14 TAPIA FOREST, MADAGASCAR

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CLASSIFICATION

National: Tapia Forest is recognised as a major vegetation type in the Atlas of vegetation of Madagascar (Rabehevitra and Rakotoarisoa 2007).
IUCN Habitats Classification Scheme (Version 3.0): 1. Forest / 1.5 Subtropical/Tropical Dry Forest

ECOSYSTEM DESCRIPTION

Characteristic native biota

A forest comprising an evergreen canopy of 10–12 m, with an understorey of ericoid shrubs. Lianas are frequent, but epiphytes are few. The herbaceous layer is dominated by grasses (Rabehevitra & Rakotoarisoa 2007).

The primary form of Tapia forest is a stratified, evergreen forest (Fig. S12.1), with a low (8 - 12 m) semi-continuous tree canopy, an understorey of ericoid shrubs, frequent lianas but few epiphytes, and a moderate to rich herbaceous component dominated by grasses (Rabehevitra & Rakotoarisoa 2007). Tapia forest is floristically diverse compared to its surrounding vegetation of denuded grassland and wooded grasslands of the high plateaux. The plants are mostly sclerophyllous, hairy or heliophilous. The tree bark in this type is frequently thick, and resistant to fire. The most characteristic species are *Uapaca bojeri*, *Sarcolaena oblongifolia*, *Pentachlaena latifolia*, *Schizolaena microphylla*, *Asteropeia labatii*, *Weinmannia* spp. and *Agarista* spp. Common canopy families are Cunoniaceae, Anacardiaceae, Rubiaceae, Ericaceae, Sarcolaenaceae and Asteraceae, while two endemic plant families (Sarcolaenaceae and Asteropeiaceae), also characterise the Tapia forest ecosystem. Poaceae and Asteraceae dominate the herbaceous stratum, with *Pachypodium rossulatum* occurring frequently on rock outcrops.

Three mammals occurring within Tapia forests are known to be hunted: *Echinops telfairi*, *Setifer setuosus* and *Tenrec ecaudatus* (Kull 2003a). Insects occurring within this ecosystem include *landibe* (*Borocera cajani*) or wild silk moth (Razafimanantsoa *et al.* 2012).

Figure 1a.

Figure 1b.

Figure S14. 1. (a) Tapia forest on Iron stone hill sides. The dominate canopy tree seen here is *Uapaca bojeri*. Near Isalo National Park Madagascar (Justin Moat). (b) Tapia forest on Sandstone. The

dominate canopy tree seen here is *Uapaca bojeri*. South of Isalo National Park Madagascar (Justin Moat).

Abiotic environment

Tapia forest typically occurs at 500–1,800 metres elevation above sea level on dissected terrain. Edaphic factors are likely to determine Tapia distribution (Kull 2003a, 2003b, 2004). Soils are derived primarily from basement gneiss, quartzite, schist, with frequent intrusions of granite. In the Isalo region (southern extent of the habitat) the forest is on eroded ruiniform sandstone, soils tend to be acidic.

Tapia forest occurs within sub-humid to sub-arid climates (Cornet 1974), although the average annual rainfall ranges from 900 mm up to 1,400 mm with 80–90 rainy days (Gade 1985). Tapia forest tends to occupy rain shadow microclimates, where rainfall is lower and temperatures are higher than the surrounding areas. The dry season ranges from non-existent to eight months or more, though typically occurs from May to September. Following the Köppen–Geiger scheme Tapia forest occurs typically in the tropical savanna to humid subtropical climate.

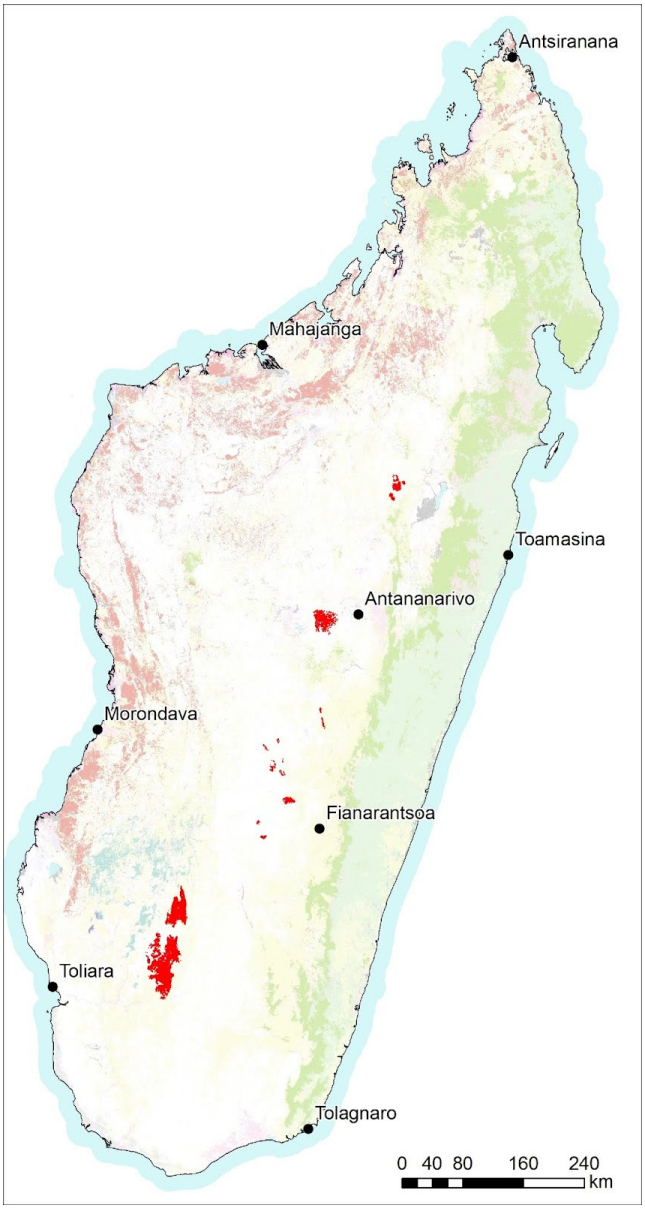

Figure S14. 2. Distribution of Tapia forest (in red, background is vegetation of Madagascar). Extent of vegetation as of 2000 (Moat and Smith 2007)

Distribution

Tapia occurs on the western and central parts of the main plateaux of Madagascar, approximately 17 - 24°S and 44.5 - 48°E (Rabehevitra & Rakotoarisoa 2007, Fig. S13.2). Substantial stands of Tapia forest occur in the south and in Isalo National Park. Smaller patches occur around Ambatofinandrahana and surrounding areas (central Madagascar west of Fianarantsoa) and Morarano (north-east of Antananarivo).

Key processes and interactions

Fire is highly influential in the distribution and diversity of Tapia forest, influencing both survival and regeneration of its component species (Rabehevitra & Rakotoarisoa 2007). this has both positive (see threatening processes) and negative aspects. Other key factors that determine the distribution of Tapia are not clear, although edaphic (soil) factors are likley to have an influence, as Tapia forest is often found on nutrient-poor rocky soils with granites and gneisses (Kull 2003a).

Interactions involving humans also influence the dynamics of Tapia forest, with burning practices likely to have involved significant modification of the system over the 1500 years of human occupation. 'Tapia' itself (*Uapaca bojeri*) is an endemic

species valued for its edible fruit which is high in Vitamin C, also the bark is used in Malagasy folk medicine to relieve diarrhoea (Gade 1985). These uses may influence the dispersal of seeds. In addition, this species is highly prized because it hosts silk worms and thereby supports village-based silk industries, which often afford it some local protection. *Uapaca* usually resprouts from roots and stumps, but can also regenerate through rhizomes and via seed dispersal (Kull 2003a).

Threatening processes

Tapia forest occurs throughout Madagascar's plateau areas, which has ensured its exposure to multiple human pressures including: charcoal manufacture, firewood and timber collecting, grazing and change in fire regime (Rabehevitra & Rakotoarisoa 2007). These threats result in transformation of Tapia forest to grassland. Individual Tapia trees have the ability to regenerate vegetatively when burnt. However, if fires are too frequent, they limit regeneration and species diversity of the herb layer can become very low. Tapia is not ideal for charcoal production due to its slow growth and low energy output, but the human pressure and lack of any alternatives, have dramatically increased the charcoal production from Tapia since the 1970's.

Kull (2003b, 2004) argues that Tapia forest owes its existence to fire, and he rebuffs the assertion that the woodlands are reducing with repeated burning. Small studies in Itermo (central Madagascar around Ambatofinandrahana) and Afotsara region (central Madagascar, between Ambostra and Ansirabe) have shown the forest to be generally stable with a few areas of increase. On the other hand, recent fieldwork south of Isalo has highlighted the increased use of Tapia for charcoal production to fuel the population influxes in the main due to localised mineral mining in the region.

An additional threat comes from non-native species (*Pinus* in the main, but also *Eucalyptus* sp.) that can encroach on Tapia forest and may affect local conditions e.g. soil characteristics, flammability and shade, although further work is needed to understand the extent of this disturbance (Kull 2003a).

Ecosystem collapse

For assessment of criteria A and B, it was assumed that Tapia forest will collapse when its mapped distribution declines to zero.

ASSESSMENT

Summary

Criterion	A	B	C	D	E	overall
subcriterion 1	DD	VU	DD	DD	DD	EN
subcriterion 2	DD	LC	DD	DD		
subcriterion 3	EN	LC	DD	DD		

Criterion A

Current decline: Limited data exist to quantify the current rate of decline (i.e. over the past 50 years) in the distribution of Tapia forest, as this ecosystem is not well respresented in some country-wide mapping of the region.

Moat and Smith (2007) use Harper *et al.* (2007) to show the general trend for the main vegetation types of Madagascar, they quote a 43% reduction in Tapia forest for a 25 year period from 1975 to 2000. However, vegetation types that occur characteristically in small patches (of which Tapia is included) are problematic to classify (Moat and Smith 2007), and the same areas were often classified very differently by Harper *et al.* (2007) and Moat and Smith (2007) due to differences in classification and

mapping methods. Inspection of the data of Harper *et al.* (2007) shows that very little of the Tapia was mapped in 1975, probably because this vegetation can be sparser and occurs in smaller patches compared to the dry and humid forest vegetation types, which were the main vegetation types in that study. The estimates of decline in distribution based on a comparison of mapping from these different sources are thus too uncertain to use for assessment of criterion A1. Further work is needed to clarify the recent changes in Tapia forest extent. As a result, the ecosystem is assessed as Data Deficient (DD) under criterion A1.

Future decline: As of 2006, 20% of the area of Tapia forest was protected in national parks (mainly in Isalo National Park). Proposed increases in number and area of protected areas (SAPM 2011) may eventually limit the ongoing decline in distribution of Tapia forest, if management of these reserves is able to eliminate exploitative activities such as wood harvesting and charcoal production. As present rates of decline are poorly known, however, there is little to drive any analysis of projected declines. Modelling responses to climate change could provide appropriate data for this criterion, but until that is carried out the rating under criterion A2 should be classified as Data Deficient (DD).

Historic decline: The current distribution of Tapia forest is most likely a remnant of a larger and more diverse forest (Kull 2003b, 2004) transformed since the arrival of humans some 1500 years ago. Although the estimates of decline (Table 1) span the entire period of human occupation, it was assumed that most (though not all) of the decline occurred since 1750 due to the increase in human population and activity during this latter period. O'Connor (1996) after Jarozs (1993) states that deforestation started "with the movement of population into the forests after 1896 and [the] French annexation [of Madagascar]".

The magnitude of historical decline was estimated by comparing environmental niche models with maps of present-day distribution. The niche models were developed by applying MaxEnt v3.2 with default settings (Phillips & Dubik 2008) to Bioclim variables (http://www.worldclim.org/bioclim) with sample points selected randomly from mapped Tapia forest over multiple iterations (J. Moat, unpubl.). Similar models were developed for other vegetation types, and Tapia forest was mapped only in pixels where it had the highest suitability value across all vegetation types. Models showing maximum and minimum extent were selection for analysis. The availability of alternative models and maps made it possible to account for uncertainty in estimates of distribution at each point in time. Niche models calculated for Tapia in comparison to the other primary vegetation in the region (unpublished) give a minimum area of 13,900 km^2 and a maximum area of 26,200 km^2. Estimates of present day extent of Tapia forest vary from 1,319 km^2 (Moat and Smith 2007) to 2,600 km^2 (DEF 1996), this variation will be largely due to the methods and scale of mapping. Total historical decline was therefore estimated to be between 81.3% and 95.0% by combining area estimates obtained from different pairs of maps (Table S12.1).

Allowing for a small amount of over-prediction and deforestation prior to 1750, and given qualitative evidence of ongoing declines from the 1990s to present, the decline in distribution since 1750 was therefore assumed to be within the bounds of 70% to 90%. Tapia forest was thus assessed as **Endangered** under criterion A3.

Table S14.1. Estimated historical decline in Tapia based on alternative models of historical distribution and alternative maps of present-day distribution.

	Maximum modelled area **26,200 km^2**	Minimum modelled area **13,900 km^2**
DEF - coverage early 1990's **2,600 km^2**	90.0% decline	81.3% decline

Moat and Smith - coverage in year 2000: **1,319 km^2**	95.0% decline	90.5% decline

Criterion B

Approximately 1,319 km2 of Tapia has been mapped from landsat satellite imagery (Moat and Smith 2007) for the year 2000. Tapia forest is often highly fragmented and sparse within the landscape.

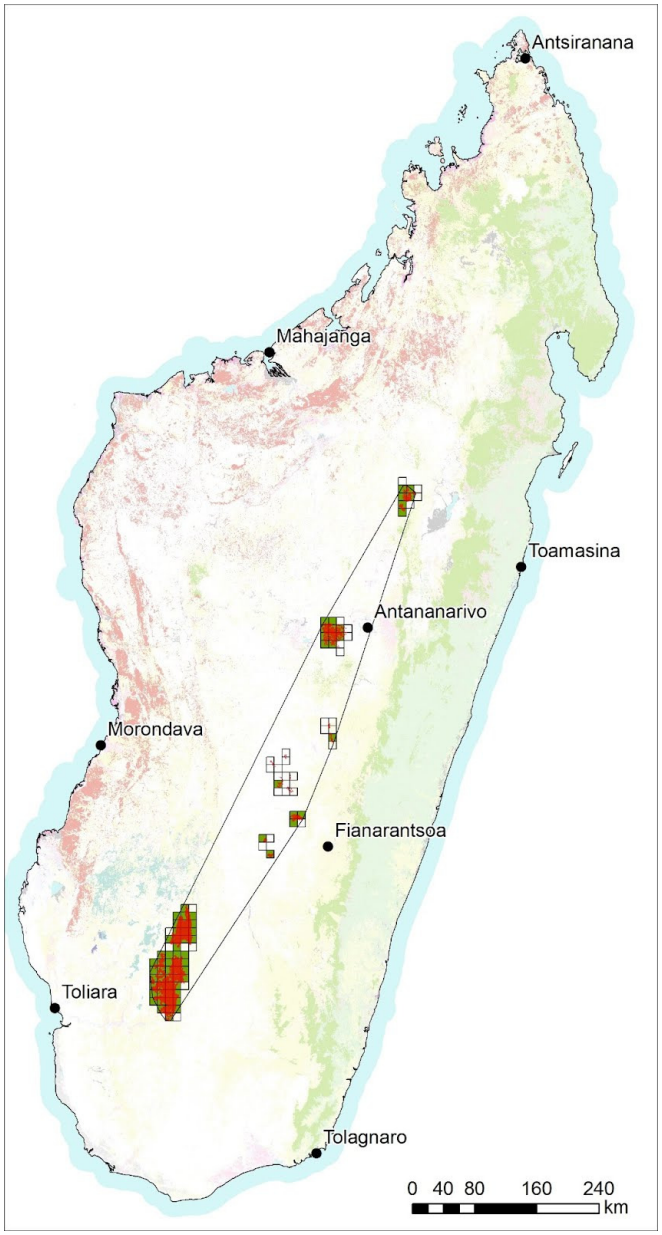

Figure S14. 3. Distribution of Tapia after Moat and Smith 2007, showing minimium convex polygon (extent of occurrence). Cells 10 x10 km (Area of occupancy) green cells are occupied with more than 1% occupancy, white cells less than 1%.

Extent of occurrence: The minimum convex polygon enclosing all occurrences (Figure S12.3) as mapped in 2000 (Moat and Smith 2007), has an area of 47,485 km2. There is good evidence for a decline in distribution (see criterion A1). Little work has been done on the future decline and quality of the ecosystem, but ongoing human pressures and plausible climate change scenarios suggest that the ecosystem is undergoing a continuing decline in distribution. Also we have observed that the ecosystem exhibits less biodiversity (and therefore decline in quality) in areas of frequent fires, especially those areas not formally protected or not safeguarded by local human populations. Insufficient information about the spatial pattern of threats precluded an estimate of the number of locations. Therefore, the status of the ecosystem under B1a(ii)b is Vulnerable.

Area of occurrence: Spatial analysis revealed that 108 10 x 10 km cells were occupied with Tapia Forest, of which 73 had over 1% level of occupancy (Figure S12.3). This estimate of Area of Occupancy is beyond the 50 grid cell threshold for Vulnerable, and hence Tapia forest was assignd a status of Least Concern under Criterion B2.

Number of locations: As noted above, too little is known about the spatial patterns of threatening processes to estimate the number of locations. Although threats are ongoing, they are not likely to rapidly affect the ecosystem. Hence the second requirement of criterion B3 is therefore unlikely to be met, even though the number of locations is unknown. The status of the ecosystem under Criterion B3 is therefore Least Concern.

Criteria C and D

Tapia forest is too poorly studied to estimate the extent and magnitude of degradation in abiotic components or biotic processes and interactions within the ecosystem. Some of the Tapia forest will have low diversity due to fire and mans influcence, but a present it would be very difficult to disentangle this from the abiotic influences (ie soils, microclimate etc). The status of the ecosystem is therefore Data Deficient under criterion C and D.

Criterion E

No quantitative analysis has been carried out to assess the risk of ecosystem collapse for Tapia forest. The status of the ecosystem is therefore Data Deficient under criterion E.

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