FLORA

OF MADAGASCAR

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CCI IVATO ANTANANARIVO

Originality

Madagascar = « megabiodiversity », with 5 % of the world biodiversity (CDB, 2014).

⇔ originality et diversity with high **endemism**.

*one of the 25 *hot spots*

7/9 species of Baobab in Madagascar with 6 endemics : *Adansonia grandidieri*, *A. rubrostipa, A. za*, *A. madagascariensis*, *A. perrieri* et *A. suarezensis*.

Endemism

Endemism : *species : 85 % - 90 % (CDB, 2014)

*families : 02,46 %

* genera : 20 à 25 % (SNB, 2012)

*tree and shrubs (Schatz, 2001) :

- familles : 48,54 %
- genres : 32,85 %
- espèces : 95,54 %

Families	Genera	Species
ASTEROPEIACEAE	1	8
SPHAEROSEPALACEAE	1	1
SARCOLAENACEAE	10	68
BARBEUIACEAE	1	1
PHYSENACEAE	1	2

Archaism

•DIDIEREACEAE in the south⇔ many affinities with the CACTACEAE confined in South America : *Faucherea laciniata - Callophyllum parviflorum*

- **Real living fossils species** : * *Phyllarthron madagascariensis* : with segmented leaves

  * species of *Dombeya* : assymetric petales

  * genera endemic *Polycardia*, ex : **P. *centralis* : inflorescences in nervation of the leaf**

*** *Takhtajania perrieri* : Witness living on the existence of primitive angiosperms of the Cretaceous in Madagascar**

Tahina spectabilis (Arecaceae)
Only in the west of Madagascar
In extinction (UICN, 2008)

Metz, 2008)

Inflorescence : ~4 m

Estimation of the floristic richness

(IUCN/UNEP/WWF, 1987; Koechlin et *al*., 1974; Callmander, 2010)

Authors	years	Families	Genera	Species
Perrier de la Bathie	**1936**	**191**	**1289**	**7370**
Humbert	1959	207	1280	10000
Leroy	1978	160	-	8200
White	1983	191	1200	8500
Guillaumet	1984	180	1600	12000
Phillipson *et al.* Goodman	2006 2008			14000
Callmander	2010			14886
Rabarimanarivo et al., (Madcat)	**2014**			**11386 + 1500 sp inconnues**
MEEFM	**2014**			**12000-13000**
CDB	**2014**	**200 à 216**		**13000-14000**

New taxa endemics

Genera and species	FAMILIES	AUTHORS	YEARS
Uvaria lombardii L. Gaut. & Deroin	**ANNONACEAE**	Gauthier et Deroin	2013
Pandanus tsingycola Callm. & Nusb.	**PANDANACEAE**	Callmander et al.	2013
Three new *Aloe* species		Letsara et al.	2012
151 species of *Aloe*		Klopper et al.	2013
Angraecum potamophilum	**ORCHIDACEAE**	Gautier et al.	2013
Tsingya bemarana	**SAPINDACEAE**		
Euphorbia pirahazo	**EUPHORBIACEAE**		
86 % species	**ORCHIDACEAE**	Rakotoarivelo et al.	2013
Bryophytes group		**Lovanomenjanahary & al.,**	**2012-2014**
		Andriamanantena *et al.*	***2014***
		Reeb et al. (sous press)	**2015**
1/106 of genera 265/586 species	**PTERIDOPHYTES GROUP**	eflora	2009
99 % of species 3 / 154 of *Dypsis* species	**ARECACEAE**	Rakotoarinivo et al.,	2013
292 species	fungi /microorganisms	CDB	2014
170 à 190 species	**BALSAMINACEAE**	Rahelivololona	2008

Floristic richness and plants litteratures

47/48 species of *Dalbergia* endemics (MBG, 2013)

Diospyros : 130 new species (MBG, 2013)

LITTERATURES

- Madagascar naturally
- Revision of malagasy taxa (AETFAT Congress , 2014)
- Catalogue des plantes menacées de Madagascar

Ravintsara

MCD

Vahatra

Tohiravina

Honko

Paysages naturels de Madagascar

Articles in scientific webs

Web UICN

Tropicos – MADCAT-eflora- …

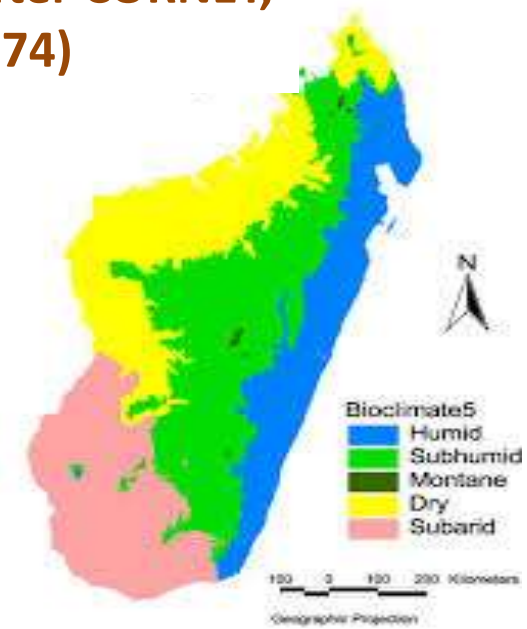
Malagasy flora affinities

- Africa

⇒Especially the soudano-zambezienne region of Africa and the occidental region of Madagascar

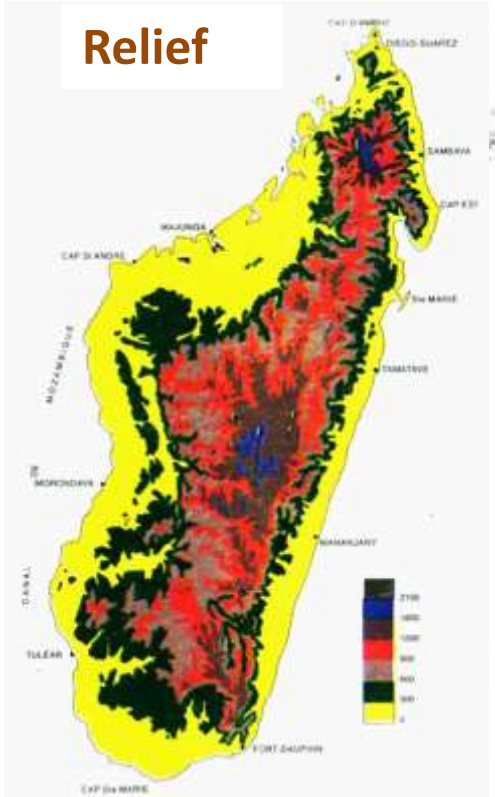
- Indo-Australo-Malaise (Schatz, 1996).

BIOCLIMAT 5 (after CORNET, 1974)

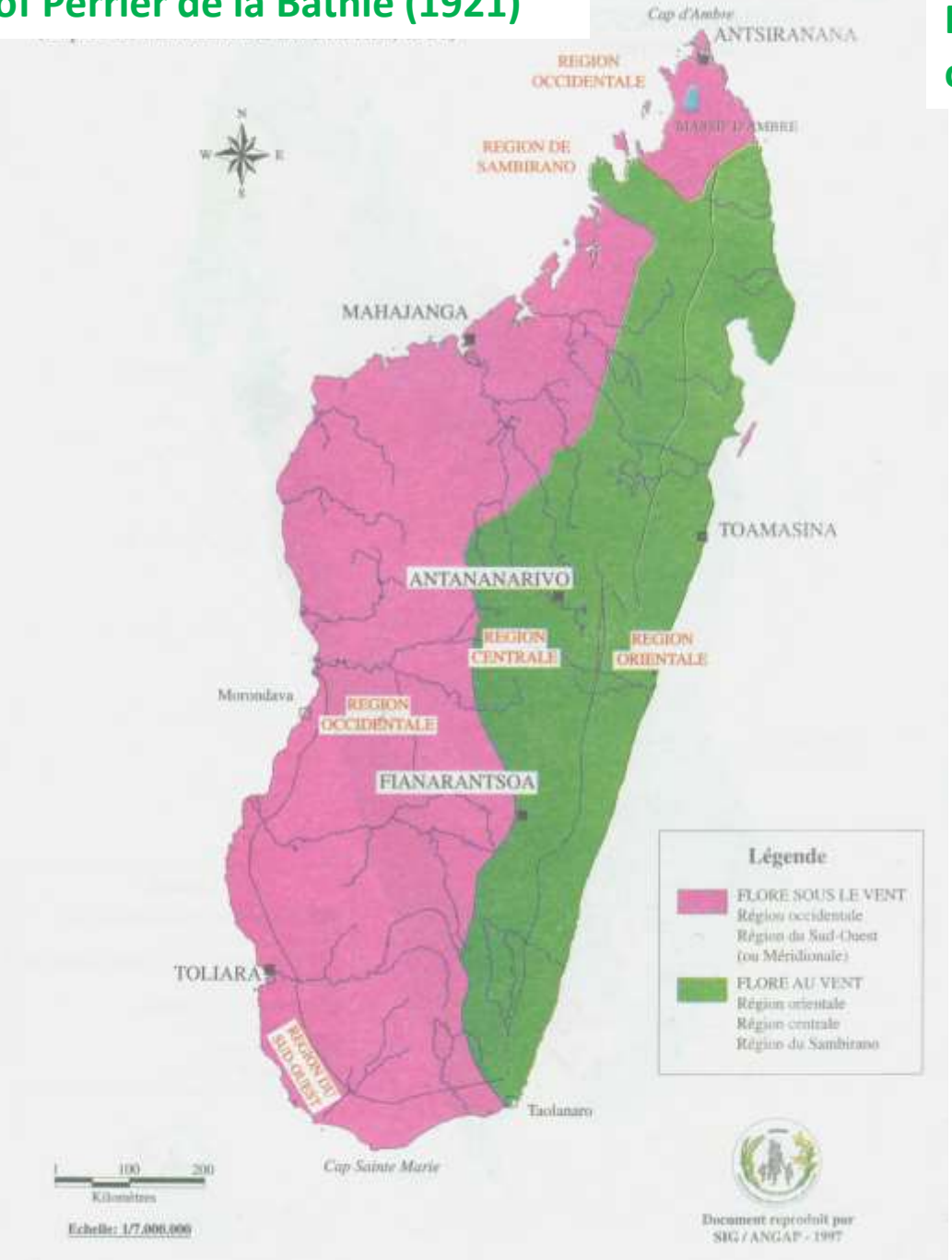


Simplified Geology Map of Madagascar (DUPUY & MOAT 1995)

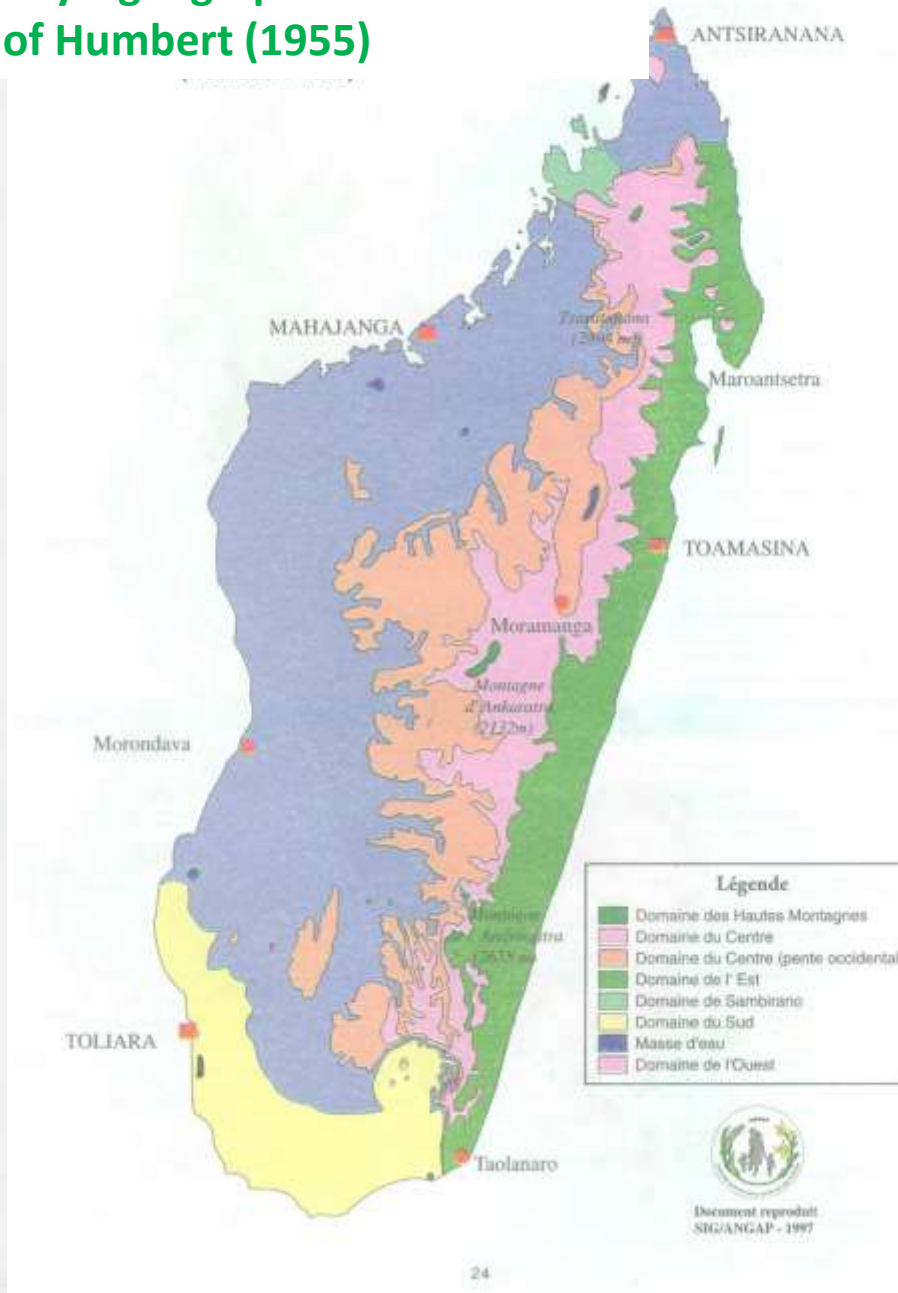
Relief



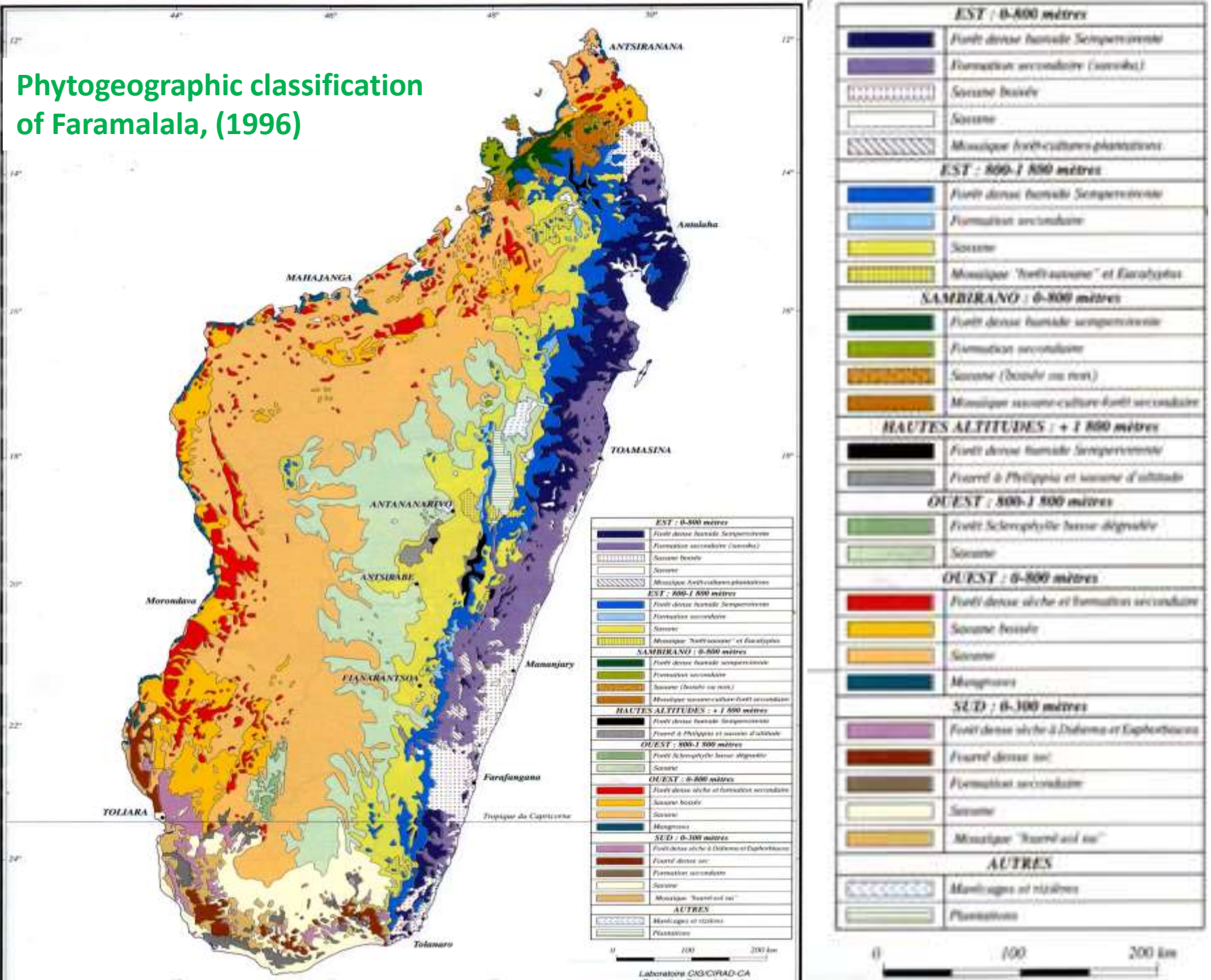
Phytogeographic classification of Perrier de la Bathie (1921)



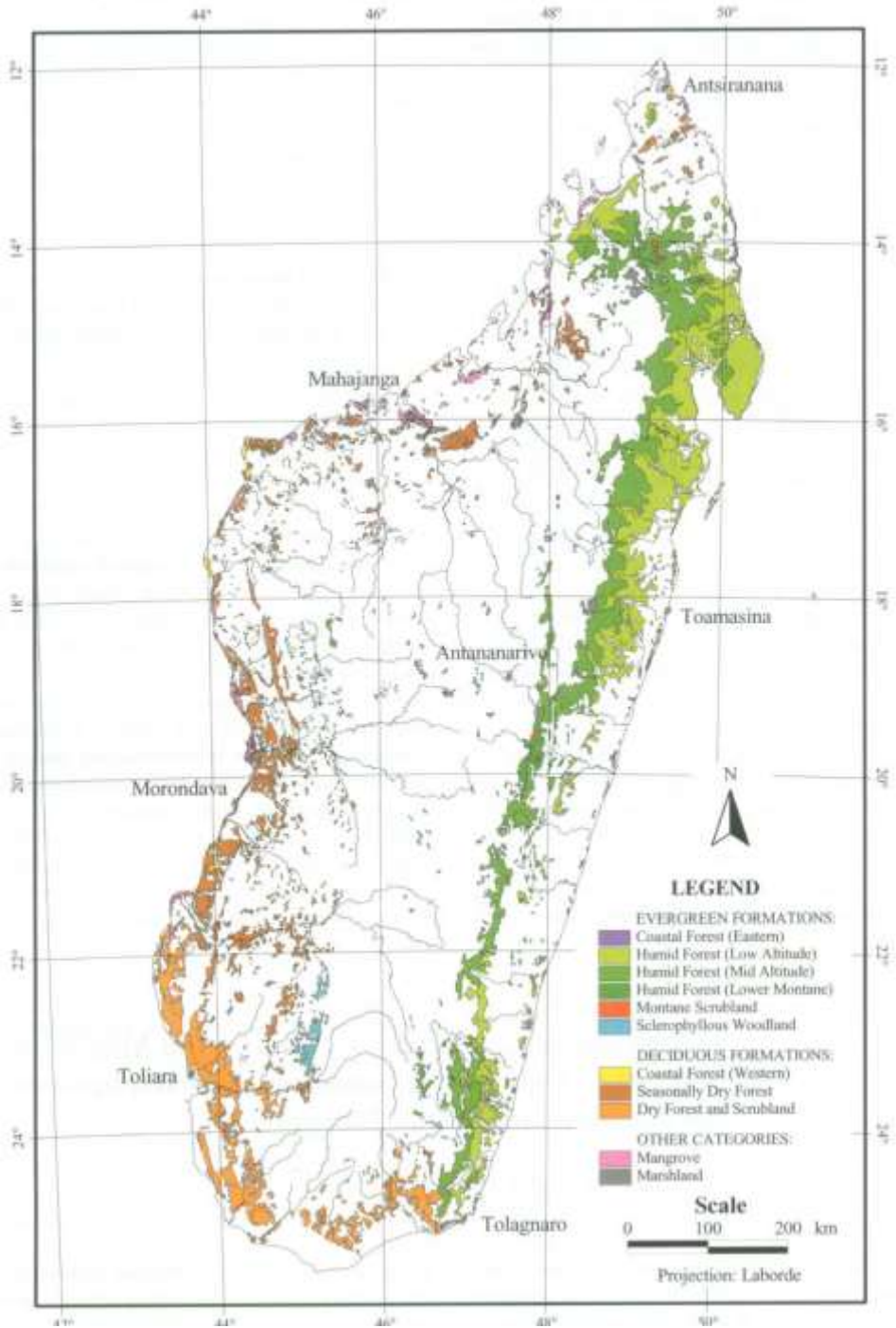
Phytogeographic classification of Humbert (1955)



Phytogeographic classification of Faramalala, (1996)



EST : 0-800 mètres
Forêt dense humide Sempervirente
Formation secondaire (savoka)
Savane buissonnante
Savane
Mosaïque forêt-cultures-plantations
EST : 800-1 850 mètres
Forêt dense humide Sempervirente
Formation secondaire
Savane
Mosaïque "forêt-savane" et Eucalyptus
SAMBIRANO : 0-800 mètres
Forêt dense humide sempervirente
Formation secondaire
Savane (buissons ou tavy)
Mosaïque savane-culture-forêt secondaire
HAUTES ALTITUDES : + 1 800 mètres
Forêt dense humide Sempervirente
Fourré à Philippia et savane d'altitude
OUEST : 800-1 800 mètres
Forêt Sclerophylle basse déguradée
Savane
OUEST : 0-800 mètres
Forêt dense sèche et formation secondaire
Savane boisée
Savane
Mangroves
SUD : 0-300 mètres
Forêt dense sèche à Didiereas et Euphorbiaceae
Fourré dense sec
Formation secondaire
Savane
Mosaïque "fourré-sol nu"
AUTRES
Mangroves et rizières
Plantations
0
100
200 km



Madagascar Remaining Primary Vegetation
Phytogeographic classification
(Dupuys, 1996)

EVERGREEN FORMATIONS
Coastal forest Eastern
Humid forest low altitude
Humid forest mid altitude
Montane scrubland
Sclerophyllous woodland

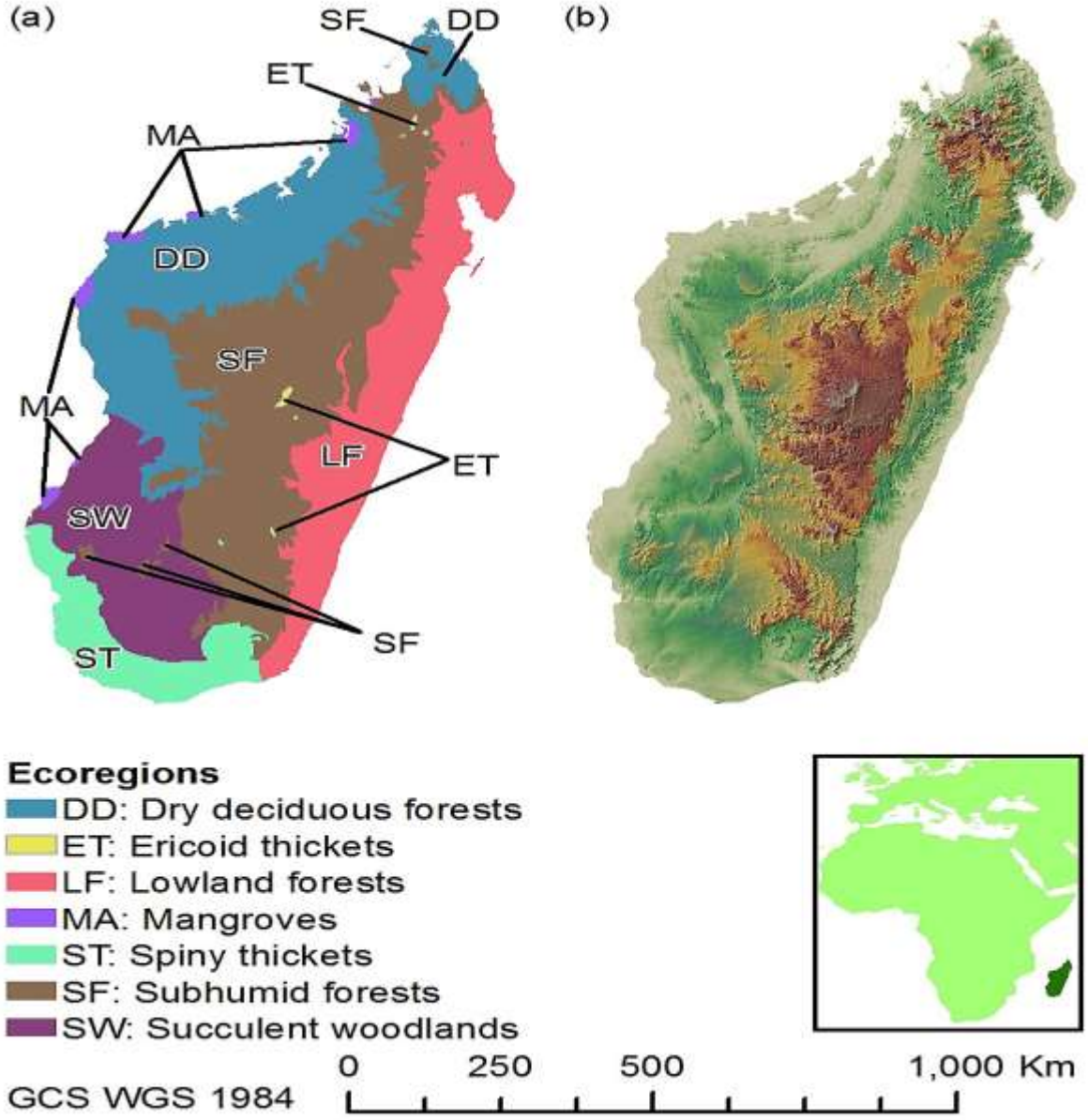
DECIDUOUS FORMATIONS
Coastal forest western
Seasonally dry forest
Dry forest and scrubland

OTHER CATEGORIES
Mangroves
Marshland

15 types of ecosystems in Madagascar (Moat & Smith, 2007)

Types of forest ecosystems	Surface (km²)	% of land cover
Forêt humide	47 637	8,06
Forêt humide dégradée	58 058	9,81
Forêt humide de l'Ouest	72	0,01
Forêt de Tapia	1 319	0,22
Forêt subhumide de l'Ouest	4 010	0,68
Forêt sèche de l'Ouest	31 970	5,40
Forêt épineuse du Sud-Ouest	18 355	3,10
Forêt sèche épineuse dégradée du Sud-Ouest	5 427	0,92
Mangroves	2 433	1,43
Forêt littorale	274	0,05

www.mobot.org



Site map showing the (a) **seven ecoregions** on which the analyses focused and (b) relief map of Madagascar, constructed using hill shade. Geographical Coordinate System (GCS) using the WGS1984 datum. *(Brown et al., 2015)*

doi:10.1371/journal.pone.0122721.s001
(published by GBIF)

Brown KA, Parks KE, Bethell CA, Johnson SE, Mulligan M (2015) Predicting Plant Diversity Patterns in Madagascar: Understanding the Effects of Climate and Land Cover Change in a Biodiversity Hotspot. PLoS ONE 10(4): http://127.0.0.1:8081/plosone/article?id=info:doi/10.1371/journal.pone.0122721

Evergreen formation (East and Center)

Humid forest low altitude (Eastern)

Humid forest mid altitude (Center East)

Sclerophyllous formation
(Center-West) (Bois de Pente Occidental)

Montane forest (Center)

Dry forest / Deciduous formation (West)

Alluvional forest

Tsingy / Karst vegetation (north-west)

Dry forest wih *Adansonia* (western)

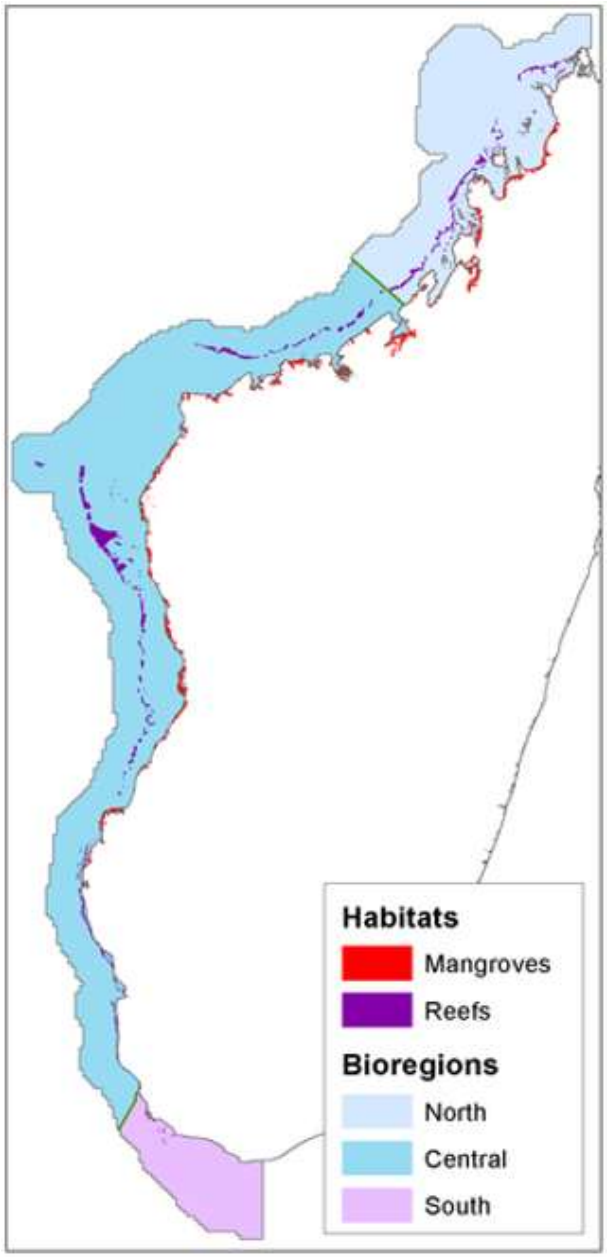
Arid forest (south west): xerophytic bush with Didiereaceae

(Rajeriarison, 2010)

3 bioregions of mangroves

* North-west unit : at Cap d'Ambre to 15 km of the Mahajanga Town,
*Central unit in the north of Mahajanga at 150 km in the south of Toliara and
*South unit : south of Toliara around the cap of Vohimena (Allnutt *et al.* 2012).

*Based on **Harper et al., (2007) and Moat et Smith (2007) studies.** ⇔ spatial data collected for three variables relevant to conservation decisions across the study area : fishing pressure, exposure to thermal stress, and biodiversity **all the west region is exposed , with need of priority conservation in the south**



Mangroves, geomorphologie des récifs coralliens et bioregions (Alnutt et al., 2012)

Natural phytogenetic ressources

***Wild crop:**

*Two species of wild rice : *Oryza longistaminata* et *O. punctata*, (E, W, N)

*Sorgho : Sorghum verticiflorum, (Moyen Ouest).

*Vigna : *Vigna vexillata* et *Vigna angivensis*, (Fabaceae); * Tubers : Yams : *Dioscorea* (DIOSCOREACEAE),

***Wild fruits :** *Uapaca bojeri*, *Strychnos*, *Physalis* et de *Cactus*, *Adansonia*, varieties of fruits (*Citrus*), *Musa perrieri*

Intraspecific genetic diversity by molecular biology on : *Dalbergia monticola, Albizia gummifera, Aphloia and Ravensara*. Precious wood : *Dalbergia* and *Diospyros*

Study of origins on : *Khaya madagascariensis, Liquidambar styraciflua, Eucalyptus spp, Pinus spp, Cupressus lusitanica, Locust tree spp and increased Tectona*

80 varieties of batata – 31 varieties of Manihot – 60 varieties of mayz
25 varieties of potatoes (CDB, 2014)

Andrianasetra, 2006

Natural phytogenetic ressources

- **Spice plants**: wild pepper plant ou **Tsiferifery**, hot pepper, *Aframomum*, *Curcuma*, , etc....
- **Fibre crop :** *Raphia farinifera* (Arecaceae) ; *Urena lobata*. *Agave cisalana* (MALVACEAE).
- **Cash crop :** *Vanilla decaryana*, *V. madagascariensis*, *V. montagnaci* et V. *perrieri*; 50 species of *Coffea* (Mascarocoffea*)*
- **Precious wood:** **Anakaraka** (Cordyla madagascariensis), **Fahavalonkazo** (Xanthoxylon sp), **Hazomainty** (Diospyros sp), **Hazomalany** (Hernandia voyroni), **Hazomena** (Khaya madagascariensis), **Hintsy** (Afzelia bijuga), **Manary** (*Dalbergia* sp), **Merana** (Brachylaena sp), **Volombodimpoana** (*Dalbergia*), **Torotoro** (*Gluta turtur*), **Vory** (*Chlorophora graceana*), **Lalona** (*Weinmannia* sp).
- **Aromatics and medicinales plants *: 2250/***12.000 species médicinales, with 18,95%. 80 genres et 196 familles. 39,6% endemic species and 8,5% endemic genera (CDB, 2014)

Introduced Plants

- 546 species introduced naturalized,
- 611 species introduced and naturalized
- 211 species with incertain statut

(CDB, 2014).

- The most represented of the families :
  - FABACEAE (224 species),
  - MYRTACEAE (143),
  - POACEAE (71),
  - CACTACEAE (52),
  - ASTERACEAE (50)
  - SOLANACEAE (33).
  - (Kull *et al*., 2012)

Introduced plants

- **Crop species**
- **From America :** *Vanilla fragrans, Zea mays, Arachis hypogea, Theobroma cacao, Ipomoea batatas* ;
- **From Asia** : *Piper nigrum, Musa spp, Mangifera indica, Colocasia esculenta* ; *Oryza sativa, Coffea spp*), *Vigna spp, Dioscorea spp*.


Ranarijaona, 2010


Andrianasetra, 2009

Invasive Alien Species (IAS)

- CDB Conference
- **IPBES e-conference on september 2015 :**

1) invasive alien species and their control (IAS)

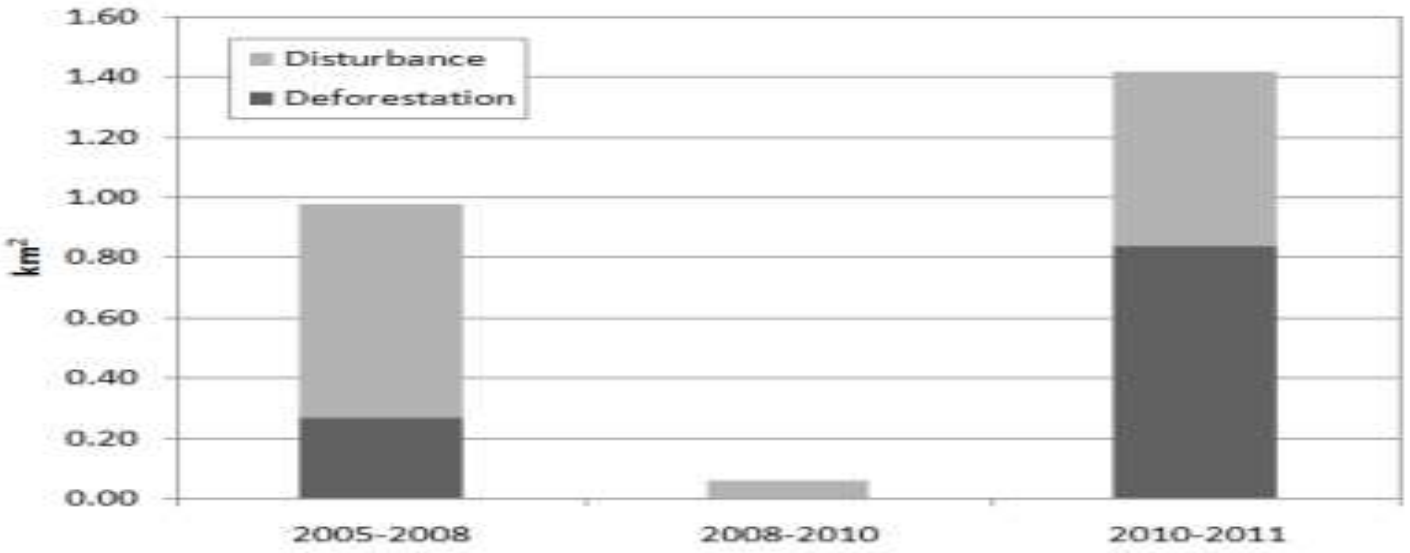
2) sustainable use of biodiversity and strengthening capacities and tools (SUB)

- Not many data published

Eichhornia crassipes, *Clidemia hi*
Psidium cattleyanum,

THREATS

Threats



(Alnutt et al., 2013)

Zone bioclimatique	Couverture des forêts naturelle (ha)		Taux de déforestation (% par an)
	2005	2010	
Humide	4 702 020	4 658 155	0,2
Sèche	2 628 029	2 554 746	0,6
Epineuse	2 070 632	2 009 792	0,6

Source : ONE, 2013

Fires (2007-2011)

,

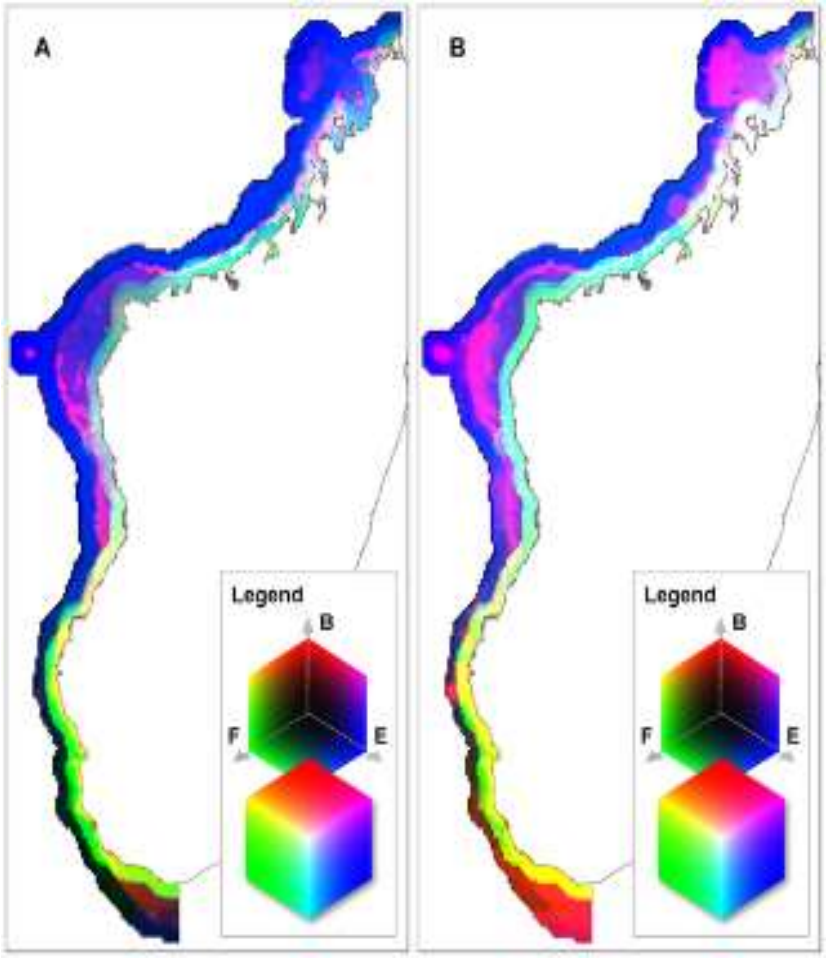
Année	Feux forêt	Feux non forêt	Total points de feux
2007	5971	56601	62572
2008	5125	41104	46229
2009	8274	50275	58549
2010	5092	42730	47822
2011	8472	50189	58661

Source: DGF/DVRN/SABVRGF.

(Cited by RANDRIANAVOSOA, 2012)

Threats on malagasy mangroves ⇔ raise 0,2 % of surface every 10 years (FAO, 2003)

Two results of RGB visual overlay of primary variables (biodiversity, fishing pressure, exposure) (Alnutt et al., 2012).



A: Biodiversity value expressed as fish species richness; B: Biodiversity value measured using the Zonation algorithm. Key shows classification in 3-dimensional RGB color cube, with biodiversity (letter B in the key) assigned to Red (z-axis), fishing (F) assigned to Green (y-axis), and exposure (E) assigned to Blue (x-axis).

Loss of diversity at the Fofifa collections *ex-situ* (CDB, 2014)

Année	1996	2006	2013	Détenteur
Arachide	349	275	243	FOFIFA
Blé	169	Abandonné	-	FOFIFA
Blé	2570	352	-	FIFAMANOR
Café	1282	3300	166	FOFIFA
Canne à sucre	338	Abandonnée	-	FOFIFA
Coton	160	912	-	Hasyma
Haricot	321	222	108	FOFIFA
Maïs			184	FOFIFA
Manioc	330	202	-	FOFIFA
Poivrier	195	Abandonné	-	FOFIFA
Riz	4127	6210	6210	FOFIFA
Soja	272	Abandon	3 (Reprise en cours)	FOFIFA
Vignes	135	98	51	FOFIFA
Voandzou	28	47	47	FOFIFA

Source : DRA /FOFIF

Modified vegetation

(south east)

Savoka à *Ravenala* (east)

Savannah with *Bismarckia* (WEST)

Measures taken against threats

- Governent political environment
- Research projects,
- Protected areas,
- Conservations *ex-situ*,
- Conservation projects
- International and national Financial supports
- **Proposed REDD projects**

5 REDD Pilot Projects in Madagascar .
* Makira – Makira Carbon Company (MCC) and Wildlife Conservation Society (WCS);
* Ankeniheny to Zahamena Forest Corridor (CAZ) – Conservation International;
* Fandriana to Vondrozo Forest Corridor (COFAV) – Conservation International;
*Holistic Forest Conservation Programme (PHCF) – WWF and Good Planet;
* FORECA – GTZ/Inter - cooperation.

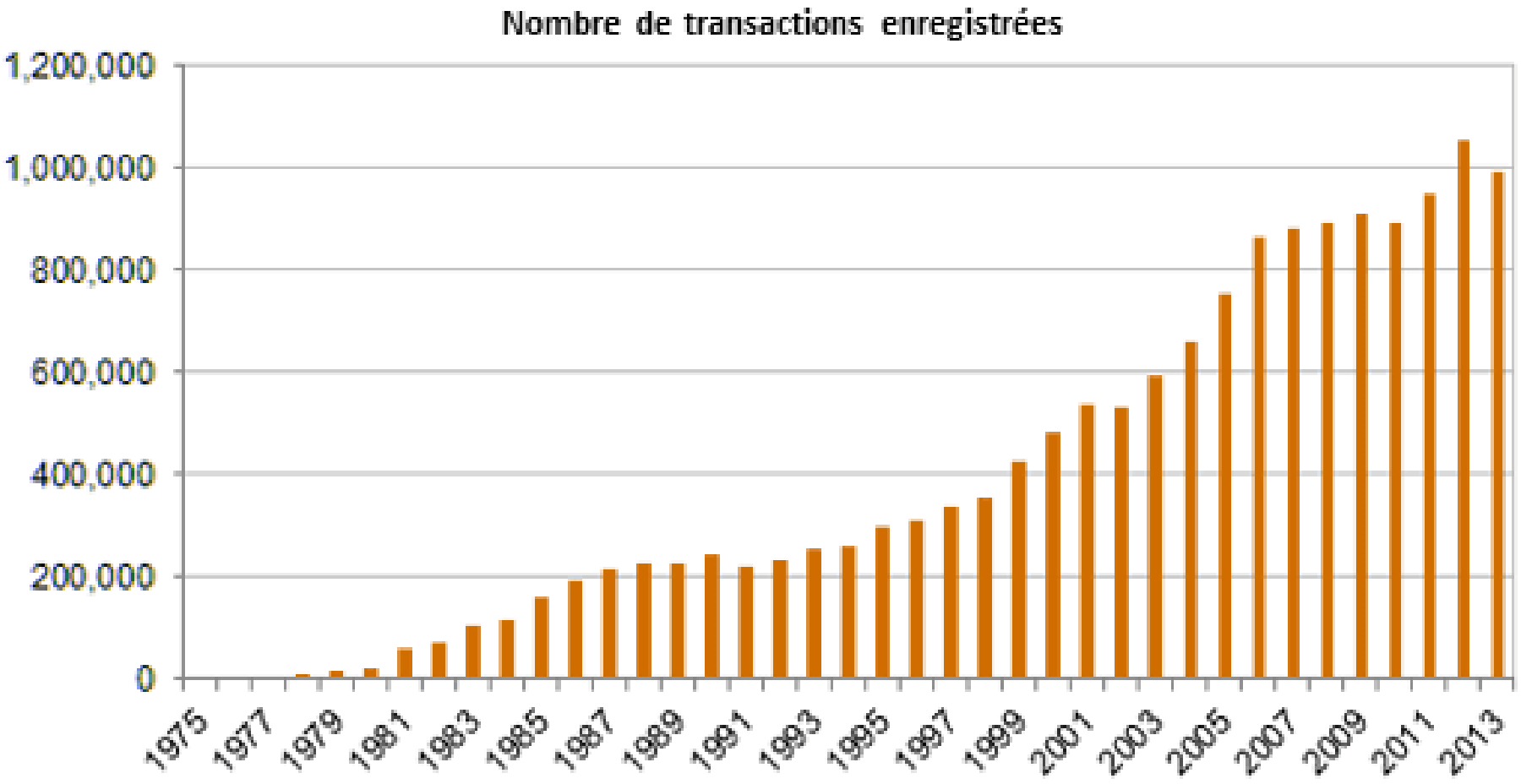
GSPM – CITES and UICN

- Since 2007, the GSPM has submitted about 700 species to IUCN's for validation.
- **On 2015 : ~1000 malagasy species are asssessed and/or validated; status according to Red List or/and CITES criteria**
- ~ 400 species published on IUCN red list;
- Assessments of CITES plants statuses are still ongoing and done by the CITES scientific authority for Flora whose members are also MPSG members: those plants are mainly **precious wood and succulent species.**

Species statute evaluated by CITES (2013) (CDB, 2014)

Nom des taxons	Statut de conservation					
	CR	EN	VU	NT	LC	DD
Diospyros	2	17	57	4		6
Dalbergia	8	18	12		5	
Euphorbia	8	6	3			
Palmiers	2	2	2			
Aloe		2	2			3
Cyphostemma			1			
Operculicarya				1		
Pachypodium			2			1
Senna			1			

CITES : Convention sur le commerce international des espèces de faune et de flore sauvages menacées d'extinction



https://www.cites.org/fra/disc/what.php consulté le 06/10/2015

Conservation *ex* situ in the Parc Botanique de Tsimbazaza (Rapanarivo, 2015)

	Familles	Espèces
Effectifs	6	39

Familles	**Espèces**
Asteropeiaceae	*Asteropeia labatii*
Physenaceae	*Physena sessiliflora*
Sarcolaenaceae	*Sarcolaena oblongifolia,*
	Schizolaena parvifolia
	Schizolaena microphylla
	Xerochlamys tampokensis
	Xerochlamys bojeriana
Sphaerosepalaceae	*Rhopalocarpus lucidus*

(Rapanarivo, 2015)

Conservation *ex* situ in the Parc Botanique de Tsimbazaza : (Rapanarivo, 2015)

B- APOCYNACEEAE	*Pachypodium densiflorum*
	P. brevicaule
	P. rutenbergianum
	P. widsorii
	P. meridionale
	P. sofiense
	P. inopinatum
	P. baronii
	P. lamerei
	P. geayi
	P. decaryi
	P. rosulatum
	P. gracilius
C- MALVACEAE (BOMBACACEAE)	*Adansonia rubrostipa*
	Adansonia za
	Adansonia suarezensis
	Adansonia grandidieri
	Adansonia madagascariensis
C- MALVACEAE (STERCULIACEAE)	*Dombeya mollis*
	Dombeya lucida
	Andringitra macrantha
	Dombeya cacuminum

Conservation *ex* situ in the Parc Botanique de Tsimbazaza (Rapanarivo, 2015)

ORCHIDACEAE	*Angraecum longicacar*
	Angraecum magdalenae
	Aeranthes henricii
	Grammagis spectabilis
	Bulbophyllum hamelinii
ARECACEAE	*Beccariophoenix fenestralis*
XANTHORRHOEACEEAE	*Aloe vaombe*
	Aloe henae
	Aloe suzannae

(Rapanarivo, 2015)

Conservation *ex* situ in the Mahajanga Reniala Park
Tahina spectabilis (Arecaceae) :
endemic species critically endangered

Age : 2 years, planted on january 2015 by the Doctoral School of Naturals Ecosystems (EDEN) University of Mahajanga

Conclusion and perspectives :
Malagasy flora = need of conservation priority

- **High elevation endemics are particularly vulnerable.**
- **Plant diversity is vulnerable** to both individual and combined effects of climate and land cover change
- Strengthen the international collaboration to protect the endangered species of extinction against the export
- need to **understand how climate and land cover change will affect plant diversity.**
- **Carry on the fructuous collaboration between ONGs, teacher searchers , students, searchers and their partnerships.**

** priorize the plant conservation projects

** **valorise all results published in many litteratures**

- Priorize research about bryophytes and aquatic plants, algal and fungi, and invasive allian species.

REFERENCES

-
- Allnutt, T. F., Asner, G. P., Golden, C. D. and Powell, G. V. N. 2013. Mapping recent deforestation and forest disturbance in northeastern Madagascar. Tropical Conservation Science Vol. 6(1):1-15. Available online: www.tropicalconservationscience.org
- **Ammann, M. 2011.** La presqu'île d'Ampasindava (Nord-Ouest de Madagascar): une région mal connue et menacée, capitale pour la compréhension de la mise en place de la flore du Domaine du Sambirano. Master en Biologie, Université de Genève, Genève.
- Barnabas H. Daru, Kowiyou Yessoufou, Ledile T. Mankga, T. Jonathan Davies. 2013. A Global Trend towards the Loss of Evolutionarily Unique Species in Mangrove Ecosystems. Plos. Published: June 21, 2013. DOI: 10.1371/journal.pone.0066686
- Brown KA, Parks KE, Bethell CA, Johnson SE & Mulligan M (2015). Predicting plant diversity patterns in Madagascar: understanding the effects of climate and land cover change in a biodiversity hotspot. PLoS ONE 10(4): e0122721. doi: 10.1371/journal.pone.0122721
- **Callmander, M. W., Bolliger, R., Hanitrarivo, M. & Nusbaumer, L. 2013.** *Pandanus tsingycola* Callm. & Nusb. (Pandanaceae), a new species endemic to western Madagascar. *Candollea*, 68: 229-235.
- **Callmander, M. W., Phillipson, P. B., Schatz, G. E., Andriambololonera, S., Rabarimanarivo, M., Rakotonirina, N., Raharimampionona, J., Chatelain, C., Gautier, L. & Lowry II, P. P. 2011.** The endemic and non-endemic vascular flora of Madagascar updated. *Plant Ecology and Evolution* 144: 121-125.
- **Cano, A. 2012.** Carte de feux en forêt de 2002-2011 Région Melaky. Conservation International.

- **Chatelain, C., Hanitrarivo, M. R., Rakotozafy, B. F. L., Bolliger, R, Luino, I., Ranirison, P. & Gautier, L. 2013.** Cartographie de la couverture forestière du massif de Beanka, Région Melaky, Ouest de Madagascar. *Malagasy Nature*, 7: 85-103.
- Clough BF (1993) The status and value of the mangrove forests in Indonesia, Malaysia and Thailand: Summary. In: Clough BF, editor. The economic and environmental values of mangrove forests and their present state of conservation in the south-east Asia/Pacific region. ITTO/ISME/JIA Project PD 71/89 Rev. 1, 1–10.
- Costanza R, d'Arge R, de Groot R, Farber S, Grasso M, et al. (1997) The value of the world's ecosystem services and natural capital. Nature 387: 253–260. doi: 10.1038/387253a0
- Direction Générale de la Météorologie : *Le changement climatique à Madagascar, m*ars 2008.
- **Gautier, L. & Deroin, T. 2013.** *Uvaria lombardii* L. Gaut. & Deroin (Annonaceae), une nouvelle espèce endémique de Madagascar, aux inflorescences spectaculaires.*Candollea*, 68: 237-244.
- **Letsara, R., Rakotoarisoa, S. & Almeda, F. 2012.** Three new *Aloe* species from Madagascar. *Malagasy Nature*, 6: 46-55.
- **Madagascar Catalogue. 2013.**Catalogue of the vascular plants of Madagascar. Missouri Botanical Garden, St. Louis, U.S.A. and Missouri Botanical Garden, Madagascar Research and Conservation Program, Antananarivo, Madagascar. Accessible à : http://www.efloras.org/madagascar.
- Ministère de l'Environnement. 2014. national de la Convention sur la Diversité Biologique Madagascar. Cinquième rapport Rapport CDB.
- **Ministère de l'Environnement.** Stratégie Nationale pour la Gestion Durable de la Biodiversité. Rapport national: 53p.
- Tadross M, Randriamarolaza L, Rabefitia Z, Ki Yip Z (2008) Climate change in Madagascar: recent past and future. Washington, D.C.: World Bank.
- **Timothée Ollivier:** *Natural capital and sustainable growth: a case study on Madagascar,* CERNA, 2008.

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