Assessment of Sokoke Scops Owl Habitat and Population Status in Dakatcha Woodland Using Remote Sensing, Acoustic Monitoring and Machine Learning

Final Report

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Executive Summary

- The main aim of the study was to determine the population status of the endangered Sokoke Scops Owl (*Otus ireneae*) in Dakatcha Woodland and to determine its ideal habitat conditions with the goal of developing appropriate intervention strategies.
- In line with this aim, the objectives of the project were: (1) to come up with a current population estimate for the Sokoke Scops Owl (SSO), (2) to determine ideal habitat factors for the SSO, (3) to identify the major threats to the SSO, (4) to build capacity within A Rocha in monitoring the SSO and its habitat, (5) to create a digital platform to create awareness and share data about Dakatcha Woodland.
- The study took place in A Rocha Dakatcha Nature Reserve (ADNR) in 2025. ADNR is a private nature reserve located within Dakatcha Woodland. Fieldwork was conducted for a total of 45 day in April, August and December 2025.
- To determine the SSO population estimate, we used a combination of call-playback surveys and acoustic monitoring using audiomoth devices. To determine the ideal habitat, we used remote sensing and field collection of habitat data. To determine the threats, we used field data collection in plots and ad hoc observations.
- There were 8 Sokoke Scops Owl territories identified during the study and 8 individuals were recorded. Of the 8 individuals, 7 were seen and one heard. Of the 7 seen, 4 were photographed.
- Based on the number of potential territories, the number of Sokoke Scops Owls at the Dakatcha Reserve is estimated at between 8 and 36 individuals based on an estimation of 8 to 18 territories.
- All Sokoke Scops Owl individuals recorded were in the Dry Coastal Forest remnant thicket habitat. Although the owl is generally known to occur in *Cynometra* forest, we did not encounter any in this habitat during our survey. In previous Dakatcha surveys, they have been found in *Cynometra* forest and it is not clear why they were absent in our survey.
- During the survey, we identified three main threats facing Dakatcha, mainly selective logging for charcoal burning, grazing by herdsmen from Northern Kenya and clearing of land for agriculture.
- It is important to act fast to purchase the remaining parcels of land within the reserve and start the process of rehabilitating degraded land. Fencing of sensitive areas should be done to protect the habitats from encroachment.

1.0 Introduction

The Sokoke Scops Owl *(Otus ireneae*) is a small owl that is endemic to the lowland forests of East Africa. It is known to occur in only three locations worldwide; Arabuko Sokoke Forest and Dakatcha Woodlands in Kenya, and East Usambara mountains in Tanzania (BirdLife 2024a).

The owl is classified as Endangered due to its small fragmented range and declining population (IUCN 2024). The total population is estimated at between 1,000 and 2,000 individuals with the majority of about 774 to 1,088 individuals (387-544 pairs) occurring in Arabuko Sokoke Forest (Habel et.al 2021, BirdLife 2024a). In Dakatcha Woodland, surveys by A Rocha Kenya since 2010 have consistently recorded about 8 individuals (Virani et.al. 2010).

The Sokoke Scops Owl prefers *Cynometra webberi* dominated forests. In Arabuko Sokoke Forest, the Sokoke Scops Owl is confined mainly to the *Cynometra* forest (Virani, 1995). This is because *Cynometra* trees have numerous cavities that the owl can use to breed.

In Dakatcha, destruction of its preferred habitat (*Cynometra* woodland) and selective logging of old, mature trees required for breeding has greatly impacted the owl (BirdLife 2024b). Given the low numbers of the Sokoke Scops Owl in Dakatcha, the owl may go locally extinct if urgent measures are not taken to protect its habitat and boost its numbers.

1.1 Objectives and Justification

This study had five main objectives.

1. To determine the current population status of the Sokoke Scops Owl at Dakatcha

Understanding how many owls are present at Dakatcha Woodland and how they are distributed within the habitat will help in deciding where to allocate conservation resources and protection efforts. It will also guide future purchase of land parcels.

2. To identify habitat factors influencing the distribution and population size of the Sokoke Scops Owl within Dakatcha.

Understanding what habitat factors the owls are reacting to will aid in developing a habitat restoration plan that will optimize for their long-term survival.

3. To identify the major threats facing the Sokoke Scops Owl at Dakatcha

Understanding the scale and distribution of threats will help formulate a threats mitigation plan

4. To train A Rocha staff and local community in monitoring the Sokoke Scops Owl and Its habitat

This will help build A Rocha's capacity to conduct well-designed acoustic, habitat and threats studies. This is crucial for long-term monitoring of Dakatcha Woodland.

5. To raise awareness about the status of Sokoke Scops Owl and its habitat

This will stimulate behaviour change, mobilize donor funding and influence legislation.

2.0 Materials and Methods

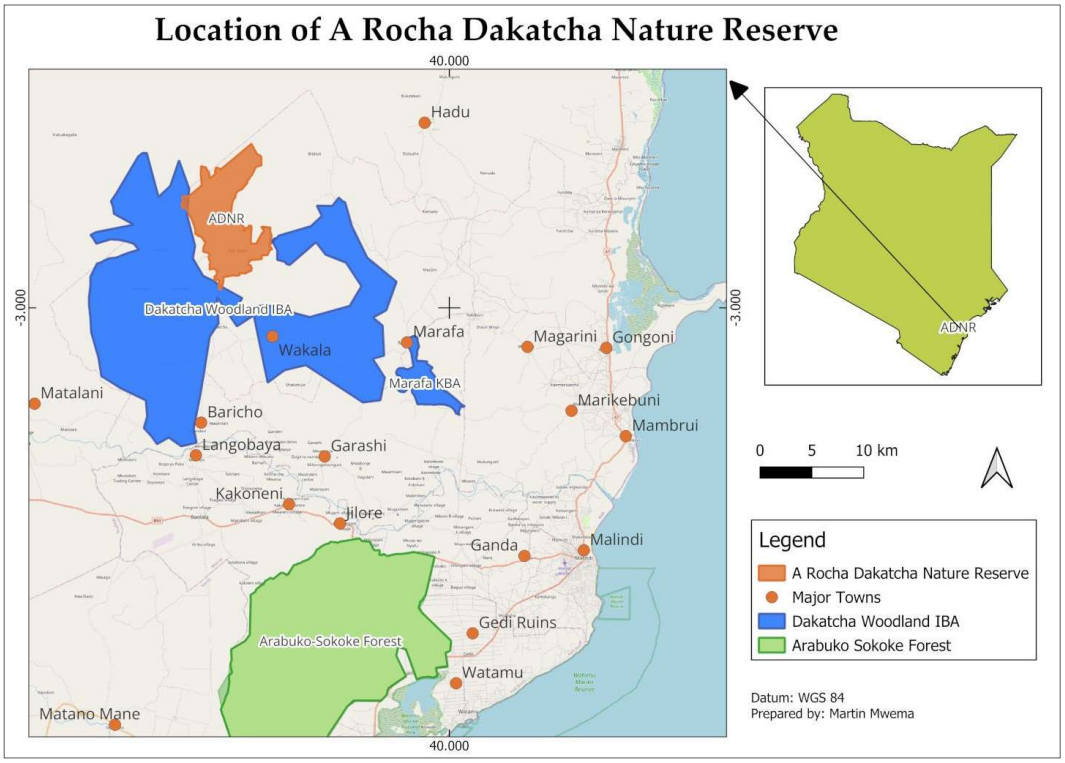
2.1 Study Area

The study took place at the **A Rocha Dakatcha Nature Reserve (ADNR)** which is located within the Dakatcha Woodlands. This is a reserve that has been established by A Rocha Kenya through purchasing parcels of land from local owners. Currently, 9,435 acres has been purchased out of a target of 10,500 acres (A Rocha Kenya, 2025).

Dakatcha Woodland is located at the Kenyan coast in Kilifi County (latitude: -2.928, longitude: 39.809) It is approximately 465,070 acres, of which 32% is forest and 17% is woodland (Nature Kenya, 2014).

Dakatcha is a woodland is internationally recognized as a Key Biodiversity Area (KBA) and Important Bird Area (IBA), hosting at least 10 red-listed bird and mammal species. These include six Endangered species, namely, Sokoke Scops Owl *(Otus ireneae*), Clarke's Weaver, (*Ploceus golandi*), Sokoke Pipit, (*Anthus Sokokensis),* Martial Eagle (*Polemaetus bellicosus), Bateleur* (*Terathopius ecaudatus*), and Golden-rumped Sengi (*Rhynchocyon chrysopygus*) (Birdlife 2024b, IUCN, 2024). The Clarke's Weaver and Golden-rumped Sengi are also endemic to Kenya.

Despite its conservation importance, Dakatcha Woodland is not formally protected within Kenya's protected area network. Most of the land is privately or community owned and the owners are not restricted on the activities they can undertake. A remote sensing study in 2014 found that roughly 50% of this KBA has been converted to farming and grazing (Nature Kenya 2014). Birdlife International classifies Dakatcha as an IBA in danger of extinction (BirdLife 2024b) and many habitats where threatened species such as the Sokoke Scops Owl was previously found has been cleared.



Map 1: *Map showing the location of A Rocha Dakatcha Nature Reserve (ADNR)*

2.2 Research Design

A systematic sampling design was used where data was collected in grids within the reserve. The study used existing A Rocha Kenya grids that are almost 1km^2 (about 929m by 929m to be exact). These grids are used for several other A Rocha Kenya studies (such as the bird atlas project). The grids are based on the Quarter-Quarter Degree Square (QQDS) used for biodiversity mapping in East and Southern Africa.

Within each grid, 4 monitoring stations were established, each about 500m from each other. A total of 192 monitoring stations were established throughout the 10,000 acres (40 km^2) of the reserve. This covered about 60% of the reserve.

Some of the grids were not sampled because they contained farms and cultivated land, especially in parcels that had already.

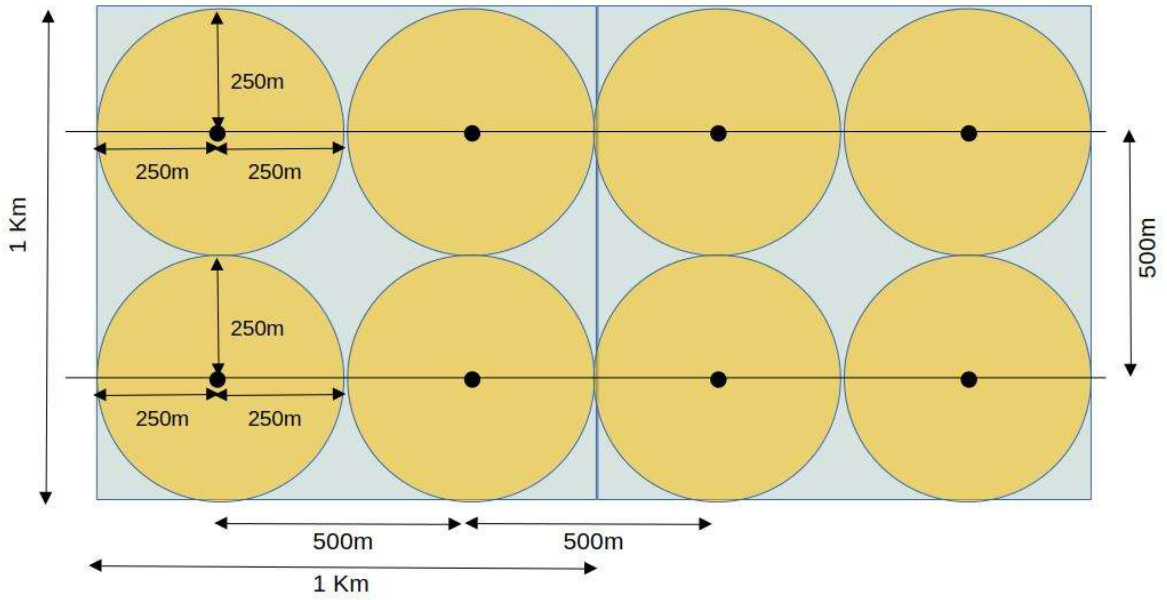


Figure 1: Diagram showing the grids and monitoring stations.

2.3 Determining the population status of the Sokoke Scops Owl at Dakatcha

We combined the use of traditional and innovative techniques (such as acoustic monitoring and machine learning) to determine with current population estimates for the Sokoke Scops Owl.

a) Call Surveys

A total of 120 transects were established within ADNR where a call-playback survey was conducted following methodology by Virani et.al (2010). One-minute-long calls were played every 200m along a 1km transect. Owls heard were recorded and the estimated number of birds calling, bearing and distance to the call was noted.

The surveys during the April 2025 and August 2025 fieldwork sessions were done at night from 7pm to 10 pm. These were mainly done to identify potential home ranges.
Surveys done in December 2025 were done early in the morning from 4am to 6am. These were done in areas where home ranges were identified in the previous surveys. The purpose of these surveys was to track the owls to their roosting sites to confirm whether they have fledglings.

b) Acoustic Monitoring

We used 18 Audiomoth devices (from Open Acoustic Devices) to do the acoustic monitoring (see details in Appendix 2).

Our target was to cover 180 sampling points for the whole project. Given that we had 3 fieldwork sessions of 15 days each, we had to target 60 sampling points per fieldwork session. To achieve this, we deployed the 18 audiomoths at least 3-4 times per fieldwork session. We deployed 18 devices for two nights (18 sampling points) in the first deployment and then moved them to the next 18 points for another two nights and continued the process to get to 4 deployments. This required at least 6-8 nights of recording and it yielded recordings from 54-72 sampling points per fieldwork session.

Photo 1: *Principal Investigator (Martin Mwema) setting up audiomoth recorders*

The audiomoths were set to record at night from 6.45 pm to 6.45 am (12 hours). This timing also captured the dawn chorus before sunrise. **A recording cycle of 1-minute (60s) on and 5 minutes (300s) sleep was used.** This yielded 10 minutes of recording per hour and 120 minutes for one Audiomoth for a night of recording (12 hours). For the two nights the Audiomoth was at a particular site, it captured 4 hours of recordings. **At this setting, the whole project for all Audiomoths yielded a total of 648 hours of recordings at a size of 233.3 GB.**

2.4 Identification of habitat factors affecting the population size and distribution of the Sokoke Scops Owl

The following methods were used to study habitat factors important for the SSO.

a) Habitat Analysis

To conduct a habitat assessment, we adapted methodologies employed by Otieno et. al. (2014) and Oyugi et.al (2008) in their habitat assessment at Arabuko-Sokoke Forest.

Within the reserve, data was collected in 4 monitoring stations in each grid as per the research design. At each monitoring station, a 10 by 10m plot was established where the following habitat parameters were collected.

- **Habitat Type.** A general description of the habitat (forest, woodland, grassland, shrubland, thicket, regenerated land or agricultural land) was done.
- **Common plant species.** The common plant species within the plot were recorded and the dominant plant species noted.
- **Topography:** The slope of the land was recorded (small, moderate, steep).
- **Canopy Cover:** The percentage area covered by the tree canopy was recorded.
- **Tree height.** Number of trees at various height classes were counted. The following height classes were used: Less than 5m (understorey), 5-15m (sub-canopy) and > 15m (canopy).
- **Tree Diameter at Breast Height (Dbh).** Number of trees at various dbh classes were counted. The following Dbh classes were used: Less than 10cm (small trees), 10-30cm (Mid-size trees), over 30cm (Mature/large trees).
- **Ground Cover:** The amount of material covering the ground (litter, bare ground, rock) was estimated as a percentage.
- **Soil type.** The dominant soil type in the plot was recorded (clay, loam, sand or mix).
- **Disturbance information.** Disturbance and threat activities were recorded. These included: charcoal burning, grazing, clearing, and selective logging among other threats.
- **Habitat photos.** Photographs of the site were taken to have an idea of the vegetation structure and soil type.

b) Remote Sensing

To determine habitat and land cover classes, we adapted methodologies employed by Rotich & Ojwang (2021) and highlighted by Phiri et. al. (2021) in their review of land cover mapping techniques.

However, instead of using only Sentinel 2 data, we used Google's Satellite Embedding dataset at 10m resolution. This assimilates data from a variety of sources including optical data (Sentinel-2, Landsat), radar (Sentinel-1), elevation (GLO-30), LiDAR (GEDI), and climate data (ERA5-Land) into an image of 64 bands (Pasquarella, 2025).

We analyzed images from June 2024 to June 2025 (one year) using Google Earth Engine. We first carried out an unsupervised classification using a random forest classifier. A supervised

classification was later carried out using collected ground control points to further refine the map. The resulting map was downloaded and styled in QGIS to develop a habitat map.

2.5. Identification of threats facing Dakatcha

We collected threat the following threat data in each monitoring station:

- **Habitat destruction threats** such as selective logging, cleared land, cut branches/stems, and charcoal kilns (evidence of charcoal burning), garbage/littering, quarrying/mining and evidence of charcoal burning (eg. Charcoal kilns)
- **Disturbance threats** such as grazing (seen or signs), presence of roads, footpaths or settlements, presence of cats or dogs, noise levels, and animal traps.

2.6. Capacity building of A Rocha staff

A Rocha Kenya already has a robust biodiversity monitoring program at Dakatcha, including for the Sokoke Scops Owl. This project aimed to support the monitoring by providing necessary equipment and conducting hands-on training on how to collect data that can feed into remote sensing and machine learning protocols.

2.7. Raising awareness

A Rocha currently does a lot of work with the local community on the ground through its community project. So, rather than focusing on the local community, it was important to cast the net to a beyond the local area.

A digital platform is the ideal method for a wider reach. Initially, the platform will consist of a website but over time incorporate a data portal. This will create a one-stop shop for all the research data and information from Dakatcha. The platform will highlight Dakatcha issues through blog posts, maps, reports and videos. The main target audience for this platform is:

- **Potential funders within and outside the country.** This will help in mobilization of resources required for Dakatcha.
- **National and international NGOs.** NGOs will have the facts and figures required for their advocacy work.
- **Media practitioners**. Journalists and other media practitioners can help amplify the message about Dakatcha.
- **Legislators.** People interested in creating laws, rules and regulations regarding Dakatcha will have a one-stop shop for all the information they need.

3.0 Results

3.1. Population status of the Sokoke Scops Owl at Dakatcha

Sokoke Scops Owl individuals were recorded in 8 locations within ADNR (see **Table 1**). In the eight locations, 7 individuals were seen (with 4 of them photographed) and one was heard.

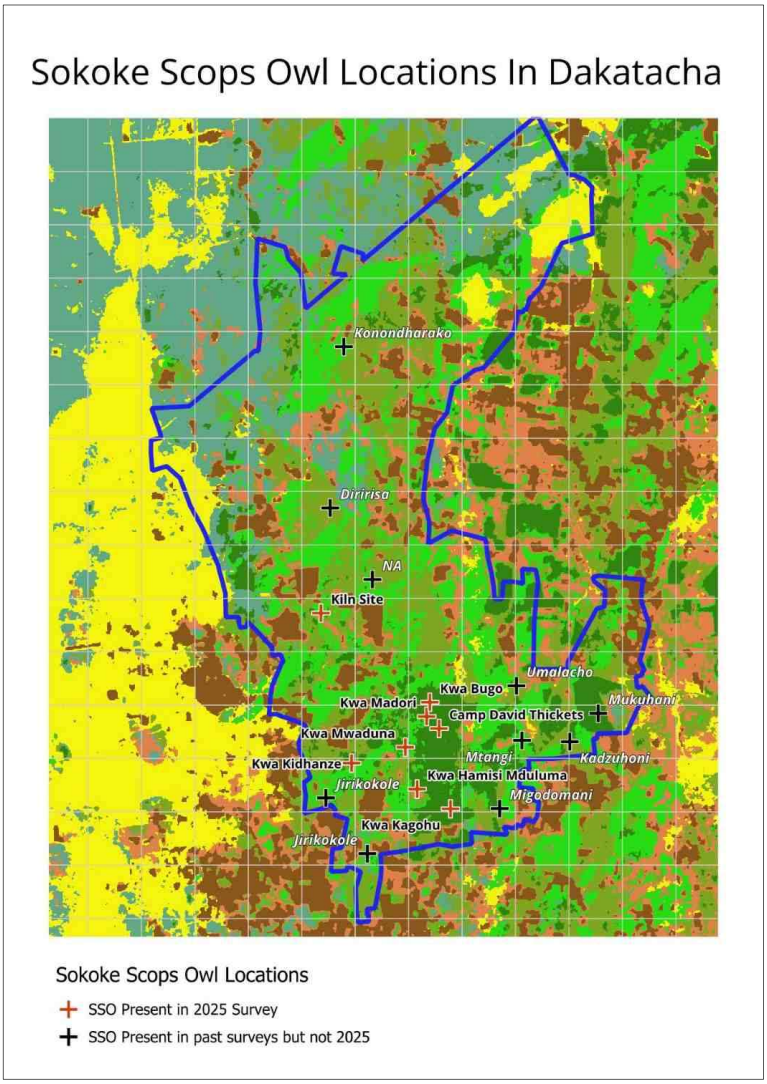
Table 1: *Sokoke Scops Owl Individuals Seen or Heard in Dakatcha*

#	Site	Date Seen	Latitude	Longitude	Habitat	Notes
1	Kiln Site	07/12/2025	-2.9356367	39.7946617	Thicket	H, S
2	Kwa Madori	08/12/2025	-2.9517857	39.8111431	Thicket	H
3	Kwa Kidhanze	09/12/2025	-2.959064	39.7994499	Thicket	H, S, P
4	Camp David Thickets	10/12/2025	-2.9536656	39.8130783	Thicket	H, S
5	Kwa Bugo	12/12/2025	-2.949569	39.8116426	Thicket	H, S
6	Kwa Kagohu	11/12/2025	-2.96621	39.8148683	Thicket	H, S, P
7	Kwa Hamisi Mduluma	13/12/2025	-2.9631253	39.8096605	Thicket	H, S, P
8	Kwa Mwaduna	14/12/2025	-2.9565778	39.8078163	Thicket	H, S, P

**H-Heard, S-Seen, P-Photo*

Figure 2 shows the four photographed individuals and **Map 2** shows the locations of the eight Sokoke Scops Owl sightings

Figure 2: *Individual Owls Seen and Photographed in Dakatcha*



Map 2: *Map showing locations of past and present SSO locations*

All the sightings were made during the December fieldwork but they had previously been heard in those sites during the April and August fieldworks. This informed the decision to track them to their roosting sites in December 2025.

Unlike sightings made elsewhere (such as Arabuko Sokoke Forest), (Virani et.al., 2010) the owls that were sighted were not in pairs in their roosting site. And no other individuals were heard calling nearby. It is therefore likely that these individuals roost alone but this needs further study to make a confirmation.

All the individuals seen were light morph adults (see **figure 2**).

There were about 10 locations where the Sokoke Scops Owl has been recorded in Dakatcha but we could not find them during our survey (see Table 2 and Map 2: Black crosses).

Table 2: Previous Sokoke Scops Owl Sightings (black crosses in Map 2) that were not recorded in our survey

#	Site	Date Last Seen	latitude	longitude	Habitat
1	Konondharako	22/08/2010	-2.894037219	39.79823574	n/a
2	Diririsa	28/08/2010	-2.919223355	39.79611204	n/a
3	Jirikokole	27/08/2011	-2.964491022	39.79544232	n/a
4	Mtangi	09/11/2012	-2.955521909	39.82601023	Cynomentra
5	Umalacho	12/11/2012	-2.946992055	39.82514016	Cynomentra
6	Jirikokole	24/11/2012	-2.973206855	39.80190905	n/a
7	Mukuhani	30/11/2012	-2.951297473	39.837902	Cynomentra
8	Kadzuhoni	26/05/2015	-2.9557167	39.8334667	Old cultivated area
9	Migodomani	25/06/2015	-2.9661667	39.8225333	Mixed forest
10	n/a	26/10/2021	-2.9303973	39.8026974	n/a

There were no young birds (juveniles or immatures) encountered during the 2025 fieldwork sessions. However, there was one young bird encountered in early June 2026 (**Photo 2**) during a fieldwork session. This indicates that there was some breeding success during the April 2026 breeding season. It is also proof that the Sokoke Scops Owls are breeding in Dakatcha despite the degraded habitat.

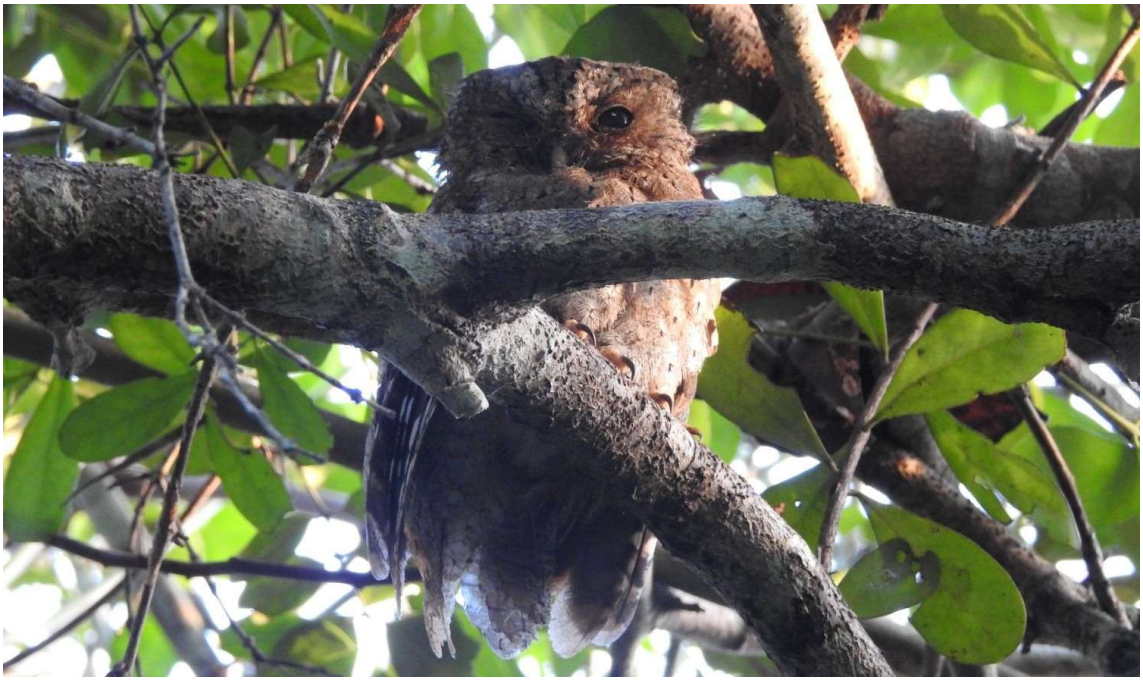
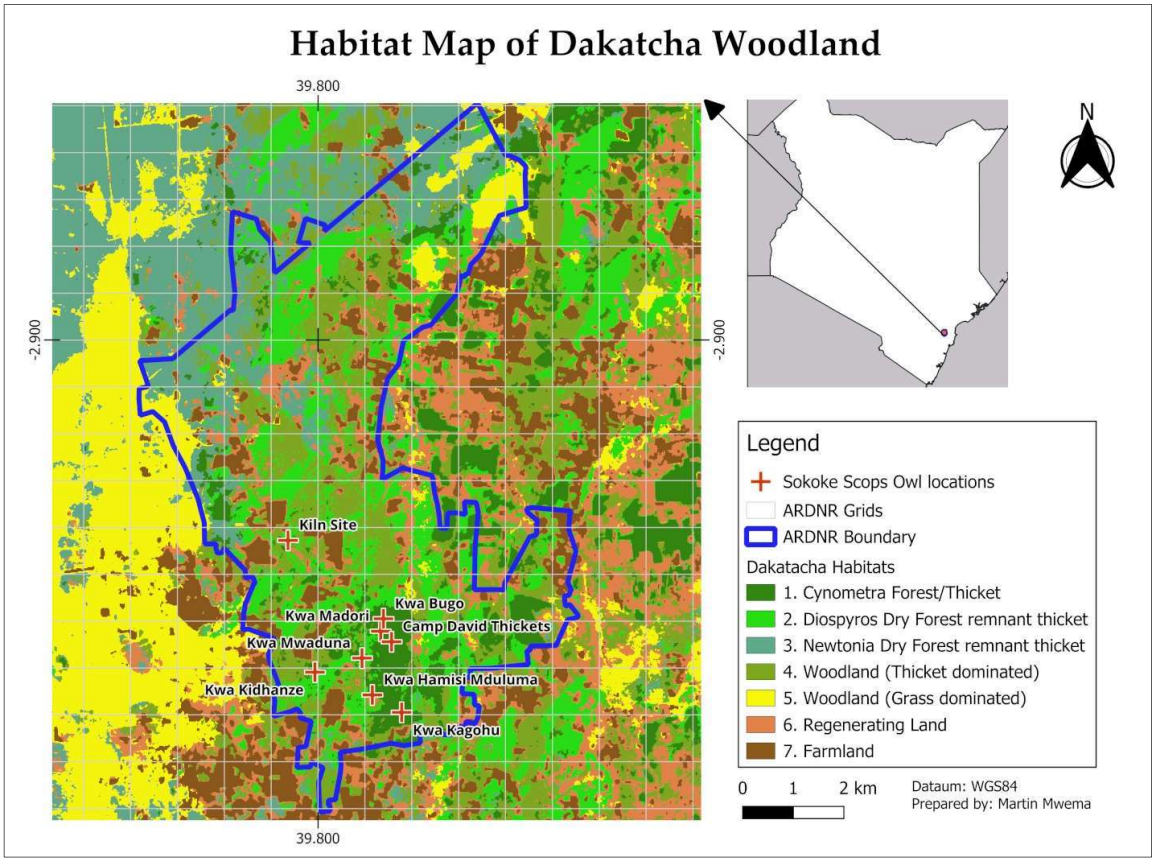


Photo 2: *A young Sokoke Scops Owl indicating breeding at Dakatcha*

3.2 Habitat factors influencing the distribution and population size of the Sokoke Scops Owl within Dakatcha.

There were 7 main habitat types that were identified through remote sensing and vegetation/habitat analysis. Aspects such as plant species, canopy cover, tree size, tree density and ground cover were considered when delineating the habitats.

Map 3 below shows the distribution of these habitat types.



Map 3: *Map showing the different habitat types in Dakatcha*

These habitat types were deemed to be distinct enough to have an effect on distribution of biodiversity particularly bird species like the Sokoke Scops Owl.

The Sokoke Scops Owl was recorded in only the Diospyros Dry Coastal Forest remnant thicket and the transition zone between the Diospyros Dry Coastal Forest remnant thicket and the *Cynometra* Forest/Thicket. Before the study, the expectation was that most of the scops owls would occur in the *Cynometra* forest as is the case in Arabuko Sokoke Forest but none were found here.

Below is a detailed description of the different habitat types encountered and their impact on the distribution of the Sokoke Scops Owl.

1. Cynometra Forest/ Thicket

The *Cynometra* Forest/Thicket habitat type (Dark green colour in Map 3), was dominated by *Cynometra webberi* trees. There were two distinct habitat sub-types within this habitat.

- **Cynometra forest**: This was characterized by taller, larger trees (often more than 4m) and a more open shrub understorey.
- **Cynometra thicket**: This was characterized by shorter, slender trees (often less than 4m height) growing very close to each other (with more than 90% density).

In other areas, you had a transition zone between *Cynometra* spp and *Diospyros* spp dominated Dry Coastal Forest.

Photo 3: *Cynometra forest habitat type*

Common understorey (bush/thicket) plant species associated with this habitat type included *Croton pseudopulchellus*, *Combretum illairii, Manilkara sulcata,* and *Uvaria acuminata*.

There were no Sokoke Scops Owls recorded in either the *Cynometra* forest or *Cynometra* thicket. However, there were a few scops owls recorded in the transition zone with predominantly Diospyros Dry Forest habitat.

This is in contrast with Arabuko Sokoke Forest where the Sokoke Scops Owl is found exclusively in the *Cynometra* forest. In Dakatcha, the owls used to be found in the *Cynometra* forest in the past. For example, in a 2012 survey, a number of owls were

recorded in the *Cynometra* forest at Mtangi, Umalacho and Mukuhani (see Table 2). It is not clear why they were not recorded in this survey.

2. Diospyros Dry Coastal Forest remnant thicket

The Diospyros Dry Coastal Forest remnant thicket habitat type (Light green colour in Map 3) is characterized by a thicket composed mainly of species such as *Croton pseudopulchellus* (dominant), *Allophyllus rubifolius*, *Grewia densa*, *Uvaria acuminata,* and *Vepris eugenniifolia.*There are also scattered *Dobera spp* trees.

This habitat type was most common in the higher and relatively wetter part of the reserve

This habitat used to be a typical Dry Coastal Forest with large tree species such as *Diospyros bussei (*dominant), *Sideroxylon inerme, Euclea racemosa, Newtonia hildebrantii, and Dobera loranthifolia.* These formed a canopy typical of a Dry Coastal Forest.

However, most of the large trees have been logged for charcoal production leaving behind a thicket with a few scattered *Dobera* trees.

Photo 4: *Diospyros Dry Coastal forest habitat type*

Majority of the Sokoke Scops Owls were recorded in this habitat. This is quite surprising because in Arabuko Sokoke Forest, the Sokoke Scops Owl has been found exclusively in the *Cynometra* forest.

We suspect that this habitat was preferred because, before the habitat was degraded by

selective logging, it had plenty of large old trees with cavities for breeding. Now, with much of these trees gone, it is likely that breeding has been impacted.

3. Newtonia Dry Coastal Forest remnant thicket

The Newtonia Dry Coastal Forest remnant thicket habitat type (Teal colour in Map 3) is characterized by a thicket composed mainly of species such as *Croton menyharthii (dominant), manilkara sulcata, Grewia densa,* and *lecaniodiscus fraxinifilius.*

Similar to the Diospyros Dry Coastal forest remnant thicket, this habitat used to be a typical Dry Coastal Forest with large tree species such as *Newtonia hildebrantii (*dominant), *Combretum hereroense, Diospyros bussei, Dobera loranthifolia and Dobera glabra.*

Here too, most of the large trees were logged for charcoal production leaving behind a thicket with a few scattered *Dobera lorantifolia, Accacia mellifera and Terminalia prunoides.*

Photo 5: *Newtonia Dry Coastal forest habitat type*

This habitat type is essentially the same habitat type as the Diospyros Dry Coastal Forest habitat with the difference being the emergent (tree) layer was once dominated by *Newtonia hildebrantii* trees instead of *Diospyros bussei* while the understorey layer was dominated mainly *Croton menyarthii* instead of *Croton pseudopulchellus*. It is also located in the lower and relatively drier parts of Dakatcha towards the north-west (map 3, Teal colour).

No Sokoke Scops Owls were recorded in this habitat during our survey but there is anecdotal

evidence that it may have been heard in early 2010 but not since. This may indicate the differences with the Diospyros dominated Dry Coastal Forest are large enough to impact habitat preference of the scops owls.

4. Woodland (Shrub/Thicket dominated)

The shrub/thicket dominated woodland habitat (Khaki green colour in Map 3) was characterized by trees, shrubs and an open canopy that allows sunlight to reach the ground. The dominant tree species in this habitat was the *Brachystegia spiciformis* trees. This formed the majority of the woodland within the reserve.

Photo 6: *Shrub/Thicket dominated Woodland with Brachystegia trees*

In some areas, however, we had woodland that was the result of degradation of the Dry Coastal Forest habitat. This type of woodland was dominated by *Dobera* species (*Dobera loranthifolia* or *Dobera glabra*) as the emergent layer rather than *Brachystegia.*

No Sokoke Scops Owls were recorded in this habitat.

5. Woodland (Grass dominated)

The grass dominated woodland habitat (Yellow colour in Map 3) was characterized by trees, a few shrubs and mostly grass or in some places bare ground. The dominant tree species in this habitat was the *Brachystegia spiciformis* . This formed the majority of the woodland outside the reserve particularly to the west of the reserve.

The open nature of this habitat was mainly due to overgrazing and browsing by livestock that had reduced the shrub layer.

Photo 7: *Grass dominated woodland habitat type*

No Sokoke Scops Owls were recorded in this habitat.

6. Regenerating Land

The regenerating land habitat (light brown colour in Map 3) represents previously cleared or farmed land that is in various stages of regeneration. It was often found at the edges of actively farmed areas.

This category encompasses several categories:

- Grassland with scattered shrubs
- Shrubland
- Thicket

Common plant species that regenerate in previously farmed land include *Thespesia danis, Dicrostachys cinerea, Clerodendrum rotundifolia, Acacia nilotica, Flueggea virosa, Commiphora schimperei,* and *Commiphora campestris.*

Photo 8: *Regenerating land habitat type*

This habitat type within the reserve is composed mainly of farmland that was bought by A Rocha and has been left to regenerate naturally.

No Sokoke Scops Owls were recorded in this habitat type.

7. Farmland

The farmland habitat type (Brown colour in Map 3) is composed of different habitat sub-types that present similar spectral signatures. These are:

- Cleared or ploughed land
- Freshly planted land
- Fallow land with grass or herbs.
- Established farms (such as maize farms and pineapple plantations)
- Orchards or Cashew nut plantations

Photo 9: *Farmland habitat type*

Actively farmed land is found in several areas within the reserve, mainly in land that has not been acquired by A Rocha.

No Sokoke Scops Owls were found in this habitat

3.3 Major threats facing the Sokoke Scops Owl at Dakatcha

We used remote sensing and fieldwork techniques to assess the major threats present and how they occur spatially. There were three major threats that emerged during our study.

a) Selective Logging

Most of the selective logging we encountered had been done in the past. Many of the stumps we encountered appeared to have been carried out several years ago. There were few fresh stumps unless outside the boundaries of ADNR on land which was still under private or local community ownership.

This indicates that selective logging has been well controlled within the reserve but continues to be a problem outside the reserve where land is still under private ownership.

Photo 10: *Charcoal Kiln on a private farm indicating selective logging for charcoal production*

b) Clearing for Agriculture

If you look at the habitat map of Dakatcha (see **Map 3**), you will see that a large amount of the area especially to the south-west and north-east of the reserve has been converted to agriculture (Habitat 5 and 6 with the brown colour). This is land that previously had habitat that could have supported the Sokoke Scops Owl.

Photo 11: *A newly cleared Cynometra Forest planted with pineapples*

There also some farms within the reserve boundaries that have not yet been purchased and farming still continues as is seen on the map. This will decrease as A Rocha Kenya buys more land to add to the reserve.

Most of the farming encountered was subsistence agriculture particularly maize farming for private consumption but there were also several instances of commercial pineapple farming.

c) Overgrazing

Grazing is emerging to be a big threat to the Dakatcha Woodland. This is mainly due to large scale grazing from Somali/Orma herders from northern Kenya who bring huge heads of cattle to the Dakatcha area in search of grass for seasonal grazing. This was particularly evident during the August fieldwork where many of these herdsmen were present were we regularly encountered 100+ heads of cattle as well as numerous cattle bomas.

Photo 12: *Influx of cattle herdsmen from Northern Kenya having an impact on local farms*

This not only has an impact on the reserve but also on the surrounding communities when these cattle get into the farms and destroy planted crops.

3. 4. Training of A Rocha staff and local community guides

Two community scouts (Samson Katisho and Jonathan Mbitha) received field-based, hands-on training of various monitoring techniques.

The scouts were already skilled in bird and plant monitoring in general so the training focused more on collecting data geared to acoustic monitoring as well as GIS data collection.

Some of the training done included:

- Using SW Maps (a mobile based mapping application). Skills taught here included navigating to specific waypoints and collecting ground control points.
- Setting up and collection of audiomoths devices in the field.
- Collecting data using Kobo Collect.

In addition to the training, the 10 audiomoths, batteries, and SD cards purchased during this project were handed over to A Rocha to facilitate the long-term acoustic monitoring. Field equipment (like binoculars) were also purchased to help with monitoring.

Photo 13: *Dakatcha monitoring team. Left- Right. Martin Mwema (Principal Investigator), Lennox Kirao (A Rocha Research Scientist), Samson Katisho (A Rocha Community Scout)*

Photo 14: *Dakatcha monitoring team. Left- Right. Lennox Kirao (A Rocha Research Scientist) shares a light moment with Jonathan Mbitha (A Rocha Community Scout) during training*

3.5 Development of a digital platform to raise awareness

We created a digital platform (website) dedicated to Dakatcha. This can be found at *dakatchawoodland.org.* Activities carried out during the duration of the project were:

- Purchase of a domain name and web hosting for several years
- Design and set up of the site (Wordpress installation, security features etc)
- Population with initial set of articles

This site will be the primary vehicle for sharing results of this project as well as other research projects in Dakatcha.

4.0 Discussion

This study raised several interesting issues regarding the future conservation of the Sokoke Scops Owl in Dakatacha.

4.1 Population Status of the Sokoke Scops Owl

We estimate the Sokoke Scops Owl population to be anywhere between **8 and 36 individuals**.

- On the lower side, **8 individuals** were positively identified in the survey.

- On the higher side, we assume that there are still Sokoke Scops Owls in the 10 other locations where they have been recorded before (Table 2) but were not encountered during our survey. This would bring the total at least 18 individuals. If we assume that they all occur in pairs, this would bring the total to **36 individuals.**

There are a few caveats to note:

- Not all the owls may occur in pairs. During the survey, all the owls we encountered at the roosting site were individuals. Perhaps in Dakatcha they occur as individuals because of the habitat (Dry Coastal Forest Thicket) as opposed to Arabuko Sokoke where they occur in pairs predominantly in the *Cynometra* forest.
- We focused our survey within 10,000 acres of the A Rocha Dakatcha Reserve (ADNR). The whole of Dakatcha is approximately 465,000 acres. Having said that, ADNR is the most likely area to contain the owls because of the conducive habitat type.

We hesitate to extrapolate numbers based on habitat because it may lead to an overestimation for the following reasons:

- It is not clear how much of the Dry Coastal Forest Thicket habitat would be suitable for them, especially since this is heavily disturbed. Given that this is the dominant habitat type in ADNR, it would lead to an overestimation.
- We surveyed at least 80% of suitable habitat within ADNR using both call-playback survey and acoustic monitoring and the pattern is that the scops owls were restricted to a particular section of the mixed thicket. Therefore, it is unlikely that numbers from within the reserve would deviate significantly from our estimates.

4.2 Sokoke Scops Owl Habitat

All the the Sokoke Scops Owls in our study were found in the Dry Coastal Forest remnant thicket habitat and its transition zone with the *Cynometra* forest. In other studies (such as at Arabuko Sokoke Forest) have found that the owls occur exclusively in the *Cynometra* forest (Virani, 1995). In past surveys in Dakatcha, the Sokoke Scops Owl was also mainly found in *Cynometra*. Therefore, what has led to this shift where none of the individuals recorded were in *Cynometra*?

Given that Dakatcha Woodland is unprotected and quite a disturbed compared to Arabuko Sokoke Forest which is protected, it is likely that the owls are more protected in the thickets. Grazing cattle, for example, find it more difficult to move through these thickets.

This raises some criticial questions:

- *Is the thicket a suitable long-term habitat for the Sokoke Scops Owl?* The thickets appear to be a remnant of a habitat that was once suitable for them (the Diospyros Dry Coastal Forest). They are still hanging on despite the degradation of their habitat. How long can they keep hanging on?
- *How do they breed in the thickets?* Part of the reason why the Sokoke Scops Owls

love mature *Cynometra* trees is because they have numerous cavities that they can use for breeding. In the thicket, most mature trees (such as *Diospyros* spp) with potential cavities have been selectively logged. So, where do the owls breed?

The fact that the owls are still present and they even appear to breed is encouraging. However, there is urgent need to further investigate the questions above because if the owls are not thriving and breeding in this type of habitat, it is likely they could go locally extinct.

4.3 Threats facing the Sokoke Scops Owl

The Sokoke Scops Owls face three main threats in Dakatcha:

- Selective logging of large trees
- Overgrazing by herdsmen
- Clearing of land for agriculture

a) Selective logging

Selective logging removes old mature trees with cavities that serve as potential breeding areas for cavity nesters such as the Sokoke Scops Owl. Given the small number of Sokoke Scops Owl, it is possible that lack of breeding cavities is a limiting factor to their population growth.

Photo 15: *Tree cavity on Cynometra Webberi tree that could serve as a breeding hole for the Sokoke Scops Owl. Such trees are being selectively logged for charcoal production.*

While selective logging within the reserve has been largely controlled, it will take a very long time for trees to grow to an age where cavities start to form. It is therefore important to explore other ways of providing breeding cavities for the owls, for example, through use of artificial nest boxes.

b) Overgrazing

Overgrazing is quickly becoming a major threat in Dakatcha Woodland. This was particularly evident during the August fieldwork where many of these herdsmen were present. During the survey, we observed that:

- The herders often cut thickets to build temporary homesteads and cattle enclosures (called 'Bomas'). Given that these homesteads are temporary, every season they come, they clear new patches of thicket.
- The cattle trample on the ground leaving bare areas and causing disturbance.
- The dogs that follow herdsmen can be a threat to small mammals such as the Fugu (elephant shrew)
- The Indian House Crow *(Corvus splendens)* is often attracted to these bomas. This is an invasive crow that is common at the Kenyan coast. It is known to destroy nests and consume eggs and chicks of smaller bird species, often causing decline in their population.

Photo 16: *An abandoned cattle boma showing scale of destruction of thicket vegetation*

Overgrazing will probably get worse in Dakatcha. In recent years, the herders have been chased away from their traditional grazing land in Agricultural Development Corporation (ADC) land which is about 50km west of Dakatcha. The ADC is currently developing the land for agriculture through the Galana-Kulalu Food Security project. This means that the herders have had to look for alternative grazing areas. Because the A Rocha Reserve (ADNR) still has a decent amount of thicket and grass compared to surrounding areas, it has become an attractive alternative for these herdsmen.

Photo 17: *Some landowners have resorted to using trenches to discourage cattle from crossing into their land*

Some land owners have started using trenches to restrict entry of livestock into their land (**Photo 17**). This is a relatively cheap solution compared to erecting an electric fence. A Rocha Kenya could explore the advantages and disadvantages of using this method as a stop-gap measure to mitigate the influx of large cattle herds as a more permanent solution (such as an electric fence) is being sought.

c) Clearing of land for Agriculture

There is an influx of people from mainland Kenya buying land in Dakatcha and converting it to agriculture. *Cynometra* forests are especially in danger because they grow on red loam soil which is particularly attractive for agriculture. The influx of buyers has also pushed up the price of land in Dakatcha making it more expensive to buy land for conservation. Most of the agriculture we observed was subsistence agriculture (particularly growing of maize) and commercial pineapple farming. Such farms are often abandoned after two to three years when fertility declines.

4.4 Training local scouts

The training of the two community scouts (Samson Katisho and Jonathan Mbitha) in various aspects of Sokoke Scops Owl and habitat monitoring especially on aspects touching on acoustic monitoring is a big boost in enhancing the research and monitoring capabilities of A Rocha Kenya.

In addition, this project has been useful in developing methodologies and providing equipment required to continue and even expand the monitoring programme.

4.5 Awareness Creation

A Rocha Kenya has done an excellent job in harnessing awareness creation online and offline through a variety of channels. This project aimed at supplementing such efforts through creating a portal for dissemination of research information and data specifically for Dakatcha. Over time, *dakatachawoodland.org* aims to be a one-stop-shop for researchers, conservationists and funders interested in Dakatcha. It will also amplify the work that A Rocha Kenya and other conservation organizations are doing in Dakatcha.

5.0 Conclusion and Recommendations

In this section, we discuss:

- The major achievements of the project
- Recommendations for further study
- Suggestions for conservation recommendations

5.1 Major achievements of the project

The following are the major achievements of this project.

- This was the first survey to photograph the Sokoke Scops Owls at their roosting sites in Dakatcha. Clear photos of 4 individuals were taken. We were also able to confirm breeding through identification of one young owl.
- We tested some of the advanced monitoring methods (such as acoustic monitoring, remote sensing, and machine learning). These methods have the potential to lower the cost of monitoring. The lessons we learnt from the study will help us in developing better methodologies that suit the Sokoke Scops Owl. This is important especially for long term monitoring.
- We did a comprehensive habitat, plants and threats analysis. This includes producing habitat maps, plant atlases and threat maps. All this information will be analyzed to develop a fine-grain understanding of the micro-habitat conditions required by the Sokoke Scops Owl. They will also help in the study other threatened species within Dakatcha.
- We conducted a thorough hands-on training of two community scouts in owl monitoring as well as habitat monitoring. This is important for long-term monitoring in Dakatcha.
- We were able to confirm breeding of another endangered species (The Martial Eagle *Polemaetus bellicosus*) within the boundaries of the reserve (**Photo 18**). This brings the number of endangered species known to be breeding within the reserve to three (Sokoke Scops Owl, Martial Eagle, and Golden-rumped Sengi). This also underscores the importance of Dakatcha in the protection of threatened biodiversity.

Photo 18: *A Martial Eagle nest was discovered during the study. This is the first confirmed breeding for this endangered eagle within the reserve boundary.*

5.2 Recommendations for further study

The following are recommendations for further studies based on our observations during this study.

- This study found that majority of the Sokoke Scops Owls were found in the *Diosypros* Dry Forest remnant thicket and also in transition zones of the *Cynometra* forest. However, during this study we did not encounter any Sokoke Scops Owls in the *Cynometra* forest despite the fact that they have been recorded there in previous surveys between 2010 and 2020. Also, in Arabuko Sokoke Forest, the scops owls are found exclusively in this habitat type. Therefore, we need for a more detailed study in this habitat to determine presence or absence. Also, if they are truly absent, it is important to know why.
- There is need for an in-depth disturbance analysis of the *Cynometra* habitat especially during the period when the herders are around. This could help us identify the reasons why the owls are not in the present even when good quality stands exist.
- There is a need for a proper assessment of availability of breeding trees and cavities especially in the Dry Forest thicket remnants where the Sokoke Scops Owls have been recorded. This study found a general lack of breeding trees and cavities in the thickets but a more focused study is required to determine breeding cavity availability in areas where the Sokoke Scops Owl has been found.
- There is need for a study to determine if the Sokoke Scops Owls are successfully breeding in Dakatcha. If there is a lack of breeding cavities, it is likely that breeding

will be impacted and there will be a need to provide supplementary breeding alternatives such as nest boxes.

5.3 Conservation Recommendations arising from the project

To ensure the long-term conservation of the Sokoke Scops Owl at Dakatcha, we make the following conservation recommendations.

a) Fast track purchase of land

A Rocha needs to fast track the purchase and securing the remaining parcels of land within the reserve. A Rocha Kenya aims to have a reserve that will be 10,500 acres in size. Currently, about 9,435 acres (or 89%) has already been purchased (A Rocha Kenya, 2025). Land prices are still fairly low in Dakatcha but they are quickly rising. Also, ideal habitat is being cleared at a fast rate. Looking at the habitat map, there is still ideal land available, for example, to the east that could potentially support SSO populations. All this means that there is still a small window of opportunity to meet or even exceed this target.

b) Securing the land

In addition to purchasing the land, the reserve will need to be secured by ensuring that it has proper documentation (i.e. title deeds). Fencing is also required to prevent encroachment. While fencing the entire reserve can be expensive, priority can be given to areas with endangered species such as the Sokoke Scops Owl and the Golden-rumped Sengi. Trenching can also be explored as a stop gap measure to deter entry of cattle into the reserve as funding for fencing is being sought.

Photo 19: *A Rocha Kenya has a dedicated team of community scouts that require support to continue protecting the reserve*

While physical barriers are an emergency solution, long-term protection should rely on support from the local community, local security agencies and the local government. There is need to demonstrate the importance of the reserve to the community and the county government not only in terms of ecosystem services but also potential revenue.

c) Habitat Restoration

Part of the land that is being purchased has been under intense pressure from selective logging and agriculture. It will need to be restored to its original state

For example, old trees that the Sokoke Scops Owl relies on for making breeding cavities have been selectively logged. There will be a need to provide supplementary artificial breeding sites in the form of nesting boxes.

d) Securing sustainable long-term funding

Reliable long-term funding is required to support protection, research and management of Arocha Dakatcha Nature Reserve (ADNR). Given its remote location and the fact that Dakatcha does not host any of the 'big five', it is difficult to derive income from tourism. Fundraising from traditional institutional donors is also not a reliable source of income. In recent years, many countries and donors have scaled down on their funding activities.

For long-term sustainability, A Rocha will need to tap into non-traditional sources of funds. These include:

- **Biodiversity credits.** Given the rich biodiversity of Dakatcha and the magnitude of threats facing the site, Dakatcha is a great candidate for the biodiversity credits market.
- **Establishing a research station.** Dakatcha is an ideal place for the establishment of a research center that can host universities, NGOS, and research institutions (local and foreign) that would pay to teach or carry out research on coastal biodiversity.
- **Crowd sourcing.** This makes use of platforms like Global Giving, Go Fund Me or M-changa. A Rocha has already successfully used crowd funding in purchase of plots for the reserve. To find out how to support A Rocha Kenya in buying land for the reserve, you can follow the link: https://www.arocha.or.ke/dakatcha-nature-reserve/

e) Research and monitoring

There is need to ramp up research at Dakatcha to support data-driven conservation efforts, especially for highly threatened species like the Sokoke Scops Owl. This can be done by:

- Creating linkages with local and international universities. A research station with laboratories and accommodation facilities will help to attract collaborators.
- Encouraging local and international researchers to join A Rocha as Research Associates. They can help in fundraising efforts as well as carrying out research.

There is still much to learn from Dakatcha and a lot remains to be studied as evidenced by our recent discovery of a breeding Martial Eagle within the reserve boundaries.

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We are sincerely grateful to Mohammed Bin Zayed Conservation Fund and African Bird Club for enabling this work to be done.

8.0 Appendices

Appendix 1: Audiomoth details

Here is a summary of the Audiomoth details to be used in the project

- **Number of Audiomoths :** 18
- **Audiomoth Version**: v 1.2.0 (https://groupgets.com/products/Audiomoth-v1-2-0)
- **Recording period:** 6.45 pm to 6.45 am (12 hours)
- **Sample rate:** 48 kHz (48,000 samples per second)
- **Gain:** Medium
- **Bit depth:** 16 bits (common for Audiomoth recordings)
- **Channels:** 1 (mono)
- **Sleep cycle:** 1 minute of recording (60s) followed by 5 minutes of sleep (300s).
- **SD Card:** 32 GB microSD card uhs 1 class 10 (n/b slower cards may not work properly at high sampling rates above 48 kHz will need uhs 3)
- **Batteries:** 3 per audiomoth, rechargeable, 2,800 mAh

Appendix 2: Sample Habitat and Threats Analysis Form

General Information

- **Name of the Site: _____**

- **Date:** _____
- **Time:** _____
- **Observers:** _____
- **Location (GPS Coordinates):** _____
- **Plot Number/Code:** _____
- **Weather Conditions:** _____ (e.g., sunny, cloudy, rain, wind speed)

General Habitat Characteristics

- **Habitat Type:** _____ (eg Cynometra Forest, Mixed Forest, Brachystegia)
- **Elevation:** _____ m (Get from GPS).
- **Slope and Aspect:** _____ (Is the land sloping? [Yes/No]. If yes, is the slope Gentle or Steep? Which side is the slope facing? Eg North, South, East, West)
- **Water Availability:** _____ (e.g., Presence/Absence of stream, pond; Distance to nearest water source)

Tree Layer Characteristics

- **Canopy Cover:** _____ % (Estimate or use densiometer)
- **Number of Trees :** _____ (To calculate density per plot)
- **Number of Dominant Tree Species:** _____ cm (Give 3 most dominant and their number)
- **Average Tree Diameter at Breast Height (DBH):** _____ cm (Measure several trees and calculate the average)
- **Number of trees with cavities _____ Is there indication of breeding?_____ If yes, identify species and suspected age (old/New)_____**

Ground Cover Characteristics

- **Dominant Ground Cover Type:** _____ (Give top 3 dominant ground cover type [leaf litter, bare soil, grass, rocks] and estimated % coverage)
- **Leaf Litter Depth:** _____ (Where leaf litter is present, give the depth)
- **Describe Soil Type/Characteristis:** _____ (Where leaf litter is present, give the depth)

Understory Characteristics

- **What are the dominant Understory Species:** _____ (List 2-3 most common)
- **Average Understory Height:** _____ m (Estimate)
- **Understory Cover:** _____ % (Estimate)

- **Vertical Structure Complexity:** _____ (Subjective assessment: Low, Medium, High. Could also be a more detailed description of the layers present)

Disturbance Survey

- **Estimated distance to Edge (road, farm, settlement):** _____ m
- **Number of Cut poles/ stems_____Dbh_____Old/New_____**
- **Signs of grazing (# of cattle/tracks/dung)_____**
- **Signs of agriculture (estimated area cleared)_____**
- **Presence of footpaths (Yes/No)_____**
- **Number of traps_____**
- **Evidence of Mining/Quarrying_____**
- **Presence of Garbage/Litter_____**
- **Evidence of charcoal burning (kilns, charcoal traces/burnt ground)_____**
- **Presence of nearby settlements_____**

Additional Notes: _____ (Record any other relevant observations, such as signs of animal activity, unusual features, or potential problems with the sampling unit.)

Photographs: (Consider taking photos of each sampling unit for later reference. Record photo numbers here if applicable.) **Photograph Number**_____