

AGRICULTURE PRACTICE AND ITS IMPACT ON FOREST COVER AND INDIVIDUAL TREES IN THE MOUNT CAMEROON REGION

ABSTRACT

Land use changes ~~is due to agricultural intensification~~ driven by ~~due to agricultural intensification~~ demographic growth and unemployment have increased pressure on the Mount Cameroon Forest. The aim of the study was to evaluate the impact of agriculture practice on forest cover and tree damage. For this, the Mount Cameroon Region was selected as the research site. Semi-structured questionnaires, interviews and focused group discussions were carried out to collect socio-economic data. In addition, field surveys and remote sensing techniques were used. Thus, ten 50 × 50 m sample plots ~~(0.25 ha)~~ were established in newly opened farms in the study sites. All trees damaged by fire during farming were sampled and the diameter at breast height (dbh ≥ 10cm) recorded.

A ground truthing ~~survey~~ was done to obtain ground reference data ~~aa during the study period~~. During this survey, geographical positioning system (GPS) points were recorded from different land uses observed (farmlands, forests, bare ground, plantations and settlement areas) using ~~a hand held~~ Garmin eTrex Venture HC GPS. Landsat Thematic (TM) and Enhanced Thematic (ETM+) images were extracted ~~from Landsat scenes of the MCR~~ for the years 1986, 2000 and 2008.

The results showed that the number of farms cultivated per household correlated positively with the family sizes of the respondents ($r = 0.98$). The annual deforestation rate was 1.09% from 1986-2000, and 0.58% from 2001-2008. Noticeably, agricultural fields were increased by 12 ha annually from 1986-2000, while they were decreased by 33.5 ha from 2001-2008. A total of 460 trees belonging to 98 species of 33 families were damaged. The average basal area of the trees was 1.3 m². The highest damage was noticed in Malvaceae. The most important species damaged were *Terminalia superba*, *Xylopia africana* and *Entandrophragma cylindricum*. Thus massive tree destruction was recorded due to land use

30 changes specifically agricultural expansions, illegal logging and fuel wood collection which
31 consequent threats to forest biodiversity.

32 **Key-Words:** Land use changes, agricultural intensifications, forest cover, tree damage

33

34 1. INTRODUCTION

35 Global record of land use changes to non-forest from forest is 4,967 million-M haectares, which
36 was projected to increase by 6% and 12% byin 2015 and 2030 respectively at the expense of
37 natural forests(1). The are was an annual deforestation rate of 0.5% for the Central African
38 Region contributed about ,accounting for 1.14 Mmillion hectare-ha forest cover loss in Central
39 African Region. Similar findings were noted in Cameroon too, with an annual agricultural
40 expansion of 0.02 ha in the Mount Cameroon Region (MCR) (2); (3). Increased population
41 pressure coupled with the need forand their demand of food are driving cause of conversion of
42 expansion in-agricultural land from forest areas production has continued to serve as one of the
43 driving forces for conversion ofin tropical forests to agricultural fields (4).This land use change
44 is one of the most crucial human impacts on natural ecosystems; causing changes inand their
45 services obtained from the ecosystem (5); 6).

46 The Mount Cameroon Region (MCR) which has rich and fertile volcanic soils (7) is close to the
47 coast, and has agro-industrial ventures such as the Cameroon Development Corporation (CDC),
48 Cameroon Tea Estate, (CTE) and small scheme holders. According to the CDC cultivates palm,
49 rubber, and banana on about 43,000 hectareha s of land was planted mainly with palm, rubber,
50 and banana on (8). Peasant agriculture has practiced the agriculture in small farms of like less
51 than 1 one hectareha which are examples of. There is mixed cropping of cocoyam, maize,
52 plantains, yams, cassava, and vegetables. All these require land use change from forest to
53 farmland. According to FAO (9), a change in the use of land was one of the three well
54 established global changes that caused forest degradation worldwide. Sunkekang (2) reported
55 that land use changes leading to the expansion of agricultural lands at the expense of natural
56 forests was the main driving force of tropical deforestation. Bird species were affected by
57 agricultural intensifications (10), due to decline in invertebrates and seed food (11). Forest

Comment [c1]: repeated

58 degradation ~~is cause of affects~~ biodiversity ~~loss and through~~ habitat destruction. ~~Other important~~
59 ~~consequene was forest dependent~~ ~~Several~~ communities ~~depend on this forest for their livelihood~~
60 ~~and they obtain services which are not usually given market financial~~ ~~affected values.~~ ~~Land use~~
61 ~~changes that favour forest degradation are detrimental to services obtained from the forest. Such~~
62 ~~services like nutrient cycling, soil formation, water availability, pollination, climate regulations~~
63 ~~as well as pest and pollution control are linked to biodiversity (12).~~

64
65 Loss of biodiversity affects ecosystem function~~ing~~ and stability, productivity at different ~~trophie~~
66 levels, ~~nutrient cycling and erosion control~~ (13). McKee et al. (14) reported that anthropogenic
67 impacts ~~caused by human population density~~ accounted for 87.9% ~~of the variation in numbers of~~
68 ~~threatened species~~ ~~threat~~ across the ~~moist humid tropical rain forest~~. ~~During the last few decades,~~
69 ~~deforestation of tropical forest has aaccelerated at an alarming rate, as extensive areas of forest are~~
70 ~~being cleared every year for different land use purposes~~ (15). ~~Humanity~~ affects forest ecosystems
71 ~~with activities such as the establishment of plantations for agro-industries, shifting agriculture,~~
72 ~~hunting, logging etc. There has been an overwhelming concern about the loss of tropical~~
73 ~~diversity and emphasis on the identification of biodiversity hot spots in an attempt to optimize~~
74 ~~conservation strategies~~ (16). According to Ellis (17), land use changes from forests to farmlands
75 ~~and selective tree harvest caused loss of biodiversity and habitat fragmentation. Such land use~~
76 ~~changes decreased core habitat areas and species requiring undisturbed core habitats suffered~~
77 ~~from local and general extinction. Rimm and Raven~~ (18) reported that habitat destruction was the
78 ~~most important cause of species extinction worldwide.~~

Comment [c2]: can you restructure this paragraph

79
80 Habitat destruction increases the vulnerability of forests to natural disasters such as floods,
81 drought, crop failure, spread of diseases, and water contamination, together with alterations in
82 the nitrogen, phosphorus, sulphur, and carbon cycles (19). ~~Habitat fragmentation and degradation~~
83 ~~may lead to loss in biodiversity and influence the life cycle of tropical tree species by reducing~~
84 ~~pollination, limiting seed dispersal and increasing seed predation (20) which may affect species~~
85 ~~population sizes and their distribution.~~ A decline in any single species is very relevant to

86 biodiversity conservation and resource management (21). Therefore this study addresses the
87 following research questions;(i) what are the different land uses and farming practices in the
88 MCR?(ii) What are the effects of land use and agriculture on forest cover? (iii) How do farming
89 practices affect individual trees and forest biodiversity in the MCR? In order to answer these
90 questions the research seeks to

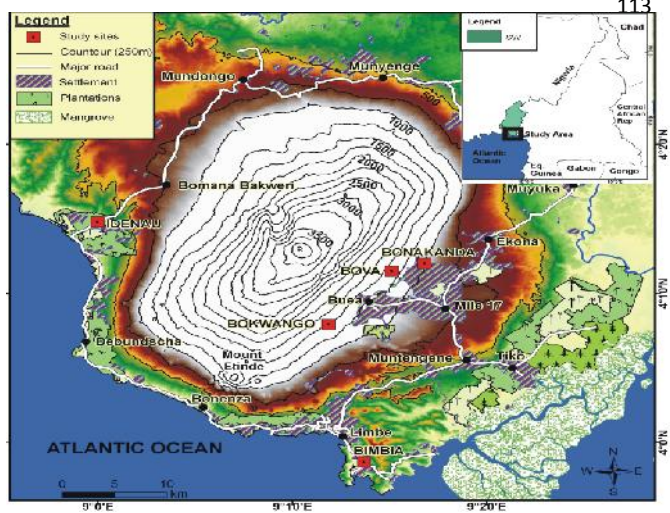
- 91 i. show the existing land use and agriculture practice.
- 92 ii. evaluate the trend of forest cover loss.
- 93 iii. evaluate the damage analysis of individual trees.

94

95 2. MATERIALS AND METHODS

96 **2.1 Study Site:** The MCR is found in the South West Region of Cameroon and covers a surface
97 area of 5,695.5 km² (3), stretching from latitude 3°57' to 4°28' N and longitude 8°58' to 9°24' E
98 (22). The region stretches just about 20 metres above sea level to 4,100 m, called Mount
99 Cameroon situated at 4°13' N and 9°10' E. This is the highest point in West and Central Africa.
100 The climate is humid with annual rainfall ranging from 2085 mm to 10,000 mm. The mean
101 annual temperature is 25°C and this decreases by 0.6°C per 100 m ascent (23). According to
102 Institute of National Statistics Cameroon, in the year 2010 there were 1,384,300 people in the
103 South West Region of Cameroon. Of this, about 400,000 people live around the Mount
104 Cameroon National Park area (24), with an average of 7.9 people per house hold (25).

105 The landscape comprises tropical beaches, swamps, tropical and ~~montane~~ Montane forests,
106 together with agricultural lands. Cable and Cheek (26) described this region as one of the most
107 biologically diverse sites in Africa, with about 2,500 indigenous and naturalized plant species,
108 with 42 of them endemic to this region. The present study was carried out in five sites;
109 Bokwoango, Bova, Bonakanda, Bimbina (Bonangombe and Bonabile), and Idenau (Sanje village,
110 Scipio and Rechts Fluss CDC camp). These areas were selected to include the leeward and
111 windward sides of the mountain, and to cut across montane and coastal settlements in the Mount
112 Cameroon Region at different elevations (Figure 1).



Comment [c3]: Could you please show the maps of villages instead of contour map

Figure 1. Map of the Mount Cameroon Region showing the study Villages

2.2 Methods

Socioeconomic-, Landsat images and biophysical data were collected.

The socioeconomic data were collected using key informant interviews, pre-set questionnaire and focused group discussions (27). This data was collected following informed consent of the respondents.

Landsat images: Remotely sensed Images TM, ETM of years 1986, 2000 and 2008 were downloaded from the Global Land Cover Facility (GLCF) at 30 m resolution (Plate 1). The

144 images were georeferenced and geocoded. These were then classified using supervised
145 maximum likelihood parametric classifier in ArcGIS image analysis software version 9.3(28);
146 (3);(29); (30); (31); and (32).The GPS coordinates were collected from four land use categories;
147 forest, settlement, water and bare ground.

148
149 Biophysical data: This was focused on damage of individual trees and data obtained through farm
150 surveys. Ten plots of 50×50 m (0.25 ha) were established within randomly selected newly
151 opened farms and sampled. Five of these farms were in the mountain forest area and 5 in the
152 coastal forest. In each sampling plot, all tree species present were counted and identified using
153 structural and morphological characteristics. Voucher specimens of unidentified samples were
154 taken to the Limbe Botanic Garden for identification and confirmation. The dbh for each
155 individual tree under damage (lower portion debarked and burnt) was measured at 1.3 m from
156 ground level. Stumps left from timber logging were counted. The dbh of the trees were used to
157 compute the basal area (BA) and relative basal area (RBA). The relative density (RD) of each
158 tree species was calculated and the total density of all tree species encountered recorded. The
159 frequency (F) of each species was calculated in the different plots studied. This was used to
160 compute the relative frequency (RF). The Importance Value Index (IVI) of each species
161 destroyed was gotten using the formula of (33) ~~(Appendix A)~~. The cover value index (CVI) was
162 calculated for each plot using the methods of (34) and (35)(Appendix A1 to A7).

164 2.3 Data analysis

165 Socio-economic data were analysed using descriptive statistics in the Statistical Package for the
166 Social Sciences (SPSS) version 13.0.

167
168 Image data analysis: Colour composites of bands 7-4-2 were used to display images in standard
169 colour composites for land use and vegetation mapping (36). ~~The Resultant~~ maps were compared
170 on pixel by pixel basis. Change detection of the various land cover categories was done by
171 comparing land cover statistics (37). Annual rates of change of land cover types were gotten by
172 dividing the total change in cover type (in ~~hectare~~has) within each period by the number of years
173 between the periods.

Comment [c4]: Could you please improve paragraph because there is no coherent in these sentences

174

175 Bio-physical data analysis: Microsoft Excel 2010 package was ~~used exploited to do co~~compute
176 ~~the ations on~~ basal area, relative frequencies and densities, cover value and importance value
177 indices. Data on number of trees damaged and basal area were ~~analyzed using statistics~~subjected
178 ~~to a one way ANOVA at the 95% confidence level.~~

179

180 3. RESULTS

181

182 ~~Please include table, figure and graphs in the respective place of the results~~

183 ~~Please make the results and discussion very short~~

184 3.1 Existing land use and agriculture practice

185 Land is used in the MCR for farming, house construction, plantations, fallow plots, tourists' site
186 and forest reserves. The most common land use identified by most respondents (35.4%) was
187 farm lands (Table 1). Results from focused group discussion and interview of the elderly showed
188 that fallow periods which was ~~five-5~~ to ~~7~~seven years ~~wh~~as dropped to ~~0~~zero to ~~2~~two years, and
189 that larger farms were now opened ~~up~~ and cultivated ~~within~~ the forest, ~~with very little respect for~~
190 ~~local restrictions on farm sizes and entry into or collection of resources from the forests.~~

191

192 ~~About 84.0% of the respondents showed that the~~ Subsistence farming was the most common
193 agricultural system practiced ~~by 84.0% of the respondents~~ while ~~nearly~~ 16.0% of them practiced
194 plantation agriculture (large estate or farm where crops such as coffee, cocoa, palm, banana,
195 rubber trees etc. are grown).

196 ~~From the results, 59~~About ~~(52.2%) of the~~ respondents owned 5-8 different farm lands while 8
197 of them (7.1%) had 13-16 farms. Twenty three (20.4%) of them owned 1-4 and 9-12 farm lands
198 respectively. Fifty four respondents (46.0%) had farms of average size 0.27 ~~heetare~~ha (ha),
199 while 2 of them (1.8%) had farms which were bigger than a ~~heetare~~ha. A cross tabulation
200 between farm sizes and number of farms showed ~~that 41(69.5%) of the 59 respondents who~~
201 ~~owned 5-8 farms had these farms of average size 0.27 ha.~~

Comment [c5]: Please include table, figure and graphs in the respective place of the results
Please make the results and discussion very short

Comment [c6]: Please rewrite this paragraph clearly

202 It was observed that households with few individuals had less number of farms, with a strong
203 positive correlation between the number of farms and family sizes ($r=0.98$) (Table 2).

Comment [c7]: Few stands for how much number

204 **Table 2.** Relationship between the size of the family (individuals per household) and the
205 number of farms owned by respondents in the study villages of the MCR.
206

Family size	Number of farms owned				Total
	1-4	5-8	9-12	13-16	
1-5 persons	21	3	0	0	24
6-10 persons	1	54	0	0	55
Above 10 Persons	1	2	23	8	34
Total	23	59	23	8	113

213
214
215 **3.2 Trend of forest cover change**
216 The results from the ground truthing data showed that out of 49 GPS points, 38
217 points which represented about 77.5% exactly fitted exactly with the land use of the classified
218 satellite imagery of 2008. From There was 1,993 ha land cover statistics; dense forest cover
219 was 1,993 ha in 1986 was. This dropped to 1,610 ha in 2008 so the with a forest cover loss of
220 was 385 ha. There was a dense forest cover loss of 305 ha from 1986 to 2000 and 78 ha from
221 2000 to 2008 (Plate 2). Agricultural fields increased by 168 ha from 1986 to 2000, and decreased
222 by 14.3 ha from 2000 to 2008.

Comment [c8]: Please rewrite as I have made correction

Cover type	Land cover for different years			Changes in surface cover, annual changes and % change								
	1986	2000	2008	1986 - 2000			2000 - 2008			1986 - 2008		
				Total Change (Ha)	Annual change (Ha/vr)	%	Total Change (Ha)	Annual change (Ha/vr)	%	Total Change (Ha)	Annual change (Ha/vr)	%
Dense forest	1993	1688	1610	-305	-21.79	-1.09	-78	-9.75	-0.6	383	-17.41	-0.87

Agricultural fields	1174	1342	1074	+168	+12	+1.02	-268	-33.5	-2.5	-100	+4.55	+0.39
Settlements/ Bare ground	45	92	150	+47	+3.36	+7.46	+58	+7025	+7.9	+105	+4.77	+10.6

Settlement areas increased by 47 ha ~~from between~~ 1986 to 2000 and further increased by 58 ha ~~between next from~~ 2000 to 2008. ~~This increasing trend continued from 2000 to 2008 at an annual rate of 7.25 ha (7.9 %).~~ Agricultural fields had an annual increase rate of 12 ha from 1986 to 2000 (1.02%). From year 2000 to 2008, agricultural fields had an annual decrease of 33.5 ha (2.5%). From 1986 to 2008, agricultural fields decreased at an annual rate of 4.55 ha (0.39%). (Table 2)

Comment [c9]: Please make sensible sentence

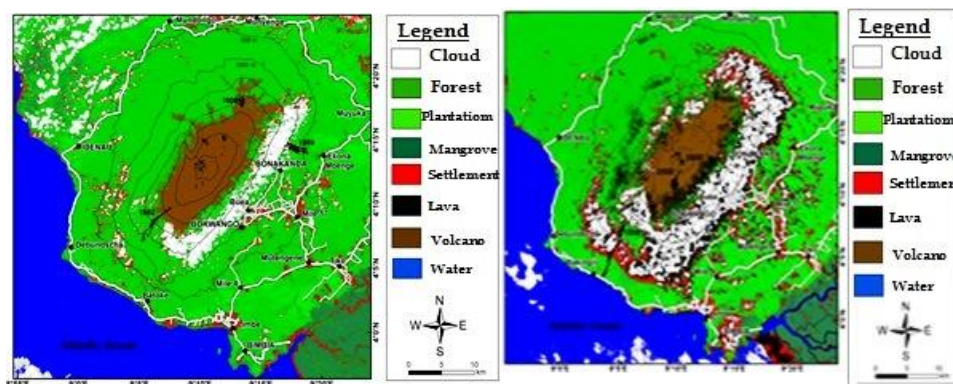


Plate 2a: 1986 classified map

Plate 2b: 2000 classified map

3.3 Record of tree damage

Results from farm surveys showed that there was massive tree destruction during the establishment of new farms. There were 49 unidentified ~~logged-tree stumps within in~~ 2.5 ha of newly opened farm land ~~sampled (which showed about 19.6-logged trees/ha).~~ The opening of some farms inside the forest ~~came was because of as a result of the~~ collection of abandoned tree branches after logging (Plate 2e). During this process, the under storey of the forest was removed (Plate 3a) followed by pruning (3b) and debarking of the bottom 1 m of all trees found in the

241 farm area. Fire was set under the debarked portions of trees (3c), and they were finally cut and
 242 carried away as fuel wood when dried (Plate 3).

243 Fuel wood was the only source of energy. ~~A in~~ about 80-90% of the households ~~visited; this was~~
 244 used fuel wood for cooking food, domestic warming, smoking fish, commercial roasting, and
 245 charcoal production. *Lophira alata* and *Rhizophora mangle* were the most used species for
 246 charcoal production and fish smoking. In the mountain villages, the most preferred species for
 247 fuel wood were 'Bwangu' (*Bridelia micrantha*), 'Sapelle' (*E. cylindricum*) 'Iroko' (*Chlorophora*
 248 *excelsa*), 'ewowo' (*Macaranga occidentalis*) and 'mosenge' (*Macaranga monandra*). These
 249 species were abundant in the area before the 1980s to the extent that a quarter in Bonakanda was
 250 named 'Wobwangu' meaning 'people of bwangu'. From our observations this tree species was
 251 rare in this quarter.

252
 253 A total of 460 trees of dbh ≥ 10 cm belonging to 98 species and 33 different families were
 254 damaged (184 trees damaged/ha). ~~The e highest record of damaged about 44 plants was found~~
 255 ~~under Malvaceae recorded the highest number of individuals family damaged (44 individuals).~~
 256 ~~The total basal area loss of trees under damage in the 2.5 ha sampled was 422.1 m² in the 2.5 ha.~~
 257 ~~The most important species in terms of IVI values were: Terminalia superba (15.8), Xylopia~~
 258 ~~africana (13.1), Entandrophragma cylindricum (12.1), Hymenostegia afzelii (11.4) and~~
 259 ~~Ceibapentandra (10.4) which possessed IVI 15.8, 13.1, 12.1, 11.4 and 10.4 respectively.~~
 260 ~~(Appendix B).~~

261 ~~The altitude elevation of the farms where the plots were established ranged from 87 m msl above~~
 262 ~~sea level in Bimbia to 1,062 m msl above sea level in Bokwango. The highest numbers of tree~~
 263 ~~destruction was 61 trees per 0.25 ha plot was recorded in Bonakanda (61 trees). But the~~
 264 ~~h Highest basal area loss was of 97.4 m² per plot was recorded in a plot in Bimbia. Mean tree~~
 265 ~~destruction was of 46 $\pm$ 2.6 trees per 0.25 hectare has plots, and mean basal area BA was of 58.5~~
 266 ~~$\pm$ 8.0 m² were recorded in the study area (Table 3).~~

267 Tree destruction and basal area loss in ten 0.25 has plots in the study villages of the MCR

<u>Locations of</u> <u>farms (sites)</u>	<u>Altitudes</u> <u>(metres</u> <u>above sea</u>	<u>No of trees</u> <u>damaged</u> <u>(0.24 ha)</u>	<u>Mean no of</u> <u>trees</u> <u>damaged</u>	<u>Basal area</u> <u>loss (m²)</u>	<u>Mean basal</u> <u>area loss</u> <u>($\pm$8m²)</u>
---	--	--	---	--	--

Comment [c10]: Please rewrite so that the sentences make sense

	level)	(±2.6)			
<u>Bokwango</u>	<u>1062</u>	<u>43</u>		<u>43.23</u>	
	<u>1001</u>	<u>30</u>	<u>36.5</u>	<u>21.12</u>	<u>32.18</u>
<u>Bova</u>	<u>1108</u>	<u>49</u>		<u>67.24</u>	
	<u>986</u>	<u>40</u>	<u>49.0</u>	<u>60.86</u>	
<u>Bonakanda</u>	<u>959</u>	<u>61</u>	<u>50.5</u>	<u>88.62</u>	<u>38.57</u>
<u>Bimbia</u>	<u>87</u>	<u>43</u>		<u>75.75</u>	
	<u>95</u>	<u>55</u>	<u>49.0</u>	<u>97.41</u>	<u>74.74</u>
<u>Idenau</u>	<u>102</u>	<u>49</u>		<u>78.55</u>	
	<u>115</u>	<u>45</u>		<u>40.90</u>	
	<u>104</u>	<u>44</u>	<u>46.0</u>	<u>41.01</u>	<u>86.58</u>
<u>Total</u>		<u>460</u>	<u>46.0</u>	<u>614.39</u>	<u>58.50</u>

268

269 Basal area loss ~~was of~~ 266.9 m² per ha ~~was recorded~~ in the coastal forest ~~and while it was~~ 225.9
270 m² per ~~hectare~~ha in the montane forest. ~~Meannumber of trees~~Average destruction ~~oyed per~~
271 ~~hectare~~was 188.8 trees ~~per ha~~ in the coastal forests and 146 trees per ~~hectare~~ha in the montane
272 forest. ~~The t-test shiwed that th~~There ~~was were~~ no significant differences in the cumulative basal
273 area loss from both sites at 95% probability level (Figure 2)

274 ~~Out of the individual trees destroyed,~~Altogether 207 trees (45.0%) ~~were destroyed were of~~
275 ~~the~~which have dbh class 10-30 cm. ~~Out of this,-~~ 115 trees ~~of them (55.6%)~~ were from the coastal
276 forest and 92 from the montane forest. In ~~case of -the~~ 31-60 cm dbh class, ~~131 trees (28.5%)~~
277 ~~were destroyed with~~ 77 trees ~~destroyed~~ from the montane forest and 54 from the coastal forest.
278 ~~In addition, Diameter classes between 120 to 150 cm, had a total of 12 trees destroyed (2.6%)~~
279 ~~with~~ 7 tree species found in the montane forest and 5 in the coastal forest (Figure 3).

280 4. DISCUSSIONS

281 4.1 Farming practice in the MCR

282 Farm lands were the major land use, which was also reflected in the occupation of the
283 respondents with majority of them being farmers. The high level of farming may be attributed to
284 the presence of fertile volcanic soils. Tourism and forest reserve land uses were low. This was
285 most likely due to increased farm lands and settlement areas.

286

287 | The uses of land keep changing and land title too as indigenes sell farmlands that were left to
288 fallow and the new owners construct houses there. Households with high education levels still
289 depended on the forest and farms for their livelihood. This was most probably caused by poverty,
290 unemployment and under employment. This finding is contrary to those of (38) who reported
291 that African households with higher education levels have more reliable sources of income and
292 do not depend on the forest. High dependence on natural forests has caused forest degradation
293 and the forest is no more continuous at low and high elevations, but broken by ‘new lay outs’
294 and towns, contradicting the view of (39) who reported that this forest was the only unbroken
295 | vegetation at 200 to 4,000_m above-sea-levels in West and Central Africa.

296
297 | Fallow periods were short and there were no long term fallow rotation periods. This drop_s in
298 fallow period is most likely attributed to land scarcity and increased population. This finding is
299 not in conformity to those of (40) who reported fallow periods of 10 to 16 years in the
300 MCR. Most newly opened farms as a result of shifting cultivation were inside the forests and
301 | forest edges, contributing to forest cover loss.

302
303 **4.2 Forest cover change pattern**
304
305 ~~About The 77.5% fit of ground truth points were matcing with the on the classified maps were~~
306 ~~probably caused by cloud cover. So, about 22.5% points were not matching, the reason may be~~
307 ~~due to disturbances in classification due to confusion of cloud and trees. In addition, This could~~
308 ~~also also it was not easy to classify the image because of -be due to the fact that small subsistence~~
309 ~~farm lands_ were located deep in the forests and could not be represented on the satellite images.~~
310 ~~From the images of 1986 and 2000 The~~, annual forest cover loss was 21.8 ha. Deforestation
311 ~~between 1986 and 2000 in the MCR but within the 1980s and 1990s had been attributed to the~~
312 ~~increase in~~ agricultural fields were less between 1980s and 1990s due to (2); (41), expansion of
313 plantations, lava flow (3) and urban development (42). ~~From the 2000 and 2008 the The~~ annual
314 deforestation dropped to 9.8 ha (0.58%) between 2000 and 2008. This decrease trend of
315 deforestation between the two periods may be due to conservation efforts by the Mount
316 Cameroon Project (MCP), several Non-Governmental Organizations (NGOs), German Agency

317 for Technical Cooperation(GIZ), and the creation of community forest reserves like Bimbia
318 Bonadikombo Community Forest Reserve (BBCFR), Woteva community forest,
319 Bakingili/Etinde community forest and Scipio council forest reserves. This annual deforestation
320 percentage is similar to that of Central Africa (0.5%) reported by (43) and that of Cameroon for
321 the 1990s (0.6%), reported by (9). This continual loss of forest probably has a serious concern on
322 carbon balance and climate change mitigation.

323

324 There was continual annual increase in settlement areas within the two periods. The increase in
325 in settlement from between 1986 to 2008 may be due to increase in populations and the need to
326 open more farms to sustain the population. According to reports by Kai (24) and WWF(25) the
327 population increase was about 4,375 persons per year between from 1987-2000 and which was
328 about 10,000 persons per year from between 2000 to 2010. Teh resultant effects were This has
329 led to the constructions of more houses and creation of more new-lay-outs for settlement within
330 the region. However, tThe decrease in agricultural fields between from the year 2000-2008 is was
331 most likely due to the surrender of some plantations done by the CDC for urban development
332 and sale of some small scheme plantations and farms to for new owners who changed the use of
333 the land from agriculture fields to house constructions.

334 4.3 Destruction of trees in farms

335 The first stage of farm preparation when new farms were opened was the removal of the under
336 storey and killing of trees. This was most likely to increase the space for planting crops and to
337 minimise shade effects. Theis same trend was identified by (44) who reported that few dominant
338 trees were felled during the preparation of small scale subsistence farms (0.5 to 2 ha) in the
339 forests of the MCR, which contributed to deforestation and loss of biodiversity.

340

341 The under storey was completely removed, which may be detrimental to shade plants, trees
342 recruitment from seedlings and the habitat of several small animals. Wright (45) reported that the
343 under storey was home to juveniles for canopy trees and life stages of small trees, shrubs and
344 herbs. The removal of this vegetation cover therefore affects the ecosystem balance and alters
345 habitats. According to Farwig et al. (20) such habitat alterations caused biodiversity loss,

346 lowered pollination, limited dispersal and increased seed predation in humid tropical forests.
347 **Bobbo et al.** (46) also reported that tree species richness decreased significantly with increased
348 levels of habitat modifications in South Western Cameroon forests. According to **Lawton et**
349 **al.**(47) such modifications of habitats reduced species richness of birds, butterflies, beetles, ants,
350 termites and nematodes in tropical forests, which were agents of pollination, and thus habitat
351 modifications are a threat to biodiversity.

352
353 Tree destruction was high in the coastal and ~~montane~~ Montane forests. The reason behind this is
354 ~~large number of trees destroyed~~ may be attributed due to ~~easy high tree population density,~~
355 accessibility ~~of the to~~ forests and high demand ~~for of~~ fuel wood. Basal area losses were high.
356 This finding ~~is in consonance~~ was also supported by ~~to those of~~ (46) and (48), ~~they who~~ reported
357 ~~significant~~ tree basal area losses ~~was due to conversion~~ when forests were converted to
358 farmlands ~~from forests~~ in South Western Cameroon. Loss of tree standing biomass negatively
359 impacts the CO₂ balance and climate change mitigation.

Comment [c11]: authors

360 ~~From our results, there were H~~ higher losses of number of trees and basal areas ~~was found~~ in the
361 coastal forests compared to ~~the M~~ montane forests. The reason was ~~is was most probably due to~~
362 higher ~~access of the people to teh forests~~ tree densities in the coastal forests ~~at low elevation;~~
363 ~~this may likely be attributed to high soil moisture content, higher rates of litter decomposition,~~
364 ~~change in elevation and climatic factors.~~ This result was also supported by ~~trend of higher tree~~
365 ~~numbers in coastal forests compared to montane forests is similar to findings of~~ (49) who studied
366 stand biomass of trees in the coastal and ~~montane~~ Montane forests of the MCR and recorded 99
367 trees per ~~hectare~~ ha (dbh ≥ 50 cm) in the coastal forests and 92 trees per ~~hectare~~ ha in the montane
368 forests of the region in 1989. According to **Vazquez and Givanish** (50) basal areas and tree
369 densities decreased ~~when moving from forests~~ at low elevation ~~than that of to those at~~ higher
370 altitudes; though (49) saw little evidence of effects ~~of elevation~~ on species ~~turnover~~ yield and
371 growth rate from low to high elevation.

Comment [c12]: Author

Comment [c13]: Author

372 ~~The From our result~~ showed the higher loss in s, the dbh class 10 – 30 cm ~~contained the majority~~
373 ~~of trees destroyed.~~ This massive loss ~~of number of trees of small dbh class is a threat to trees~~
374 ~~recruitment from seeds and the biodiversity of the MCR, harbouring several endemic tree~~

375 species, especially as the forest is a secondary forest recovering from disturbances ranging from
376 anthropogenic to natural disasters during eruptions of mount Cameroon.

377 because |

Comment [c14]: Could you please reason

378 The higher destruction was recorded in -Malvaceae had the highest destruction family, probably
379 because this species was ~~ey are among the~~ dominant tree species in the forests of the MCR.
380 This was also supported by Findings by Watts and Akogo (51) and Tako et al.(52). They noted
381 ~~them these species amongst the came dominant tree species in the forests of the MCR having in~~
382 gaps created by past lava flow in MCR. Ecologically,- Terminalia superb (White afara),
383 Xylopiiafricana, Entandrophragma cylindricum(Sapelle), Hymenostegia afzelii and
384 Ceibapentandra (Boma) were the most important species destroyed ~~in terms of the IVI values~~
385 ~~because people like to use these species for . This was most likely attributed to their large sizes~~
386 ~~and extensive uses as~~ furniture wood, construction materials, fuel wood and medicine. According
387 to Broklesby and Ambrose (53) and Forboseh et al. (49)Hymenostegia spp. was one of the
388 dominant species in the ~~montane~~ Montane forests of the MCR, while Entandrophragma spp.and
389 Ceiba pentandra were culturally important and highly used species in the region.

390 5. Conclusions

391 From our studies, the following conclusions can be drawn:

- 392 ■ Land use changes particularly agricultural intensification with high dependence on natural
393 fertile soils favoured shifting cultivation, leading to loss of forest cover in the MCR.
- 394 ■ There was massive tree destruction during the opening of new farms inside the forest and
395 fuel wood collection which is detrimental to the plant and animal diversity supported by the
396 forest in the MCR.

397

398 6. Recommendations

399 Based on findings of this research, the following are recommended:

- 400 ■ The boundary of forest reserves should be well traced, and areas for farming properly
401 carved out, with sign posts to show forest reserves and farming areas.

- ~~Bigger sanctions should be levied on defaulters to limit encroachments to forest reserves.~~
- ~~The tourism sector of the area should be developed with better facilities and be properly organised, within Mount Cameroon and the coast, which has great potentials to attract tourists and would employ several locals and reduce pressure on the forest.~~
- Alternative livelihoods options that do not depend on extensive land use can be promoted in this sensitive region to reduce pressure on natural forests.

REFERENCES

1. ~~FAO STATS www.fao.org/metadata. 2008.~~ In: Ravindranath NH, Manuvie R, Fargione J, Pep Canadell, Goran Berndes, Jeremy Woods, Helen Watson, and Jay Sathaye (2010). GHG Implications of Land Conversion to Biofuel Crops. *Scope Biofuel* Report, chapter 4
2. Sunkekang RM. (2006). Forest Policy: Forest Loss and land use cover change in Cameroon. PhD thesis, Oklahoma State University.
3. Kah EF, Tchindjang M, Tonye E and Talla T (2008). Combined Supervised Classification methods in Remote Sensing for the Evaluation of forest Dynamics along the slopes of Mount Cameroon. The International Archives of Photogrammetry, *Remote Sensing and Spatial Information Science* Vol. 37 Part B 8
4. Sayer J. A., Harcourt C. S. Collins N. M. (1992): The Conservation Atlas of Tropical Forests.
5. Chapin F, Zavaleta E, Viner V, Naylor R, Vitousek P, Reynolds H, Hooper D, Lavorel S, Sala O, Hobbie S. (2000). *Nature* vol. 405 pp.234-242
6. Luck GW, Ricketts TH, Daily G, Imhoff M (2004). *Proc Nat. Acadsci USA* Vol. 101 pp. 182-186
7. Fonge BA, Yinda GS, Focho DA, Fongod AGN and Busman RW (2005). Vegetation and soil status on an 80year old lava flow of Mt Cameroon, *West Africa Lyonia Journal of Ecology and application* Vol. 8(1) pp. 19-41

Formatted: Highlight

Comment [c15]: could you please reduce 2/3rd reference

Formatted: Highlight

Formatted: Font: Times New Roman, 12 pt, Highlight

Formatted: Highlight

- 431 8. ERM (Environmental Resource Management) (1998). Environmental Impact Assessment of
432 plantation Expansion by Cameroon Development Cooperation in Forested Lowland of the
433 Mount Cameroon Region. A report prepared for MCP, Limbe and DFID London 166p
- 434 9. FAO. (Food and Agricultural Organization) (1985). Changes in Shifting Cultivation in
435 Africa. FAO Soils Bulletin, 24, FAO Rome, Italy
- 436 10. Donald PE, Sanderson FJ, Burfield IJ, and Van Bommel FPJ. (2006). Further evidence of
437 continent wide impacts of agricultural intensification on European farmland birds.
438 *Agricultural Ecosystems and Environment* Vol. 116 pp. 189-196
- 439 11. Wilson J D, Morris AJ, Arroyo BE, Clark SC, and Bradbury RB. (1999). A Review of the
440 Abundance and Diversity of invertebrate and plant foods of graminivorous birds in Northern
441 Europe in relation agricultural change. *Agriculture Ecosystems and Environment* Vol. 75
442 pp. 13-30
- 443 12. MEA (Millennium Ecosystem Assessment) (2005a). Ecosystem and human well-being.
444 MEA, Island Press Covelo C.A
- 445 13. Tohru K, Kimiko O, Ian T, Ken S, Takeshi T and Kazuyuki F. (2010). The role of forest
446 Biodiversity in the sustainable use of ecosystem goods and services in agro-forestry,
447 Fisheries and Forestry. Proceedings of international Symposium for the convention on
448 biological Diversity, Tokyo Japan
- 449 14. Mckee JK, Sciulli PW, Foose CD and Waite TA. (2003). Forecasting Global Biodiversity
450 Threats Associated with Human Population Growth. *Biological conservation* Vol.115
451 pp.161-164
- 452 15. Tchouto MGP (2004). Plant diversity in a central African rainforest. Implications for
453 biodiversity conservation in Cameroon. PhD thesis, University of Edinburgh/Royal Botanic
454 Garden of Edinburgh.
- 455 16. Beentje HJ. (1996). Centres of plant diversities in Africa, the biodiversity of African plants.
456 Kluwer Academic publishers. The Netherlands, 101-109 pp
- 457 17. Ellis F. (2000). Rural livelihood and diversity in developing countries. Oxford, Oxford
458 University press
- 459 18. Rimm SL and Raven P. (2000). Biodiversity: Extinction by numbers. *Nature* Vol. 403 pp.
460 843-845

- 461 19. MEA (Millennium Ecosystem Assessment) (2005b). Biodiversity and Human Well Being.
462 Biodiversity Synthesis. Island Press
- 463 20. Farwig N, Blesher B, Vonder GS and Borning GK (2007). Does forest fragmentation and
464 selective logging affect seed predation rates in *Prunusafricanum*? *Biotropica* 42 (2) pp. 218-
465 224
- 466 21. Chamberlain J, Cunningham A and Nasi R. (1998). Diversity in forest Management: Non-
467 Timber Forest Products and bush meat. *Renewable Resource Journal*, Vol. 22 (2)
- 468 22. Fomete NT and Tchouto MG, (1998). Mont Cameroun, la gestion des ecosystems forestiers
469 du Cameroun. A laube de l'an 2000 (Eds) pp. 127-144
- 470 23. Fraiser PL, Hall JB, Healey JR. (1998). Climate of the Mount Cameroon Region, Long and
471 Medium term rainfall, temperature and sunshine data. SAFS, University of Bongor MCP-
472 LBG, Limbe 56pp
- 473 24. Kai Schmidt-Soltau (2003). Rural Livelihood and Social Infrastructure around Mount
474 Cameroon. GmbH Back ground information for the M.C-SE GIS
- 475 25. WWF (World Wide Fund for nature) (2010). Central African 2010 fact sheet, Mount
476 Cameroon National Park, panda. Org
- 477 26. Cable S and Cheek M. (1998). The plants of Mount Cameroon. A conservation check list
478 Royal Botanic Garden Kew, London.
- 479 27. Akinwumi A, Mbila D, Blaise G, Nkamleu D. (2000). Economic Analysis of the
480 Determinants of Adoption of Alley Farming by farmers in the forest Zone of South West
481 Cameroon. *Agriculture, Ecosystems and Environment* 80 (20001) pp. 255-265
- 482 28. Cogolton RG (1991). A Review of Assessing the Accuracy of Classification of Remotely
483 Sensed Data, *Remote Sensing of Environment* 37 pp. 35-46
- 484 29. Bauer M, Yuan F and Sawaya K (2003). Multi-temporal landsat images classification and
485 change analysis of land cover in the twin cities (Minnesota) Metropolitan area. Second
486 international workshop on the analysis of multi temporal remote sensing Images Ispra, Italy.
487 pp. 1-8
- 488 30. Anderson S, Roach S, and Witmer R (1976). A land use and land cover classification system
489 for use with remote sensor data. Geological survey professional papers No: 964. Washington.
490 United States Government Printing office

- 491 31. Fox II Lawrence and Stern A. Carlson (1999). Using a GLS and Land sat-TM image
492 classification to assess the health of the Klamath River Hydro-Basin in North America.
493 Humboldt. State University Arcata, California 95521 USA
- 494 32. Anisara P and Rajendra P (2008). Changes in land use and rural livelihoods: A study of
495 Phathalung watershed in Southern Thailand. *Asian Pacific Journal of Development* 18 (2)
- 496 33. Mueller-Dombois D and Ellenberg H. (1974). Aims and methods of vegetation ecology. John
497 Wiley and sons New York 337p
- 498 34. Tiwari SC. (2005). Concepts of Modern Ecology. *Vegetation* Vol. 85 pp. 17-120
- 499 35. Diogo SB, Leiton SD and Flavo F. (2010). Adaptive success index; a criterion for
500 identifying most important species. *Journal of Ecology and the Natural Environment* Vol. 2
501 (11) pp. 259-260
- 502 36. Trotter C M (1998). Characterizing the topographical effects at red wavelengths using
503 juvenile conifer canopies. *Int. J. Remote Sensing* 19 (11) pp. 2215-2221
- 504 37. Bokye E, Odai S N, Adjei K A and Annor F O (2008). Land sat Images for Assessment of
505 the impacts of Land use and Land Cover Changes on the Berekesse Catchment in Ghana.
506 *European Journal of Scientific Research* 22 No2 pp. 219-278
- 507 38. Kamanga P, Vedeld P and Sjastad E (2009). Forest Incomes and rural Livelihoods in
508 Chiradzulu District Malawi, *Ecological Economics* Vol. 68(3) pp. 613-624
- 509 39. Thomas B and Check M. (1992). Vegetation and plant species on the south side of mount
510 Cameroon in the proposed Etinde Rainforest Reserve. 37pp Report to Cameroon
511 Government/OD A/ RBG, Kew.
- 512 40. Ardener E, Ardener S and Warrington WA. (1960). Plantations and villages in the
513 Cameroons. Some Economic and Social Studies, Oxford University Press, Oxford In:
514 Ambrose-Orji B, Acworth J, Abonge G, and Manga H (1998): Rapid Agricultural Surveys
515 Methodology notes. MCP, Limbe.15pp.
- 516 41. Siwe RN and Koch B (2008). Change vector analysis to categorise land cover change
517 processes using the tassellated cap as biophysical indicator, description, implementing land
518 sat TM and ETM to detect land cover and land use changes in the Mount Cameroon Region,
519 using the CVA technique with the tasselled cap as biophysical indicator. *Environmental*
520 *Monitoring Assessment*. 145 pp. 227-35

- 521 42. Njohjam PN (2000). Integration of Remote Sensing and GIS in Land use planning for
522 Sustainable Natural Resource Management within the Mount Cameroon Region West Africa.
523 *International Archives of Photogrammetry and Remote Sensing* 33 Part B7 Amsterdam
- 524 43. WRI (World Resource Institute) (1994). World Resources report, 1994-1995. New York:
525 Oxford. Oxford University Press, p. 10, 33
- 526 44. Siwe RN. (2006). Evaluating the efficacy of remote sensing techniques in monitoring forest
527 cover and forest cover change in the Mount Cameroon Region. Ph.D. Thesis Albert Ludwig's
528 University, Freiburg Im Breisgau-Germany
- 529 45. Wright SJ. (2002). Plant diversity in tropical forests. A Review of Mechanisms of Species
530 Co-existence *Ecologia* 130: 1-14
- 531 46. Bobbo SK, Walter MN, Sainge MN, Njokagbor J, Fermon H and Murlenberg M. (2006).
532 From Forest to Farmland. Species richness patterns of trees and under storey plants along a
533 gradient of Forest Conversion in South Western Cameroon. *Biodiversity and Conservation*
534 Vol.15 pp. 4097-4117
- 535 47. Lawton JH, Bignell DE, Bolton B, Bioemers GF, Eggleton P, Hammond PM, Hodda M, Holt
536 RD, Larsen TB, Mawdsley NS, Srivastava DS and Watt AD. (1998). Biodiversity
537 inventories, indicator taxa and effects of habitat modifications in tropical forests. *Letters to*
538 *Nature* Vol.391 pp. 72-76
- 539 48. Zapfack L, Engwald S, Jonke B, Achoundong G and Madong B (2002). The impact of land
540 conversion on plant biodiversity in the forest zone of Cameroon. *Biodiversity and*
541 *Conservation* 11 pp. 2047-2061
- 542 49. Forboseh PE, Sunderland T, James C. and Bainga M. (2011). Tree population dynamics of
543 three altitude vegetation communities on Mount Cameroon (1989-2004) *Journal of Mountain*
544 *Science*. Vol.8 No 4 pp. 495-504
- 545 50. Vazquez GA, Givanish JT. (1998). Altitude gradients in tropical forests composition,
546 structure and diversity in the Sierra de Manantlan. *Journal of Ecology* Vol. 86 pp. 949-1020
- 547 51. Watts J and Akogo GM. (1994). Biodiversity assessment and developments towards
548 participatory forest management on Mount Cameroon. *The common wealth forestry review*
549 *Oxford* Vol. 73(4) pp. 221-230

- 550 52. Tako C, Mojoko S. and Ekema D. (Eds) (1996). User group analysis for participatory forest
551 management in Bwassa, Likombe, Mapanja villages. Mount Cameroon Project (MCP) Limbe
552 53. Broklesby MA and Ambrose-Oji B. (1997). Neither the forest nor the farms. Livelihood in
553 the Forest Zone, The Role of shifting Agriculture in Mount Cameroon “Rural Development
554 Forestry Network Paper 12/d summer 1997 24pp

Comment [c16]: Could you please reduce the reference in 2 pages

559 LIST OF TABLES

561 **Table 1.** Respondents view on the main land uses in the study villages of the MCR.

Land-use	Frequency	Percentage	562
Farm lands	40	35.39	563
Plantations	19	16.81	564
House construction	21	18.58	565
Fallow plots	17	15.04	566
Tourist site	10	8.85	567
Forest reserve	06	5.33	

571 **Table 2.** Relationship between the size of the family (individuals per household) and the
572 number of farms owned by respondents in the study villages of the MCR.

Family size	Number of farms owned				Total
	1-4	5-8	9-12	13-16	
1-5 persons	21	3	0	0	24
6-10 persons	1	54	0	0	55
Above 10 Persons	1	2	23	8	34
Total	23	59	23	8	113

Table 3. Surface cover areas of different land uses of the MCR for the year 1986, 2000 and 2008, with cover changes and percentage change from 1986-2000 (14 yrs.), 2000-2008 (8 yrs.) and 1986-2008 (22 yrs.)

Cover type	Land cover for different years			Changes in surface cover, annual changes and % change								
	1986	2000	2008	1986-2000			2000-2008			1986-2008		
				Total Change (Ha)	Annual change (Ha/yr)	%	Total Change (Ha)	Annual change (Ha/yr)	%	Total Change (Ha)	Annual change (Ha/yr)	%
Dense forest	1993	1688	1610	-305	-21.79	-1.09	-78	-9.75	-0.6	383	-17.41	-0.87
Agricultural fields	1174	1342	1074	+168	+12	+1.02	-268	-33.5	-2.5	-100	+4.55	+0.39
Settlements/ Bare ground	45	92	150	+47	+3.36	+7.46	+58	+7025	+7.9	+105	+4.77	+10.6

Table 4. Tree destruction and basal area loss in ten 0.25 hectares plots in the study villages of the MCR

Locations of far ms (site s)	Altitudes (me tres abo ve sea leve	No of trees dam age d (0.2 4 ha)	Mean no of tree s dam age d (±2.	Basal area loss (m ²)	Mean basal area loss (±8 m ²)
------------------------------	------------------------------------	----------------------------------	----------------------------------	-----------------------------------	---

Formatted: Justified, Indent: Left: 0", Hanging: 0.63", Space After: 10 pt, Line spacing: Multiple 1.15 li

	d)		e)		
Bokwango	1062	43		43.23	
	1001	30	36.5	21.12	32.18
Bova	1108	49		67.24	
	986	40	49.0	60.86	
Bonakanda	959	61	50.5	88.62	38.57
Bimbia	87	43		75.75	
	95	55	49.0	97.41	74.74
Idenau	102	49		78.55	
	115	45		40.90	
	104	44	46.0	41.01	86.58
Total		460	46.0	614.39	58.50

Formatted: Indent: Left: 0", Hanging: 0.63", Space After: 10 pt, Line spacing: Multiple 1.15 li

Formatted: Indent: Left: 0", Hanging: 0.63", Space After: 10 pt, Line spacing: Multiple 1.15 li

Formatted: Indent: Left: 0", Hanging: 0.63", Space After: 10 pt, Line spacing: Multiple 1.15 li

Formatted: Indent: Left: 0", Hanging: 0.63", Space After: 10 pt, Line spacing: Multiple 1.15 li

Formatted: Indent: Left: 0", Hanging: 0.63", Space After: 10 pt, Line spacing: Multiple 1.15 li

Formatted: Indent: Left: 0", Hanging: 0.63", Space After: 10 pt, Line spacing: Multiple 1.15 li

Formatted: Indent: Left: 0", Hanging: 0.63"

LIST OF FIGURES AND PLATES

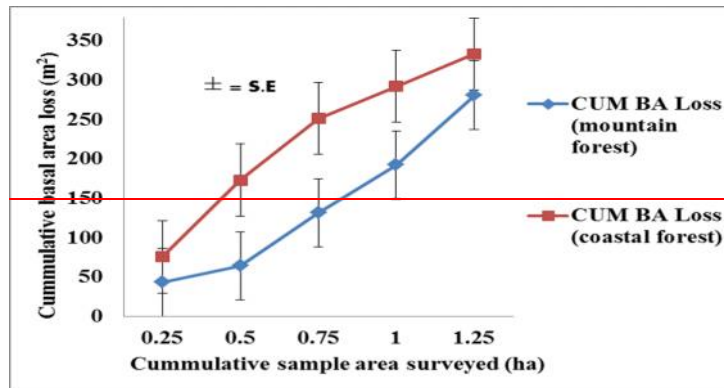


Figure 2: Cumulative basal area loss in the coastal forest, compared with that of the montane forest in the study sites

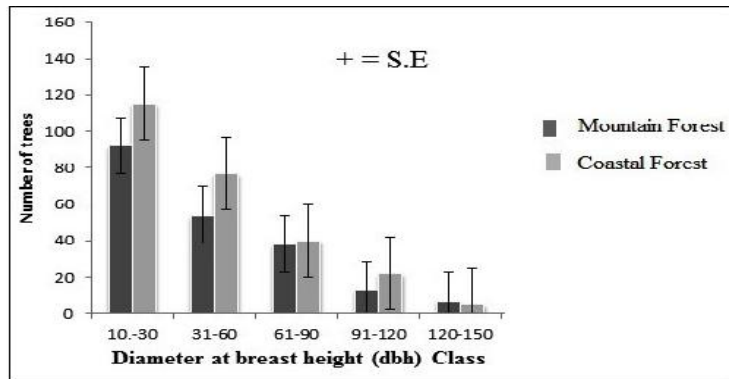


Figure 3. Diameter classes of trees destroyed between the two ecotype forests survey in the Mount Cameroon region.

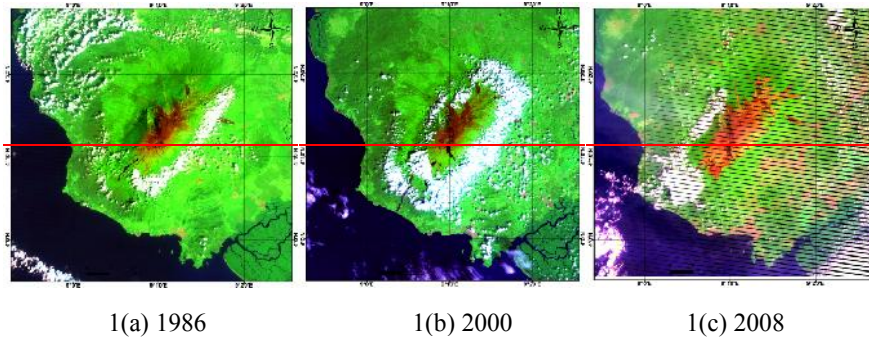


Plate 1. Extracted images of land Landsat scenes of the Mount Cameroon Region of (a) 1986, (b) 2000 and (c) 2008

Plate 2: Classified maps of land cover of the MCR for (a) 1986, (b) 2000 and (c) 2008 settlement extract



(a) Removal of the understorey

(b) Pruning, tilling and first planting



(c) Bottom 1m tree debarked and burnt

(d) Tree species, cut for timber



(e) Abandoned wood that attracts the villages as they search for fuel wood

(f) Established cocoyam farm, all trees cut and carried away

Plate 3: Stages of farm preparation showing tree destruction, involving understorey removal (a), pruning and tilling (b), killing of pruned trees (c), logged trees for timber within the farms (d), abandoned wood in farmlands (e) and an established farm where all dried up destroyed trees had been cut down and used for fuel wood (f) in the mountain forest of the MCR.

651 **APPENDIX A**

652 ~~A1: $IVI = RD + RBA + RF$~~

653

654
655 ~~A2:~~ $RD = \frac{\text{Density of species}}{\text{Total Density}} \times 100$
656

657 ~~A3: $BA = \pi (\frac{1}{2} DBH)^2$~~

658

659 ~~A4:~~ $RBA = \frac{\text{Basal area of species}}{\text{Total basal area}} \times 100$

660

661
662 A5: $F = \frac{\text{N}^{\circ} \text{ of plots in which species is present}}{\text{Total N}^{\circ} \text{ of plots}} \times 100$
663

664

665 ~~A6:~~ $RF = \frac{\text{Frequency of species}}{\text{Total frequency}} \times 100$

666

667

668 ~~A7: $CVI = RD + RB$~~

669

670

671

672

673

674

675

676

677

678

679

680

681

682

683 **APPENDIX B**

684 Different tree species destroyed in ten plots of 0.25 ha. each from newly opened farms, their
 685 frequency (F), relative frequency (RF), density (D), relative density (RD), diameter at breast
 686 height (DBH), basal area (BA), relative basal area (RBA) and importance value index (IVI) in
 687 the study sites
 688

	SPECIES	FAMILIE S	F	RF	D	RD	DBH (M ²)	BA	RBA	IVI
1	<i>Aidiageniculata</i>	Icacinaceae	0.1	0.45	1	0.22	0.26	0.053	0.01	0.68
2	<i>Allophylus africanus</i>	Sapindaceae	0.2	0.91	2	0.44	0.36	0.10	0.02	1.36
3	<i>Alsodeiopsisweissenborniana</i>	Icacinaceae	0.3	1.36	6	1.31	0.91	0.65	0.11	2.77
4	<i>Annickiachlorantha</i>	Annonaceae	0.2	0.91	4	0.87	0.88	0.61	0.01	1.87
5	<i>Anthoeleistavogelii</i>	Loganiaceae	0.2	0.91	2	0.44	0.31	0.08	0.01	1.35
6	<i>Antidesmavogelium</i>	Phyllanthaceae	0.1	0.46	3	0.66	0.98	0.76	0.12	1.23
7	<i>Araliopsissoyaxii</i>	Rutaceae	0.1	0.46	1	0.22	0.45	0.16	0.03	0.70
8	<i>Aulacocalyxcaudata</i>	Rutaceae	0.1	0.46	1	0.22	0.43	0.15	0.02	0.69
9	<i>Aulacocalyxalbotii</i>	Fabaceae	0.1	0.45	1	0.22	0.37	0.11	0.02	0.69
10	<i>Baphiasp</i>	Fabaceae	0.1	0.46	1	0.22	0.32	0.08	0.01	0.68
11	<i>Brideliamicrantha</i>	Phyllanthaceae	0.5	2.26	8	1.74	1.09	0.93	0.15	4.15
12	<i>Calycosiphoniaspathielyx</i>	Rubiaceae	0.2	0.91	2	0.44	0.87	0.59	0.10	1.44
13	<i>Carapaparviflora</i>	Meliaceae	0.2	0.91	2	0.44	0.73	0.42	0.07	1.41
14	<i>Cecropiasp</i>	Moraceae	0.1	0.46	3	0.66	0.97	0.74	0.12	1.23
15	<i>Ceibapentandra</i>	Malvaceae	0.2	0.91	14	3.04	7.13	39.91	6.49	10.44
16	<i>Chytranthussp</i>	Sapindaceae	0.4	1.81	10	2.17	1.09	0.93	0.15	4.12
17	<i>Cleistopholis patens</i>	Annonaceae	0.2	0.91	5	1.09	1.86	2.72	0.44	2.44
18	<i>Coelocaryonpreussii</i>	Myristicaceae	0.1	0.46	8	1.74	1.12	0.99	0.16	2.35
19	<i>Coffeasp</i>	Rubiaceae	0.1	0.46	2	0.44	0.42	0.14	0.02	0.91
20	<i>Cola chlamydantha</i>	Malvaceae	0.3	1.36	10	2.17	1.44	1.63	0.27	3.80
21	<i>Cola flavo-volonina</i>	Malvaceae	0.2	0.91	7	1.52	0.88	0.61	0.10	2.53

22	<i>Cola laterita</i>	Malvaceae	0.2	0.91	5	1.09	0.63	0.31	0.05	2.04
23	<i>Cola marsupium</i>	Malvaceae	0.2	0.91	6	1.31	0.71	0.40	0.06	2.27
24	<i>Cola praeacuta</i>	Malvaceae	0.4	1.81	11	2.39	1.53	1.84	0.30	4.50
25	<i>Cola sp</i>	Malvaceae	0.3	1.36	5	1.09	0.66	0.35	0.06	2.50
26	<i>Crotonogynetalbotii</i>	Euphorbiaceae	0.2	0.91	2	0.44	0.41	0.13	0.02	1.36
27	<i>Daeryodes edulis</i>	Burseraceae	0.2	0.91	3	0.66	0.92	0.66	0.11	1.67
28	<i>Daeryodes klaineana</i>	Burseraceae	0.1	0.46	2	0.44	0.47	0.17	0.03	0.92
29	<i>Dead trees</i>		0.2	0.91	5	1.09	0.78	0.48	0.08	2.07
30	<i>Deinbollia pychnophylla</i>	Sapindaceae	0.2	0.91	2	0.44	0.61	0.29	0.05	1.39
31	<i>Dichostemma glaucescens</i>	Euphorbiaceae	0.3	1.36	4	0.87	0.89	0.62	0.10	2.33
32	<i>Didymosalphinx sp</i>	Rubiaceae	0.1	0.46	1	0.22	0.2	0.03	0.01	0.68
33	<i>Diogoazinkenkeri</i>	Oleaceae	0.2	0.91	3	0.66	1.76	2.43	0.40	1.95
34	<i>Diospyros zenkeri</i>	Ebenaceae	0.1	0.46	2	0.44	0.87	0.59	0.10	0.98
35	<i>Diospyros gabonensis</i>	Ebenaceae	0.2	0.91	2	0.44	0.76	0.45	0.08	1.41
36	<i>Diospyros ituriensis</i>	Ebenaceae	0.1	0.46	1	0.22	0.53	0.22	0.04	0.71
37	<i>Diospyros kamerunensis</i>	Ebenaceae	0.2	0.91	3	0.66	0.76	0.45	0.074	1.63
38	<i>Diospyros korupensis</i>	Ebenaceae	0.2	0.91	3	0.67	0.78	0.48	0.08	1.64
39	<i>Diospyros preussii</i>	Ebenaceae	0.2	0.91	3	0.67	0.68	0.36	0.06	1.62
40	<i>Diospyros zenkeri</i>	Ebenaceae	0.1	0.46	2	0.44	0.43	0.15	0.02	0.91
41	<i>Discoglyxanlon hexandrium</i>	Euphorbiaceae	0.4	1.81	5	1.09	1.31	1.35	0.22	3.12
42	<i>Drypetes sp</i>	Putrangivaceae	0.2	0.91	4	0.87	1.31	1.35	0.22	1.99
43	<i>Dysplasia sp</i>	Moraceae	0.6	2.7	10	2.17	1.98	3.08	0.50	5.39
44	<i>Entandrophragma cylindricum</i>	Meliaceae	0.5	2.26	12	2.61	7.54	44.63	7.26	12.13
45	<i>Ficus sp</i>	Moraceae	0.2	0.91	4	0.87	1.43	1.61	0.26	2.04
46	<i>Garcinia sp</i>	Clusiaceae	0.1	0.46	1	0.22	0.24	0.05	0.01	0.68
47	<i>Harungana madagascariensis</i>	Clusiaceae	0.3	1.36	6	1.31	1.56	1.91	0.31	2.97
48	<i>Homalium letestui</i>	Salicaceae	0.3	1.36	4	0.87	0.87	0.59	0.097	2.32
49	<i>Hymenostegia afzelii</i>	Fabaceae	0.3	1.36	8	1.74	8.07	51.12	8.32	11.42
50	<i>Jollydora duparquetiana</i>	Connaraceae	0.3	1.36	7	1.52	0.87	0.59	0.10	2.98
51	<i>Kigelia africana</i>	Bignoniaceae	0.4	1.81	7	1.52	2.75	5.94	0.97	4.30

		ae								
52	<i>Klainedoxagabonensis</i>	Irvingiaceae	0.1	0.46	1	0.22	0.65	0.33	0.06	0.72
53	<i>Lasianthera africana</i>	Teaceae	0.2	0.91	6	1.31	0.82	0.53	0.09	2.30
54	<i>Leptaulus dephnoides</i>	Teaceae	0.4	1.81	13	2.83	2.09	3.43	0.56	5.19
55	<i>Macaranga monandra</i>	Euphorbiaceae	0.3	1.36	5	1.09	0.98	0.75	0.12	2.57
56	<i>Macaranga sp</i>	Euphorbiaceae	0.2	0.91	3	0.66	0.97	0.74	0.12	1.68
57	<i>Massularia acuminata</i>	Rubiaceae	0.1	0.46	4	0.87	0.84	0.56	0.09	1.41
58	<i>Memecylon sp</i>	Memecylaceae	0.2	0.91	3	0.66	0.75	0.44	0.07	1.63
59	<i>Microdesmis puberula</i>	Pandaceae	0.1	0.46	1	0.22	0.26	0.05	0.01	0.68
60	<i>Microdesmis sp</i>	Pandaceae	0.2	0.91	3	0.66	0.75	0.44	0.07	1.63
61	<i>Musanga cecropioides</i>	Moraceae	0.4	1.81	8	1.74	1.93	2.92	0.48	4.03
62	<i>Napoleonaea sp</i>	Leechthidae	0.2	0.91	3	0.66	0.68	0.36	0.06	1.62
63	<i>Oncobaglaea</i>	Salicaceae	0.1	0.46	2	0.44	0.44	0.15	0.03	0.91
64	<i>Picnanthus angulensis</i>	Myristicaceae	0.2	0.91	5	1.09	5.08	20.26	3.30	5.29
65	<i>Pleiocarpus bicarpellatus</i>	Apocynaceae	0.1	0.46	1	0.22	0.18	0.03	0.01	0.67
66	<i>Polyceratocarpus parviflorus</i>	Annonaceae	0.2	0.91	3	0.65	2.51	4.95	0.81	2.36
67	<i>Polysia fulva</i>	Araliaceae	0.4	1.81	9	1.96	3.87	11.76	1.91	5.68
68	<i>Rauvolfia vomitoria</i>	Apocynaceae	0.6	2.72	10	2.17	2.18	3.73	0.61	5.50
69	<i>Rhabdophyllum sp</i>	Moraceae	0.2	0.91	2	0.44	0.87	0.59	0.10	1.44
70	<i>Rinorea dentata</i>	Violaceae	0.1	0.46	2	0.44	0.44	0.15	0.03	0.91
71	<i>Rinorea oblongifolia</i>	Violaceae	0.2	0.91	2	0.44	1.56	1.91	0.31	1.65
72	<i>Rothmannia hispida</i>	Rubiaceae	0.2	0.91	2	0.44	0.69	0.37	0.06	1.40
73	<i>Santirabasa lfera</i>	Burseraceae	0.1	0.46	2	0.44	0.87	0.59	0.10	0.98
74	<i>Solanum sp</i>	Solanaceae	0.3	1.36	4	0.87	0.79	0.49	0.08	2.31
75	<i>Spathodia companulata</i>	Bignoniaceae	0.1	0.46	2	0.44	0.65	0.33	0.05	0.94
76	<i>Staudtia kamerunensis</i>	Myristaceae	0.1	0.46	3	0.66	0.68	0.36	0.059	1.16
77	<i>Strombosia scheffleri</i>	Oleaceae	0.1	0.46	2	0.44	0.71	0.40	0.064	0.95
78	<i>Strombosia sp</i>	Oleaceae	0.4	1.81	6	1.31	3.87	11.76	1.91	5.03
79	<i>Strombosia sp1</i>	Oleaceae	0.2	0.91	2	0.46	1.06	0.88	0.14	1.48

80	<i>Strombosia sp2</i>	Olaeaceae	0.1	0.46	1	0.22	0.36	0.10	0.02	0.69
81	<i>Strombosiosistetranda</i>	Olaeaceae	0.1	0.46	2	0.44	1.99	3.11	0.51	1.39
82	<i>Tabenomontanabrachyantha</i>	Apocynaceae	0.2	0.91	2	0.44	0.52	0.21	0.035	1.37
83	<i>Tabenomontanasp</i>	Apocynaceae	0.1	0.46	5	1.09	2.51	4.95	0.81	2.34
84	<i>Terminalia superba</i>	Combretaceae	0.1	0.46	3	0.66	10.72	90.21	14.68	15.78
85	<i>Tremaorientalis</i>	Ulmaceae	0.3	1.36	4	0.87	0.87	0.59	0.10	2.32
86	<i>Tricalysiasp</i>	Rubiaceae	0.1	0.46	4	0.87	0.76	0.45	0.07	1.40
87	<i>Trichiliasp</i>	Sapindaceae	0.1	0.46	1	0.22	0.30	0.07	0.01	0.68
88	<i>Trichosecyphaklainei</i>	Anacardiaceae	0.2	0.91	3	0.65	1.09	0.93	0.15	1.71
89	<i>Turreanthusafricanus</i>	Meliaceae	0.4	1.81	6	1.30	1.83	2.63	0.43	3.54
90	<i>Uapacasp</i>	Euphorbiaceae	0.1	0.46	2	0.44	4.76	17.79	2.89	3.78
91	<i>Unidentified — stump (logged)</i>	-	1	4.56	49	10.66	15.67	192.8	31.37	46.54
92	<i>Uvariadendronsp</i>	Annonaceae	0.2	0.91	5	1.09	1.46	1.67	0.27	2.26
93	<i>Vernoniaconferta</i>	Asteraceae	0.4	1.81	8	1.74	0.98	0.75	0.12	3.67
94	<i>Vitexsp</i>	Verbanaceae	0.2	0.91	3	0.66	0.55	0.24	0.04	1.60
95	<i>Voacangapsilocalyx</i>	Apocinaceae	0.2	0.91	4	0.87	0.65	0.33	0.05	1.83
96	<i>Warneckejasminoides</i>	Melastomataceae	0.2	0.91	5	1.09	1.98	3.08	0.50	2.49
97	<i>Xylopiasfricana</i>	Annonaceae	0.5	2.26	14	3.04	7.82	48.01	7.81	13.12
98	<i>Zanthoxylon spp.</i>	Rutaceae	0.3	1.36	4	0.87	1.75	2.40	0.39	2.62
TOTALS			22.1	100	460	100		614.5	100	300