

mountain. Research should be undertaken to establish this species is still extant at this site and, if so, conservation would be required to prevent this species becoming Critically Endangered.

There are also five Vulnerable species present within this IPA. Both *Ammannia parvula* and *Cynanchum oresbium* are only known from Nampula Province, both occurring at only a single other locality outside this IPA. A further Vulnerable species, the cycad *Encephalartos gratus* is known in this IPA from Serra Merripa, although it may yet be found to occur on Mount Inago. This species is native to Mozambique and Malawi but is threatened by habitat clearance estimated to be reducing the area of occupancy by 30% per generation (Donaldson 2010).

Another Vulnerable species native to both Mozambique and Malawi, *Gladiolus zambesiacus*, was collected on Mount Inago (Matimele #2533). This species is currently known from less than 11 locations in montane and submontane areas of southern Malawi and northern Mozambique (Darbyshire et al. 2019b). There is only a single other confirmed locality for this species in Mozambique, nearby Mount Namuli [MOZTIPA004]. The Inago-Namuli specimens represent a distinct form, different from the Malawian specimens, with narrower leaves and thickened leaf margins and midribs (Goldblatt 1993). Further research may find the Inago-Namuli form represents a distinct species.

The final Vulnerable species present at this IPA, *Khaya anthotheca*, is widespread, found from Mozambique to tropical West Africa, but is threatened by overharvesting as a valuable hardwood species (Hawthorne 1998). There are nine Mozambican endemic species in total occurring within this IPA. The threatened species *Ammannia parvula* and *Cynanchum oresbium* are the most range limited of these endemics. *Encephalartos turneri* (LC) also has a narrow range, endemic to Nampula and Niassa provinces, but is abundant within this limited area (Bösenberg 2010). Alongside these endemic species is the near-endemic *Euphorbia decliviticola* (LC), known from a range of only 5,744 km², predominantly in Mozambique with one location in Malawi (Osborne et al. 2019).

Justicia asystasioides, collected on Mount Inago in 2017 (Matimele #2537), is a further species of note. Although also native to Tanzania and Malawi, this IPA and Mount Mabu [MOZTIPA012] are the only known locations for this species in Mozambique. There are likely further species of conservation interest within the remaining forest fragments of Inago and Merripa. For example, *Memecylon nubigenum* (EN) and *Pyrostria chapmanii* (EN) occur on both Mount Namuli and Ribáuè, either side of this IPA, and so are likely to occur within Inago-Merripa. Further botanical collecting at this site, particularly on Serra Merripa, is of great urgency as habitat continues to be lost before its conservation value can be fully established.

Habitat and geology

Inago-Merripa IPA encompasses Mount Inago (1,870 m) and Serra Merripa (1,023 m), excluding the spine of inselbergs that run between these two peaks. The mountains are granite-porphyrite intrusions, dating from around 630 – 550 million years ago, in the

surrounding 1,100 – 850 million year old Nampula and Namarroi series migmatites (Bayliss et al. 2010; Macey et al. 2010). Average temperatures for Malema district range from 15 – 22°C in June and July to 21 – 29°C in October. Rainfall can vary year on year but averages at 1,300 mm annually, with much of this falling between December and March (Bayliss et al. 2010; World Weather Online 2021). The mountains, however, also receive moisture from frequent mists (Torre & Correia #16564).

Biodiversity surveys of a range of taxa were conducted in 2009 by Bayliss et al. (2010), as part of this work the plant species that characterise the different ecosystems on Mount Inago were recorded. In contrast, there has been little botanical collecting on Serra Merripa, with many of the specimens dating from A. R. Torre's visits in the 1960s. Much of the below description is based on the Inago survey work by Bayliss et al. (2010). It is highly likely that the species compositions of ecosystems on Serra Merripa are similar to those on Inago due to the short distance between them both, although Serra Merripa peaks at a lower altitude so montane elements will likely be absent or very limited.

Below 1,000m much of this IPA is covered by woodland vegetation, although this is highly fragmented by agriculture (Google Earth 2020). Woodland on the foothills and lower slopes of Mount Inago was described by Bayliss et al. (2010) as having distinct strata, with a 10 – 15 m canopy comprised of *Parinari curatellifolia*, *Brachystegia* sp., *Albizia adianthifolia*, *Burkea africana* and *Syzygium cordatum*. Although the *Brachystegia* species present in these woodlands was not identified by Bayliss et al. (2010), Lötter et al. (2021) state that *B. torrei*, and sometimes *B. spiciformis* and *B. bussei*, are present within this habitat type (categorised by Lötter et al. (2021) as Northern Inselberg Woodland). The mid-canopy is composed of species such as *Protea petiolaris*, *Cussonia arborea*, *Vitex doniana* and *Strychnos* sp., while herbs and grasses, such as *Themeda triandra* and *Hyparrhenia* spp., cover the ground layer. At lower altitudes, this woodland transitions into miombo. It is likely that this miombo has a similar composition of the woodland of the footslopes, although *Brachystegia* is likely more dominant on the surrounding plain. It is clear from satellite imagery that this habitat, like the inselberg woodland, is also highly fragmented by agriculture (Google Earth 2020).

Bayliss et al. (2010) also made collections in the gallery forests on Mount Inago, with canopy trees reaching 15 – 30 m and including species such as *Khaya anthotheca*, *Breonadia salicina*, *Englerophytum magalismontanum* and *Newtonia buchananii*. The mid-canopy, between 8 – 15 m tall, consists of species such as *Sterculia africana*, *Cussonia spicata*, *Trema orientalis* and *Anthocleista grandiflora* with smaller shrubs and tree ferns occurring below. Collection data from Serra Merripa describe riverine soils as red clay (Torre & Paiva #10439), the habitat within these areas is otherwise largely undocumented, although likely bears similarities to those of Mount Inago.

At higher altitudes, between 1000 – 1600 m, there are patches of forest categorised by Bayliss et al. (2010) as "semi-deciduous, wet forest". Canopy trees are relatively large, with DBH over 50 cm and height between 20 – 30 m. Species include *Drypetes natalensis*, *Schefflera umbellifera* and *Newtonia buchananii*. Forest on Serra

Merripa is likely very similar, with this habitat described as dense fog forest including *Newtonia buchananii*, *Ekebergia capensis* and *Khaya anthotheca* (Torre & Correia #16583), although the latter species is likely associated more with riverine forest (Burrows et al. 2018). Smaller trees such as *Myrianthus holstii* occur in forest the understory on Mount Inago, while the herbaceous species in this forest are yet to be documented in any detail. Although mid-altitude forest was thought to have been extensive on these mountains, patches of forest are limited to around 1 – 10 ha in size and are now largely confined to inaccessible areas, below granite domes and in steep ravines (Bayliss et al. 2010). Due to extensive conversion of habitat on Serra Merripa, there appears to be little or even no montane forest remaining on this inselberg, while it was previously extensive on the south facing plateau of this inselberg (Google Earth 2020; Lötter et al. 2021).

In more exposed rocky areas, particularly on rocky slopes and granite domes above 1,500 m, the landscape is open (Google Earth 2020). Succulent *Euphorbia*, including *E. corniculata* and *E. declivicola*, and *Aloe* species, including endemic species *A. menyharthii* subsp. *ensifolia*, occur in these areas. On high altitude plateaux tussocks of the sedge *Coleochloa setifera* are frequent. *Exacum zombense* (LC), a near-endemic, herbaceous species typical of seasonal seepages in the shallow soils of rock faces and outcrops, was recorded from high altitude wooded grassland on Mount Inago (Matimele #2529). Other rock-loving flora, such as *Aeollanthus serpiculoides*, *Cyanotis lanata* and *Linderniella gracilis* (Matimele #2528, #2525, #2526) have also been collected from these high-altitude areas. The Vulnerable species *Ammannia parvula* occurs on granite outcrops of Mount Inago, likely occurring in seasonal pools in the rocky landscape. Cycads are also present on exposed outcrops with *Encephalartos turneri* (LC) occurring on both mountains. *E. gratus* (VU) has also been recorded from the rocky slopes of Serra Merripa, further investigation may find this species is also present on Mount Inago.

Machambas occur throughout Inago-Merripa IPA, forming a patchwork within mid-altitude forest and lowland woodland habitats. On Mount Inago, these plots are mainly used to grow maize; however, other crops such as tomatoes, onions, green peppers, and beans are also grown. In these areas, irrigation systems are used to channel watercourses onto productive land (Bayliss et al. 2010).

Conservation issues

The habitats within this IPA are highly fragmented by agricultural expansion. Mid-altitude to montane forest is now largely restricted to small patches in inaccessible areas such as steep slopes below granite domes and in ravines. On Mount Inago forest patches are generally 1 – 5 ha in size but would have previously covered large areas of the mid-altitude plateaux (Bayliss et al. 2010). The forested areas of Inago became occupied during the Mozambican Civil War, as local people sought refuge in the relative security of this mountainous landscape. Following settlement by refugees, forests began to be cleared to make way for machambas (Bayliss et al. 2010). It is likely that the Serra Merripa also had areas of montane

forest, particularly on the southern plateau below the rockier peaks (Lötter et al. 2021), however, much of this has now been cleared for agriculture (Google Earth 2020).

Clearing of montane habitats for machambas is of particular conservation concern, given the rare and threatened species that reside within these habitats, but also because a loss of forested areas may reduce the provision of ecosystem services, such as water regulation and soil stabilisation. Cultivation on the mountain also involves the irrigation of crops through redirecting water (Bayliss et al. 2010), which may reduce water availability for riverine habitats as well as for communities who live downstream, particularly in the dry season. On the other hand, the riverine forests are thought to direct carry volumes of water during the wet season (Bayliss et al. 2010), degradation of these areas could expose the mountain slopes to erosion and could cause flooding downstream. The use of fire to clear land in preparation for farming is an additional threat as it brings the risk of unintentional burns of larger swathes of land (Bayliss et al. 2010).

Bayliss et al. (2010) recommend that local authorities should encourage people to move agricultural land off the mountain and instead farm fertile areas of the surrounding plain, with support for from NGOs to develop more sustainable agriculture. However, much of the land surrounding the mountains is or has been used for farming already (Google Earth 2020), while the frequent mists and irrigation systems on the mountain likely support a more reliable harvest than those on the plains. People who farm on the mountains may, therefore, be resistant towards the idea of moving. A great deal of support and cooperation would be required to facilitate alternative, sustainable production systems for local people. One project on nearby Mount Namuli could offer some guidance on balancing conservation with sustainable production and community development. NGOs Legado and Nitidæ are collaborating on a project, running between 2018 – 2022, to support communities around Namuli, through securing land rights for local people, improving healthcare provision and supporting greater market access. Alongside this, the project has been supporting communities in developing a long-term natural resource management plan while also working towards establishing the site as a Community Conservation Area (Nitidæ 2021). Some of the strategies employed by this project could also be applied within this IPA to support local environmental restoration and economic development.

Although this IPA does not fall within a protected area, Mount Inago has been recognised as a KBA. Amongst the triggers for this KBA are a species of frog, *Nothophryne inagoensis* (EN), and chameleon, *Rhampholeon bruessoworum* (CR), that are both known only from the forest fragments on Mount Inago and are both severely threatened by the continued encroachment of agriculture into these areas (IUCN SSC Amphibian Specialist Group 2019; Tolley et al. 2019). The presence of these species would also allow the KBA to also qualify as an Alliance of Zero Extinction site. In addition, the butterfly taxon *Cymothoe baylissi* subsp. *monicae* is known only from Mount Inago and Mount Mabu. As a sedentary species, which generally does not move between forest patches, *C. baylissi* subsp. *monicae* is at high risk of becoming locally extirpated on Mount

Inago (Van Velzen et al. 2016). Protection of the remaining forest patches and restoring areas to reconnect these forest fragments is of great importance in preventing the extinction of these species. Avian taxa recorded on Mount Inago include Thyolo Alethe (*Chamaetylas choloensis* - VU), with this IPA being the most easterly locality for this species, and East Coast Akalat (*Sheppardia gunningi* - NT) (BirdLife International 2017, 2018). Both of these species were observed by Bayliss et al. (2010) in forest patches on the mountain, further highlighting the importance of these forests for their conservation value.

The landslide hazard, a measure of risk and impact of landslides on people and assets, was assessed as high to very high in this IPA (World Bank 2019). A geological analysis by Mizuno et al. (2018) found that Mount Inago is constantly displacing a few millimetres each year but is also at risk of a deep-seated landslide following an earthquake or heavy rainfall. Such a landslide is predicted to have the potential to displace up to 200 million m³ of debris, which would be catastrophic in scale. The authors state that the last such event occurred in 887 AD following an earthquake and moved an estimated 350 million m³ of debris. There may be little that can be done to prevent deep-seated landslides here, as the depth of the presumed slip surface is far beyond the roots of vegetation on this mountain, although changes in hydrology through habitat clearance may well have some impact. Further research to confirm the risk of landslide on this mountain is recommended by Mizuno et al. (2018). This risk should be assessed primarily for consideration of the safety of the people who live on and around Inago, for which such a disaster would cause huge loss of life and suffering, but would also be of importance for conservation planning, particularly if habitat protection or restoration could play any role in mitigation of landslide risk or magnitude. Ex situ conservation measures may also need to be considered for the highly threatened or site endemic species should there be a high risk of landslide in the near future.

Site assessor(s)

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IPA criterion A species

SPECIES	QUALIFYING SUB-CRITERION	≥ 1% OF GLOBAL POPULATION	≥ 5% OF NATIONAL POPULATION	1 OF 5 BEST SITES NATIONALLY	ENTIRE GLOBAL POPULATION	SOCIO-ECONOMICALLY IMPORTANT	ABUNDANCE AT SITE
<i>Rytigynia torrei</i> Verdc.	A(i)	✓	✓	✓	—	—	Unknown
<i>Encephalartos gratus</i> Prain	A(i)	✓	✓	—	—	—	Unknown
<i>Cynanchum oresbium</i> (Bruyns) Goyder	A(i)	✓	✓	✓	—	—	Frequent
<i>Ammannia parvula</i> S.A.Graham & Gandhi	A(i)	✓	✓	✓	—	—	Unknown
<i>Khaya anthotheca</i> C.DC.	A(i)	—	—	—	—	✓	Frequent
<i>Gladiolus zambesiacus</i> Baker	A(i)	✓	✓	—	—	—	Unknown

IPA criterion C qualifying habitats

HABITAT	QUALIFYING SUB-CRITERION	≥ 5% OF NATIONAL RESOURCE	≥ 10% OF NATIONAL RESOURCE	1 OF 5 BEST SITES NATIONALLY	AREAL COVERAGE AT SITE
Medium Altitude Moist Forest 900-1400 m	C(iii)	—	—	—	14

General site habitats

GENERAL SITE HABITAT	PERCENT COVERAGE	IMPORTANCE
Forest - Subtropical/Tropical Moist Montane Forest	—	Minor
Rocky Areas - Rocky Areas [e.g. inland cliffs, mountain peaks]	—	Minor
Savanna - Moist Savanna	—	Major
Artificial - Terrestrial - Arable Land	—	Major

Land use types

LAND USE TYPE	PERCENT COVERAGE	IMPORTANCE
Agriculture (arable)	—	Major

Threats

THREAT	SEVERITY	TIMING
Agriculture & aquaculture - Annual & perennial non-timber crops - Small-holder farming	High	Ongoing - trend unknown
Biological resource use - Logging & wood harvesting	Low	Ongoing - trend unknown
Residential & commercial development - Housing & urban areas	Low	Ongoing - trend unknown
Transportation & service corridors - Roads & railroads	Low	Past, not likely to return
Natural system modifications - Dams & water management/use - Abstraction of surface water (agricultural use)	Medium	Ongoing - trend unknown
Geological events - Avalanches/landslides	Unknown	Future - inferred threat

Conservation designation

DESIGNATION NAME	PROTECTED AREA	RELATIONSHIP WITH IPA	AREAL OVERLAP
Mount Inago	Key Biodiversity Area	IPA encompasses protected/conservation area	351

Management type

MANAGEMENT TYPE	DESCRIPTION	YEAR STARTED	YEAR FINISHED
No management plan in place		—	—

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