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REDISCOVERY OF THE DINAGAT BUSHY-TAILED CLOUD RAT *CRATEROMYS AUSTRALIS* (MUSSER, HEANEY & RABOR, 1985) (MAMMALIA: RODENTIA: MURIDAE) FROM DINAGAT ISLAND, PHILIPPINES

OPEN ACCESS

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Abstract: The Dinagat Bushy-tailed Cloud Rat *Crateromys australis* belongs to the group of Cloud Rats, arboreal and folivorous nocturnal rodents endemic to the forests of the Philippines. The species, endemic to a small island Dinagat in the Philippines, was discovered and captured in 1975. Since then, despite repeated surveys, no specimen was found until 2012. It is listed as Critically Endangered by IUCN Red List and was even believed to be extinct. Finally, Dinagat Bushy-tailed Cloud Rat was rediscovered in January 2012 and its presence confirmed on Dinagat Island. The rediscovery of this species underlines the local, national and international importance of Dinagat Island (or Dinagat-Siargao cluster of islands), as the most distinct subcentre of species endemism within the Greater Mindanao Faunal Region. Unfortunately, only one locally protected area exists on the whole island and none of the last remaining native forest habitats on Dinagat are currently protected at the national level. Mining and habitat destruction constitute a serious threat to this species. We believe that this rediscovery may provide some important and timely impetus and urgency to the need for a more rational, scientifically-based and island-wide, development program on Dinagat by also incorporating an island/region-wide biodiversity conservation strategy that would help ensure the effective, longer-term protection of the larger majority of the few remaining natural habitats in this region.

Keywords: Asian Musk Shrew, Cloud Rat, *Crateromys australis*, Dinagat, Philippines, Philippine Cloud Rats Conservation Programme, Tarsier.



Crateromys australis
Dinagat Bushy-tailed Cloud Rat

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICALLY ENDANGERED	EXTINCT IN THE WILD	EXTINCT
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INTRODUCTION

The Cloud Rats are a group of arboreal and folivorous nocturnal rodents endemic to the forests of the Philippines. They are the largest members of the subfamily Murinae and include some of the most spectacular and beautiful rodents in the world distinguished from other murids by their large size and densely furred tails. Currently there are five genera and at least 13 species (i.e., *Batomys* 5 spp.; *Carpomys* 2 spp.; *Crateromys* 4 spp.; *Musseromys* 1 sp.; and *Phloeomys* 2 spp.). Three of the five genera (i.e. *Carpomys*, *Musseromys* and *Phloeomys*) are confined to the 'Greater Luzon Faunal Region', whereas *Batomys* and *Crateromys* spp. also occur elsewhere in the Philippine Archipelago 'sensu stricto' (i.e., all areas east of Huxley's Line and therefore excluding the Palawan Faunal Region; Fig. 1).

The two Luzon Island endemic 'slender-tailed' Cloud Rats of the genus *Phloeomys*, i.e., *P. cummingsi* and *P.*

pallidus, remain relatively widely and contiguously distributed throughout the remaining forested areas of southern and northern Luzon, respectively. In marked contrast, all four *Crateromys* spp. have peculiarly restricted and disjunct ranges, widely scattered amongst each of the four main Philippine faunal regions—i.e., 'Greater' Luzon, Mindoro (Ilin Island), West Visayas (Panay Island) and Mindanao (Dinagat Island; Fig. 1). Although the behavioural ecology and habitat requirements of all species remains poorly known, the few available data indicate that both species of *Phloeomys* are adaptable and able to persist in degraded habitats, even in predominantly agricultural land, so long as sufficient cover remains. *Crateromys* spp., on the other hand, seems much less tolerant of deforestation and other human disturbance, presumably because of their more arboreal habits. Being confined to higher altitude forests of the Cordillera Central, *C. schadenbergi* is also perhaps the only species to merit the 'cloud' epithet since all other species mostly inhabit low- and/or mid-



Figure 1. The Philippines showing principal 'faunal regions' and location of the 'Dinagat - Siargao cluster' of islands, which constitute the most distinct sub-centre of species endemism in the 'Greater Mindanao Faunal Region'.

elevation forests. Nonetheless, all Cloud Rat species are ultimately threatened by a loss of habitat, and all three of the Luzon endemic forms are also intensively hunted for food (Oliver et al. 1993). Therefore, The Philippine Cloud Rats Conservation Programme based on international cooperation was started. The Programme is based around the implementation of priority recommendations arising from surveys, that investigated the conservation status and likely future research and management needs of all six species over the majority of their known ranges.

The Dinagat Bushy-tailed Cloud Rat *Crateromys australis* is endemic to Dinagat Island (Fig. 1). The single known (now holotype) specimen of *C. australis* (Image 1) was collected in 1975 in Balitbiton, Loreto municipality, Surigao del Norte Province, Dinagat island, Philippines (Fig. 2) during one of the first scientifically organised faunal surveys of Dinagat Island, led by Dr. Dioscoro S. Rabor, doyen of Philippine vertebrate zoology (Musser et al. 1985). The holotype was collected from a disturbed lowland forest, near a logging road. This survey also resulted in the discovery of the Dinagat Moonrat *Podogymnura aureospinula* and the subsequent discovery of other new Dinagat endemic mammals, including the Dinagat Hairy-tailed Rat *Batomys russatus*; both species now IUCN Endangered. The single new Cloud Rat specimen was deposited in the American Museum of Natural History, but not formally described until 10 years later (Musser et al. 1985).

The species was subsequently feared 'extinct' by some authorities (e.g., Ong et al. 2008) as no other specimens were recorded during various follow-up expeditions by trained investigators. Given the species' relatively small body size and presumed nocturnal and arboreal lifestyle the species is naturally 'elusive' in scientific survey terms (i.e., quite unlikely to be successfully located during short-term expeditions using standardised survey techniques), but also unlikely

to be familiar to local hunters and other informants unless specifically targeted using specialised hunting techniques (e.g., by 'smoking-out' tree holes located by especially trained dogs, as happens in many parts of Luzon where the much larger sized *Phloeomys* spp. are routinely hunted using such methods; Oliver & Cox 1990). The alternative presumption that the species most likely survived as long as sufficient native forest habitat remained was supported during the course of two island-wide ethno-biological surveys conducted in 1990 and 2007/8; wherein very few selected interviewees (mostly traditional hunters identified locally as being most knowledgeable about wildlife in each area) were aware of the species' existence (Fig. 2). As such, the only compelling, contemporary accounts referred to chance sightings of animals (previously unfamiliar to the informants) evidently disturbed from daytime nest sites during tree-felling operations (Pedregosa-Hospodarsky 1990, 2009; Oliver et al. 1993).

In this report we present a rediscovery of the Dinagat Bushy-tailed Cloud Rat *Crateromys australis* and its scientific documentation for the first time after capture of the holotype in 1975 and also present recommendations for further steps in conservation of this Critically Endangered Dinagat endemic species.

Dinagat Island

The Dinagat Island lies northeast of the north-eastern peninsula of Mindanao, part of the 'Dinagat-Siargao cluster' of islands (Fig. 1). Much of the island has been cleared but several areas of closed canopy forest remain there, principally on the Mt. Kambinlio and Mt. Redondo ranges in the north of the island. The highest point of the island is below 1000m and the forest is mainly lowland type. Dinagat was declared an island province, with a total land area of 1036.34km², in 2006. The major economic activities on the island are agriculture, fisheries, collection of forest products

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Image 1. Holotype specimen of *C. australis*, not previously recorded since 1975

(Mallari et al. 2001) and mining. It is a Mineral Reserve under Republic Act No. 391 issued in 1939 by the Department of Environment and Natural Resources. It is rich with metallic and non-metallic mineral resources which include aluminous laterite ore, nickeliferous laterite, phosphate, limestone, siliceous and gold deposits. In 1988 the island still had 58% forest cover, in 2009 the island had only 34% forest cover left and these remaining forests are mostly within the claimed areas of several mining companies (Pedregosa-Hospodarsky 2009) (Fig. 3).

Mt. Kambinlio and Mt. Redondo area on Dinagat Island are recognized as a Key Biodiversity Areas with an extremely high critical priority of conservation with illegal logging, mining and land conversion (kaingin) being the main threats (Mallari et al. 2001; Ong et al. 2002; Conservation International Philippines et al. 2006). However, there is no area protected at a national level. Dinagat Island constitutes a distinct subcentre of species' endemism (albeit with biologically inferred links to Siargao and Bucas Grande Island 'cluster') within the 'Greater Mindanao Faunal Region'. Many of the threatened and restricted-range species of the Mindanao and Eastern Visayas Endemic Bird Area have been recorded on Dinagat, most of which are likely to have populations in the forests on Mt. Kambinlio and Mt. Redondo. Dinagat Island has three (four) endemic species of mammals, which is a very high number for such a small island. These are the Endangered Dinagat Gymnure *Podogymnura aunospinula*, which is common in both primary and secondary forest there, the Dinagat Hairy-tailed Rat *Batomys russatus* and the Dinagat Bushy-tailed Cloud Rat *Crateromys australis* (Musser et al. 1985; Mallari et al. 2001). The Dinagat population of the Philippine Tarsier *Tarsius syrichta* has been recently classified as a different (sub) species, genetically distinct from Bohol, Samar, Leyte or Mindanao populations (Brown et al. 2014).

METHODS

Following a three year research study of the Philippine Tarsiers *Tarsius syrichta*; IUCN: 'Near Threatened') on Bohol, the first author was encouraged by the Philippine Biodiversity Conservation Foundation, Inc. to extend and apply her night-time field research techniques and experience to include other, higher conservation priority areas and species. Dinagat Island was the obvious first choice in this regard; partly because it was presumed to support one of the most

likely threatened and genetically isolated Philippine Tarsier populations (as suggested by Brandon-Jones et al. 2004 before it was confirmed by Brown et al. 2014), but also because it was an evidently distinct sub-centre of mammalian endemism within the 'Greater Mindanao Faunal Region'. To these ends, a study was conducted over a 10-day period (05–15 January 2012) in Loreto Municipality in central-north Dinagat (Fig. 2). As a part of a broader survey direct observations of local wildlife were conducted inside the forest during the evening hours, usually from 17:00–19:00 hr or shorter in case of heavy rain. Observational hours were spent simply listening for Tarsier vocalisations (N.B. 'play-back' recordings of Tarsier vocalisations seldom elicit salient responses in Philippine Tarsiers) from two separate vantage points.

Additionally, we interviewed local residents - farmers or workers of mining and logging companies - who spent significant time in the forests. The Cloud Rat is locally called 'buot' which, however, is also a local name for squirrel and these animals are often confused



Figure 2. Distribution map of Dinagat Bushy-tailed Cloud Rat *Crateromys australis* reported by locals (according to Pedregosa-Hospodarsky 2009) (circles), place of finding of the holotype in 1975 (square) and place of observation during our study (star).

by locals (Pedregosa-Hospodarsky 2009; Řeháková & Řehák pers. obser. 2012). During interviews we asked about the presence of 'buot' and let the locals describe the appearance and size and body and tail colour. We also showed pictures of the holotype and also of the Philippine Tree Squirrel *Sundasciurus philippinensis* and Philippine Pygmy Squirrel *Exilisciurus concinnus* and asked the people to identify the animal that they had seen. The locals were approached on town meetings where we then highlighted the importance of finding and protection of an endemic Cloud Rat with black-white-tailed rat and orange body or privately with the help of local assistants.

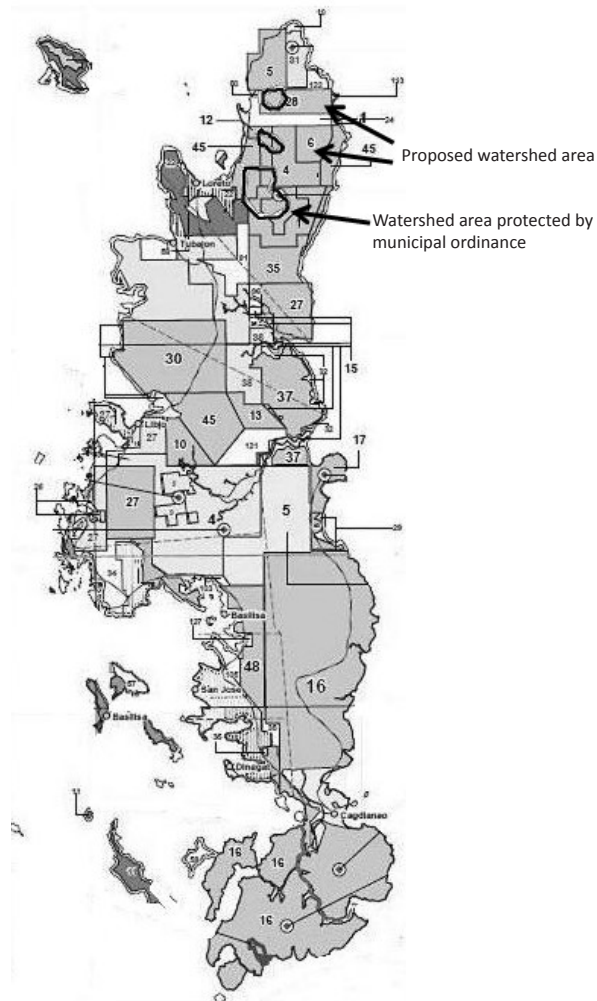


Figure 3. Map of mining claims, watershed area currently protected by municipal ordinance (total area of 8.676km²) and two proposed protected watershed areas (according to Tenement control map of region XIII, 2011).

RESULTS

Direct observation

No Tarsier vocalisations were recorded at the study site during this period, but attention was instead drawn to the rustling movements and unfamiliar calls of other species - most notably the (hitherto) elusive Cloud Rat. A single (presumed to be the same) individual was continuously observed for periods of 20 minutes as dusk fell (17:55–18:35 hr) on three separate nights leading to the first sound recordings and both still and video film documentations of this species in the wild. For the first time during our study the Dinagat Bushy-tailed Cloud Rat was spotted on 08 January 2012 at 18:05hr which was already after sunset. First, the noise caused by an animal climbing in vegetation was noticed. Following that, a rat of approximate body length of 25–30 cm, greyish body and distinctive black-white hairy tail was spotted walking in trees and on the trail towards the observer. A silent rattling vocalization was heard and recorded ([Audio 1](#)). The Cloud Rat got scared by the flash light, ran away and returned after a few minutes. It crossed the trail and climbed the nearby vegetation—tree stems, branches and vines to an approximate high of 3m. The cloud rat was observed for around 10 minutes before it disappeared. Its movement was slow, climbing the branches from one to another and quite noisy. The recorded vocalization was analysed using the bioacoustic software Avisoft (Avisoft-SASLab Pro Software, Version 5.1.01). The call consisted of several strophes. A spectrogram is provided in Fig. 4. The maximal intensity was at a frequency level of 10840 (± 94) kHz (average \pm SD), maximum frequency was 19014 (± 306) kHz, duration was 0.797 (± 0.25) s, interval between strophes was 1.77 (± 1.39) s, (n=8).

For the second time the Cloud Rat was spotted on 11 January 2012 at 17:58hr, again it was already dark, approximately 30m upwards from the first sighting place. This time the encounter lasted only for a few seconds, just to enable the observer to identify the black-white tail. Finally, the Cloud Rat was observed on 14 January 2012 at 18:25hr at the same place as the first

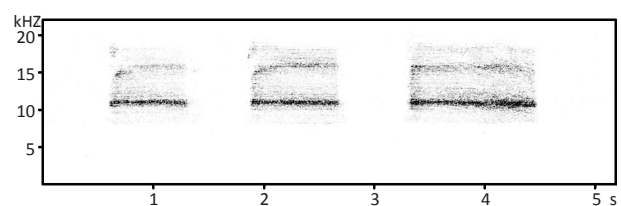


Figure 4. Spectrogram of the vocalization of the Dinagat Bushy-tailed Cloud Rat *Crateromys australis*.

observation. Again, first, the noise of the animal climbing in the vegetation was noticed. Then the rat was spotted not more than 2m from the observer approximately 1.5m above ground. As we started to take pictures and video recordings using the flash light, the animal climbed higher up to 5–6m (Video 1). It moved slowly, using the branches and vines as a substrate. The observation lasted about 10 minutes. The body was grey-brown-reddish, the tail was black-white coloured, hairy but slender than in other *Crateromys* species (Image 2). The body was approximately 25–30 cm long as well as the tail. The video recordings are submitted as an electronic supplement. No vocalization was heard at this time.

Besides the Cloud Rats we observed the Philippine Tree Squirrel *Sundasciurus philippinensis* during four evenings. In contrast to the Cloud Rat, this species was observed before sunset, between 17:00hr and 17:30hr, was fast moving and emitted loud and conspicuous vocalizations. On one evening while returning from the forest we found a dead Asian Musk Shrew *Suncus murinus* (Image 3). Also our local assistant reported previous sightings of Asian Musk Shrew around his house.

Interviews

Most of the people interviewed during our study who had claimed that they had seen the 'buot' identified the Philippine Tree Squirrel and not the Dinagat Bushy-tailed Cloud Rat. Only one farmer reported that he had seen a Cloud Rat. The animal he described had a brown colour body and a distinct black and white hairy tail. According to him it was very beautiful. He also correctly classified the animal on the pictures provided with a note that the body colour was distinct. This animal was spotted in

May 2011 near his coconut farm in Kaburkahan, Loreto. He saw the rat at around 8:00hr climbing on a vine on a big tree on the top of a cliff.

DISCUSSION

The Dinagat Bushy-tailed Cloud Rat (*Crateromys australis*) is currently listed as Critically Endangered as the presumed extent of occurrence is less than 100km² with increasing habitat reduction (Ong et al. 2008). This mammal was known only from one individual so far. Repeated surveys did not find it; therefore some scientists (e.g., Ong et al. 2008) believed that this species may be extinct. During our study we documented sighting the Dinagat Bushy-tailed Cloud Rat for the first time since the holotype was captured in 1975 and obtained the first photo, video and audio recordings from the wild. We have proven its existence in Loreto Municipality, Dinagat Island where currently only one semi-protected area exists (watershed area of a total area of 8.676km²; Fig. 3). The animal(s) observed and documented during our study have a body size of 25–30 cm and around same-sized tail. The body colour was grey-brown-reddish, which is in contrast with the highly conspicuous orange fur colour of the holotype. The holotype had a uniform colour of the body except the throat and upper chest which were slightly paler (Musser et al. 1985, Image 1). Also in the animal(s) recorded during our study, the ventral part of the body was significantly lighter. The tail was distinctively black-white and hairy as documented in the holotype.

In all three cases it was spotted closely after sunset in accordance with its predicted nocturnal activity. During our focal observation the animal(s) was moving slowly and relatively loudly on the tree stems, branches and



Image 2. Dinagat Bushy-Tailed Cloud Rat *Crateromys australis* photographed during our observation by still camera (Canon EOS 300) (a) and video camera (Sony HDR-SR11) (b); N.B. general features, darker dorsal and lighter ventral pelage colours and, especially, the diagnostic bi-coloured tail.



Image 3. Asian Musk Shrew *Suncus murinus* found during our study.

vines, in one case emitting silent rattling vocalizations. It is an elusive creature which seems to be sensitive to people. These facts together with its nocturnal activity is probably the reason why this animal is almost unknown to local residents and was therefore not located during previous ethno-biological surveys. During our study only one farmer reported a sighting of Cloud Rat in May 2011 in the morning. The animal was spotted climbing a big tree which is consistent with previous observations in dead trees or a tree hole (Pedregosa-Hospodarsky 2009) and indicates that Dinagat Bushy-tailed Cloud Rats may use tree holes as resting sites during the day as reported for other Cloud Rat species (Oliver et al. 1993). The ecology and behaviour of this species is absolutely unknown. The holotype was collected from disturbed lowland forest, near a logging road. Our observations in a protected watershed area and observations of locals in proximity of big trees indicate that the species may be dependent on primary forest. It is not known whether this species is able to persist in secondary forests (Ong et al. 2008).

Interviewed local residents often misinterpreted the Philippine Tree Squirrel as a Cloud Rat. This species was also observed during our survey. However, it is much smaller, active during the daytime and moves quickly in comparison to the Cloud Rat. Also the unified colour of the body and tail makes it easily distinguishable from the Cloud Rat.

Another mammal spotted during our study period was a dead specimen of the Asian Musk Shrew *Suncus murinus*. According to our knowledge this species has not been found on Dinagat Island earlier (see Musser et al. 1985; Heaney et al. 2010), therefore this sighting provides important data about the distribution of the species.

No Tarsier observations were made or vocalizations heard during this study (despite the first author and our local assistant confirming occurrence of several specimens in Loreto locality during the past three years), thereby leading to related concerns such as possible and unexpected patchy distribution of this species on Dinagat.

CONCLUSIONS

Conservation concerns and needs

There is increasing scientific evidence that Dinagat (together with Siargao and Bucas Grande Islands) constitutes a distinct sub-center of species endemism within (or perhaps even separate from the rest of) the

'Greater Mindanao Faunal Region'. Although precise remaining forest cover data is still wanting it is clear that Dinagat currently supports far more extant native forest than the rest of this distinct (sub-) region combined, and that the continued existence of these habitats is obviously crucial to the future survival prospects of all Dinagat endemic species, as well as globally important populations of diverse other threatened Greater Mindanao and Philippine endemic species. There are, however, no National Integrated Protected Areas System (NIPAS) (or any other 'effectively protected') 'protected areas' on Dinagat. On the contrary, all such habitats are now seriously threatened by active mining claims (Fig. 3). Clearly and obviously Dinagat epitomises the underlying conflict of interest between the Philippine's genuine and pressing socio-economic development needs and its 'exceptionally extraordinary' global importance as to its regional and global biodiversity conservation issues.

In light of these concerns, and 'any second and last chances' as may be obtained as per the future survival prospects of Dinagat Bushy-tailed Cloud Rat, Dinagat Tarsier and other Dinagat Island endemic taxa, we would respectfully urge the immediacy of the need for a major review of all existing mining claims and other threats to the biodiversity of this region, with a view to ensuring the setting-aside of as much still intact native forest and other wildlife habitats as possible. In doing this, we do not suggest that all such mining claims (etc.) are rescinded, but rather that all salient government organizations, local government units and other key stakeholders meet together to forge and to implement the enactment of an integrated environmental/biodiversity conservation management plan for this region in view of its evident (if not fully understood) local, national and international importance. If the rediscovery of *C. australis* may mean anything it must surely mean an opportunity to review and agree on a better balance between the genuine socio-economic development and longer-term biodiversity conservation management needs of this region. The mineral resources of Dinagat are available elsewhere, but its biodiversity is unique.

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Author Contribution: MŘ conducted the fieldwork, analysed the data, wrote the substantial portion and compiled the final version of the current paper. VŘ conducted the fieldwork. WLRO encouraged the study and made significant comments on the current version of the paper.

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Czech Abstract: Velemyš dinagatská *Crateromys australis* patří do skupiny velemyší, stromových listožravých nočních hlodavců endemicky žijících ve filipínských lesích. Tento druh, endemit ostrova Dinagat, byl objeven a chycen v roce 1975. Přestože po něm od té doby pátralo několik expedic, byl následně objeven až v roce 2012. Je zapsán jako Kriticky Ohrožený v Červeném seznamu IUCN a byl dokonce považován za vyhynulý. Velemyš dinagatská byla znovuobjevena v lednu 2012 a tak byla prokázána její přítomnost na ostrově Dinagat. Toto znovuobjevení podtrhuje lokální, národní i mezinárodní význam ostrova Dinagat (či skupiny ostrovů Dinagat-Siargao) jako centra druhového endemismu v rámci regionu Greater Mindanao Faunal Region. Bohužel na celém ostrově existuje jen jedno lokálně chráněné území a žádný z posledních zbývajících lesních habitatů na Dinagatu není v současnosti chráněn na celonárodní úrovni. Těžba nerostných surovin a ničení prostředí představují pro tento druh výraznou hrozbu. Věříme, že znovuobjevení velemyší dinagatské může poskytnout důležitý a včasný impuls k nutnosti vytvoření racionálního, vědecky podloženého celoostrovního programu rozvoje na Dinagatu, který bude zahrnovat také ostrovní/regionální strategii ochrany biodiverzity, což by pomohlo zajistit efektivní a dlouhodobou ochranu většiny z několika málo zbývajících přírodních habitatů v této oblasti.