**British Indian Ocean Territory Ecosystem Action Plan (EAP)**
**MOIST SAVANNA**

**Figure 1**. Savanna on Nelson's Island, Chagos Archipelago, with breeding brown booby (*Sula leucogaster*) and brown noddy (*Anous stolidus*).

## SUMMARY

IUCN habitat classification: 2.2 Moist savanna

Description: Moist savanna (hereafter called savanna), as defined in this EAP is more encompassing than the IUCN definition of this habitat. In the context of this assessment it is defined as, "open areas dominated by grasses, sedges and herbaceous herbs and occur where the local hydrology is such that it does not allow the development of a tree or shrub layer resulting in savanna-like open areas" [1]. This native habitat has tracts greater than 0.1 $km^2$ on 16 of the 55 islands of the archipelago. Prior to human arrival savanna may have been more extensive, especially on islands that had native habitats cleared for coconut *Cocos nucifera* L. plantations, though evidence for this is anecdotal. Savanna covers 14.6 $km^2$ of the terrestrial landmass (*c*. 2.9% of the total landmass of the archipelago). It is a critical habitat for terrestrial nesting seabirds and supports ≈ 200,000 breeding pairs annually, > 70% of the total number of pairs of seabirds breeding in the archipelago [2]. The guano of breeding seabirds has been proven to benefit multiple ecosystems both terrestrial

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and marine [3]. It is also important habitat for native invertebrates, particularly Orthoptera and Lepidoptera. There is realistic scope to increase (or regain) the acreage of savanna in the Chagos Archipelago that would have benefits to multiple taxa in other ecosystems.

Threats: Invasive native and alien species constitute the most immediate threat to the ecological integrity of the savanna tracts, with climate variation posing a potentially significant, but unpredictable, long-term threat. Research is required to understand the ecological functionality of savanna ecosystems in the Chagos Archipelago.

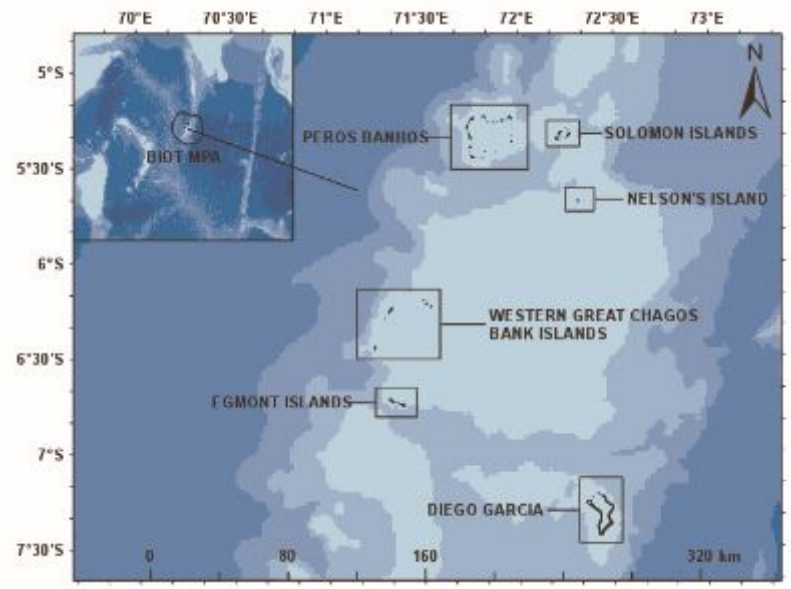


**Figure 2**. The Chagos Archipelago (British Indian Ocean Territory - BIOT) showing its position in the central Indian Ocean and its atolls (MPA = Marine Protected Area).

## DISTRIBUTION

Distribution Total Extent: *c* 14.6 km$^2$

Tracts of savanna are still present in all atolls of the Chagos Archipelago to some degree. Over the past two centuries, much of the archipelago's native habitat was cleared for copra production. This involved clearing native habitat with good soil and planting coconut [4]. In addition, some areas with poor substrate where savanna was probably present were also converted to plantation. This was achieved by digging bowls into the substrate, lining and fertilising these with coconut mulch and then planting nuts. Evidence of this practice is still present on Diego Garcia, Middle Brother and islands in north-eastern Peros Banhos. The four largest tracts of savanna (Table 1) are found on islands that were farmed for coconut but had had areas of poor substrate that were not converted to plantation; this is possibly indicative that savanna was once more extensive. One of the finest remaining examples of savanna is found on North Brother on the western rim of the Great Chagos Bank (Fig. 3).

**Figure 3**. One of the most pristine tracts of savanna in the Chagos Archipelago on North Brother, western Great Chagos Bank. Brown booby appear to be the principle ecosystem engineer of this habitat, the trampling of the herbs by this breeding species combined with poor substrate may be preventing successional growth and colonisation by shrubs.

## ECOLOGY

Ecosystem characteristics – Physical: The ecology of savanna in the Chagos Archipelago has not been studied to date. Of what is known, the ecosystem is characterised by a poor soil layer that drains quickly, thought to be a result of the hydrology of its calcareous substrate [1] combined with high precipitation (average 4,000mm/annum in Peros Banhos [5]), that prevents the growth of woody plants and promotes a halophytic/xerophytic herbaceous layer. Breeding seabirds are presumed to be the principle ecosystem engineers of this habitat. Studies in the Seychelles [6] have demonstrated that breeding sooty tern (*Onychoprion fuscatus*) directly impact the vegetation composition and physical structure of colony areas in habitat similar in all aspects to the savanna of the Chagos Archipelago. Habitat modification by these birds is achieved through trampling, seawater droplets and guano deposits [6]. Despite only covering c. 2.9% of the terrestrial landmass, savanna supports the greatest number of breeding seabirds of any habitat in the Chagos Archipelago, holding ~200,000 breeding pairs annually of which Sooty Tern comprise the bulk of the population [2].

Ecosystem characteristics – Biological: Historically, the ecology of many of the larger islands of the Chagos Archipelago was altered through the conversion of native ecosystems to monoculture coconut plantations (4, 7, 8]. Latterly, the largest island of Diego Garcia has

dramatically changed through habitat clearance associated with the creation of a military establishment [9]. However, due to their inaccessibility and/or remoteness some islands remained free of ecological traumatisation [8] and contain biomes reflective of pre-man conditions. From these relict islands it is known that the principle floral components of savanna are the grasses *Lepturus repens* (G. Forst.) R. Br. and *Stenotaphrum micranthum* (Desv.) C.E. Hubb., the sedge *Fimbristylis cymosa* R. Br. and the vascular plants *Portulaca mauritiensis* Poelln., *P. oleracea* L., *Ipomoea macrantha* Roem. & Schultes, *Achyranthes aspera* var. *velutina* (Hook & Arn.), *Boerhavia repens* L., *Sida pusilla* Cav. and *Triumfetta procumbens* G. Forst. [10]. Seabirds are the dominant vertebrate community with breeding populations of sooty tern (~150,000 pairs/annum), brown booby (~1,000 pairs/annum) and bridled tern (*Onychoprion aneathetus*) (<100 pairs/annum) being almost exclusive to savanna on rat-free islands [2]. Brown noddy breeds in tens of thousands in savanna [11] but, inexplicably, colonies of this magnitude have not been recorded recently [2, 12].

The other prominent community in this ecosystem are invertebrates. Also poorly researched in the Chagos Archipelago, of what is known [13], Orthoptera and Lepidoptera are most likely the prevalent Orders. Terrestrial land crabs of the families Coenobitidae, Gecarcinidae, Grapsidae, Potamoidae and Ocypodidae can reach remarkable densities in the absence of predation and, on islands with scarce mammalian and avian fauna, can be the dominant large animals. Filling several ecological niches, they are often ecosystem engineers and the top predators, especially on wet tropical islands [14]. In the Chagos Archipelago, land crabs are the dominant fauna year-round on most islands with the robber crab (*Birgus latro*) being the top native terrestrial predator [15, 16]. Land crabs are present in savanna in the Chagos Archipelago, primarily as scavengers of breeding seabird colonies, they are not the dominant taxon as far is known. On islands where alien invasive black rats, (*Rattus rattus*) occur [17], these are the top predators in savanna.

## CONSERVATION STATUS

On islands that were historically intensely farmed for coconut, much savanna habitat is likely to have disappeared. Their disappearance coupled with the introduction of invasive vertebrates, notably black rats, cats (*Felis catus*), dogs (*Canis lupus familiaris*) and pigs (*Sus scrofa domestica*) had catastrophic consequences for the breeding seabirds [18] and probably, invertebrate communities, e.g. Orthoptera. On islands that escaped the ravages of conversion to coconut plantations and introduction of invasive rats, where savanna still exists it provides a haven for breeding seabirds [2]. Except for Diego Garcia, all islands of the Chagos Archipelago are within the Category 1 (Strict No-Take) Chagos Marine Protected Area. Inside the MPA, 16 islands containing savanna tracts >0.1 $km^2$ are present (Table 1). Of these, eight are IUCN recognised or proposed Important Bird and Biodiversity Areas (IBAs) [12, 29] and these islands plus two others are Strict Nature Reserves where access is usually only granted to MPA enforcement patrols and visiting scientists. As an additional protection level, access to the entire Chagos Archipelago is severely restricted and visits to the northern atolls (Fig. 2) by yachts is by permit only with access to limited, designated moorings and islands [19].

## CURRENT THREATS

At a local level, the remaining savanna is now impacted and threatened by natural, native plant interactions, alien invasive species and a combination of both. On a global scale, climate variation and associated sea level rising potentially will have dire consequences for savanna ecosystems, but the exact extent and impact is uncertain.

**Natural Native Plant Interactions**:

***Cassytha filiformis* L.**: This native, obligate parasitic vine occurs on 32 of the 55 islands of the Chagos Archipelago [10]. On these islands it regularly parasitises and kills stands of *Scaevola taccada* (Gaertn.) Roxb. On Diego Garcia, where *S. taccada* provides essential shoreline protection in areas with critical military assets, *C. filiformis* is controlled [20]. In the northern atolls it periodically blankets over savanna on islands where large colonies of internationally important breeding seabirds occur. Months after the parasitism event the carpeted savanna dies off (and starts to recover) and the parasite disappears. Whilst this natural process is taking place, the savanna provides sub-optimal habitat for the seabird colonies because the vine cover denies access for birds to lay their eggs on a solid substrate and entangles chicks that eventually die of thermal stress and exhaustion. **Impact – Low**

**Figure 4**. *Cassytha filiformis* L. parasitizing and killing shoreline protecting *Scaevola taccada* (Gaertn.) Roxb. on Isle de Passe, Solomon Islands, Chagos Archipelago. A native plant, *C. filiformis* often smothers savanna which then provides sub-optimal breeding habitat for the internationally important seabird colonies of the archipelago.

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***Cocos nucifera* L.**: Coconut is a naturally occurring tree in the Chagos Archipelago [10] that is essential to the stability of beach-crests. It is present on every island with a substrate capable of supporting a sprouting nut. Historically, throughout the entire archipelago, native habitat was cleared to make way for coconut plantations [4, 7, 9, 18] and it is assessed that, excluding Diego Garcia, 63% of island cover is now coconut dominated [7]. It is probable that with the development of the plantations, much savanna habitat was lost. The natural expansion of both native stands and former plantations through falling nuts has the capacity to encroach and outcompete savanna ecosystems. **Impact –- Low (Historic – High)**

**Alien Invasive Species**

**Vascular Plants - *Leucaena leucocephala* (Lam.) de Wit**: This aggressive invader of disturbed areas is listed as one of the '100 of the World's Worst Invasive Alien Species'. It can form dense monospecific thickets and is difficult to eradicate once established. It renders extensive areas unusable and inaccessible and threatens native plants [21]. *L. leucocephala* arrived in the Chagos Archipelago via Diego Garcia, it has now colonised the Strict Nature Reserve and Important Bird and Biodiversity Area of South Brother [10] on the remote western Great Chagos Bank. If not controlled and its dispersal restricted, *L. leucocephala* will cause local extinction of savanna ecosystems. **Impact – High**

**Vascular Plants - *Stachytarpheta jamaicensis* (L.) Vahl**: This introduced vascular plant is present on 21 islands [10]. Classified as an invasive in Kenya and Tanzania [22] and recognised as providing sub-optimal breeding habitat for sooty tern in the Seychelles [6], in the Chagos Archipelago it detrimentally impacts savanna by outcompeting native plant species and subsequentially providing poor habitat for breeding seabirds. It should be considered an invasive plant in the Chagos Archipelago. **Impact – Medium**

**Vascular Plants - *Casuarina equisetifolia* L.**: Following research conducted by Royal Botanic Gardens, Kew, in 2018 on Diego Garcia, *C. equisetifolia* is now thought to be introduced to the Chagos Archipelago [23]. It has been recorded on 16 islands [10] and as in Florida [24], it should be considered an invasive species especially in the eco-sensitive northern atolls. In the Chagos Archipelago, as elsewhere [24], it alters natural habitat, reduces native biodiversity, inhibits the growth of other species and modifies successional patterns. On islands that have savanna and *C. equisetifolia*, as a rapid coloniser of disturbed areas, it has the capacity to outcompete the native communities to local extinction. **Impact - Medium**

**Vascular Plants - *Hibiscus tiliaceus* L.**: Thought to be non-native, this species is present on 19 islands of the Chagos Archipelago [10]. Not considered invasive, *H. tiliaceus* has colonised the eco-sensitive islands in the northern atolls of Middle Brother and Petite Bios Mangue [10] and Danger and possibly North Brother. It is present as a shoreline species, competing with native species for arboreal breeding seabirds. The architecture of *H. tiliaceus* is such that it is generally avoided by tree nesting seabirds and where it is colonising and displacing native shoreline trees such as on Danger Island, seabirds are shifting breeding locations. *H. tiliaceus* has the capacity to encroach and outcompete savanna ecosystems in the Chagos Archipelago. **Threat - Low**

**Biosecurity - Spread of non-native plant species from Diego Garcia to the northern atolls**: The military facility on the largest island of Diego Garcia is now the principle access point for non-native species to the Chagos Archipelago. It is thought there are ~240 species of non-native plant on this island [10], many arriving since the construction of the military facility in the early 1970's. Amongst these non-native species are a suite that if introduced to the islands of the northern atolls could have a detrimental impact upon savanna ecosystems to the point of local extinctions. Prime candidates are *Mimosa invisa* Martius *ex* Colla*, Hippobroma longiflora* (L.) G.Don, *Rivina humilis L., Epipremnum pinnatum* (L.) Engl. and *Tabebuia heterophylla* (DC) Britton. As an example of their potential negative impacts on native ecosystems, the latter species was introduced as an ornamental in the plantation era to two islands [10], left unmanaged it has now invaded the forested areas of eastern Diego Garcia where it has formed entangled, impenetrable monoculture stands. **Impact – High**

**Vertebrates - Black Rat (*Rattus rattus*)**: Black rats detrimentally impact all tropical oceanic island ecosystems on invasion [25]. Their impact upon savanna has not been studied in the Chagos Archipelago but like other island ecosystems, their predation of seeds, flowers and pollinators will be causing an unnatural ecosystem shift. **Impact – High**

**Global Mean Sea Level Rise (GMSLR)**: Projected GMSLR for 1.5°C of global warming has an indicative range of 0.26 – 0.77m, relative to 1986–2005 [26], though a short series of sea level data from the Chagos indicates a rise currently of 5.5 mm per year [27]. All islands in the Chagos Archipelago are those of typical atolls, with a low elevation of generally < 2m (4, 9). Based upon the above figures, with an even rise in global temperature of 1.5°C, most of the archipelago would be submerged in *c*. 360 years. Many models of global warming predict higher temperature rises in shorter timeframes that would bring forward the date the archipelago would disappear underwater. **Impact – Unknown**

**Climate variation**: Research on the effect of climate variation on oceanic island ecosystems is lacking, though it certainly will impact and alter them to some extent. Research on a global scale is required to address these uncertainties. **Impact – Unknown**.

**General – Lack of information on ecosystem functionality of savanna**: Despite savanna being a critical breeding habitat for internationally important seabird colonies in the Chagos Archipelago, except for inventorying the plant species of this ecosystem, there has been no research into its functionality. The lack of information on for example, its present health, the drivers and engineers, and biotic and abiotic interactions within the ecosystem are a cause for concern, especially when changes to the ecosystem may occur in the future through climate variation. **Impact** - **Unknown**.

**Table 1**. Islands of the Chagos Archipelago that have stands of savanna >0.1km$^2$, their conservation status and current local threats to the ecosystem. GCB = Great Chagos Bank. SPA = Special Protected Area. MPA = Marine Protected Area. SNR = Strict Nature Reserve. IBA = IUCN designated or proposed Important Bird and Biodiversity Area.

| ISLAND | ATOLL | SIZE OF SAVANNA (km$^2$) | CONSERVATION STATUS | THREAT |
|---|---|---|---|---|
| Eagle Island | GCB | 4.9 | MPA | *Cassytha filiformis* present<br>Monoculture coconut plantations<br>*Stachytarpheta jamaicensis* present<br>*Hibiscus tiliaceus* present<br>Suppression of ecosystem by *R. rattus* |
| Pierre | Peros Banhos | 3.8 | MPA | Monoculture coconut plantations<br>Suppression of ecosystem by *R. rattus* |
| Yéyé | Peros Banhos | 1.6 | MPA, SNR | Monoculture coconut plantations<br>*Stachytarpheta jamaicensis* present<br>Suppression of ecosystem by *R. rattus* |
| Poule | Peros Banhos | 1.1 | MPA | Monoculture coconut plantations<br>*Stachytarpheta jamaicensis* present<br>*Casuarina equisetifolia* present<br>*Hibiscus tiliaceus* present<br>Suppression of ecosystem by *R. rattus* |
| South Brother | GCB | 0.6 | MPA, SNR, IBA | *Leucaena leucocephala* presenty<br>*Stachytarpheta jamaicensis* present |
| Petite Coquillage | Peros Banhos | 0.6 | MPA, SNR, proposed IBA | |
| Lubine complex | Egmont Islands | 0.5 | MPA | Monoculture coconut plantations<br>Suppression of ecosystem by *R. rattus* |
| Nelson's Island | GCB | 0.4 | MPA, SNR, IBA | *Cassytha filiformis* present |
| Grand Souer | Peros Banhos | 0.3 | MPA | *Cassytha filiformis* present<br>Monoculture coconut plantations<br>*Stachytarpheta jamaicensis* present<br>*Casuarina equisetifolia* present<br>*Hibiscus tiliaceus* present<br>Suppression of ecosystem by *R. rattus* |
| Parasol | Peros Banhos | 0.3 | MPA, SNR, IBA | *Cassytha filiformis* present |
| Sea Cow | GCB | 0.2 | MPA, SNR, IBA | *Cassytha filiformis* present<br>*Stachytarpheta jamaicensis* present |
| Middle Brother | GCB | 0.2 | MPA, SNR, IBA | *Cassytha filiformis* present<br>*Hibiscus tiliaceus* present |
| Sudest complex | Egmont Islands | 0.2 | MPA | Monoculture coconut plantations<br>Suppression of ecosystem by *R. rattus* |
| Grand Bois Mangue | Peros Banhos | 0.2 | MPA, SNR | *Cassytha filiformis* present<br>*Hibiscus tiliaceus* present |
| Longue | Peros Banhos | 0.2 | MPA, SNR, IBA | *Cassytha filiformis* present |
| North Brother | GCB | 0.1 | MPA, SNR, IBA | *Stachytarpheta jamaicensis* present |

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## RELEVANT POLICIES AND LEGISLATION

**International**: Seven of the 16 islands that contain savanna tracts >0.1 $km^2$ are designated as IUCN Important Bird and Biodiversity Areas (IBAs) [29]. In addition, Petite Coquillage was proposed as an IBA in 2008 [12].

**Local**: The eight designated/proposed IBAs plus Yeye and Grand Bois Mangue are Strict Nature Reserves. The Strict Nature Reserve Regulations 1998 provide the IBAs with legal protection. Under these Regulations, it is an offence for anyone to enter any of the Reserves, or to carry out activities there, without the written permission of the BIOT Administration [19]. With the exception of Diego Garcia atoll and the surrounding seas out to three nautical miles, the entire Chagos Archipelago is Category 1 (Strict No-Take) Marine Protected Area.

## ACTION NEEDED

**Manage invasive species**: The BIOT Administration has identified eleven conservation and environmental priorities to ensure the protection of the unique environment of the Territory. Among these is "Eradicating invasive rats which threaten native seabird populations and impact the delicate balance of BIOT's ecosystem" [19]. Eradicating invasive alien rats would benefit multi ecosystems in the Chagos Archipelago [3] and should be given the highest priority of all intervention actions. Invasive alien and native vascular plants pose a threat to savanna habitat from which *Leucaena leucocephala* is globally accepted as the plant with the highest capacity to swiftly alter ecosystems [21]. A programme of invasive plant management is required to control or eradicate invasive plant species starting on the rat-free islands that are identified as IBAs and have valuable tracts of savanna remaining (Table 1).

**Expand savanna habitats**: One of the objectives within the BIOT Administration's strategic conservation objectives (2018 – 2023) is "To conserve or enhance marine and terrestrial ecosystems and their inherent biodiversity including, where practicable, restoration and rehabilitation of damaged or degraded habitats" [28]. Historically, 75% of the terrestrial ecosystems on islands were altered to monoculture stands of coconut [7]. Although the biodiversity losses to multi ecosystems through this action are unknown it is certain that breeding seabird numbers would have catastrophically declined (with associated losses to other ecosystems), coupled with declines in invertebrate and floral communities. The removal of non-natural coconut plantations for the rehabilitation of savanna ecosystems (and other ecosystems, e.g. native woodlands) is achievable though would require long-term management to achieve ecological stability of the desired floral communities and habitat.

**Biosecurity of Northern atolls**: The major route of non-native and invasive species in to the Chagos Archipelago is via the airport and port on Diego Garcia. The most likely modern route of non-native and invasive species to the northern atolls is from Diego Garcia. Within the eleven conservation and environmental priorities the BIOT Administration has identified is "Protecting BIOT from invasive flora and fauna" [19]. Protecting the northern atolls from

invasive species emanating from the invasive hot spot of Diego Garcia should be given the highest priority within the biosecurity measures being implemented in the Territory.

**Engage in climate monitoring**: "Climate change is a key stressor in BIOT, one which must be carefully monitored with a view to identifying the implications it may have on conservation management. As BIOT has almost none of the usually common, localised impacts such as sewage discharge, overfishing and shoreline alteration, it is a very valuable location where the effects of climate change can be understood separately from those caused by local stressors, thereby providing a point of comparison for the rest of the world" [28]. The BIOT Administration has recognised the value of the Chagos Archipelago as a global research centre for climate change and is encouraging academic institutions, independent researchers and NGOs to engage in climate science within the Territory. One of the objectives of the environmental focus of BIOTA is "Understanding and mitigating against the effects of global climate change where possible" [19]. The call for climate research by BIOTA requires broadcasting to as wide a net as possible and research supported where possible and practical at the earliest opportunity.

**Conduct research**: BIOTA has recognised the requirement to better understand the delicate ecosystems of the terrestrial environment and have as an environmental objective **"**Understanding more about BIOT's unique terrestrial environment" [19]. Research, especially at the ecosystem level is required urgently to assist in countering future threats at the global (e.g. climate change) and local (e.g. invasive species management) scale.

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