A PROPOSAL FOR INTEGRATING PAPUA NEW GUINEA'S NATIONAL FOREST INVENTORY WITH APPROPRIATE BIODIVERSITY INDICATORS

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Aims of the proposal

Current phase of FAO's programme: designing a **multipurpose National Forest Inventory (NFI)**, key component of the National Forest Monitoring System that PNG is required to establish in order to participate in the future REDD+ mechanism *(UN-REDD PNG 2011)*

Aims:

To develop a ***methodology for biodiversity assessment and monitoring*** *that can be integrated into the design of the planned NFI of PNG.*

Constraints

The **high biodiversity** richness and **knowledge gaps**

Third largest expanse of tropical rainforest on the planet

Estimated 200,000 species of plant and animals (26,318 reported by IUCN)

Wide areas of yet to be surveyed

(PNG's 4th National Report to the CBD 2010)

Large areas to be investigated

All PNG forests

Logistic constraints

Restricted time for sampling, difficulties in reaching some plot, security problems

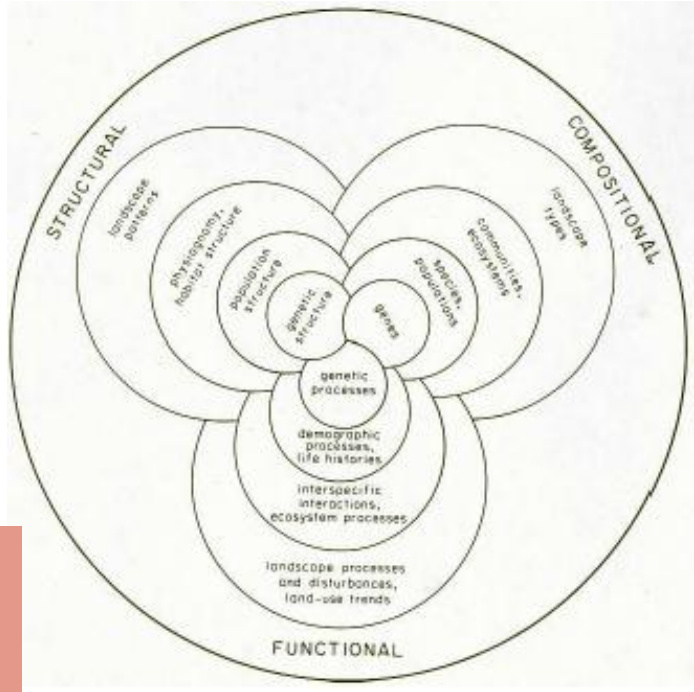
It would not be feasible to evaluate the entire biodiversity in a tropical forest, in terms of time and people needed, as well as costs **(Lawton et al. 1998, Nature)**

Indicators

Biodiversity indicators

Biodiversity is not just a number of genes, species and ecosystems, but should also cover the most important ***structural***, ***functional*** and ***compositional*** aspects of biodiversity (Noss ,1990)

Selection process represents a trade-off between choosing indicators that reflect some useful measure of ecological integrity or biodiversity, and those that can be feasibly sampled.



Noss (1990)

According to Gardner (2008) it requires:

- **the identification of a clear conservation objective or question**
- **the use of ecologically meaningful selection criteria that can identify indicator taxa relevant to this objective**
- **the analysis of the cost-effectiveness of sampling different taxa**
- **the availability of multi-taxa field data that can provide an empirical basis for the selection process**

Critical literature review

Expert based evaluation

INDICATOR SELECTION

It is not possible to be certain to select a priori the best indicators

A first **large selection of indicators** will be further assessed in terms of their performance with respect to the REDD+ goals

Indicators typologies

According to Lindenmayer (1999) we can identify three main typologies of indicators

Structure based indicators

Landscape level: connectivity, heterogeneity

Stand level: stand structural complexity (eg. horizontal and vertical arrangement, age, and size of trees)

Taxon based indicators

Group of taxa whose richness is highly correlated with that of unrelated groups

Indicators of functional diversity

Based on plant functional traits

Data from NFI about TREES

Structure based indicators

Stand level: stand
structural complexity
(eg. horizontal and vertical arrangement, age, and size of trees)

Taxon based indicators

Tree composition

Promising indicators for biodiversity in REDD+ (Imai et al. 2014):

- **Easy sampling** (Gardener et al. 2008)
- **Taxonomy is generally well described**
- **It has shown a high cross-taxon congruency** (Barlow et al. 2007; Howard et al. 1998; Kati et al. 2004)

Data from NFI are sufficient?

BIODIVERSITY SURROGACY remains a highly contentious issue (Lawton et al. 1998; Hess et al. 2006)

- Richness of one group is often highly correlated with that of unrelated groups (Blair 1999; Swengel & Swengel 1999), even though the richness of any particular group is a notoriously unreliable surrogate of the richness of all groups combined (Hess et al. 2006)

- A range of taxa is required for reliable surrogacy of total species richness (Inara et al. 2010)

- Surrogate taxa are likely to be biome-specific (Larsen et al. 2009)

we propose to integrate the planned NFI data with a number of additional biodiversity indicators

Fragmentation

Background

Monitor the **FRAGMENTATION** of habitat

Formann (1995)

AFFECTS

Spatial processes	Patch number	Average patch size [1]	Total interior habitat [2]	Connectivity across area [3]	Total boundary length [4]	Habitat	
						Loss	Isolation
Perforation	0	–	–	0	+	+	+
Dissection	+	–	–	–	+	+	+
Fragmentation	+	–	–	–	+	+	+
Shrinkage	0	–	–	0	–	+	+
Attrition	–	+	–	0	–	+	+

Biodiversity, *total* ***carbon storage*** *and other ecosystems processes* (e.g., Fahrig 2003, Fisher and Lindenmayer 2007) *and over expected natural leves is generally indicative of* ***degradation***

Methods

Remote Sensing and/or
GIS software

Indicators

Metric	*Calculation*	*Unit*	*Relation to degradation*	*Caveats and constraints*
Mean Patch Size	Total forest area divided by the total number of patches	Hectares	Increasing: degradation due to area effects	Mean patch size can increase as a result of elimination of small forest patches
Mean Perimeter-Area Ratio	The mean ratio of the patch perimeter to area across all patches	Dimensi on-less	Increasing: degradation via edge effects	Ratio can decline through the elimination of smaller and more complex patch shapes
Patch density	The number of patch divided by total landscape area	N/100ha	Increasing: degradation via edge effects	Limited interpretative value by itself: it conveys no information about the size and spatial distribution
Incidence function model	The mean distance between all landscape patches, based on shortest edge-to-edge distance	Metres	Increasing: degradation due to isolation effects	Loss of individual isolated patches can cause a decrease in the mean nearest neighbor distance
Forest Integrity Index	Combined metrics of patch size, connectivity, and edge effects	Dimensi on-less	Declining: reduced ability to produce goods and services, and therefore increasing degradation	Relationship to specific goods and services not established – complexity may obscure more understandable trends

Stand structure

Background

Within-stand distribution of trees and other plants attributes such as size, age, vertical and horizontal arrangement, is related with forest biodiversity or other their features

Trees

Data about trees will be collected by NFI, according to FAO's methodology

We add only the evaluation of **regenerative capacity** of the forest as a whole and\or for target tree species

Foliage

Foliage arrangement **was not considered because of sampling constraints** and the little consensus as to what measure to use it as indicator

Non Tree Plant Diversity (NTPD)

Lianas, Shrubs, Herbs, Epiphytes

Field collection for stand structural diversity (NTDP)

1.000 Permanent plots

Lianas

- Number of stems (rooted in the plot)
- Number of trees with lianas attached at the trunk
- Measure of stems (>5cm; 1,30m)

Shrubs (plant <3m)

- Number of stems (classified as multi-stemmed or single-stemmed)
- Cover of three layers (High: 2-3m, Middle: 1-2m, Low: 0-1m) : (1)<10% (2)10-40% (3)40-70% (4)70-100% (Cover Index: CI)

Palms (plant <3m)

- Cover Index for each morpho-species identified in the field

Field collection for stand structural diversity (NTDP)

Herbs

- Cover Index
- Cover Index of tall (>1m) herbaceous plants (e.g. Musa, Araceae, tree ferns, Marattiaceae, Zingiberaceae)

Epiphytes

- Number of individuals in the area encompassing the five Cluster-Plots

Measure and estimate species richness

Background

Diversity of a range of taxa represents a surrogacy of total species richness

Indexes

α, Simpson, Shannon (Magurrann 2004)

Estimated Richness using non-parametric estimators (Chao et al. 2005)

Trees

Data about trees will be collected by NFI, according to FAO's methodology

Non Tree Plant Diversity (NTPD)

Fauna

Field collection for taxon based indicators

100 Super plots

Non Tree Plant Diversity (NTPD)

- Collection of three individuals (**with taxonomic traits**) for each presumed species located in the plot
- Storage of samples
- Shipment to Herbarium (PNG, Rome, Australia)

Fauna

PASSIVE CAPTURE, at least **24h** of trap operation

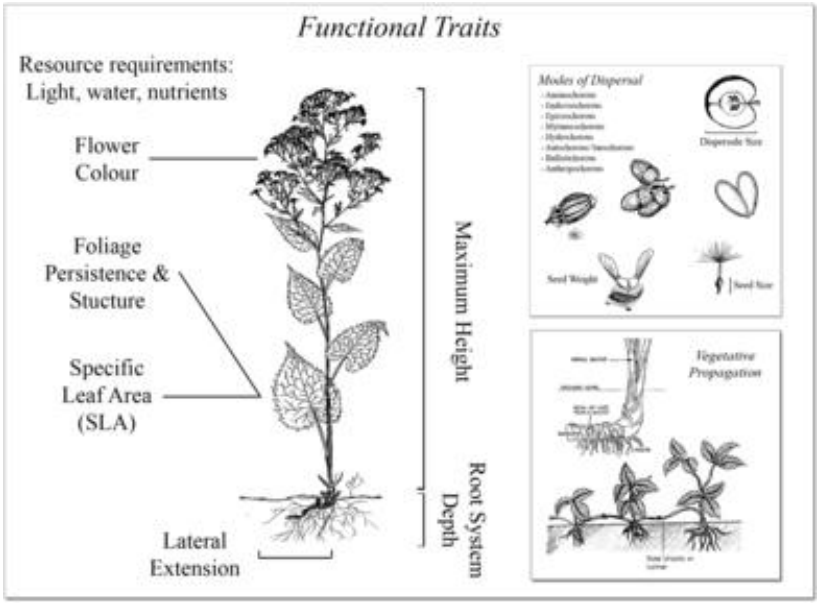
- **Pitfall traps**: small (**200cc**), unfenced, for walking insects and other arthropods;10 traps along straight line ,100m distanced
- Larger (**5l**) **pitfall traps**: small amphibians, reptiles and mammals; 3 traps, 100m distanced
- **Malaise traps**: flying insects (Hymenoptera and Diptera); three traps placed according natural features
- Shipment to specialist such as the Papua Insects Foundation

Background

Plant Functional Traits (PFTs) have been proved to be a useful **surrogate of a complete floristic inventory,** and in some cases as a **biodiversity indicators** (Gillison et al. 2013).

They can be related to plant function in relation to main environmental constrains, and how they are relevant to the distribution of species:

- among **different forest management**
- along **climatic gradients** (Lavorel et al. 2007)
- **grazing** disturbance (Adler et al. 2005)
- **nutrient availability** (Dyer et al. 2001)



Field collection for functional diversity indicators

1.000 Permanent plots

Non Tree Plant Diversity (NTPD)

Collection of three individuals for each identified morpho-species (taxonomic traits not needed)

The evaluation of all PTFs in the field, for every morpho-species, is extremely **time consuming** and **expensive:**

Only a subset of PFTs will be recorded in the field

PFTs considered

Growth form: life form[1], plant height[1], regeneration[1] (clonality properties) and spinescence[1]

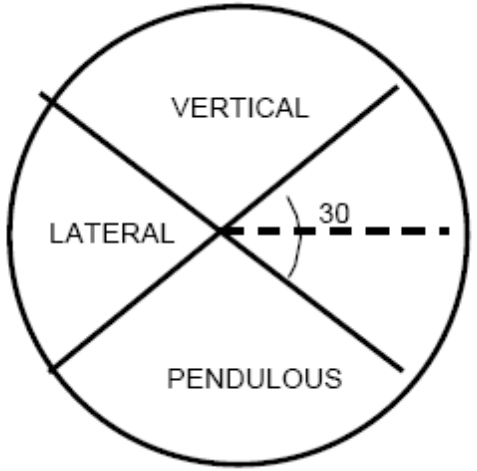
Leaf traits: Leaf inclination[1], Leaf chlorotype[2], Leaf morphotype[2], Specific Leaf Area[2], Specific Leaf Mass[2] and Specific Leaf Weight[2]

1: data obtained from the NTPD protocol; 2: data obtained subsequently from the herbarium material

PFTs collected in the field

Leaf inclination

- Vertical: >30° above horizontal
- Lateral: + or - >30°
- Pendulous: >30° below horizontal
- Composite: variety of inclinations



Leaf inclination (from Gillison 2006)

Leaf chlorotype

- Dorsiventral: chlorophyll is mainly on the upper side of a flat leaf
- Isobilateral: chlorophyll is equally distributed on both sides of the leaf
- Deciduous
- Achlorophyllous : without chlorophyllous

Leaf morphotype

- Rosulate: >30° above horizontal
- Succulent
- Parallel veined
- Filicoid
- Carnivorous

Spinescence

• No spines, thorns or prickles; (a simple tick on the field protocol)
• Annotate if there are soft spines; and the plant hurts when hit carelessly

The following spines may occur along the stem and not be included in the herbarium samples therefore is important to annotate the presence of spines for one of the following categories:

• Intermediate or high density of hard, sharp spine equivalents >5mm
• Intermediate or high density of hard, sharp spine equivalents >20 mm
• Intermediate or high density of hard, sharp spine equivalents >100 mm; for example rattan

Indicator type	Level	Sub-level		Required measurements / sampling	N. of plots	Information retrieved from indicators
Structure-based	Landscape			Measured through remote sensing and/or GIS software. Based on new forest map developed by JICA.		Fragmentation of natural habitat, as an indicator of degradation
	Stand	Trees		All measurements as already planned for the NFI	**1000 perm. plots**	Structural complexity related to biodiversity, conservation status
		Non-Tree Plant species	Lianas	Number of stems that are rooting within the plot site	**1000 perm. plots**	
			Shrubs	1) classification as multi-stemmed or single-stemmed (monopodial)		
				2) number of stems of each growth form (single/multi stemmed)		
				3) cover index (**1**:<10%; **2**:10-40%; **3**: 40-70%; **4**:70-100%) of three shrub layers: High (2-3m); Middle (1-2m) and Low (0-1m)		
				4) cover index for each morpho-species of young Palms not taller than 3m: (1) <10% (2) 10-40% (3) 40-70% (4) 70-100%		
			Herbs	1) cover index : (1)<10% (2)10-40% (3)40-70% (4)70-100%		
				2) occurrence and cover index of tall plants (e.g. Musa, Araceae, tree ferns, Marattiaceae, Zingiberaceae)		
			Epiphytes	Abundance of epiphytes (number of individuals)		

Indicator type	Level	Sub-level	Required measurements / sampling	N. of plots	Logistic simplications	Information retrieved from indicators
Taxon-based	Stand	Trees	NFI data	**1000 perm. plots**		Measures and estimates of biodiversity: α, Simpson, Shannon, Estimated richness using nonparametric estimators (Chao et al. 2005)
		Non-Tree Plant species	Three individuals (with taxonomic traits: e.g. flowers, fruits, seeds) to be collected for each presumed species within a plot	**100 superplots**	Three individuals with taxonomic traits have to be collected, processed and sent to PNG, Australian and Italian herbaria	
		Fauna	1) Pitfall traps, small, unfenced, for walking insects and other arthropods (10 traps in a straight line ad a distance of 10 m from each other)		Sampling procedure requires at least 24 h. Specimens should be collected both at dawn and at dusk. Samples shall be preserved and dispatched for analysis	
			2) Pitfall traps, larger, fenced for small amphibians, reptiles and mammals (3 traps at a distance of 100 m from each other)			
			3) Malaise traps for flying insects, particularly Hymenoptera and Diptera			

Indicator type	Level	Sub-level	Required measurements / sampling	N. of plots	Logistics implications	Information retrieved from indicators
Functional diversity	Stand	Non-Tree Plant species	Three individuals for each species (or morpho-species) to be collected within a plot *Growth form*: life form[1], plant height[1], regeneration[1] (clonality properties) and spinescence[1.] *Leaf traits*: Leaf inclination[1], Leaf chlorotype[2], Leaf Morphotype[2], Specific Leaf Area[2], Specific Leaf Mass[2] and Specific Leaf Weight[2]. 1: data obtained from the NTPD protocol; 2: data obtained subsequently from the herbarium material.	**1000 perm. plots**	Three individuals have to be collected, processed and sent to PNG, Australian and Italian herbaria. Taxonomic traits are not needed. A subset of PFTs recorded in the field, others analysed in herbarium	Measures of functional diversity. PFTs as surrogates of a complete floristic inventory; PFTs as indicators of disturbance

Large selection of indicators to be analyzed and possibly refined in the final steps of the project

questions/suggestions

Thank you for your attention