such groups, structures and platforms, and ongoing support and facilitation should be a priority for Azafady and other conservation actors in the region.

Figure 12. The Miaro committee are a group of community members that aim to improve natural resource management in Sainte Luce

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