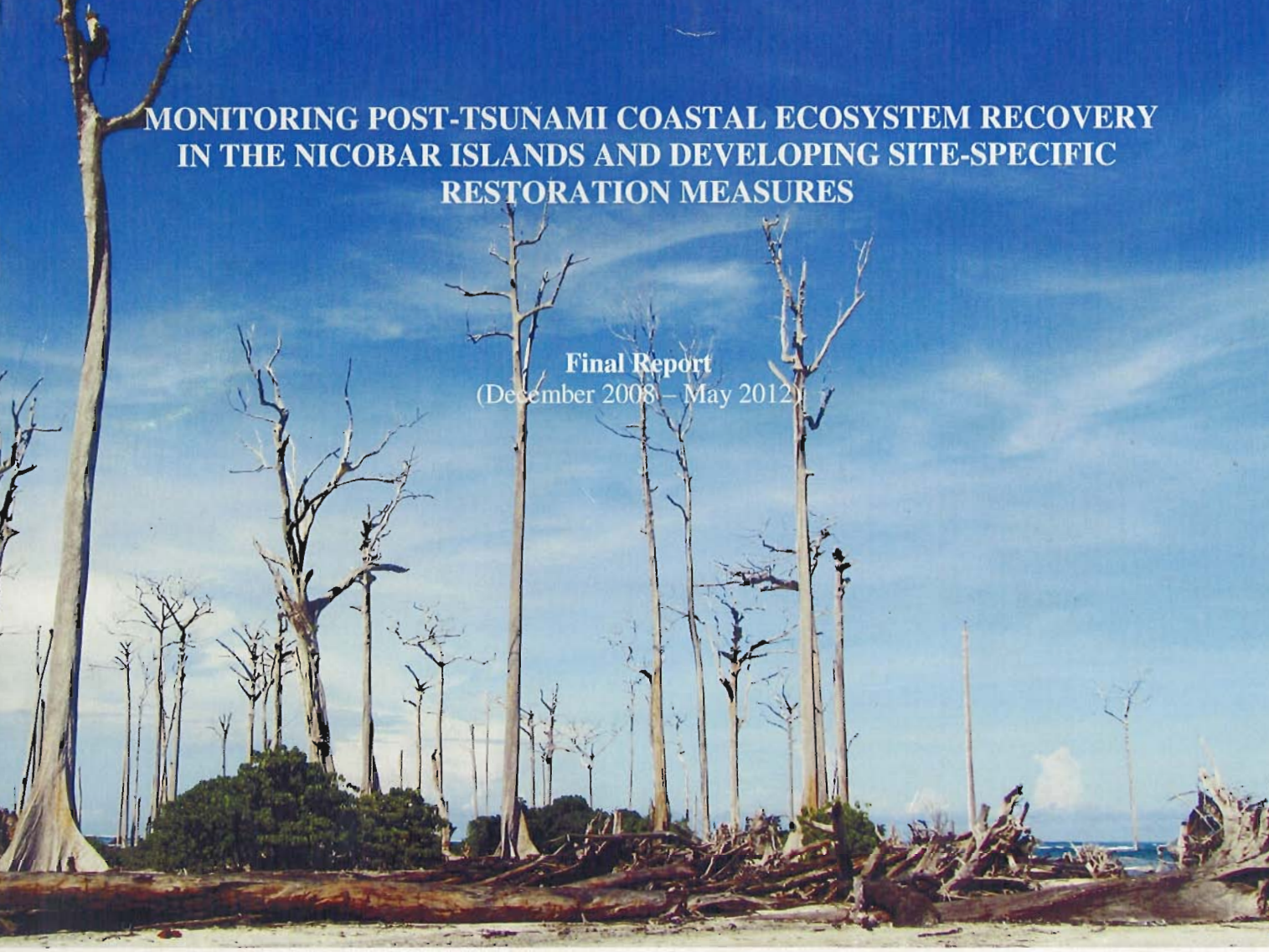

MONITORING POST-TSUNAMI COASTAL ECOSYSTEM RECOVERY IN THE NICOBAR ISLANDS AND DEVELOPING SITE-SPECIFIC RESTORATION MEASURES

Final Report
(December 2008 – May 2012)

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SENIOR RESEARCH FELLOWS

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CONTENTS

SUMMARY

Island ecosystems are rich in biodiversity and more prone to natural and anthropogenic disturbances. The mega earthquake of 9.3 magnitude and subsequent tsunami on December 26, 2004 had disastrous impacts on people and biodiversity of south-east Asia. The close vicinity to the epicenter of the earth quake attributed to the maximum damage levels in Nicobar Islands in terms of human lives and coastal biodiversity. The tsunami had completely destroyed or significantly damaged all vegetation that existed in the coastal area between the beach and the hill. The mega earth quake had resulted in a tilt in the land with southernmost Nicobar Islands having sunk by about 1.6 m while the Northern most Andaman Islands have been elevated by about 1.2 m. Coastlines have receded towards the hills, at places by several hundred meters, often resulting in very little or no land between the hills or high ground and the sea.

The impacts to coastal ecosystems have been: (1) physical uprooting of coastal forests and mangroves by the tsunami, (2) scorching of littoral vegetation due to salt stress from sea water inundation, (3) dying out of mangroves due to perennial submergence of the pneumatophores, (4) sea water inundation of inland freshwater bodies, destruction of marshes and creeks, and (5) physical destruction of coral reefs by the tsunami waters. Hence, there was a need to assess the damage to understand the changes and address issues on restoration. SACON and Andaman Forest department initiated this project to asses the post tsunami status of flora and fauna in the tsunami affected areas of Nicobar Islands. The objectives of this project were i) to assess and monitor vegetation regeneration in tsunami affected littoral forests, ii) to assess impacts of tsunami on mangrove forests and monitor the natural re-colonization of mangrove species, iii) monitor species of fauna that inhabit coastal ecosystems, focusing on the Nicobar Megapode along with other endemic bird species and Robber Crab, iv) to develop and implement appropriate site specific strategies to restore damaged habitats.

Sampling plots of 50 x 20 m size were established to assess and monitor the colonization of plant species in the predetermined sites of tsunami affected littoral forests. All the woody plants $\geq$ 10 cm GBH were enumerated from the sampling plots. Snags were also enumerated from the sampling plots to get an idea of pre-tsunami littoral forest. Control plots were

established in unaffected or less affected littoral forest for comparison. Entire coastal line of Nicobar Islands were surveyed to assess the impacts of tsunami on the mangrove forest and to study the natural colonization of mangrove species. All the saplings ≥ 1cm GBH were enumerated from the belt transacts of various size (100-500 X 10 m) to study mangrove re-colonization. Sampling plots of 20 x 20 m were laid in the scorched mangrove habitats and all the snags were enumerated.

Natural regeneration of littoral forest species were studied from 105 sampling plots distributed over 54 sampling sites of Nicobar Islands. Vegetation in the unaffected littoral forest was studied from 21 sampling plots. Littoral forest was classified into three types namely Sandy Regenerating Vegetation (SRV), Sand Loamy Regenerating Vegetation (SLRV) and Unaffected Forest (UF) based on the sand and coral rubble deposition in the soil substrate during tsunami.

In general, the species richness was highest in UF with 133 plant species followed by SLRV (123 species) and SRV (45 species). Similar pattern was observed in the species richness/plot, where UF has showed maximum richness 18.04(SD±8.17) followed by SLRV 16.39(SD±7.09) and SRV 5.58(SD±3.95). Basal area $ha.^{-1}$ m^2 is again highest for UF 73.88 (SD±29.08) followed by SLRV 28.23(SD±20.95) and SRV 2.41(SD±3.76). Stem density/plot was highest in SLRV 164.12(SD±74.40) followed by UF 87.47(SD±52.22) and SRV 18.72(SD±18.28). One-way ANOVA showed that the mean species richness, stem density and basal area/plot varied significantly between UF, SLRV and SRV ($F_{2,86} = 29.844$, $p<0.01$; $F_{2,86} = 48.956$, $p<0.01$; $F_{2.86} = 85.751$, $p<0.01$). Natural regeneration is poor in SRV due to the disturbance caused at the substrate level. High variation in vegetation composition observed in SRV during the study period suggests that the natural regeneration is slowly getting accelerated, perhaps due to improvement in soil condition. Only 13 species could be identified from snag enumeration and the total basal area was calculated as 38.6 m^2/ha.

In SRV, the pioneering vegetation is classified as *Casuarina equisetifolia-Hibiscus tiliaceus-Dendrolobium umbellatum* series. The co-dominant species for SRV are *Macaranga peltata-Morinda citrifolia-Lannea coromandelica.* The pioneer vegetation in SLRV is characterized

by *Macaranga peltata-Terminalia bialata-Terminalia catappa.* The co-dominant species in SLRV are *Dendrolobium umbellatum-Boehmeria nivea-Claoxylon indicum.* Unaffected forest vegetation is characterized by *Terminalia bialata-Manilkara littoralis-Pterocymbium tinctorium* and the co-dominant species are *Syzygium samarangense-Sloetia sideroxylon-Orophea katschallica.*

Mangrove re-colonization was studied from 25 locations distributed over eight Islands. A total of 17 species of mangroves were enumerated of which five species were recorded for the first time from the Nicobar Islands and one species namely *Sonneratia ovata* is a new record for India. The overall stem density of mangrove saplings in the re-colonizing sites is 146 individuals $ha.^{-1}$. *Rhizophora mucronata, Rhizophora stylosa* and *Bruguiera gymnorrhiza* are the dominant true mangroves. *Lumnitzera racemosa, Sonneratia alba, Lumnitzera littorea* and *Sonneratia ovata* are the dominant back mangroves. The basal area of pre-tsunami mangrove forest was estimated as 24.55 m^2 (10.8±SD) $ha.^{-1}$. The stem density estimated for the pre-tsunami mangrove forest is 325(121.4±SD) individuals $ha.^{-1}$.

The high species diversity in tropical forests makes it more resilience to any disturbance event. Very often studies have established the fact that when a forest ecosystem is disturbed, it reconciles by itself. However, disturbances that affect the soil quality of the habitat will result in long-lasting effects on species composition. Human intervention is needed in such cases for the speedy recovery of species composition and ecosystem functions. Based on the present study, restoration measures were suggested for both mangrove and littoral habitats of the Nicobar Islands.

In littoral forest, restoration activities can be possible only at few sites were SRV prevails. Based on the adaptation tendency of plant species to the conditions in SRV, 17 species are suggested for habitat restoration. In the case of mangroves, species that show better colonization tendency are suggested for habitat restoration. Seed collection sites are also given for the effective implementation of restoration programs.

The tsunami impact has affected the floral and faunal diversity along the coastal belt. The species of faunal groups that have been affected the worst include the Nicobar Megapode, a mound building megapode endemic to the Nicobar Islands whose greatest concentrations were in the littoral forests due to the propensity of megapodes to build incubation mounds close to the beach. Concerns have been also raised on the impact of the tsunami on five other bird species endemic to Nicobar Islands. Among all the costal inhabiting species, Robber Crab was possibly the worst affected, since it almost exclusively inhabits a very narrow (less than 100 m) strip along the coastline. The present study aimed to assess the status of species of fauna that inhabited coastal ecosystems, focusing on Nicobar Megapode and other endemic bird species and Robber Crab.

Bird surveys were conducted in 64 different locations in 17 islands of Nicobars with the following objectives, i) to make an inventory of bird communities, ii) understand the bird distribution and abundance patterns in the tsunami-affected and unaffected habitats. Point counts of five minute duration at every 100m intervals were carried out in different habitats to study the bird communities. A total of 10216 individuals comprising 85 species were recorded during 1188 point counts (490 counts in tsunami-affected & 698 in unaffected habitats). In all, 77 species of birds were recorded in the tsunami-affected littoral areas, while 57 were recorded from the unaffected habitats. Olive-backed Sunbird, Asian Glossy Starling and Oriental White-eye were the most abundant species in the tsunami-affected habitat. Abundant species found in the tsunami-affected area consisted largely of frugivores, a few insectivores and nectarivores. Green Imperial-pigeon and Nicobar Bulbul constituted the most abundant threatened species in the unaffected habitats. Island-wise occurrence of threatened and endemic bird species in Nicobar is discussed. Green Imperial-pigeon and Long-tailed Parakeet constitute the most widely distributed and abundant species in Nicobar Islands. Nicobar Parakeet was common in Great Nicobar island group (Relative Abundance (RA)= 1.3). South Nicobar Serpent-eagle (RA= 0.12) was uncommon and Nicobar Sparrowhawk (RA=0.02) rare in their respective distributional ranges. From the present study, it appears that the loss of coastal habitats due to tsunami has not significantly influenced the population of endemic birds except Nicobar Megapode.

Rank abundance curve indicated low evenness as few species dominates the bird communities of the two habitats and have much higher abundances than most of the other low ranking (uncommon) species. Several bird species (except endemics) found during this study, including the dominant ones are generalist species which are resilient to habitat change. Margalef's richness index indicated greater species richness in tsunami-affected area than the unaffected habitats. Tsunami-affected areas provided a heterogeneous habitat allowing more bird species to occur. Lesser abundance of the endemic species that occurred in tsunami-affected areas suggests that their re-colonisation from adjacent unaffected habitats and establishment has been only partial. However, their occurrence in the tsunami-affected area an indication of those species' resilience and recovering ability.

During the present study, a total of 106 bird species have been recorded from Nicobar Islands. A Checklist of birds of Nicobar Islands showed that avifauna of this region comprises 141 species belonging to 44 families when historical, new, isolated and doubtful records were considered. Four new bird species hitherto unrecorded from the Nicobar Islands were sighted during the surveys.

A total of 73 km coastline habitat (34.9 km of suitable habitat and 38.1 km of unsuitable habitat) in 44 sites of 15 islands with known distribution range of Nicobar Megapode were surveyed to assess its post-tsunami status. Direct sighting of megapodes, calls and the presence of its mounds were recorded along transects walked during bird point count surveys. Enumeration of active mounds was used in all the previous studies to assess the population of Nicobar Megapode. In the present study also, only active mounds were considered for population estimation. Mounds of megapode were characterised basically into three types: Type A, regular in shape and built on an open spot away from trees; Type B, irregular in shape and built against the buttress or stem of a large living tree; Type C, also irregular in shape but built against, around, under or over a dead rotting tree-stump or log. Mounds were assigned into active, inactive and abandoned categories. Distance of mounds from sea-coast, canopy cover (%) and height over the mounds were estimated visually. GPS locations and elevations of mounds were noted. The mound size was also calculated.

Megapodes were sighted from 13 of the 17 islands surveyed. During the present study, first sight record of Nicobar Megapode from Pilo Milo and Cubra was made. Of the total 73 mounds recorded, Type C mounds were common (46.6%), followed by Type A (27.45%). Low representation of Type B mounds could be due to scarcity of large live trees in the coastal areas after the tsunami. Status of mounds located included, active (40, 54.8%), inactive (17 mounds, 23.3%) and abandoned (15 mounds, 20.5%) and the status of one case was uncertain. Mean distance of the mounds from the beach was 85.5m (SD ±146.3). Mean size (volume) of active and inactive mounds was 3.98±4.18m^3 (range 0.2m^3 to 26.8m^3). The smaller size of the mounds indicated that active and inactive mounds were constructed after tsunami. Sand-loamy or sandy substrates were largely preferred to loamy or gravel mound substrates. Average canopy cover and height over the mounds were 47.5±22.8% and 19.5±12.6m respectively. The moderate amount of canopy cover over the mounds found during the present study was due to the regeneration of habitat that is happening for the last 6 years. This study shows similar patterns in the case of distance of mounds from coast, mound type and size, as observed by Sivakumar (2007), which indicates that no major change in mound characteristics of the Nicobar Megapode has happened in Nicobar Islands.

Based on the 40 active mounds located along 73 km long coastal habitats surveyed, it is estimated that 376 mounds to occur along 687 km long coastline of Nicobar Islands within the known distribution range of megapode. Approximately, 376-752 breeding pairs of Nicobar Megapode were estimated to occur in Nicobar Islands when one pair per mound is set as the lower limit and two pairs per mound was set as the upper limit. The present study indicates that the population of Nicobar Megapode remains stable after its 70% decline due to habitat loss reported in the earlier post-tsunami surveys. High incidence of active mound sightings was made in Bompoka when compared to other islands. In the central group of islands, Bompoka Island should be given priority in the conservation programs on Nicobar Megapode. Continuous monitoring of the currently surviving population is suggested.

Out of the 64 locations surveyed during October 2009-August 2011, Robber Crab could only be sighted from two locations (a pair at Bompoka and one individual at Chawra). Sightings of just three individuals and few indirect evidences during the entire study period show the very rare occurrence of this species in Nicobar Islands.