Modelling and scenarios of biodiversity-2013

Acronym	**BioSceneMada**	**Earlier proposal**	
Coordinator	VIEILLEDENT, Ghislain	**Affiliation**	CIRAD
English title	Biodiversity scenarios under the effect of climate change and future deforestation in Madagascar		
French title	Scénarios d'évolution de la biodiversité sous l'effet conjoint du changement climatique et de la déforestation à Madagascar		
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Keywords:
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Keywords:
biodiversité, changement climatique, déforestation, Madagascar, aires protégées, REDD+, zones refuge

Type of ecosystems studied:
terrestre, insulaire, tropical, forêt

Disciplines / fields of expertise of the participants involved:
biologie de la conservation, écologie, statistique, modélisation, informatique, politiques publiques et biodiversité, sciences naturelles (botanique, zoologie)

Geographical focus countries and regions (territories, areas, seas) concerned:
Madagascar, niveau national, forêt primaire subsistante

Project summary:
Madagascar is widely known for its exceptional biodiversity both in terms of number of species and high endemism rates. This unparalleled biodiversity is severely threatened by both climate change and deforestation, the latter being associated to a rapid population growth. Using biodiversity maps and biodiversity data collected by the REBIOMA project (http://data.rebioma.net), associated to recently published demographic and deforestation models (http://phcfM.sf.net), we first propose to estimate the loss of biodiversity that would be associated with various scenarios of demographic growth and deforestation at the national scale. Second, we propose to estimate the loss of biodiversity that would be associated with various climate change scenarios (IPCC scenarios A2a and B2a for example) deriving future biodiversity maps (obtained from climatic niche models), and identifying climatic refugea areas and areas with high risk of biodiversity loss. Third, we propose to estimate the loss of biodiversity under both the effect of climate change and deforestation. Comparing present and future maps of biodiversity, we propose to identify high priority areas for biodiversity conservation (future biodiversity hotspots under threat of deforestation for example). This results should help design a more effective protected area network in Madagascar and ensure that REDD+ national program occurring in Madagascar maximises the biodiversity co-benefits of new carbon projects.

Project summary:
Madagascar est reconnu pour son exceptionnelle biodiversité (nombre d'espèces et endémisme). Cette biodiversité est sévèrement menacée par le changement climatique et la déforestation, cette dernière étant liée à une croissance rapide de la population. En utilisant des cartes de biodiversité issues des données collectées par le projet REBIOMA (http://data.rebioma.net), ainsi que des modèles démographiques et de déforestation (http://phcfM.sf.net), nous proposons premièrement d'estimer la perte de biodiversité associée à différents scénarios de croissance démographique et de déforestation à l'échelle nationale. Deuxièmement, nous proposons d'estimer la perte de biodiversité associée à différents scénarios de changements climatiques (ex. scénarios A2a et B2a du GIECC) en produisant des cartes de biodiversité future (obtenues à partir de modèles de niche climatique) et d'identifier les zones refuges et les zones à fort risque de perte de biodiversité. Troisièmement, nous proposons d'estimer la perte de biodiversité associée à l'effet conjoint du climat et de la déforestation. En comparant les cartes présentes et futures de la biodiversité, nous proposons d'identifier les zones prioritaires pour la conservation de la biodiversité (ex. zones refuges à fort risque de déforestation). Ces résultats permettraient d'améliorer l'efficacité du réseau d'aires protégées et d'assurer que le programme national REDD+ maximise les co-bénéfices des projets carbone pour la biodiversité.

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BioSceneMada

Biodiversity scenarios under the effect of climate change and future deforestation in Madagascar

1 Project description for non-research audience.

Séparée de l'Afrique puis de l'Inde il y a respectivement environ 165 et 88 millions d'années, la faune et la flore de Madagascar ont évolué de façon isolée. L'île est mondialement connue pour son incroyable biodiversité, caractérisée par des taux d'endémisme élevés, une importante diversité spécifique chez certains taxa, et l'absence totale d'autres groupes. Cette biodiversité est concentrée principalement dans les forêts tropicales de l'île et se trouve fortement menacée par la déforestation et les changements climatiques.

Dans ce projet, nous proposons d'établir une carte actualisée de la biodiversité malgache en nous appuyant sur des inventaires portant sur plus de 7000 espèces de la flore et de la faune locale. A partir de modèles de niche climatique pour les espèces et de modèles de déforestation, qui s'appuieront sur différents scénarios climatiques et de croissance démographique, il s'agira de répondre à la question suivante : quelles sont les zones à plus fort risque de perte de biodiversité face à la déforestation et au changement climatique à Madagascar ?

Ce projet présente plusieurs aspects innovants. D'abord, il s'appuie sur de nouvelles données d'inventaire de la biodiversité à Madagascar, qui n'étaient pas disponibles auparavant. Ensuite, de nouveaux modèles et algorithmes seront testés et comparés aux méthodes plus couramment utilisées pour prévoir précisément la déforestation et l'évolution future de la biodiversité. Enfin, il permettra aux décideurs et gestionnaires sur place, qui doivent également faire face à des problématiques de développement et de réduction de la pauvreté, d'optimiser les stratégies de conservation de la biodiversité sur la base de résultats scientifiques.

Madagascar est actuellement fortement impliqué dans la lutte contre la déforestation à travers l'élaboration d'un programme national REDD+ (qui vise à Réduire les Emissions liés à la Déforestation et à la Dégradation des forêts) et dans la mise en place d'un Système national d'Aires Protégées à Madagascar (SAPM) couvrant actuellement près de 10% du territoire national. Concernant le programme REDD+, ce projet permettra de fournir des outils pour évaluer les co-bénéfices en termes de biodiversité des projets orientés carbone. Concernant le SAPM, il permettra d'identifier les zones refuges pour la biodiversité face aux changements climatiques et de prioriser les efforts de conservation sur le terrain (par exemple en identifiant les zones refuges à fort risque de déforestation).

2 Detailed project description

2.1 Context of the proposal

2.1.1 Madagascar outstanding biodiversity

Madagascar separated from the African continent about 165 million years ago, and the breakup of Indo-Madagascar started 88 million years ago (Ali & Aitchison, 2008). This continental island was settled by humans only *ca.* 2300 ago (Burney *et al.*, 2004; Cox *et al.*, 2012; Tofanelli *et al.*, 2009). The flora and fauna of Madagascar followed its own evolutionary path that helped to produce Madagascar's exceptional biodiversity and high endemism rates in many taxonomic groups (Crottini *et al.*, 2012; Goodman & Benstead, 2005). Madagascar contains five percent of global known biodiversity on just 0.4 percent of the world's landmass ; it has four times as many palm species (Dransfield & Beentje, 1995) and one-quarter as many vascular plant species as all Africa in one-fiftieth the land area (Schatz *et al.*, 1996). Similarly, more than half of the chameleons of the world reside in Madagascar. Endemism at family and genera levels is also elevated ; 23 out of 24 amphibian genera, and one out of four amphibian families are endemic to Madagascar (Vieites *et al.*, 2009). Over 83% of vascular plants (Schatz, 2000) and as many as 86% of macro-invertebrates are endemic to the island (Goodman & Benstead, 2005). And Madagascar's vertebrate phylogenetic beta-diversity is higher than all of central and south America (Holt *et al.*, 2013). Madagascar's terrestrial biodiversity is mainly concentrated in forests (Hannah *et al.*, 2008) which include several woody vegetation types such as humid forests in the East and North, spiny dry forests in the South, and deciduous dry forest in the West (Du Puy & Moat, 1996).

2.1.2 Threats to biodiversity

Madagascan unparalleled biodiversity is severely threatened by both climate change (Hannah *et al.*, 2008; Vieilledent *et al.*, in press) and deforestation (Allnutt *et al.*, 2008; Harper *et al.*, 2007; Vieilledent *et al.*, 2013). Several authors have warned conservationists regarding the potential biodiversity loss associated to anthropogenic climate change in Madagascar. Many Madagascan species, for example reptiles, have narrow climate envelopes or ranges in which they occur and will be particularly vulnerable. Studying 30 species of reptiles and amphibians in the highest massif in Madagascar, Raxworthy *et al.*

(2008) showed an up-slope displacement of 19–51 m between 1993 and 2003 associated to local climate warming. Up-slope displacement can potentially lead to extinction of species currently present at the highest elevations. Moreover, several authors have predicted a significant habitat loss under the effect of climate change for both animal species (see Andriamasimanana & Cameron (2013) for the study of nine species of Madagascan birds) and plant species (Hannah *et al.*, 2008; Vieilledent *et al.*, in press), that could potentially lead to species extinction (see the example of *Adansonia suarezensis* in Vieilledent *et al.* (in press)).

While Madagascar's terrestrial biodiversity is mainly concentrated in forests, recent analyses using remote sensing reveal that only 10–15% of original forest remains, with deforestation continuing at around 1% per year (Achard *et al.*, 2002; Harper *et al.*, 2007; Vieilledent *et al.*, 2013). Meanwhile, the human population has more than tripled since 1950, and continues to grow at nearly 3% per year (Raftery *et al.*, 2012; Vieilledent *et al.*, 2013). In Madagascar, people's livelihoods depend to a great extent on forest resources ; initial estimates indicate that the country's natural capital represents 49 percent of the country's total wealth (World Bank, 2013). Vieilledent *et al.* (2013) have recently demonstrated the link between demography and deforestation intensity in Madagascar and underlined the risk of an increase in the speed of deforestation in the short term as the country is facing a rapid demographic expansion. Moreover, several measures (e.g., gross domestic product per capita) consistently place Madagascar's economy at the bottom-tenth of all countries, potentially increasing pressure to use remaining natural forests.

Due to both the high levels of diversity and endemism in the island and the decline of natural habitats, Madagascar is universally recognised as a global conservation priority (Brooks *et al.*, 2006; Myers *et al.*, 2000).

2.1.3 REDD+ programme in Madagascar

To avoid deforestation and mitigate climate-change, Madagascar is in the process of implementing a national program for Reducing Deforestation from Deforestation and forest Degradation (REDD). Several REDD+ pilot projects have been developed in Madagascar, mainly in the humid tropical forest of the East coast (see for example the PHCF, "Programme Holistique de Conservation des Forêts" presented in Vieilledent *et al.* (2013)). People from the ONE institute ("Office National de l'Environnement") are strongly implicated in the coordination of local REDD+ pilot projects at the national level through the MRV group in Madagascar (Monitoring, Report and Verification group). For example, people from ONE participated in the elaboration of a national forest carbon map combining data from more than 2500 forest plots inventories collected by the different environmental NGO's and scientific institutes which have been collaborating in REDD+ pilot projects in Madagascar. Although the REDD+ programme is principally focused on carbon, both REDD+ national programme and local projects will have to include biodiversity safeguards and co-benefits. At the moment, no information nor tools regarding biodiversity (but see Allnutt *et al.* (2008)) is available to REDD+ stakeholders to ensure that forest protected areas established for REDD+ projects facilitate both carbon stock sequestration and biodiversity conservation.

2.1.4 Protected area network in Madagascar

To conserve Madagascan biodiversity, a remarkable work has been done since the Vth IUCN World Parks Congress held in Durban in 2003, in designing an effective protected area network integrating present biodiversity hotspots and the existing protected areas at the national level (Kremen *et al.*, 2008). Currently, under the Madagascar National Parks management (MNP formerly known as ANGAP, "Association Nationale pour la Gestion des Aires Protégées"), there are over 50 protected areas in Madagascar divided into Strict Nature Reserves (IUCN category I), National Parks (IUCN category II) and Special Reserves (IUCN category IV) (Rabearivony *et al.*, 2010). Among these protected areas, many are in a temporary status or in process of creation (Rabearivony *et al.*, 2010). The future protected area network in Madagascar (SAPM, Madagascar Protected Areas System) should cover more than 10% of the national land surface and would overlap most of the remaining natural forests.

In the context of actual fast anthropogenic climate-change (IPCC, 2007; Loarie *et al.*, 2009), it is very likely that numerous species won't be able to track suitable environments (Menéndez *et al.*, 2006). This is partly explained by species' limited dispersal and colonisation capabilities (Menéndez *et al.*, 2006; Vieilledent *et al.*, in press) and also by a loss of suitable habitat (associated to deforestation) outside the present protected areas (Vieilledent *et al.*, in press) that would prevent species to colonise new sites, even if species do not show dispersal limitation and even if the climate is suitable. In this case, species should experience a contraction of their distribution areas (Andriamasimanana & Cameron, 2013; Hannah *et al.*, 2008; Raxworthy *et al.*, 2008; Vieilledent *et al.*, in press). As a consequence, most of the biodiversity should concentrate in refugia areas inside actual protected areas which are covering present biodiversity hotspots. Identifying such areas seems particularly important to guide conservation efforts and to promote the choice of relevant sites for biodiversity conservation while defining their conservation status (Special Reserves or Strict Nature Reserves).

2.2 Objectives and working hypotheses

The objective of our project is to develop biodiversity scenarios under the effect of both deforestation and climate-change (Fig. 1). First, biodiversity scenarios including deforestation could be used in the context of the REDD+ programme to ensure that forest protected areas established for REDD+ projects facilitate biodiversity conservation in addition to carbon sequestration. The final aim would be to provide "reference levels" or "baselines" at the national level regarding the loss of biodiversity associated to "business-as-usual" deforestation. These baselines for biodiversity loss would be similar to baselines for carbon emissions which are currently required for every REDD+ project to compute carbon credits. Second, biodiversity scenarios including climate change could be used to identify future refugia areas for biodiversity and maximise the effectiveness of the protected area network in Madagascar. Third, biodiversity scenarios including both deforestation and climate change could be used to define top priority areas for biodiversity conservation, for example future local biodiversity hotspots under threat of deforestation.

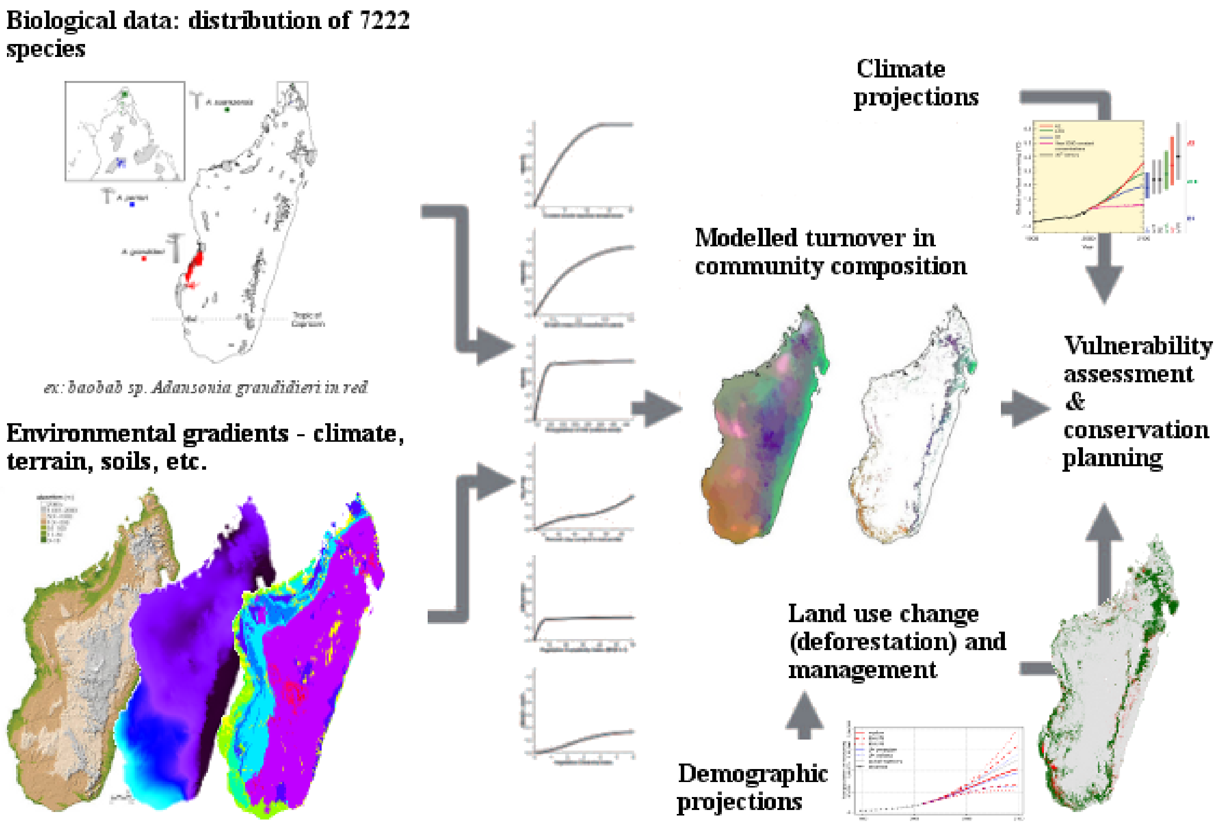

FIGURE 1 – **Schematic description of the project.** Models combine large amounts of biological, environmental and demographic data to assess how biodiversity is likely to be affected by climate change and deforestation. Results will be used for conservation planning.

To do so, we first propose to estimate the loss of biodiversity that would be associated with various scenarios of demographic growth and deforestation at the national scale (Fig. 1). We will use biodiversity data collected by the REBIOMA project (`http://data.rebioma.net`) to derive biodiversity maps from generalised dissimilarity models (GDM, see Ferrier *et al.* (2007) for theory and Allnutt *et al.* (2008) for an application in Madagascar). Using various demographic scenarios for Madagascar (Raftery *et al.*, 2012; Vieilledent *et al.*, 2013) we will develop deforestation scenarios at the national scale adapting the methodology used at the regional scale by Vieilledent *et al.* (2013). We will finally estimate the loss of biodiversity associated with the predicted future deforestation following the methodology presented in Allnutt *et al.* (2008). Second, we propose to identify future refugia areas for biodiversity under various climate change scenarios proposed by the IPCC (2007). We will derive future biodiversity maps (obtained from GDM) and highlight both areas with high risk of biodiversity loss and refugia areas. Third, we will overlap future deforestation and biodiversity maps to identify top priority areas for biodiversity conservation in Madagascar. We will also engage with the Government of Madagascar and regional authorities to incorporate climate change and deforestation considerations into biodiversity management planning. Our specific objectives include identifying policy actions that can help take recommended forest conservation and restoration activities to scale, and promoting the inclusion of top priority areas for biodiversity conservation in the Madagascar Protected Areas System.

2.3 Description of methods and proposed activities

2.3.1 Biological data

For biodiversity data, we will use a wide variety of species-level plant, invertebrate and bird collections (Table 1). Most of the data on invertebrates have been already compiled in Allnutt *et al.* (2008) who focused on invertebrates for two reasons : first, most species are not vertebrates so that any comprehensive biodiversity assessment should consider non-vertebrates to the extent possible. Second, Madagascar's vertebrate distributions are generally better known than those of non-vertebrates, thus their status is well understood relative to other groups. Two large data-sets for birds (241 species) and trees (5238 species) will complement the original data-set. We underline the importance of the data-set for tree species which comes from the inventory of 2745 forest plots representative of every forest type that can be found in Madagascar. These data-set have been initially compiled by the ONE Madagascar to derive a national forest carbon map at the national level but will be used to study tree species distribution in our case.

Dataset	Sp. count	Pres. records	% forest dep.	Source
Ants	116	1112	98	B. Fisher
Birds	241	9196	NA	GBIF, eBird
Butterflies	297	8803	70	C. Kremen, D. Lees
Ferns	474	3376	79	F. Rakotondrainibe
Ficus	24	205	NA	Missouri Botanical Garden
Land Snails	588	1616	84	T. Pearce
Legumes	373	6449	NA	J-N. Labat, D. DuPuy
Palms	159	738	98	H. Beentje, J. Dransfield
Plants	165	2627	100	G. Schatz
Solanaceae	28	80	NA	Missouri Botanical Garden
Therevid flies	19	110	84	G. Kampmeier, M. Irwin
Trees	5238	2745[a]	100	IEFN1-ONE Madagascar
Total	**7722**[b]		**88**	

Table 1 – **Biological data that will be used to derive biodiversity maps**. Two large data-sets for birds (241 species) and trees (5238 species) will be added to the original data-set compiled by Allnutt *et al.* (2008).
[a] Number of forest plots.
[b] Might include duplicate species from Palms, Plants and Trees data-sets.

2.3.2 Generalized dissimilarity models and remaining forest in 2010

Generalised dissimilarity modelling (GDM) is a statistical technique for analysing and predicting spatial patterns of turnover in community composition (beta diversity) across large regions (Ferrier *et al.*, 2007). The approach includes an ability to (1) rapidly analyse data-sets containing very large numbers of species, (2) make use of data for all species in these data-sets, regardless of the number of records per species, and (3) extrapolate patterns in compositional turnover beyond sampled communities. An additional strength of the GDM approach relative to other community-level modelling approaches is the ability to accommodate both the curvilinear relationship between environmental (and/or geographic) separation and compositional dissimilarity between sites, and the variation (non-stationarity) in the rate of compositional turnover at different positions along environmental gradient. Specifically, GDM uses GLMs (Generalised Linear Models) to model observed Bray–Curtis dissimilarity d_{ij} between pairs of locations i and j as a function of n environmental variables, x_1 to x_n, using an exponential link function (Eq. 1). Dissimilarity d_{ij} is expressed as a function of the number A of species common to both sites i and j, the number B of species present only at site i, and the number C of species present only at site j (Eq. 1).

$$-\ln(1-d_{ij}) = a_0 + \sum_{p=1}^{n} |f_p(x_{pi}) - f_p(x_{pj})|$$

(1)

$$d_{ij} = 1 - 2A/(2A + B + C)$$

The approach can be applied to a wide range of assessment activities including visualisation of spatial patterns in community composition, distributional modelling of species or community types, conservation assessment, and climate-change impact assessment (Elith *et al.*, 2006; Ferrier *et al.*, 2007).

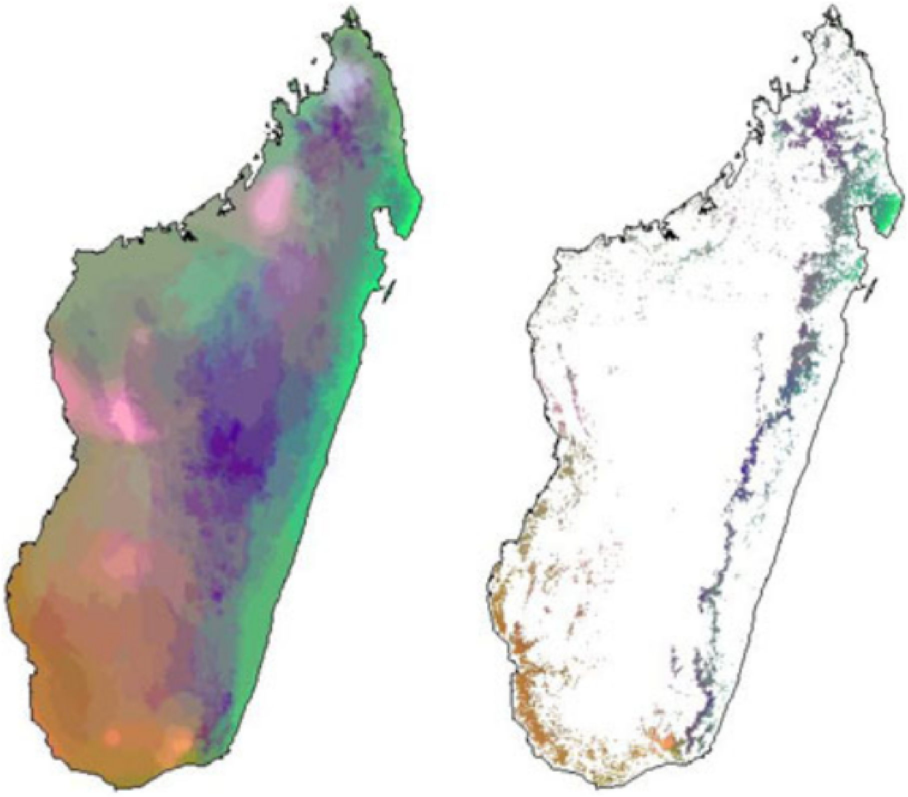

FIGURE 2 – **Pattern of biological dissimilarity across Madagascar prior to habitat loss (left) and in remaining forest in 2000 (right) (Allnutt *et al.*, 2008).** Cells are coloured according to their positions along three axes of a metric multi-dimensional scaling space fitted to predictions from a composite GDM model. Similar colour or tone indicates similar biological composition. GDM can be used to estimate biodiversity loss associated with deforestation.

These models have been previously used by Allnutt *et al.* (2008) to estimate biodiversity loss associated with deforestation that occurred before 2000 (Fig 2). We propose to use GDM in association with the updated biological data-set (Table 1) to derive an actualised map of biological dissimilarity in the remaining forests of Madagascar in 2010. In continuation of the study of Harper *et al.* (2007), an actualised map of past deforestation in Madagascar is available for the periods 1990-2000-2005-2010 (Fig. 3).

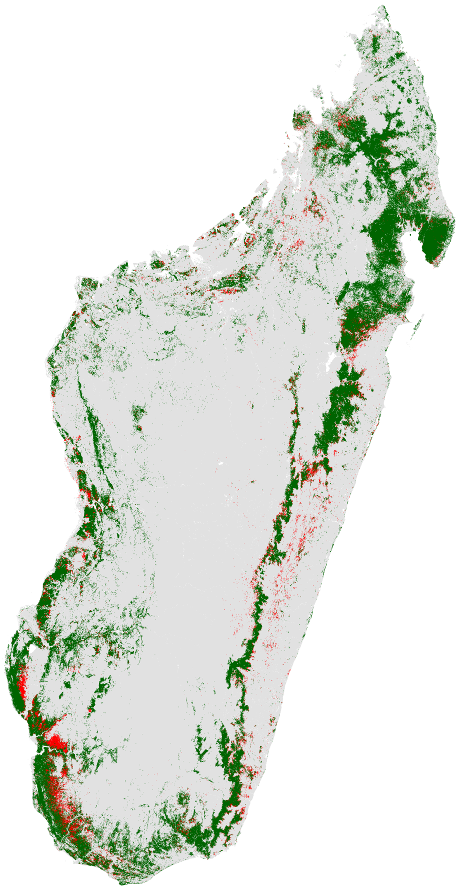

FIGURE 3 – **Map of past deforestation for the period 1990-2010.** The map shows the deforested areas (red) and the remaining forest (green). We can observe a high variability of the deforestation intensity between regions.

2.3.3 Future deforestation and scenarios of biodiversity

As said previously, an actualised map of past deforestation in Madagascar is available for the periods 1990-2000-2005-2010 (Fig. 3). Using this map as input data, we propose to develop a deforestation model at the national scale. This work will be based on the study by Vieilledent *et al.* (2013) who proposed a methodology to properly estimate the deforestation rates and identify the spatial factors driving deforestation at the regional scale. One challenge is to develop a model at the national scale as the deforestation process might be substantially different from one region to another (Vieilledent *et al.*, 2013). Indeed, the deforestation intensity might vary spatially (from one region to another) without the spatial factors being able to properly explain the spatial variation in the intensity of deforestation between regions at the national scale (Fig. 3). One solution would be to introduce spatial random effects for regional grid cells (100 × 100 km for example) to account for the variability in the intensity of deforestation at the cell level (Green *et al.*, 2013). The deforestation model will then be used to forecast deforestation at the national scale.

Vieilledent *et al.* (2013) have estimated the relationship between population density and deforestation in Madagascar. This relationship will be used to forecast deforestation following various scenarios of demographic growth for Madagascar (see Fig. 4 from Raftery *et al.* (2012)). We propose also to compare forecasts of deforestation assuming a constant deforestation rate estimated from past deforestation and assuming an increasing deforestation rate due to demographic expansion.

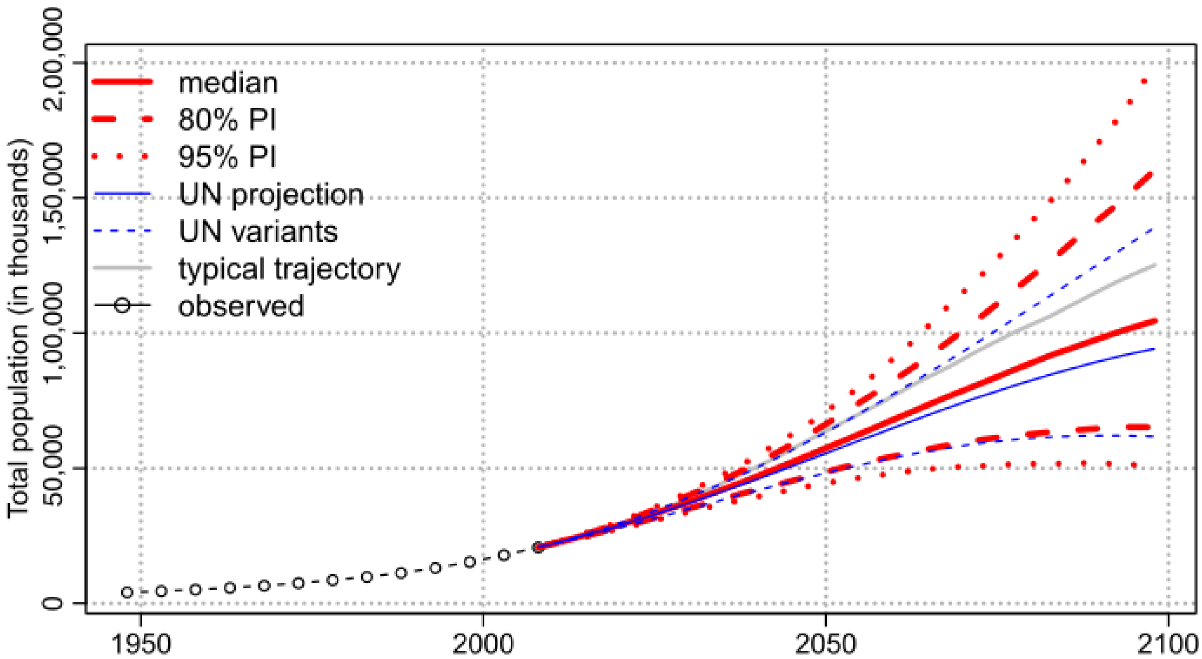

FIGURE 4 – **Population projections for Madagascar, 2010–2100 (Raftery *et al.*, 2012).** The Bayesian predictive distributions are shown in red : median–solid ; 80% prediction interval–dashed ; 95% prediction interval–dotted. The UN WPP 2010 projection is shown as a solid blue line. The typical trajectory is shown as a solid gray line.

Combining the map of biological dissimilarity across Madagascar (Fig. 2) and maps of future deforestation, we will be able to estimate the loss of biodiversity associated to various scenarios of demographic growth and deforestation at the national scale (Allnutt *et al.*, 2008).

2.3.4 GDM and biodiversity scenarios under climate change

Use of GDM to assess potential climate change impacts will proceed in two steps. First, we will use GDM to relate compositional dissimilarity between all pairs of sites (i.e. all grid cells where species were recorded) to their current habitat defined by environmental factors (climate, topography, soil, etc.). This step will provide functions that will describe how species community composition changes as a function of environmental gradient in space. Next, we will use this model to predict how species community composition would change in time given the amount of environmental change between current climate and future climate at each location. In this case, environmental change occurs not in space but in time because the climate at each location changes from present to future. The implicit assumption when GDM is used in this context is that the amount of compositional change modelled between two locations separated in current environmental space can be used to approximate how much a single location will differ in composition given an amount of environmental change in time (Fitzpatrick *et al.*, 2011).

We will used the climatic scenarios of the IPCC (2007) to forecast dissimilarity pattern across Madagascar. We will use contrasted scenarios such as scenario A2a, which describes a highly heterogeneous future world with regionally oriented economies (high rate of population growth, increased energy use, land-use changes and slow technological change) and scenario B2a, which is locally and regionally oriented but with a general evolution towards environmental protection and social equity.

Comparing present en future maps of biological dissimilarity, we will be able to quantify the habitat change at each location (see figure 9 in Ferrier *et al.* (2007)) and identify areas with high risk of biodiversity loss. We will also be able to identify climatic refugia areas (areas with similar biological dissimilarity between present and future maps). As underlined by several authors (Elith *et al.*, 2006; Ferrier *et al.*, 2007; Fitzpatrick *et al.*, 2011), the use of GDMs to forecast biodiversity changes under climatic constraint is still in the exploratory stage. Performance of GDM to accurately forecast biodiversity change will have to be assessed and confirmed and the approach will have to be compared (i) to more common approaches using for example species distribution models (SDM, see Elith *et al.* (2006) for theory and Vieilledent *et al.* (in press) for an application in Madagascar), and (ii) to alternative algorithms for predicting change in biodiversity pattern such as "gradientForest" (Ellis *et al.*, 2012).

2.3.5 Scenarios of biodiversity under both the effect of climate change and future deforestation

Combining maps of future deforestation and maps of habitat change, we will be able to identify top priority areas for biodiversity conservation such as refugia areas for biodiversity under high risk of deforestation. Moreover, comparing the results under the two constraints, we should be able to compare the biodiversity loss that would be associated on one hand to future deforestation and on the other hand to climate change. This should help us identify the main threat to biodiversity and help setting conservation priorities (Thuiller, 2007).

2.3.6 List of scientific activities

Scientific activities are listed in Tab. 2.

Id	Description	People
1	Compile biological data-set	GV, TA, MP, DR
2	Complement with new IEFN1-ONE data	GV, DR, JRR
3	Complement with new GBIF-eBird data	GV, MP, DR
4	Run GDM using biological data to obtain present dissimilarity maps	GV, TA
5	Revise demographic growth scenarios	CG, GV
6	Develop deforestation scenarios at the national scale	CG, GV
7	Estimate the potential loss of biodiversity due to future deforestation	GV, TA
8	Run GDM to project future dissimilarity map under climate change	GV, TA
9	Estimate the potential loss of biodiversity due to climate change	GV, TA
10	Estimate the potential loss of biodiversity due to both climate change and deforestation	GV, TA, CG
11	Run GDM and kernel regressions to identify future refuge areas for biodiversity under climate change	GV, TA
12	Identify refuge areas under threat of deforestation	GV, TA
13	Writing of scientific articles	GV, TA, CG, MP, DR, JRR
14	Elaborate a proposal for a national biodiversity conservation strategy	GV, MP, DR, JRR
15	Conferences for presentation of results	GV, TA, CG, MP, DR, JRR

TABLE 2 – **List of scientific activities**.

2.3.7 Summary of the project models and scenarios

Project models and scenarios are summarised in Tab. 3.

2.4 Anticipated results and benefits

2.4.1 Methodological advances

On a methodological point of view, this project is an opportunity to test different approaches for modelling biodiversity and deforestation. We will compare GDM (community level approach, Ferrier *et al.* (2007)) with SDM (species level approach, Guisan & Zimmermann (2000)) for projecting future biodiversity under climate change. For the community level approach, we will also compare the performance of GDM and "gradientForest" (Ellis *et al.*, 2012) which use two different algorithms. Each approach will be tested for the management and analysis of a large biodiversity data-set (more than 7000 taxa, Table 1). The objective is to identify the advantages and disadvantages of each approach and to transfer

Territories / spatial scale considered	Madagascar, tropical forests, national level, 1 km × 1km resolution
Types of models used or developed	Atmospheric ocean general circulation models (AOGCM, IPCC (2007)), generalised dissimilarity models (GDM, Ferrier *et al.* (2007)), species distribution models (Guisan & Zimmermann, 2000) and deforestation models (Mas *et al.*, 2007; Vieilledent *et al.*, 2013)
Types of scenarios to be imported (inputs)	Climatic scenarios (IPCC, 2007), demographic scenarios (Raftery *et al.*, 2012), and deforestation scenarios (Vieilledent *et al.*, 2013)
Types of scenarios to be developed (outputs)	Deforestation scenarios (following Vieilledent *et al.* (2013)) at the national scale, biodiversity scenarios under both the effect of climate change and future deforestation
Timescales covered by the scenarios imported or developed	Predictions until 2080, time-step of 10 years (following Ramirez & Jarvis (2008))

Table 3 – **Project models and scenarios**.

the results to the scientific community for applications in other biodiversity hotspots and tropical countries. For deforestation modelling, we will test the interest of using spatial random effects (Green *et al.*, 2013) to take into account the heterogeneity of the deforestation process at the national scale. Most studies on deforestation modelling were done at a regional level (Vieilledent *et al.*, 2013) and obtaining an accurate model at the national level is a scientific challenge.

2.4.2 Practical benefits

Currently, there is no tool to assess biodiversity safeguards and co-benefits of REDD+ projects which focus on carbon. This is a problem, particularly for Madagascar, where the highest deforestation rates are in tropical dry forests (Fig. 3) which have low carbon stocks (roughly from 15 to 50 Mg.ha^{-1} of C, with a lower interest for REDD+ investors) but high biodiversity. Combining biodiversity maps and projections of future deforestation, it will be possible to obtain baseline scenarios associated to biodiversity loss, equivalent to baseline scenarios for carbon emissions. Such tools will be particularly useful for pilot REDD+ project managers (mainly environmental NGOs such as CI, WCS, Blueventures, GoodPlanet/ETC Terra and Madagascar National Parks) and for REDD+ national actors (such as the "Ministère de l'Environnement et des Forêts" and the "Office National de l'Environnement") which coordinate REDD+ actions at the national level.

Another interesting result would be the identification of refugea areas for biodiversity under climate change. Using this information, it would be possible to refine the actual protected area network and to increase its effectiveness for biodiversity conservation under climate change. Based on the identification of refugea areas, it will be possible to propose an ecological network of protected areas including core areas of conservation, stepping stones and corridors (Fig. 5) along which movement can occur, thus permitting ecological flows such as genes flow or re-colonisation (Matisziw & Murray, 2009). This results should be particularly useful for stakeholders implicated in the conservation planning at the national scale such as the "Ministère de l'Environnement et des Forêts" and Madagascar National Parks. They should be able to use these results to confirm or adapt the conservation status of the actual protected areas (Special Reserves or Strict Nature Reserves) and possibly create new protected areas with particular relevance for biodiversity conservation.

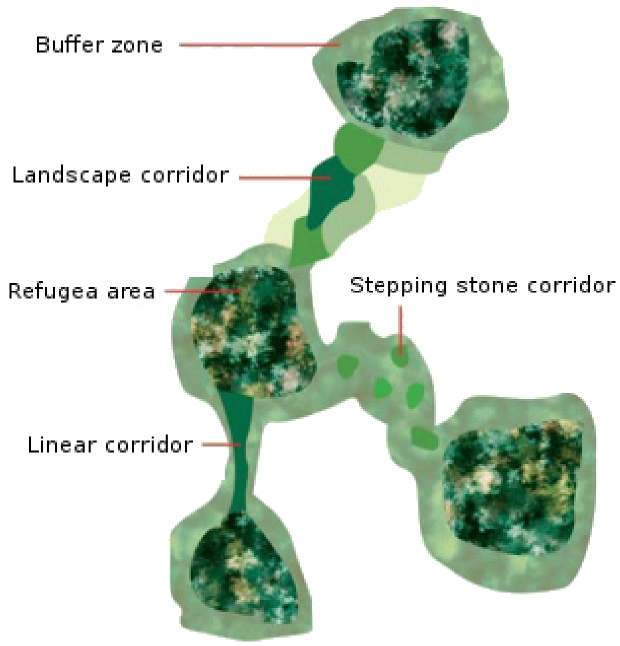

FIGURE 5 – **Schematic representation of the ecological network concept with refugea areas, corridors and stepping stones.**

2.5 Involvement of stakeholders and dissemination of results

Stakeholders will be involved at different steps of the project. First, they will participate in the launch workshop where they will be presented the project. Objectives and activities will be discussed to ensure that the project is fully in line with national conservation strategies and policies adopted so far. Stakeholders will be regularly informed of the work in progress and preliminary results through a mailing list, meetings at ONE in Antananarivo and the project website.

The project will use new methodologies to model and project biodiversity and deforestation. Capacity building with technicians and engineers from local stakeholders' institutions will be conducted to transfer the methodology developed through the project. Two training sessions of one week each will be planned : one at the end of year 2014 and one at the end of year 2015 (see timetable in Section 4).

Finally, stakeholders will participate in the scientific result analysis (maps of future biodiversity under climate change and future deforestation) to propose a national strategy for biodiversity conservation. The MEF and MNP will participate in the discussions regarding the effectiveness of the protected area network. The MEF and REDD+ MRV group will participate in the discussions regarding the choice of relevant sites for REDD+ projects with benefits both for carbon sequestration and biodiversity conservation.

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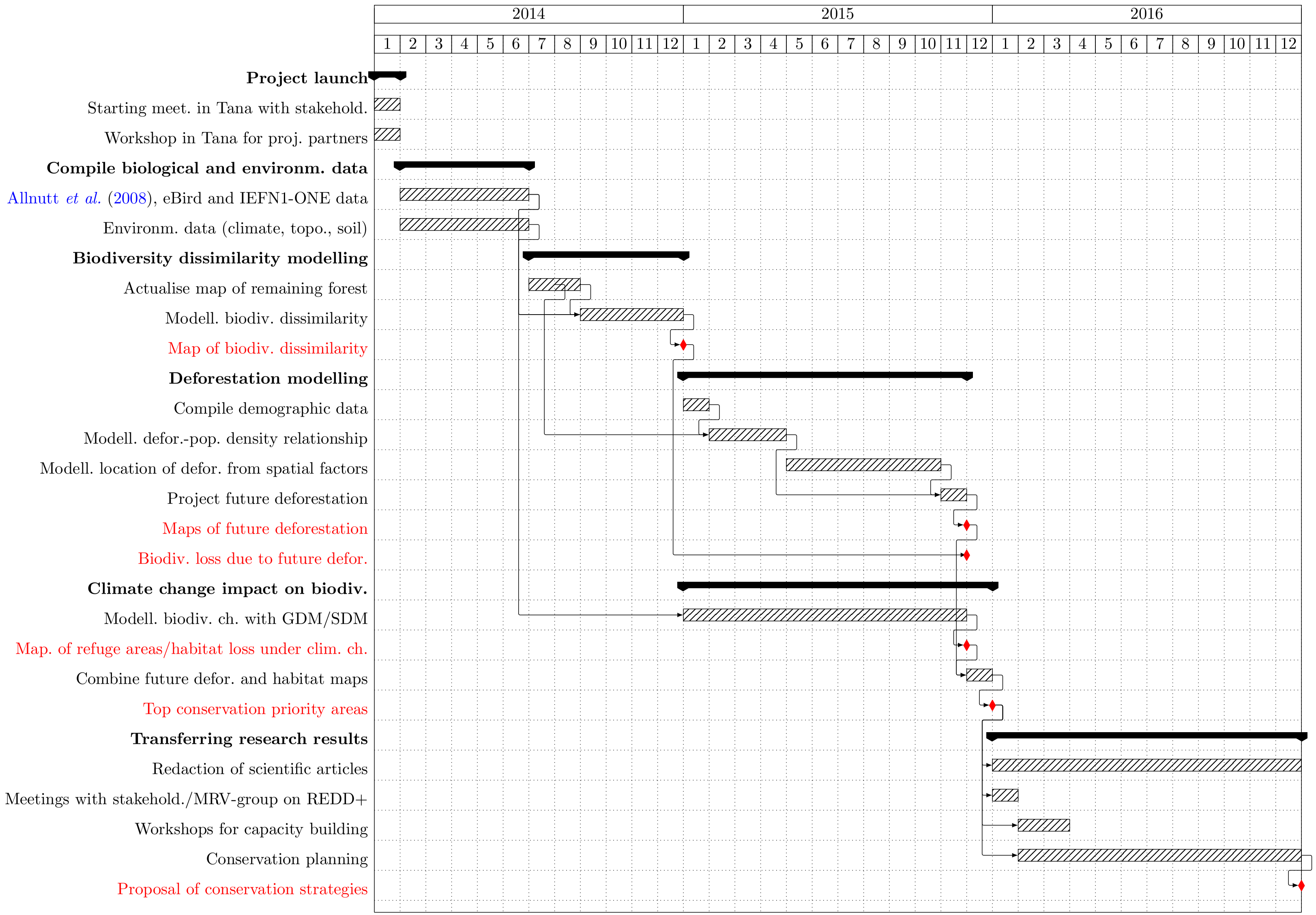
4 Timetable of activities



5 List of scientific deliverables and expected date of completion

Id	Deliverables (scientific article)	Date of completion
Biodiversity modelling		
1	Comparison of GDM and gradientForest to derive biodiversity dissimilarity maps in Madagascar	12/2014
Deforestation modelling		
2	Long term (1990-2010) and large spatial (national level) study on the relationship between people and deforestation in Madagascar	05/2015
3	Forecasting deforestation at the national scale in Madagascar using spatial random effects	11/2015
4	Predicting future biodiversity loss associated to deforestation in Madagascar	11/2015
Climate change impact on biodiversity		
5	Comparing GDM ans SDM to predict future biodiversity under climate change	11/2015
6	Identifying refuge areas and areas with high risk of biodiversity loss under climate change in Madagascar	11/2015
7	Deforestation and climate change in Madagascar : identifying top priority areas for biodiversity conservation	12/2015

TABLE 4 – **List of scientific deliverables**.

6 List of deliverables relevant for stakeholders

We identified the following deliverables relevant for stakeholders (Tab. 5). The scientific results will be transferred to stakeholders using reports written from scientific articles including georeferenced maps to facilitate conservation planning and management of development projects. We will also (i) organise workshops including stakeholders, (ii) participate in international conferences and (iii) build a web platform to gather and transfer the results to stakeholders in Madagascar and outside. The main stakeholders we identified in Madagascar (see Section 8.4) are : the Ministry of Environment and Forests, the REDD+ MRV group, Madagascar National Parks, the Office National de l'Environnement, the main environmental NGOs working in Madagascar (WWF, ETC Terra, WCS, CI, Blueventures).

Id	Deliverables	Applications
1	Maps of potential future deforestation	(i) impact of demographic growth on deforestation, (ii) decision helping for family planning/agricultural development, (iii) identification of areas with high potential for avoided deforestation (REDD+)
2	Maps of biodiversity loss associated to future deforestation	(i) biodiversity safeguards and co-benefits for REDD+ projects, (ii) priority areas for biodiversity conservation
3	Maps of future biodiversity showing refugea areas and areas with high risk of biodiversity loss under climate change	(i) vulnerability of Madagascan biodiversity to climate change, (ii) priority areas for biodiversity conservation under climate change
4	Maps showing the overlap between future refugea areas for biodiversity and areas with high risk of deforestation	(i) top priority areas for biodiversity conservation, (ii) conservation planning
5	Report with recommendations regarding the conservation planning in Madagascar	(i) optimises protected area network, (ii) actualisation of the status of existing protected areas, (iii) creation of new protected areas at relevant sites for biodiversity conservation

TABLE 5 – **List of deliverables for stakeholders**.

7 Follow up of the project activities

7.1 Follow up of the scientific activities

Cirad, WCS/REBIOMA and ETC Terra have offices in Antananarivo. This will facilitate the follow up of the scientific activities after the end of the project. As said previously, capacity building with technicians and engineers from local institutions will be conducted to transfer the methodology developed through the project and REBIOMA will continually enhances the biodiversity data base for Madagascar with new observations. Thus, local institutions will have the possibility to further develop or update the biodiversity scenarios themselves with a punctual support by project partners in the future if needed.

7.2 Follow up of project activities relevant for stakeholders and policy-makers

The recent political crisis in Madagascar led to an increase of poverty and to a decrease of the means of actions of the government to protect biodiversity. In this context, there is a high risk that protected areas will be reduced to “paper parks” (Erwin, 1991) and that conservation planning will be of no use. To address this problem, despite the unsettled political situation in the country and the fact that Madagascar's transitional government is not recognised by the international community, the World Bank has fortunately decided to loan an extra 52 million dollars (36 million euros) to Madagascar over three years to fund environmental projects. The financing will help boost conservation actions in 30 national parks and three new protected zones covering a total area of 2.7 million hectares (6.6 million acres). The financing will be used (i) for development projects at the periphery of protected areas to provide alternatives to deforestation for agriculture, and (ii) for surveillance programmes of the protected areas. In this case, it seems realistic to think that it will be possible to apply the recommendations from the BioSceneMada project regarding the conservation strategy in Madagascar. This justifies scientific efforts and the financial support at short to medium term to help save Madagascan biodiversity against climate change and deforestation.

8 Consortium description

8.1 Overall description

Number of partners (institutions) involved :	5
Research partners :	Cirad, University of Berkeley
Non-academic partners :	ETC Terra, WCS/Rebioma, ONE
Financial coordination by :	Cirad

8.2 List of academic partner institutions

PARTNER 1 : Cirad

- Team leader : Ghislain Vieilledent
- Other participants : Miguel Pedrono
- Requested budget : 57,650.00 euros
- Description : Ghislain Vieilledent will be the coordinator of the project. He spent the last three years in Madagascar conducting research projects in ecology and conservation biology in partnership with local institutions. As an ecologist with a strong background in statistics and computer science, he will conduct the data compilation and the modelling activities with the support of the other participants. Miguel Pedrono, as a specialist in conservation biology and conservation planning, will help to compile the biodiversity data and will lead the team for the development of effective conservation strategies from the results of the modelling procedure. Miguel will be based in Madagascar for the project duration and will be the local contact for Madagascan partners and stakeholders.
- Use of budget : The budget for Cirad will be mainly used for travels and accommodations to allow workshop sessions between remote partners and training sessions with stakeholders. The budget will also be used for funding three MSc students, both from

France and Madagascar, to allow capacity building and training of young scientists throughout the project. A part of the project will be used to maintain a data server for holding a website and sharing results, maps and documents.

PARTNER 2 : University of California, Berkeley

- Team leader : Thomas Allnutt
- Other participants : none
- Requested budget : 21,100.00 euros
- Description : Thomas Allnutt, as a specialist in species distribution modelling and GIS, will provide support to obtain present and future maps of biological dissimilarity across Madagascar.
- Use of budget : The main part of the budget will be used for workshop sessions in France and Madagascar. The rest of the budget will be used for publication and conference fees.

8.3 List of non-academic partners

PARTNER 3 : ETC Terra

- Team leader : Clovis Grinand
- Other participants : none
- Requested budget : 23,400.00 euros
- Description : ETC Terra is a French NGO born within the "Action Carbone" programme of GoodPlanet Foundation created by Yann Arthus-Bertrand. ETC Terra has a strong experience in development and management of projects in the sectors of renewable energy, forest conservation and agro-ecology. Clovis Grinand and Ghislain Vieilledent have already collaborated on several publications including a study about the relationship between demography and deforestation in Madagascar (Vieilledent *et al.*, 2013). Clovis Grinand, as a specialist in remote sensing, GIS and modelling, will provide support for the development of the demographic and deforestation scenarios at the national scale for Madagascar.
- Use of budget : The main part of the budget will be used for workshop sessions in France and Madagascar, for training of MSc students and capacity building.

PARTNER 4 : WCS/Rebioma

- Team leader : Dimby Razafimpahanana
- Other participants : none
- Requested budget : 15,400.00 euros
- Description : The Wildlife Conservation Society (WCS) was founded in 1895 as the New York Zoological Society (NYZS) and currently works to conserve more than two million square miles of wild places around the world. It is one of the most active environmental NGO in Madagascar with several conservation, development and

REDD+ projects in Madagascar. REBIOMA (REseau de la BIOdiversité à MAdagascar) is a WCS project in Madagascar with technical support from the University of California, Berkeley (UCB). It aims at promoting the use of biodiversity data and tools in systematic conservation planning since 2002. REBIOMA have strengthened collaboration with several national and international institutions, and support to the government branch in charge of Environment through the "Madagascar Biodiversity and Protected Areas Directorate". Dimby Razafimpahanana and Thomas Allnutt have already worked closely together on a study analyzing the loss of biodiversity associated to past deforestation in Madagascar (Allnutt *et al.*, 2008). Dimby Razafimpahanana, as a specialist in data base management and GIS, will lead activities regarding the compilation of the biodiversity data.
- Use of budget : The main part of the budget will be used for workshop sessions in France and for Madagascan MSc student training.

PARTNER 5 : ONE

- Team leader : Jean-Roger Rakotoarijaona
- Other participants : none
- Requested budget : 8,950.00 euros
- Description : The Office National de l'Environnement is a national Malagasy institution that was created in 1990. Its missions are (i) to deploy and manage the national environmental data system, (ii) to monitor and report the environmental status of Madagascar. ONE is strongly implicated in the development of the REDD+ program at the national level : the institution is leading the MRV (Monitoring, Report and Verification) REDD+ group and took an active part in the redaction and actualisation of the RPP (Readiness Project Proposal). Through a project funded by AFD (Agence Française de Développement) in 2012–2013, ONE, Cirad and ETC Terra have already collaborated to make all REDD+ stakeholders (MEF, MNP, environmental NGOs, scientific institutes) work together (i) to share common methodologies, (ii) to share data and results of pilot REDD+ projects, (iii) to coordinates the REDD+ action in Madagascar. One example is the realisation of a national carbon map for Madagascar using field data collected by different institutions. Jean-Roger Rakotoarijaona is the Director of Environmental Studies at ONE. He will contribute to the elaboration of the conservation strategies from the scientific results obtained through the project. He will be responsible for organising meetings with the project stakeholders to (i) present the project aims, (ii) inform the stakeholders of the ongoing work and preliminary scientific results, (iii) discuss and elaborate the conservation strategies, (iv) organise courses for capacity building.
- Use of budget : The main part of the budget will be used for organising meetings and capacity building sessions in Antananarivo.

8.4 Stakeholders not included within consortium

STAKEHOLDER 1 : Ministère de l'Environnement et des Forêts

The Ministry of Environnement and Forests (MEF) is the nodal agency in the administrative structure of the Government of Madagascar, for the planning, promotion, coordination and overseeing the implementation of environmental and forestry programmes. Such programmes include the SAPM (Madagascar Protected Area System) and the REDD+ programme at the national level. Thus, the MEF will be the main interlocutor regarding the potential applications of the project for conservation planning. Objectives and activities will be discussed with the MEF to ensure that the project is fully in line with national conservation strategies and policies adopted so far. The MEF will participate in the scientific result analysis (maps of future biodiversity under climate change and future deforestation) to help propose a national strategy for biodiversity conservation both in terms of effectiveness of the protected area network and in terms of REDD+ projects co-benefits for biodiversity (see Section 2.5).

Contact : Mamitiana Andriamanjato
REDD+ coordinator
Address : **Ministère de l'Environnement et des Forêts**
101 Antananarivo – Madagascar
Email : ngamamitiana1010@yahoo.fr

STAKEHOLDER 2 : Madagascar National Parks

Madagascar National Parks (MNP) was founded in 1990. This association of private right has been recognised of public utility in December 1991. It assures the conservation and the lasting and rational management of the national network of the national parks and reserves of Madagascar. MNP and WCS/REBIOMA, with the technical support from the University of California, Berkeley (UCB) have improved biodiversity conservation planning in Madagascar supporting the process of the Durban vision for expanding the marine and terrestrial protected area network, serving the SAPM (Madagascar Protected Areas System) (Kremen *et al.*, 2008).

Contact : Liliane Parany
Address : **Madagascar National Parks**
Immeuble Madagascar National Parks
Ambatobe – BP 1424
101 Antananarivo – Madagascar
Email : contact@madagascar.national.parks.mg

STAKEHOLDER 3 : REDD+ MRV group

The REDD+ MRV group is in charge of the coordination of local REDD+ pilot projects at the national level. Jean-Roger Rakotoarijaona is the president of the MRV group. The group organises meetings and workshops to promote sharing of data and methodology among REDD+ stakeholders for the monitoring, report, and verification of carbon emissions associated to deforestation. The group is open to every institution associated to the implementation of the REDD+ programme in Madagascar (MEF, MNP, University of Antananarivo, environmental NGOs, scientific institutes). It is responsible for the redaction of the RPP (Readiness Project Proposal) for Madagascar.

Contact : Jean-Roger Rakotoarijaona
President of the REDD+ MRV group
Address : **ONE**
Antaninarenina – BP 822
101 Antananarivo – Madagascar
Email : jr.rakotoarijaona@gmail.com

STAKEHOLDER 4 : Environmental NGOs

Several international environmental NGOs are strongly implicated for the biodiversity conservation in Madagascar. WCS and ETC Terra, partners of the project, are two of them. Among the others, we identified Conservation International (CI), the World Wildlife Fund (WWF) and Blueventures. These three NGOs have already worked with project partners on several occasions : they are part of the REDD+ MRV group, Cirad and WWF have collaborated on forest tree inventories and estimates of carbon stocks in the Ranobe–PK32 protected area in 2012.

Contact : Andriambolantsoa Rasolohery
Conservation planning
Address : **Conservation International**
BP 5178
101 Antananarivo – Madagascar
Email : arasolohery@conservation.org

Contact : Simon Rafanomezantsoa
Director of the terrestrial program
Address : **WWF–Madagascar & Western Indian Ocean**
Près lot II M 85 ter Antsakaviro
101 Antananarivo – Madagascar
Email : srafanomezantsoa@wwf.mg

Contact : Garth Cripps
Director of the Blue Forests program
Address : **Blueventures**
101 Antananarivo – Madagascar
Email : garth@blueventures.org

9 Partner agreement forms

FICHE D'ENGAGEMENT PARTENAIRE / PARTNER AGREEMENT FORM

Cette fiche est à compléter par chaque partenaire du projet et à faire signer par le directeur du laboratoire dont elle dépend, ou par une personne habilitée à engager l'organisme/l'entreprise :
This form should be filled by each partner of the project and signed by the head of the laboratory, or by a person authorized to commit the organization/company :

Acronyme du projet / Project acronym: BioSceneMada

Titre du projet / Project title: Scenarios of biodiversity in Madagascar under climate change and future deforestation

Nom du laboratoire ou du service / Laboratory or department carrying out the work : UPR BSEF

Organisme de tutelle dont dépend le laboratoire ou service /
Organization to which the laboratory or department belongs : Centre de coopération international en recherché agronomique pour le développement (CIRAD)

Responsable scientifique du projet / Project leader :
Nom / Last name : Vieilledent
Prénom / First name : Ghislain
Fonction / Position : Scientific Researcher

Directeur de laboratoire ou personne habilitée à engager l'organisme/l'entreprise / Head of the laboratory or authorized person :

Nom / Last name : FABRE
Prénom / First name : Pierre
Fonction / Position : Directeur du Département Environnement et Sociétés du CIRAD
Tél / Phone : 04.67.59.39.71
E-mail : dir-es@cirad.fr

Je, soussigné(e) Pierre FABRE, donne mon accord pour la participation de mon organisme à ce projet / I, the undersigned *last name first name*, agree to the participation of my laboratory/organization/company in this project

Fait à / Place : Montpellier Le / date : 17 juin 2013

Signature / Signature :

CENTRE DE COOPERATION INTERNATIONALE EN RECHERCHE AGRONOMIQUE POUR LE DEVELOPPEMENT
CIRAD
ENVIRONNEMENTS ET SOCIETES
CAMPUS DE BAILLARGUET
34398 MONTPELLIER CEDEX 5
FRANCE

FICHE D’ENGAGEMENT PARTENAIRE / PARTNER AGREEMENT FORM

Cette fiche est à compléter par chaque partenaire du projet et à faire signer par le directeur du laboratoire dont elle dépend, ou par une personne habilitée à engager l’organisme/l’entreprise :
This form should be filled by each partner of the project and signed by the head of the laboratory, or by a person authorized to commit the organization/company :

Acronyme du projet / Project acronym: BioScene Mada

Titre du projet / Project title: Biodiversity scenarios under the effect of climate change and future deforestation in Madagascar

Nom du laboratoire ou du service / Laboratory or department carrying out the work :
Kremen Lab, Department of Environmental Science, Policy and Management

Organisme de tutelle dont dépend le laboratoire ou service /
Organization to which the laboratory or department belongs :
University of California, Berkeley

Responsable scientifique du projet / Project leader : Ghislain Vielledent, CIRAD

Nom / Last name : Allnutt

Prénom / First name : Thomas

Fonction / Position : Visiting Scholar

Directeur de laboratoire ou personne habilitée à engager l’organisme/l’entreprise / Head of the laboratory or authorized person :

Nom / Last name : Allnutt

Prénom / First name : Thomas

Fonction / Position : Visiting Scholar, Kremen Lab

Tél / Phone :

E-mail : tom.allnutt@berkeley.edu

Je, soussigné(e) *nom prénom*, donne mon accord pour la participation de mon laboratoire/organisme/entreprise à ce projet / I, the undersigned *last name first name*, agree to the participation of my laboratory/organization/company in this project

Fait à / Place : Oakland, CA   Le / date : 19 June 2013

Signature / Signature :

FICHE D'ENGAGEMENT PARTENAIRE / PARTNER AGREEMENT FORM

Cette fiche est à compléter par chaque partenaire du projet et à faire signer par le directeur du laboratoire dont elle dépend, ou par une personne habilitée à engager l'organisme/l'entreprise :
This form should be filled by each partner of the project and signed by the head of the laboratory, or by a person authorized to commit the organization/company :

Acronyme du projet / Project acronym:
BioSceneMada
Titre du projet / Project title:
Biodiversity Scenario under the effect of CC and future deforestation in Madagascar
Nom du laboratoire ou du service / Laboratory or department carrying out the work :
Service Recherche & Développement
Organisme de tutelle dont dépend le laboratoire ou service /
Organization to which the laboratory or department belongs :
ETC TERRA.
Responsable scientifique du projet / Project leader :
Nom / Last name : Grinand
Prénom / First name : Clovis
Fonction / Position : Chef de projet R&D

Directeur de laboratoire ou personne habilitée à engager l'organisme/l'entreprise / Head of the laboratory or authorized person :

Nom / Last name : Tiberghien
Prénom / First name : Matthieu
Fonction / Position : Directeur
Tél / Phone : +33 612312723
E-mail : m.tiberghien@etcterra.org

Je, soussigné(e) *nom prénom*, donne mon accord pour la participation de mon laboratoire/organisme/entreprise à ce projet / I, the undersigned *last name first name*, agree to the participation of my laboratory/organization/company in this project

Fait à / Place : Paris Le / date : 13/06/2013

Signature / Signature :

Etc Terra
127, rue d'Avron, 75020 PARIS
Tél : +33 (0) 9 53 22 76 22
SIRET : 753 391 190 00012

FICHE D'ENGAGEMENT PARTENAIRE / PARTNER AGREEMENT FORM

Cette fiche est à compléter par chaque partenaire du projet et à faire signer par le directeur du laboratoire dont elle dépend, ou par une personne habilitée à engager l'organisme/l'entreprise :
This form should be filled by each partner of the project and signed by the head of the laboratory, or by a person authorized to commit the organization/company :

Acronyme du projet / Project acronym:
BioSceneMada
Titre du projet / Project title:
Biodiversity scenarios under the effect of climate change and future deforestation in Madagascar
Nom du laboratoire ou du service / Laboratory or department carrying out the work :
Réseau de la Biodiversité de Madagascar
Organisme de tutelle dont dépend le laboratoire ou service /
Organization to which the laboratory or department belongs :
Wildlife Conservation Society Madagascar Program
Responsable scientifique du projet / Project leader :
Nom / Last name : *Razafimpahanana*
Prénom / First name : *Andriamandimbisoa*
Fonction / Position : *REBIOMA Project Coordinator*

Directeur de laboratoire ou personne habilitée à engager l'organisme/l'entreprise / Head of the laboratory or authorized person :

Nom / Last name : *Holmes*
Prénom / First name : *Christopher*
Fonction / Position : *Country Program Director*
Tél / Phone : *+(261) 32 11 880 22*
E-mail : *cholmes@wcs.org*

Je, soussigné(e) *nom prénom*, donne mon accord pour la participation de mon laboratoire/organisme/entreprise à ce projet / I, the undersigned *Christopher Holmes*, agree to the participation of my laboratory/organization/company in this project

Fait à / Place : *Antananarivo* Le / date : [illegible]7 JUIN 201[illegible]

Signature / Signature :

FICHE D'ENGAGEMENT PARTENAIRE / PARTNER AGREEMENT FORM

Cette fiche est à compléter par chaque partenaire du projet et à faire signer par le directeur du laboratoire dont elle dépend, ou par une personne habilitée à engager l'organisme/l'entreprise :
This form should be filled by each partner of the project and signed by the head of the laboratory, or by a person authorized to commit the organization/company :

Acronyme du projet / Project acronym: BioSceneMada

Titre du projet / Project title: Biodiversity scenarios under the effect of climate change and future deforestation.

Nom du laboratoire ou du service / Laboratory or department carrying out the work :
Office National pour l'Environnement

Organisme de tutelle dont dépend le laboratoire ou service /
Organization to which the laboratory or department belongs : Office national pour l'environnement

Responsable scientifique du projet / Project leader :
Nom / Last name : Rakotoarijaona
Prénom / First name : Jean Roger
Fonction / Position : Directeur des informations environnementales.

Directeur de laboratoire ou personne habilitée à engager l'organisme/l'entreprise / Head of the laboratory or authorized person :

Nom / Last name : Rakotoary.
Prénom / First name : Jean Chrisostome
Fonction / Position : Directeur Général.
Tél / Phone : +261.20.22.259.99.
E-mail : jcrakoto@pnae.mg.

Je, soussigné(e) *nom prénom*, donne mon accord pour la participation de mon laboratoire/organisme/entreprise à ce projet / I, the undersigned *last name first name*, agree to the participation of my laboratory/organization/company in this project

Fait à / Place : Antananarivo Le / date : 19. juin. 2013.

Signature / Signature :

MINISTERE DE L'ENVIRONNEMENT ET DES FORETS
OFFICE NATIONAL POUR L'ENVIRONNEMENT
REPOBLIKAN'I MADAGASIKARA

PROJECT PARTICIPANTS:

Coordinator			
VIEILLEDENT, Ghislain		**Status**	CH Chercheur
Email	ghislain.vieilledent@cirad.fr	**Tel**	+261.32.07.822.10
Address	Cirad, UPR BSEF, Campus International de Baillarguet, 34 398 Montpellier Cedex 5	**Country**	France
Affiliation	Centre de coopération Internationale en Recherche Agronomique pour le Développement - CIRAD		
Laboratory	Unité Bien et Services des Ecosystemes Forestires Tropicaux - UPR BSEF		
Equipe de recherche			
Main research interests	- Conservation biology: effect of deforestation on climate change and biodiversity, effect of climate change on species distribution. - Community ecology: impact of the intra-specific variability on species competition, theoretical (simulation modelling) and experimental (permanent forest plots) approaches. - Sustainable management of tropical forests through forest dynamics modelling. - Development of new statistical methods and tools for ecology (four R packages: MCMCpack, hSDM, phcfM, twoe)		
Position	Scientific research in ecology		
Former positions	- 2012-present: Scientific researcher in ecology, Cirad, Montpellier, France - 2009-2012: Scientific researcher in ecology based in Madagascar, Cirad-Fofifa, Antananarivo, Madagascar - 2005-2009: PhD student in forest ecology, IRSTEA, Grenoble, France - 2004-2005: In charge of environmental studies in agricultural technical institutes, France		
Education	- 2009: PhD in Applied statistics to forest ecology, AgroParisTech, France - 2004: Master in Ecological Anthropology, MNHN, AgroParisTech and University Paris 7, France - 2003: Master in Agronomy and Ecology, ENSAR, France		
Scientific responsabilities	- Supervision: 7 MSc from 2009 to present, 1 PhD thesis started in 2013. - Reviewer for scientific journals in the field of ecology and forestry (PLoS ONE, For. Ecol. and Manag., Ann. of For. Sc., Ecol. Mod., etc.). - Teaching ecology, statistics and modelling at university (Université Joseph Fourrier Grenoble, FIF-ENGREF Nancy, ESSA Forêt Antananarivo) and for technical institutes (MRV-group: ONE, MNP, CI, WCS in Madagascar).		
Projects (in the last 5 years)	- 2012–2013 Technical support to the Office National de l'Environnement in Madagascar for the development of the REDD+ national program, AFD, 47960 €. Coordinator. - 2012 Tree architecture in the western dry forests of Madagascar, WWF, 3500 €. Coordinator. - 2011–2012 Modelling intensity and location of deforestation in Madagascar, GoodPlanet, 9000 €. Task leader. - 2010–2011 Developing new tree biomass allometric models for Madagascar, WWF–GoodPlanet, 8750 €. Task leader.		
Publications	**Total number of publications: 16** **Number of articles in peer-reviewed journals: 15** **Number of book chapters: 1** **Number of book written or edited: 0** **Number of citations (Web of Science [WoS] or Google Scholar Citations [GSC]): 142 [GSC]** **H-index factor (Specify WoS and/or GSC): 8 [GSC]**		
	- Vieilledent G., Cornu C., Cuní-Sanchez A., Leong Pock-Tsy J.-M. and Danthu P. In press. Vulnerability of baobab species to climate change and effectiveness of the protected area network in Madagascar: towards new conservation priorities. Biological Conservation. [doi: 10.1016/j.biocon.2013.06.007]. - Vieilledent G., Grinand C. and Vaudry R. 2013. Forecasting deforestation and carbon emissions in tropical developing countries facing demographic expansion: a case study in Madagascar. Ecology and Evolution. Article first published online: 3 MAY 2013. [doi: 10.1002/ece3.550]. - Asner G. P., Clark J. K., Mascaro J., Vaudry R., Chadwick K. D., Vieilledent G., Rasamoelina M., Balaji A., Kennedy-Bowdoin T., Maatoug L., Colgan M. S. and Knapp D. E. 2012. Human and environmental controls over aboveground carbon storage in Madagascar. Carbon Balance and Management. 7:2. - Asner G. P., Mascaro J., Muller-Landau H. C., Vieilledent G., Vaudry R., Rasamoelina M., Hall J. and van Breugel M. 2012. A universal airborne LiDAR approach for tropical forest carbon mapping. Oecologia. 168(4): 1147-1160. - Vieilledent G., Vaudry R., Andriamanohisoa S. F. D., Rakotonarivo O. S., Randrianasolo H. Z., Razafindrabe H. N., Bidaud Rakotoarivony C., Ebeling J. and Rasamoelina M. 2012. A universal approach to estimate biomass and carbon stock in tropical forests using generic allometric models. Ecological Applications. 22(2): 572-583.		

<table>
<tr><th colspan="4">Participant 2</th></tr>
<tr><td colspan="2">THOMAS, Allnutt</td><td>Status</td><td>CH Chercheur</td></tr>
<tr><td>Email</td><td>tom.allnutt@gmail.com</td><td>Tel</td><td>+1.510.642.8414</td></tr>
<tr><td>Address</td><td>UCB 217 Wellman Hall Berkeley,
California 94720-3114, USA</td><td>Country</td><td>United States</td></tr>
<tr><td>Affiliation</td><td colspan="3">University of California, Berkeley - UC-Berkeley</td></tr>
<tr><td>Laboratory</td><td colspan="3">Department of Environmental Science, Policy and Management -</td></tr>
<tr><td>Equipe de recherche</td><td colspan="3">Kremen Lab</td></tr>
<tr><td>Main research interests</td><td colspan="3">- Biodiversity conservation
- Biodiversity informatics
- Conservation planning and priority-setting
- Species distribution modelling
- Web and database application development
- Spatial modelling and tools, including Geographic Information Systems, remote sensing</td></tr>
<tr><td>Position</td><td colspan="3">Scientific researcher for the REBIOMA project</td></tr>
<tr><td>Former positions</td><td colspan="3">- 2008-2013 RéBioMa Project (UC Berkeley, WILDLIFE CONSERVATION SOCIETY) Berkeley, CA, Antananarivo, Madagascar. Biodiversity Informatics/Conservation Planning Specialist

- 2005-2008 INDEPENDENT CONSULTANT, Washington, DC, Irvine CA. Technical support for clients including WWF (US, Madagascar, Senegal, Guianas), Conservation International (Madagascar), GEF and USAID

- 1998-2005 WORLD WILDLIFE FUND, Washington, DC. Senior Conservation Specialist</td></tr>
<tr><td>Education</td><td colspan="3">- BA Geography, minor Biology, Boston University, 1991 cum laude
- MA Geography, with thesis, University of Maryland, 1997</td></tr>
<tr><td>Scientific responsabilities</td><td colspan="3">Scientific responsibilities have included: research design for marine and terrestrial conservation planning to support the implementation of new protected areas in Madagascar; research to support forest mapping in Madagascar protected areas, to answer specific questions regarding the rate of illegal logging in relation to recent political events; leading a study to apply new modelling techniques to quantify biodiversity losses from deforestation in Madagascar 1950-2000.</td></tr>
<tr><td>Projects (in the last 5 years)</td><td colspan="3">- Madagascar Conservation Planning: Coordinated several priority setting exercises to support the expansion of marine and terrestrial databases in Madagascar. This included leading the collection and formatting of biodiversity data, developing species distribution models with MaxEnt, and running software (Zonation, Marxan) to identify priority areas. Lead author on peer-reviewed paper describing marine priority setting.

- Madagascar Biodiversity Database: Managed the development of an web application that serves validated biodiversity distribution data and generates species distribution models for Madagascar. Coordinated teams of US-based and Madagascar-based developers, managed web server; helped develop consensus taxonomy, helped coordinate data review.

- Mapping Illegal Logging. Led study design and image analysis to map illegal logging in NE Madagascar 2008-2011. Lead author on peer-reviewed technical paper describing results.</td></tr>
<tr><td rowspan="2">Publications</td><td colspan="3">Total number of publications: 25
Number of articles in peer-reviewed journals: 10
Number of book chapters: 3
Number of book written or edited: 0
Number of citations (Web of Science [WoS] or Google Scholar Citations [GSC]): 161 [GSC]
H-index factor (Specify WoS and/or GSC): 5 [GSC]</td></tr>
<tr><td colspan="3">- Allnutt, T.F., T.R. McClanahan, S. Andréfouët, M. Baker, E. Lagabrielle, C. McClennen, A.J.M. Rakotomanjaka, T.F. Tianarisoa, R. Watson, C. Kremen. 2012. Comparison of marine spatial planning methods in Madagascar demonstrates value of alternative approaches. PLoS ONE 7(2): e28969. doi:10.1371/journal.pone.0028969.

- Olson, D., D.A. DellaSala, R.F. Noss, J.R. Strittholt, J. Kass, M.E. Koopman, T.F. Allnutt. 2012. Climate change refugia for biodiversity in the Klamath-Siskiyou Ecoregion. Natural Areas Journal 32(1):65-74. doi: http://dx.doi.org/10.3375/043.032.0108

- Kremen, C, A. Cameron, T. Allnutt, A. Razafimpahanana. 2010. Rare and threatened species and conservation planning in Madagascar. Pages 221-222 in: Sodhi, N. and P. Ehrlich, eds. Conservation Biology for All. Oxford University Press. 344 pp.

- Olson, D., L. Farley, A. Patrick, D. Watling, M. Tuiwawa, V. Masibalavu, L. Lenoa, A. Bogiva, I. Qauqau, J. Atherton, A. Caginitoba, M. Tokota'a, S. Prasad, W. Naisilisili, A. Raikabula, K. Mailautoka, C. Morley, T. Allnutt. 2009. Priority forests for conservation in Fiji: landscapes, hotspots and ecological processes. Oryx, 44(1):57-70.

- Allnutt, T.F., S. Ferrier, G. Manion, G.V.N. Powell, T.H. Ricketts, B.L. Fisher, G.J. Harper, M.E. Irwin, C. Kremen, J-N. Labat, D.C. Lees, T.A. Pearce, and F. Rakotondrainibe. 2008. A method for quantifying biodiversity loss and its application to a 50-year record of deforestation across Madagascar. Conservation Letters 1:173-181.</td></tr>
</table>

Participant 3

PEDRONO, Miguel		**Status**	CH Chercheur
Email	miguel.pedrono@cirad.fr	**Tel**	+261.(0)32.07.235.35
Address	Cirad, Ampandrianomby, BP 853, 101 Antananarivo, Madagascar	**Country**	France
Affiliation	Centre de coopération Internationale en Recherche Agronomique pour le Développement - CIRAD		
Laboratory	Animal et Gestion Intégrée des Risques - AGIRs		
Equipe de recherche	AGIRs		
Main research interests	Miguel's interests lie in the conservation of biodiversity in tropical countries. He is particularly interested in how to bridge the gap between academia and on-the-ground practice in the domain of conservation biology and thus how to improve conservation effectiveness. He focuses his work on real-life conservation issues including efforts to save Madagascan species.		
Position	Chercheur en biologie de la conservation		
Former positions	- Researcher in Conservation Biology, UR Animal and Integrated Risk Management, CIRAD, Antananarivo, Madagascar, 2002 – present - Post-doctoral Research Associate and Lecturer, Department of Ecology Systematic and Evolution, University Paris-Sud (Orsay), France, 2001 – 2002 - Post-doctoral Research Associate, Department of Ecology, French Institute of Pondicherry, India, 2000 – 2001		
Education	- PhD (Ecology), Paris VI University, France, 2000. Interactive management between wild and captive populations: conservation strategy for the ploughshare tortoise in Madagascar - MSc (Population Biology), Tours University, France		
Scientific responsabilities	Miguel has been a researcher in Conservation Biology at CIRAD since 2002 and has been permanently based in Madagascar since 2009 where he participates in ecology projects and research studies. He is also the supervisor of various students from the University of Antananarivo and from universities in France. He is a member of the IUCN Species Survival Commission (Tortoise and Freshwater Turtle Specialist Group), and member of the editorial board of 'Madagascar Conservation & Development' journal.		
Projects (in the last 5 years)	- Coordinator of Wild Cattle Conservation Project in Vietnam (1M EUR from FFEM): Implementation of conservation initiatives for gaurs (Bos gaurus) and Bantengs (Bos javanicus) in Vietnam, and Technical Assistant of Cat Tien National Park. - Task Leader of the waterbird component of the GRIPAVI Project in Madagascar (3,6 M EUR from Ministry of Foreign and European Affairs): initiate research studies on the waterbirds of Lake Alaotra in Madagascar. - Task Leader of the ecological restoration project of Beanka Reserve in Madagascar (Biodiversity Conservation Madagascar): in charge of the scientific component of the project.		
Publications	**Total number of publications: 22** **Number of articles in peer-reviewed journals: 20** **Number of book chapters: 2** **Number of book written or edited: 1** **Number of citations (Web of Science [WoS] or Google Scholar Citations [GSC]): 115 [GSC]** **H-index factor (Specify WoS and/or GSC): 7 [GSC]**		
	- Pedrono M, Griffiths OL, Clausen A, Smith LL, Wilmé L, Burney D. 2013. Using a surviving lineage of Madagascar's vanished megafauna for ecological restoration. Biological Conservation 159, 501-506. - Chouteau P, Jiang Z, Bravery BD, Cai J, Li Z, Pedrono M, Pays O. 2012. Local extinction in the bird assemblage in the greater Beijing area from 1877 to 2006. PLoS ONE 7, e39859. - Pedrono M. 2011. Wasted efforts: why captivity is not the best way to conserve species. Madagascar Conservation & Development 6, 57-59. - Clausen A, Vu Hoang H, Pedrono M. 2011. An evaluation of the environmental impact assessment system in Vietnam: the gap between theory and practice. Environmental Impact Assessment Review 31, 136-143. - Pedrono M, Smith LL, Clobert J, Massot M, Sarrazin F. 2004. Wild-captive metapopulation viability analysis. Biological Conservation 119, 463-473.		

Participant 4

<table>
<tr><td colspan="2">DIMBY, Razafimpahanana</td><td>Status</td><td>AA Autre acteur</td></tr>
<tr><td>Email</td><td>dimby@wcsmad.org</td><td>Tel</td><td>+261.(0)20.22.597.89</td></tr>
<tr><td>Address</td><td>Villa Ifanomezantsoa, Soavimbahoaka,
Antananarivo 101, Madagascar</td><td>Country</td><td>Madagascar</td></tr>
<tr><td>Affiliation</td><td colspan="3">Réseau de la Biodiversité à Madagascar - REBIOMA</td></tr>
<tr><td>Laboratory</td><td colspan="3">not applicable - N/A</td></tr>
<tr><td>Equipe de recherche</td><td colspan="3"></td></tr>
<tr><td>Main research interests</td><td colspan="3">Conservation planning, biodiversity database, GIS and remote sensing</td></tr>
<tr><td>Position</td><td colspan="3">Coordinateur du projet REBIOMA</td></tr>
<tr><td>Former positions</td><td colspan="3">- REBIOMA Project Coordinator</td></tr>
<tr><td>Education</td><td colspan="3">- 1997, Master in “Tools for Earth Observation and Information Management for Environment”, CFISGE, Madagascar
- 1998, Master in “Integrated Management of Territories – LandUse Planning”, INA-PG, France</td></tr>
<tr><td>Scientific responsabilities</td><td colspan="3">Andriamandimbisoa (aka 'Dimby') is the REBIOMA project coordinator. Since 2001, REBIOMA has improved biodiversity conservation planning in Madagascar, by:
- Providing easy access to update and validated data on the biodiversity of Madagascar,
- Providing an opportunity for institutions and scientists to share and publish their occurrence data for conservation use,
- Making data available for quantitative conservation planning.</td></tr>
<tr><td>Projects (in the last 5 years)</td><td colspan="3">- October 2007-September2010, MacArthur Foundation: REBIOMA: A Global Network of Biodiversity Data for Reef to Ridge Conservation Planning and Implementation in Madagascar. Coordinator of the Project

- June 2019 - June 2010 - START: Climate change planning inside and outside protected areas. Principal Investigator

- October 2010 - September 2013, MacArthur Foundation: REBIOMA: A global network of biodiversity data for reef to ridge conservation planning, monitoring and management in Madagascar. Coordinator of the Project

- July 2011 - June 2013, JRS Foundation: REBIOMA – Using online technology to promote sharing of high-quality biodiversity data and applied conservation. Principal Investigator</td></tr>
<tr><td rowspan="2">Publications</td><td colspan="3">Total number of publications: 3
Number of articles in peer-reviewed journals: 3
Number of book chapters: 0
Number of book written or edited: 0
Number of citations (Web of Science [WoS] or Google Scholar Citations [GSC]): 253 [GSC]
H-index factor (Specify WoS and/or GSC): 2 [GSC]</td></tr>
<tr><td colspan="3">1. C. Kremen, A. Cameron, A. Moilanen, S. J. Phillips, C. D. Thomas, H. Beentje, J. Dransfield, B. L. Fisher, F. Glaw, T. C. Good, G. J. Harper, R. J. Hijmans, D. C. Lees, E. Louis Jr., R. A. Nussbaum, C. J. Raxworthy, A. Razafimpahanana, G. E. Schatz, M. Vences, D. R. Vieites, P. C. Wright, M. L. Zjhra Aligning Conservation Priorities Across Taxa in Madagascar with High-Resolution Planning Tools in Science 320, 222 (2008);

2. L. Rasoavahiny, M. Andrianarisata, A. Razafimpahanana, A. N. Ratsifandrihamanana Conducting an ecological gap analysis for the new Madagascar Protected Area System in The international journal for protected area managers, PARKS Vol. 17 N° 1 IMPLEMENTING THE CBD POWPA, 2008 IUCN

3. Hannah, L.; Dave, R.; Lowry, P. P.; Andelman, S.; Andrianarisata, M.; Andriamaro, L.; Cameron, A.; Hijmans, R.; Kremen, C.; MacKinnon, J.; Randrianasolo, H. H.; Andriambololonera, S.; Razafimpahanana, A.; Randriamahazo, H.; Randrianarisoa, J.; Razafinjatovo, P.; Raxworthy, C.; Schatz, G. E.; Tadross, M. & Wilmee, L. Climate change adaptation for conservation in Madagascar Biology Letters, 2008, 4, 590-594</td></tr>
</table>

Participant 5

GRINAND, Clovis		Status	Doctorant
Email	c.grinand@etcterra.org	Tel	+33.(0)6.47.32.04.37
Address	Association Etc Terra, 127 rue d'Avron, 75020 Paris, France	Country	France
Affiliation	ETC Terra - ETC Terra		
Laboratory	not applicable - N/A		
Equipe de recherche			
Main research interests	My main research interest is in ecosystem monitoring using remote sensing, mainly focused on soil properties and land use change mapping.		
Position	Research and develoment project manager at ETC Terra		
Former positions	- GIS and remote sensing Project Manager at GoodPlanet Foundation : 1 year - Soil and remote sensing engineer at Institut de Recherche pour le Développement (IRD Madagascar and France) : 3,5 years		
Education	2009-2010: MSc in GIS for land use mapping, AgroparisTech, Montpellier, France 2004-2006: MSc in Geology and Remote Sensing, Université d'Orléans, France 2003-2004: BSc Geology and environment, University of Greenwich, UK		
Scientific responsabilities	I am currently managing R&D projects at EtcTerra NGO. The scope of the projects are mainly focused on land use mapping and land cover change modelling.		
Projects (in the last 5 years)	- Development of a web-portal on a REDD+ pilot project (http://phcf.actioncarbone.org), project leader - Estimation of past 2000-2010 deforestation at large scale over, project leader - Modelling baseline scenario of deforestation, coordinator - Development of the methodology to map soil organic carbon at regional scale, project leader - Estimation of biomass at local scale using airborne LiDAR measurement, project coordinator - Mapping soil organic carbon for Madagascar, project leader		
Publications	**Total number of publications: 8** **Number of articles in peer-reviewed journals: 5** **Number of book chapters: 0** **Number of book written or edited: 0** **Number of citations (Web of Science [WoS] or Google Scholar Citations [GSC]): 53 [GSC]** **H-index factor (Specify WoS and/or GSC): 3 [GSC]**		
	- Grinand, C., Rakotomalala, F., Gond, V., Vaudry, R., Bernoux, M., Vieilledent, G. In press. Estimating deforestation in tropical humid and dry in Madagascar from 2000 to 2010 using multi-Landsat satellite images and the Random Forests classifier. Remote Sensing of the Environment. - Vieilledent G., Grinand C. and Vaudry R. 2013. Forecasting deforestation and carbon emissions in tropical developing countries facing demographic expansion: a case study in Madagascar. Ecology and Evolution. 3:1702-1716. doi: 10.1002/ece3.550. - Le Maire, G., Marsden, C., Nouvellon, Y., Grinand, C. Hakamada, J.S., Laclau, J-P. 2011. MODIS NDVI time-series allow the monitoring of Eucalyptus plantation biomass. Remote Sensing of Environment, 115(10):2624-2625 - Razakamanarivo R.H., Grinand C., Razafindrakoto, M.A., Bernoux, M., Albrecht, A., 2011. Mapping organic carbon stocks in eucalyptus plantations of the central highlands of Madagascar: A multiple regression approach. Geoderma, Volume 162, 3-4, 335-346 - Grinand C, Arrouays, D, Laroche B. Martin, M.P. 2008. Extrapolating regional soil landscapes from an existing soil map : Sampling intensity, validation procedures, and integration of spatial context. Geoderma, 143, 180-190		

Participant 6

RAKOTOARIJAONA, Jean-Roger		Status	AA Autre acteur
Email	jr.rakotoarijaona@gmail.com	Tel	+261.32.07.822.10
Address	ONE, Antaninarenina, Antananarivo 101, Madagascar	Country	Madagascar
Affiliation	Office National de l'Environnement à Madagascar - ONE		
Laboratory	not applicable - N/A		
Equipe de recherche			
Main research interests	-		
Position	Head of the environmental data department at ONE		
Former positions	- 1998-present: Head of the environmental data department, ONE, Madagascar - 1991-1998: Research assistant in statistics, OCDE, Paris, France		
Education	- 2006: PhD, Economy of the environment, Universités Saint Quentin/Antananarivo, France/Madagascar - 1991: MSc, Econometry, Université des Sciences Sociales, Toulouse, France		
Scientific responsabilities	- President of the 'Comité Technique National REDD+ Madagascar (CT-REDD)' - Responsible for the redaction of the R-PP (REDD Readiness Preparation Proposal) for Madagascar - Madagascar negotiator on climate change		
Projects (in the last 5 years)	- 2012-2013: Development of the national REDD+ programme, AFD, Coordinator -		
Publications	**Total number of publications: 4** **Number of articles in peer-reviewed journals:** **Number of book chapters:** **Number of book written or edited:** **Number of citations (Web of Science [WoS] or Google Scholar Citations [GSC]):** **H-index factor (Specify WoS and/or GSC):**		
	- Andriamahefazafy F., Méral Ph., Rakotoarijaona J.-R., 2007, « La planification environnementale : un outil pour le développement durable ? », in Chaboud C., Froger G., Méral Ph. (dir.), Madagascar face aux enjeux du développement durable. Des politiques environnementales à l'action collective locale, Paris : Karthala, 23-49. - Vahanen, T., Rakotoarijaona, J.-R., Busson, F., Holmes, C., & Dolch, R. (2009). REDD Madagascar. Madagascar Conservation & Development, 4(2), 138-143. - Rakotobe, Z. L., Rakotoarijaona, J. R., Hawkins, F., Vynne, S., & Kennedy, E. SCALING UP REGIONAL INITIATIVES FOR MEASURING PROGRESS TOWARDS THE 2010 TARGET: TOWARDS A NATIONAL BIODIVERSITY MONITORING SYSTEM FOR MADAGASCAR. CBD Technical Series No. 17, 34. - Rakotoarijaona J.-R., Environnement et économie, in Ministère de l'Environnement et des Forêts, Rapport sur l'état de l'environnement 2012, Antananarivo, ami 2012.		

Budget breakdown per cost category:

	Total Cost	Requested Budget
Permanent Staff	148 500,00\€	
Temporary Staff	21 000,00\€	21 000,00\€
Equipment	11 000,00\€	11 000,00\€
Travel & subsistance	71 150,00\€	71 150,00\€
Consumables	13 800,00\€	13 800,00\€
Provision of services	1 500,00\€	1 500,00\€
Indirect costs (max 7% of requested budget)	8 050,00\€	8 050,00\€
TOTAL	275 000,00\€	126 500,00\€

Budget breakdown per partner:

	Year 1	Year 2	Year 3	Years 4 and 5
Permanent Staff	47 500,00\€	43 500,00\€	57 500,00\€	0,00\€
Temporary Staff	9 000,00\€	9 000,00\€	3 000,00\€	0,00\€
Equipment	8 600,00\€	600,00\€	600,00\€	1 200,00\€
Travel & subsistance	34 450,00\€	18 850,00\€	17 850,00\€	0,00\€
Consumables	2 600,00\€	2 600,00\€	6 600,00\€	2 000,00\€
Provision of services	300,00\€	300,00\€	600,00\€	300,00\€
Indirect costs (max 7% of requested budget)	2 012,50\€	2 012,50\€	2 012,50\€	2 012,50\€
TOTAL	104 462,50\€	76 862,50\€	88 162,50\€	5 512,50\€

Budget breakdown per year:

		Total Cost	Requested Budget
Partner 1	Cirad	146 150,00\€	57 650,00\€
Partner 2	University of Berkeley	33 100,00\€	21 100,00\€
Partner 3	ETC Terra	47 400,00\€	23 400,00\€
Partner 4	WCS/Rebioma	27 400,00\€	15 400,00\€
Partner 5	ONE	20 950,00\€	8 950,00\€
TOTAL		275 000,00\€	126 500,00\€