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Review Article

Achieving sustainable conservation in Madagascar: The case of the newly established Ibity Mountain Protected Area

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Abstract

Globally, the number of protected areas (PAs) has increased exponentially during the last 25 years, particularly in biodiversity-rich developing countries. Many recent initiatives have integrated local-scale socio-economic development into both design and management. Because the rates of deforestation and species extinction are increasing in most parts of the world, substantial efforts have been made to build and strengthen local environmental organizations, to establish new protected areas (NPAs), and to improve natural resource management. An NPA was recently established at Ibity Massif in central Madagascar, where a community-based conservation project is being coordinated by the Missouri Botanical Garden (MBG). In December 2008, a temporary protection order was issued, and definitive establishment of the NPA, which falls under Category V of the IUCN PA system, is expected before the end of 2015. This initiative has involved significant outreach and community education programs to raise awareness of Ibity's conservation and economic importance and the threats to its biodiversity, along with ongoing efforts to reduce fire frequency and implement ecological restoration projects with significant local community participation. In order to ensure the sustainability of this NPA, a co-management plan has been implemented involving MBG, local authorities, and the local population. This study describes the diagnostic process undertaken at Ibity in order to: 1) disseminate the data gathered to inform establishment of the NPA; and 2) summarize the initial state of the environment on the massif prior to the implementation of a management plan, as a baseline for assessing the NPA's effectiveness.

Keywords: Management plan, protected area, fire, conservation.

Résumé

Globalement, le nombre d'aires protégées (AP) a augmenté de façon exponentielle au cours des 25 dernières années, en particulier dans les pays en développement plus riches en biodiversité. De nombreuses initiatives récentes ont intégré le développement socio-économique à l'échelle locale dans sa conception et gestion. Etant donné que les taux de déforestation et d'extinction des espèces sont en augmentation dans la plupart des régions du monde, des efforts considérables ont été faits pour construire et renforcer les organisations locales de l'environnement, pour créer de nouvelles aires protégées, et pour améliorer la gestion des ressources naturelles. Une nouvelle AP est actuellement mise en place dans le massif d'Ibity, dans les haut-plateaux au centre de Madagascar, où un projet de conservation basé dans la participation communautaire est coordonné par le Missouri Botanical Garden (MBG). En Décembre 2008, un arrêté temporaire de protection a été délivré et la mise en place définitive de la nouvelle AP qui est classé dans la catégorie V selon le système des aires protégées de l'UICN est attendue avant la fin de 2015. Cette initiative a impliqué un programme de vulgarisation et d'éducation à la communauté centré sur la sensibilisation de la conservation de la diversité d'Ibity et de l'importance économique, les menaces qui pèsent sur la biodiversité, et les efforts en cours pour réduire la fréquence des feux et la mise en œuvre des projets de restauration écologique avec une importante participation de la communauté locale. Afin d'assurer la durabilité de cet AP, un plan de co-gestion a été mis en place impliquant MBG, les autorités locales et la population locale. Cette étude documente et synthétise le processus de diagnostic entrepris à Ibity afin de: 1) faciliter la diffusion des données recueillies afin d'informer l'établissement de la nouvelle AP; 2) résumer l'état initial de l'environnement sur le massif avant la mise en œuvre d'un plan de gestion et d'établir ainsi une base de référence qui peut être utilisée pour évaluer l'efficacité des nouvelles AP.

Mots-clés : Plan de gestion, Aire protégée, Feu, Conservation.

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Introduction

The establishment of protected areas (PAs) is one of the main tools used to reduce and prevent habitat loss, fragmentation, and the resultant decline and loss of wild populations of plants and animals [1–3]. PAs have two main roles: 1) to encompass a representative sample of the biodiversity of the regions in which they are located; and 2) to buffer biodiversity from threats to its persistence [4]. Threats to habitat integrity can be direct, such as the conversion of natural and semi-natural ecosystems to farmlands or other land uses, or they can be indirect, such as pollution or the introduction of invasive non-native species [5].

Margules and Pressey [4] proposed a six-stage process for the development of conservation projects: 1) compile data on the biodiversity of the region where the conservation project is planned; 2) identify conservation goals for the region; 3) review existing conservation areas; 4) select additional conservation areas, taking available opportunities into account; 5) implement conservation actions; and 6) maintain the required values of conservation areas. These authors emphasized that when establishing PAs, it is crucial to conduct a proper diagnosis to provide baseline data against which conservation objectives can be set and upon which evaluation can be based. The success of a conservation project is by no means guaranteed by the creation of the protected area. To be effective and sustainable, PAs also require adaptive management that draws from ongoing evaluation based on good monitoring protocols and reliable baseline data. To optimize the long-term success of a conservation project, establishing and managing a new protected area (NPA) must be carried out in collaboration with the local human population, taking their needs into account within the framework of sustainable socioeconomic development [6]. The diagnostic stage must therefore factor in both biodiversity and people's current and projected future environmental needs and impacts, which are often inadequately documented or understood [7].

The natural vegetation of Madagascar's highlands is highly fragmented [8, 9], with a history of human occupation dating back more than 2,000 years [10]. The highlands lie in the center of the island and cover about 70% of its total area. The natural grasslands, woody grasslands, sclerophyllous woodlands and evergreen forests that once dominated the area have largely been replaced by vast expanses of anthropogenic vegetation (secondary grassland and open woody formations of various ages), as well as agricultural areas such as rice paddies and to a lesser extent farmland, through the extensive use of human-set bush fires as an agro-pastoral tool [11]. Because of the apparent homogeneity of the vegetation that occurs in parts of the highlands today and the extensive area now used for agriculture, the network of PAs has always been limited in this part of the island. There are, however, some

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highland grasslands and grassland/shrubland/woodland mosaics that constitute centers of high floristic diversity and endemism [12], and the conservation of these areas is most important to ensure that representative stands of remaining native highland vegetation are able to persist.

One such area is the Ibity Massif, a quartzitic massif located 25km southwest of Antsirabe, which was formally granted temporary protection in December 2008, the initial step in the process of formally being recognized as an NPA. The final document that formally created the Ibity NPA, which included a Governance Action Plan and an Environmental and Social Management Plan, was validated on February 6, 2014 by the Committee that oversees Madagascar's new Protected Areas System (Système d'Aires Protégées de Madagascar - SAPM) under the co-supervision of the General Directorate of Forests and the Directorate of Madagascar's Protected Area System. The final decree giving the NPA permanent protection should be officially approved by mid-2015. Ibity's geomorphology, soil characteristics, elevation, climate, and current fire regime support unique plant communities that are home to many species, both herbaceous and woody, endemic to Madagascar and in some cases to the Ibity region or the massif itself [13]

The initiative to establish an NPA on Ibity began in 2003 and was promoted by the Missouri Botanical Garden (MBG) in partnership with Conservation International (CI) [14]. MBG used the large amount of information on Madagascar's flora gathered over the last 30 years to identify priority areas for plant conservation [15–17]. A total of 11 priority areas (covering ca. 60,000 ha) were selected and proposed for NPAs, including Ibity [15]. Establishing NPAs is often hampered by inadequate baseline data and the fragmentary or inaccessible nature of key information [3, 18, 19]. Moreover, those projects that do collect sufficient data often target values or parameters that are of little or no use for establishing meaningful conservation priorities and ensuring effective protection and monitoring [20, 21]. The present paper documents the diagnostic process undertaken at Ibity in order to: 1) facilitate dissemination of the data gathered to inform establishment of the NPA; 2) summarize the initial state of the environment on the massif prior to the implementation of a management plan as a baseline for assessing the NPA's effectiveness.

Protected areas in Madagascar

The IUCN defines protected areas as "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" [22]. In 1980, the "World Conservation Strategy" emphasized the need to protect the functioning of ecological processes and to maintain protected areas by addressing development needs [23]. Conservation efforts often take into account these considerations along with general principles of ecology and both social and ethical factors [5]. The conservation of natural ecosystems in present-day Madagascar can only be achieved by reaching a sustainable balance with local human needs. Conservation efforts must therefore be based on strategies for managing an entire landscape, including areas dedicated to production and others to protection [4]. The Madagascar Code of Protected Areas (Code des Aires Protégées de Madagascar, COAP) [24] is closely aligned with this inclusive model, intended to protect biodiversity and ecological habitats, facilitate research, promote ecotourism, and contribute to the sustainable development of the populations living in proximity to PAs, while also contributing to regional and national economic development [25]. In practice, however, this inclusive model is very difficult to implement because of the complexities of each local situation, and therefore some targets are often not fully achieved.

Starting in 2003, Madagascar's environment ministry began implementing the –SAPM process, designed to increase the area managed for conservation from 1.8 million ha to a total of 6 million ha [26]. This has been accomplished in large part by establishing partnerships with national and international non-governmental organizations (NGOs) such as Conservation International, the Wildlife Conservation Society, the Worldwide Fund for Nature, the Missouri Botanical Garden, and others,

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which have taken on the responsibility of establishing and managing NPAs in collaboration with local communities. In 2001, a total of 78 sites were identified as priority areas for conservation [17, 27, 28]. The total coverage of Madagascar's protected areas has increased over the last decade by more than 4.3 million ha [29], 40.7% of which are in proposed PAs that are still in the process of obtaining government approval, while the remainder (59.3%, or nearly 2.6 million ha) have formally been granted temporary or permanent protection [28].

Diagnostic of the Ibity New Protected Area

During the diagnostic stage, three principal parameters must be identified [5]: a) the target environmental system, including its components, structure, history, present dynamics and trends; b) the current impacts on the system and the demands that will be placed on it by humans; and c) the capacity and resilience of the system to satisfy these demands and the management required to deliver them in a sustainable manner.

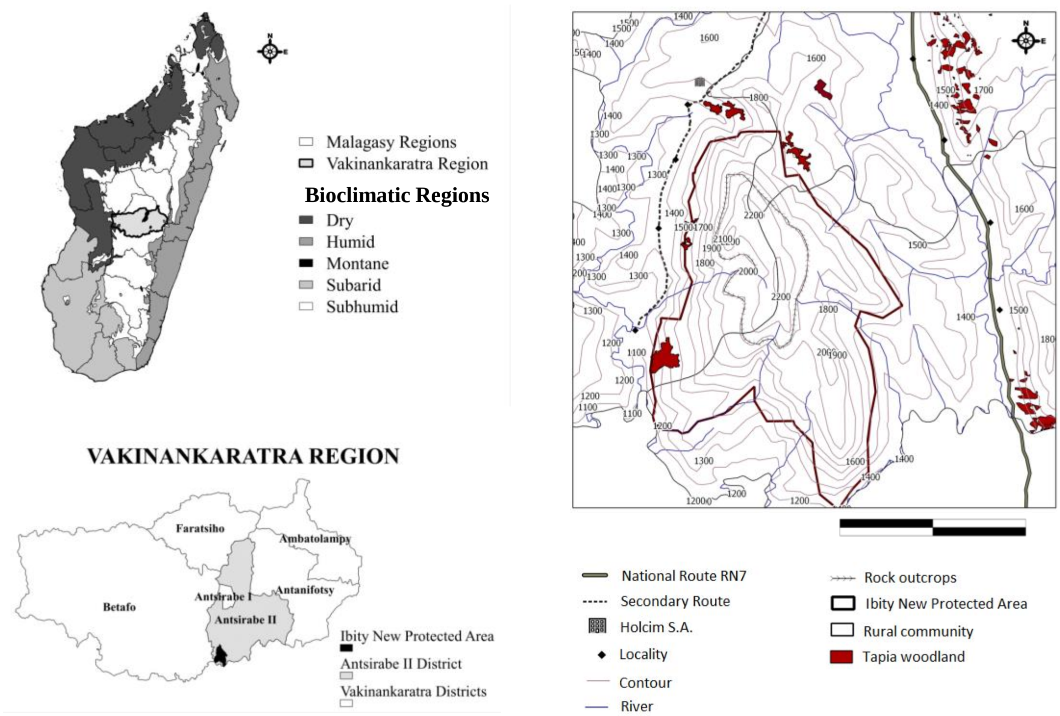

Fig. 1. Location of the Ibity NPA and its surroundings (Vakinankaratra Region, Antsirabe II District, Rural Communes of Manandona, Sahanisvotry and Ibity).

Physical setting of the Ibity New Protected Area

The Ibity NPA is located in Madagascar's central highlands, 200 km southwest of the capital, Antananarivo, and 25 km south of the city of Antsirabe (47°01'E 20°07'S; Fig. 1). The land belongs to the Malagasy state and thus comprises "*Terrain Domanial*" (Land owned by the state, as opposed to private land owned by individuals or companies). There are no private holdings within the NAP itself, although there are a few areas used for agriculture where ownership based on traditional occupation is formally recognized. Ibity's elevation ranges between 1,400 to 2,254m, which makes it the highest quartzitic massif in Madagascar. The climate is characteristic of tropical highlands, classified as Cwb (C: warm weather; w: dry winters; b: warm summers) using the Köppen classification system [30], with

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cool and dry winters (June to October) and rainy summers (November to May). Average annual rainfall is 1,583mm (based on data from 1961 to 1990; Meteorology Service of Ampandrianomby).

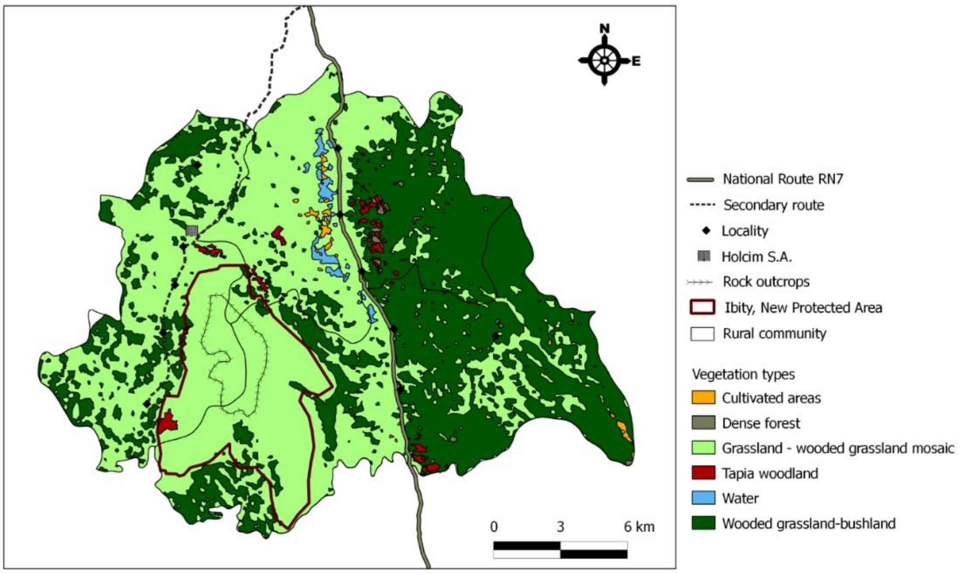

Fig. 2. Vegetation map of the Ibity Massif. Adapted from Moat & Smith (2007). The wooded grassland-bushland vegetation type, not mentioned in Appendix 1, comprises areas planted with exotic species.

Biological characteristics of Ibity

During the diagnostic stage, the flora and fauna of Ibity mountain were inventoried and mapped, human uses were described, and the effects of human pressures were assessed in order to inform the process of delimiting the NPA and setting precise conservation objectives [13, 31, 32]. Five vegetation types were identified on Ibity using the classification system of White [33]: dense forest, open forest, woody grasslands, grasslands and freshwater aquatic and marsh vegetation (Appendix 1). A preliminary vegetation map of the Ibity area was prepared based on photo-interpretation of LANDSAT TM 1999/158-074 satellite images and was then used to make an initial assessment of the distribution of the plant formations represented on the massif. Plant formations were then confirmed on the ground, during which physiognomy and floristic composition of each type were described. The results were compiled and presented in maps using IDRISI 3.2, ARCVIEW 3.2 and MAPINFO software [13]. This initial draft vegetation map was updated with information fromthe Atlas of the Vegetation of Madagascar (Fig. 2) [34].

The vegetation mosaic found today on Ibity is dominated by grasslands interspersed with fragments of tapia woodland, which is composed of *Uapaca bojeri* Baill. (locally known as '*tapia*', Phyllanthaceae) in association with other woody species belonging to Sarcolaenaceae, Madagascar's largest endemic plant family [35]. Comparison of results from the inventory work with information in the Madagascar Catalogue [36] shows that a total of 423 species in 89 families and 251 genera were recorded from the massif (Appendix 3), of which 46 species were defined as conservation targets (species with a restricted distribution or endemic to the Malagasy highlands, quartzitic massifs, or Ibity itself) [37].

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Ibity mountain was selected by MBG as one of 11 priority areas for conservation because of its notable floristic diversity and endemism, coupled with the apparently high level of threat. Seven species belong to families endemic to Madagascar (six Sarcolaenaceae and one Asteropeiaceae), and a total 25 species are known only from the Ibity massif itself. Several plant families are particularly species-rich, such as Asteraceae (especially the genera *Helichrysum* and *Senecio*), Lamiaceae, and Fabaceae. Ibity also has a particularly high level of diversity of *Aloe* (Xanthorrhoeaceae), with 12 species (four endemic to the massif) [37]. Moreover, the vegetation on Ibity mountain is of particular interest as habitat for wild silk worms (*Borocera madagascariensis*), whose cocoons are collected by local residents to produce cloth [38, 39]. This insect is restricted to a few regions in the highlands of Madagascar where tapia trees are present. Other insects also play important ecological roles, including as pollinators, and many vertebrate species were also identified that would benefit from protection, including three species of bats, 42 bird species, 20 species of reptiles and 10 of amphibians (see Birkinshaw et al. [13] for details).

Because grasslands are dominant on the massif, occupying 98.5% of the land area, a focused study was carried out on five sites to describe their species richness and composition. While this formation is mainly dominated on Ibity by *Loudetia simplex* (Nees) C.E. Hubb. subsp. *stipoides* Bosser (Common russet grass, Poaceae), four distinct types of grassland can be distinguished (Appendix 2) according to their dominant grass species. At each site, a species inventory was conducted using the minimum area protocol of Bouxin and Gautier [40], which uses the smallest quadrat size after which no additional species are found. Species were recorded within an area of 1m², then 2m², then 4m², 8m², 16m², etc., until no new species were encountered. Using a species-area curve, the minimum area was reached at either eight or 16m², depending on the site [13]. The upper stratum of the sampled plots had a species composition specific to each of the four grassland types, dominated by either a single species or an association of several species. Three of the types (*Loudetia madagascariensis* grassland (locally known as *'danga'*), *Aristida similis* grassland (known as *'Horombavy', 'Kifafavavy' or 'Ahitsorohitra'*) and *Urelytrum humbertianum* grassland) have the same dominant species in their lower stratum (*Fimbristylis* sp., Cyperaceae). Woody species are present only in *Loudetia simplex* and *Loudetia madagascariensis* grasslands.

Spatio-temporal evaluation of vegetation dynamics

The spatio-temporal evaluation of vegetation dynamics was studied on Kiboy, a smaller massif situated just to the north of Ibity, in order to assess changes between 1991 and 2000, the decade preceding the establishment of the NPA. This was done through the comparison of aerial photographs (E=1/50.000, mission91 ING/FTM 99/500, pictures 0856 and 0857; and E=1/10.000, mission N50-FTM-252/100/2000, pictures 08 and 09) and satellite images.

Stereoscopic analyses of aerial photos enabled interpretation of the images using the distinguishing criteria established in the field. These analyses showed that between 1991 and 2000, a small decrease was observed in cover of sclerophyllous forest and gallery forest, and a sharp decrease was recorded for grasslands (Table 1). By contrast, an increase in cover was observed for the woody savanna, eucalyptus savanna, and pseudo-steppe (Table 1). During this 10-year period, the cover of woody savanna and eucalyptus savanna increased to the detriment of the grasslands (Table 1), reflecting an increase in the area reforested by HOLCIM S.A., which operates a nearby cement factory, in cooperation with villagers living in the region. Tapia woodland presented signs of disturbance, and the understory of wooded grassland was poor in woody species. On the other hand, other pyrophytic woody species, such as *Pentachlaena latifolia* H. Perrier (locally known as *'Vandrikarana'*, Sarcolaenaceae) and *Philgamia glabrifolia* Arènes (Malpighiaceae), began to colonize grasslands and to spread.

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Current trends and human impacts on Ibity vegetation

Before establishment of the Ibity NPA was initiated, fire was believed to be the main cause of degradation and threat to plant diversity in natural and semi-natural ecosystems on the massif, as revealed by interviews with local community members [13]. Fires that impact the massif are mainly accidental in nature, escaping the control of local people who intentionally burn to renew grass for cattle or to clear fields. Together with human exploitation of Ibity's ecosystems, fire is responsible for the decrease in the area of gallery forest observed in the study of vegetation dynamics, and these factors have also led to changes in the structure of tapia woodlands [35] affecting plant phenology [41] and seed germination [42].

Table 1. Evolution of cover for each major vegetation type on Ibity Massif between 1991 and 2000.

Vegetation type	1991		2000	
	Area in hectares	% of total	Area in hectares	% of total
Sclerophyllous forest	35	24.9	34	24.2
Gallery forest	1.4	1	1.3	0.9
Loudetia simplex herbaceous grassland and woody grassland	91	64.8	83	59.1
Pseudo-steppe	6.5	4.6	10	7.1
Eucalyptus tree savanna	6.5	4.6	8.1	5.8
Eucalyptus shrub savanna	0	0	4	2.8

In October 2003, Kiboy was struck by a fire at the end of the dry season, triggering a burn that was very aggressive because of the high accumulated fuel load and low fuel moisture at that time of year [43, 44]. This event provided an opportunity to carry out a pair of one-year ecological studies, one on plant community structure and composition [31] and another on plant phenology [32], in order to begin assessing the effects of fire on Ibity's vegetation.

Impacts of fire on Ibity's herbaceous grassland plant community

The ecological effects of fire on grassland vegetation were studied with respect both to structure and to species composition, richness, and biomass. Three sites with *Loudetia simplex* grassland on quartzitic soil were chosen at altitudes between 1,665m and 1,755m in the burned zone, and three additional sites were examined in the unburned zone (control). At each site, five 100m transects were established, along which 100 points that were read with a pin at 20cm intervals (for a total of 500 points per site using the pin-transect methodology). At each point, the species touching the pin were noted, along with the number of contacts and the height at which each species touched the pin. In order to compare primary production (kg/ha/year) in the burned and unburned areas, plant biomass was sampled every month for one year following the 2003 fire by cutting the vegetation at 5cm above the ground in two 1m² quadrats at each study site (12 samples total); fresh and dry biomass were then weighed.

Impacts of fire on plant phenology

To assess the effect of fire on plant phenology, we selected ten taxa endemic to Madagascar and monitored individuals every two months for one year starting in December 2003, two months after the fire: *Abrahamia ibityensis (H. Perrier) Randrian. & Lowry, ined. (Anacardiaceae)*, *Aloe capitata var.* quartzicola *H. Perrier* (locally known as *'Vahona'*, Xanthorrhoeaceae), *Dialypetalum compactum Zahlbr.* (Campanulaceae), *Distephanus polygalifolius (Less.) H. Rob. & B. Kahn* (Asteraceae)*, Dioscorea hexagona Baker* (locally known as '*Oviala',* Dioscoreaceae)*, Pachypodium brevicaule Baker* (locally

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known as 'Tsimondrimondry' or 'Kimondrimondry', Apocynaceae*), Pentachlaena latifolia, Philgamia glabrifolia, Uapaca bojeri, and Xerochlamys bojeriana (Baill.) F. Gérard* (locally known as *'Fotona'*, Sarcolaenaceae). These ten taxa were chosen among the 46 species that were defined as conservation targets in order to include species from different types of habitat. These taxa were monitored in four vegetation types, depending on the areas in which they were found: sclerophyllous forest, rocky outcrop vegetation, herbaceous grassland, and woody grassland. Monitoring was carried out in twenty 20m×50m permanent plots, ten each in the burned and unburned areas (one plot/taxon/area). In each plot, 50 individuals of the taxon being sampled were randomly chosen and marked. The phenological stage [vegetative (Vg), in floral bud (Fb), in flower (Fl) and in fruit (Fr)] and the number of seedlings were noted. *Rasoafaranaivo* [32] showed a global reduction in flowering and fruiting after fire, while some species did not produce flowers and fruits at all in the year following the fire. This result was confirmed by Alvarado et al. [41] in a recent study carried out on Ibity Mountain itself on the thirteen most common woody species belonging to seven families, representing 33% of woody species richness in Ibity's tapia woodlands. They found that fire reduced the percentage of individuals flowering and fruiting, and that flower and fruit production were lower at the more frequently burned sites. They also showed that increased fire frequency reduced the reproductive synchronization of species throughout the landscape. These findings led the authors to suggest that fire also impacts the timing of plant reproduction at community and landscape levels.

Human demands on resources and environmental capacity to satisfy them

To assess demands placed on the resources of the Ibity massif from human use and to evaluate potential anthropogenic pressures, we studied the socio-economic context and natural resource use. Open question interviews were carried out with members of the local communities (local councilors, representatives of various stakeholder groups, and individual stakeholders themselves), focusing on several key issues: grazing (place, mode, etc.), agriculture, and fire (period, use, place). Land-use around Ibity was mapped from LANDSAT TM 1999/158-074 satellite images and verified on the ground [13].

Although the Ibity massif is not permanently habited, the surrounding area is populated. Three rural districts (Sahanivotry, Mananadona and Ibity) have a total estimated population of about 34,000 people living in 16 villages whose jurisdiction covers an area of ca. 10,000 ha within 5km of the massif, yielding a population density of 3.1 persons/ha [13]. Old tombs found on the massif indicate human presence dating back many centuries. Today, most members of the local population belong to the Vakinankaratra ethnic group, with minorities of Merina and Betsileo people.

The main economic activity of the local population is agriculture, primarily the cultivation of rice, but also of cassava, corn, and sweet potato, along with raising livestock (zebu cattle, pigs, and poultry). Other secondary activities practiced around the massif include fishing, extraction of precious stones, raising silkworms (*Borocera madagascariensis*) to make wild silk cloth, and in the private sector, the industrial exploitation of calcareous rock (marble) by the HOLCIM S.A. cement factory. The fruits of tapia (*Uapaca bojeri*) are collected mainly for local consumption or for sale in local markets. Tapia, the main tree present on the Ibity massif, is also cut and used for construction or as fuel wood. The local population uses some plants for traditional medicine and for cultural purposes. Traditional practitioners from areas farther away from the massif (Ambositra, Fandriana, Faratsiho, etc.) also collect plants on Ibity to treat various diseases. *Pachypodium brevicaule,* endemic to the Ibity and Itremo massifs, is illegally harvested by storekeepers from Antsirabe, and the local population is paid to collect it in great quantities (Obs. Pers). This species, which is listed in CITES Annexe II [45], is sold and exported illegally from Madagascar [37]. Mammals, such as *Tenrec ecaudatus* (Tailess Tenrec), *Setifer setosus* (Greater Hedgehog Tenrec), *Hemicentetes nigriceps* (Highland Streaked Tenrec) and *Pteropus rufus* (Madagascan Flying Fox), as well as birds, such as *Buteo brachypterus* (Madagascar

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Buzzard), *Numida meleagris* (Helmeted Guineafowl) and *Margaroperdix madagascariensis* (Madagascar Partridge), are occasionally hunted and consumed by the villagers.

While the Ibity massif is rich in semiprecious stones (mainly quartz and beryl), there are few mines and only one operates legally with an official permit. In 2011, gold was found at Ambohipo in the southeastern sector of Ibity. Exploitation began in January, and c. 500 people quickly migrated to the area from rural districts close to the massif. Three months later a peak in activity was reached, with an estimated 4,000 persons present, many coming from far away. Gold exploitation has since decreased and the number of persons involved in mining at Ambohipo is now down to about 200. The Missouri Botanical Garden, working with the local representatives of the forest and mining departments and in collaboration with local communities, implemented a control system to forbid exploitation within the limits of the NPA. Today only the lower slopes outside the NPA are affected by mining.

At present, activities related to tourism are not significant in the region; the Ibity massif remains largely unknown despite its spectacular landscape, waterfalls, natural swimming pools, old tombs, semiprecious stones, caves, bats, and charming and unusual vegetation, with many succulents and orchids. However, given its proximity to the important tourist center of Antsirabe and its easy access from Antananarivo, Ibity has significant potential as a tourist destination, which could help improve the region’s economy.

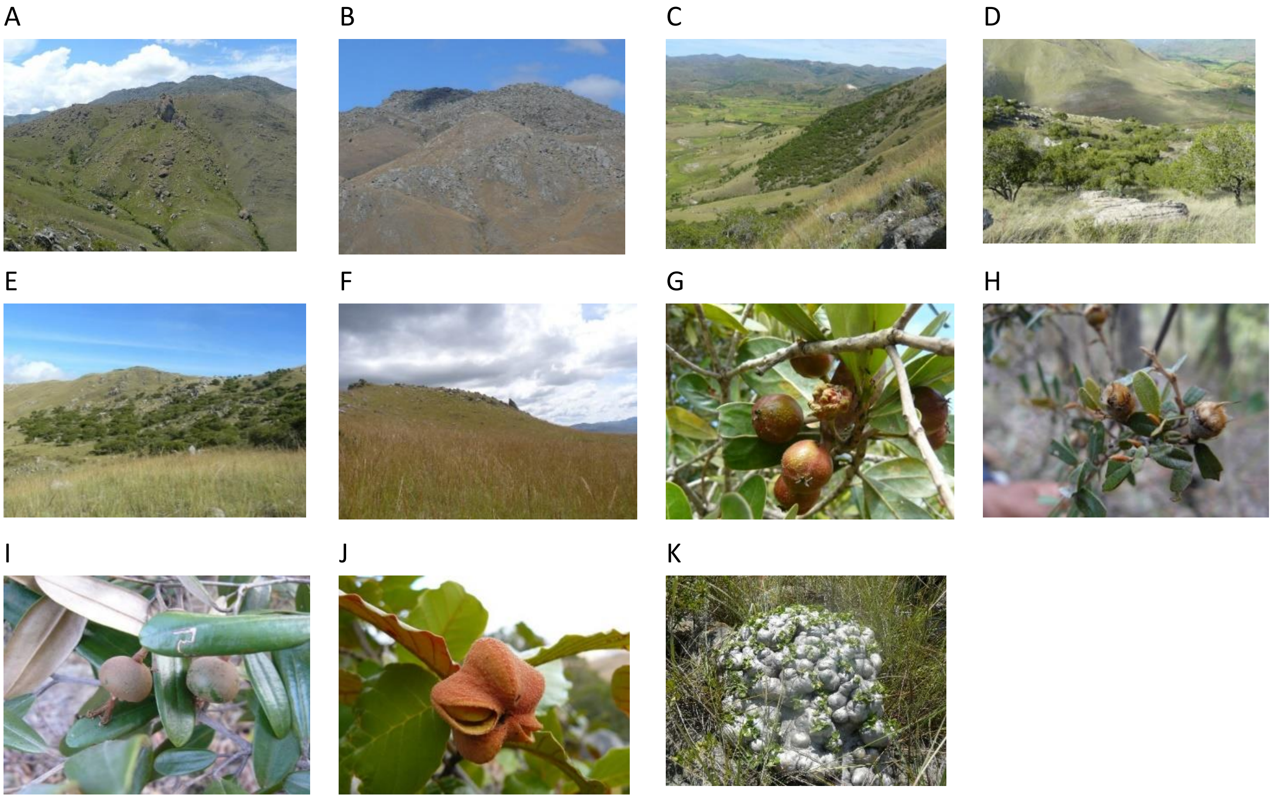

Fig. 3 (A) General landscape of Ibity new protected area, (B) rocky outcrops, (C, D, E) mosaic tapia woodland-savana, and (F) *Loudetia simplex* savanna. Endemic plants of Madagascar present in Ibity Mountain (G) Leaves and fruits of *Uapaca bojeri* (Phyllantaceae), (H) Leaves and fruits of X*erochlamys bojeriana* (Sarcolaenaceae), (I) *Sarcolaena oblongifolia* (Sarcolaenaceae), (J) *Pentachlaena latifolia* (Sarcolaenaceae) and (K) *Pachypodium brevicaule* (Apocynacae) (photos credit: Swanni T. Alvarado).

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Delimitation of the New Protected Area and the implementation of its management plan

The diagnostic

The diagnostic studies carried out by the Missouri Botanical Garden on Ibity Massif [13] (Fig. 3 A, B], the results of which were summarized above, yielded a robust understanding of ecosystem dynamics and responses to disturbances. This type of information is essential for the sound implementation of biodiversity protection and management programs in protected areas and peripheral zones [5]. Interviews with members of the local population in the Ibity area showed that grasslands play a crucial role in supporting rural livelihoods, soil protection, and the maintenance of the region's livestock system [13]. Herbaceous species are used for roofing on local dwellings, as forage for zebu cattle, and for medicinal purposes. Tapia woodland (Fig. 3C, D, E) and dense forest, the other main natural formations occurring on the massif, are threatened by other types of anthropological activities. Repeated bush fires on Ibity during the dry season (from May to October) were shown to have a negative impact on soils [46] and on the structure and composition of vegetation [35], as has been observed elsewhere [47–50].

While fire can temporarily increase productivity and species richness in some grassland systems [51], an increase in frequency above natural levels negatively affects species abundance and richness: fire-sensitive species decrease in abundance until they disappear, while those adapted to fire increase [47, 49, 50] (eg. Loudetia simplex savanna see Fig 3F). When burned, tapia woodlands have a reduced cover of shrubs and young trees in the undergrowth, an increased herbaceous stratum, and a fragmented canopy [35]. *Uapaca bojeri* is fire tolerant [39, 52] (Fig. 3G) and high fire frequency is thus favorable for this species, which becomes dominant as adults. However, its seedlings, which are less fire-tolerant, become rare. Ibity's trees and shrubs are exploited by local people for timber, to make handles for tools, and as a source of wood for charcoal production (few large trees now remain on the massif). This reduces not only the fertility and resistance of trees and shrubs but also fragments the canopy, allowing herbs to grow and increase in abundance, which in turn further favors fires.

Fire is a traditional management tool, widely used in many parts of the tropics. It continues to play a significant role in various agricultural and social practices [53], including at Ibity [39], where fire is used for pasture improvement and renewal. Most other native woody vegetation types that occurred in the central highlands have been replaced by grasslands formed during the last 1,500–2,000 years, primarily due to a human-caused increase in fire frequency well above that of the natural regime [14]. However, regular, frequent burning accelerates the processes of soil erosion and favors the establishment of fast growing herbaceous species such as *Aristida similis* Steud. and *Imperata cylindrica* (L.) P. Beauv. (cotton wool grass, spear grass and locally know as '*Tenina*') [54, 55]. Fire also reduces the regeneration of certain woody species such as *Uapaca bojeri* by killing both young seedlings and the cocoons of the wild silk worm, *Borocera madagascariensis* [12, 39]. Grazing is practiced on the massif's mid- and low-elevation slopes, mainly on the districts of Manandona and Sahanivotry [37]. The upper areas, characterized by steep slopes that exceed 60° in the rocky, quartzitic outcrops, are less used for cattle. Ibity appears to be following the same transformation process that likely occurred earlier throughout much of the Malagasy highlands, where humans likewise used fire as a management tool for raising livestock and crops, reducing forest cover in favor of herbaceous, sometimes exotic species [56–58].

As the human population increases around Ibity, farmers expand their cultivation farther up the massif in the limited areas with soils that permit reasonable harvests, causing the replacement of grasslands with agricultural fields; this extension of cultivation towards steeper slopes increases soil erosion [54]. The selective cutting of woody species in tapia woodland, mainly autochthonous species such as *Xerochlamys* spp. (Fig. 3H) and *Sarcolaena oblongifolia* (locally know as *'Voandrozana';* Fig. 3I), often used as fuel wood, can favor in certain cases the dominance of *Uapaca bojeri* [52]. The harvest of succulent plants such as *Aloe* spp. and *Pachypodium brevicaule* (Fig. 3K) for the clandestine international market are direct threats for these species. Another factor that compounds disturbance

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is the introduction of exotic species such as *Pinus kesiya* (Baguio pine)*, P. patula* (Patula pine), *Acacia dealbata* (silver wattle) and *Eucalyptus robusta* (swamp mahogany), all of which affect certain remnant formations, as they are heliophilous, fast growing, colonise outside planted areas, and are also very useful for the local population [52]. In the northern part of Ibity, the mid- and lower slopes were reforested with eucalyptus, and because germination of this fire tolerant exotic species is stimulated by fire, regeneration is now being seen on the massif and the range of eucalyptus is expanding.

Conservation objectives

The second stage in the process of establishing the Ibity NPA, following a thorough diagnostic, was to identify conservation objectives. The diagnostic studies determined that 46 species represented conservation targets, along with three vegetation types: dense forests, tapia woodlands, and grasslands on rocky outcrops. According to Margules and Pressey [4], despite a certain subjectivity in the determination of targets, the value of the conservation objectives for a newly established NPA must be explicit. For example, information about the ecological and biological importance of a given species (e.g., whether it is rare, endemic and/or threatened) must be taken into account so that key targets are not excluded or under-represented within the protected site. Acquiring reliable knowledge about both vegetation and biodiversity is therefore crucial in the process of establishing an NPA [59, 60]. Vegetation traits should be used as criteria to determine which sites will be targeted for conservation. Some traits are precise and can be relatively easily quantified and measured (size, diversity), while others are less so (such as wilderness); some are strictly ecological (diversity, rarity) while others reflect development threats or vulnerability (fragility) [61]. The general objectives for the conservation strategy at Ibity were: 1) to restore the gallery forests on the massif; 2) to restore tapia woodlands, including improving regeneration; 3) to reduce the risk of extinction of species that are threatened or have a restricted distribution, and 4) to manage exotic invasive species inside the NPA [13].

Implementation of conservation actions

In practice, delimiting an NPA is complex because of the interactions between ‘natural’ ecosystems and humans, who create productive landscapes (‘managed ecosystems’) associated with agricultural systems in which disturbance, transformation into extensive exploitation systems, and fragmentation occur and often expand [4, 62, 63]. The conservation benefit of a protected area, as perceived in an international and scientific context, is often not fully understood by the local population living in and around a site targeted for conservation [64]. To address the issue of whether and how rural populations should be allowed to utilize the resources within a protected area, two models of sustainable biodiversity management are used in economically developing countries: an exclusive model, and an inclusive model [65, 66]. In the first of these, management tries to deflect the interests of the population away from a future protected area, using anti-participative ways to minimize or exclude human presence within the conservation area. The second model focuses not just on biodiversity but also on the welfare of the humans who live near the protected area and use its resources, and does so by explicitly including them in the planned management. In Africa, the exclusive model has prevailed to date at least in part due to the colonial histories of most countries as well as postcolonial influences [64, 65], and this has also been the case in Madagascaruntil recently. An approach based on the inclusive model has been used at Ibity.

An assessment of the extent of tapia woodland in other protected areas in Madagascar confirmed that it was far from adequate to ensure the long-term conservation of this vegetation type. Indeed, tapia woodland covered only 2,600 km² [67] in four main areas of Madagascar’s central highlands, of which just one, located within Isalo National Park, is included in the country’s system of protected areas. The establishment of two complementary protected areas on the Ibity and Itremo massifs was thus proposed [29]. Ibity has benefited from temporary protection since 2008, and Itremo since 2010. The conservation area on Ibity covers 6,136 ha, comprising three zones: a Strict Protection Zone (SPZ, 1,598

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ha), a Buffer Zone or Sustainable Use Zone (SUZ, 4,594 ha), and a Controlled Activity Zone (CAZ, 14 ha) (Table 2).

Table 2. Summary of authorized and forbidden activities in Ibity NPA.

Activities	Strict Conservation Zone (SCZP)	Sustainable Use Zone (ZSU)	Controlled Activity Zone (ZCA)
Research	✓	✓	✓
Grazing		✓	✓
Harvest of herbal medicine		✓	✓
Harvest of tapia fruits		✓	✓
Harvest of native seeds		✓	✓
Harvest of cocoons of wild silk worms (Borocera madagascarensis locally known as Landy Be,)		✓	✓
Harvest of fuel wood (kitay)		✓	✓
Tourism		✓	✓
Agriculture			✓
Wood exploitation			✓
Wood exploitation for charcoal			✓
Harvest of *Pachypodium* spp.			

Identifying conservation objectives must be followed by conservation actions [4]. To facilitate the sustainability of the Ibity conservation project over the midterm, a local association was established to enable communication with and the participation of the surrounding villages. Conservation actions to date include environmental education about the management of fire and natural resource exploitation on the massif (in particular of plants and minerals), and the identification and establishment of complementary projects for socioeconomic development and ecological restoration of native ecosystems. Local nurseries have been established to propagate key plant species (such as *Abrahamia ibityensis, Aphloia theiformis* (locally know as *'Voafotsy'*), *Carissa edulis* (know as 'Fantsikala' or 'Fatsimbala') and *Uapaca bojeri*) as well as ornamentals that are under pressure from illegal exploitation (*Aloe* spp., *Pachypodium brevicaule*) and certain other species of economic interest such as *Morus alba* (mulberry, locally known as *Voaroihazo*) and *Carica papaya* (papaya). Propagation efforts also focus on exotic, fast growing tree species (e.g. *Acacia* sp.) for ongoing reforestation efforts outside the protected area in order to reduce pressure on native tree species.

Because the long-term ecological viability of protected areas is influenced by and depends directly upon socio-ecological processes that operate beyond their boundaries and adjacent buffer zones [53], a multidisciplinary management approach is necessary. At Ibity, the high frequency of fire was identified in the diagnostic studies as a potential threat for certain vegetation types, and most fires were found to be connected to agricultural activities and thus causally independent from the ecosystems that they impact [11, 54]. In most rural landscapes where fire is used as a tool, cost-benefit analyses of alternative options for clearing fields or supplying fresh, palatable grazing for cattle during the dry season show that measures to limit or eliminate burning have a negative impacts on the local human population's socio-economic wellbeing [53]. Moreover, a recent study has shown that the nearby Itremo massif, where another NAP has been delimited, has both lower fire frequency and lower plant diversity than on Ibity [35]. Many species on Ibity are likewise fire tolerant and/or require fire to

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one extent or another. An optimal fire regime must now be determined by carrying out more detailed studies focusing on fire (eg. Fire frequency, intensity, severity and recurrency) which is a top management priority for Ibity.

In the tropics, fire has also played a major role in initiating the establishment of many protected areas [53]. In Africa, for example, local populations were accused by colonial authorities of causing land degradation by the use of fire [39, 68]. Degradation by fire and the associated supposition of "bad land management" were in some instances used as a justification to expel traditional owners and expropriate land rights from local populations. In contrast, the NPA at Ibity, established as a Category V protected area (Landscape/seascape conservation and recreation) [69], is a conservation effort based on the inclusive model [65, 66]. According to the definition provided by Dudley [22], category V protection focuses on the interaction between people and nature having created a zone different from the original ecosystem with significant ecological, biological, cultural and scenic value, where protecting the integrity of this interaction is essential for the conservation of such values, including biodiversity. Conservation actions taken without consideration of their social and environmental effects on the local population tend to increase poverty in nearby rural communities [70, 71]. For this reason the establishment of the NPA at Ibity has focused on preserving and maintaining the current landscape and its associated biodiversity as well as interactions with the local population and their traditional management practices.

Governance and sustainable management

The Ibity NPA has a participatory type of governance involving local authorities, the local population, and MBG staff members. Three management boards, one for each municipality included in the NPA, are now being established. Each management board is composed of the local mayor (Fokontany chief), notables, one local police officer, one Tilin'afo representative and a representative of each local development NGO operating in the area. The management boards' work is supported and guided by an Orientation and Evaluation Board. co-chaired by the Regional Forestry Directorate and an honorary member of the Vakinankaratra (Vak) Region; other members include the Vak Mine Service,, tourism NGOs, representatives of each municipality (Ibity, Manandona, Sahanivotry), and one representant each from the region (DRATR), the police, and local development operators. The Missouri Botanical Garden organizes thematic groups, bringing together various stakeholders for the implementation of particular activities.

In order to ensure the sustainability of the Ibity NPA, the management plan implemented by MBG includes the following main points:

1. *Management support*: Assistance for the activities organized by the Management Boards (MBs); organization of a monthly meeting with each MB, including passing judgment on infractions; organization of training sessions on management and good governance for the MBs; surveying the activities of each MB to evaluate its success; and monitoring the different projects being implemented (using outcome indicators, impacts, and threats).
2. *Promotion of eco-tourism*: Training local guides in ecotourism; creation of local guide associations to improve their ability to deal with the behavior of tourists; placing information boards on the site to inform tourists about appropriate behavior; developing and distributing material promoting ecotourism.
3. *Application of local community roles (known as dina), including early fire detection and the prevention of mining and exploitation of woody plants inside the NAP*; creation of local patrols to survey human activities in the NPA; planting alternative trees to meet human needs for wood for fuel and construction; creation of associations to support fuelwood production and to promote alternative activities for fuelwood producers.

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4. *Facilitation of development in the municipalities surrounding Ibity*: Support for local NGOs to secure funding and establish or expand development projects.
5. *Support for responsible, legal mining outside the NAP*: Promotion of efforts to incorporate ecosystem restoration activities in mining projects.
6. *Facilitation of research activities*: Support for research on Tapia regeneration and on the effects of fire on vegetation.

Conclusions

The delimitation of the Ibity NPA was the result of a careful inventory, research focusing on land uses and their impact, and extensive discussions and negotiations involving the population living in the surrounding area, local authorities, representatives of three Ministries (Forest and Environment, Energy and Mines, and Landowners and Land Management), and the Missouri Botanical Garden, which served as the NGO promoter of this initiative. Close cooperation among the project managers, the local population and the relevant authorities must now be maintained in order to minimize and manage the risk of possible conflicts between the legitimate needs of the local population and the goal of conserving biodiversity, and to ensure that local stakeholders benefit directly from conservation activities while continuing to exercise their rights to use the area's natural resources sustainably. Concerning fire management, despite the fact that burning has long been seen as destructive and undesirable (resulting in a dominance of herbaceous species when fire frequencies are high, along with a reduction of biodiversity, an increase in soil erosion, etc.), it is both impossible and undesirable to eliminate fire from Ibity's landscape, as is the case in many tropical areas. Fire is intimately connected to local cultural identity and management practices, as well as to ecological diversity and resilience. However, many questions remain concerning how best to manage the Ibity NPA so that its rich and diverse vegetation can be protected and maintained. It will be particularly important to determine the most appropriate and sustainable fire regime (frequency, timing, etc.) for the different vegetation types found on the massif. A study was underway to assess the impact of fire on grassland vegetation and tapia woodland, focusing on composition and structure [35], phenology [41], germination [42], and impacts on post-burning seedling resilience. The results of this work will inform an improved set of management actions for the Ibity NPA and the surrounding area, and the successful implementation of an integrated conservation strategy.

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Appendix 1 Vegetation types on Ibity Massif. [13]. For family names of species see Appendix 3.

Vegetation type (White 1983)	Alternative names	Structural definition	Characteristic taxa	Observations
Dense forest	Evergreen forest	Vegetation comprising a continuous stand of trees at least 10m tall with interlocking crowns	*Ilex aquifolium*, *Polyscias ornifolia*, *Rhus taratana*, *Tina* sp., *Weinmannia stenostachya*	This vegetation type is rare and restricted at present to degraded fragments (e.g. Vohipisaka; < 1 % of the land area)
Woodland	Tapia woodland, sclerophyllous forest	Open stands of trees at least 8 m tall, with a canopy cover of 40% or more, and with a ground layer usually dominated by grasses and other herbs	*Agarista salicifolia*, *Sarcolaena oblongifolia*, *Schefflera bojeri, Schizolaena microphylla, Uapaca bojeri*	This vegetation type covers approximately 2% of the massif. The largest and the most intact fragments are in the southwestern part of Kiboy (outside the protected area) and in the east and south of Ibity (within the protected area)
Woody grasslands	Woody savanna	Land covered with grasses and other herbs, with woody plants covering included between 10 and 40% of the ground.	*Abrahamia ibityensis*, *Aloe* spp., *Asteropeia densifolia*, *Leptolaena pauciflora, Pentachlaena latifolia, Vernonia* spp., *Xerochlamys bojeriana*	This vegetation type is found on rocky outcrops, protected from bushfires, but can also be found in the mid-slopes (covering ca. 50% of the massif)
Grasslands	Savanna	Land covered with grasses and other herbs, with woody plants covering no more than 10% of the ground.	*Crotalaria ibityensis, Pachypodium brevicole*, species of Poaceae, Cyperaceae, Lamiaceae	This vegetation type covers approximately 40% of the Massif.
Freshwater aquatic and marsh vegetation	Bog/marsh	Herbaceous freshwater bog/marsh and aquatic vegetation	Species of Poaceae, Cyperaceae, Eriocaulaceae, Orchidaceae, *Utricularia livida, Drosera natelensis*	Some zones covered with marshes/bogs are found in the higher slopes (< 1% of the massif)

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Appendix 2 Structure and composition of four herbaceous grassland types on Ibity Massif. For family names of species see Appendix 3.

	***Loudetia simplex* subsp. *stipoides* grassland**	***Loudetia madagascariensis* grassland on sandy soil**	***Aristida similis* grassland**	***Urelytrum humbertianum* grassland**
Location	Common throughout the massif	Principally in the summit area	Generally on lower slopes	On the crest
Altitude	1550-1900 m	since 1916 m	1200-1600 m	2014 m
Vegetation cover	> 90%	70%	80%	25-30%
Upper herbaceous stratum	80-120cm	80-130cm	60-150cm	> 80cm
	Loudetia simplex subsp. *stipoides*, *Loudetia madagascariensis, Pteridium aquilinum, Urelytrum humbertianum* and *Sporobolus centrifuges*	*Loudetia madagascariensis* only	*Aristida similis* and *Hyparrhenia rufa* only	*Urelytrum humbertianum*, *Erica* sp., *Loudetia madagascariensis* and *Cyperus obtusiflorus*
Middle herbaceous stratum	50-80cm	40-80cm	40-60cm	
	Schizachyrium sanguineum, Ctenium concinium and *Sporobolus centrifugus*	*Sporobolus centrifugus, Vaccinium emernensis, Brachiaria antsirabensis* and *Cyperus obtusiflorus*	*Cyperus obtusiflorus* and *Cynonkis* sp.	
Lower herbaceous stratum	10-30cm	< 30cm	< 30cm	< 20cm
	Cyperaceae	Dominated by *Fimbristylis* sp.	Dominated by *Fimbristylis* sp.	*Dominated by Fimbristylis* sp.
Woody species	Low density of: *Pinus* spp. (exotic), *Xerochlamys bojeriana, Agauria* sp., *Aphloia theiformis* and *Schefflera bojeri*	Low density of: *Vaccinium emirnensis*		

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Appendix 3 List of plant species collected on Ibity. Species identifications were confirmed in Antananarivo at the reference herbarium of the Parc Botanique et Zoologique de Tsimbazaza and at the offices of the Missouri Botanical Garden (MBG), using the *Flore de Madagascar et des Comores* [1] and the "Flora of the grasses of pasture and the cultures of Madagascar" [2] [1]. Endemicity = 1: endemic to Ibity; 2: endemic to Ibity and Itremo; 3: Madagascar to endemic, 4 = undefined; 5: not endemic to Madagascar

Family	Species	Endemicity
Acanthaceae	*Hypoestes isalensis* Benoist	3
Acanthaceae	*Hypoestes perrieri* Benoist	1
Anacardiaceae	*Abrahamia buxifolia* H. Perrier, ined.	3
Anacardiaceae	*Abrahamia ibityensis* H. Perrier, ined.	2
Anacardiaceae	*Rhus taratana* (Baker) H. Perrier	3
Aphloiaceae	*Aphloia theiformis* (Vahl) Benn.	5
Apiaceae	*Peucedanum capense* (Thunb.) Sond.	4
Apocynaceae	*Carissa edulis* (Forssk.) Vahl	5
Apocynaceae	*Catharanthus lanceus* (Bojer ex A. DC.) Pichon	3
Apocynaceae	*Ceropegia* sp. 1	4
Apocynaceae	*Craspidospermum verticillatum* Bojer ex A. DC.	3
Apocynaceae	*Cynanchum andringitrense* Choux	3
Apocynaceae	*Cynanchum compactum* Choux	2
Apocynaceae	*Cynanchum fimbricoronum* P.T. Li	3
Apocynaceae	*Cynanchum itremense* Liede	2
Apocynaceae	*Cynanchum lineare* N.E. Br.	3
Apocynaceae	*Cynanchum mahafalense* Jum. & H. Perrier	3
Apocynaceae	*Cynanchum* sp. 1	4
Apocynaceae	*Pachypodium brevicaule* Baker	2
Apocynaceae	*Pachypodium densiflorum* Baker	3
Apocynaceae	*Pentopetia* sp. 1	4
Apocynaceae	*Plectaneia thouarsii* Roemer & Schultes	3
Apocynaceae	*Secamone buxifolia* Decne.	5
Apocynaceae	*Secamone* cf. *linearifolia* Klack.	3
Apocynaceae	*Secamone sparsiflora* Klack.	3
Araliaceae	*Polyscias ornifolia* (Baker) Harms	3
Araliaceae	*Polyscias zanthoxyloides* (Baker) Harms	3
Araliaceae	*Schefflera bojeri* (Seem.) R. Vig.	3
Arecaceae	*Dypsis decipiens* (Becc.) Beentje & Dransf.	3
Asparagaceae	*Arthropodium caesioides* H. Perrier	3
Asparagaceae	*Chlorophytum tripedale* (Baker) H. Perrier	2
Asparagaceae	*Dracaena reflexa* Lam.	5
Aspleniaceae	*Asplenium aethiopicum* (Burm. f.) Bech.	5
Aspleniaceae	*Asplenium buettneri* Hieron. ex Brause	5
Aspleniaceae	*Asplenium friesiorum* C. Chr.	5

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Family	Species	Endemicity
Aspleniaceae	*Asplenium mildbraedii* Hieron.	5
Aspleniaceae	*Asplenium sulcatum* Lam.	5
Asteraceae	*Acanthospermum* sp. 1	4
Asteraceae	*Anisopappus chinensis* Hook. & Arn. var. *dentatus* (DC.) S. Ortiz, Paiva & Rodr. Oubiña	5
Asteraceae	*Aspilia rugulosa* Humbert	3
Asteraceae	*Aster madagascariensis* (Humbert) Humbert	2
Asteraceae	*Athrixia debilis* DC.	4
Asteraceae	*Crassocephalum rubens* (B. Juss. ex Jacq.) S. Moore var. *sarcobasis* (DC.) C. Jeffrey & Beentje	5
Asteraceae	*Dicoma* sp. 1	4
Asteraceae	*Distephanus glutinosus* (DC.) H. Rob. & B. Kahn	3
Asteraceae	*Distephanus trinervis* Bojer ex DC.	3
Asteraceae	*Emilia graminea* DC.	3
Asteraceae	*Epallage dentata* DC.	3
Asteraceae	*Gerbera* sp. 1	4
Asteraceae	*Helichrysum adhaerens* Humbert	3
Asteraceae	*Helichrysum benthamii* R. Vig. & Humbert	3
Asteraceae	*Helichrysum candollei* (Bojer ex DC.) R. Vig. & Humbert	4
Asteraceae	*Helichrysum chermezonii* Humbert	3
Asteraceae	*Helichrysum cremnophilum* Humbert	3
Asteraceae	*Helichrysum deltoideum* Humbert	1
Asteraceae	*Helichrysum forsythii* Humbert	3
Asteraceae	*Helichrysum hypnoides* (DC.) R. Vig. & Humbert	3

Family	Species	Endemicity
Asteraceae	*Helichrysum ibityense* R. Vig & Humbert	1
Asteraceae	*Helichrysum manopappoides* Humbert	3
Asteraceae	*Helichrysum perrieri* Humbert	1
Asteraceae	*Helichrysum saboureaui* Humbert	3
Asteraceae	*Helichrysum viguieri* Humbert	3
Asteraceae	*Hubertia adenodonta* (DC.) C. Jeffrey	3
Asteraceae	*Hubertia faujasioides* (Baker) C. Jeffrey	3
Asteraceae	*Hubertia lampsanifolia* (Baker) C. Jeffrey	3
Asteraceae	*Hubertia myricifolia* (Bojer ex DC.) C. Jeffrey	3
Asteraceae	*Humea madagascariensis* Humbert	1
Asteraceae	*Hypochoeris* sp. 1	4
Asteraceae	*Hypochoeris radicata* L.	4
Asteraceae	*Madagaster madagascariensis* (Humbert) G.L. Nesom	3
Asteraceae	*Neojeffreya decurrens* (L.) Cabrera	5
Asteraceae	*Rochonia cinerarioides* DC.	3
Asteraceae	*Senecio baronii* Humbert	3
Asteraceae	*Senecio cochlearifolius* Bojer ex DC.	4
Asteraceae	*Senecio hildebrandtii* Baker	3
Asteraceae	*Senecio leandrii* Humb.	3
Asteraceae	*Senecio marnieri* Humb.	1
Asteraceae	*Senecio melastomifolius* Baker	3
Asteraceae	*Senecio mesembryanthemoides* Bojer ex DC.	3
Asteraceae	*Senecio quartziticolus* Humbert	2
Asteraceae	*Senecio resectus* Bojer ex DC.	3
Asteraceae	*Senecio riparius* DC.	3
Asteraceae	*Stenocline* sp. 1	3

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Family	Species	Endemicity
Asteraceae	*Taraxacum* sp. 1	4
Asteraceae	*Vernonia delapsa* Baker	3
Asteraceae	*Vernonia ibityensis* Humbert	2
Asteraceae	*Vernonia nudicaulis* Less.	4
Asteraceae	*Vernonia rhodolepis* Baker	3
Asteropeiaceae	*Asteropeia densiflora* Baker	3
Balsaminaceae	*Impatiens* sp. 1	4
Begoniaceae	*Begonia* cf. *baronii* Baker	3
Blechnaceae	*Blechnum tabulare* (Thunb.) Kuhn	5
Campanulaceae	*Dialypetalum compactum* Zahlbr.	2
Campanulaceae	*Dialypetalum floribundum* Benth.	3
Campanulaceae	*Wahlenbergia perrieri* Thulin	2
Campanulaceae	*Wahlenbergia subaphylla* (Baker) Thulin	5
Caryophyllaceae	*Polycarpa corymbosa* Kuntze	5
Clusiaceae	*Symphonia* sp. 1	4
Commelinaceae	*Commelina madagascarica* C.B. Clarke	3
Commelinaceae	*Commelina major* H. Perrier	3
Commelinaceae	*Commelina nudiflora* L.	3
Commelinaceae	*Commelina speciosa* (L. f.) Thunb.	5
Convolvulaceae	*Ipomoea desmophylla* Bojer ex Choisy	3
Crassulaceae	*Kalanchoe bitteri* Hamet & H. Perrier	2
Crassulaceae	*Kalanchoe hildebrandtii* Baill.	3
Crassulaceae	*Kalanchoe integrifolia* Baker	3
Crassulaceae	*Kalanchoe laxifolia* Baker	3
Crassulaceae	*Kalanchoe miniata* Hilsenb. & Bojer ex Tul.	5
Crassulaceae	*Kalanchoe tetraphylla* H.Perrier	3
Cunoniaceae	*Weinmannia stenostachya* Baker	3

Family	Species	Endemicity
Cyatheaceae	*Cyathea dregei* Kunze	3
Cyatheaceae	*Cyathea melleri* (Baker) Domin	3
Cyperaceae	*Bulbostylis trichobasis* (Baker) C.B. Clarke	3
Cyperaceae	*Costularia pantopoda* (Baker) C.B. Clarke	3
Cyperaceae	*Cyperus impubes* Steud. var. *fallax* (Cherm.) Kük.	3
Cyperaceae	*Cyperus macrocarpus* (Kunth) Boeckeler	3
Cyperaceae	*Cyperus niveus* Retz.	5
Cyperaceae	*Cyperus* cf. *obtusiflorus* Vahl	5
Cyperaceae	*Cyperus xerophilus* Cherm.	5
Cyperaceae	*Kyllinga odorata* Vahl	4
Cyperaceae	*Kyllinga brevifolia* Rottb. var. *intricata* (Cherm.) Lye	5
Cyperaceae	*Machaerina* sp. 1	4
Cyperaceae	*Pycreus nitidus* (Lam.) J. Raynal	4
Cyperaceae	*Scirpus fluitans* L.	3
Cyperaceae	*Scleria hilsenbergii* Ridl.	3
Cyperaceae	*Scleria melanomphala* Kunth	5
Davalliaceae	*Nephrolepis* sp. 1	4
Dennstaediaceae	*Microlepia* sp. 1	4
Dioscoreaceae	*Dioscorea heteropoda* Baker	5
Dioscoreaceae	*Dioscorea hexagona* Baker	3
Dioscoreaceae	*Dioscorea soso* Jum. & H. Perrier	3
Droseraceae	*Drosera madagascariensis* DC.	5
Droseraceae	*Drosera natalensis* Diels	5
Dryopteridaceae	*Athyrium schimperi* Moug. ex Fée	4
Dryopteridaceae	*Dryopteris inaequalis* (Schldl.) Kunte.	4
Dryopteridaceae	*Elaphoglossum conforme* (Sw.) Schott	5
Dryopteridaceae	*Elaphoglossum coriaceum* Bonap.	3

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Family	Species	Endemicity
Dryopteridaceae	*Elaphoglossum decaryanum* Tardieu	3
Dryopteridaceae	*Elaphoglossum deckenii* (Kuhn) C. Chr.	5
Dryopteridaceae	*Elaphoglossum hybridum* (Bory) Brack.	5
Dryopteridaceae	*Elaphoglossum lancifolium* (Desv.) C.V. Morton	5
Dryopteridaceae	*Elaphoglossum poolii* Christ	3
Dryopteridaceae	*Elaphoglossum spathulatum* (Bory) T.Moore	5
Elaeocarpaceae	*Elaeocarpus hildebrandtii* Baill.	3
Equisetaceae	*Equisetum ramosissimum* Desf.	4
Ericaceae	*Agauria polyphylla* Baker	3
Ericaceae	*Erica ciliata* Bubani	3
Ericaceae	*Erica cryptoclada* (Baker) Dorr & E.G.H. Oliv.	3
Ericaceae	*Erica ibityensis* (H. Perrier) Dorr & E.G.H. Oliv.	1
Ericaceae	*Erica latifolia* Andrews	3
Ericaceae	*Erica lecomtei* (H. Perrier) Dorr & E.G.H. Oliv.	3
Ericaceae	*Erica pilosa* Lodd.	3
Ericaceae	*Vaccinium secundiflorum* Hook.	3
Erythroxylaceae	*Erythroxylum corymbosum* Boivin ex Baillon	5
Erythroxylaceae	*Erythroxylum leandrianum* Payens	3
Euphorbiaceae	*Lobanilia* sp. 1	4
Euphorbiaceae	*Macaranga alnifolia* Baker	4
Fabaceae	*Abrus aureus* R. Vig.	3
Fabaceae	*Alysicarpus* sp. 1	4
Fabaceae	*Chamaecrista* sp. 1	4
Fabaceae	*Chamaecrista lateriticola* (R. Vig.) Du Puy	3

Family	Species	Endemicity
Fabaceae	*Chamaecrista stricta* E. Mey.	4
Fabaceae	*Crotalaria ankaratrana* R. Vig.	3
Fabaceae	*Crotalaria diosmifolia* Benth.	3
Fabaceae	*Crotalaria emirnensis* Benth.	3
Fabaceae	*Crotalaria ibityensis* R. Vig. & Humbert	2
Fabaceae	*Crotalaria tanety* Du Puy, Labat & H.E. Ireland	3
Fabaceae	*Desmodium barbatum* (L.) Benth. & Oerst.	3
Fabaceae	*Eriosema procumbens* Benth. ex Baker	3
Fabaceae	*Indigofera lyallii* Baker	5
Fabaceae	*Indigofera pedunculata* Hilsenberg & Bojer ex Baker	3
Fabaceae	*Kotschya africana* Endl.	5
Fabaceae	*Mimosa* sp. 1	4
Fabaceae	*Mundulea anceps* R. Vig.	3
Fabaceae	*Ophrestia lyallii* (Benth.) Verdc.	3
Fabaceae	*Rhynchosia versicolor* Baker	3
Fabaceae	*Tephrosia ibityensis* (R. Vig.) Du Puy & Labat	1
Fabaceae	*Tephrosia lyalli*i Baker	3
Fabaceae	*Tephrosia subaphylla* R. Vig. ex Du Puy & Labat	1
Fabaceae	*Vigna angivensis* Baker	3
Fabaceae	*Vigna keraudrenii* Du Puy & Labat	3
Fabaceae	*Zornia puberula* Mohlenbr.	3
Gentianaceae	*Anthocleista madagascariensis* Baker	3
Gentianaceae	*Exacum exiguum* Klack.	3
Gentianaceae	*Ornichia madagascariensis* (Baker) Klack.	3
Gentianaceae	*Tachiadenus longiflorus* Griseb.	4

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Family	Species	Endemicity
Gesneriaceae	*Streptocarpus ibityensis* Humbert	2
Gesneriaceae	*Streptocarpus itremensis* B.L. Burtt	2
Gesneriaceae	*Streptocarpus thompsonii* R. Br.	3
Gleicheniaceae	*Dicranopteris linearis* (Burm. f.) Underw.	5
Gleicheniaceae	*Gleichenia polypodioides* (L.) Sm.	5
Hamamelidaceae	*Dicoryphe* sp. 1	5
Huperziaceae	*Huperzia stricta* (Baker) Tardieu	4
Hymenophyllacea e	*Trichomanes cupressoides* Desv.	5
Hypericaceae	*Hypericum* sp. 1	4
Hypericaceae	*Psorospermum* sp. 1	4
Icacinaceae	*Cassinopsis* sp. 1	4
Iridaceae	*Aristea kitchingii* Baker	3
Iridaceae	*Crocosmia crocosmiiflora* (Lemoine ex Morren) N.E. Br.	5
Iridaceae	*Gladiolus dalenii* Van Geel	5
Iridaceae	*Gladiolus perrieri* Goldblatt	2
Lamiaceae	*Coleus fimbriatus* Lebrun & Touss.	4
Lamiaceae	*Plectranthus circinnatus* Hedge	3
Lamiaceae	*Plectranthus persoonii* (Benth.) Hedge	3
Lamiaceae	*Plectranthus secundiflorus* (Baker) Hedge	3
Lamiaceae	*Salvia sessilifolia* Baker	3
Lamiaceae	*Stachys filifolia* Hedge	3
Lamiaceae	*Tetradenia goudotii* Briq.	3
Lamiaceae	*Vitex betsiliensis* Humb.	2
Lauraceae	*Aspidostemon parvifolium* (Scott-Elliot) van der Werff	4
Lauraceae	*Beilschmiedia* cf. *madagascariensis* (Baill.) Kosterm.	3

Family	Species	Endemicity
Lauraceae	*Cassytha filiformis* L.	5
Lauraceae	*Potameia* sp. 1	4
Lentibulariaceae	*Utricularia livida* E. Mey.	5
Liliaceae	*Chlorophytum tripedale* (Baker) H. Perrier	2
Linaceae	*Linum emirnense* Bojer	3
Lobeliaceae	*Lobelia* cf. *anceps* L.	5
Lomariopsidaceae	*Elaphoglossum confrome* (Sw.) Schott	3
Lomariopsidaceae	*Elaphoglossum coriaceum* Bonap.	5
Lomariopsidaceae	*Elaphoglossum deckenii* (Kuhn) C. Chr.	5
Lomariopsidaceae	*Elaphoglossum lancifolium* (Desv.) C.V. Morton	5
Lomariopsidaceae	*Elaphoglossum poolii* Christ	3
Lycopodiaceae	*Lycopodiella cernua* (L.) Pic. Serm.	5
Malpighiaceae	*Philgamia denticulata* Arènes	3
Malpighiaceae	*Philgamia glabrifolia* Arènes	1
Malvaceae	*Andringitra leucomacrantha* (Hochr.) Skema	3
Malvaceae	*Andringitra macrantha* Bak.	3
Malvaceae	*Dombeya lucida* Baill.	3
Malvaceae	*Dombeya pubescens* (Hochr.) Arènes	3
Malvaceae	*Grewia* sp. 1	4
Malvaceae	*Rulingia madagascariensis* Baker	3
Malvaceae	*Sparrmannia dicolor* Baker	3
Malvaceae	*Triumfetta* sp. 1	4
Melastomataceae	*Dichaetanthera crassinodis* Baker	3
Melastomataceae	*Medinilla ibityensis* H. Perrier	1
Melastomataceae	*Medinilla torrentum* Jum. & H. Perrier	3
Melastomataceae	*Memecylon bakerianum* Cogn.	3

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Family	Species	Endemicity
Melastomataceae	*Rousseauxia minimifolia* (Jum. & H. Perrier) Jacq.-Fél.	3
Monimiaceae	*Tambourissa purpurea* (Tul.) A. DC.	3
Montiniaceae	*Kaliphora madagascariensis* Hook. f.	3
Myrsinaceae	*Embelia concinna* Baker	5
Myrsinaceae	*Monoporus* sp. 1	4
Myrsinaceae	*Oncostemum bojerianum* A. DC.	3
Myrtaceae	*Eugenia* sp. L	4
Myrtaceae	*Syzygium bernieri* (Drake) Labat & G.E. Schatz	3
Myrtaceae	*Syzygium emirnense* (Baker) Labat & G.E. Schatz	3
Myrtaceae	*Syzygium parkeri* (Baker) Labat & G.E. Schatz	3
Oleandraceae	*Oleandra distenta* Kunze	5
Orchidaceae	*Aerangis cryptodon* (Rchb. f.) Schltr.	3
Orchidaceae	*Aerangis ellisii* (B.S. Williams) Schltr	3
Orchidaceae	*Angraecum curvicaule* Schltr.	3
Orchidaceae	*Angraecum magdalenae* Schltr. & H. Perrier	3
Orchidaceae	*Angraecum rutenbergianum* Kraenlz.	3
Orchidaceae	*Angraecum sororium* Schltr.	3
Orchidaceae	*Benthamia bathieana* Schltr.	5
Orchidaceae	*Benthamia cinnabarina* (Rolfe) H. Perrier	3
Orchidaceae	*Benthamia glaberrima* (Ridl.) H. Perrier	3
Orchidaceae	*Benthamia herminioides* Schltr.	1
Orchidaceae	*Benthamia rostrata* Schltr.	3
Orchidaceae	*Bulbophyllum baronii* Ridl.	3
Orchidaceae	*Cynorkis angustipetala* Ridl.	3
Orchidaceae	*Cynorkis baronii* Rolfe	3

Family	Species	Endemicity
Orchidaceae	*Cynorkis cardiophylla* Schltr.	3
Orchidaceae	*Cynorkis flexuosa* Lindl.	5
Orchidaceae	*Cynorkis gibbosa* Ridl.	3
Orchidaceae	*Cynorkis gymnochiloides* (Schltr.) H. Perrier	2
Orchidaceae	*Cynorkis perrieri* Schltr.	3
Orchidaceae	*Cynorkis sacculata* Schltr.	2
Orchidaceae	*Cynorkis uniflora* Lindl.	3
Orchidaceae	*Eulophia ibityensis* Schltr.	1
Orchidaceae	*Gastrorchis francoisii* Schltr.	3
Orchidaceae	*Habenaria alta* Ridl.	3
Orchidaceae	*Habenaria ambositrana* Schltr	2
Orchidaceae	*Habenaria bathiei* Schltr.	3
Orchidaceae	*Habenaria monadenioides* Schltr.	2
Orchidaceae	*Jumellea brachycentra* Schltr.	3
Orchidaceae	*Jumellea ibityana* Schltr.	1
Orchidaceae	*Liparis* sp. 1	4
Orchidaceae	*Polystachya anceps* Ridl.	5
Orchidaceae	*Polystachya henrici* Schltr.	4
Orchidaceae	*Polystachya monophylla* Schltr.	3
Orchidaceae	*Polystachya perrieri* Schltr.	1
Orchidaceae	*Polystachya rosea* Ridl.	4
Orchidaceae	*Polystachya waterlotii* Guillaumin	3
Orchidaceae	*Satiryum* sp.	4
Orchidaceae	*Tylostigma nigrescens* Schltr.	3
Orobanchaceae	*Buchnera* sp. 1	4
Orobanchaceae	*Harveya* sp. 1	4
Orobanchaceae	*Radamaea montana* Benth.	3

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Orobanchaceae	*Sopubia lemuriana* H.-P. Hofm. & Eb. Fisch.	3
Orobanchaceae	*Sopubia triphylla* Baker	3
Osmundaceae	*Osmunda regalis* L.	5
Oxalidaceae	*Oxalis* sp. 1	4
Phyllanthaceae	*Phyllanthus betsileanus* Leandri	2
Phyllanthaceae	*Phyllanthus casticum* Willemet	3
Phyllanthaceae	*Phyllanthus vakinankaratrae* Leandri	3
Phyllanthaceae	*Uapaca bojeri* Baill.	3
Piperaceae	*Peperomia* sp. 1	4
Piperaceae	*Peperomia tetraphylla* Hook. & Arn.	5
Pittosporaceae	*Pittosporum pachyphyllum* Baker	3
Poaceae	*Alloteropsis semialata* (R. Br.) Hitchc.	5
Poaceae	*Andropogon eucomus* Nees subsp. *huillensis* (Rendle) Sales	5
Poaceae	*Andropogon ibityensis* A. Camus	3
Poaceae	*Aristida similis* Steud.	3
Poaceae	*Arundinaria ibityensis* A. Camus	1
Poaceae	*Brachiaria dimorpha* A. Camus	5
Poaceae	*Craspedorfachis africana* Benth.	5
Poaceae	*Ctenium concinnum* Nees	5
Poaceae	*Digitaria ciliaris* (Retz.) Koeler	5
Poaceae	*Digitaria humbertii* A. Camus	5
Poaceae	*Eragrostis atrovirens* (Desf.) Trin. ex Steud.	5
Poaceae	*Eragrostis capensis* (Thumb.) Trin.	5
Poaceae	*Eragrostis lateritica* Bosser	5
Poaceae	*Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult.	5

Family	Species	Endemicity
Poaceae	*Hyparrhenia rufa* (Nees) Stapf	5
Poaceae	*Imperata cylindrica* (L.) Raeusch.	5
Poaceae	*Loudetia simplex* (Nees) C.E. Hubb. subsp. *stipoides* Bosser	3
Poaceae	*Melinis repens* (Wild.) Zizka	5
Poaceae	*Panicum ibitense* A. Camus	3
Poaceae	*Paspalum commersonii* Lam.	5
Poaceae	*Pennisetum pseudotriticoides* A. Camus	5
Poaceae	*Perotis* aff. *patens* Gand.	4
Poaceae	*Sacciolepis delicatula* Mez.	3
Poaceae	*Sporobolus centrifugus* (Trin.) Nees	5
Poaceae	*Sporobolus pyramidalis* P. Beauv.	5
Poaceae	*Trachypogon polymorphus* Hack.	5
Poaceae	*Urelytrum madagascariense* A. Camus	3
Polygalaceae	*Polygala arvicola* Bojer	3
Polygalaceae	*Polygala grandidieri* Baill.	4
Polypodiaceae	*Lellingeria oosora* (Baker) A.R.Sm. & R.C. Moran	5
Polypodiaceae	*Lepisorus excavatus* (Bory ex Willd.) Ching	5
Polypodiaceae	*Pleopeltis schraderi* (Mett.) Tardieu	3
Primulaceae	*Maesa lanceolata* Forssk.	5
Proteaceae	*Faurea forficuliflora* Baker	3
Pteridaceae	*Cheilanthes hirta* Sw.	5
Pteridaceae	*Notholaena inaequalis* Kunze	5
Pteridaceae	*Pellaea calomelanos* (Sw.) Link	5
Pteridaceae	*Pellaea pectiniformis* Baker	5
Pteridaceae	*Pellaea viridis* (Forssk.) Prantl	5
Pteridaceae	*Pityrogramma argentea* (Willd.) Domin	5

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Family	Species	Endemicity
Pteridaceae	*Pityrogramma calomelanos* (L.) Link	5
Pteridaceae	*Pteris catoptera* Kunze	5
Pteridaceae	*Pteris humbertii* C. Chr.	3
Pteridaceae	*Pteris marcodon* Baker	3
Restionaceae	*Restio mahonii* (N.E. Br.) Pillans	5
Rhamnaceae	*Phylica emirnensis* (Tul.) Pillans	5
Rubiaceae	*Alberta minor* Baill.	3
Rubiaceae	*Anthospermum ibityense* Puff	3
Rubiaceae	*Canthium* sp. 1	4
Rubiaceae	*Carphalea kirondron* Baill.	3
Rubiaceae	*Chassalia* sp. 1	4
Rubiaceae	*Coffea buxifolia* A. Chev.	3
Rubiaceae	*Coffea* sp. 1	4
Rubiaceae	*Galium* sp.	4
Rubiaceae	*Nematostylis anthophylla* (A. Rich.) Baill.	3
Rubiaceae	*Oldenlandia herbacea* (L.) Roxb.	5
Rubiaceae	*Otiophora pauciflor*a Baker	3
Rubiaceae	*Otiophora scabra* Zucc.	3
Rubiaceae	*Peponidium* sp. 1	4
Rubiaceae	*Psychotria reducta* Baker	3
Rubiaceae	*Psychotria* sp. 1	4
Rubiaceae	*Rytigynia seyrigii* Cavaco	3
Rubiaceae	*Schismatoclada* sp. 1	4
Rubiaceae	*Spermacoce* sp. 1	4
Rubiaceae	*Tricalysia cryptocalyx* Baker	3
Rutaceae	*Melicope madagascariensis* (Baker) T.G. Hartley	3
Salicaceae	*Homalium parkeri* Baker	3

Family	Species	Endemicity
Santalaceae	*Thesium humbertii* Cavaco & Keraudren	3
Santalaceae	*Viscum* sp. 1	4
Sapindaceae	*Dodonaea madagascariensis* Radlk.	3
Sapindaceae	*Tina isoneura* Radlk.	3
Sapindaceae	*Tina striata* Radlk.	3
Sarcolaenaceae	*Leptolaena pauciflora* Baker	3
Sarcolaenaceae	*Pentachlaena latifolia* H. Perrier	1
Sarcolaenaceae	*Sarcolaena oblongifolia* F. Gérard	3
Sarcolaenaceae	*Schizolaena microphylla* H. Perrier	3
Sarcolaenaceae	*Xerochlamys bojeriana* (Baill.) F. Gérard	3
Sarcolaenaceae	*Xerochlamys elliptica* F. Gérard	2
Schizaeaceae	*Schizaea* sp. 1	4
Scrophulariaceae	*Alectra sessiliflora* (Vahl) Kuntze	1
Selaginellaceae	*Selaginella goudotiana* Spring	3
Selaginellaceae	*Selaginella nivea* Alston subsp*. humbertii* Stefanov. & Rakotondr.	2
Stilbaceae	*Halleria ligustrifolia* Baker	3
Stilbaceae	*Nuxia capitata* Baker	3
Tectariaceae	*Arthropteris orientalis* (J.F. Gmel.) Posth.	5
Thelypteridaceae	*Macrothelypteris torresiana* (Gaudich.) Ching	5
Thymelaeaceae	*Dais glaucescens* Decne.	3
Thymelaeaceae	*Gnidia gnidioides* (Baker) Domke	3
Thymelaeaceae	*Octolepis ibityensis* Z.S. Rogers	1
Thymelaeaceae	*Peddiea involucrata* Baker	3
Urticaceae	*Pilea macrocarpa* C.J. Chen.	4
Velloziaceae	*Xerophyta aymoninii* Phillipson & Lowry, ined.	3
Velloziaceae	*Xerophyta dasylirioides* Baker	3

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Family	Species	Endemicity
Vitaceae	*Cissus floribunda* (Baker) Planch.	3
Woodsiaceae	*Athyrium schimperi* Moug. ex Fée	5
Xanthorrhoeaceae	*Aloe alfredii* Rauh	1
Xanthorrhoeaceae	*Aloe capitata* Baker var. *quatziticola* H. Perrier	2
Xanthorrhoeaceae	*Aloe compressa* H. Perrier	2
Xanthorrhoeaceae	*Aloe eximia* Lavranos & T.A. McCoy	2
Xanthorrhoeaceae	*Aloe florenceae* Lavranos & T.A. McCoy	2
Xanthorrhoeaceae	*Aloe ibitiensis* H. Perrier	2

Family	Species	Endemicity
Xanthorrhoeaceae	*Aloe laeta* A. Berger	1
Xanthorrhoeaceae	*Aloe manandonae* J.-B. Castillon & J.-P. Castillon	2
Xanthorrhoeaceae	*Aloe pachydactylos* T.A. McCoy & Lavranos	1
Xanthorrhoeaceae	*Aloe parallelifolia* H. Perrier	2
Xanthorrhoeaceae	*Aloe rugosquamosa* (Perrier) J.-B. Castillon & J.-P. Castillon	2
Xanthorrhoeaceae	*Aloe trachyticola* (H. Perrier) Reynolds	1
Xyridaceae	*Xyris capensis* Thunb.	4

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