seed madagascar

sustainable environment, education & development

SEED's Conservation Research Programme

ANNUAL REPORT 2022

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Executive Summary

This report summarises the activities of SEED Madagascar's (SEED) Conservation Research Programme (SCRP) throughout 2022. Since its establishment in 2010, SCRP has worked closely with SEED's Environment and Sustainable Livelihoods Department, the local Sainte Luce community, international institutions, and local authorities to understand the importance and use of the littoral forest and surrounding habitats and contribute towards its long-term protection. SCRP aims to expand scientific knowledge, support conservation of native fauna and flora, and highlight the importance of biodiversity and conservation in Sainte Luce through dissemination of learnings locally, regionally, and internationally. Throughout 2022, SCRP has achieved success across multiple areas of the conservation programme. At the project level, SCRP completed nine years of long-term lemur population monitoring, and four years of long-term amphibian and reptile monitoring across four forest fragments. SCRP also gained deeper insight into current populations of, and threats to, Sainte Luce's threatened palm species, completing namely a population census in five forest fragments and conducting semi-structured interviews and consultations with local experts and stakeholders. SCRP made great strides in conserving the future sub-populations of these palm species, collecting more than 5,000 seeds from the six species and growing them in SEED's nursery to be planted in forest fragments once mature in 2023/24. Concurrently, SCRP have continued to build the capacity of the research team and local stakeholders in a variety of data collection techniques; an important area of SCRP's approach that will continue to be built upon in 2023 and beyond. With the reopening of international borders, 2022 saw the return of international staff and volunteers and the resumption of the volunteering programme in Sainte Luce after a two year hiatus. The return of international volunteers brought vital capacity to SCRP, and enabled SCRP's environmental education sessions, amongst other aspects of SCRP's work, to take place in two local primary schools once again. With added staff capacity, analysis of SCRP's historical datasets has also become possible, with this forming a key focus of SCRP's work in 2023.

1 Introduction

SCRP's work is focused in the extreme southeast of Madagascar within the littoral forests of Sainte Luce, Anosy region. Covering approximately between 1,500-1,600 hectares, Sainte Luce's littoral forest fragments are considered to be amongst the largest and most intact examples of this threatened habitat type remaining in Madagascar. Sainte Luce's littoral forests are believed to be naturally fragmented; however, a variety of pressures including reliance on natural resources by dependent local communities and climate change are reducing further the extent and quality of the 17 remaining littoral forest fragments. In addition, proposed mining operations in the region by QIT Madagascar Minerals (QMM), a subsidiary of Anglo-Australian multinational mining company, Rio Tinto, proposes to exploit large areas of land, with many forest fragments standing within the mining footprint. To mitigate some of the impact of the proposed mining operations, QMM has created Avoidance Zones (AZ), within which mining will not take place, and it is illegal to harvest natural resources. The S8, S9, and S17 fragments are AZs and are protected, whilst the S6 and S7 fragments have been designated as Community Resource Zones (CRZ), and can be used to access natural resources (Figure 1). SCRP works in all five of these fragments, with transects used for long-term monitoring established in S7, S8, S9, and S17. SCRP does not have transects in S6, but regularly visits the fragment to conduct population assessments of the Madagascar flying fox (*Pteropus rufus*) colony.

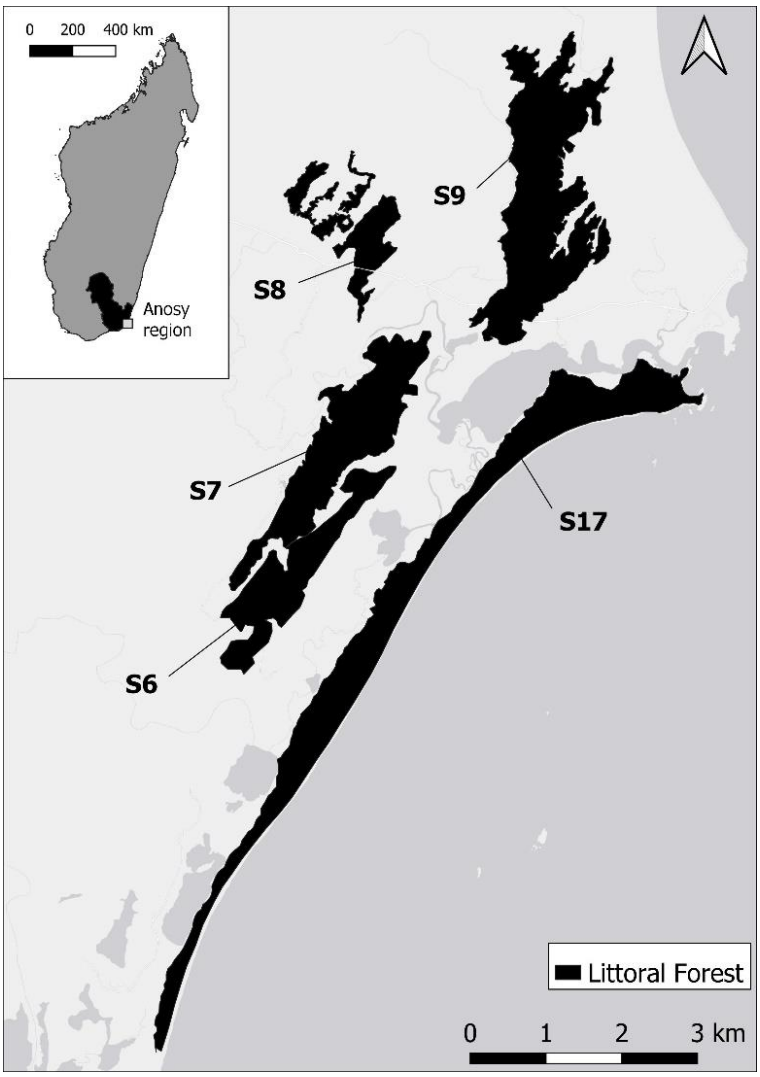

Figure 1 - Map of Sainte Luce study site and five focal littoral forest fragments.

During the COVID-19 pandemic, organisational capacity was dramatically reduced, with international staff being repatriated to their home countries. In November 2021, Madagascar resumed international travel into the country, allowing international staff to return and assist national staff in the development and implementation of new and existing projects. The return of international volunteers, and associated funding, allowed SCRP's long-term monitoring of nocturnal lemur, reptile (e.g. chameleons, skinks, snakes), and frog species to resume. In total, SCRP saw a total of 20 volunteers join the programme throughout 2022.

As a consequence of the pandemic, many of SCRP's long-term monitoring projects were put on hold and the focus of the national researchers shifted towards data collection for shorter-term and project-focussed research. In 2022, SCRP continued work on three main projects: the Ala Programme, Project Mahampy, and Project Palms. As departmental capacity has increased, SCRP have continued research on some smaller research areas, including Project Varika, and Project Rufus. Furthermore, SCRP has empowered members of local communities through the development and practice of research skills. This year, SCRP worked closely with the Ala Programme's corridor landowners, providing each landowner with the experience and skills needed to accurately monitor the progress of trees growing on their land. Through regular practice and mentorship from national SCRP researchers, the eight landowners are now confident monitoring progression of their corridors. SCRP have also continued to work closely with members of Sainte Luce's Weavers' Cooperative, who have been investigating how different harvesting techniques impact the health of the *mahampy* reedbeds. As part of Project Palms, SCRP have also worked closely with local experts and

local/regional forest management organisations (e.g. C.O.B.A.[1], F.I.M.P.I.A[2], and Policin'Ala[3]) to better understand the historical and contemporary uses and population trends of six threatened palm species in Sainte Luce. Conversations with these parties have also filled key gaps in knowledge regarding distribution, seasonality, habitat requirements, and seed dispersal that will help ensure the future sustainability of these species.

Figure 2 – Aerial photograph of one of the Ala Programme's five biological corridors (Corridor 3). Photograph by Daniel Wood.

2 Project Progress

2.1 Long-term Population Studies

2.1.1 Long-term Monitoring of Nocturnal Lemur Species

In 2011 SCRP began visual encounter surveys (VES) along set transects (forest paths) searching for three nocturnal lemur species in Sainte Luce: Anosy mouse lemur (*Microcebus tanosi*), Southern woolly lemur (*Avahi meridionalis*), and Thomas' dwarf lemur (*Cheirogaleus thomasi*). This study aims to compare population density and monitor changes in the population of each species in forest fragments over a period of 10-years. All three species are listed as Endangered by the IUCN Red List (Donati et al. 2020b, Donati et al. 2020c, Ganzhorn et al. 2020) and are only found in the southeast of Madagascar. Taken together, understanding the current status and history of each of these keystone species[4] is important not only for the species' conservation, but because they are key indicators of the health of Sainte Luce's forests.

To date, monitoring has been conducted in four forest fragments: three avoidance zones (S8, S9 and S17), and one community resource zone (S7). A distance sampling approach has been employed, during which

[1] C.O.B.A. – Communautés de Base – Forest Management Association
[2] F.I.M.P.I.A. - Fikambanan'ny Mpiaro ny Ala - Forestry Police Committee
[3] Policin'Ala – Local Forest Police
[4] Keystone species: a strongly interacting species that is disproportionately connected to more species in a food web (Mishra, Singh, and Shukla, 2019).

when a nocturnal lemur is observed a variety of measurements are recorded. Additional information regarding the habitat are also recorded, including species of tree inhabited at time of observation, tree trunk circumference, total height of tree, and percent canopy cover.

Prior to the COVID-19 pandemic, eight years of data had been collected. Due to capacity limitations, data collection was paused during 2020 and 2021. Research was able to resume at the beginning of 2022 with the return of international staff and volunteers to support the national team and assist in data collection. Between January and October 2022, 52 nocturnal observational surveys were completed, with 147 individual lemurs observed. Most observations of nocturnal lemurs were made in S9 (69 individuals observed), with the fewest made in S17 (11 individuals observed). Relatively few individuals were observed in S7, with 15 individuals observed during the time period. *A. meridionalis* have been observed most often in 2022 (56 individuals observed), with *M. tanosi* being the least frequently observed species (38 individuals observed). 47 *C. thomasi* individuals have been observed in the same time period. The end of 2022 marks an important milestone for SCRP; the collection of 9 years of data collection on the project. In 2023, SCRP will complete 10-years of observational data collection and will start to assess how lemur populations have changed in Sainte Luce over time, disseminating the findings of this analysis locally, nationally and internationally.

Figure 3 – Anosy mouse lemur (Microcebus tanosi) observed during a nocturnal lemur survey in S8 South.

2.1.2 Long-term Monitoring of Diurnal and Nocturnal Herpetofauna Species

SEED has conducted herpetological studies since 2010, including specimen collection, genetic barcoding, and population monitoring through distance sampling. Madagascar exhibits high levels of endemism and threat amongst herpetofauna (amphibians and reptiles) species, with the herpetological community of Sainte Luce being no exception. SCRP's holistic approach has allowed a comprehensive understanding of the amphibian and reptile community of Sainte Luce to be gained. Based on this research, SCRP confirmed

that at least 22 distinct species of amphibian and 54 species of reptile are present in Sainte Luce. Furthermore, SCRP's genetic research in 2014-15 indicated that 17 of these herpetofauna species represent candidate new species in need formal identification and description (see Section 4.2 Project Ferova for more details). New findings are still emerging from this research, with SCRPs efforts contributing towards a recent work examining the evolutionary patterns of diversification and limb reduction in Malagasy fossorial skinks (Belluardo et al. 2023).

Since 2017, SCRP has conducted visual encounter surveys of all herpetofauna species using distance sampling methods, with the objective of monitoring species abundance and distribution in four littoral forest fragments (S7, S8, S9 and S17) over time. This data will be used to estimate population densities of each species within different forest fragments, in addition to the habitat requirements of each species.

Due to research limitations during the COVID-19 pandemic, SCRP was unable to conduct any long-term herpetofauna monitoring. However, in 2022, this important facet of SCRP's research was able to resume. Since 2017, 429 observational surveys have been completed across S7, S8, S9, and S17, 84 of these surveys taking place in 2022. Since January 2017, 7,694 observations of 58 species have been made by SCRP, with 1,161 observations being made in 2022 alone. 3,211 individual observations have been made in S9 since 2017; the highest number of the four surveyed forest fragments. Comparatively fewer observations have been made within the community-resource zone (S7), with only 1,750 total observations made since 2017. Similarly, a greater number of amphibian and reptile species have been observed within S9 (48 species observed) compared to other forests. Despite the higher level of disturbance and fewer total observations, species richness in S7 was not dissimilar to that of S9 (41 species observed). Five species have been observed more frequently, including: Watterson's tree frog (*Guibemantis wattersoni;* 1,598 observations; locally endemic), Elongate leaf chameleon (*Palleon cf. nasus;* 1,141 observations; locally endemic), *Gephyromantis leucocephalus* (leaf litter frog; 808 observations), *Phelsuma parva* (Day gecko; 806 observations), and Lined day gecko (*Phelsuma lineata;* 385 observations). Elongate leaf chameleon have been most frequently observed in S9 (695 observations), whereas Watterson's tree frog, an Endangered species found only in the littoral forests of southeast Madagascar, is the species with the highest number of observations in S7 (382 observations) and S8 (650 observations). The most frequently observed species within S17 since 2017 has been *Gephyromantis leucocephalus* (70 observations). As SCRP progress into 2023 and the fifth complete year of data collection for this research area, SCRP will complete analysis of the collect data; identifying patterns in abundance and distribution of particularly rare and threatened species. Findings will be shared with local stakeholders, as well as informing regional, national and international audiences about Sainte Luce's unique herpetofauna assemblage.

Figure 4 – Female Elongate leaf chameleon (Palleon cf. nasus) observed in the S9 forest fragment.

2.2 Ala Programme

The Ala Programme aims to re-connect isolated populations of three nocturnal lemur species in small forest remnants with a larger protected forest fragment (S8) through the establishment of forest corridors. Due to their arboreal nature, Sainte Luce's nocturnal lemur species are very reluctant cross open ground to disperse into new habitat, meaning that populations currently existing in the separated remnants surrounding S8 are isolated. Joining forest remnants with S8 will enable isolated sub-populations to become reconnected and increase viable habitat.

In 2022, the Ala Programme planted a fifth corridor, which will in time connect species in Remnant One (R1) with those in Remnant Three (R3) (Figure 5). Corridor Five (C5) joins four other corridors planted during the project; three planted in 2019 (Corridor One (C1), Three (C3), and Four (C4)) and one in 2020 (Corridor Two (C2)). The corridors have initially been planted with *Acacia magnium* seedlings, with the aim that this introduced plant will help native seedlings establish through the provision of shelter and shade, and improved soil fertility. SCRP has continued to play a key role in monitoring the survival and growth of all planted seedlings, with 13 assessments of the native and acacia seedlings within set quadrats in each of the programme's five corridors taking place in 2022. Monitoring survival and growth of native seedlings will continue in 2023, with assessments of survival rates of native seedlings taking place too.

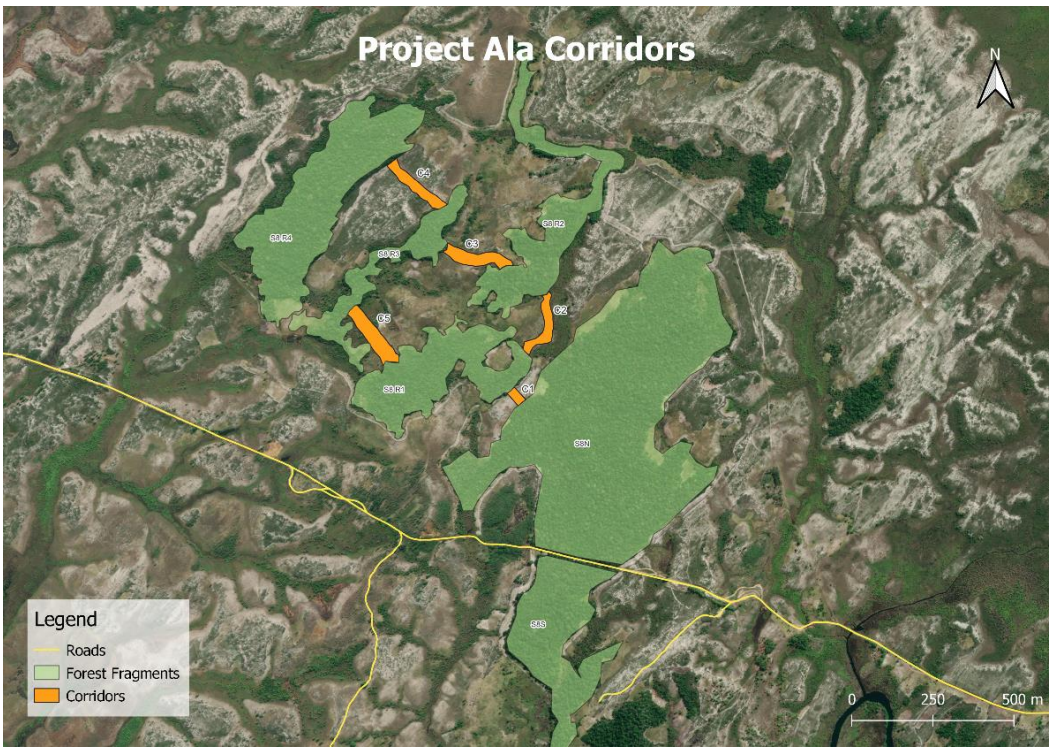

Figure 5 –Ala Programme study site map.

Since 2019, monitoring of lemur, amphibian, reptile, and invertebrate populations within the corridors and adjoining littoral remnants has been conducted to gain an understanding of species richness, diversity, and the local distribution of these groups. This research has been complemented by floral research to monitor project progress more completely. Transect-based visual encounter surveys have been used to assess lemur, amphibian and reptile biodiversity in the corridors, while a permanent quadrat-based catch-and-release methodology was employed to assess the invertebrate community present within each corridor and adjoining littoral forest remnant. Monitoring of lemur, amphibian, reptile, and invertebrate species has taken place within C1, C2, C3, and C4. Faunal monitoring will begin in C5 once the corridor is at an age where it can support faunal species.

119 visual encounter surveys for lemurs have been conducted across all corridors, 22 of which took place in 2022. At the time of publishing, no observations of the nocturnal lemur species have been observed within the four monitored corridors. In late 2022 and in collaboration with local forest management bodies (FIMPIA, Policin'ala, and Chef Fokontany[5]), four camera traps were installed in two of the corridors as part of a one-month trial to assess the suitability of this technique for capturing lemur presence within the corridors. In this period, one Thomas' dwarf lemur was observed on the edge of R2, near the end of C3 (Figure 6). SCRP are excited to redeploy camera traps to continue monitoring the corridors in 2023. In 2022, other observations of lemurs on forest/corridor edges were made, including Thomas' dwarf lemurs and Southern woolly lemurs observed near C1, C2, and C4. Additionally, one observation of a species of civet, Spotted fanaloka (*Fossa fossana*), was made during a nocturnal survey in C2 in April 2022.

[5] Chef Fokontany: village leader and primary authority figure in Sainte Luce.

Figure 6 – Photograph of Thomas' dwarf lemur (left) spotted on the edge of Remnant 2 overlooking Corridor 3.

Monitoring of amphibian and reptile biodiversity within corridors continued in 2022, with 19 diurnal and 19 nocturnal surveys in four corridors completed between January and October 2022 (105 total surveys completed in corridors since monitoring began). During this period, 56 observations of amphibian and reptile species were made, bringing the total number of observations made within corridors to 190 since 2019. Additionally, a total of 12 species have now been observed across the four corridors (Table 1).

Table 1 – Amphibian and reptile species observed within each of the Ala Programme's corridors since 2019.

Species Latin Name	Species Common Name	Corridor 1	Corridor 2	Corridor 3	Corridor 4
Acrantophis dumerili	Madagascar tree boa		1		
Calumma nasutum	-			1	
Dromicodryas bernieri	Bernier's striped snake		1		
Furcifer lateralis	Carpet chameleon		3	2	1
Furcifer verrucosus	Madagascar warty chameleon	1	1	5	1
Heterixalus boettgeri	Boettger's reed frog	6	10	5	12
Madagascarophis meridionalis	Madagascar cat-eye snake			1	

Mimophis mahfalensis	Madagascar big-eyed snake					
Phelsuma modesta	Modest day gecko					4
Ptychadena mascariensis	Mascarene grass frog				3	1
Trachylepis elegans	Elegant mabuya		4	29	22	35
Trachylepis gravenhorstii	Gravenhorst's mabuya		1	5	24	11
		Total	**12**	**50**	**63**	**65**

Figure 7 – Elegant skink (Trachylepis elegans) observed in Corridor 3 in September 2022 (left), and Boettger's reed frog (Heterixalus boettgeri) observed in Corridor 2 in March 2022 (right).

Invertebrate biodiversity surveys also continued in 2022, with a total of 16 surveys completed across four corridors. To assess the progress made in this research area, SCRP completed a preliminary analysis of all collected invertebrate observational data in May 2022. Between August 2019 and February 2022, 27 invertebrate biodiversity surveys were conducted. 2,055 observations of 18 orders were made in the corridors and littoral forest remnants. Orthoptera (grasshoppers and crickets) were the most frequently observed order in the corridors and remnants, in addition to Hymenoptera (bees, wasps, and ants) and Arachnida (spiders and scorpions). 1,100 observations of 13 orders have made within corridors, while 955 observations of 16 orders were made within littoral forest remnants. Our analysis shows that new species are continuing to be recorded in each corridor (Figure 8). With invertebrate research continuing in each of the four corridors in 2023, SCRP hopes to begin seeing similarities between invertebrate community assemblages in corridors and littoral forest remnants as time progresses.

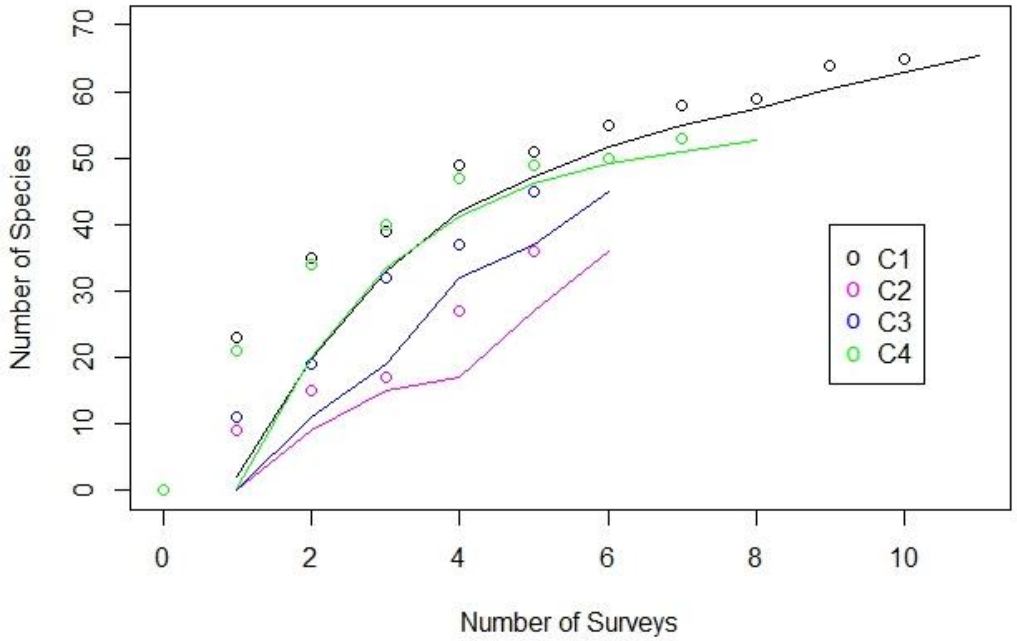

Figure 8 - Species Accumulation Curve (SAC) of invertebrate species observed within corridors 1, 2, 3 and 4 between August 2019 and July 2022.

2.3 Project Palms

The littoral forests of Sainte Luce support a variety of endemic and threatened species, including some of the last remaining populations of a variety of palm species. As one of Madagascar's most endangered plant groups, palms face a variety of intensifying threats, including habitat loss, fire, mining, and increasing human dependence on natural resources. A recent study highlighted declines of up to 65% in two threatened palm species (*Beccariophoenix madagascariensis* and *Chrysalidocarpus saintelucei*) in the Sainte Luce area over an eight year period (2011-2018), with declines largely attributed to anthropogenic pressures (Hogg et al. 2013). However, despite their importance for both biodiversity and local livelihoods, the palm species in Sainte Luce remain relatively understudied and poorly understood. To address these challenges, Project Palms aims to utilise research and conservation action to understand and improve the population status of six palm species identified by the IUCN Red List as Threatened, including: *Beccariophoenix madagascariensis* (Status: Vulnerable)*, Chrysalidocarpus prestonianus* (Status: Vulnerable) (Figure 9)*, Chrysalidocarpus psammophilus* (Status: Endangered)*, Chrysalidocarpus saintelucei* (Status: Endangered), *Dypsis brevicaulis* (Status: Critically Endangered) and *Dypsis scottiana* (Status: Vulnerable) (Rakotoarinivo and Dransfield, 2012 a; b; c; d; e; f).

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Figure 9 – Adult C. prestonianus observed in during seed collection.

In 2022, SCRP made great insights into the populations and distributions of each of the target species by conducting a comprehensive population census. A transect-based methodology was adopted to record the number of adult, sub-adult and juvenile individuals of each species in each of Sainte Luce's five littoral forest fragments (S6, S7, S8, S9, and S17). Supplementary information for adult-aged individuals was also recorded, including total height of palm, trunk circumference, and whether the individual was flowering or fruiting. Since October 2021, 116,790 total individuals have been observed across five forest fragments, with *D. scottiana* being the most frequently observed species (65,920 individuals) (Figure 10). *C. psammophilus* were also frequently observed (32,419 individuals), however *B. madagascariensis, C. prestonianus, C. saintelucei, and D. brevicaulis* were not as abundant. Most of the observations of these six species were made in S7, S8 and S9, with the fewest observations made in S6 and S17; most individuals observed being of juvenile and sub-adult age (Figure 11). As the project progresses, SCRP will begin a deeper analysis of the data collected during the census, gaining a better understanding of the local distributions and abundances of each species to inform future conservation actions.

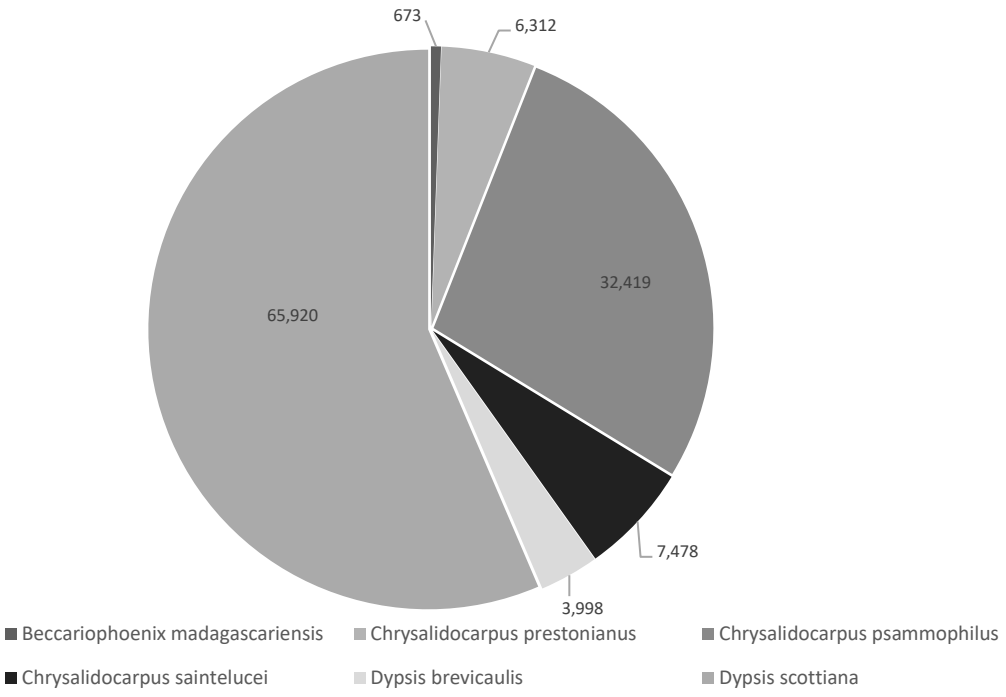

Figure 10 – Total adult, sub-adult, and juvenile individuals observed of each species across all five littoral forest fragments.

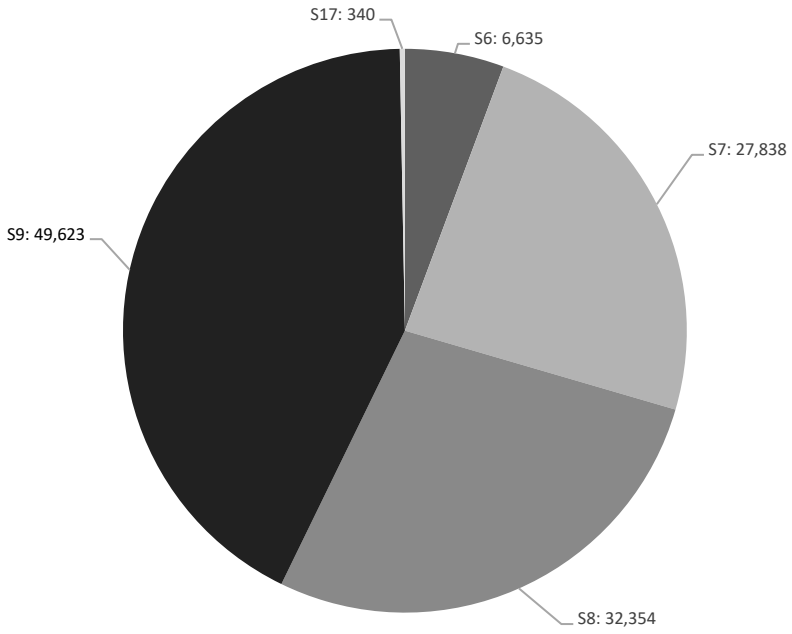

Figure 11 – Total adult, sub-adult, and juvenile individuals observed within each littoral forest fragment

This year, SCRP also began research to better understand the environmental requirements of each of the project's six target species. Measurements of the soil, topography and surrounding habitat have been taken for healthy adult individuals. This data will be used to fill knowledge gaps regarding the natural history of each species, while also providing guidance on where future seedlings should be planted. 77 microhabitat assessments were completed in 2022, with 120 total assessments to be completed in 2023. Concurrently,

seed collection for each species has been taking place. In 2022, SCRP collected 5,408 seeds from a total of 110 healthy adult palms (Table 2). Of these, 5,204 seeds have been planted in the project nursery, with 46 *B. madagascariensis*, 57 *C. prestonianus,* 302 *C. psammophilus*, 64 *C. saintelucei*, 0 *D. brevicaulis,* and 1 *D. scottiana* seeds having germinated at the time of publishing.

*Table 2 – Summary of seed collection and germination as of December 2022. *The majority of C. saintelucei seeds still remain to be collected.*

Species	Total number of seeds collected	Total number of adults collected from	Total number of seeds planted in nursery	Total number of seeds germinated	Germination success rate (%)
B. madagascariensis	1037	10	972	197	20.27
C. prestonianus	1038	8	1021	129	12.63
C. psammophilus	965	10	940	322	34.26
*C. saintelucei**	291	2	291	64	21.99
D. brevicaulis	1006	62	999	139	13.91
D. scottiana	1071	18	981	1	0.10
Total	**5182**	**109**	**4978**	**470**	**9.44**

This year has also been one of collaboration for the project. Early in 2022, the project reached out to Missouri Botanical Gardens (MBG) to collaborate and share learnings. This collaboration culminated in a cross-visit to MBG's littoral forest restoration sites in Agnalazaha littoral forest, Atsimo-Atsinanana region, where insights were made that will inform restoration strategies going forward. As Project Palms moves into 2023, further new and exciting opportunities for the project await. With 64 *C. saintelucei* seedlings collected in 2020 reaching maturity, planting and post-planting monitoring of these seedlings will take place during the rainy season in collaboration with local and regional stakeholders (Chef Fokontany, COBA, DIREDD[6], FIMPIA, Policin'ala, and QMM Biodiversity Team). Collection and germination of the remaining *C. saintelucei* seeds will also take place in 2023.

2.4 Project Rufus

Project Rufus focuses on the *in-situ* conservation of *Pteropus rufus* (Madagascan flying fox) through community engagement and scientific research. Declines in national *P. rufus* populations in the past have been attributed to hunting, disturbance and deforestation, with the species listed by the IUCN Red List as Vulnerable (Racey, 2016). One important *P. rufus* colony exists within a botanically diverse littoral forest fragment in Sainte Luce, S6, which also faces significant environmental pressures, including deforestation and future local mining operations.

In 2016, the Sainte Luce colony was estimated to contain 130 individuals (Hyde Roberts et al. 2016), a decline from an estimated 300-350 individuals in 2000 (Bollen and Elsacker, 2002). SCRP has been collecting roost population data since 2016, during which a 48ha logging and hunting exclusion zone was established around the base of the roost in collaboration with local community members. Members from the nearby Fokontany, Tsiharoa North, have continued to monitor and manage the integrity of the exclusion zone in 2022.

[6] DIREDD: Ministere de l'environment et du developpement durabale, Ministry of the Environment and Sustainable Development.

SCRP has continued to monitor the roosts in the S6 fragment in 2022, collecting data on five occasions between January and November. Roost counts in January showed that population appeared relatively unchanged to counts in 2021, with colony population estimates of between 300-500 individuals. Due to the forest's dense nature and the colony roosting across multiple trees, accurate colony counts are extremely challenging. In February and March, two large tropical cyclones (Tropical cyclones Batsirai and Emnati) made landfall 200-300 hundred kilometres north of Sainte Luce, producing high winds and heavy rainfall locally. When the team returned to the roost in April to make a population estimate, the colony's population remained unchanged. However, several large trees within the exclusion zone had been damaged or blown over during the cyclone's high winds. Due to significant variations in monthly population estimates and increasing dependence on natural resources by local communities, it is important that monitoring of the colony continues in 2023. During 2022, SCRP has continued to raise awareness of *P. rufus* and the important ecological role they play in Sainte Luce with local community members - holding a presentation on the importance of this species during World Environment Day in Sainte Luce.

Figure 12 – Madagascan flying foxes (Pteropus rufus) observed at the roost in S6 in August 2022. Photo taken by Katie Newton.

2.5 Project Mahampy

Mahampy (*Lepironia articulata*) is a species of reed found in Madagascar's wetlands that is traditionally used by local communities for weaving baskets, hats, and mats. SCRP has collaborated with Project Mahampy since 2020 to better understand *mahampy,* the physical characteristics of Sainte Luce's wetlands, and the biodiversity the wetlands contain.

Figure 13 – Raziva (local SCRP guide) assessing wetland water sample for presence of dragonfly larvae in March 2022.

2022 marked a new phase of SCRP's research within this understudied environment. Following initial learnings regarding mahampy and wetland biodiversity made in 2020 and 2021, SCRP implemented a mixed-methods approach to more thoroughly study wetland biodiversity. This method focussed on three key taxonomic groups: birds, herpetofauna and plants.

Between December 2021 and March 2022, four surveys were carried out in each of the six target wetlands, with the exception of Wetland 17 and 26, which could not be surveyed in December due to fire. During this period, a total of 24 belt transect surveys were conducted, encompassing 220 quadrats within which floral biodiversity and water characteristics were assessed. During each survey, a floral biodiversity survey, water assessment, bird biodiversity survey, and herpetofauna biodiversity survey were conducted. From these surveys, a total of 29 bird species were observed across the six wetlands, including: Madagascar malachite kingfisher, Madagascar white-faced whistling duck, and Purple heron. In addition, a total of 11 herpetofauna species were observed, including: two species of snake (*Dromicodryas bernieri* and *Mimophis mahfalensis*), three species of frog (*Blommersia blommersae, Heterixalus boettgeri*, *and Ptychadena mascariensis*), three species of day gecko (*Phelsuma lineata, P. modesta,* and *P. parva*), one species of chameleon (*Furcifer lateralis*), and two species of skink (*Trachylepis elegans* and *T. gravenhorstii*). The study wetlands were also found to be rich in plant species, with 54 species observed across all of the study wetlands. The scientific names were unknown for many of the floral species, with identification of these species and creation of a floral species inventory forming an area of further research in 2023. Assessments of the environmental variables were made during transects, examining the depth, pH, salinity, and

sediment level of the water within each of the wetlands. To account for seasonal variations in each of these environmental variables, a full year of data collection is needed. An additional 240 water assessments across all six wetlands were completed in 2022, with research continuing in early 2023 and analysis of the completed dataset taking place in 2023.

This year also marked a continuation of the collaborative participatory monitoring element of Project Mahampy, with members of the Weavers' Cooperative leading research into the impacts of harvesting technique (cutting the reeds vs pulling the reeds during harvesting) and fire on the health of the *mahampy* reedbeds and reed growth. Research will continue in 2023 with continued support from SCRP researchers.

2.6 Project Varika

The Red-collared brown lemur (*Eulemur collaris*) is the only cathemeral[7] lemur in Sainte Luce and is recognised as an Endangered species (Donati et al. 2020). The species is threatened locally by several pressures, including hunting for bushmeat, mining and habitat loss. Red-collared brown lemurs play a key role in seed dispersal and maintaining forest health, while concurrently promoting regional tourism which provides supplementary income streams for local community members. In 2018, SCRP determined that this species had naturally recolonised S8, a protected forest fragment which in recent history the species had been absent from (Hyde Roberts, 2020b). This interesting and rare event prompted the need to evaluate the local populations of this species.

The goal of Project Varika (*Varika* being the vernacular name for *E. collaris*) is to conduct an updated population assessment of *E. collaris* in the newly colonised S8 fragment in order to inform conservation efforts. To better understand the remaining populations of *E. collaris* in S9 and S17, surveys were also conducted in these fragments. Daytime visual encounter surveys (VES) following established transects began in October 2021 and continued in 2022. Since October 2021, 61 VES surveys have been completed in each of the three forest fragments, 49 of which took place in 2022. Due to the size of the S8 fragment and the small number of individuals within the colonising group, SCRP determined that the transect-based VES was not appropriate for surveying this single group and would instead be monitored opportunistically. In May 2022, SCRP observed the lone group while completing research for Project Palms, whereupon seven individuals (four males and three females) were observed. One juvenile was identified in the group – a promising sign for the future prospects of this group. When this group was last observed in 2018, the group comprised 3-5 members. This exciting observation confirms the continued presence of this group in S8 and indicates that the group is increasing in size.

Between October 2021 and October 2022, 108 individual observations of E. *collaris* were made in S9, and 17 observations in S17. During this period, 56 observations of females, 59 observations of males, and 22 observations of juveniles were made. Surveys continued in November and December 2022 and work will carry on into 2023 in order to improve SCRP's ability to make accurate population estimates of the *E. collaris* in Sainte Luce's largest remaining littoral forest fragments.

[7] Cathemeral: an pattern of activity observed in an animal that is neither solely diurnal, nocturnal or crepuscular, but instead is irregularly active during the day and night (Allaby, 2009)

Figure 14 – Male Red-collared brown lemur observed on the edge of SCRP's campsite in Sainte Luce. Photo taken by Katie Newton.

3 Community Engagement and Partnership

3.1 Quarterly Environmental Education Sessions

In 2022, SCRP returned to the primary schools in Ambandrika and Manafiafy villages to deliver focussed and interactive environmental education sessions on a range of locally important topics. With a two-year hiatus since the last sessions, attendance was high in each of the schools, with between 50 and 120 students present for each school session. SCRP delivered 8 educational sessions in 2022, four in each primary school, covering the following areas:

- The six threatened palm species of Sainte Luce - *How have their populations have changed over time? Why have their populations of changed of time? What are the impacts of losing palms on local livelihoods? What can be done to protect them?*
- Ecosystem services in Sainte Luce – *What role do forests play in the Sainte Luce ecosystem? What role do mahampy swamps play in the Sainte Luce ecosystem? What role do oceans play in the Sainte Luce ecosystem? How are all three ecosystems connected to each other? Why do we need to protect each ecosystem? How can we protect each ecosystem?*
- Climate Change – *What is climate change? What is causing climate change? How is climate change effecting us now? How will climate change affect us in the future? What can we do to prepare for/prevent climate change?*
- The importance of lemurs of Sainte Luce – *Why are lemurs important for people and biodiversity in Sainte Luce? What lemurs are present in Sainte Luce and how are they different from one another? Why is Sainte Luce unique? Why is it important to protect each species of lemur in Sainte Luce? How can we protect lemurs in Sainte Luce?*

Sessions involved music, games, and interactive questions and answers to ensure that students were maximising learning potential during the sessions. Following the completion of interactive lessons, games were played to reaffirm the information provided during the lesson. Activities typically involved games and acting out scenarios relating to the lesson.

In August 2022, SCRP began to run two sessions concurrently; one for younger students (4-8 years old) during which activities that developed fine motor skills (e.g. colouring in an informative sheet about an important species in Sainte Luce) in addition to building awareness of the topic being taught; and the other session for older students (9-15 years old) following a more typical lesson structure before the group activity. This adjustment to lesson format has been successful, with Hoby (leader of the education sessions) observing improvements in attention in both classes. SCRP looks forward to running more sessions in 2023, raising awareness of further areas of the Sainte Luce environment effecting the lives of people across Sainte Luce, as well as the importance of ecosystem conservation.

Figure 15 – Hoby, Conservation Programme Team Leader and environmental education session lead, presenting a lesson at Mahatalaky Primary School.

3.2 Volunteering Programme

Following the lifting of Madagascar's international border restrictions at the end of 2021, international volunteers were able to return to Madagascar and contribute towards the Conservation Research Programme from January 2022. This year, SCRP welcomed 20 volunteers to the research camp in Sainte Luce, during which volunteers brought much-needed capacity to the research taking place, particularly the long-term monitoring programmes for lemur and herpetofauna species, as well as Project Palms' population census. Without volunteers, many of SCRP's ambitious research goals would not have been achieved. Alongside contributing towards primary data collection, volunteers also played a pivotal role in the design and implementation of the aforementioned educational sessions; providing key feedback and insight into how best the lessons and activities could be implemented. As the programme moves into 2023, SCRP is excited to welcome more volunteers onto the programme.

3.3 Collaboration with CAFF/CORE

In October 2022, SCRP welcomed a representative from Madagascar's Ministry of the Environment, CAFF/CORE[8], to the Sainte Luce site for a period of two weeks. During this time, the research team had the opportunity to present and discuss past, current, and future SCRP research focusses with CAFF/CORE. The visit was also a valuable opportunity to receive feedback regarding the research programme as well as SEED's conservation strategy more generally. Opportunities for future collaboration were also identified. SCRP and SEED would like to thank CAFF/CORE for their time and continued support of the research in Sainte Luce, and SEED looks forward to continuing this partnership with CAFF/CORE into 2023.

4 Projects in Development

With the future of Sainte Luce's littoral forest and surrounding ecosystems uncertain with mounting external environmental pressures, SCRP's research must continue to adapt to inform current and future conservation action. In collaboration with SEED's Project Development team, SCRP have developed proposals for future projects which, when departmental capacity allows, will form of SCRP's next research steps.

4.1 Project Fia

Madagascar's freshwater ecosystems are thought to be home to highly diverse and endemic fish populations. However, Sainte Luce's freshwater and brackish ecosystems are threatened by deforestation, habitat degradation, overfishing, invasive species, and mining operations. Project Fia aims to establish the first validated inventory of freshwater fish species across four freshwater habitat types (littoral forest streams/*mahampy* wetlands/main river channels/estuaries) within Sainte Luce - likely yielding multiple undescribed species, as well as insights into the ecosystem at large. SEED hopes to use the information gained through this project to inform future conservation action in the region, protect a critically important natural resource, and produce the first ever peer-reviewed publication on this subject.

[8] CAFF/CORE - Comité Ad Hoc Flore et Faune (CAFF), qui fait partie du Comité d'Orientation sur la Recherche Environnementale (CORE). A committee comprising members from the ministries of Water & Forests, Science, Research, Education, The National Environment Office, Madagascar National Parks (ANGAP), and Tsimbazaza Zoo and Botanical Gardens (PBZT) that is part of the Steering Committee on Environmental Research in Madagascar.

Figure 16 – Freshwater river in Sainte Luce that the local community and SCRP regularly use to access the community resource zone (CRZ), S7. Photograph by Katie Newton.

4.2 Project Ferova

The littoral forests of Sainte Luce host a wide variety of endemic herpetofauna species. Through SCRP's assessments in 2016, 22 species of amphibian and 54 species of reptile were found to be present in Sainte Luce. Of these, 24 species were identified as being in need of further research. Eight species have been identified as being candidate new species, seven identified by the IUCN's Red List of Threatened species as being Critically Endangered, Endangered or Data Deficient, and 9 species being of particular interest due to limited current understanding. All of the species have extremely limited information regarding their ecology, demography, and morphology. Project Ferova aims to improve understanding of these understudied and undescribed species by identifying specific knowledge gaps and conducting surveys tailored to the target species to increase the chances of observation. The information produced through Project Ferova will provide valuable insight into numerous threatened, rare, and previously undescribed amphibian and reptile species, including those presumed locally extinct, to develop long-term conservation strategies in the region.

Figure 17 – Matoatoa spannringi (Ghost gecko). One of Project Ferova's focal species and rarely observed in Sainte Luce.

4.3 Project Microbats

One of the most understudied vertebrate groups within Sainte Luce are Microchiroptera, microbats. Bat species are often identified as keystone in forest habitats, critical to the normal functioning of complex ecosystems. However, there is limited knowledge of the diversity and abundance of this group in Sainte Luce, with only one published study briefly describing the seven species detected (Jenkins et al. 2007). In this study, one unusual echolocation was detected that was not known from any of the Hipposideridae species in Madagascar, possibly representing a new species or a significant international range expansion. Project Microbats aims to take prior research a step further, and establish the first validated inventory of microbats in Sainte Luce. Species richness, abundance, and distribution information, along with morphological and genetic analysis completed by a professional and experienced partner, will fill key knowledge gaps and inform future local conservation management strategies.

4.4 Camera Trapping

Very little is known regarding predation dynamics in the Sainte Luce's littoral forest. Interactions between predators such as and lemurs are understudied, yet these relationships shape lemur behaviour, population dynamics, and distribution. Sainte Luce has subpopulations of four lemur species, however the extent,

variety, and populations of various predator species are less known due to their low abundance and shy nature. Obtaining a full predator assessment using camera trapping within forest fragments can help inform the scope of lemur predation dynamics in this region and understand predator presence and predation interactions. Furthermore, it will provide a greater understanding of the current abundance of rarely observed predators. SEED aims to use images/footage collected by camera traps to determine home ranges of local predators, natural behaviours, and lemur predation. These scientific findings will contribute to the overall understanding of predator interactions and will expand our knowledge of predator species within Sainte Luce.

5 Publications

Belluardo. F., Muñoz-Pajares. A. J., Miralles. A., Silvestro. D., Cocca. W., Ratsoavina. F. M., Villa. A., **Hyde Roberts. S.**, Mezzasalma. M., Zizka. A., Antonelli. A., Crottini. A. (2022). Slow and steady wins the race: Diversification rate is independent from body size and lifestyle in Malagasy skinks (Squamata: Scincidae: Scincinae). *Molecular Phylogenetics and Evolution*, *178*, 107635.

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6 Future Directions

In 2022, SCRP continued to design, organise, and complete high quality research across of range of complex subject areas. During this period, capacity building of national staff and local stakeholders has formed a central pillar of SCRP's approach, with this important element of SCRP's approach continuing in 2023. With the completion of 9-years' worth of lemur population monitoring and a local population census of threatened palms, closer communication and collaboration with key local stakeholders and expert knowledge holders, and improvements to the efficacy of SCRP's education and outreach strategy made, 2022 has proven to be a productive and successful year. SCRP hope to take these successes and learnings into 2023, continuing to develop and improve the programme across all aspects. With localised environmental pressures mounting, SCRP is keen to evaluate its approach and identify future critical research areas helping to protect the ecosystem at large. Furthermore, SCRP is excited at the prospect of analysing the significant quantity of data collected in 2022 and in year's previous, disseminating findings to local communities as well as across national and international channels. In doing this, SCRP hopes to evaluate the effectiveness of its strategy and approach to produce even more impactful, conservation-focussed research and action in the future.

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