

# A Working Conservation Action Plan for Lake Oku



Produced at the Lake Oku Conservation Action Plan Workshop, held at the Oku Fon's Palace, Elak-Oku, North West Region, Cameroon

21<sup>st</sup> October 2013

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## Executive Summary

Lake Oku is one of the last pristine high elevation crater lake ecosystems in Cameroon. It is the only known habitat of the 'Critically Endangered' Lake Oku Clawed Frog, and the second known locality for the Vulnerable, rare plant *Isoetes biafrana*. In October 2013 a one day workshop was held for the conservation of the Lake Oku ecosystem, including the endemic frogs that dwell within. The aim was to draft a working action plan for the effective conservation of this unique lake and surrounding forest (Plantlife Sanctuary protected area). Workshop delegates included traditional elders of the Oku community, quarter heads of settlements adjacent to the lake, users of the forest around the lake (grazers, carvers, herbalists), tour guides, religious groups, technicians from the local council and government ministries (including Ministry of Forestry and Wildlife). Targets were identified, and included healthy populations of frogs and the wider biodiversity of the lake, good water quality and the forest surrounding the lake.

Threats identified included:

- introduction of fish and other exotic organisms (including pathogens);
- sedimentation to the lake through degradation of the adjacent forest (particularly through livestock and building construction);
- pollution of the lake through littering by visitors and run-off of chemicals from adjacent road;
- unregulated visits to the lake.

The highest priority actions outlined for the lake are:

- Designate a full time guard for the lake;
- Prohibit introductions of any living organism, fish in particular;
- Remove livestock from the Plantlife Sanctuary;
- Establish a committee of authorities for environmentally sensitive planning;
- Include an environmental impact assessment requirement for planning applications;
- People seen moving to lake with detergents should be challenged and informed;
- Continue protection of forest, as this will mitigate sedimentation of lake;
- Field workers to disinfect equipment before and after work in lake;
- Collect a rescue population of the declining *Phrynobatrachus njiomock* for an *ex-situ* rescue program;
- Increased patrols by forest guards.

This is the first action plan produced for this irreplaceable and valuable ecosystem, and will be subsequently reviewed on a periodical basis to enable adaptive management of Lake Oku.

**List of acronyms and abbreviations**

CRAUC – “Conservation and Research for Amphibians Unique to Cameroon” Project

IUCN – International Union for the Conservation of Nature

LGC Oku – Local Grazers Co-operative

MINEPAT – Ministry of Economy, Planning and Regional Development

MINEPIA – Ministry of Livestock, Fisheries and Animal Industries

MINFOF – Ministry of Forestry & Wildlife

SOPISDEW – Society for the Promotion of Initiatives in Sustainable Development and Welfare

## **INTRODUCTION**

### **Environment & Biodiversity**

Environment is the term given to the physical, chemical and biological conditions of a given place at a given time. It influences what life is present and in turn, life can influence the environment (Lovelock and Margulis, 1974). The influence of life on the environment is also dependent on the variety of life – biodiversity – as in which species are present (bacteria, fungi, plants, animals) (Balvanera et al., 2006, Cardinale et al., 2006). Society’s awareness of the importance of biodiversity and the need for a healthy environment is not a new thing. Different organisms provide many benefits to people, initially as food, “beasts of burden”, for construction, for clothing, for companionship, for scientific research, for inspiration and recreation. With changes to how people live, and where they live, came changes to how and which species people interact with. This caused declines and extinctions of many different species, from losses of certain plants, to birds and large mammals through overexploitation or persecution. Similarly, how people manage their land, water and mineral resources has altered the physical environment whilst societies develop, such as deforestation, pollution or introducing alien species. The negative, often unintended, changes to the environment lead to the mobilization of scientists to advise society on the mitigation of these problems. First the “Environment Ethic” was articulated (Leopold, 1933, Wilson, 1999), which is where humanity takes responsibility for its impact on the surrounding environment. The term “biodiversity” was then coined to describe biological diversity, the variety of life in the form of different species and ecosystems they form (UN, 1992b).

### **Legal frameworks**

In 1992, the world’s nations gathered in Rio de Janeiro, Brazil, for the Earth Summit. Here, nations discussed what was to be done about the degrading environment and the loss of species. Firstly, Agenda 21, the action plan for sustainable development was put forward (UN, 1992a). This was followed by the Convention on Biological Diversity, which firstly recognised that the biodiversity of each nation was the sovereign property of that nation (UN, 1992b). Targets were drawn up to end the loss of species through anthropogenic causes.

Cameroon is a signatory to the Convention on Biological Diversity and is thus committed to protecting its biodiversity. It does this through the work of the Ministry of Forestry and Wildlife, which enforces laws on exploitation of vulnerable species (e.g. timber, monkeys, apes), manages protected areas and grants permissions to researchers to investigate the status of the country’s biodiversity so it may be managed better.

### **Conservation Action Planning**

The “Conservation Action Plan” is a tool developed to address biodiversity and environmental problems. It typically involves all stakeholders involved with some aspect of the fate of a given target. Such targets could be a healthy population of a particular animal, or plant, or agreeable quality of an environmental resource, such as water or air. Countries implement the Convention of Biological Diversity using a range of activities, first of all introducing laws to stop the decline and permit restoration of biodiversity and environmental quality. Other means include monitoring to

determine the need for action should biodiversity or other targets continue to decline or fail to recover.

## **THE LAKE OKU CONSERVATION ACTION PLAN WORKSHOP**

### **Workshop aim**

The aim of this workshop was to produce a conservation action plan targeting the ecological quality of Lake Oku.

### **Workshop process**

The workshop was held over one day at the Oku Fon's Palace. Prior to the workshop, stakeholders were considered based on the seven years of work in the area by the organisers (CRAUC Project). These included national, municipal and traditional representatives of different capacities, but also groups who might be involved with the lake, such as tour guides, local environmentalists, field pastors, and representatives of adjacent settlements (quarter heads). As many stakeholder groups were invited as possible and those not invited will have been omitted only by error.

The workshop would consist of delegates arriving and registering in the morning. They would all introduce themselves to the wider group. The workshop facilitator would then introduce the workshop and its goals. The targets of this workshop revolved around the lake, with open discussion about what is significant about the lake and targets that should be conserved. Groups would then be separated to discuss threats to the specified targets, and possible solutions. Groups were separated into: traditional authorities (elders, chiefs, etc); forest users (honey gatherers, grazers & carvers); and "technicians" (delegates of local government, ministries of wildlife and livestock, local environmentalists, field pastors). After this, lunch would be provided. Following lunch the working conservation action plan would be drafted with delegations, time frames and priorities discussed for each action (see below).

As not necessarily all stakeholders will have been able to attend the workshop, notably international experts on certain taxonomic groups, the conservation action plan originating from this workshop is considered a working version that is to be reviewed, renewed and adjusted as time goes on. This includes sending out a draft of this action plan for comment by stakeholders who were not able to attend the workshop. It is normal for conservation action plans to be reviewed and adapted as they are implemented as part of adaptive management.

### **Stakeholders of Lake Oku**

Before and during the workshop, stakeholders involved with the management and future of Lake Oku and surrounding forests identified:

- Traditional authorities – Fon & Kwifon council, for traditional rites;
- Municipal authorities – Oku Municipal Council, developing infrastructure in the area;
- National technical authorities – Ministry of Wildlife and Forestry, who are responsible for the Kilum-Ijim Plantlife Sanctuary, where Lake Oku occurs;
- Local community from surrounding area:

- Tourism guides;
- Livestock grazers;
- Honey gatherers;
- Medicinal plant collectors;
- Fuel wood collectors;
- Hunters;
- Cameroon Baptist Convention – the old Baptist rest house above the lake is frequently used by Christian worshippers;
- International scientists and conservation advisors.

In hindsight, there are potentially other groups who might have an impact on the lake, such as the Kom and Fulani community. In addition, school groups and tour guides from outside the area could have an impact, though could be locally regulated. Although their presence at the lake might be seldom, this should be monitored and if they are having an impact that cannot be controlled by the existing action plan then they should be included in subsequent workshops.



Figure 1. Delegates at the Lake Oku Conservation Action Plan Workshop, Oku Fon's Palace

## Workshop delegates

<b>Name</b>	<b>Organization</b>	<b>Occupation</b>
Tah Kennette Konsum	SOPISDEW	Teacher
Chifon Amos Sam	Grazer's Association	Grazier
Ngum Emmanuel	Security Grazier	Farming
Mankoh John Tabi	Carver	Carver
Nfoume Jacob Ngum	Traditional Rover	Farming
Tantoh Tongle	Palace Attendant	Farming
Oscar Nyingchia	Oku Fon's Palace	Field assistant
Ndukong Augustine	MINEPIA	Veterinarian
Nsokse Samson	Grazier	Farming
Chief Fai Bainkong	Traditional Authority	Chief of Mboh village
Ebahio Fai Ndifon	Traditional Authority	Traditional Authority
Chief Kumbong	Traditional Authority	Chief of Kissotin
Ngwang Philip	Traditional Authority	Carver
Njong Felix	Ngashie	Traditional healer
Kumbong Ernest	Grazier	Farming
Laah Rene	LGC Oku	Journalist
Tenze Daniel	MINFOF	Divisional chief of post
Chief Bailack	Ngashie	Chief
Chiateh Kingkoh Godlove	Elak-Oku Council	Development/Tourism Officer
Terrence Ngum	Elak-Oku Council	Staff
Fai Chimtom	Traditional Authority	Chief of Jiyane
Lobsumba Ephom	Traditional Authority	Traditional Authority
Nkiese Isaiah Tata	Grazers CIG Oku	Grazier
Yoffinde Noel	Oku Fon's Palace	Traditional Authority
Ndifon David	Oku Fon's Palace	Tour Guide
Ndifon Roland	MINEPAT	Resource person
Nyamjale Amos	Oku Grazer's Association	Carpenter
Nkaimbi Philemon	Oku Grazer's Association	Carving
Kolem Henry	Oku Grazer's Union	Grazier/carver
Labah Song Samuel	Oku Grazer's Union	Trading
Laah Felix	FUG group	Carving
Fonmbi Peter	Grazer's Union	Carving
Gwagai Stephen	Elak-Oku Council	Mayor's 1st deputy
Fai Ndifon Nonki	Traditional Authority	Village Head Elak
Mosei Raymond	Clerk/Beekeeper	Farming
Rev Ebjaff Martin	Oku Field Pastor	Pastor
Timothy Keng		Student/grazer
Esau Mahbour Fofuleng	MINEPIA	Delegate-Noni
Ndifon Emmanuel Bose	Lui	
Ndahng Joseph	Keyon	Herbalist
Chianan Saleh David	Grazier's Union	Grazer
Nshom James Keng	Traditional Authority	

**Contributors to action plan outside of workshop:**

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<b>Name</b>	<b>Organization</b>	<b>Occupation</b>
Dr David Blackburn	California Academy of Sciences, USA	Assistant Curator of Herpetology
Dr Martin Cheek	Royal Botanic Gardens, Kew, UK	Botanist
Dr Christopher Durrant	Institute of Zoology, Zoological Society of London	Biosafety Officer
Dr Jean Michel Onana	Yaoundé Herbarium	Botanist
Dr Greg Tanyileke	Cameroon Ministry of Science & Innovation (MINRESI)	Hydrogeochemist
Mr Benjamin Tapley	London Zoo - Zoological Society of London, UK	Team Leader for Reptiles & Amphibians (carer of Lake Oku Clawed Frog colony in London Zoo)

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## A REVIEW OF TARGETS

### Lake Oku: its biodiversity and environment

Lake Oku has an area of 243 hectares, a mean depth of 32 metres, a maximum depth of 52 metres and occurs at an elevation of 2,227 metres above sea level. It is surrounded by the Killum-Ijim Forest. The water is generally clear, indicating a low level of dissolved nutrients, plus a healthy population of organisms that consume phytoplankton. Indeed, a regional study of lakes in the region found nitrates, a pollutant that affects water clarity, to be lowest in Lake Oku. Dissolved oxygen is higher than most other lakes measured in the region (CRAUC Project, In Prep).

There are two frogs found only in or around Lake Oku: the Lake Oku Clawed Frog, *Xenopus longipes*, which is exclusively aquatic and does not leave the lake; and the Puddle Frog, *Phrynobatrachus njiomock*, which is found in the lake but also the forest around the lake. Other organisms that live in the lake include aquatic invertebrates, which range from case-bearing caddisfly larvae (Trichoptera), aquatic snails, water boatmen (Corixidae), chironomid larvae, water scorpions (Nepidae), and larvae of the Dragonflies (Odonata) (CRAUC Project, In Prep). All these invertebrates have different feeding habits, from shredding leaf litter, to scraping rocks to predating smaller animals. There are freshwater sponges, which are still unidentified. Vast colonies of aquatic plants occur in the lake and include *Ceratophyllum* sp., *Myriophyllum* sp. and the rare *Isoetes biafrana* that is found in only one other lake in Bioko (Cheek et al., 2000). So far, studies on the microscopic plankton have not taken place in Lake Oku, but it is likely to consist of bacteria, hypomycete fungi that digests leaf litter, phytoplankton (microscopic plant cells) and zooplankton (microscopic animals). There is a large population of waterfowl living on the lake, including Little Grebe (*Tachybaptus ruficollis*) and African Black Duck (*Anas sparsa*).

The forest belt surrounding Lake Oku is probably what makes it unique among the many other lakes of the highlands of Cameroon, which have degraded or eliminated forest belts (CRAUC, In Prep). Forest vegetation around any lake will contribute to the processes within that lake (Pace and Prairie, 2005). This includes providing shade to the lake edge, but more importantly shedding leaf litter into the lake, which provides one base to the broader food web (the other base being photosynthesis). If not consumed by smaller organisms, this leaf litter can also become buried in the sediment and act as a carbon sink (the trees originally pulling carbon dioxide from the atmosphere and storing partly in the leaves) (Pace and Prairie, 2005). As well as inputs of leaf litter, the trees are also a source of insects and other creatures falling into the water, which will feed either frogs, aquatic invertebrates or form detritus for organisms towards the base of the food web. Even the presence of trees by the water's edge will provide perching spots for birds or monkeys, which themselves might drop plant matter or faeces into the lake that will be assimilated by the lake ecosystem. The other function of a forest belt around a lake will be the provision of shade and stabilization of soil that prevents pollution and siltation of the lake. Thus loss or degradation of forest around the lake will cause changes to the ecosystem processes and physical properties of Lake Oku.

Within the forest surrounding the lake are an important population of the rare trees *Dovyalis cameroonensis* (which might be extinct elsewhere in the world) (Cheek and Ngolan, 2006) and the 'Critically Endangered' *Oxyanthus okuensis* (Cheek et al 2000). There are chameleons (*Trioceros serratus*, *Chamaeleo quadricornis*), other reptiles include the skink lizard *Lacertaspis chriswildi*, and the harmless snake *Bothrolycus ater* (CRAUC Project, unpublished data). There is a rarely seen

population of rare Preuss' Guenon monkeys (*Cercopithecus preussi*), smaller mammals (such as shrews, mice, rats, bats and genet cats) and forest birds such as Bannerman's Touraco (*Tauraco bannermani*). Birds of prey such as the Kite (*Milvus* sp.) often fly over the lake and have been observed snatching items from the lake's surface. The increasingly rare Night Frog, *Astylosternus ranoides* (IUCN: Endangered) is found in the forests surrounding the lake, with tadpoles also found in the lake itself (CRAUC, In Prep).

Lake Oku is a landmark for the communities that surround it, especially for the Oku community (Koloss, 2000). A lake does feature in the lore of the Kom and is thought also to be that of Oku. Each year around April, the Oku community have a gathering at the lake for ritual rites, including the Fon of Oku. Here members of the Oku community enter the lake and drink the water. The lake is also a major feature of a tourist's schedule in Oku. Christian groups often visit the lake for retreats and schools make field trips to the lake. A recent survey of households in Oku noted most members of the community use the lake for: sight-seeing (in addition to tourists from outside); collecting plants for traditional medicine; collecting water; tending bee hives in the surrounding forest; other uses already mentioned above.



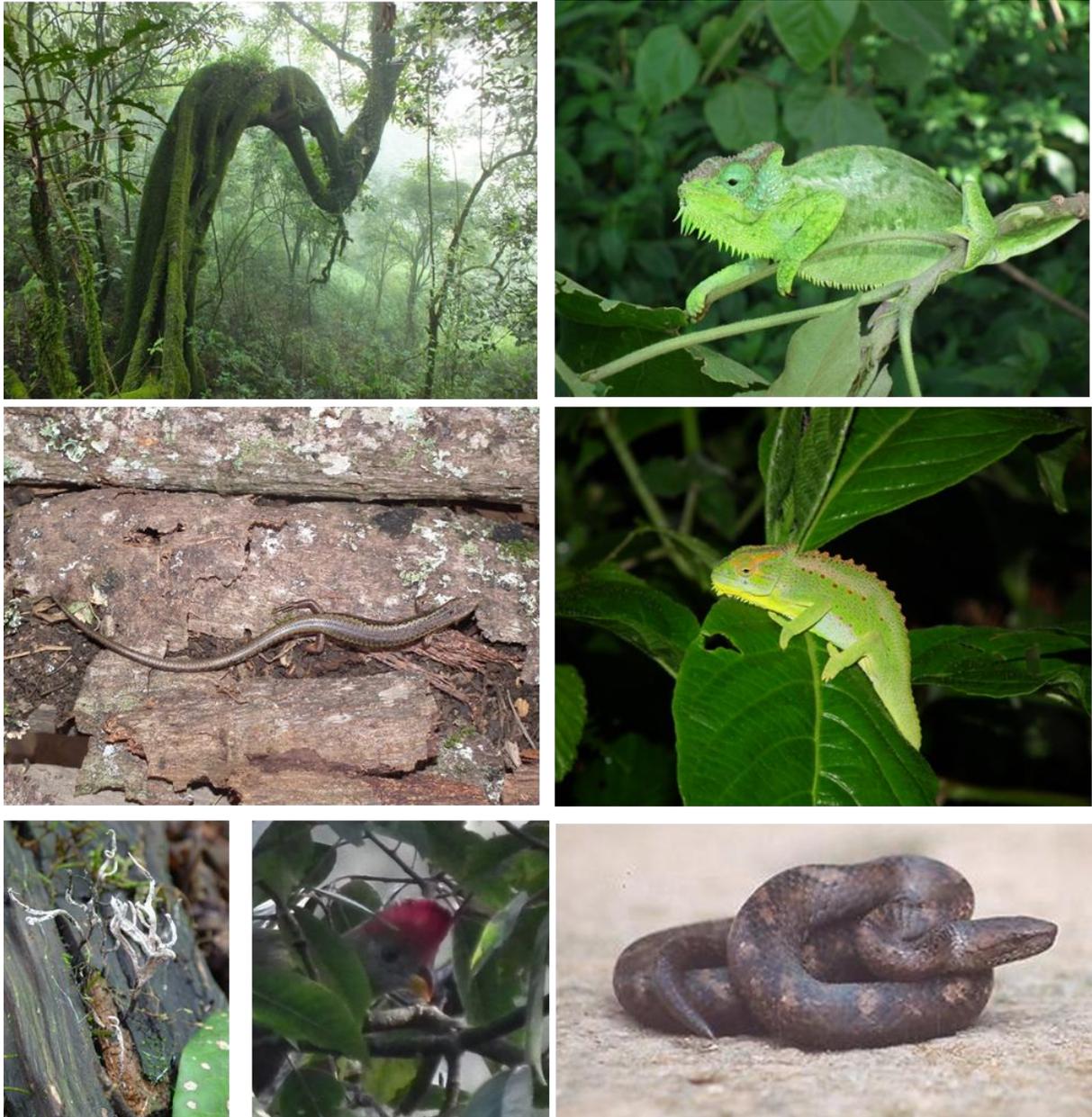
**Figure 2. Aquatic plants of Lake Oku.** Left, underwater forests of *Myriophyllum* sp.; right, the globally rare *Isoetes biafrana* (IUCN conservation status: Vulnerable)



**Figure 3. Aquatic invertebrates of Lake Oku.** Clockwise from top left: Dragonfly (Odonata) larva (predator); Cased-caddisfly (Tricoptera) larva (shredder, scraper); freshwater sponge (filter-feeder, absorber); Dragonflies emerging at lake's edge (predators of other flying insects).



**Figure 4. Anurans of Lake Oku.** Clockwise from top left: endemic Puddle Frog, *Phrynobatrachus njiomock*; Lake Oku Clawed Frog, *Xenopus longipes*, tadpole of Night Frog, *Astylosternus ranoides* often observed in the lake; adult Night Frog, *Astylosternus ranoides* (IUCN conservation status: Endangered).



**Figure 5. Forest surrounding Lake Oku.** Clockwise from top left: mature montane forest trees; Four-horned Chameleon (*Chamaeleo quadricornis*); Peacock Chameleon (*Trioceros serratus*); Snake (*Bothrolycus ater*); Bannerman's Touraco (*Tauraco bannermani*); forest fungi breaking down dead wood; Chris Wild's Skink, (*Lacertaspis chriswildi*).

### **Threats to Lake Oku and its ecology**

Threats to freshwater ecosystems are universal (Dudgeon et al., 2006), and include pollution, invasive alien species, overexploitation of aspects of the biota, climate change, physical habitat change including changes in hydrology. In the case of Lake Oku, current identified threats consist of:

- Fish introduction (invasive alien species);
- Novel pathogens being introduced from outside (invasive alien species);
- Runoff of vehicle oils and other chemicals from road (pollution);
- Visitors to the lake throwing rubbish into and around the lake (pollution);
- Degradation of the forest by livestock (habitat change);
- Degradation of the forest by building constructions (habitat change);
- Degradation of the forest by wood cutting (habitat change).

Not yet observed but possible (“horizon scanned”) threats to the lake include:

- Changes to the temperature, rainfall or other aspects of climate from industrialised climate change (climate change);
- Collections of plants and animals for commercial purposes (overexploitation).

A broader threat that encompasses all of the above is that of mismanagement or neglect. This is a fundamental topic to governance. It is here mentioned in passing, but something those involved with any management plan should be aware of.



**Figure 6. Threats to Lake Oku.** Clockwise from left: Introduction of fish (image is a Tilapia held on a farm near the lake); garbage thrown into the lake, in this case a battery that will release toxic chemicals such as acid and mercury; degradation of forest by livestock, causing siltation and changes to ecosystem processes of the lake.



**Figure 7. Emerging threat to Lake Oku: habitat destruction through developments for tourism.** Longer term impacts are likely to include further degradation of forest and lake through wood cutting for fuel, unless the developers and tourism managers manage this to prevent negative impacts.

## Past & current interventions at Lake Oku and the surrounding forest

Lake Oku was briefly mentioned by German explorers in the 19<sup>th</sup> Century (Koloss, 2000), but there were scant research publications on the lake until the Lake Nyos disaster in the 1980s (Kling, 1988). Its physical characteristics were measured, notably its depth, area and mixing, all measures to assess the risk of limnic eruptions of gas, for which Lake Oku was assessed to have a low risk. The first recorded biological field work at the lake was that of the botanist Thorbecke between 1907 and 1908 (Cheek et al 2000). This was followed by visits of other botanists to the mountain, but it was Keay & Lightbody in 1951 who discovered *Isoetes biafrana* in the lake. Work on invertebrates has been limited, with only certain zooplankton studied (Green and Kling, 1988). First amphibian work described at the lake was by French biologist Jean-Louis Amiet who made brief collections and mentioned possibly two unique frogs living in and around the lake (Amiet, 1971, Gartshore, 1986). This was followed by Mary Gartshore, who made additional observations on the amphibians living in and around the lake as part of the International Council for Bird Preservation's expedition to appraise the status of Cameroon's mountain forests in 1984, acknowledging that there were two potentially endemic (unique) frog species living in the lake (Gartshore, 1986). It was not until 1991 when a Swiss scientist, Catherine Loumont described one of the frogs as a new species, the Lake Oku Clawed Frog, *Xenopus longipes* (Loumont and Kobel, 1991).

Following the International Council for Bird Preservation's (now Birdlife) expedition to Oku in 1984, efforts were made to improve the protection of the forests on Mount Oku. From 1987, these efforts morphed into the Kilum-Ijim Mountain Forest Project, a collaboration between Birdlife and the Cameroon Ministry of Environmental Protection. The outcome of this was the establishment of eleven community forests divided across the whole forest belt. These would be community managed in the form of forest management institutions. Lake Oku and the forest surrounding Lake Oku were demarcated as the Kilum-Ijim Plantlife Sanctuary in 2002. This government protected area is a core conservation area surrounded by community managed forests. The Ministry of Forestry and Wildlife employs a conservator to enforce laws protecting the Plantlife Sanctuary. Signage demarcates the boundary of the Plantlife Sanctuary. There is apparently no plan to protect or manage Lake Oku specifically, other than to control access and for general forest conservation which will have a positive impact.

Scientists interested in the systematics of amphibians have since visited Lake Oku to collect frogs to understand their evolutionary biology (Evans et al., 2004, Blackburn, 2008, Blackburn et al., 2010), and have made some contributions to highlighting the unique and tenuous status of the lake's ecology to the local community. These researchers also engaged with the traditional authorities in the naming of new species. For example, the endemic Puddle Frog of the lake, *Phrynobatrachus njiomock* was named with assistance of the Oku community, "njiomock" being the Oku word for "number 11", in homage to Amiet's reference of "sp. 11" to the undescribed additional *Phrynobatrachus* in Oku (Zimkus and Gvoždík, 2013). The CRAUC (Conservation and Research for Amphibians Unique to Cameroon) Project began initially in 2008 following a brief reconnaissance to Lake Oku in 2006. Its aims are to generate ecological information on the amphibians of Mount Oku (and other parts of Cameroon), to raise awareness of the importance of amphibians to the Oku community, to use amphibians as an umbrella for wider environmental health management. These aims have been achieved for many species of amphibian on Oku, with the elders, other authorities and community receiving talks, reports, leaflets on the uniqueness of Mount Oku's amphibians. This

includes work in the forests, farmland, summit grasslands and the lake. Baselines obtained by CRAUC and earlier amphibian scientists have also enabled assessment of the status of amphibians around the lake (Hirschfeld et al, in review)

### ***Ex-situ* management of Lake Oku's organisms**

*Ex-situ* refers to working with a species outside of its native range, basically in laboratory conditions or similar. This practise is controversial for preventing species extinction as it is only a short term action that has a great risk of failure due to its narrow scope of stopping absolute extinction of a species in the face of broader environmental degradation. There is also a very real risk that novel pathogens may be introduced to populations when they are maintained outside of their geographical range then reintroduced. Many *ex-situ* programmes lack an exit strategy and so require long term commitment and funding. *Ex-situ* management organized by Western institutions can be viewed as imperialistic and removes the need for husbandry capacity to be developed *in-situ*, which thus excludes local stakeholders. Therefore, *ex-situ* management occurs in only extreme circumstances.

*Ex-situ* programmes cannot work in isolation to work in the field, though there are circumstances when conditions in the field are completely hostile to the persistence of a species (or to conservationists). This could be unregulated hunting pressure, or an extreme climatic event, or the arrival of a disease. The latter scenario has occurred for many amphibian populations across the globe, with animals taken into zoos when a particular fungal disease arrives to a new area where rare frogs might occur. Western institutions typically lead the way in this technique as they usually have facilities and expertise to breed amphibians in captivity. Knowledge on issues like biosecurity, as well as a local capacity building have now provided the incentive to set up facilities in the host countries adjacent to target amphibian habitat, though not always feasible.

As Lake Oku is such an isolated, unique ecosystem with uncertain futures, *ex-situ* management is a tool that might be applied to many of its taxa.

Amphibians are often subjected to *ex-situ* management when threatened with extinction due to their smaller, more manageable size, their tendency for endemicty in small ranges and vulnerability to sudden decline, particularly due to disease (Griffiths and Pavajeau, 2008, Zippel et al., 2011). The discovery of sick and dead Lake Oku Clawed Frogs in 2006 triggered a series of attempts to export animals to facilities in America and Europe for captive assurance populations. Prior to this, it had already been advised to establish a captive population of the frogs in case something like a new disease or fish were introduced to the lake wiping the frogs out (Tinsley and Measey, 2004). A collection of 45 frogs was taken out in 2006 to America, though only 18 survived with further deaths over time, all turning out to be female. Following this, dialogue between conservationists and amphibian biologists took place on methods for safer transport of frogs, with 80 animals brought to Europe in 2008, to London and Antwerp Zoos. As this collection was also female biased (only a few males), a further 20 male frogs were exported and divided between these two institutions. So far, none of these populations have bred successfully, though different methods to coax the frogs into breeding are being deployed. A recent export took place in 2013 of 25 frogs by the California Academy of Science with the aim of studying reproductive biology. The aims for export of this group is separate from strictly *ex-situ* goals in that they are purely research and educational based (D. Blackburn, pers. comm.), but it is hoped this group will be successful in working out how to breed

these animals to benefit both their *ex-situ* and *in-situ* conservation. Critical to the success of this work is learning about the reproductive biology of this species. It is noted here that frog exports were authorised by the Fon of Oku and the Ministry of Forestry and Wildlife, the recipient institutions transparently and conscientiously managing these populations to strict ethical and legal standards.

Setting up of a captive breeding colony in Cameroon, near to Oku with a similar climate would achieve biosecurity and capacity building targets, but needs to be carefully thought out for the long term sustainability of such an initiative. This was originally proposed by the Taxon Management Plan for *Xenopus longipes*, but no action was taken. One representative of Amphibian Ark (an international organization devoted to preventing extinction of amphibians using *ex-situ* methods) proposed using a laboratory in Yaoundé, but had yet to address the issue of temperature regulation in the warmer city compared to the cooler mountain lake. In the next five years, T. Doherty-Bone is planning on constructing a field study centre in Oku, where such a breeding facility might also be set up.

It is otherwise fortuitous that the Lake Oku Clawed Frog's population has not collapsed. The sudden decline and disappearance of the Puddle Frog *Phrynobatrachus njiomock* is a cause for concern and represents a missed opportunity to set up a safety net captive population. A scientific description of this species was only first provided in 2013, by which time it had been missing since 2010. The causes of its decline are still unknown and whether an *ex-situ* programme would have been effective are uncertain.

Threat	Action	Delegation	Resources?	Timeframe	Priority
Invasive species:					
Introduction of animals, plants or other organisms, notably fish.	Prohibit introductions of any living organism, fish in particular.	MINEPIA, MINFOF, Traditional Council.	Already in place.	+	High
Disease	Field workers to disinfect equipment before and after work in lake. This can include cleaning and drying.	Conservators and researchers.	Can be achieved very easily. Already be in place for the CRAUC project.	Short	High
	Assess risk of birds spreading diseases between water sources. Culling is likely not to be an option.	CRAUC Project, others?	Not clear, TDB to assess	Long term	Low
	Collect a rescue population of the declining <i>Phrynobatrachus njiomock</i> if its population makes a recovery.	CRAUC Project, D. Blackburn of California Academy of Sciences	Need to check first with institutions that could hold this species. A centre breeding these in Oku would be ideal, but no centre exists at present.	Long	High
Forest destruction:					

Infrastructure developments	Include an environmental impact assessment requirement for planning applications.	Municipal council. CRAUC Project, MINFOF, other technical stakeholders to advise.	In progress.	Medium term	High
	Establish a committee of authorities for planning.	Municipal council, Traditional Council & MINFOF (in case of work in Plantlife Sanctuary). CRAUC Project to be kept informed to advise.	Not in place	Long term	High
	Establish a means to fuel the new bar/restaurant that does not require fuel wood from the forest.	Municipal Council, with advice from MINFOF & CRAUC Project	Not in place	Medium to long term	Medium
Grazing by livestock	Remove livestock from Plantlife Sanctuary. Difficult to know the owner of the goats – grazers can trace the owners of the goats. The panel advise the following:  - Rally at villages/settlements to discuss with grazers the plan cited below  - Radio AND traditional announcement: “Any goat found in forest should be considered property of the Council (Municipal or	Quarter heads of Kissotin, Mboh, Jikijem, Mbokevu, Lang, Ngemsebah (rally), Traditional council (announcement), Municipal Council (radio announcement and enforcement), MINFOF Plantlife Conservator (radio announcement and enforcement).	In progress.	Short term	High

	<p>Traditional?)</p> <p>- Agreeing a deadline for impoundments – one month has been recommended.</p>				
Wood cutting	<p>* Action not decided/agreed:</p> <p>There is a conflict of opinion between MINFOF &amp; members of traditional council as to the activities in the Plantlife Sanctuary:</p> <p>MINFOF would insist no one enters the Plantlife Sanctuary, but the Traditional Authorities claimed some entry is or should be allowed. MINFOF delegate pointed out that hunting/wood collection is for the community forests, not the Plantlife Sanctuary.</p> <p>The below are written post-workshop by the workshop organiser.</p> <p>Possible actions:</p>	Possible delegations:	Possible resources:		

<ul style="list-style-type: none"> <li>- Verify the legality of entry into the Plantlife Sanctuary;</li> </ul>	<ul style="list-style-type: none"> <li>- MINFOF, Traditional Authorities, Council, D.O.'s office?</li> </ul>	<ul style="list-style-type: none"> <li>- MINFOF personnel could obtain the original legal documents declaring the Plantlife Sanctuary.</li> </ul>	<ul style="list-style-type: none"> <li>- Short term</li> </ul>	<ul style="list-style-type: none"> <li>- High</li> </ul>
<ul style="list-style-type: none"> <li>- Monitor wood collecting activities in the Plantlife Sanctuary, such as impacts of “tree-killing” cutting of barks on trees?;</li> </ul>	<ul style="list-style-type: none"> <li>- MINFOF, researchers?</li> </ul>	<ul style="list-style-type: none"> <li>- MINFOF guards, other local technicians?;</li> </ul>	<ul style="list-style-type: none"> <li>- Medium term</li> </ul>	<ul style="list-style-type: none"> <li>- Medium</li> </ul>
<ul style="list-style-type: none"> <li>- Provide an alternative for collecting fuel wood in the Plantlife Sanctuary;</li> </ul>	<ul style="list-style-type: none"> <li>- MINFOF, Traditional Authorities, environmental NGOs, researchers &amp; foreign donors?</li> </ul>	<ul style="list-style-type: none"> <li>- Not obvious where this can take place;</li> </ul>	<ul style="list-style-type: none"> <li>- Long term</li> </ul>	<ul style="list-style-type: none"> <li>- Medium</li> </ul>
<ul style="list-style-type: none"> <li>- MINFOF to allow a concession for some collection, but with an aim to slow it down. The importance of dead wood being left uncollected for forest processes ( to allow nutrient cycling and survivorship of nutrient</li> </ul>	<ul style="list-style-type: none"> <li>- MINFOF, Traditional Authorities, Council, with external advise from researchers? (TBC)</li> </ul>	<ul style="list-style-type: none"> <li>- Uncertain, needs consideration.</li> </ul>	<ul style="list-style-type: none"> <li>- Long term</li> </ul>	<ul style="list-style-type: none"> <li>- Medium</li> </ul>

	cyclers) is an emerging topic, needs further research and discussion that might benefit from an abstaining or regulating in the Plantlife Sanctuary at the very least.				
Pollution:					
Litter	Deployment of a guard at lake.	MINFOF, Council, Traditional authorities.	To be decided.	Long term	Medium
	Sensitization using noticeboard, leaflets, word of mouth:  - Broad, generic focus; - Focused on lake.  Direct, verbal action for litterers “TAKE YOUR RUBBISH HOME”.	CRAUC Project, Environmental NGOs, Church groups, schools, Council, Traditional Authorities	Leaflets already been produced on lake, with sensitization on littering delivered in public meetings on the lake. Notice board for lake in preparation, as are leaflets focussed on litter and waste.	Short to long term  (it will be an ongoing process of awareness)	Medium
	Investigate possibility of using a net in lake surrounding shore to stop garbage spreading to rest of lake.	Local tour guides?? CRAUC Project can advise.	To be followed up	Long term	Medium
Chemicals: detergent	As above. Deploying a guard at the lake. People seen moving to lake with detergents should be challenged and	Traditional Authorities, MINFOF	In place	Long term	High

	informed.				
Chemicals: runoff from road	Continue protection of forest, as this will mitigate the runoff into the lake.	MINFOF, Traditional Authorities	In place	Long term	High
	Monitor extent and effects of siltation and other pollutants from road	CRAUC Project	Being assessed	Medium term (by December 2014)	Medium
Siltation	The biggest influx of sediment apparently comes from the tourist's path. It is possible to create soil traps, such as sand bags, rocks that can stop the silt getting into the lake.	Municipal Council; CRAUC Project	To be sought	Medium term	Medium
Unregulated visits	Post a guard from the community at the lake to meet visitors and advise on their activities. This guard (if not from MINFOF) could be backed up by government forest guards for gross-violators of laws.	Traditional Authorities/MINFOF	Obtainable	Medium term	Medium
Hunting	Increased patrols by forest guards.	MINFOF	Was not assessed during this workshop. Guards are available in	Short term	High

			Elak, anywhere else?		
Medicinal plant collection	Research on usage, offtake, sustainability and baseline of aquatic plants.	CRAUC Project, other research institutions???	Being assessed: Can the Yaoundé Herbarium to send technicians and collaborate on research projects, with local technicians?	Long term	Low
Bush fires	Identify bee farmers working around lake. Sensitization about best practise for bee keepers that incurs a low risk of fire. Contact honey co-operative on appropriate techniques.	MINEPIA, Municipal Council & CAMGEW.	In place, will require merely letter/phone call/visit to office	Short term	Medium
Climate Change	Assess impacts of changing climate on the Lake and surrounding forest.  Industrial society impacting the Earth's climate systems	MINRESI, CRAUC	Partly in place with basic measurements of temperature, but more sophisticated techniques and broader sampling regimes are in need of design.	Long term	Medium

<p>will have an impact on the climate of Oku and its lake. This is not caused by the Oku community, but by the external factors, so not necessarily worthy of discussion for action at this scale, just that the Oku community be aware of this issue.</p>				
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## Unfinished Matters

There are other issues with the conservation of Lake Oku that were not dealt with in the workshop. The issue over access to the Plantlife Sanctuary by the community was discussed but not resolved. Other issues not discussed but might be presented include:

- Fraud. There has been a Buea-based NGO called the Bova Wildlife Conservation Centre, claiming to work in Lake Oku and has been applying to foreign donors claiming funds to work in Oku. This group has been successful in defrauding at least two international conservation donors. Not only is money dedicated to environmental protection being lost, this reduces confidence in foreign donors in supporting legitimate projects in Oku.

## Conclusion

Despite taking place over one day, a considerable amount of progress has been made towards the conservation of Lake Oku. This builds on work of previous practitioners who have ultimately made it possible to be aware of the importance of the lake. It is limited by higher government officials not included at this stage, or the presence of most international scientists who otherwise contributed *in absentia*. The advantage of this is local community representatives were able to contribute more to the workshop. Much work is still needed to implement, review and adapt the action plan in order to protect the uniqueness of Lake Oku for future generations to benefit and enjoy.



At the end of the workshop, His Excellency the Fon of Oku dispenses palm wine to the workshop delegates.

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## Appendix 1.

### Biosecurity for visitors to Oku

#### ***What is biosecurity***

Biosecurity is preventing the spread of living organisms, particularly harmful species such as disease-causing pathogens.

#### ***Why do biosecurity***

Within modern society people frequently travel across larger distances, potentially taking with them many different animals, plants and diseases.. Organisms that survive such journeys can cause harm to crops, livestock, wildlife and people. For example, seeds carried on people's clothing can turn out to be weeds that can reduce crop yields. Soil on people's shoes can contain diseases which affect livestock and native fauna. In Oku, many frogs have disappeared very suddenly; scientists believe it was caused by such an incident that introduced a new disease.

Biosecurity measures can prevent many different pests from proliferating. It has been found that preventing the arrival of new pest insects or microbial pathogens is far more effective and efficient than managing them after they arrive.

#### **Biosecurity works!**

#### ***What needs to be done?***

Visitors to Oku are either natives returning home, nationals from outside the region or foreigners i.e. tourists, volunteers, development workers, scientists. The Oku visitor's book shows people from 29 different countries, from five different continents. The most common international visitors are from Germany and France, and the furthest travelled visitor coming from Australia. All these countries have their own native pathogens and other organisms which if released could wreak havoc in Oku if not controlled.

To reduce the risk of disease and pest spread tour operators should make sure visitors have cleaned and dried their equipment of any soil, or seeds before entering Oku. Keeping a foot mat soaked with disinfectant at the entry of tourist offices and houses where visitors enter on arrival is one way to ensure all visitors have at the very least disinfected their footwear. Prior to a trek, in case they have different foot wear to when they arrived, visitors should be instructed to disinfect their footwear before setting off.

For domestic biosecurity, local people travelling outside of Oku should remember to clean and dry clothes, equipment and footwear and are aware that carrying plants and animals might introduce undesired organisms or have undesired consequences themselves. Any unusual insects or plants encountered should be presented to local scientists, including technicians of the Ministry of Livestock and Agriculture.



**Figure 8. An example of biosecurity infrastructure. Foot bath for tourists entering a forest in Uganda. This concrete base has a mat soaked in disinfectant. Tourists wipe their feet before entering the forest to kill any microbes or pests that might cause harm to the wildlife they are going to see. In this case, there are many chimpanzees, monkeys and buffalos. Stopping the spread of disease means keeping a healthy environment for people and wildlife alike.**



**Figure 9. Field worker disinfecting footwear in bucket of bleach solution upon completing a day's research at Lake Oku. The contents of the bucket are disposed of away from the forest on concrete so the bleach breaks down without harming the environment.**





**Lake Oku as viewed from the Oku summit grasslands.**