# Anthropogenic Impacts on Protected Area of Burundi. Case Study of Ruvubu National Park

Ntowenimana Remegie*, Gu Yansheng

School of Environmental Studies, China University of Geosciences, 388 Lumo Road, Wuhan, Hubei 430074, China. ntowenimana@yahoo.fr

**Abstract:** Forty six plots have been conducted in Ruvubu national park along the Ruvubu River in Karuzi province to determine the effects of anthropogenic impacts on the forest. Thirty six of these quadrats were laid out in steep gully hill along the south west of the park. Ten plots were outside the protected area. The Ruvubu National Park vegetation includes a complex of forest and woodland, savannah shrub, grasslands and wetlands. Overall, forest area in the Ruvubu National Park significantly impacted by three gap-forming disturbances: logging (80%), tree harvesting (13.3%), and cultivation (6.3%). Forest disturbance was greater outside the reserve (48.3%) than inside (12.2%) reiterating the significant role played by this protected area in habitat and species conservation. Two species diversity indices were calculated: Shannon-wiener's, and Evenness index E. The results revealed that Shannon's index and Evenness were the best to explain the observed differences in the structure of the forest subjected to uneven levels of disturbance. [The Journal of American Science. 2008; 4(2):26-33]. (ISSN 1545-1003).

**Keywords**: Anthropogenic Impact, Protected Area, Ruvubu National Park, Burundi

## 1. Introduction

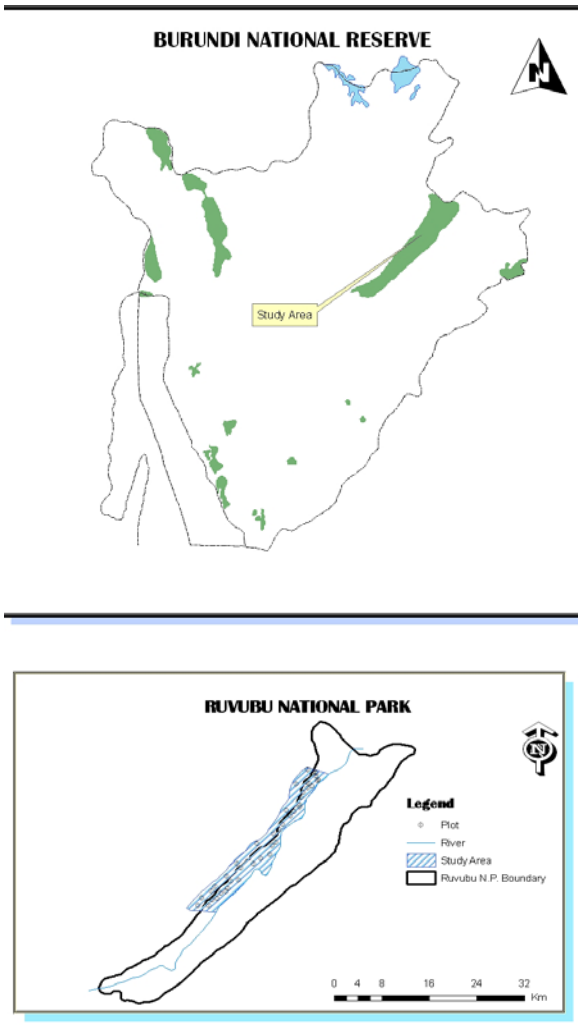
In recent years ecologists have turned their attention towards the loss of biodiversity, particularly in tropical forests around the equator where these hotspots are concentrated (Myers et al. 2000; Beck et al. 2002). Deforestation of tropical forests not only jeopardizes biological diversity but also climate systems of the world (Myers 1989; Schwartzman et al. 2000).In addition to high species diversity and endemism, tropical forests are also home to rural communities in need of economic sustainability. Conservation of tropical forest is thus one of the greatest human challenges involving delicate balance between complex-fragile ecosystems, and impoverished populations. Consequently, shifting cultivation remains the biggest threat to tropical forests (Myers 1987) and has exacerbated the natural fragmentation of landscapes affecting whole ecosystems and biota (Brender et al. 1998). Natural ecosystems in Burundi include the forests, savannas, woodlands, lowland prairies, and marshes and other aquatic settings. Burundi has 14 protected areas with a total surface area of approximately 127,662.85ha, 4.6% of the total country (MINATTE, 2000). Burundi's protected areas include several vegetation types, including some that practically do not exist outside of these defended areas. The biggest causes of biodiversity degradation are agricultural land-clearing and other poorly adapted farming methods. The Ruvubu forest park ,which constitutes the study area of this paper, is a protected area which lies in the sub-humid agro-ecological zone with abimodal rainfall, the long rains from late February to May /June followed by short rains. This ecosystem remains, however, under severe threats due to many unsustainable practices maintained by the local people. These forests have been subjected to increasing destruction of forest cover due to clear cutting, burning and slashing mainly for agriculture as well as forest deterioration due to harvesting and utilization of different forest products (Deckers 1994; Medley 1993). Habitat loss, forest fires, logging, hunting for bush meat, war and the capture of live infants for sale have all contributed to this decline (Marshall et al. 2000). We examined the impacts of human activities on forest patches in and out of the Ruvubu forest park. Herein, we discuss the implication of these impacts on conservation and management of the forest ecosystems

## 2. Materials And Methods

### 2.1.Study Area

Ruvubu National Reserve is 193 square miles (500 km2) in size and covers a strip of land from one to six miles (1.5-10 km) wide along both sides of the Ruvubu River in eastern Burundi. It was freed from human inhabitants and returned to complete wild life. Wildlife in the Ruvubu basin and Pare National

de la Ruvubu includes hippo, crocs, buffalo, leopard, antelope, monkeys and some lion. More than 425 bird species have been recorded.




**2.2 Data Collection**

The selection of sampling points for the study areas were based on gradient-directed transects "Gradsect".This sampling approach used intensively at Chino State park of California Department of Parks and Recreation Inventory , Monitoring and Assessment Program (IMAP, 1996), and in conservation site selection in Australia (Austin and Heyliger,1989;1991). At each plot of the sampled location, a transect quadrat of 30m´ 30m was completed. All information concerning the biological diversity and of the park were collected and evaluated for further use. The species diversity of all plot sites investigated were analyzed and compared with each other. The simplest method to determine species diversity is to count the number of species in the community (the species richness) (McIntosh, 1967). Species diversity is not only a measure for the number of species; diversity is also expressed in Evenness. The mean species percent cover

was calculated for the different disturbance groups, and diversity was quantified by mean of trees indices: Species richness(S) (Magurran, 1988), Shannon's diversity index (H) (Shannon, 1949) and Simpson's diversity index (D) (Simpson, 1949). Shannon's index is calculated as follows: $H = \sum_{i=1}^{s} pilogpi$ **(1)**

Where $p_i$ is the relative abundance of species *i.* Simpson's(D) ,a diversity index heavily weighted towards the most abundant species in the sample while being less sensitive to species richness ,is calculated as: $D = \sum_{i=1}^{s} pi^2$ , $\sum_{i=i}^{s} \frac{ni(n-1)}{N(N-1)}$ ; **(2)**

Where $n_i$ is the number of individuals in the $i^{th}$ species and N the total number of individuals. As D increases, diversity decreases and therefore Simpson's index is usually expressed as 1-D or 1/ D, $D = \sum_{i=2}^{s} pi^2$ **(3)**

In this study, the former expression (1-D or 1/ D) will be used.
Two indices of Evenness were used: Pielou's (J) (Pielou, 1969, 1975) and Simpson's (E)

$$J = \frac{H_{(s)}}{H_{(max.)}}, \quad \textbf{(4)}$$

Where H(s) = the Shannon-Wiener information H (max.) = the theoretical maximum value for H(s) if all species in the sample were equally abundant. The Simpson's Evenness index (E) is calculated as the relation between the value of the Simpson's diversity index for the sampled site D and the maximum possible value of the index for given species number and sample site D Max (Pett,1974) ;then:

$$E = \frac{D}{D_{(max)}} \quad , D_{(max)} = \frac{S-1}{S}\frac{N}{N-1} \qquad \textbf{(5)}$$

Where S is the number of species and N the number of individuals.

The indices were calculated for all plants, Growth forms (trees, shrub, and herbs) and vertical layers with each plot as previously reported (Mac Arthur, 1965).

**2.2 Human impacts Classification**

**Human activities were categorized as follows:**

(1) Resource utilization is defined as human practices that do not necessarily result in partial/complete forest cover removal but resulted into deterioration of forest stature. These activities included:

Tree harvesting, which included cutting plant parts for various human utilizations such as thatching, wine tapping, constructions of animal traps and sometimes firewood collection. Thatching and wine tapping involved the chopping off the crowns of trees and tapping of the sap, respectively. Animal trapping involved the use of snares. Firewood collection involved gathering dried twigs and to a lesser extent cutting young stems and branches. Logging**,** which includes cutting trees for construction of canoes, furniture, building materials and charcoal burning, Charcoal burning involved burning of felled logs under earth mounds from various tree species.

(2) Land use practices are defined as human activities that resulted to partial or complete removal of forest canopy cover. These were identified as follows:

Cultivation entailed the complete or partial clearances of areas of forest for agriculture through slash and burn techniques, which affected all species. This practice sometimes also causes fragmentation of the affected forest patches.

**2.3 Forest Classification**

Data collected from human was collated and used to provide overall assessment of the status of forests surveyed. Disturbance levels were categorized as detailed by Muoria et al. (2002) from level 1 to 4.

**3. Results And Discussion**

**3.1 Forest status**

The Table 1 describes the main human activities observed in the forty-six quadrats sampled. In general, Logging was observed in 36 plots and accounted for 80% of human activities, tree harvesting in 6 quadrats or 13.3%, and cultivation in 3 plots (6.6%). Furniture was constructed from *Spyrostachys venenifera*, while building materials were obtained largely from *Phoenix reclinata*. From the observation, cultivation had the most devastating effects on forest cover due to partial or complete vegetation clearance. The most affected species due to tree harvesting were *Borassus aethiopuim*, *Phoenix reclinata* and *Hyphaene compressa*. While the most preferred tree species for construction of canoes and beehives were *Diospyros kabuyeana*, *Ficus sycomorus*, *Mimusops fruticosa* and *Mangifera indica*. Thirty-six plots impacted by logging were those from inside the park (numbers 11,.., 36). The remaining plots affected by other factors (harvesting, cultivation) were found outside the Park**.** Ten forest patches severely impacted by cultivation alone were those plotted outside the protected area (no. 1,2,3,4,5,6,7,8.9,10),. Three plots, (numbers 42, 45 and 46, respectively) were heavily impacted by human activities. Six forest transects affected by both tree harvesting and cultivation were located (no. 3, 4, 5, 6, 7, 8, 9) near the access facilities. Along the river channel, only one forest plot (no. 35), was affected by tree harvesting.

Four other forest patches affected by logging are near the current river channel (Table 1). They include all plot surveyed in the protected area (Table 1). Forests impacted by all kind of disturbance factors include all plots with the difference degree of severity.

Out of the forty-six forest plots evaluated, 12 plots had little or no disturbance while 12 plots were heavily disturbed. Of the heavily impacted forests, six were in the reserve and six outside the protected area (Table 2). Seventeen plots were found moderately impacted by human activities; among them fifteen are from the protected area while two plots are from outside (Table 2). Only five out of all have obvious impacts of human without being totally cleared. They are partly from both outside and in the protected forest (Table

**Table 1**. **Frequencies and proportional occurrence of categorized human activities.**

| Activities | Frequency | % |
|---|---|---|
| Logging | 36 | 80 |
| Tree harvesting | 6 | 13.3 |
| Cultivation | 3 | 6.6 |
| total | 45 | 100 |

**Table 2 Severity levels of disturbance on the forest using a scale of 1-4.**

| Destruction levels | Forest inside the park | | | Forest outside of the park | | |
|---|---|---|---|---|---|---|
| | Numbers of plots | Area | % | Numbers | Area | % |
| 1 | 12 | 108 | 32.3 | 0 | 0 | 0 |
| 2 | 15 | 135 | 40.4 | 2 | 16 | 19.7 |
| 3 | 3 | 27 | 8 | 2 | 16 | 19.7 |
| 4 | 6 | 54 | 16.1 | 6 | 54 | 60 |
| Total | 36 | 334 | 100 | 10 | 90 | 100 |

Scale 1: little or no destruction; scale 2: moderate levels of destruction; scale 3: extensive human destruction with no section of forest completely cleared: scale 4: highest levels of destruction with sections of the forest completely cleared.

**3.2 Human Activities and Natural Impacts on the Riverine Forests along the Ruvubu River.**

Our study has shown that through shifting cultivation, logging and other human activities are still impacting the Ruvubu National park even if it is placed under protection laws and lead to loss of biodiversity in the forest. Anthropogenic activities out the forests are actively practiced in the form of slash-burn agriculture, selective logging and several other deleterious uses of forests (Table 1). Shifting cultivation combined with some natural impacts contributed to the alarming loss of endemic and threatened species in the forest. The most impacted forest, portion laid out from the edge of the protected area south to the north (no. 1 to 10 ), was affected by both cultivation and logging with high level of destruction (table 2) and affects 86.6% of the total area (table 1) the significant role played by this protected area in habitat and species. The impact of tree harvesting and natural impacts on the forests inside the Ruvubu National park is enormous. Changes caused by both tree harvesting and natural impacts outside the Ruvubu National park forests do not necessary immediately remove forest cover; instead they are more likely to cause progressive degradation of forest structure and biodiversity. In the long-term, this progressive degradation leads to partial or complete loss of forest cover. One important aspect that was not evaluated during this study was the loss of mature forest due to bank erosion. This type of evaluation would necessitate long-term monitoring of these potential sites, which was beyond the scope of this research study. Future studies should incorporate the impact of bank erosion and evaluating its role as a natural impact on the forests. As a whole, the combinative impact of cultivation and natural dieback or cultivation has resulted in the highest percentage forest area loss in the Ruvubu National park. Both human and natural impacts are responsible for changes in forest cover and forest stature. As this study has indicated, areas that have experienced significant area loss due to the Ruvubu National park dynamism could be significantly related to changes in human activities, which further complicate current and potential conservation and management strategies in and out of the reserve. Human exploitation of forest resources can involve rapid, non-sustainable harvesting of particular species (Gentry and Va'squez 1988), while Natural impacts(flooding ,dieback ) can result in a progressive degradation of forest structure and biodiversity that leaves behind standing but biologically and economically depleted forests. The riverine habitats on the Ruvubu National park are highly vulnerable to perturbations due to the Ruvubu National park dynamism and the continual human overexploitation.

The riverine forests within the protected area represent 84% of the forest ecosystem and may thus be inadequate to provide resources to stem the current decline in endangered primate populations. However, the importance of the unprotected forest patches situated outside the reserve for the survival of both endangered species cannot be overemphasized. The survival of these species depends on the future management and conservation of the majority of forest patches that are situated out of the reserve. The fact

that the greatest area of forest loss was outside the reserve implies the immediate need to initiate conservation programs outside the protected area. Forest fragmentation not only isolates floral and faunal population but it also impedes gene flow between forest patches (Marsh et al. 1987). This study demonstrates that the effects of natural impacts are just as important, and therefore, future studies should not only examine the long-term effects natural impacts on the endangered species, but also study the combinative effects of both natural and human impacts on these species.

**Table 3 Shannon -Wiener index (Hs) and Evenness (E ) for twenty pairs plots.**

| Plot | Latitude | Longitude | Hs | E |
|---|---|---|---|---|
| 1 | -3.213 | 30.261 | 3.728 | 0.889 |
| 2 | -3.2 | 30.267 | 3.08 | 0.854 |
| 3 | -3.189 | 30.282 | 3.231 | 0.857 |
| 4 | -3.181 | 30.287 | 3.23 | 0.859 |
| 5 | -3.164 | 30.305 | 3.45 | 0.824 |
| 6 | -3.144 | 30.321 | 3.24 | 0.834 |
| 7 | -3.11 | 30.351 | 3.45 | 0.768 |
| 8 | -3.0555 | 30.395 | 3.67 | 0.823 |
| 9 | -3.012 | 30.41 | 3.57 | 0.813 |
| 10 | -2.989 | 30.427 | 3.339 | 0.834 |
| 11 | -3.212 | 30.278 | 3.267 | 0.822 |
| 12 | -3.203 | 30.283 | 3.278 | 0.824 |
| 13 | -3.201 | 30.291 | 3.275 | 0.825 |
| 14 | -3.192 | 30.296 | 3.24 | 0.828 |
| 15 | -3.189 | 30.303 | 3.53 | 0.854 |
| 16 | -3.184 | 30.307 | 3.78 | 0.8957 |
| 17 | -3.173 | 30.311 | 3.37 | 0.823 |
| 18 | -3.171 | 30.323 | 3.89 | 0.831 |
| 19 | -3.15 | 30.326 | 3.78 | 0.832 |
| 20 | -3.144 | 30.345 | 3.78 | 0.849 |

### 3.3 Anthropogenic Impacts on the Species Diversity

In this paper ,we have also conducted a comparison of species composition between the different plots surveyed .The aim was to understand the composition of the forest by taking example of 20 plots .We analyzed if and in which way the tree structure of Ruvubu National park was influenced by different human activities like logging, harvesting tree and cultivation. Species within habitat diversity was measured with the Shannon-Wiener function and evenness .Table 3 present the analysis values for 20 plots studied .High diversity was recorded in the disturbed forest (outside the protected area) The higher the disturbance and the younger a forest site is, the more divers is the habitat (Scully 2001).Undisturbed or little disturbed inside the protected area of the forest have the lowest measured diversity. The evenness values are higher in than in more disturbed forest of the park. in these plots more dominant species occur beside only few rare species . The more equal a distribution of species in a given habitat and the higher an evenness value, the more species with similar abundance occur. Thus, the older secondary forest sites have lower evenness values dues to the occurrence of some dominant species, like trees in upper canopy, and a few species in low coverage or abundances in the understory vegetation. The Shannon-Wiener index can also be expressed in units of species number. In the following diagram the measured values were applied against a disturbance gradient (Figure 4). Human disturbance like selective logging or cultivation of the park seems to have an influence on the plant species diversity. After disturbance, a habitat is more heterogeneous because of small, sunny gaps beside dense forest, different microclimate conditions in a near distance, etc. These heterogeneous environments offer diverse possibilities for high amount of different species. The

theories that moderate disturbances promote species diversity are also supported by several authors and by the present study (Gentry 1982, Collins et al. 1995, Hiura 1995, Laurence et al. 2001). In sum, it can be stated that the Simpson's diversity and evenness indices are the best measurement to determine disturbance levels in forest functioning ecosystems as previously suggested (Franklinetal.2002).

**4. Conclusions**

The research findings allows us to summarize the main points as follows: The pattern of forest disturbance in Ruvubu National park is dominated by logging, cultivation and tree harvesting .Comparison between all gap-forming disturbances in the forest , cultivation is the most source of disturbance in terms of the area affected. Research results also demonstrate that the tree species indices (Shannon-Wiener's H', Simpson' index d' and Evenness) of forest decrease in the order: outer to inner the forest. It has shown also that there are variations in tree species diversity between different plots of the same location, especially when are taken from the ecotone or near the edges of forest.

**Acknowledgement:**

We are thankful to china scholarship council for its support awarded though China University of geosciences (Wuhan).

4/22/2008

**References**

1. Austi, M.P. and P.C., Heyligers. 1989. Vegetation survey design for conservation :Gradsect sampling of forest in Northeastern new south Wales. Biological Conservation 50:13-32.
2. Austin, M.P., 1991. Vegetation theory in relation to cost efficient surveys. pages 17-22, C.R.margules and M.P. Austin, editors. Nature Conservation: cost effective biological urveys and data analysis, Australia.
3. Beck J, Schulze CH, Linsenmair KE, FieldlerK. 2002. From forest to farmland: diversity of geometrid moths along two habitat gradients on Borneo. J Trop Ecol. 18:33–51
4. Bender DJ, Contreras TA, Fahrig L 1998. Habitat loss and population decline: a meta-analysis of the patch size effect. Ecology 79(2):517–533
5. California Department of Park and Recreation. December 1996. *A plan for the Natural Resources Inventorying Program at Chino state Park.* Los Lagos District with assistance from the Resource management Division.
6. Collins, S.L., Glenn, S.M., & Gibson, D.J., 1995.Experimental-Analysis of intermediate disturbance and initial floristic composition-Decoupling cause and effect, ecology 76 (2): 486-492
7. Decker, B.S., 1994. Effects of habitat disturbance on the behavioral ecology and demographics of the Tana Red Colobus (*colobus badius rufomitratus*). Int J Primatol 15(4):703-736
8. Franklin, J.F., Spies, T.A., Van Pelt, R., Carey, .B.,Thornburgh,D.a.,Berg, D.R.,Lindermayer, D.B., Harmon, M.e., Keeton, W.S., Shaw, D.C ., Bible, K., Chen., J.,2002. Disturbances and structural development of natural forest ecosystems with silvicultural implicayions, using douglas-fir forests as an example. For . Ecol. Manage. 155, 399-423
9. Gentry,A.H., 1982. Changes in plants communities diversity and floristic composition on environment and geographical gradients, Ann. Missouri. Bot.Gard. 75(1): 27-37
10. Gentry , A.H., Va´squez R.,1988. Where have all the Ceibas gone? A case history of mismanagement of tropical forest resource. Forest Ecol. Manage. 23:73–76 1172. Biodivers. Conserv. 2007.16:1161–1173 123
11. Hiura, T., 1995. Gap forming and species diversity in japanese beech forests – A test of intermediate disturbance hypothesis on a geographical scale , Oecologia 104 (3): 265-27
12. Laurance, W.F., Perez-Salicrup, D., delamonica, P., Fearnside, P.M., D'Angelo, S., Jerozolinski, A., Pohl, L.& Lovejoy, T.E., 2001. Rain forest fragmentation and the structure of Amazon liana communities, Ecology 82 (1): 105-116

13. McIntosh,R.P.,1967. An Index of diversity and the relation of certain concepts to diversity, Ecology.
14. Muller-Dumbois & Ellenberg, H., 2002. Aims and Methods of vegetation Ecology, New York
15. Marsh ,C.W., Johns AD, Ayres ,J.M., 1987. Effects of habitat disturbance on rain forest primates. In: Marsh, C.W., Meittermeier, RAP. (eds) Primate conservation in the tropical rain forest. Alan R. Lists, NY, pp. 83–107 Econ. Bot. 47(2):171–183
16. MINATTE, 2001. Première Communication Nationale au Titre de la Convention cadre des nations Unies sur les Changements Climatiques, Bujumbura.
17. Muoria, P.K., Karere, G.M., Moinde, N.N., Suleman, M.A., 2002. Primate census and habitat evaluation in the Tana delta region, Kenya. Afr J Ecol 40:1–7
18. Myers, N. 1989. Deforestation rates in tropical countries and their climate implications. Friends of the Earth, London.
19. Myers ,N., Mittermeier, RAP., Mittermeier, C.G., Fonseca, G., Kent, J., 2000. Biodiversity hotspots for conservation priorities. Nature 403:853–858
20. Pett, R.K., 1974. The measurement of species diversity. Annu. Rev. Syst. 5, 285-305
21. Pielou, E.C., 1969. An introduction to Mathematical Ecology. Wiley, New York.
22. Pielou, E.C.,1975. Ecological Diversity. Willey, New York.
23. Schwartzman, S., Moreira, A., Nepstad, D., 2000. Rethinking tropical forest conservation: perils in parks. Conserv. Biol. 14(5):1351–1357
24. Scully, C., 2001. The effects of human disturbance on vegetation of Kakamega Forest, Kenya, Ms. Thesis at Columbia University.
25. Shannon, C.E., 1949. The mathematical theory of communication in Shannon, C.E. Weaver, W.(eds), The mathematical theory of communication .University of Illinois Press, Urbana, pp. 29-125.
26. Simpson, E.H., 1949.Measurement of Diversity.nature,163, 688
27. Whitmore,T.C., 1997. Tropical forest abundance ,disappearance and species loss.In: Laurance & Bierregaard, R.O.,(eds), (1997),Tropical Forest Remnant: Ecology, Management ,and conservation of fragmented communities, University of Chicago press, Chicago, Illinois. Pp 3-12.