Project Update: September 2019

Introduction

Ecosystem services (food, medicinal, economic and social) of higher fungi are very useful for local populations (Soro et al. 2019, Fadeyi et al. 2017, Kamou et al. 2015: Koné et al. 2013, Yorou et al. 2014). Despite all their usefulness, in the region of Wari-Maro in northern Benin, there is an incessant degradation of the natural habitats of the higher fungi. The main causes of this degradation are related to the selective felling of fungi partner trees for timber and lumber, charcoal, firewood, slash-and-burn agriculture and fire fires frequent bushes lead to the disappearance of certain species and the decrease in the area of habitats. Yorou & De Kesel 2011, have already reported through the IUCN Red List of higher fungi in Benin the anthropogenic pressures that are affecting the natural habitats of the higher fungi in northern Benin. With this in mind, thanks to our project, we began to document all stakeholders on the usefulness of higher fungi for humans and forest ecosystems and the dynamics of vegetation cover in natural habitats.

This first phase of our project allowed us to know the current state of the natural habitats and the natural productions of the higher fungi useful according to different ages to better educate the local populations on the good practices of conservation and sustainable management of the fungi. The current report gives some details on the dynamics of the vegetation cover of the natural habitats of the higher fungi and the actions of awareness.

Methodology

Prior to the awareness sessions, we uploaded a series of satellite images of the Wari-Maro region from 1998 to 2018 to assess the dynamics of past and present land occupation of the Wari-Maro Forest Reserve. In addition, we made projections for the year 2042 to see what would be the land occupation of the natural habitats in the Wari-Maro Forest Reserve. These maps have allowed us to show the extent of forest depletion and we have calculated trends for the next year.

Plots with an area of 900 m² have been installed on sites whose regeneration age is in the order of 10; 15, 20 and 25 years (Photo 1 and 2). The age of regeneration is the time since the site was abandoned by local people. To have the ages of the plots surveys local farmers to have them. In the plots, we recorded the fresh biomass, the number of carpophores and the presence / absence of all locally higher fungi species using the method explained in De Kesel et al. (2017). Similarly, we recorded the type of human activities carried out, the vegetation cover and grazing intensity. The identification of certain fungi specimens has been carried out in the laboratory of our research unit in Tropical Mycology and Plant-Soil-Fungi Interaction (MyTIPS).

Once this stage was completed, awareness sessions were organized with a variable number of people in the riparian villages. Sensitized villages are those in which the natural habitats of fungi are the most degraded. The villages in which the awareness took place are: Wari-Maro, Agbassa Abéokouta and Wanou. Target persons were local people, schoolchildren and loggers. In addition, posters were distributed to forest resource conservation directorates, village chiefs, youth and those involved in awareness raising. These posters explained the usefulness of fungi for forest populations and ecosystems and highlighted the endangered fungi species and partner trees of ectomycorrhizal fungi to be protected for the safeguarding of this group of fungi in forest ecosystems. In the same way, these posters spoke about the dynamics of the land occupation in the Wari-Maro forest reserve from 1998 to 2018 and for the future the year 2042 how would be the vegetal cover of the study area.

Photo 1 : Plot installation

Photo 2: The persons responsible for the installation of the plots

Results

- **Dynamics vegetation cover from 1998 to 2018 of the Wari-Maro Forest Reserve**

The vegetative cover of the Wari-Maro Forest Reserve from 1998 to 2018 has experienced a significant regression because of the different anthropogenic pressures on the natural habitats of the superior mushrooms (Tables 1). We observe that, in 1998, the area occupied by agglomerations is 8.94 ha and 18 years later, i.e. in 2018, it occupies 13.86 ha, an increase of approximately 4 ha (Table.1, Fig.1, 2).

At the same time, the areas occupied by woodland / savannah woodland, dense forests and gallery forests in 1998 are 77194.48 ha or 69.48% respectively; 5186.91 is 4.67% and 10331.60 is 9.30% (Table.1, Fig.1, 2). While in 2018 the areas occupied by woodland / wooded savannahs, dense forests and gallery forests are respectively 20489.03ha and 18.44%; 1056.49ha is 0.95% and 2184.82 ha is 1.97% (Table.1, Fig.1, 2). We also observe that nearly 75% of the vegetation cover of the different natural habitats disappeared between 1998 and 2018.

If we maintain the same intensities of current human pressure for the coming years on the natural habitats of the Wari-Maro Forest Reserve, by 2042 all woodland, dense forests and gallery forests will be transformed into savanna herbaceous or even disappear in the study area (Tabel.2, Fig.3).

Therefore, it urges to curb the anthropic pressures on the natural habitats of the higher fungi. This may be possible through the establishment of income-generating activities that contribute to the sustainable conservation and management of natural habitats of higher fungi.

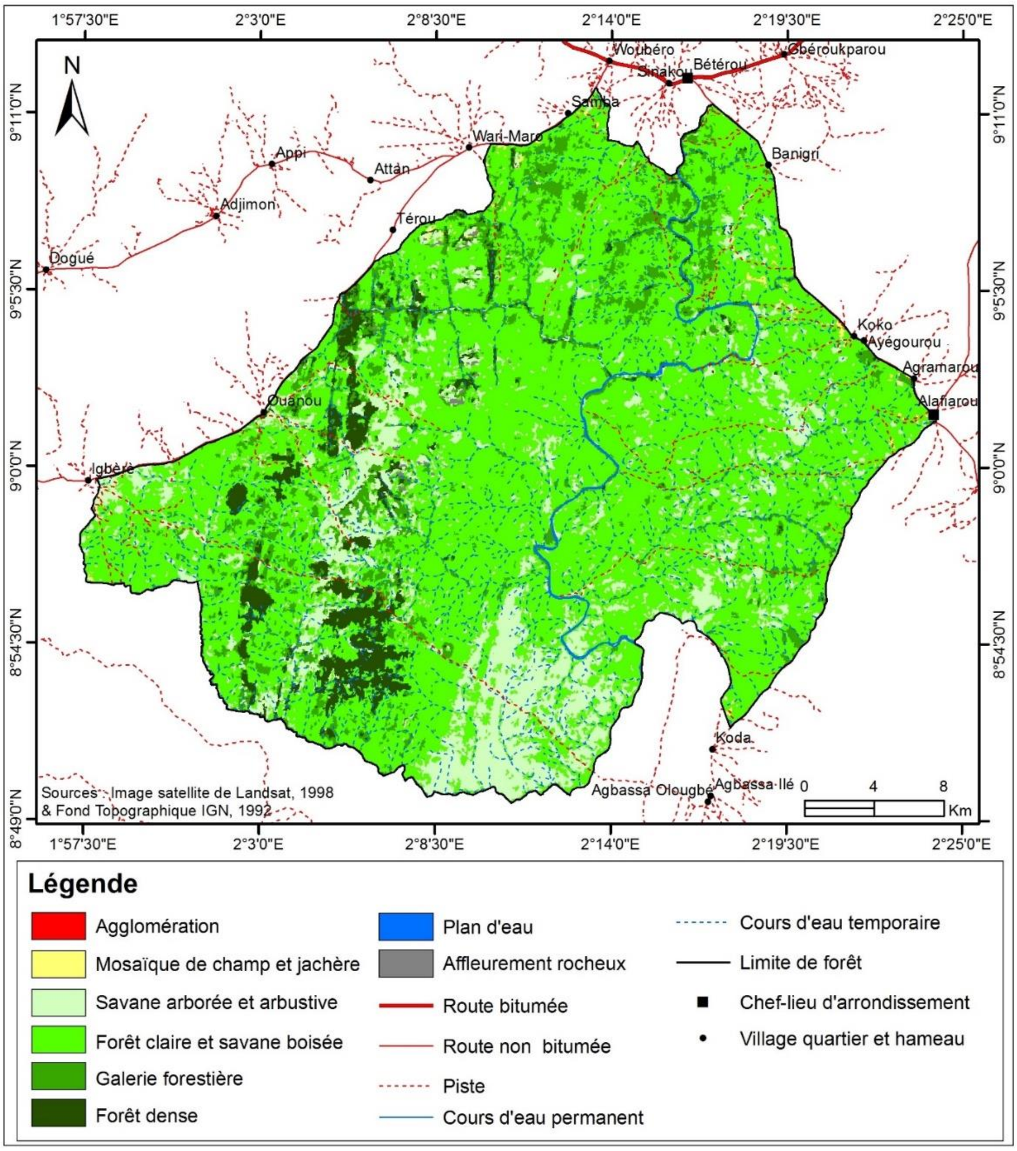


Fig.1: Land Cover Units of the Wari-Maro Forest Reserve in 1998

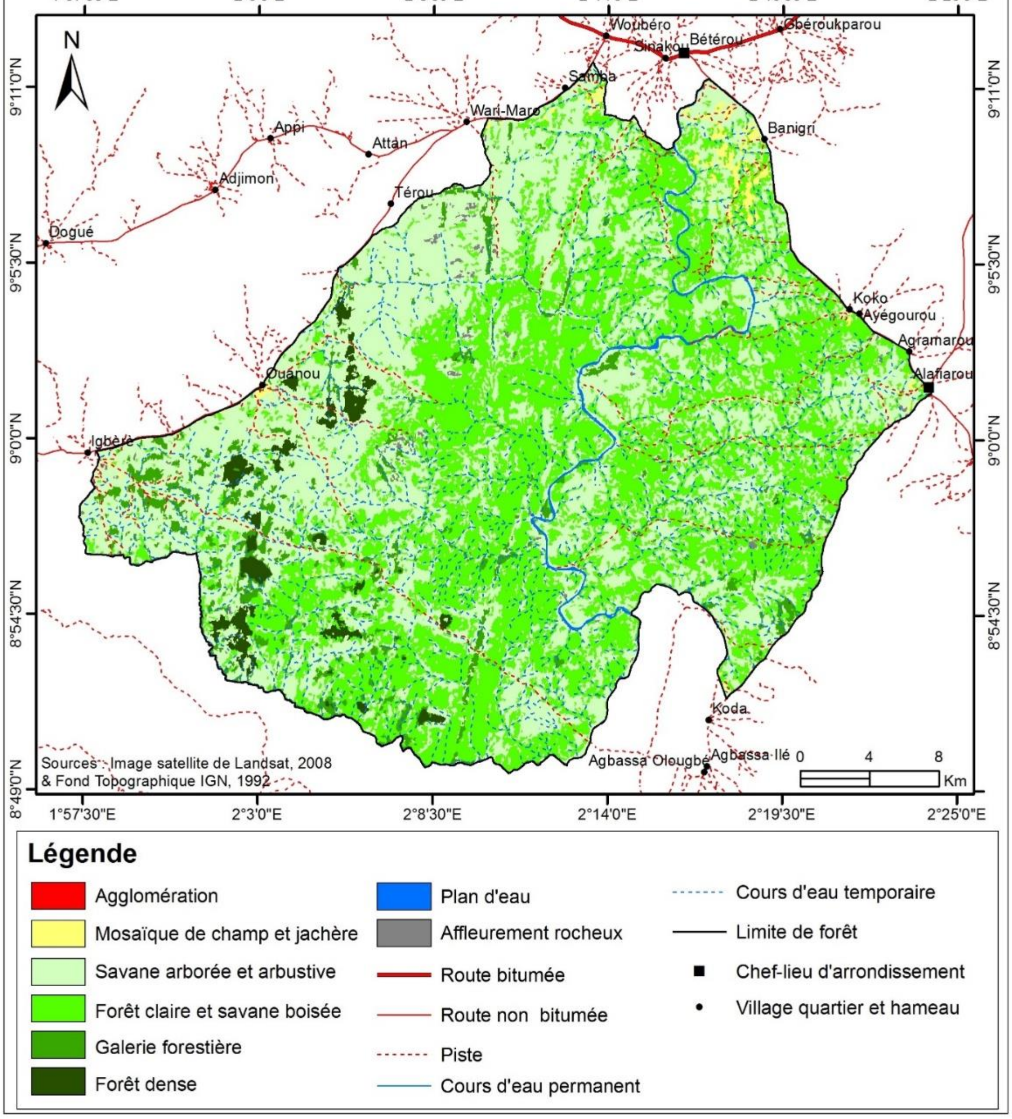


Fig.2: Land Cover Units of the Wari-Maro Forest Reserve in 2008

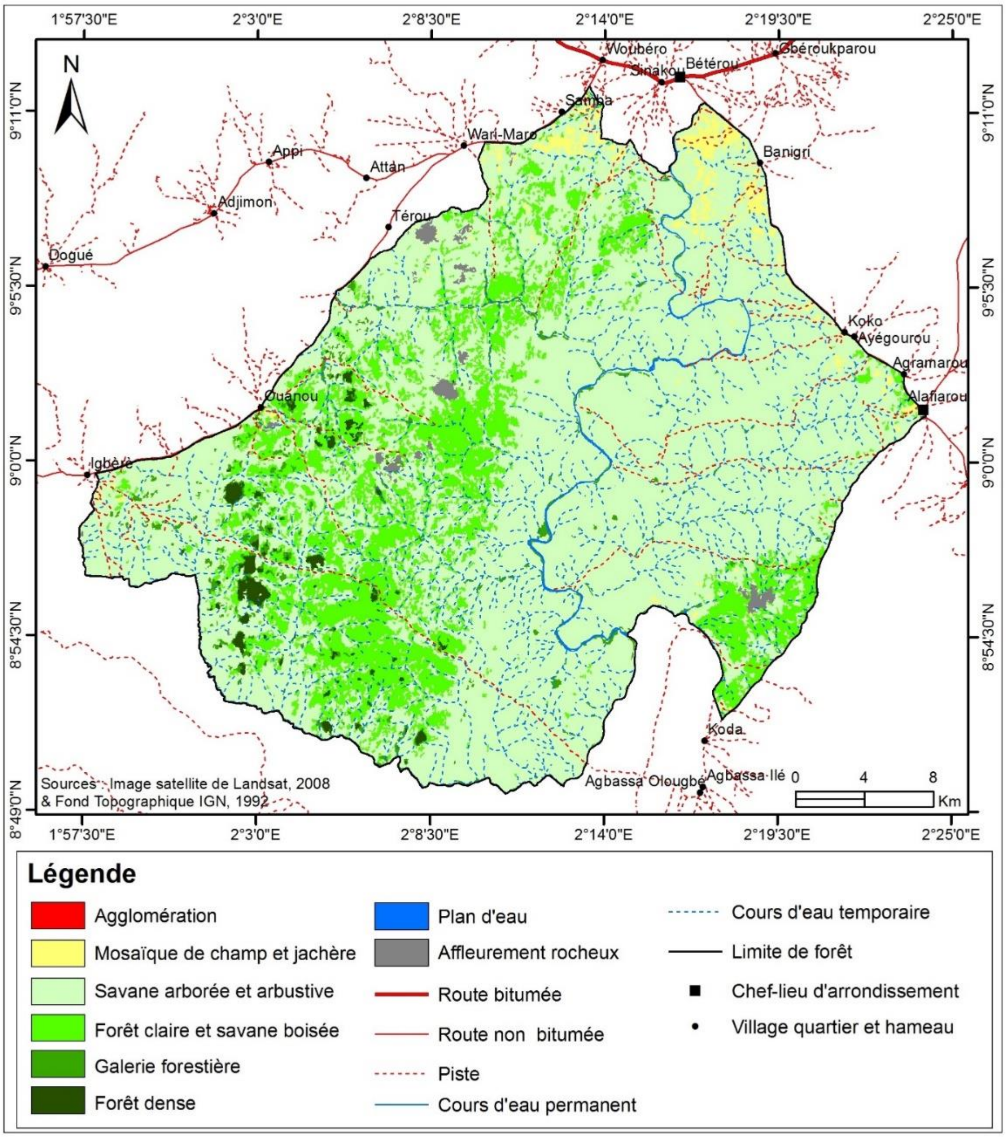


Fig.3: Land Cover Units of the Wari-Maro Forest Reserve in 2018

Table.1: Rate of evolution of vegetation cover from 1998 to 2018

	1998		2008		2018	
Units of occupation	**Area (ha)**	**Proportion (%)**	**Area (ha)**	**Proportion (%)**	**Area (ha)**	**Proportion (%)**
Agglomeration	8.94	0.01	10.55	0.01	13.86	0.01
Field mosaic and fallow	363.52	0.32	1157.65	1.04	2149.64	1.93
Savannah with trees and shrubs	17310.09	15.58	54499.19	49.06	84089.79	75.69
Woodland and wooded savannah	77194.48	69.48	47644.85	42.89	20489.03	18.44
Dense forest	5186.91	4.67	1982.34	1.78	1056.49	0.95
Galery forest	10331.60	9,30	4759.11	4.28	2184.82	1.97
Body of water	497.24	0,45	582.50	0.52	265.11	0.24
Rock outcrop	202.61	0,18	459.19	0.41	846.63	0.76
Total	111095.38	100,00	111095.38	100.00	111095.38	1003.00

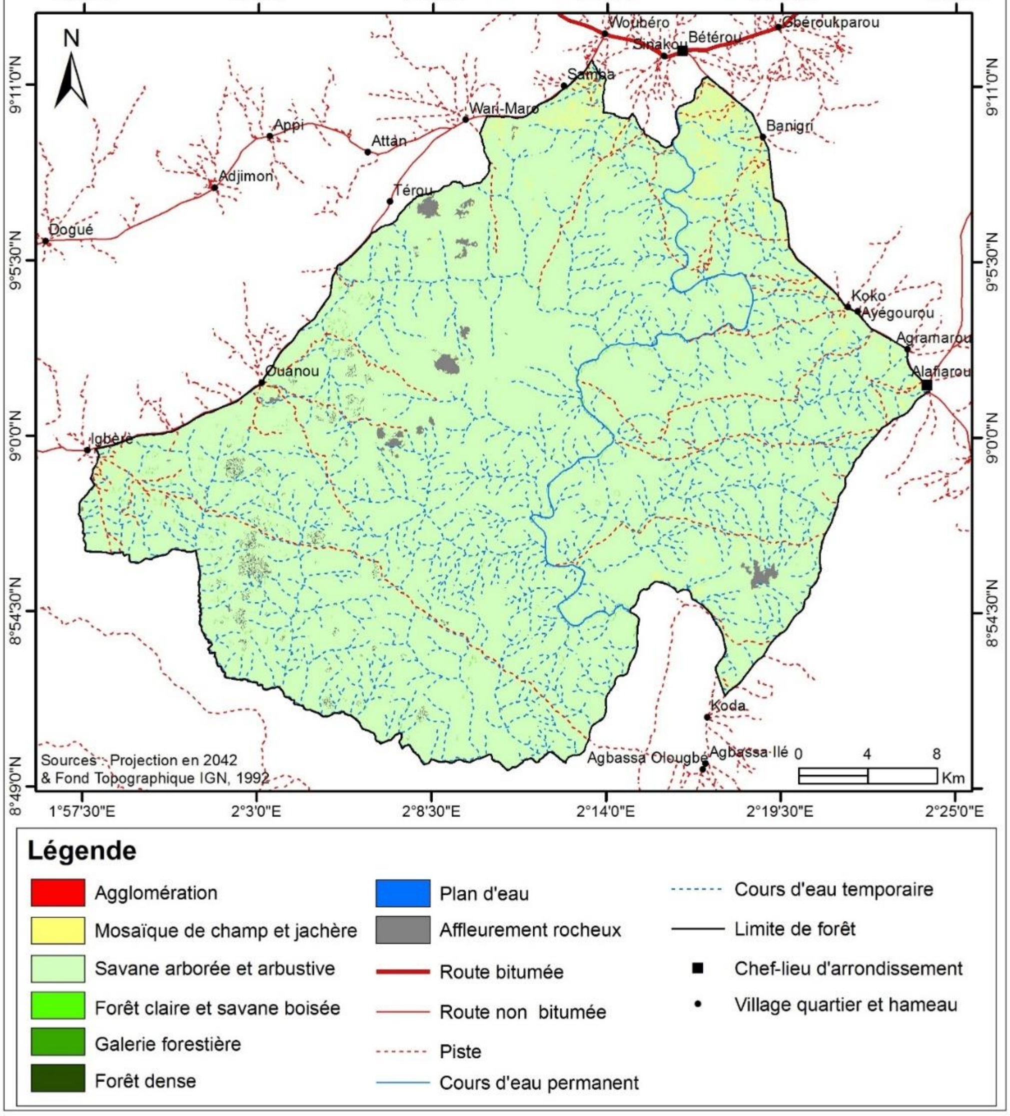


Fig.4: Projection map of the vegetation cover of the forest reserve for the year 204

Table.2: Projection map of the vegetation cover of the forest reserve for the year 2042.

Units of occupation	2042	
	Superficie (ha)	**Proportion (%)**
Agglomeration	15.33	0.01
Field mosaic and fallow	1214.15	1.09
Savannah with trees and shrubs	108220.55	97.41
Woodland ant wooded savannah	344.75	0.31
Dense forest	337.21	0.30
Galery forest	87.83	0.08
Body of water	119.04	0.11
Rock outcrop	756.53	0.68
Total	111095.38	100.00

- **Natural production of edible mushrooms according to the age of natural habitats dominated by *Isoberlinia doka***

During the mycological season from June to August 2019, all plots included, we collected 72 species of edible fungi in the Wari-Maro Forest Reserve (Table 3; 4; 5 and 6).

For this purpose, in plots P1 (10 Year), P2 (15 Year), P3 (20 Year) and P4 (25 Year) all respectively dominated by I. doka, we recorded respectively 48; 53; 43 and 40 species of edible fungi in the Wari-Maro Forest Reserve (Fig.5). Similarly, a total of 72.18 kg / ha of fresh biomass of all top edible fungi species in all plots was recorded in the Wari-Maro Forest Reserve (Fig.6). In plots P1 (10 Year), P2 (15 Year), P3 (20 Year) and P4 (25 Year) we recorded respectively 47.89 kg / ha; 205.2 kg / ha; 136.25 kg / ha and 109.57 kg / ha of fresh biomass (Fig.6).

Then, in the plots P1 (10 Year), P2 (15 Year), P3 (20 Year) and P4 (25 Year), we collected respectively 555; 9191; 9362; 7622 of carpophores in the Wari-Maro Forest Reserve (Fig.7).

Finally, we can deduce that the maximum fallow period to restore the productivity of natural habitats to higher fungi is 15 years in the Wari-Maro Forest Reserve. Beyond this period (15 years) the productivity of higher fungi decreases.

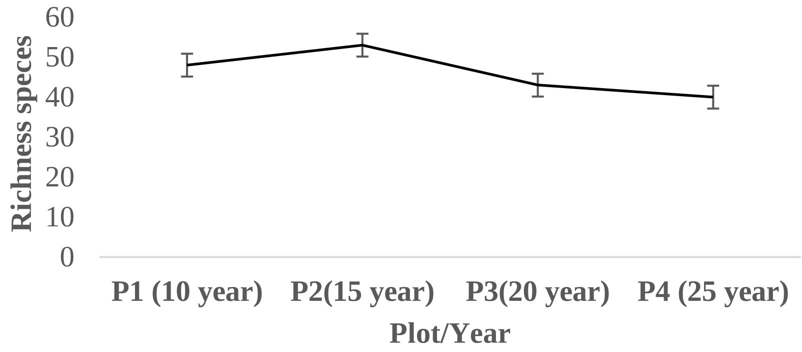


Fig.5: Richness speces of edible fungi species according to the age of the plots

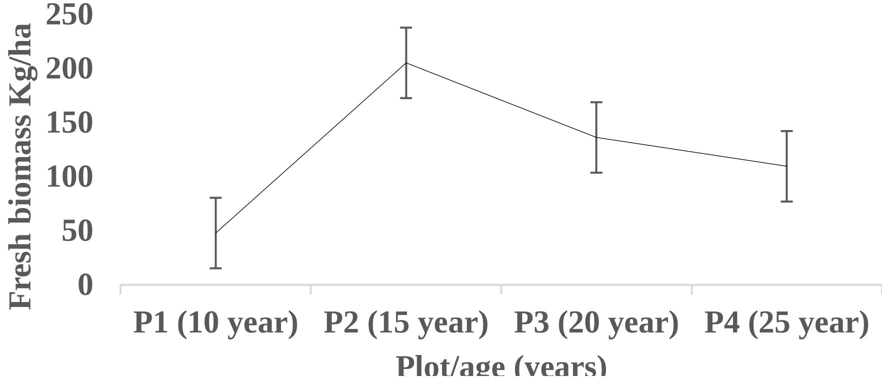


Fig.6: Fresh biomass of edible fungi species according to the age of the plots

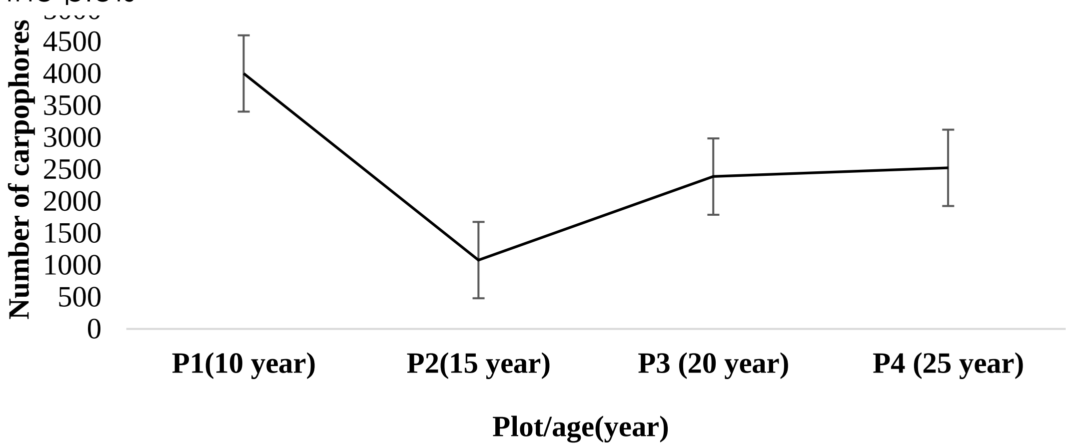


Fig.7: Number of carpophore of edible fungi species according to the age of the plots

- State of conservation of natural habitats of higher fungi

The natural habitats of the higher fungi in the Wari-Maro Forest Reserve are degraded and the species resident there are highly threatened (Photo.3). Anthropogenic activities such as: shifting cultivation on brulis (Photo.4), illegal logging of *Isoberlinia doka* wood (partner trees of useful higher fungi) (Photo 5), production of charcoal (Photo 6), firewood and grazing are major human activities carried out in the natural habitats of the higher fungi. They have a direct impact on biodiversity in general, the disappearance of certain ectomycorrhizal (EcM) trees such as *Afzelia africana* and even the regression of the abundance of forest species such as: *Isoberlinia spp*, *Uapaca togoensis*, *Berlinia grandifolia* ... etc. And likewise, the disappearance of some species of higher fungi useful to the local population. To restore the proper functioning of degraded natural habitats, we first made the local populations aware of the harmful effects of agricultural practices and para-agricultural activities (charcoal, logging, etc.) on natural habitats of higher fungi. Then, we showed them the importance of practicing income-generating activities that contribute to the sustainable conservation of natural habitats such as the cultivation of edible fungi.

Photo. 3: Natural habitats of degraded fungi

Photo. 4: Itinerant agriculture on brulis carried out in the heart of the Wari-Maro forest reserve

Photo. 5: Illegal logging of *Isoberlinia doka* wood in the heart of the Wari-Maro Forest Reserve

Photo. 6: Charcoal production with *Isoberlinia doka* in the heart of the Wari-Maro Forest Reserve

Photo. 7: Ectomycorrhizal trees uprooted by the wind

Acknowledgements

I thank the communities of Wari-Maro and Agbassa for hosting the awareness-raising actions. I thank Tchan Kassim Fadeyi Olivia, Boni Soulemane, local population and Wari-Maro Water and Forests Officers. We are very grateful to Rufford Small Grant for funding project: 26916-1. We also thank the Laboratory of Ecology, Botany and Plant Biology for its advice and the Research Unit in Tropical Mycology and Plants-Soil-Mushroom Interaction.

Annexes1

Table.3: List of edible higher fungi species of the Plot N ° 1 age 10 years

Species	**Number of carpophores**	**Biomass fresh (kg/ha)**
Amanita craseoderma	12	0.34
Amanita crassiconus	4	0.20
Amanita loosii	3	3.37
Amanita masasiensis	40	7.42
Amanita sp13	1	0.30
Amanita sp4	2	0.21
Amanita sp6	3	0.91
Amanita sp7	4	0.58
Amanita sp9	1	0.24
Amanita subviscosa	89	7.80
Cantharellus floridilus	4	0.01
Cantharellus floridilus	19	0.03
Schizophylum sp	1	0.02
Gyporus sp	6	3.20
Inconnus	7	0.04
Inconnus sp1	79	2.52
Inconnus sp2	1	0.02
Inconnus sp3	4	0.06
Inconnus sp4	71	0.73
Inconnus sp5	5	0.03
Inconnus sp6	4	0.02
Inconnus sp8	50	0.03
Inconnus sp9	10	0.01
Lactarius densifolius	2	0.03
Lactarius foetens	2	0.17
Lactarius gymnocarpoides	4	0.60
Lactarius saponaceus	2	0.27
Lactarius sp	1	0.09
Lactarius velutissimus	6	0.43
Lactifluus gymnocarpoides	9	0.43
Lactifluus velutimus	7	0.16
Lactifluus gymnocarpoides	2	0.17
Lactifluus melleus	7	0.56
Lactifluus sudanicus	1	0.09
Lactifluus velutismus	1	0.08
Lactifluus gymnocarpoides	8	0.31

Lentinus squarrosulus	6	0.47
Leucopaxilus sp	2	0.78
Marasmius heinemannianus	1	0.01
Russula compressa	3	0.12
Russula congoana	6	0.20
Russula oleifera	8	1.46
Russula rubroalba	9	1.08
Termitomyces meduis	20	0.36
Termitomyces microcarpus	15	0.08
Termitomyces robustus	11	0.31
Termitomyces sp	1	0.01
Termitomyces sp1	1	0.02
Total général	**555**	**47.89**

Table.4: List of edible higher fungi species of the Plot N ° 2 age 15 years

Species	**Number of carpophores**	**Fresh Biomass (kg/ha)**
Amanita craseoderma	152	0.41
Amanita loosii	2991	0.16
Amanita masasiensis	1837	1.09
Amanita rubescents	49	0.02
Amanita subviscosa	163	0.31
Auricularia cornea	2	0.01
Auricularia polytricha	9	0.18
Cantharellus floridilus	13	0.64
Cantharellus floridilus	8	0.64
Cantharellus sp	8	0.01
Clavilinopsis sp	1	0.06
Calvinia ornatipes	8	0.11
Calophyllum sp	1	0.01
Inconnus sp3	37	0.76
Inconnus sp4 cf. russula	290	0.28
Inconnus sp5	28	0.57
Inconnus sp6	203	0.24
Inconnus sp8	23	1.90
Inconnus sp9	1	0.12
Lactarius flammans	363	0.38
Lactarius gymnocarpoides	25	0.06
Lactarius luteopus	3	0.01
Lactarius saponuceus	32	0.03
Lactarius tenellus	20	0.23
Lactifluus cf. flammans	33	0.01
Lactifluus flammans	259	0.27

Lactifluus guellei	23	0.01
Lactifluus velutimus	11	0.01
Lactifluus bruneocarpus	10	0.01
Lactifluus flammans	17	0.02
Lactifluus guellei	14	0.01
Lactifluus longicysdiosus	26	0.02
Lactifluus luteopus	19	0.03
Lactifluus melleus	6	0.01
Lactifluus saponanceus	90	0.02
Lactifluus velutismus	10	0.02
Panelus sp	2	0.02
Psathyrella tuberculata	3	0.07
Pleurotus cytidiosus	1	0.02
Pleurotus abalonus	9	0.07
Russula rubroalba	99	0.12
Russula cellulata	199	0.20
Russula compressa	833	0.74
Russula congoana	839	2.04
Russula oleifera	337	0.24
Schizophylum commun	2	0.21
Schizophylum sp	7	0.03
Termitomyces meduis	16	0.09
Termitomyces microcarpus	6	0.11
Termitomyces robustus	11	0.03
Termitomyces sp2	30	0.03
Termitomyces sp3	6	0.01
Termitomyces striatus	6	0.01
Total	**9191**	**205.2**

Table.5: List of edible higher fungi species of the Plot N ° 3 age 20 years

Species	**Number of carpophores**	**Fresh biomass (kg/ha)**
Amanita craseoderma	60	0.17
Amanita loosii	2375	0.12
Amanita subviscosa	54	0.10
Auricularia cornea	2	0.01
Calvinia ornatipes	8	0.11
Clophylium sp	1	0.01
Inconnus sp3	37	0.76
Inconnus sp4 cf russula	290	0.28
Inconnus sp5	18	0.40
Inconnus sp6	202	0.13
Inconnus sp8	17	1.02
Inconnus sp9	1	0.12
Inocybe auricoma	178	4.63

Lactarius flammans	326	0.34
Lactarius luteopus	3	0.01
Lactarius saponaceus	32	0.03
Lactarius tenellus	18	0.22
Lactifluus flammans	259	0.27
Lactifluus guellei	23	0.01
Lactifluus velutimus	11	0.01
Lactifluus flammans	17	0.02
Lactifluus guellei	14	0.01
Lactifluus gymnocarpoides	326	0.24
Lactifluus longicysdiosus	26	0.02
Lactifluus luteopus	16	0.02
Lactifluus melleus	6	0.01
Lactifluus saponanceus	90	0.02
Lactifluus velutismus	7	0.01
Mycoamaranthus sp	406	0.22
Psathyrella tuberculata	3	0.07
Russula rubroalba	99	0.12
Russula cellulata	199	0.20
Russula compressa	833	0.74
Russula congoana	822	1.97
Russula oleifera	337	1.23
Russula oleifera	751	0.38
Russula rubroalba	1513	1.46
Schizophylum commun	1	0.20
Schizophylum sp	6	0.02
Termitomyces meduis	14	0.07
Termitomyces sp2	9	0.02
Termitomyces sp3	6	0.01
Termitomyces stratus	6	0.01
General Total	**9362**	**136.25**

Table.6: List of edible higher fungi species of the Plot N ° 4 age 25 years

Species	**Number of carpophores**	**Fresh biomass (kg/ha)**
Amanita craseoderma	79	0.28
Amanita loosii	53	0.01
Amanita masasiensis	542	0.38
Amanita subviscosa	490	0.93
Auricularia polytricha	67	0.49
Inconnus	23	0.36
Inconnus sp1	28	0.42
Inconnus sp1	106	0.39
Inconnus sp2	14	0.17
Inconnus sp3	4	0.04
Inconnus sp5	4	0.03
Inconnus sp6	3	0.36

Inconnus sp7	100	0.14
Inconnus sp8	57	0.26
Lactarius densifolius	13	0.02
Lactarius flammans	979	0.74
Lactarius foetens	25	0.02
Lactarius gymnocarpoides	296	0.40
Lactarius luteopus	46	0.08
Lactarius saponaceus	162	0.02
Lactarius tenellus	169	1.42
Lactifluus sudanicus	10	0.01
Lactifluus flammans	300	0.27
Lactifluus sp	21	0.01
Lactifluus flammans	153	0.16
Lactifluus gymnocarpoides	898	0.96
Lactifluus saponanceus	25	0.01
Lactifluus velutismus	129	0.24
Russula rubroalba	202	0.26
Russula cellulata	350	0.21
Russula compressa	554	0.68
Russula congoana	675	2.14
Russula oleifera	100	0.03
Russula rubroalba	729	0.70
Russula velutissimus	17	0.01
Termitomyces	13	0.01
Termitomyces meduis	25	0.19
Termitomyces robustus	3	0.01
Termitomyces sp3	13	0.01
Termitomyces striatus	145	0.11
General total	**7622**	**109.57**

Annexes 2: Some species of edible fungi from local populations in the Wari-Maro Forest Reserve.


Amanita loosii


Lactifluus flammans

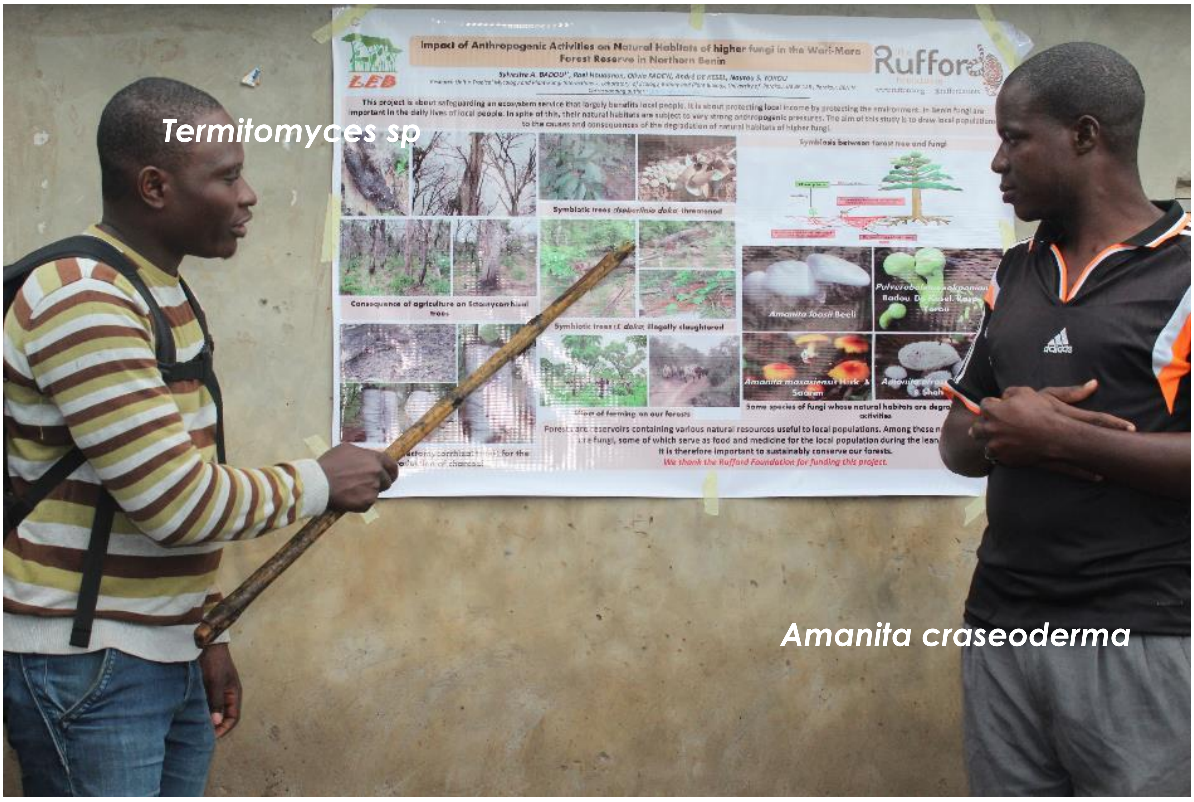

Amanita masasiensis


Lactifluus sp


Termitomyces sp


Russula compressa

Annexes 3: Some pictures of the awareness sessions



Manager project (Sylvestre A. BADOU) explanation of good conservation practices and sustainable management of natural habitats of higher fungi to local populations.

Translation of local guide information (Henri) into local language

Local populations during awareness

Awareness team members

Local committee members responsible for long-term follow-up on new guidelines for the sustainable conservation of natural habitats of higher fungi.