FOREST RESILIENCE FOR LIVELIHOODS AND ECOSYSTEM SERVICES

by

Ashley D. Milton
A Dissertation
Submitted to the
Graduate Faculty
of
George Mason University
in Partial Fulfillment of
The Requirements for the Degree
of
Doctor of Philosophy
Environmental Science and Policy

Committee:

_____	Dr. Daniel Sklarew, Dissertation Director
_____	Dr. A. Alonso Aguirre, Committee Member
_____	Dr. Hazel McFerson, Committee Member
_____	Dr. Toni-Lyn Morelli, Committee Member
_____	Dr. Albert Torzilli, Graduate Program Director
_____	Dr. Robert Jonas, Department Chairperson
_____	Dr. Donna Fox, Associate Dean, Student Affairs & Special Programs, College of Science
_____	Dr. Peggy Agouris, Dean, College of Science
Date: _____	Summer Semester 2015 George Mason University Fairfax, VA

Forest Resilience for Livelihoods and Ecosystem Services

A Dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at George Mason University

by

Ashley D. Milton
Bachelor of Science
Florida Agricultural and Mechanical University, 2009

Director: Daniel Sklarew, Professor
Department of Environmental Science and Policy

Summer Semester 2015
George Mason University
Fairfax, VA

DEDICATION

This dissertation is dedicated to

Patrice Hémery Lumumba

ACKNOWLEDGEMENTS

I acknowledge that **Black Lives Matter**.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Central Africa Program Office ..... CARPO
Central Africa Regional Program for the Environment ..... CARPE
Central African Republic ..... CAR
Clean Development Mechanism ..... CDM
Community Based Natural Resources Management ..... CBNRM
Conference of Parties ..... COP
Democratic Republic of Congo ..... DRC
Department of Forest Management ..... DIAF
Digital Elevation Model ..... DEM
Direction de Development Durable ..... DDD
Driver-Pressure-State-Impact-Response ..... DPSIR
Ecosystem Restoration Services ..... ERA
Emission Reduction Program Idea Note ..... ERPIN
Enhanced Thematic Mapper plus ..... EMT+
Extraction Zones ..... ERZ
Food and Agricultural Organization ..... FAO
Forest Carbon Partnership Facility ..... FCPF
Forest Law Enforcement, Governance, and Trade ..... FLEGT
Indian Ocean Dipole ..... IOD
International Union for the Conservation of Nature ..... IUCN
Lake Télé-Lake Tumba ..... LTLT
Mabali Scientific Reserve ..... MSR
Measurement, Reporting, and Verification ..... MRV
Ministry of Environment, Conservation of Nature and Tourism ..... MECNT
Monitoring the Forest of Central Africa ..... FACET
Narrative Policy Framework ..... NPF
Non-timber Forest Product ..... NTFP
Observatoire de la Gouvernance Forestiere ..... OGF
Observatoire Satellital des forêts d'Afrique Centrale ..... OSFAC
Participatory Rural Appraisal ..... PRA
Payment for Ecosystem Services ..... PES
Protected Area ..... PA
Reducing Emissions from Deforestation and Degradation ..... REDD
REDD plus the Payments for Ecosystem Services ..... REDD+
Republic of Congo ..... ROC
Structural Adjustment Programs ..... SAP

Sustainable Forest Management ..... SFM
United Nations ..... UN
United Nations Conference on the Environment and Development ..... UNCED
United Nations Framework Convention on Climate Change ..... UNFCCC
United Nations Forum of Forests ..... UNFF
United Nations Office for the Coordination of Humanitarian Affairs ..... UNOCHA
United States Agency for International Development ..... USAID
United States Forest Service ..... USFS

ABSTRACT

FOREST RESILIENCE FOR LIVELIHOODS AND ECOSYSTEM SERVICES

Ashley D. Milton, Ph.D.

George Mason University, 2015

Dissertation Director: Dr. Daniel Sklarew

Deforestation in the Congo Basin is altering the natural functioning and services of the ecosystem and adversely impacting highly vulnerable human populations who rely on their proper functioning. There is currently no framework that comprehensively addresses the historical and cultural complexities that are persistent in Central African societies and that also include, from a micro scale, the detailed voices of local communities. Without such a holistic framework, it is difficult to evaluate the effectiveness or harmfulness associated with current management strategies in responding to deforestation at the various levels. This transdisciplinary mixed method study determined the most salient indirect and direct causes of forest loss, the impacts resulting from an altered state, and the effectiveness of current management responses by assessing changes in forest cover, forest provisions, and trends in forest management. Because forests are common goods, the elasticity of forests are dependent on a multitude of human activities and attitudes. Therefore, data collected via survey tools were used to evaluate the role of multiple

stakeholders in the state of the Congo Forest using the Driver-Pressure-State-Impact-Response (DPSIR) framework, a structured analytical tool created by the European Environmental Agency for better understanding of Integrated Environmental Assessments. To best explore local to international perspectives on the effectiveness of current strategies in sustaining forests for livelihoods and ecosystem services, research methods included conducting remote sensing analysis of Landsat satellite images, interviewing over 325 individuals living in 25 communities in the Lake Télé-Lake Tumba Landscape of northwestern Democratic Republic of Congo and 20 individuals working on forest management, conservation, and funding, and a climate analysis using 40 years of weather data collected from a scientific reserve located within the landscape. Results highlight that local populations are highly environmentally literate and their knowledge is a useful tool for qualifying environmental changes, such as reduced lake health, animal health, and plant health. Remote sensing results show the forest is in a state of decline and climate findings confirm the ecological health of the landscape has been reduced demonstrated by major shifts in the traditional agricultural calendars and the effects are having adverse public health impacts on local communities. The process of this research itself interfaces science and policy and thus recommendations focus on how to make effective payments to communities for supporting alternative livelihoods in order to prevent deforestation while next steps should focus on the implications of forest loss and the promotion of a One Health approach at the landscape level.

CHAPTER 1: FOREST RESILIENCE FOR LIVELIHOODS AND ECOSYSTEM SERVICES: AN INTRODUCTION TO THE ECOLOGICAL AND SOCIOCULTURAL CAUSES AND EFFECTS OF FOREST LOSS

The State of Forests

Tropical, temperate, and boreal forests cover 31% of the earth's land area (FAO, 2010). Tropical forests have the greatest diversity of species (Posa et al., 2011) and will be the focus of this dissertation. The largest blocks of tropical forests are the Amazon, the Congo Basin, and those forests in Southeast Asia. They are located near the equator and typically only have two types of seasons, rainy and dry, each occurring twice with one greater the other with lesser magnitudes. Precipitation is evenly distributed throughout the year across the region and temperatures average 20-25 degrees Celsius (Inogwabini et al., 2006). The tree canopy is diverse and multilayered while soils are considered to be nutrient-poor.

Industrialization, subsistence practices, and other anthropogenic deforestation activities stress the forest ecosystem and cause a stimulus reduction in forest resilience. Stress is denoted as an external factor or stimulus that provokes an internal response (Odum, 1985; Rapport et al., 1985). Forest resilience is reduced when external stresses occur at a rate faster than the internal response rate. Once internal responses are overwhelmed, e.g., invasive species taking control, retrogression of the original ecosystem occurs creating an unstable community habitat. Development activities and human population growth over time are major types of stresses. Over half of terrestrial

habitats that have been converted occurred in tropical and subtropical rainforest countries (FAO, 2010). Ecosystem services, products of functioning forests that benefit human, are reduced as a result. This introductory chapter will provide a brief literature review of the most salient drivers of, pressures on, impacts to, and responses to tropical rainforest loss globally.

The Drivers of Rainforest Loss

Drivers of deforestation are defined as the social, demographic and economic developments in societies and the corresponding changes in lifestyle (Kristensen, 2011). This definition was adopted as part of a strategic look at Integrated Environmental Assessments, where overall levels of consumption and production pattern are the driving force of environmental change. Drivers can originate and act globally, regionally, or locally (European Environmental Agency, 2007). Below I provide a summary highlighting key points from a literature review conducted on drivers of tropical deforestation.

Politics and Governance – There are sociopolitical and sociocultural factors driving forest cover. Consequently, forest areas within political boundaries can be useful determinants of forest change (Rudel, 2013; Geist and Lambin, 2002). The United Nations and the World Bank present forest statistics by country, showing that political boundaries are used for aggregating information on forests and their attributes. Thus, the policies, regulation, and administration bodies that occur within such bodies that are the bases for determining the catalyst of external factors stimulating forest loss. For example, the emergence from colonial rule in Congo Basin Forest countries has often been

followed by years of conflict, instability, and widely acknowledged corruption which are linked to having an influence on forest cover (Hochschild, 1998; Oliver and Atmore, 2000; Wrong, 2002; Pottieir, 2003; de Wasseige et al., 2009; Rudel, 2013), show the direction of policy is the driver of rates of forest change.

Economic Growth and Development - For a long time, forests were often seen only for the economic value of the timber and timber products (Balick and Mendelsohn, 1992). However, forest resources are used for various economic and development situations, at international, national, and local scales. There are also a host of non-market social and customary values that forests offer for sustaining local human populations that have not received monetary value. The expansion of illegal logging, commercial soy production, and cattle ranching has caused extensive deforestation in Brazil often not accounting for forest dwelling communities. Accordingly, deforestation in Brazil from 1993-1998 had a positive correlation with rapid national economic growth (Burgess et al., 2012; Butler, 2008; Frayssinet, 2013). This demonstrates a connection between nation state economics and the state of forests and also highlights the disparities of trickledown economics as non-timber forest products are rarely valued (Balick and Mendelsohn, 1989).

Culture - Culture, whether historical or newly ingrained, applies to individual household behavior as well as governing bodies. Some tropical forest communities are in remote locations and with limited reach of government services have created a culture where forest populations rely solely on forest for survival even as they are being destroyed. Cultural practices are sometimes so ingrained that they are perpetuated even if

they are destructive (Oliver and Atmore, 2000). In Madagascar, there is a culture of burning as the farmers land management tool described by Kull (2005, 2009, 2013). This formerly effective practice, useful in an open island with low human population density of shifting peoples, is now a primary source of deforestation for a country that has increased its population by four fold over the last 50 years (Clark, 2012). High forest reliance can also be attributed to formal legislation and formal systems frequently undermining locally-based traditional and customary systems of land rights. For example, in Central African forest societies it is not unusual for more than one customary tenure system to operate in the same space and in certain areas (Long, 2011). It is the merging of these multiple ideologies that has created new cultural norms, but also new culturally complex problems that drive deforestation because of the competing interests.

Population Growth - Population growth can significantly undermine traditional agricultural systems by increasing forest removal as populations seek better quality soil for planting crops (Hurni & Ludi, 2000). For example, in Lampung, Indonesia, forest cover decreased as population increased (Moran, 1994; Fraser, 1998). Human populations growth threaten the maintenance of biodiversity through the destruction of habitats (Food and Agriculture Organization of the United Nations, 2012). Where there are large portions of the population directly dependent on forests for livelihoods, population growth is likely to increase deforestation, in combination with other pressures (Geist and Lambin, 2001; Oliver and Atmore, 2000).

The Pressures of Rainforest Loss

Pressures are human activities that induce environmental change, such as the use of resources and land (EEA, 2007). Pressures are derivatives of drivers and are the direct causes of environmental change. Pressures exist in three forms: excessive use, change in land use, and excretion of waste. Pressures are the result of humans fulfilling a need, e.g. slash-and-burn agriculture practiced for food security or a logging concession sought for national economic security. Agriculture, fishing, hunting, commercial concessions, roads, temporary camps, refugees, and poverty, elaborated in detail below, are some of the most salient pressures occurring in tropical rainforest (de Wasseige et al., 2009; Geist and Lambin, 2002).

Agriculture - Swidden fallow agriculture or "slash-and-burn" is practiced in forests and has been used for many generations in many countries. It consists of slashing forest vegetation and burning the debris. Plots are left fallow in order to regenerate after varying periods of cultivation. Although nation state economies have changed, most forest-dwelling communities in South America still practice slash-and-burn agriculture, growing cassava, bananas, maize, beans, and rice for subsistence (Gari, 2001). Most land clearing in sub-Saharan Africa is for similar subsistence agriculture (Cleaver & Schreiber, 1993). And in India as well, there is a dominance of an agrarian economy, where agriculture sustains the foundation of these populations (Ravindranath et al., 2008). However, economic and population growth are increasing the pressure this traditionally practiced system places on the forest environment (Nye and Greenland, 1961; Geist and Lambin, 2002). A rising populations equates to less available land, which also limit variability among fallow periods thus creating a long-term cycle of

deforestation (FAO, 2001). Therefore, as it stands, this method of feeding communities may not be sustainable with a large increase in population.

Fishing - Aquatic biodiversity found in water bodies is important for the health of these ecosystems and the drinking water that they provide. Fishing is also an important source of food for communities living in forest who have access to lakes and rivers. Fish stocks and bushmeat are interchangeable sources of protein for forest-dwelling communities with access to waterways (Barnes, 2002; Inogwabini, 2014). Fishing has become more attractive as human populations increase and returns on hunting and agroforestry decrease as a result of deforestation (Inogwabini, 2014). In some instances, the use of poison, lack of education, and assumptions perpetuated by untrue practices also play a factor in diminished lake health (Mputu, 2013). Over-use of forest too, especially near riparian areas, can lead to erosion, loss of organic matter, loss of plant nutrients, and generate lower yields (Inogwabini et al., 2014).

Hunting - As commercial hunting increases, communities gain greater access to forests (Forest Monitor, 2006). The access created by commercial hunting and the loss of animals makes it hard for forests to regenerate because changes in predator pray relationships can affects primary productivity. Overhunting impedes seed dispersal and predator-prey relationships; both then alter vegetative makeup of forests (Redford, 1992). Commercial hunters use fire as a tool to clear forests in order to increase visibility, making it easier to kill animals (Afolayan, 1980; FAO, 1997; Martin, 1983). Fire used to clear large and small patches of forestland causes degradation and fragmentation of forests. Greater access allows local communities to increase their use of forests for

subsistence purposes because access equates to increased livelihood security. This is especially true when other factors such as commercial logging are also concomitantly occurring as this perpetuate economic marginalization due to poor fiscal transfers and increased forest dependence.

Commercial Concessions - Forestlands are leased to timber or mining companies as a way to promote sectorial growth and gain economic capital for the nation state. Forest concessions pressure forest communities because economic growth and development are often done without community consent, involvement, or benefit (Det Norske Veritas, 2012). Untold wealth in minerals and other mined natural resources made via concessions are highly centralized. The lack of fiscal decentralization and ability to acquire wealth in these communities has exacerbated conflict and competition for control over forests or other natural resources at many scales (Human Rights Watch, 2005). Concessions are also harmful because they allow communities to easily access new areas of forest for agriculture cultivation instead of allowing the forests to regenerate. This is a short-term benefit with long-term negative repercussions.

Roads - Access to forest resources is greatly increased through the creation of roads from the establishment of a commercial logging post. Roads increase community access to forests where cleared lands make it easy to practice slash-and-burn agriculture. In the Maringa Lopori Wamba Landscape of the Democratic Republic of Congo (DRC), it was determined that 89% of the 1,355 detected forest fire points were located within one kilometer of an existing road (OSFAC, 2007). Roads cause deforestation and the access they create further increases deforestation (Geist & Lambin, 2001). On the other

hand, roads provide access and opportunity; newly cleared lands in a geographically dense forest equate to increased access to food and thereby increase livelihood security. The increased food-security is a short-term benefit because the longer-term impacts of environmental degradation create greater food insecurity for communities.

Temporary Camps - Most people who work for logging companies originally come from outside the area and stay for months to years at a time (Forest Monitor, 2006). Transients or migrants use large-scale capture techniques to get a bigger bang for their buck. Logging camps each have their own modern hunting camp with Western guns and ammunition (de Wasseige et al., 2014). Many of these workers rely almost entirely on bushmeat, whereas locals also consume fish and forest products as well as agricultural products (Rose, 2002). Logging workers turned immigrant hunters use local guides to hunt in forests, supplying locals with guns and other trapping tools. Also, fishing communities are drawing transient populations who contribute to the diminished lake health through the introduction of commercial fishing techniques. Recently, violence over fishing rights was seen in the Equateur province of DRC (BBC, 2009, 2014). These fishermen travel long, far, and thus invest substantial resources in equipment. They tend to fish at higher rates to obtain higher returns on their investments. And, because their exist a culture of "everything that is edible is fair game" (Rose, 2002), when wildlife becomes the edible norm to a point where the pressure pushes species beyond their ecological threshold, there are grave consequences for forest ecosystems.

Refugees - War impacts human populations as it is one of the most significant causes of forced-mass-migration across country borders (Mannion, 2003). Armed

conflicts increase pressure on the natural environment by further threatening species and deteriorating habitats (Essayas, 2010). Refugee camps are established to provide food and shelter for the influx of migrant people. Conflict-driven migration pressures forests because of the resources needed to start over, rebuild, and sustain livelihoods (Biswas & Quiroz, 1996; Mannion, 2003). Refugee camps cause rapid and dire environmental change (Mannion, 2003). The sudden arrival of approximately two million refugees into the DRC created serious economic and environmental problems for the host country (Biswas & Quiroz, 1996). For example, at the end of the Rwandan civil war in 1994, 1.5–2.0 million people were forced to flee, most of them ending up in the DRC (Sato et al., 2000). During this time, the refugee group cut 150km^2 of forest from the DRC's Virunga National Park, just northwest of Rwanda and home to many of the world's only mountain gorillas (Draulans and Van Krunkelsven, 2002). Refugees of the ongoing conflict in the eastern DRC continued to cause an increase in deforestation (Huggins, 2005), while the return of refugees to their land of origin has further driven deforestation by instigating new land claims and by intensifying tension between communities (Vlassenroot, 2013).

Poverty - Recent DRC Minister of Environment José Endundo Bononge believes "the enemy of the forest is its misery and poverty" (Radio Okapi, 2009). Poverty greatly influences forest cover because it creates situations and circumstances where communities are forced to over-exploit their natural resources in order to survive. This is a fundamental explanation of anthropogenic deforestation in African forest communities. Poverty creates a perpetual cycle of deforestation leading to what is defined as a poverty trap (Malcolm X, 1964; World Food Programme, 2014). Farmers cannot afford to let

their lands rest in between planting for fear they will starve. And so, even though soil fertility decreases, subsequently decreasing crop yields, farmers continue to plant. Moreover, poor communities do not have access or technology such as fertilizers, fishing tools, or other extractive resources; thus communities rely on traditional practices and agricultural fields are expanded deeper into the forest to access more fertile soils.

A study conducted by Rudel (1995) used poverty, in addition to capital, as an indicator of deforestation, showing it to be a chain-logical causation. If capital-driven poverty is treated as a variable of nationally-acquired foreign debt (Wibowo and Byron, 1999), and the national government is impoverished, then the constituency state will be too; citing the fallout from the 2015 bank closures in Greece (Blackstone et al., 2015). Thus, is it not surprising that forest-dwelling populations account for some of the highest poverty rates (United Nations, 2013; World Bank, 2000) and that land reforms have rarely worked to the benefit of poor local forest-dwelling communities (Long, 2011). Geist & Lambin (2001) show poverty to be a dangerous driver of deforestation as it creates desperate circumstances for forest dwelling communities. Communities often solely rely on the forest for their entire livelihoods with no governmental assistance. And globally as human activities use resources unsustainably, it creates more poverty because over-exploitation of forestlands leads to diminished ecosystem services for forest-dwelling communities to rely upon.

The Impacts of Rainforest Loss

The effects of rainforest loss are omni-directional, impacting plant, animal, and human health. These impacts are omni-directional because they have local to global

impacts, e.g., local livelihood security and global climate security. Forests are impacted by climate (Malhi et al., 2013) and have impacts on climate (Avissar and Werth, 2005). Other impacts that occur from rainforest loss are alteration of water cycles and losses in biodiversity, discussed further below.

Climate - Changes in global climate dynamics have long regulated forestlands (IPCC, 2014). Changes in global precipitation influence vegetation (Berbet and Costa, 2003) where significant reduction facilitates deforestation (FAO, 2007). Warming in the tropical eastern Pacific has global consequences, particularly for forests. These El Niño events are warm sea-surface temperatures that result in decreased precipitation in the Sahel, particularly in Ghana (Dirmeyer & Shukla, 1994). And La Niña events are known to have cooling effects over the African region, in particular over Mozambique (Bonan, 2008; Williams and Hanan, 2011).

At the same time that global climate change is a driver of forest cover change, deforestation and degradation, particularly in the tropics, have global climate effects. As forest cover decreases, CO_2 in the atmosphere increases (Brovkin et al., 2004). This happens because forests store carbon, sequestering it from the atmosphere. Deforestation causes loss of sequestered carbon and release carbon into the atmosphere as wood decays. A forest cover loss of 17% in the Amazon had a significant impact on rainfall regimes in the region (Chase et al., 1999). Under complete deforestation scenarios, local temperatures could increase locally by 5 °C and rainfall could decline locally by 47%, with the greatest impact during the dry season (Hoare and Rainforest Foundation UK, 2007).

Deforestation contributes largely to decline in the net primary productivity (NPP) variability of tropical forests (Zhao and Running, 2010). The Intergovernmental Panel on Climate Change (IPCC) (2012) showed that, from 1970-2004, deforestation contributed 17.3% of global CO_2 emissions, demonstrating that forest NPP is a major driver of recent increases in atmospheric CO_2. Zhao and Running (2010) cite many researchers who provide evidence that, globally, terrestrial NPP decreased from 2000-2010 and contributed to an increase in atmospheric CO_2. Deforestation causes a loss in local NPP that can impact global climate through teleconnections (Avissar, 1995; Claussen, 2002; Pielke et al., 2002). Teleconnections are anomalies that are connected to each other across large distances. For example, deforestation in Central Africa has far-reaching consequences; impacts on precipitation patterns have been identified as far away as the Midwestern United States (Avissar & Werth, 2005).

Deforestation is affecting precipitation and warming in both global- and micro-climates and the localized effects are poorly understood for tropical forests. Deforestation rates in northern temperate and boreal regions suggest that subsequent surface air temperature cooling has feedbacks that can be seen at the global scale via atmospheric and oceanic responses (Bonan et al., 1992). However, large-scale tropical deforestation has localized feedbacks that reduce precipitation and increase land surface temperatures (DeFries et al., 2002). And so, existing research has been able to quantify the effects of deforestation in temperate climates and at large scales and also at small scales in the Amazon forests, however, the effects of small-scale deforestation happening in the forests of the Congo Basin are not clear (Avissar et al., 2002; Chase et al., 1999).

Deforestation has a significant influence on local microclimate (Brinkmann & Ribeiro, 1971; Chase et al., 1999; Nkem et al., 2008), resulting in less evapotranspiration, rainfall, and warmer temperatures at the local level (Eltahir & Bras, 1994). Berbet and Costa (2003) evidence suggests that the pressures induced within local land-climate interactions that are caused by global change are more significant in regulating forest cover. In other words, local land-climate interactions are more important as forests play a large role in shifting local climate, helping to regulate air temperature and water cycles (Foley et al., 2005).

Water Resources - Deforestation in tropical forests greatly impacts water quantity, quality, and habitats. Forest riparian buffers provide wildlife corridors, stabilize banks, and protect water quality from nonpoint source pollution and excess sedimentation (Correll, 1997). There is significant recycling of water that occurs in rainforests and other moist vegetated habitats (Chase et al., 1999). In the rainforests of Africa, atmospheric moisture content and cycling of water rely more on vegetation contribution in comparison to other tropical forest its size, e.g., the Amazon (Snyder et al, 2004). The Congo Basin Forest recycle 55-90% of its water while the Amazon Forest recycles 15-32% (Gong & Eltahir, 1996). Evapotranspiration in tropical rainforests is significantly reduced when trees are replaced with grasslands or bare soil (Delire et al., 2008; Eltahir & Bras, 1994). Thus, deforestation in the African tropics is likely to have a greater influence on water resources.

Biodiversity - Changes in forest cover have huge effects on biodiversity (Berbet & Costa, 2003; Sala, 2000). Deforestation leads to biodiversity losses such as depletion of

fisheries and reduction of megafauna. It also induces adverse multitrophic effects, for example, land use intensification has adverse effects on many components of the decomposer food web where changing conditions can alter the competitive balance to favor one species over another (Tylianakis et al., 2008). Scholars such as Donald (2006), Green (2005), and Tilman (2001) state that expansion and intensification of agriculture in forests is the greatest threat to biodiversity, due to the loss of forest habitat. Oil palm plantations, for instance, have fewer than half the vertebrate species of primary forests and lower species richness in comparison to logged secondary growth forests (Fitzherbert et al., 2008). Reduced biodiversity adversely impacts public health and local livelihoods and can potentially impact the diversity of human communities from the loss of food security.

Human – Forests provide essential ecosystem services for humans such as health and social services, disease regulation, livelihood support through the provision of local jobs, water through watershed protection, water flow regulation and precipitation generation, food through non-timber forest products (NTFPs), nutrient cycling, and climate security, to name several (MEA, 2005). Deforestation and its omni-directional impacts will disproportionately affect the poor and geographically vulnerable populations as the world moves toward a more populated planet by 2050 (Malthus, 1998; McMichael et al., 1998; Garg, 2014; Ngonghala et al., 2014). Deforestation increases the vulnerability and thus the impacts felt by natural resource-dependent communities through various primary (environmental) and secondary (sociocultural) effects (Adger et al., 2002; Bonan, 2008; Eastaught, 2008; IPCC, 2008). There are approximately 1.6

billion people worldwide who depend on forests for their livelihoods (World Bank, 2008). These populations are vulnerable because of historical and contemporary problems – such as exploitation, marginalization, and invalidation of local knowledge – that are linked to natural resource mismanagement that increases deforestation (Brown, 2009).

Deforestation causes food insecurity that can lead to malnutrition and even starvation (World Food Programme, 2014). Populations that rely on forests for their livelihoods are the most adversely impacted by the loss of ecosystem services. For instance, the increase in atmospheric CO_2 caused by deforestation affects all areas of the globe. Altered climate systems are likely to exacerbate existing conditions, further diminishing ecosystem services (Chapin et al., 2000; IPCC, 2012; Nkem et al., 2013) and potentially creating an influx of climate refugees (Biswas & Quiroz, 1996; Sato, 2000; Nkem et al., 2008; Refugee Studies Centre, 2008).

Human activity such as agriculture and other forest pressures magnify the impacts of these changes through loss of flood buffers and increased erosion (Thompson et al., 2012). The UN Office for the Coordination of Humanitarian Affairs reported that the number of natural disasters such as hurricanes, cyclones, droughts, and floods have increased due to more frequent extreme weather events. As a result of deforestation, large-scale mudslides in Honduras after Hurricane Mitch in 1998 were magnified because of pressures humans placed on the environment. There were close to 11,000 deaths, over 11,000 missing, and 2.7 million homeless and displaced people, making it the deadliest hurricane in the Western Hemisphere in 200 years (History, 2009). In the 1990s, there

was over $600 billion in calculated losses from natural disasters (Abramovitz, 2001). Hurricane Michael cost more than the national incomes of both Honduras and Nicaragua, the two most impacted countries, combined (Thompson et al., 2012).

The Response to Rainforest Loss

Forests are under constant pressure from high levels of resource extraction, changing population dynamics, and changes in climate. Forest policy and management must be highly dynamic; for example, carbon cycling and climate change have become more relevant in the last 10 years, just as sustainable forest management has captured much attention (von Gadow et al., 2000; Aguirre at al., 2012). However, managers cannot forego addressing human dimensions of forest management in order to preserve biological integrity, or vice-versa. Sustainable forest management must include a diversity of disciplines and of stakeholders who come from various backgrounds to produce a multi-functional and holistic approach (von Gadow et al., 2000; Agurrie et al., 2012). The following section outlines ongoing management strategies and innovative approaches to forest management and highlights lessons learned.

Protected Areas

The International Union for the Conservation of Nature (IUCN) defines protected areas (PAs) as locations that receive legal protection because of their biological and or cultural value. PAs are created to help safeguard natural habitats, biodiversity, and resources for human populations. They can be critical tools to conserve biodiversity, provide for life's essentials, buffer rain runoff from waterways, and serve as economic engines. For example, 33 of the world's largest 105 cities obtain a significant portion of

their drinking water from PAs (Secretariat of the Convention on Biological Diversity, 2008). Currently, PAs comprise 11.5% of the Earth's terrestrial surface (Essayas, 2010; IUCN, 2004). In the Amazon, protected areas cover 44% of forests (Verissimo et al., 2011).

Despite 30 years of acknowledging that people should be included in protected areas, there is still much debate within the conservation community surrounding the impact of these protected areas on rural communities (IUCN, 2004; Tallis et al., 2008; Verissimo et al., 2011). There are both strict protected areas, allowing only conservation-related use, and multiple use protected areas. In India, for example, 15.6 million hectares of forestlands have been established as PAs where all human intervention and activities are banned (Indian Institute of Forest Management, 2013; ITTO, 2005). In Central Africa, protected areas inclusive of human activities have proven to have success (de Wasseige et al., 2009).

Many PAs do not meet their objectives because of improper management or lack of resources (Oates, 1999). Another limitation of PAs in being an effective management tools is the existence of paper parks. Paper parks receive little to no resources for implementation, making them exist only in theory and not in practice (Bonham et al., 2008; Bruner, 2001; Cifuentes et al., 2000; IUCN, 2004). However, protected areas have increased the validity through the practice and implementation of policy focused on multiple use approaches (Nelson & Chomitz, 2011). Multiple use approaches to PAs support local populations and their livelihoods while also contributing to the conservation of ecosystem services on larger scales. IUCN World Parks Congress recommended that

PAs "should not exist as an island, divorced from social, cultural and economic context in which they are located," because if they are not developed with strategies addressing the rights and needs of the local people they will face an increasing threat of failure (Barrow & Fabricius, 2002; Dudley et al., 1999). For example, conserving forest in protected areas, yet allowing deforestation in the surrounding area, alters climate, such as rainfall patterns, within the PAs (Roy et al., 2005). Therefore, this demonstrates it is difficult to compartmentalize the forest environment and the entire forest must be protected.

Afforestation and Reforestation

Affectation is the establishment of forests where there was previously no forests. Afforestation increases the canopy cover or carbon density of the forest (Watson et al., 2000). Afforestation has also been proven successful in its ability to replenish diminished ecosystem services (Shames, et al., 2012). Afforestation has been used to combat deforestation in Africa for many years (FAO, 1989; Arora & Montenegro, 2011; Shames et al., 2011). In South Africa, afforestation projects have been said to economically benefit the country because they uplift impoverished communities, and positively impacts biodiversity and water resources (Mkwalo, 2011). Xue and Shukla (1996) ran a computationally simplified vegetation model that correlated with other cited models to show increases in environmental variables such as precipitation and soil moisture occur with afforestation.

Reforestation is the intentional replanting of trees in forests. Forest regeneration helps combat the effects of climate change, increases carbon storage, and provides watershed protection, habitats for wildlife, and shade for homes. Globally, governments

are participating in reforestation projects. Across the United States, the U.S. Forest Service (USFS) is heavily engaged in reforestation efforts. Every year the USFS plants trees on thousands of acres of land from Maine to Hawaii (Westover, 2011). Reforestation is required in Germany as a part of the federal forest laws (German Government, 2006). In India, it has been reported that the forest sector is a marginal source of net CO_2 emissions; however, the country still set a goal of bringing one-third of the geographical area under forest cover by 2012 (Ravindranath et al., 2008). In China, some replanting programs have proven to be successful in increasing forested land area, including the Natural Forest Conservation Program (Zhang, 2000). However, projects such as the Green Wall of China have had limited success, likely because Northern China is not suitable for extensive tree planting (Jiang, 2009; Watts & zorrespondent, 2009).

Developing countries struggle even more and have limitations because forest density, making travel conditions hard, dissemination of data is often limited, existing knowledge and information is not used effectively by stakeholders, and other knowledge gaps and deficiencies make effective monitoring and management difficult (Blaser, 2009). A report released by the African Carbon Forum in 2011 highlighted challenges to afforestation and reforestation in developing countries as being regulatory, finance, capacity and land tenure issues (World Bank, 2011). However, it is important to point out that these barriers have not impeded the establishment of these projects.

Reforestation projects are on the rise in Africa, proving to increase climate resilience and improve local livelihoods. For example, Humbo community farmers in Ethiopia conducted the first large-scale forestry Clean Development Mechanism (CDM)

project in Africa to be registered with the United Nations Framework Convention on Climate Change (UNFCCC) (Shames et al., 2011). The project is located in the Ethiopian Rift Valley and is estimated to remove 880,000 metric tons of CO_2 from the atmosphere over the 30-year crediting period. In the DRC, the Ibi Batéké reforestation project is set to absorb close to 1.6 million tons of CO^2 from 2008 – 2037 (World Bank, 2011).

Paradigm Shift

The "timber above all else" primacy or Wake theory is the idea that timber production does not impede other forest functions. This theory began to shift to an ecosystem-based paradigm during the late 1980s early 1990s (von Gadow et al., 2000). A supply and demand study was conducted on the context of this paradigm shift (Solberg et al., 1996). The conclusions of this study show that the demand and supply for wood does not raise warnings or red flags regarding supplying the demand. However, the same study demonstrates global projections show a steady demand for wood and wood products and also for forest services, e.g., climate sequestration. Sample et al. (1993) highlight how the practice of forestry underwent a profound and rapid change. Only more recently have non-wood goods and services seen as important globally (von Gadow et al., 2000; UNMEA, 2005).

Sustainable Forest Management

Despite all the progress made with regard to forest management, there are so many competing demands for forests and forest resources that their sustainability is in question. In order to sustain forests for competing demands of goods and services, multi-disciplinary and holistic approaches need to be the basis for managing forest as one

ecological unit with multiple resources and benefactors (von Gadow et al., 2000; Sharma & Rowe, 1992; Aguirre et al., 2012; Evans, 2012). The UN Food and Agricultural Organization (FAO) broadly defines sustainable forest management as "…the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems." Sustainable forest management (SFM) seeks to maintain balance between the ecosystem perspective, sociocultural and political perspectives, and resources by managing forests according to the needs of the plant, animal, and human populations directly reliant on them. In 2008, the United Nations (UN) and a multi-donor trust fund launched the reducing emissions from deforestation and degradation (REDD) in developing countries – a program to combat climate change from deforestation. In 2010, REDD became REDD+ by including points on development in human communities focused on conservation, enhancement, and sustainable management.

REDD+ is a market strategy that provides financial incentives to reduce greenhouse gas emissions by making forests' role in climate mitigation as lucrative as destructive uses (Parker et al., 2008). REDD+ is now considered the best strategy for sustainably managing forests for all its many competing demands (Parker et al., 2008; Phelps et al., 2012). REDD+ goes beyond protecting against deforestation, forest degradation, and climate change mitigation; it has the potential to contribute to poverty alleviation, and to sustain biodiversity and ecosystem vitality (Advisory Group on

Finance Collaborative Partnership on Forests, 2012). The decisions that came out of Conference of Parties (COP) 19 in Warsaw in 2013 still contain no concrete decisions on explicit requirements for implementing parties of REDD+ to address drivers and they provide little information to clarify sources of financing (Climate Law & Policy, 2014).

The Sustainable Forest Management Challenge

There are many laws and policies that attempt to manage the world's forests, each possessing their own set of strengths and weaknesses. Policies are often not actualized or are diluted by the time they reach local-scale implementation. This poses a huge political question: why are policies created to be beneficial for individuals living in forested communities not reaching their targeted audience? Established global agreements have not reached the individual or national levels regarding the best approaches for managing forests that balances conservation and development (Sharma & Rowe, 1992; Naughton-Treves et al., 2005; Porter-Bolland et al., 2012). Although these myriad policies have attempted to accomplish sustainable forest management, historically they have not addressed forest management from a holistic point of view and they have not been tailored to meet the needs of local populations (Sharma & Rowe, 1992; von Gadow et al., 2000; Gough et al., 2008; Carr et al., 2009; Essayas, 2010).

Forests are a common good and all stakeholders benefiting from the services and goods that forests provide should have the ability and the platform to partake in the conservation on their forests. Currently, the way policies and management strategies are set up, not all users currently have a voice and not all voices produce equal reciprocal actions. More successful policies attempt to include local, national, global, and traditional

ideals (Naughton-Treves et al., 2005; Nelson & Chomitz, 2011). However, in many instances, there still exist government decisions that promote deforestation (Burgess et al., 2012; Evans, 2012; Sharma & Rowe, 1992). For example, governments through means such as concession policies and royalty systems directly control price and thus demand for tropical forest products via exchange rate policies, taxes or no-tax trade barriers, and other forms of price control (Burgess et al., 2012; Moran, 1994).

A global analysis on drivers of tropical deforestation by Geist and Lambin (2002) revealed that national to global scale policy and economic factors are driving local-proximate level factors such as agricultural expansion and wood extraction that cause deforestation. Still, managers are not clear on what drivers are, what pressures are, and how they are connected for local cases. Thus from this study, analysis reveal there is no universal policy for controlling tropical deforestation. Rather, their finding showed a great need for detailed local-level information on the complex set of proximate causes and underlying drivers in any given location prior to any policy intervention.

Problem Statement

Deforestation in the Congo Basin is altering the natural functioning and services of the ecosystem and adversely impacting highly vulnerable human populations who rely on their proper functioning. Deforestation and climate change work together in a positive feedback loop such that altered climate systems exacerbate existing land cover conditions thus further diminishing ecosystem services, for example climate stability (Chapin et al., 2000; IPCC, 2012; Nkem et al., 2013). Alteration of ecosystem services provided by

forests is adversely impacting highly vulnerable human populations who rely on their proper functioning for their livelihoods (Inogwabini et al., 2006).

Reducing forest loss helps to address climate change and also helps ensure the provision of essential ecosystem services beyond carbon storage and sequestration. Ecosystem services, such as food provisions, are needed for sustaining healthy livelihoods in forested communities. Forest managers have been using REDD+ strategies to reduce deforestation and its impacts. But, without a framework that clearly outlines the problem and attempted solutions, it is difficult to evaluate the effectiveness, or harm, associated with current management strategies in responding to deforestation at the various scales.

The Driver-Pressure-State-Impact-Response (DPSIR) framework provides an opportunity for examining causal factors and resulting of omni-directional impacts of deforestation. Such a framework allows for holistically organizing, disseminating, and assessing all forest dynamics and monitoring and evaluating existing sustainable forest management practices that respond to the driver's impacts of deforestation. In summary, the problem is a lack of a framework for holistically understanding the most salient causes of forest loss, the impacts resulting from an altered state, and the effectiveness of current management responses are unknown for these forests.

The purpose of this transdisciplinary mixed methods study is to determine the most salient indirect and direct causes of forest loss, the impacts resulting from an altered state, and the effectiveness of current management responses in the Democratic Republic of Congo. By using the DPSIR framework, I will be able to convey the integrated drivers,

pressures, state, impacts, and responses to deforestation in order to make recommendations for improved and additional sustainable forest management strategies at various implementation scales. Therefore, I propose five sub-questions (see Table 1) that will help to answer my overall research question, what are the ecological and sociocultural causes and effects of forests cover lost in the DRC?

Table 1: Sub-research questions, associated prediction of findings, and data sources gathered and used for analysis

What are the ecological and sociocultural causes and effects of forest cover lost in the Democratic Republic of Congo?

	Sub-Questions	Hypothesis	Data
State of forests	1. To what extent is deforestation happening?	Forests shrank in the study area from the 1986 to 2010.	1) Literature review 2) Satellite images 3) Ground observations 4) Survey questionnaires
Drivers and pressures causing deforestation	2. What are the main drivers and pressures of deforestation?	The following pressures cause deforestation around Lake's Mai Ndombe and Tumba are most salient: (1) slash-and-burn agriculture, ease of transportation: (2) waterways, (3) roads, (4) poverty, and (5) overfishing, (6) forest concessions, (7) conflict, and (8) transient camps. The following drivers cause deforestation: (1) political and institutional factors,	1) Literature review 2) Survey questionnaires

		(2) economic factors, (3) technological factors, (4) demographic factors, and (5) cultural factors	
Impacts of deforestation	3. How is deforestation adversely impacting ecosystem services and indirectly changing livelihoods?	Goods and services provided by forest ecosystems are diminishing due to deforestation. This result in adverse impacts on the livelihoods of forest dwelling populations.	1) Literature review 2) Survey questionnaires 3) Weather trend
Responses to local deforestation	4. How effective are current management strategies at this study site at responding to drivers, pressures and impacts of deforestation?	Management is not completely effective because of the absence of a systematic framework such as DPSIR.	1) Literature review 2) Survey questionnaires
DPSIR responses to environmental change	5. How useful is DPSIR in communicating complex forest dynamics and what are some recommendations from its use?	Using DPSIR to include all stakeholders' perspectives allows for improved forest management that better addresses the problem of environmental changes.	1) Literature review 2) Survey questionnaires 3) Weather data

Methods

The Lake Télé-Lake Tumba Landscape of the Congo Basin is the location of the case study. There are sustainable forest management strategies currently being implemented there to combat deforestation for climate and livelihood security. To answer these sub-questions I collected both qualitative and quantitative data and used methodologies and analysis techniques from disciplines such as geography, political science, history, economics, and ecology.

In order to test hypothesis 1 regarding net forest loss over the period of 1986-2010, annual land cover images were gathered from various geological databases (Table 1). Remote sensing technology was used to analyze images of the study area from 1986 and 2010 in order to measure changes in forest cover.

In order to test hypothesis 2 regarding the most salient drivers and pressures of deforestation at both study sites, local population surveys were conducted with questions addressing various aspects of the DPSIR framework. Local population interviews were analyzed in conjunction with key informant stakeholder interviews and existing literature.

In order to test hypothesis 3 regarding diminishing of goods, services, and altered livelihoods as a result of deforestation in the study area, the literature review, local population and key informant survey data, and environmental data were used. Environmental data consists of lake water levels, precipitation, air temperature, and humidity rates that were collected daily.

In order to test hypothesis 4 regarding effectiveness of on-going management strategies in addressing various aspects of deforestation, survey data from key informant and local populations stakeholders were compared to national and international REDD+

goals and objectives. Management responses to DPSIR were assessed for effectiveness based on data taken from local population surveys.

In order to test hypothesis 5 regarding how current management can better respond to deforestation, all previously mentioned data were used to determine if DPSIR is an effective tool for analyzing and disseminating complex forest management information, why or why not, and to provide some recommendations that will address gaps in on-going management that can improve response to various aspects of deforestation outlined by this framework.

Analysis

This research aims to explore the phenomenon of deforestation through qualitative and quantitative collected data. Data collected and analyzed using mixed methods to encourage the use of multiple worldviews. Because this work will use both qualitative and quantitative data, the multiple studies approach to mixed methods will be used (Creswell and Clark, 2007). The multiple studies approach works such that a quantitative study with reported results will inform a qualitative study with reported results and vice versa. The linking of data from distinct components of mixed methods in order to draw more well-rounded conclusions is called triangulation. Local population, managerial population, environmental trends, and literature reviews were comparatively analyzed using triangulation. Better conclusions are drawn from the combination of methodologies in the study of the same phenomenon.

Results

These findings will offer insight into the effectiveness, or lack thereof, of ongoing forest management strategies. By using the DPSIR framework to outline challenges, advancements, and lessons learned I hope to provide results that can be extrapolated and applied to the entire Congo Basin and possibly other tropical rainforests. Therefore, the purpose of the study is to produce recommendations for applied and operational sustainable management of the Congo Forest in ways not previously discussed in literature.

Dissertation Outline

Chapter 2 will discuss trends in forest cover within the Lake Télé-Lake Tumba Landscape. Satellite images will be presented to study small-scale forest loss. This geographical analysis will provide a baseline for studying change over time. Most importantly, this chapter seeks to analyze satellite images to confirm that forest loss is occurring by using multiple sources of data. It will provide a more complete and detailed picture of the changing state of these forests.

Chapter 3 will discuss the most salient causes of deforestation in the landscape. Local communities survey responses will help determine which pressures discussed in the literature are most persistent on the ground. Surveys also capture information on drivers, impacts, and local community adaptations made as a result of forest loss. Environmental change conversations, especially regarding deforestation, have operated at high political levels, often negating and excluding local contributions. I will provide a more holistic picture through narrative that highlights the need for all stakeholders to be

included in the various levels of rhetoric and thought in discussing how to best proceed in sustainably managing forest.

Chapter 4 will discuss the most important ecological and human impacts occurring because of the mosaic of deforestation happening in the landscape. Deforestation is often discussed as a problem of slash-and-burn agriculture without an understanding of why, and climate change is often discussed as something far away and a problem for future generations without realizing that climate change is an issue of the now. Without garnering or hedging local inputs into global models, discussions continue to remain at high levels and local impacts on human communities and climate system remain unknown. Because of this, multiple sources of data have been collected and used to determine ecological health of the landscape. Local response and adaptation trend data can fit into larger-scaled discussions in order to better assess the impacts of deforestation at the local scale.

Chapter 5 will discuss the effectiveness of existing policies and management strategies in meeting sustainable forest management goals and objectives. There is much confusion with regards to identifying drivers and pressures of deforestation. Often times in literature, rhetoric, and thought, drivers are mistaken for pressures and vice versa. Because of the incorrect classifications of these categories, citizens, policy makers, and scientist have not been able to effectively manage forests due to a lack of crossing disciplines. Also, because of this confusion, transparency is often lacking as well. All stakeholder voices play a role in monitoring and evaluating of current management. By

introducing equity in participation, accountability can be garnered and transparency can increase.

Chapter 6 will discuss the effectiveness of DPSIR as a tool for organizing, communicating and disseminating forest management information. Managers do not currently use a holistic framework such as DPSIR, making it extremely difficult to manage for the problems associated with structural forest loss, ecological function degradation, and human health degradation. Misclassification or ignoring categories of DPSIR has led to shortsighted policies. Also, knowledge can exist in a vacuum with limitations placed on how it is distributed, who can distribute it, and its validity. DPSIR is an inclusive problem-structuring mechanism that addresses the multitude of issues at various scales that surround deforestation. It can be extrapolated and applied to other locales experiencing similar ecological changes.

CHAPTER 2: DEFORESTATION AMONG RIPARIAN LAKE COMMUNITIES IN NORTHWESTERN DEMOCRATIC REPUBLIC OF CONGO

Background

Forests are being destroyed at alarming rates across the world. Globally, 13 million hectares of forests were converted or lost annually from 2000 to 2010 (FAO, 2010; Hansen et al., 2013a). Remote sensing has been used to quantify forests and their attributes for more than 70 years (Carneggie and Lauer, 1966; Knippling, 1970; Bwangoy et al., 2010; Potapov et al., 2012). For example, forest quantification has been used to determine agricultural patterns (Aldrich, 1968; Xia et al., 2014), wildlife management (Croon et al., 1968; Carneggie, 1970; de Wasseige et al., 2009), soil management (Baumgardner et al., 1969; Luney and Dill, 1970), and for detecting forest fires (Parker and Wolff, 1965; de Wasseige et al., 2012). The forest of the Congo Basin Forest is the world's second largest tropical rainforest. However, it has been sparsely researched in relation to its size and importance (Malhi et al., 2013; Bwangoy et al., 2010); most studies on forests have been conducted in the Amazon, Southeast Asia, the Boreal zone, or, primarily, the world's temperate forests.

The Congo Basin has experienced 2-3% forest cover loss per decade over the past 25-30 years (Duveiller et al., 2008; Hansen et al., 2013; Ernst et al., 2013; Tyukavina et al., 2013). The combination of modern technological and development pressures and increasing subsistence agricultural practices has led to extensive clearing of primary

forests (Bwangoy et al., 2013). Bandundu and Equateur Provinces, the third and fourth largest provinces in the Democratic Republic of Congo, have experienced 2.4% and 2.3% forest loss respectively from 2000 to 2010 (OSFAC, 2010). Deforestation for these two provinces is high in the absolute sense within the country, even though the deforestation rates presented above are relatively low in comparison to other rainforests. These forests are at risk for increasingly rapid deforestation in the future because of high population density and limited amount of exploitable non-forested land. This raises fear for food supply (de Wasseige et al., 2009; Dirmeyer et al., 2014).

This paper focuses on the Lake Télé-Lake Tumba Landscape in these provinces to better understand (1) to what extent deforestation within the landscape is detectable by satellite; (2) which communities are experiencing high, moderate, or low amounts of deforestation; and (3) to what extent is deforestation occurring within the landscape detectable by local communities.

State of DRC Forests

Sixty-seven percent of the land cover in the Democratic Republic of Congo (DRC) is forest. The forests of the Congo Basin are composed of a variety of ecosystems, such as deltas, dense evergreen forest, and wetlands. These forests contain some of the richest concentrations of terrestrial biodiversity in the world (de Wasseige et al., 2010). The region is home to over 10,000 plant species, 80% of which are endemic; 1,000 bird species, 36% of which are endemic and 16% threatened; and approximately 400 mammal species, with twenty-three species considered threatened or endangered - including the western, eastern, and mountain gorillas, the common chimpanzee, the pygmy chimpanzee

(also known as the bonobo), and the forest elephant. These forests and the resources they provide support over 40 million people in DRC alone and 75 million across the Congo Basin.

Study Area

The Lake Télé-Lake Tumba Landscape (LTLT) (Figure 1) is the world's largest swamp forest and the largest wetland in Africa (Seyler et al., 2010). Located in the heart of the Congo Forest, the LTLT Landscape covers a 126,000 km^2 spread between eastern Republic of Congo and northwestern DRC (de Wasseige et al., 2010). The vegetation in the area is broken down into four categories, where inundatable forest accounts for 58.3%, dense forest accounts for 31.2%, forest-cultivation mosaic accounts for 2.8%, savannahs account for 3.1% and the remaining 5.9% is water (OSFAC, 2010). There are three lakes within this landscape: Lake Télé, located in the Republic of Congo; and Lakes Tumba and Mai Ndombe, located in the DRC. In 2007, the area between Lake Tumba, the Ngiri River, and Lake Mai-Ndombe was named the world's largest wetland of international importance established by the Ramsar Convention. It also comprises the largest freshwater mass in Africa. The 65,696 km^2 area of the DRC side is also the largest uninterrupted Ramsar site in the world (de Wasseige et al., 2012).

The LTLT forests support a high diversity of animals and people. There are many species of megafauna that can be found in the landscape. Between Lake Mai Ndombe and the Lokoro River, approximately 120 fish species, the Allen swamp monkey, the Congo clawless otter, the giant otter shrew, several kingfisher species, and brown semi-aquatic snakes have been recorded (Seyler et al., 2010). In DRC, there are approximately 250

ethnic groups speaking over 700 languages (International Rescue Committee, 2006). The populations living on the DRC side of LTLT are ethnically diverse and unevenly distributed. The Mongo group, also known as the Bantu, is the majority group, and they cohabitate with the minority Twa group. The majority of people from all ethnic backgrounds base their livelihoods on forest resources, receiving their dietary protein from forests and waterways (de Wasseige et al., 2009; Inogwabini, 2014). Although the majority of the population in the landscape is clustered around the provincial seat of Mbandaka, there are also varying amounts of deforestation happening around the lakes within the landscape that need to be further investigated.

Materials and Methods

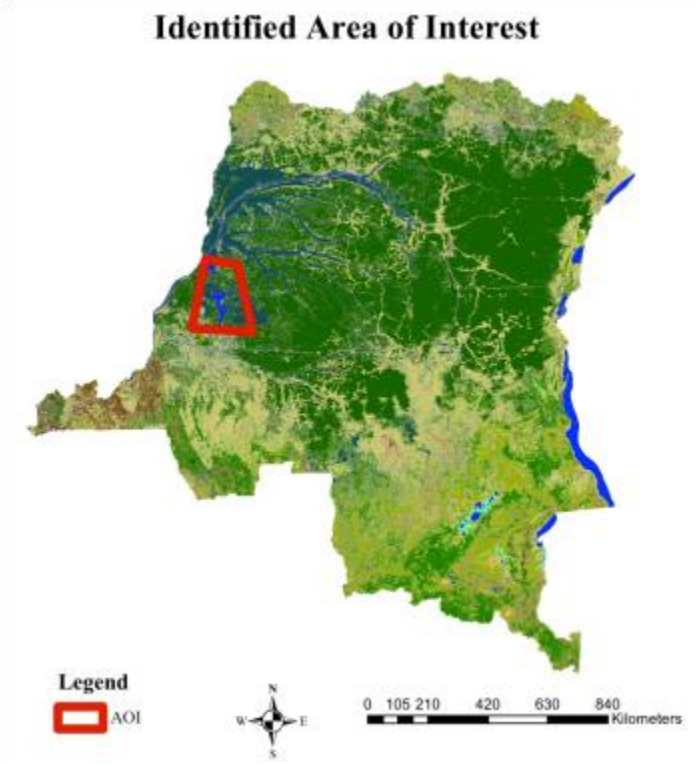

Figure 1: The Lake Tele-Lake Tumba Landscape

Study Site

The bowl-shaped depression represented in present day DRC and the Republic of Congo makes up the low-lying central part of the Congo Basin, also known as the Cuvette Centrale is the study site for this research (Bwangoy et al., 2010). The Cuvette Centrale is a shallow lake basin that gradually filled with sediment over the years, forming a shallower basin with limited topographical variation and traversed by slowly flowing rivers (Kadima et al., 2011). This area of 1,176,00 km^2 may have originated from a late Proterozoic failed rift and a subsequent relaxation punctuated by two regional deformational episodes, which result from the North-West to South-East contraction (Dally et al., 1992; de Wit et al., 2015). As a result, wetlands dominate, making up 56% of the landscape (Bwangoy et al., 2010). This deformation also resulted in the very low-lying southwestern part of the basin with Lake Tumba, Lake Télé, and Lake Mai-Ndombe as residual lakes.

This area is considered important because the vegetation regulates water and controls downstream flooding. The buffer zone helps to filter water, serve as a carbon sink, and act as a breeding ground for fish spawning during lake pulsing events. In 2010, this area was cited as poorly studied (Bangwoy et al., 2010) due to the lack of its mention in global vegetation maps (Campbell, 2005), despite being acknowledged as a priority conservation site in 2000 (Inogwabini, 2007). In present day, this region is being discussed more frequently, with Lake Mai Ndombe designated as a freshwater area of highest priority (Toham, 2006: de Wasseige et al., 2015). However, in the LTLT

Landscape, biodiversity is still relatively unknown outside of timber inventories (Wildlife Works, 2012).

These lakes are very shallow; Lake Tumba's maximum depth does not exceed 8m and Lake Mai Ndombe has an average depth of 3m (Wildlife Works, 2012). Slopes are more pronounced around Lake Mai Ndombe, where most input is determined by the in-flow of water. Lake Tumba is located directly below the Congo River, is 765 km in size, and is fed by five major rivers and flows indirectly into the Congo River via the Irebu channel. Lake Mai Ndombe, meaning "Lake Water Black", is much larger than Lake Tumba at 2,300 km^2 is fed by many rivers and flows into the Congo River via the Mfimi and Kasai Rivers. Bolong'Onsongo, Bolong'Olule, Lokoro, Lotoy and Lobeke are among the most important tributaries. Both lakes are considered to be black water lakes, meaning they are humic, acidic, chemically poor, and loaded with detritus of plant matter (de Wasseige et al., 2014). The brown–color of the water comes from tannins, originating from decomposing organic matter, phenolic acids, and lack of clay particles in the soil that would otherwise absorb these dark humic materials.

Climate in the study area is described by Bultot (1974) and Samba (2008) as warm and humid. There are two wet and two dry seasons, a major rainy season from September to December, and a minor rainy season from February to May. Temperatures are ~25°C year-round. At Lake Mai Ndombe, the rainy season occurs during October and November and has a maximum monthly rainfall average of 225mm, documented in October (Hughes and Hughes, 1992). The dry season occurs from June to August with a minimum monthly average rainfall of 10-50mm in July. Lake Tumba experiences a small

flood from May to June and a large flood from September to January. Bultot recorded a 2°C difference between the hottest month, March, and the coldest month, July. Average rainfall was approximately 1800mm annually with 115 days of rain. Climate in these forests, along with other ecological properties such as abundant animals contributes to forest dwelling communities' health and income.

A participatory rural appraisal (PRA) was conducted in communities surrounding Lake Mai Ndombe (Wildlife Works, 2012). Wildlife Works PRA findings show 89% of those surveyed reported salaries have steadily been in decline. Selling cassava bread is the only source of income outside of seasonal fish sales that were mostly small-scale and made during the dry season. The findings also show that between 85 and 95% of people living in the area had access to education but the quality was severely lacking. Schools were made up of tree branch structures; class sizes were large with an average of 80 children, and it was not uncommon to find 18-year-old primary school students and 30-year-old secondary school students. Teachers were largely under qualified and under paid, a status perpetuated by the low level and low quality of public services.

Health care is only accessible in Lokanga at the Ngongo Secondary Hospital and the General Hospital located in Inongo. The Ngongo secondary hospital has a medical doctor who also serves as the western Lake Mai Ndombe Health Zone Commissioner. The Lokanga secondary hospital has two nurses who perform basic surgery, commonly for appendicitis and hernias. In Inongo, there are four medical doctors on duty; one serves as the western Inongo territory Health Commissioner (Wildlife Works, 2012). These

three health facilities operate in very old and collapsing buildings, and they lack basic equipment and medication for patient care.

Analysis of Forest Cover Change

Landsat data have been available since 1975 and are well suited to map forest cover and change in the Congo Basin (Hansen et al., 2008; de Wasseige et al., 2009). Landsat provides a high enough resolution to detect the small-scale changes characteristic of those occurring in the Congo Basin. Forest cover and forest cover loss data are available circa 1990 for the entire Congo Basin. Hansen (2008), Lindquist (2008), and Potapov (2012) conducted a complete quantification of forest cover and loss per decade in the Democratic Republic of Congo from 2000 to 2010 derived from Landsat and MODIS satellite data for which I used to determine forest loss within the delineated study area.

FACET Landsat Images

The Observatoire Satellital des forêts d'Afrique Centrale (OSFAC) in collaboration with the University of Maryland, produced maps of changes in forest cover in Central Africa in 2012 under the name of FACET where detailed methods are highlighted in Potapov (2012). FACET is a comprehensive, high-resolution (60m) map of forest cover loss for the entire Congo Basin created using 8,881 30m resolution Landsat EMT+ images for three time periods. The best available pixels were selected to create composites for 2000, 2005, and 2010 and mosaicked for the entire country. After combining the images into a mosaic, two 60m cloud-free images of forest change were produced, one from 2000 to 2005 and one from 2005 to 2010. Each image was a

classified map of forest cover for the entire DRC. To assess change, a training model was used to train the detection of each classification. FACET used the Decision Tree Approach for the wall-to-wall methodology (OSFAC, 2010). Decision Tree classified images as primary and secondary forests as well as forest and non-forest. The same was done for change and non-change. Using the results for change classes, a final mosaic was produced for all classes: primary, secondary, and woodland. Woodlands are not used for practicing slash-and-burn therefore this study will only focus on primary and secondary classes.

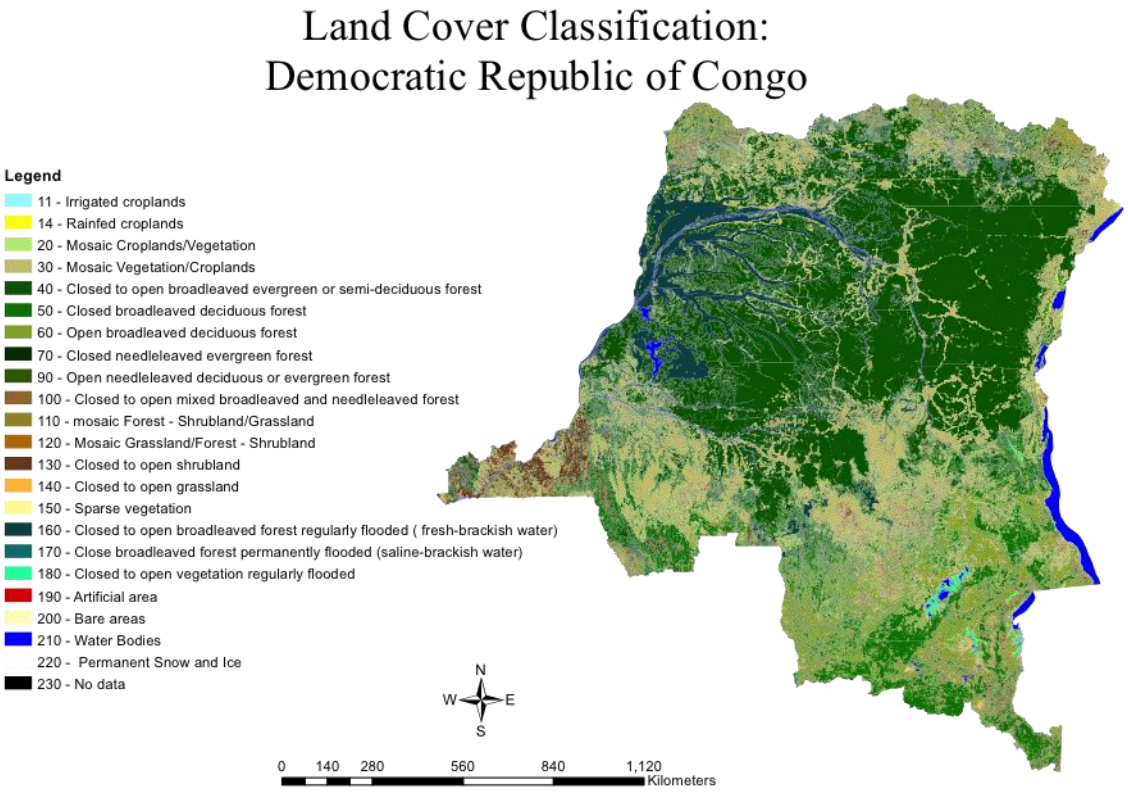

Figure 2: Classification map of DRC delineating 23 types of land cover

Remotely Sensed Landsat Images

In order to determine to what extent deforestation was occurring I used the U.S. Geological Survey database to locate the best possible cloud-free image of the study area at an earlier time. From this search, one 1986 Landsat image of the study area was found with comparable parameters to the Landsat data used by OSFAC to quantify forest loss in DRC. Satellite imagery of the landscape in 1986 was downloaded from the U.S. Geological Survey's Earth Explorer website. This image was consistent with previously acquired Landsat images. This older image was used to show forest cover prior to 2000. This image acted as the baseline image of forest cover for this study. The data elevation model used for the analysis is GTOPO30, also downloaded from Earth Explorer (downloaded March 2013).

Forest cover change was assessed for the LTLT landscape. Trends in forest cover loss from 1990 to 2000 were quantified by using data analyzed by South Dakota State University, and the University of Maryland College Park, in cooperation with the United States Agency for International Development (USAID) Central Africa Regional Program for the Environment (CARPE), and NASA as presented in the 2010 State of the Forest Report. FACET data were downloaded from the CARPE website[1] using the Mapper tool. ArcGIS 10.1 software was used to digitally categorize images from the FACET Data from 2000, 2005, and 2010. These images were then compared to determine the amount of deforestation within the study area only, by using changes in the amount of land cover for each five-year period.

[1] http://congo.iluci.org/carpemapper/

First, land cover change from 2000 to 2005 and from 2005 to 2010 was determined digitally using categorized maps converted from raster to vector format (Figure 2). A "change" attribute was applied to their attribute tables, and zonal statistic tools were used to determine where they differed. The satellite image of forest cover in the study area from 1986 was analyzed visually by overlaying images to determine forest regression. It was compared to the 2010 data to show forest loss. A visual comparison was done because the 1986 satellite image could not be classified (Figure 3). Using the digital elevation model (DEM), aspect, slope, and hill shade data were extracted for the study AOI. To perform this, the DEM was clipped from the study AOI polygon and the aspect, slope extremes, and hill extremes were calculated for the study AOI.

Second, ArcGIS was used to determine areas experiencing high, moderate, and low amounts of primary and secondary deforestation. This was done by creating a ratio formula in hectares within ArcGIS to identify areas of deforestation within the study area from 2000-2010. The original raster image was converted to a shape file polygon. The primary forests 2000-2005 dataset was merged with the 2005-2010 dataset, creating one fluid dataset from 2000-2010; the same was done for secondary forests. The spatial analysis tool was used to extract forest cover in the study AOI from 2000 to 2010. What remained was deforested area that was categorized by ratios into high, moderate, and low amounts. Ten to 15 areas of primary and secondary deforestation were highlighted in each category.

Third, highlighted results of deforestation areas for Lakes Mai Ndombe and Tumba were then mapped to include water bodies, roads, villages, tributaries, and

commercial concessions on 20 km^2 and 16 km^2 scales, respectively. Figures 5 and 6 show maps depicting the mosaics of deforestation occurring at Lake's Mai Ndombe and Tumba, respectively. All communities living adjacent to an identified area of deforestation were recorded at each lake. Twenty-five communities were selected, 13 around Mai Ndombe and 12 around Tumba. Communities surveyed around each lake are listed below in Tables 2 and 3.

Lastly, survey data were used to test if what was seen from above via satellite detection can be sensed on the ground. Responses were analyzed and presented using descriptive statistics. Perception findings were compared with satellite results.

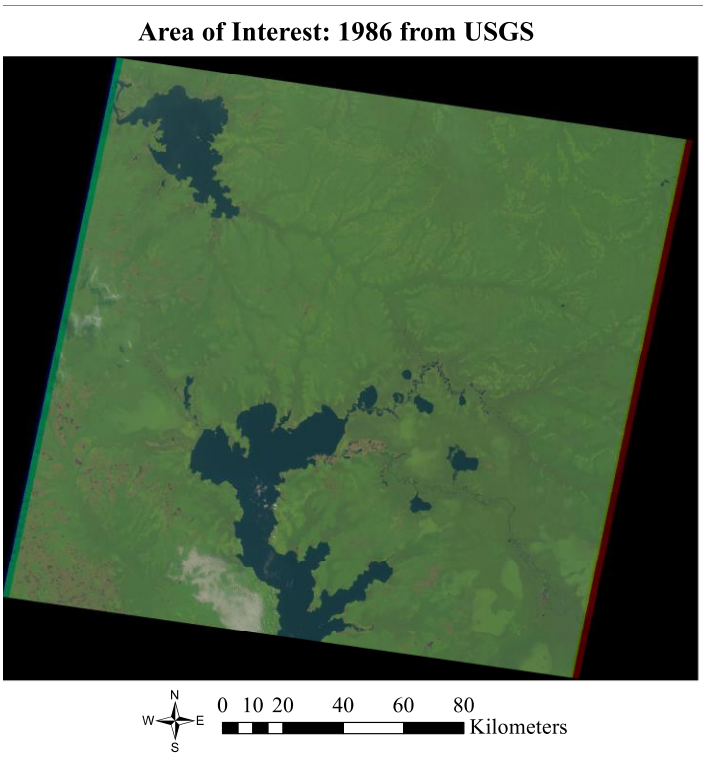

Figure 3: USGS Landsat image of the study area from 1986

Surveys

A survey questionnaire was created and administered in communities with on-going deforestation informed by the remote sensing analysis. Surveys and ground truthing were conducted to determine community perceptions of forest cover and forest cover loss. Community members were asked if deforestation in their area was low, moderate, or high. Surveys also captured demographic information and community perception on forest attributes.

Results and Discussion

Satellite Detection

The results from the visual comparison of the 1986 Landsat image and the 2010 FACET data image show that forest cover has been decreasing over the past 25 years. FACET show since 1990, just over one percent or 810 km^2 of deforestation has occurred per decade across the landscape, see Table 1. And, based on the analysis of FACET data, the study area experienced 700 km^2 of deforestation, representing 86% of the LTLT's deforestation from 2000-2010 (Figure 4). From 2000-2010 86% of the deforestation that occurred in LTLT occur around Lakes Tumba and Mai Ndombe. Figure 4 shows forest loss from 2000-2005 and from 2005-2010.

Table 1: Forest and forest loss in the Lake Télé-Lake Tumba Landscape - Data sources: State of Forest, 2010 and OSFAC, 2010

Baseline: Forest cover and forest cover loss from 1990 to 2010				
	1990	2000	2005	2010
Forested Landscape Area Km^2	100,285	99,336	99,177	98,666
Forest Loss Km^2	-	919	189	511

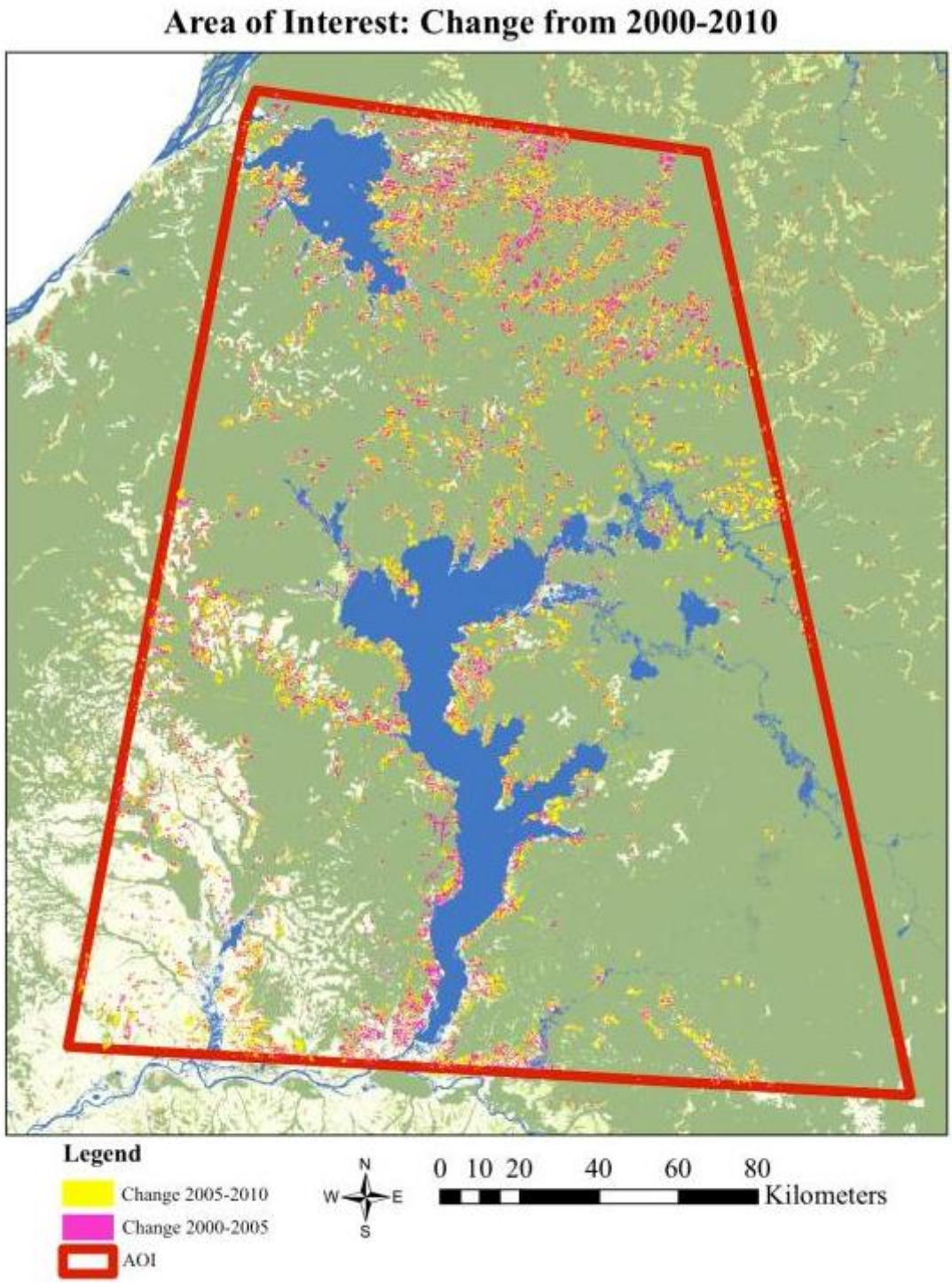

Figure 4: Forest loss in the study area 2000-2005 (pink) and 2005-2010 (yellow)

Community Demographics and Detection

Of the sampled population, 86% are Bantu and the remaining 14% are Twa. Twa living around Lake Tumba (Figure 6) are spread across many communities whereas those interviewed at Lake Mai Ndombe (Figure 5) were mostly clustered in Ikita, community number 13 in Table 2. Seventy-seven percent of the sample population is married, 6% are single, and 10% are divorced or widowed. The majority of those surveyed identified having a minimum of lower secondary education, and farming, fishing, and teaching are the most reported occupations, respectively. Age demographics at Lake Mai Ndombe are clustered between 10-29 years old and at Lake Tumba between 30-49 years. The average age across the landscape is 41 ±13, and household sizes are typically between 6 and 10 persons. At Lake Mai Ndombe, most people have lived there 20-29 years and at Lake Tumba most people have lived there from 40-49 years.

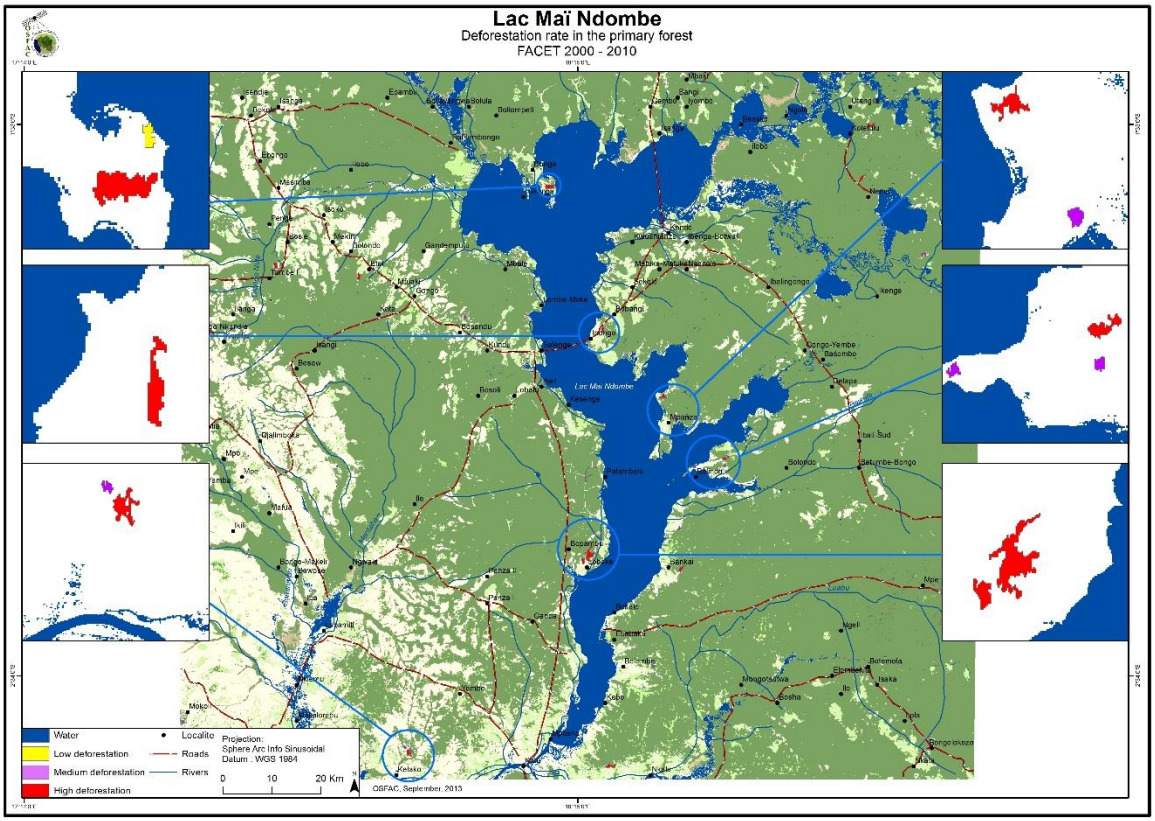

Figure 5: Areas of high (red), moderate (purple), and low (yellow) deforestation occurring in primary forests around Lake Mai Ndombe from 2000-2010

Figure 6: Areas of high (red), moderate (purple) and low (yellow) deforestation occurring in primary forests around Lake Tumba from 2000-2010

Table 2: Lake Mai Ndombe village demographics and detectable deforestation rates

Area ID	Village	Primary Deforestation	Secondary Deforestation	Transit	Popu-lation	# of Surveys
1	Kolobeke	M *(L, M)*	*(L)*	Motorbike	500	10
2	Inongo	H *(L, M, H)*	*(L, M, H)*	Foot	35,000	28
3	Mpanza	M, H	H	Boat	1,000	10
4	Mpatambalu	L *(L, M, H)*	*(H)*	Pirogue	1,192	4
5	Bokobene	*(M)*	-	Pirogue	1,483	5
6	Bopambo	H *(M, H)*	-	Pirogue	1,400	10
7	Lobeke	H *(L, M, H)*	*(H)*	Pirogue	2,675	13
8	Kesenge	L *(H, L)*	*(H)*	Motorboat	2,268	19
9	Nselenge	*(H)*	M, H *(H, L)*	Pirogue	3,557	26
10	Inunu	L *(H)* L, M	-	Pirogue	117	6
11	Mbale	*(H, M, L)*	*(L, H)*	Pirogue	2,512	15
12	Lukanga	H *(H)*	L, M *(L, M, H)*	Pirogue	15,843	21
13	Ikita	H *(L)*	L, M	Pirogue	300	5
				Total	67,047	172
Satellite Detected: H= High M= Moderate L= Low				Community Perception: *H, M, L*		

Around Lake Mai Ndombe, 56% of the 172 community members surveyed use primary forest for their agriculture activities. Residents at Lake Mai Ndombe account for 81% of primary forest usage in the landscape (N=322). Good harvest and production properties were mentioned by 31% and fertile lands were mentioned by 46%. When asked why, the following phrases were common responses translated from surveys: it is the best place to practice our livelihood activities (referring to practicing agriculture); these lands were left to us by our ancestors; and without the forest there is no life here. Descriptions of positive soil characteristics were used by 13% of those respondents in asserting why they used primary forests. And 3% of respondents choose to use primary forests to avoid domestic animals. Domestic animals were said to steal food and destroy

compound gardens. One respondent was recorded as saying “the more distance from the house, the better,” this was so animals do not eat planted crops.

Only four of 13 villages around Lake Mai Ndombe use secondary forest: Mpanza, Nselenge, Mbale, and Lukanga (Table 2). Around Nselenge, a rubber company has a concession in the forests and community members are not permitted to cut trees around the concession. This drives the community to practice agriculture farther from their homes, and is likely the reason why no primary deforestation was recorded around this community. Fifteen percent of individuals surveyed at Lake Tumba use primary forests and describe the soil as being productive, unexploited, original, new, and producing a good harvest. The majority (85%) uses secondary forests because it is the forest available, close to home, or no primary forests exist nearby. Only 9% of users say they inherited the land from their ancestors at Lake Tumba. It is important to note that inheritances are best explained as spiritual connections as well as physical tradition.

There is a mosaic of deforestation occurring around Ikita and Lukanga at Lake Mai Ndombe. Lukanga is the second largest village surveyed and Ikita is the second smallest. Ikita is a Twa village where community members feel extremely marginalized by the Bantu majority. The Twa living in Ikita all identified using home gardens because swamp forests surround them or because the land is productive. In Lukanga, 86% of the population use secondary forests. Respondents use these forests because they are the forests that exist and there are no more primary forests there. Primary deforestation is high in Lukanga and could explain the high usage of secondary forests. Of those that use secondary forests in Lukanga, only 16% stated fertility to be a reason. Lastly, Mpanaza is

a moderately large village located on the east bank of Lake Mai Ndombe, south of Inongo. Ninety percent of community members use primary forests and 10% use secondary forest for agriculture activities. Primary forest usage here is stated to be linked to soil fertility and for ease in facilitating the transport of goods.

There is a relationship between type of forests and perception of fertility. Around Lake Tumba, 15% of households use primary forests to practice agriculture activities compared to 84% of secondary forest usage. When community members were asked why secondary forests are used, 54% stated because there was a lack of primary forests and other land opportunities, 27% stated because of fertile lands, and 14% stated because of good production and harvest qualities. Of those who do use primary forests, 44% reported it was because of high production, 76% because of space and opportunity and 24% because of fertile lands. The population (N=322) perceives that deforestation is occurring; where 45% perceive forest loss to be high, 35% perceive that it is moderate, and 20% perceive forest loss to be low.

Lohenge is experiencing low primary and secondary deforestation, shown in Table 3. Deforestation is occurring in primary forests here because agriculture plots are being extended. In Ituta low levels of primary forest deforestation are occurring from agriculture extension also. Maanga is experiencing patches of low and moderate deforestation whereas Bibebeke and Nkoso are experiencing high primary forest loss deeper in forests.

Ehanga was the only community that we were not welcomed to survey in. Because the Mabali Scientific Reserve (MSR) located nearby, this liking caused the

Ehanga community to feel over researched. Over researched communities are those communities that show increased apathy and indifference towards engagement because as engagement increases they feel supporting mechanisms decrease (Clark, 2008). Therefore, Mabinza, a neighboring community, was selected as a replacement.

Table 3: Lake Tumba demographics and method of transport to reach destination

Lake Tumba						
Area ID	Village	Primary Deforestation	Secondary Deforestation	Mode of Transit	Popula-tion	# of Surveys
1	Lohenge	L *(H)*	L *(L, H)*	Pirogue	1,721	10
2	Ntondo	*(L)*	M, L *(L, M, H)*	4x4	4,074	20
3	Bikoro	*(M, H)*	L, M, H *(L, M, H)*	Vehicle	13,266	30
4	Ituta	L	L, H *(M)*	Pirogue	1,337	5
5	Nkoso I,II	H *(L, H)*	M *(H)*	Pirogue	2,201	10
6	Mpenda	-	M *(M, H)*	Motorbike	3,813	15
7	Bokaka	*(M, H)*	L, M, H *(M, H)*	Motorbike	1,689	10
~~8~~	~~Ehanga~~	~~M~~	~~—~~	~~Foot~~	~~1,551~~	~~5~~
8	*Mabinza	*(H)*	*(L, H)*	Foot	2,485	5
9	Lukanga	*(M, H)*	M *(L, H)*	Pirogue	2,825	10
10	Maanga	L, M	L, H *(L, M, H)*	Pirogue	1,684	5
11	Mpaha x3	M *(L, H)*	L *(L, M, H)*	Motorbike	6,920	20
12	Bibebeke	L, M, H	M, H *(M, H)*	Pirogue	2,583	10
				Total	44,598	150
Satellite Detected: H= High M= Moderate L= Low				Community Perception: *H, M, L*		

Conclusion

A mosaic of deforestation occurs adjacent to communities living around Lakes Mai Ndombe and Tumba, with all communities experiencing some degree of high, moderate, or low amounts of forest loss. Lake Tumba is experiencing higher deforestation than Lake Mai Ndombe. Communities living around Lake Tumba mostly

use secondary forests for agriculture activities. At Lake Mai Ndombe, deforestation is lower and more individuals practice agriculture in primary forests. Culturally, forests are important to these communities and primary forests give community members the biggest bang for their buck.

These findings serve as a training model for validating multiple sources of data used for detecting environmental change. The inclusion of local communities responses used for validating satellite data also provide extremely useful insight into why deforestation is occurring. This information will be useful for helping interested parties sustainably mange these forests, but most importantly I believe the consensus garnered from these findings shed light on the underutilized source of human communities for helping to close the gap in explaining environmental changes through narrative.

CHAPTER 3: ANTHROPOGENIC CAUSES OF DEFORESTATION IN THE LAKE TÉLÉ-LAKE TUMBA LANDSCAPE OF THE DEMOCRATIC REPUBLIC OF CONGO

Background

Forested area across the tropics declined by 0.49% annually from 1990-2010 (Mayaux et al., 2014). Forests account for 13% of Africa's landmass (Mayaux et al., 2004). Central Africa contains 89% of Africa's forest cover, and the Democratic Republic of Congo (DRC) contains the majority of that, holding 54% of the Congo Forests (Mayaux et al., 2013). The forests of the Congo Basin are experiencing slower overall deforestation in comparison to other tropical rainforests globally (Hansen et al., 2010; Bwangoy et al., 2010) where forest cover change rates are some of the lowest in the world (Megevand et al., 2013).

The European Union's Forest Law Enforcement, Governance, and Trade (FLEGT) policies have seemingly stabilized deforestation rates in Congo Basin Forest countries, except the DRC where deforestation rates are higher (de Wasseige et al., 2012; Samyn et al., 2012). The forests in the Democratic Republic of Congo experienced 0.13%±0.02 of gross deforestation from 1990 to 2000 and 0.26%±0.04 from 2000 to 2005 (Celine et al., 2013). And from 2000-2010, the Bandundu and Equateur Provinces of DRC experienced 2.2% and 2.4% forest loss, respectively (OSFAC, 2010). These are the second- and third-most forested provinces of the DRC.

It has long been accepted as popular narrative by scientist, policy experts, and NGOs, that slash-and-burn agriculture is the primary driver of deforestation. In reference to these practices, Jacks and Whyte (1939) convey that "the African has no instinctive love for land as such; at all comparable to the European, until they develop a greater love of, and establish a 'symbiotic relationship' to the land they will not willingly hold or cultivate it in order to conserve it." Nye and Greenland (1961) perceive that 'traditional' slash-and-burn agriculture was once sustainable and now is not because of a decline in fallow length. Szott (1999) states, "…in the humid tropics, the shifting cultivation cycle traditionally consisted of three to fifteen years of growth of unmanaged secondary vegetation, which is cut and burned at the initiation of a one- to four-year-long cropping cycle… and, fallow periods throughout the tropics have increasingly shortened as a result of land pressure arising from human population growth." However, a study of 396 farming households conducted in 49 villages in southern Cameroon found large variations in fallow length among different plots, even within the same household (Ickowtiz, 2004). And, in the last 10 years, the main pressures of deforestation discussed have expanded to include the commercial logger, the cattle rancher, and the small-scale farmer (Devers and Vandeweghe, 2006; de Wasseige et al., 2010, 2012). Therefore, since fallow lengths are seemingly more rotational, following no distinct pattern, and other larger causing pressures exist in forests nowadays, then shifting cultivation cannot be the primary reason for deforestation (Ickowtiz, 2004; 2006).

For a long time, local environmental literacy has been falsely classified (Jacks and Whyte, 1939), local customs have been blamed for the state of forests (Nye and

Greenland, 1961), and local practices have been criticized for being a major contributor to deforestation and climate change (Yale School of Forestry, 2015). Acknowledgement of and adaptations to forest pressures have been slow. For example, the World Bank Forest Policy Paper published in 1991, ended its support for commercial logging in primary forests and created a new vision of working in forests that emphasizes conservation, reduces poverty, and improved rights for local people. Because the World Bank has ended its support for industrial logging practices, this has not equated to other entities and industries ending these harmful practices (Virunga, 2014). In contrast to the earlier analyses, the World Bank stated in 2010 that the main threats of deforestation are poverty, political instability, and governance.

The small-scale farmer is subject to a host of pressures, such as population growth, pervasive poverty, misdistribution of traditional farmlands, inequitable land tenure systems, inadequate attention to subsistence agriculture, adverse aid and trade patterns, and international debt. However, the literature portrays the small-scale farmer as accounting for much more deforestation than the other aforementioned pressures combined, although also being less blameworthy (Ickowtiz, 2006).

Most recently, a study conducted by the Yale School of Forestry showed that only 27-34% of harvested fuel wood worldwide is considered unsustainable (Bailis et al., 2015). The sustainability threshold was created and based on annual harvest not exceeding incremental re-growth. Findings from the Yale School of Forestry study and those of Ickowtiz (2004, 2006), are providing concrete contrast to long-held beliefs and assumptions that fuel wood is a major driver of deforestation and climate change. This

shows forest communities are little able to comprehend, let alone control, what is occurring and without an integrated effort of sufficient scope there is every prospect that the demise of tropical forests within another few decades (Ickowtiz, 2006). Therefore, there is a need for more localized quantification and qualification of the causal factors driving forest change.

Urban population growth is an example of a driver spurring deforestation in sub-Saharan Africa (Malhi et al., 2013; Rudel et al., 2013) and in the tropical rainforests of Southeast Asia and Latin America (DeFries et al., 2010). In Kinshasa, DRC, population growth led to some 400 km of agricultural expansion north of the city easily accessible along the Congo River (Peterson, 2000; Rudel, 2005; Ernst et al., 2013). And, all across Central Africa there are high amounts of deforestation seen around cities and transportation corridors as a result of urbanization and the growing demand for agricultural products.

The population shift is attributed to recent changes of political economies to an extractive resource focus, which has led to sectorial financial booms and a retardation of agricultural markets. However, in DRC, industrialization has not happened. Therefore, the reverse may also be occurring where individuals are trapped in environmental and economic poverty cycles, and thus totally dependent on forests. And, because human use, conservation, and management of forests varies from nation to nation, political units can provide crucial evidence about the pattern of driving forces that cause forest clearing. Therefore, this chapter seeks to determine which drivers are causing forest loss in the DRC using localized information on pressures within the determined political boundary.

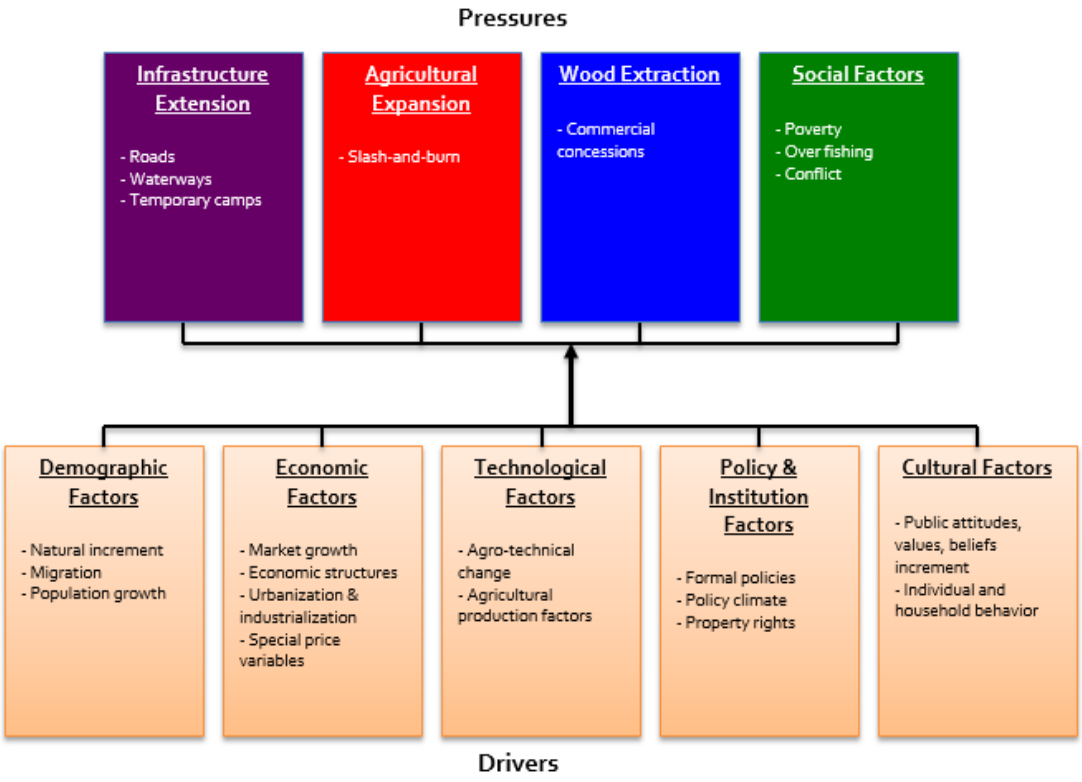

Figure 1: Causal linkage model of deforestation underlying drivers influencing proximate-level pressures. Adapted from Geist and Lambin (2001)

Proximate Causes of Deforestation

Pressures broadly defined according to the Drive-Pressure-State-Impact-Response Framework, a strategic response to Integrated Environmental Assessment created by the European Environmental Agency, are emissions, waste, and other environmental damaged that are the result in meeting a need (Kristensen, 2004). Pressures causing deforestation, which Geist and Lambin (2001) refer to as proximate causes of forest loss, are human activities that cause deforestation and degradation. Land-use changes that directly impact forest cover, such as slash-and-burn agriculture shown in Figure 1, are

pressures that lead to deforestation. And, according to theory and empirical evidence, other human activities such as transportation infrastructure or commercial food production exert 'stress' on the environment as a result of the production or consumption processes (Odum, 1989, Turner et al., 1990, 1993; Kristensen, 2004).

Various scholars have grouped human-induced pressures of deforestation into three broad categories over the past 30 years: infrastructure extension, agricultural expansion, and wood extraction (Hosonuma 2012; Rudel et al., 2009; Geist and Lambin, 2002; Lambin, 1994; Ledec, 1985). Other pressures discussed by these scholars include environmental factors, biophysical drivers, and social trigger events. Social trigger events are abrupt and shocking events that cause social chaos, e.g., war, revolution, and displacement. Since the purpose of this chapter is to determine the main anthropogenic causes of deforestation, the following four categories narrow the focus of pressures causing deforestation in tropical rainforest: agricultural expansion, wood extraction, infrastructure extension, and social triggers.

Underlying Drivers of Deforestation

Geist and Lambin's meta-analysis (2001) and review (2002) of tropical drivers of deforestation identify drivers as the social processes that are the fundamental catalysts of the deforestation process. For example, economic factors such as urbanization can drive deforestation for agricultural products. Economic drivers can also cause a relocation, redistribution, or cessation of pressures in a particular location. The theory that an increase in the sale of a natural resource increases the demand for labor, such that the

price of extraction labor outcompetes the labor needed for agriculture, is known as the Dutch Disease Theory (Rudel et al., 2013).

Dutch Disease Theory is a dynamic used to explain forest loss in correlation to the growth of cities in Central Africa by Rudel and scholars. Booming resource extraction jobs promote urbanization causing more people to migrate to cities in search of work. In theory, as urban areas expand, tropical deforestation should slow in rural and remote areas. Rural to urban shift patterns show that urbanization can induce migration, create jobs, contribute to peri-urban and urban deforestation seen around cities, and slow rural deforestation because of the retardation of the agriculture sector due to the price increase of labor in cities.

Furthermore, Rudel (2013) analyzes determinants of tropical forest loss in sub-Saharan Africa by using political boundaries and variables within them as units for determining change in forest cover. Therefore, the use of political boundaries acknowledges that human behavior drives deforestation. And since the purpose of this chapter is to determine the main anthropogenic causes of deforestation, the following five categories will be the focus of the driver discussion: demographic factors, economic factors, technological factors, cultural factors, and political and institutional factors.

Tandem of Factors Causing Deforestation

DPSIR is a strategic tool to perform an Integrated Environmental Assessment to determine logical tandem connection helping to articulate that human wants and needs drive environmental change. Drivers influence pressures that chain-logically cause deforestation on the ground. Chain-logical connections or *tandems* are one or multiple

underlying factors driving one or multiple pressures. Figure 1 show tandems between driver and pressure, however, tandems can also exist between drivers and pressures individually. Thus, tandems are defined as observed relations or synergies among two or more drivers and/or pressures. Two-factor tandems, hereafter referred to as a driver-pressure tandem, are one underlying factor, hereafter referred to as driver, driving one proximate factor, hereafter referred to as pressure that contributes directly to deforestation. For comparability of results, driver-pressure tandems will be the only tandems considered in this study, as they are already discussed in existing literature on deforestation (Geist and Lambin, 2001, 2002). For examples, see Figure 2 where possible tandems are connected with arrowed lines to show linkages between drivers and pressures that cause deforestation.

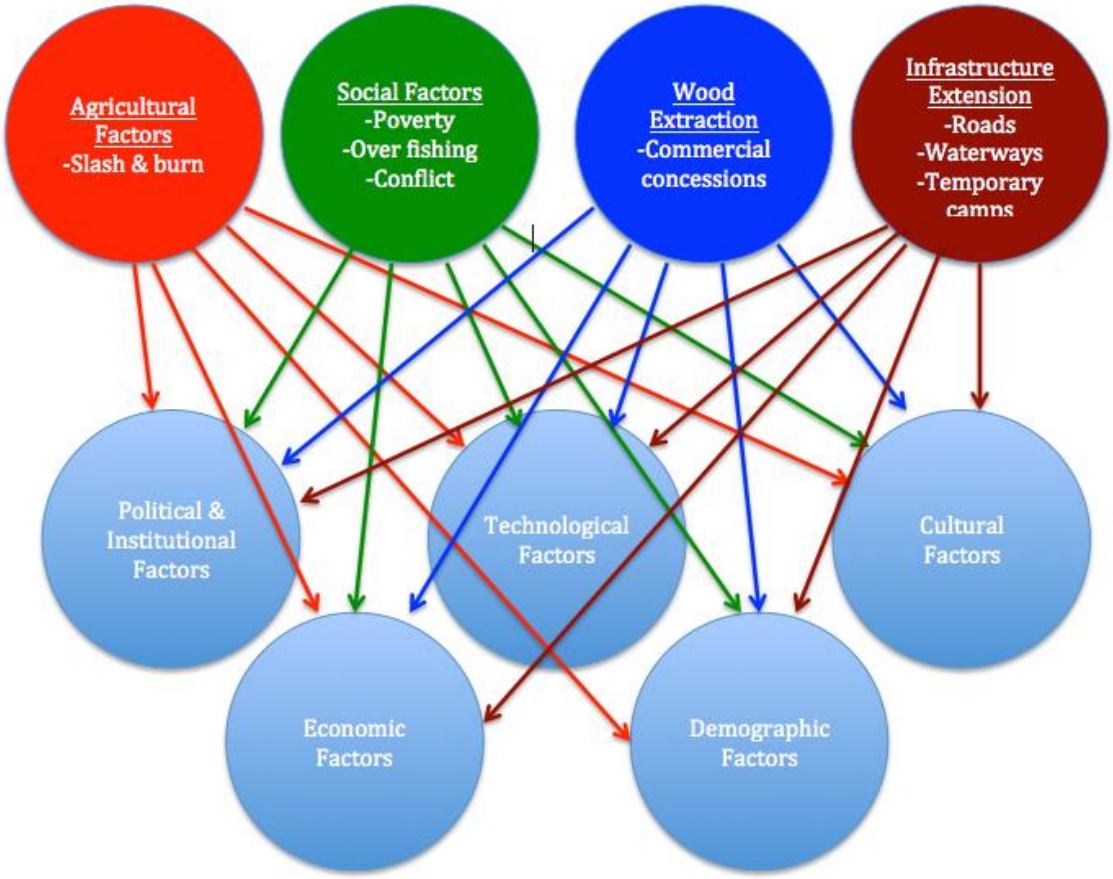

Figure 2: Driver-pressure tandem model where colored lines hypothesize connection of pressures to drivers.

Problem Statement

There are indirect-drivers and direct-pressures occurring in tropical rainforests that cause deforestation. Because the application and value of local knowledge is severely lacking in the Congo Basin region, the identification of localized drivers and pressures concomitantly causing deforestation in these forests needs to be further understood. Previously cited works have determined causations of deforestation occurs in two steps and there are a host of socio-political drivers that influences proximate level pressures. Thus, this chapter will determine using local population surveys, the perception of the

most salient pressures causing deforestation within the political boundaries of the Lake Télé-Lake Tumba Landscape in order to determine to most salient drivers influencing forest cover.

Predictions

1. I predict that the following are the most salient pressures causing deforestation in the LTLT Landscape: access to roads and waterways, commercial concessions, overfishing, poverty, and slash-and-burn.
2. I predict that the following are the most salient underlying drivers of deforestation in the LTLT Landscape: a high cultural dependence on forest, failed governance, high population growth, low-to-no technology, and an unstable economy.
3. I predict that a few driver-pressure tandems, rather than all, will be most persistent.

Methods

Study Area

The LTLT Landscape is located within the boundaries of the aforementioned Bandundu and Equateur provinces and also crosses into the Republic of Congo. The LTLT Landscape is a major wetland on the continent situated in the heart of the Congo Basin region (de Wasseige et al., 2009, 2010). Gross deforestation within the LTLT Landscape was 1.7% between 2000 and 2010 (Chapter 2 of this dissertation). Satellite analysis qualified by survey data were able to show that there is a mosaic of deforestation occurring in scales around the lake communities in the landscape. And, although forest loss here is well below those of other major contributors, deforestation and degradation

caused mostly by human can incite other changes to forest dynamics (Rapport et al., 1998).

This study was conducted in 25 LTLT communities adjacent to Lakes Mai Ndombe (Figure 3) and Tumba (Figure 4) between October 2013 and May 2014. There were 13 communities sampled around Lake Mai Ndombe and 12 sampled around Lake Tumba. These communities were selected based on having a mosaic of high, moderate and/or low primary and secondary deforestation adjacent to their communities, as determined by Landsat satellite images (see Chapter 2 for more details on methods used for remote sensing analysis and for community selection).

The population for the 25 villages in the study area is estimated to be 107,219, 67,847 around Lake Mai Ndombe and 44,598 around Lake Tumba (See Chapter 2 for full population count by village). Community population demographics were collected from field partners. For Lake Mai Ndombe, data was acquired from Ecosystem Restoration Services (ERA) and Wildlife Works (WLW). For Lake Tumba, data was acquired from the WWF Central Africa Program Office (CARPO). These numbers were verified on site in communities with local chiefs and heads of villages; there were no significant discrepancies between community population numbers. A sample size of 270 persons was determined based on a 90% confidence level and a 5% margin of error.

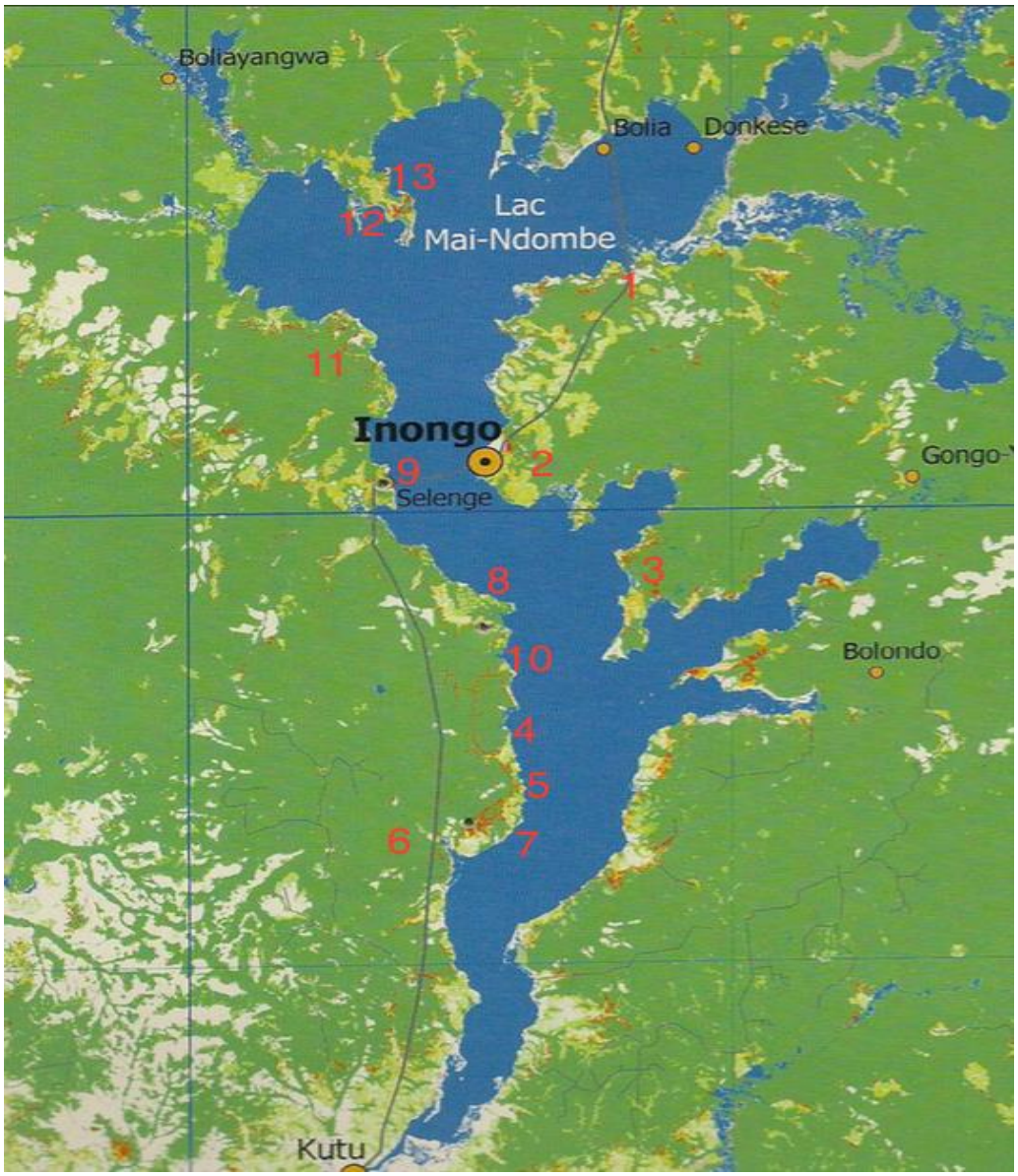

Figure 3: Lake Mai Ndombe community delineation map
1. Kolobeke; 2. Inongo; 3. Mpanza; 4.Mpatambalu;
5. Bokebene; 6. Bompambo; 7. Lobeke; 8. Kesenge;
9. Nselenge; 10. Inunu; 11. Mbale; 12. Lokanga; 13. Ikita.

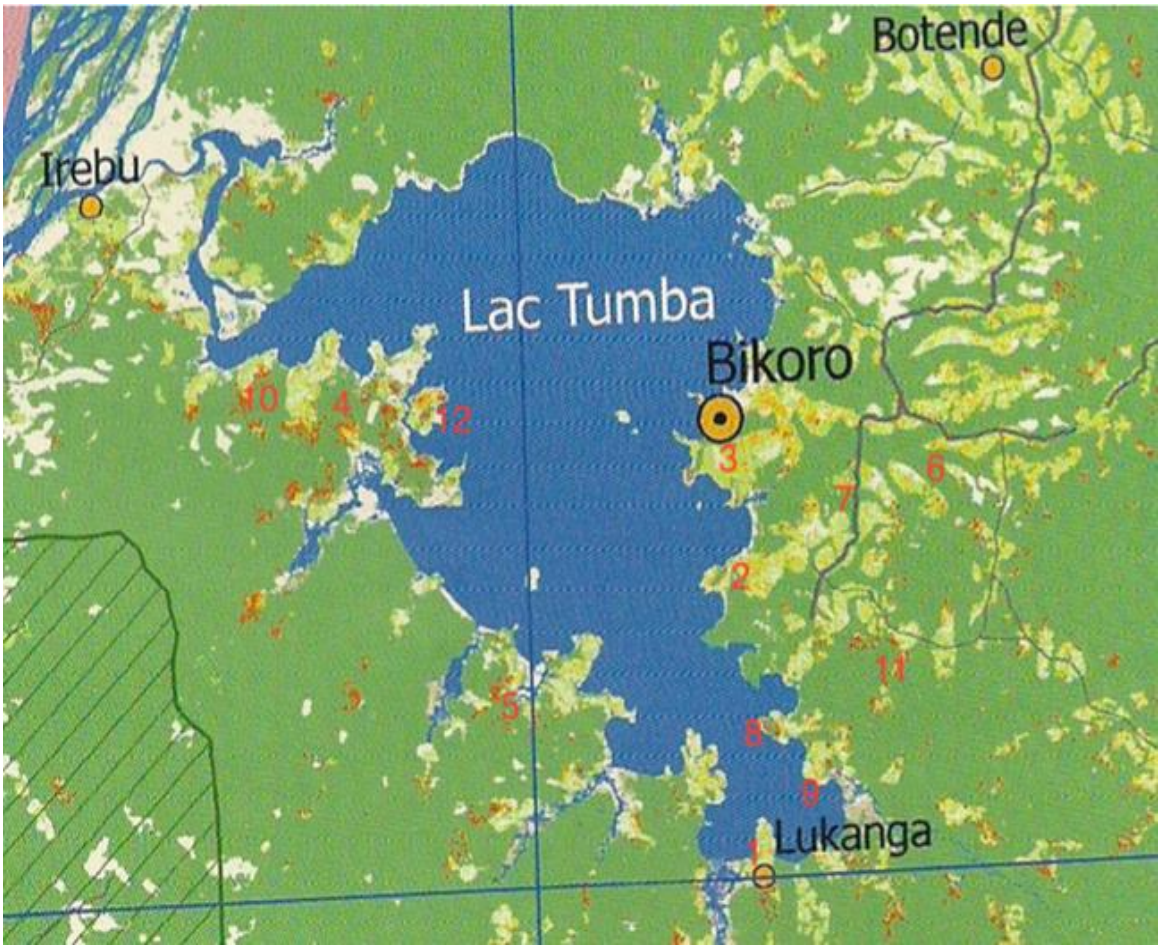

Figure 4: Lake Tumba community delineation map
1. Lohenge; 2. Ntondo; 3. Bikoro; 4. Ituta; 5. Nksos I & II;
6. Mpenda; 7. Bokaka; 8. Mabinza; 9. Lokanga; 10. Maanga;
11. Mpaha (Pole, Bolia, Lukumu); 12. Bibebeke.

Surveys

Prior to conducting surveys, data collection involved selecting *animateurs.* Animateurs are skilled community engagers that are familiar with the community and the customs of the area. Animateurs for this study were selected with the aid of the ERA, who has had local staff and projects in the area for three years. Animateurs were trained by the principle investigator and conducted trial interviews in order to become familiar with questions, interviewing techniques, and selection of respondents. Knowledge and identification of perceived activities causing deforestation were collected using semi-structured surveys; see Appendix A for survey tools and Figure 5 for study area. Respondents were asked to rank potential deforestation pressures in their perceived order of magnitude on a one (most important) to six (least important) scale.

Once in the village, the protocol was first to meet with the local chief or head of affairs to explain the summary of research, procedures, benefits, and consent. After receiving consent from the chief, surveys were proctored by trained male and female animateurs fluent in the local languages of Lingala, Bolia, and Kikongo. Survey respondents were selected from one of the following venues: gathering outside meeting with local chief, randomly selecting houses, or individuals in the market area. First, individuals were sampled from the crowd gathered outside the home of the chief, then interviews would end with random house selection. Market areas were only used to access respondents in Inongo and Bikoro, the largest markets at each lake.

During the course of this study, 322 individuals were surveyed. In order to account for certain biases, adjustments were made to the sampling methods to include vulnerable populations. Within the study area, populations such as Twa groups are highly

marginalized and their population density in comparison with the Bantu is too low for random sampling. Therefore, in order to include a representative number of their population, they were specifically sought within communities, whereas Bantu groups were randomly sampled. Similarly, women were purposively sampled due to patriarchal society structures. This was adjusted for by having female animateurs proctor surveys to women in communities.

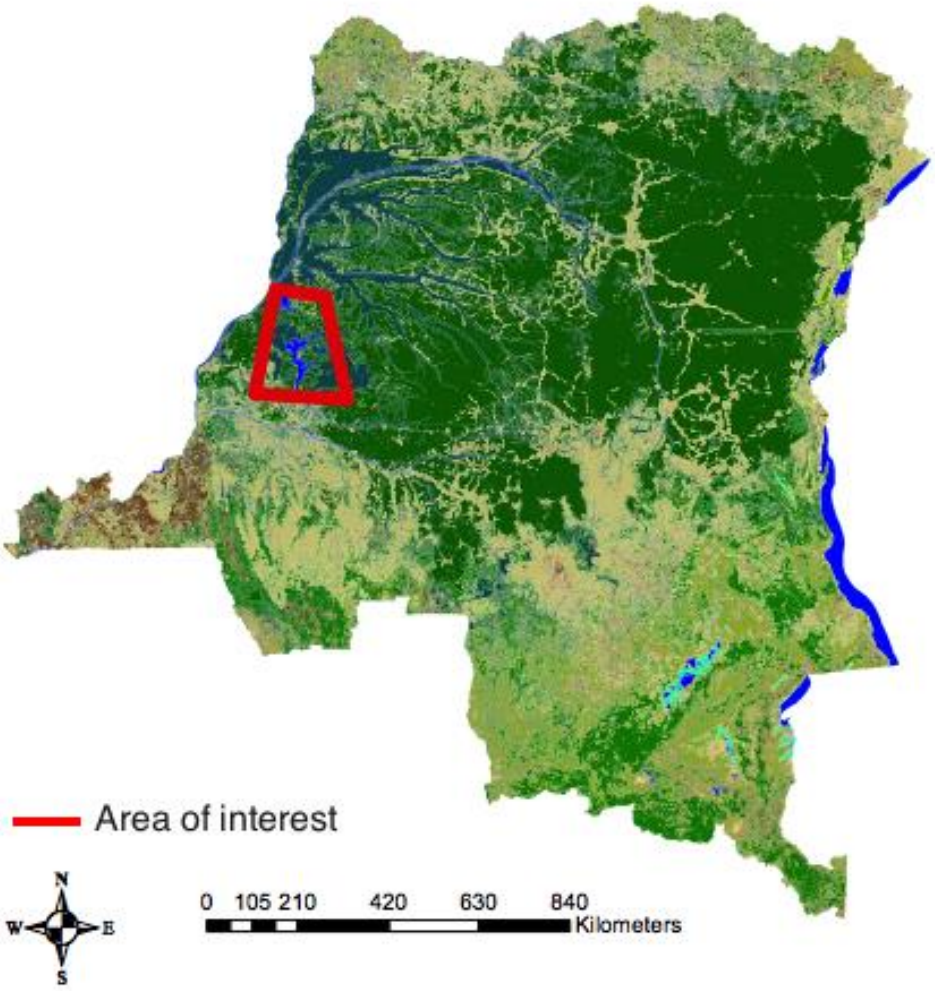

Figure 5: Study area within the DRC portion of the Lake Tele-Lake Tumba Landscape

Literature review

A literature review was conducted to determine the anthropogenic drivers adversely effecting forest cover in the DRC. Document searches included scholarly databases such as Google Scholar and Web of Science to acquire reports from the World Bank, IMF, WWF, and Wildlife Works. Searches were conducted over two years, January March 2012 to March 2014. Geist and Lambin (2001) driver categories –

political, economical, technological, demographical, and cultural – were used to broadly categorize the information. These categories define the scope for identifying drivers. Driver information was then aggregated into timeline format. A timeline of events from 1887 to 2013 was populated using all information gathered from the database searches.

Mixed Method Data Analysis

Pressure analysis

Landscape rank- Using only data from Question 1 (Q1), of the local population survey (Appendix A), I created an entire landscape ranking to determine the most important pressure perceived to be causing deforestation by individuals across the landscape.

Village rank- Using responses to questions regarding ranking of pressures (Q1), temporary camps (Q3) and conflict (Q47), a village ranking was conducted to determine the pressure perceived as most adversely affecting the forest within the landscape. Pertinent responses (to Q1, Q3, and Q47) were analyzed for all 25 villages. Q1 is a ranking question and a village was counted as ranking a pressure as most important based on the statistical mode of responses within each village. Q3 and Q47 are Yes/No questions and for these variables a village was only counted for ranking a pressure as most important if 50% or more of the village sample population ranked a pressure as such.

Pressure tandems- Using data from the village rank analysis, two-, three-, and four-factor interlinking pressures were determined by counting villages that ranked a subset of pressures as the top two, three, or four most harmful to forests. Interlinkages

among pressures using two- and three-factors were determined based on previously identified village rankings used for analyzing Q1, Q3, and Q47.

Driver analysis

Narrative Policy Framework (NPF) is an empirical approach used for reporting driver evidence (Jones and McBeth, 2010). Using specific driver and pressure categories and following NPF, driver evidence was grouped and classified into specific activities and then used to validate broader driver categories. Timelines highlighted key points in history, and narratives will chronologically present this information in a story-like manner. Results will be determined by counting the occurrence of drivers interacting with pressures on-going in the landscape and presented in tables and figures to show trends of events. Narratives were presented to complement tables and figures in the result section, which best capture influences over time (Büthe, 2002).

Tandem Analysis

Driver-pressure tandem- Evidence from specific driver narratives and survey data were used to validate hypothesized driver-pressure tandems modeled from the Geist and Lambin (2001) study. Drivers are linked to pressures using a chain logic connection. Drivers and pressures were connected chain-logically with evidence gathered in data collection. Chain logic causal connection, discussed in Geist and Lambin (2001) as the method of analysis for linking drivers to pressures, shows that deforestation occurs in a two-step process, citing the original logging-agriculture tandem for describing how farmers would not have access if not for the logger who opened up the forest (Walker,

1987). Accordingly, driver-pressure tandem frequencies in this study will be derived from connections with localized pressures occurring within the LTLT Landscape.

Results

Respondents answered an average of 54 (±15) questions in interviews lasting one to two hours. This section will present results of drivers, pressures, and tandems. Evidence for drivers will be presented in tables, figures, and in narratives below.

Literature Review Results: Drivers causing deforestation

Political and Institutional Factors Results

Table 1: Political and institutional drivers of deforestation in the Lake Télé-Lake Tumba Landscape

Works cited: Kaplan, 2007; Kuditshini, 2008; Shekhawat, 2009; Marysse, 2004[23]; Nachega, 2005; Foreign Policy Magazine, Fund for Peace.

1885:	Congo Free State established
1908:	Belgian Congo established
1960:	May, Patrice Lumumba named first Prime Minister
	June, Congo gains independence
	September, Lumumba dismissed from office
1961:	January, Lumumba is murdered
1963:	Country joins the World Bank
1965:	Country name is changed to Zaire
	Joseph Mobutu's successful coup
1967:	Nationalization of soil and subsoil by Mobutu
1974:	Constitutional power grant Mobutu authority over E, J, and L branches
1976:	First structural adjustment loan taken
1982:	"*L'Ordonnance-Loi* no. 82/006" (2/25/82) - regulates the political, territorial and administrative organization of the deconcentration

[2] Nzinga, N.V., "*Programme Intérimaire Renforcé* (PIR) *et Evaluation à mi-parcours du Programme Economique du Gouvernement* (PEG)", *Notes de conjoncture*, Kinshasa, *Octobre* 2003; IMF, DRC - Third review Under the Three-Year arrangement Under the Poverty Growth Facility and Request for waiver of Performance Criteria, EBS/04/26, Washington, D.C., February 26, 2004, forthcoming on www.imf.org projections

[3] The data are based on World Bank World Development Indicators and the *Lukusa*, CEDA, 1999, IFS

1987: "*L'Ordonnance-Loi* #87-004 (1/10/87) regulatory rules of fiscal deconcentration enacted
1990: IMF halts financial aid
Zaire moves to multiparty system
1995: Disinflation program launched
1997: Mobutu ousted from office by Laurent Kabila
1998 to 2003: Second Congo War
Unfair natural resource contracts by rebel forces and the Kinshasa government
1998: Country name is changed to the Democratic Republic of Congo
August, New currency called Congolese Franc introduced
No state budget until 2001
2001: January, Laurent Kabila assassinated
Son, Joseph Kabila takes office as President
2002: Fiscal policies enacted by the IMF
World Bank and IMF privatized mining and forest resources
August, Forestry Code, Mining Code, and Investment Code announced
2003 to 2007:
Unfair natural resource contracts
were established government
2003: July, transition government begins
2005: May, New constitution adopted however business still operates as usual
Ranked fourth worst administered state by World Bank
Ranked second of 76 countries as a failed state after *Cote d'Ivoire*
2006: First free and fair election
Ranked second most unstable state in the world
Ranked second of 146 countries as a failed state after Sudan
2007: New government formed
December, Global and Inclusive Agreement marking the end of the war
2008: 91 of 156 logging contracts were suspended

2009-2012: Ranked in the top five failed states

2013: Ranked second as a failed state

Formal policies created and controlled by the DRC government, such as those on taxation, concessions, economic development, investments, displacement, and land policies have failed (Kaplan, 2007; Marysse, 2004; Nachega, 2005). The corruption seen in formal policies of the country is concomitantly fueled by poor performance and

clientelism that occur from the informal policies also running within the country (Kuditshini, 2008). Corruption manifests in the weak institutional capacity, large displacements of people, and poor environmental management, in particular with regard to property rights regimes and deeply rooted land tenure insecurity (Table 1). Historically what has existed on paper differs from that in actual practice. The DRC is a failed state and its political and institutional failures are driving deforestation across the landscape.

Policies in the DRC have a history of being enacted without regard for the land or the people (Table 1). An Oxford law scholar drew up the Constitution of the Congo Free State in 1884, a tactic used by Leopold to end the land race in the DRC - yet it has only continued. Using money he gained from exploited cheap labor of the Congo Slave State during the rubber boom, Leopold financed his own palaces and public works projects in Belgium (Oliver and Atmore, 2000). During the colonial period, the Belgian Congo was tasked with repaying the debt owed from the misappropriations under King Leopold. Policies were put in place that allowed concession companies, now 'quasi government officials,' to reorganize labor in order to extract resources from the land to repay colonial debts.

Joseph Mobutu served as president from 1965 to 1997. The formal policies or lack thereof of the Mobutu administration and the informal policies contributed to deforestation and widespread national level poverty. Policies during the 1960's and 1970's continued to operate without regard for the land or the people under the rule of Mobutu. Like Leopold, his leadership has been described as a kleptocracy, theft for the benefit of himself (Verhaegen and Vale, 1993; Marysse, 2004). In 1963, the DRC joined

the World Bank. In 1974 Mobutu granted himself constitutional authority over all three branches of government with no presidential checks (Shekhawat, 2009). In 1976 DRC received its first structural adjustment loan from the World Bank and in 1977 long-term debt equaled $2900 million.

Table 2: Political and institutional drivers of deforestation in the Lake Télé-Lake Tumba Landscape

SPECIFIC ACTIVITIES		EVIDENCE
FORMAL POLICIES	Taxation, charges, prices, tariffs	Revenue and tax collection = just over 10% of GDP (Shekhawat, 2009)
	Credits, subsidies, concessions Finance, investment, trade	$400 Billion in diamond smuggled out in recent years (Kaplan, 2007)
	Economic development	Disinflation program launch based on consolidation and credit restraint, used only for 6 months (Nachega, 2005)
	Finance, investment, trade	IMF halts financial aid (Shekhawat, 2009; Nachega, 2005)
	Population (migration)	Rwandan genocide, influx of 1.5 to 2 million refugees (Biswas and Quiroz, 1996)
	Land	Constitution on 24 June 1967 stipulates 'the Congolese soil and sub-soil belong to the State (Kuditshini, 2008)
INFORMAL POLICIES	Corruption, lawlessness	60-80% of customs revenues are estimated to be embezzled (Shekhawat, 2009)
	Growth (development) coalitions	Multinational companies that are operating in this sector and that are in cahoots with the political class comfortably installed in Kinshasa (Kuditshini, 2008)

	Poor performance, mismanagement	Weak institutional capacity due to political clientelism (Kuditshini, 2008)
	Clientelism, vested interests	1965-1997 the country's resources plundered for the benefit of the leader (Kaplan, 2007)
	Redefinition of policy goals	1974, constitutional power granted Mobutu authority over executive, legislative, and judicial branches for which he banned political parties while making membership in his party, the Popular Revolutionary Movement, compulsory. (Shekhawat, 2009)
PROPERTY RIGHTS REGIMES	Land tenure insecurity	
	Race for property rights	1884, an Oxford law scholar drew up the Constitution of the Congo Free State in, a tactic used by Leopold to end the land race in the DRC (Oliver and Atmore, 2000)
	Titling, legalization	Late 1800s, the word *treaty* was a euphemism, for many chief had no idea what they were signing (Hochschild, 1998)
	Malfunction customary rights	
	Deprivation, marginality	Cloth traded for *treaty's* bought land and labor (Hochschild, 1998)
	'Quasi open access conditions	

From 1980 to 1990 the government lost control over its fiscal policies. In 1982 and 1983 the *L'Ordonnance-Loi* nos. 82/006 and 83/004 were announced as structural adjustment programs (Marysse, 2004). *Loi* no. 82/006 included policies for administrative decentralization and 83/004 for fiscal decentralization. These policies were

needed to combat high inflation during the economic crisis. In 1987, *Loi* no. 87/00 was enacted to shape rules and regulations for *Loi* no. 83/004 and by 1995, finally, a disinflation program was launched. Its aim was consolidation and restraint. Government expenditures were to be limited to cash in treasury; the program failed after six months (Nachega, 2005). Weak institutional capacity created an illegitimate culture where there are no effective sanctions for misconduct. Shortly after, in 1997, Mobutu was ousted from office after serving over 30 years in the capacity as President, and in 1998 the country's name was changed to the DRC.

There were unfair leasing and illegal selling of land for concessions that directly caused forest loss, concomitantly fueling agriculture and poverty (Wallace, 1994). Still, the DRC continues to carry forth a business as usual culture. Unfair natural resource contracts were made by rebel leaders and also the Kinshasa government from 1998 to 2003 (Kuditshini, 2008). The new Congolese Franc was released in August 1998 and around the same time the second Congo war started (Nachega, 2005). This was the beginning of an economic depression for the country. And, because of the war, there was no state budget from 1998-2002 (Shekhawat, 2009).

In 2001, the IMF enacted major fiscal policies that restricted DRC spending. The World Bank and IMF privatized mining and forest resources through the creation of the Investment Code announced in February, the Mining Code announced in July, and the Forestry Code announced in August of 2002 (Table 1). Similar illegal contracts continued to be established during the transitional government from 2003 to 2007 because of corruption and lack of oversight. In 2005, the new constitution was adopted; however,

policies and administrative practices still embodied business as usual. The Constitution still gave regional government's great power and control; however, the president still has overriding executive authority (Kaplan, 2007). In 2006, the World Bank ranked DRC as the second-most unstable country in the world. From 2008 to 2014, DRC has ranked in the top five of the Fund for Peace Fragile State Index, who classified the country as a failed state (Marysse, 2004, Clement, 2004; Fund for Peace, 2014). Thus, there is a history of poor extremely political performance in country.

Economic Factor Results

Table 3: Economic drivers of deforestation in the Lake Télé-Lake Tumba Landscape

Works cited: Kaplan, 2007; Kuditshini, 2008; Shekhawat, 2009; Marysse, 2004; Nachega, 2005; Foreign Policy Magazine, Fund for Peace

1965 to 1974: Inflation averaged 21 annually
1976: $27 million structural adjustment loan taken
1977: Country's long-term debt = $2,900 million
1981 to 1990: Government loses control over fiscal policies
1983: Inflation = 77%
1984 to 1985: Inflation averaged 24% annually
1987: Country's long-term debt = $23.7 billion
1988: Inflation = 100%
1989: Inflation = 54%
1990: Fiscal deficit = 11% of GDP
Inflation ↑265%
1991-1995: Fiscal deficit averages 19% of GDP
Money Growth = 3,594%
Inflation = 5,422%
1995: January, disinflation program launched
Summer, disinflation program fails
Inflation = 23,000%
Foreign Debt (loans) = $14 billion
1997: Inflation = 14%
1998: Inflation ↑135%
1999: Inflation ↑483%
2000 to 2005: National revenue tripled
Inflation ↑511%
2001: Free float exchange regime established
2002: Inflation ↑16%
2003: Inflation ↑8%
2005: GDP growth of 7%
2006: Aid increased to 56% of national budget

Economic poverty is a driver of deforestation in the LTLT Landscape. The Congolese are environmentally rich and poverty was created in the shift from an agrarian society to a monetary society. Poverty as an economic driver of deforestation in DRC was created in the historical marginalization of the Congolese. This occurred originally under the rule of King Leopold during the rubber boom, which lasted from 1895 to 1905 (Oliver and Atmore, 2000).

The connection between resources and monetary wealth is realized to be in extraction. Historically, this was accomplished via low-cost labor. During the time of the rubber boom, concessionary companies compelled Congolese to tap natural rubber vines deep in forests for very small rewards (Hochschild, 1998; Wrong, 2001). The reorganization of labor for a market economy created destitution for forest communities, where wages paid were not transferable to acquire goods on the created market. Previous isolation in dense forest away from trade routes left little chance of acquiring individual wealth as the land grab race for Africa during the colonial periods progressed.

Economic poverty was created because financial decentralization is not actualized and poverty is created by the informal breakdown within the structured system (See Table 3 for a complete timeline of economic events). For example, large individual gains made by King Leopold in the pre-colonial era show firsthand the poverty created from marginalization of equality in economic power. This form of poverty was continued and thus was fueled as a driver of deforestation during the colonial period from 1965 to 1997 under the rule of President Joseph Mobutu. Economic structures were put in place to

advance the financial security of the country through redistribution of wealth did not reach forest communities.

The historical analysis of DRC shows it is estimated that $4 - 10 billion were illegally siphoned from the country during the Mobutu regime (Kaplan, 2007; Dunn, 2007; Wrong, 2001) (Table 4). Informal economic structures created an economic crisis in 1980 that lasted until 1990, when the government lost control over its fiscal policies (Nachega, 2005). This sparked a near economic collapse during the 1990s (Shekhawat, 2009). There was rapid and uneven economic growth and in 1995; the DRC was experiencing hyperinflation at 23,000% and had accumulated $14 billion in foreign debt. Large gains were made from the country's common goods such as the forests; however, most of the benefits went to few individuals.

Table 4: Economic drivers of deforestation in the Lake Télé-Lake Tumba Landscape

SPECIFIC ACTIVITY		EVIDENCE
MARKET GROWTH AND DEVELOPMENT	Rapid market growth	
	Increased market accessibility	2002, Mining, Forestry, and Investment Code announced (Kuditshini, 2008)
	Growth of sectorial industries	
	Lucrative foreign exchange earnings	2000-2005, National revenues tripled (Shekhawat, 2009)
	Growth in demand, consumption	
SPECIFIC	Rapid and uneven	1990-2000, Near economic collapse

ECONOMIC STRUCTURES	growth	(Shekhawat, 2009)
	Large individual gains	1965-1997: $4-$10 billion siphoned (Dunn, 2007)
	Poverty & related factors	2002, Financial Flows between Central Government and Region are minimal (Marysse, 2004)
	Economic downturn, crisis	1980-1990, Government loses control over fiscal policies (Nachega, 2005)
	Indebtedness, foreign debt	1995, Foreign debt $14 billion (Kaplan, 2007)
URBANIZATION & INDUSTRIALIZATION	Urbanization	4.15% urban population growth rate (Rudel et al., 2013)
	Industrialization	
SPECIAL ECONOMIC PARAMETERS	Cheap and abundant production factors	
	Special low cost conditions	
	Price (value) increases	
	Price decreases (cash crop)	Coffee and cocoa plantations that have mostly been abandoned due to the low market prices (Wildlife Works, 2012)

More recent economic structures put into place, such as the Mining, Forestry, and Investment Codes announced in 2002 are failed policies that, when highlighted, show the perpetual relationship between country economics and rural poverty. The idea of increased accessibility of market goods is to promote market growth and earnings.

However, agricultural areas across the country and specifically within the landscape had good networks of coffee and cocoa plantations, but were abandoned because of low market prices (Wildlife Works, 2012).

From 2000 to 2005, national revenues tripled (Shekhawat, 2009) and urban population growth rate was 4.15% (Rudel et al., 2013). These statistics support Dutch Disease Theory as described in Rudel (2013) because, as economies grow, more individuals move to cities in search of opportunities. However, the growth of markets, sectorial industries, and demand were not proven to be significant drivers of migration in DRC because, like many other central Africa countries DRC did not go through an industrial revolution. Individuals were moving to the city for opportunities because of the extreme poverty persistent in rural societies, however, without industrialization, opportunities for these individuals were severely lacking. If industrialization together with urbanization stunts rural deforestation, then deforestation should primarily occur in peri-urban areas (Rudel et al., 2013); this is not the case in the DRC. The informal sectors grew financially and small groups of individuals in power acquired wealth, but opportunities did not grow at rates needed to reverse the trends of rural deforestation.

Demographic Factor Results

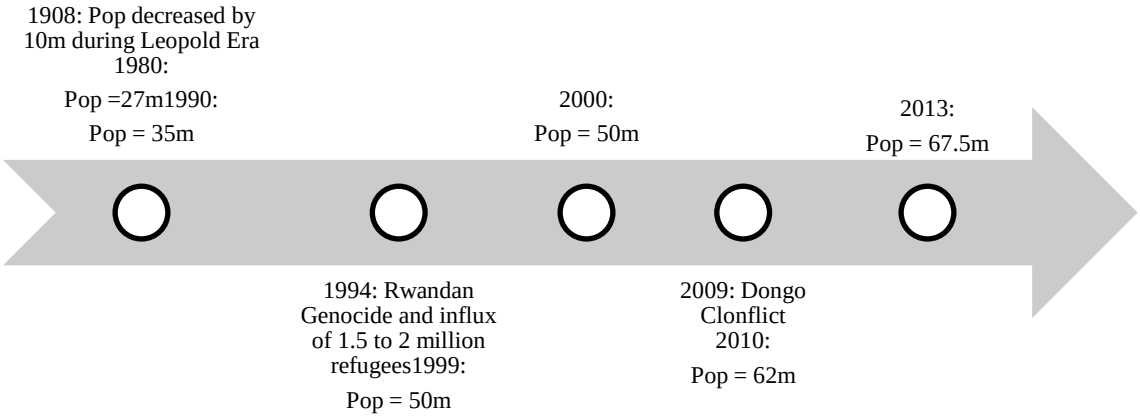

Figure 6: Timeline of demographic drivers of deforestation in the Lake Télé-Lake Tumba Landscape Population data derived from the following sources: World Bank, Marysse, 2004; Hochschild, 1998; Sanguma, 2012; and Biswas and Quiroz, 1996

City populations in DRC became the ruling class and the focus of the government (Oliver and Atmore, 2000). Population growth is delineated on the timeline in Figure 6. After independence, the Congolese, significantly unprepared because of the failure of colonial structures, forced to govern themselves, began holding political, military, and governmental positions. An analysis on decentralization trends in the country found that payments made were mostly for salaries and retirements and that overall transfers made to the regions were insignificant (Marysse, 2004). Public officials at regional and local levels, in particular soldiers and police, used their position to earn wages via informal tax collection due to lack of provisions from the central government. High accumulation of foreign debt and the lack of transfer payments create economic poverty from inability to rely on the government for provisions at multiple levels. This builds distrust among

citizens toward political officials and creates a class system within existing political structures as civil servants fight for resources.

Table 5: Demographic drivers of deforestation in the Lake Télé-Lake Tumba Landscape

	SPECIFIC ACTIVITIES	EVIDENCE
POPULATION GROWTH	Natural increment	Failure to adapt childbearing habits to lower death rates experienced in pre-colonial and colonial eras (Oliver and Atmore, 2000)
	In-migration	
UNEVEN SPATIAL DISTRIBUTION	Population density	
LIFE CYCLE FEATURES		Life expectancy is 47 and 51 for men and women, respectively (Wildlife Works, 2012)

Historical evidence, taken from the literature review, and survey results, taken from local population interviews, were used in determining which demographic factors contribute to deforestation in the landscape (See Table 5). From the results of the literature view and surveys, it was determined that DRC has a steadily growing population that has a high dependence on forests. Over the past 30 years, population growth has averaged 3.4% according to the World Bank. Natural incremental population increases are attributed to childbearing habits not adapting to changing advances in public health, such as reduced death rates experienced in pre-colonial and early-colonial times (Oliver and Atmore, 2000). Also contributing to an increase in population is in-migration

from rent-seeking migrants, such as farmers, fishermen, and soldiers. In-migrants coming into LTLT are those who have more resources e.g., money, tools, and weapons, and have been exploiting the forest at faster rates than those without.

Technology Factor Results

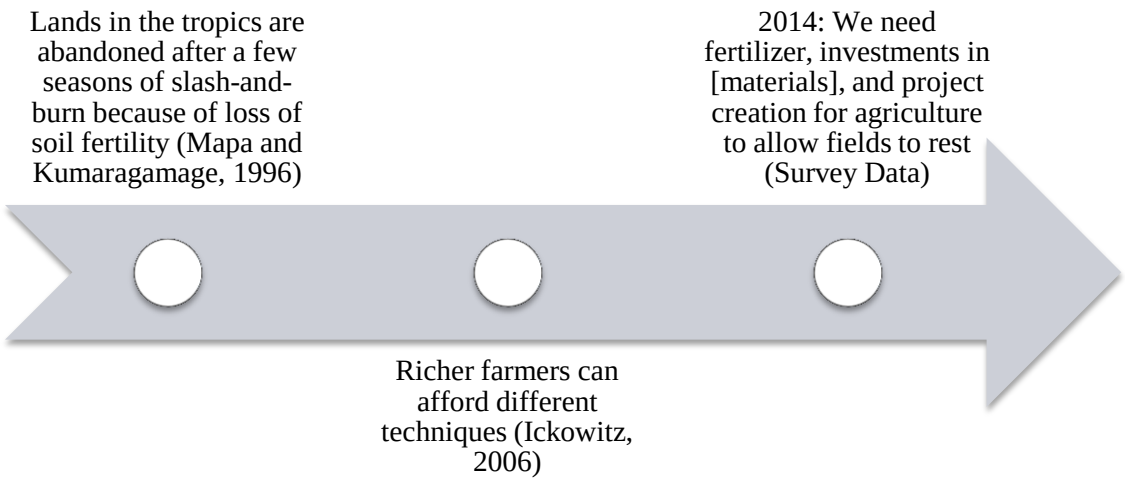

Figure 7: Timeline of technological driver of deforestation in the Lake Télé-Lake Tumba Landscape

Access to technology such as hunting tools, fishing nets, guns, and other resources associated with temporary camps and migrant workers contribute to deforestation in the LTLT Landscape via the tragedy of the commons theory[4]. Tools

[4] Tragedy of the common arises from situations in which multiple people acting independently and rationally for their own self-interest will ultimately deplete a shared, limited resource even though it may not be in their best interests to do so. The paradox of many and the resource curse amplify these conditions (McFerson, 2010).

make resource extraction easier but also unsustainable. Temporary camps are similar to invasive species, changing the dynamics of the ecosystem rapidly, having adverse and unsustainable impacts. Poor soil performance forces agro-technical changes (Table 6), which in this landscape is plot extension rather than plot intensification. Survey results show farmers are poor and lack access to technology such as fertilizers for which they say would improve the diminishing soil fertility. This is particularly true at Lake Tumba, where survey responses from communities highlight requests for fertilizer, materials, and agriculture development projects that will reduce the spread of fields deeper into forests. Figure 7 show views of shifting cultivation over time from various perspectives.

Table 6: Technological drivers of deforestation in the Lake Télé-Lake Tumba Landscape

Specific Activities		**Evidence**
Production factors in agriculture	Low technical level	Request for fertilizer, investments [e.g., materials], and project creation for agriculture in order to allow fields to rest were common request recorded (Survey Data)
	Labor-related factors	
	Labor-related factors	Lands in the tropics are abandoned after a few season of slash-and-burn because of loss of soil fertility (Mapa and Kumaragamage, 1996)
	Capital-related factors	Richer farmers can afford different techniques (Ickowtiz, 2006)
Technological factors in the wood sector	Poor logging performance	
	Waste in processing	
	Consumption	
Agro-technical change	Land-use intensification	See low-technical level
	Land-use extensification	Communities extend fields into forests because lands become unproductive

		(Survey Data)	
	Agriculture involution		
	Landholding size	The Plantation *Reunies de Bandundu* (PRB) owns 25 km^2 of rubber plantation in the *Nselenge*, *Mpili*, and *Kesenge* triangle (Wildlife Works, 2012)	
	Market versus subsistence production orientation		
	Intensity of labor and capital used	Fishing communities in the landscape are experiencing diminishing returns because of fine nets being used by opportunistic fishermen (Survey Data)	

Cultural Factor Results

Low expectations make the tragedy of the commons theory the fundamental cultural ideology of life in the Congo. A culture of low expectations drives poverty through further reliance on forests for livelihoods because there is a lack of government provisions due to mismanagement and poor fiscal administration. A culture of abuse was created by mass killings, beheadings, and decapitations under Leopold (Hochschild, 1998). This is historical evidence that alludes to the disregard and unconcern for the people of the Congo that persists into present day (Table 87). A culture of poverty was created during the land grab for colonial Africa. The interior of the country was already economically poor due to its isolation in dense forests, which left these communities outside of trade routes. Therefore, these populations had no taxable sources of income

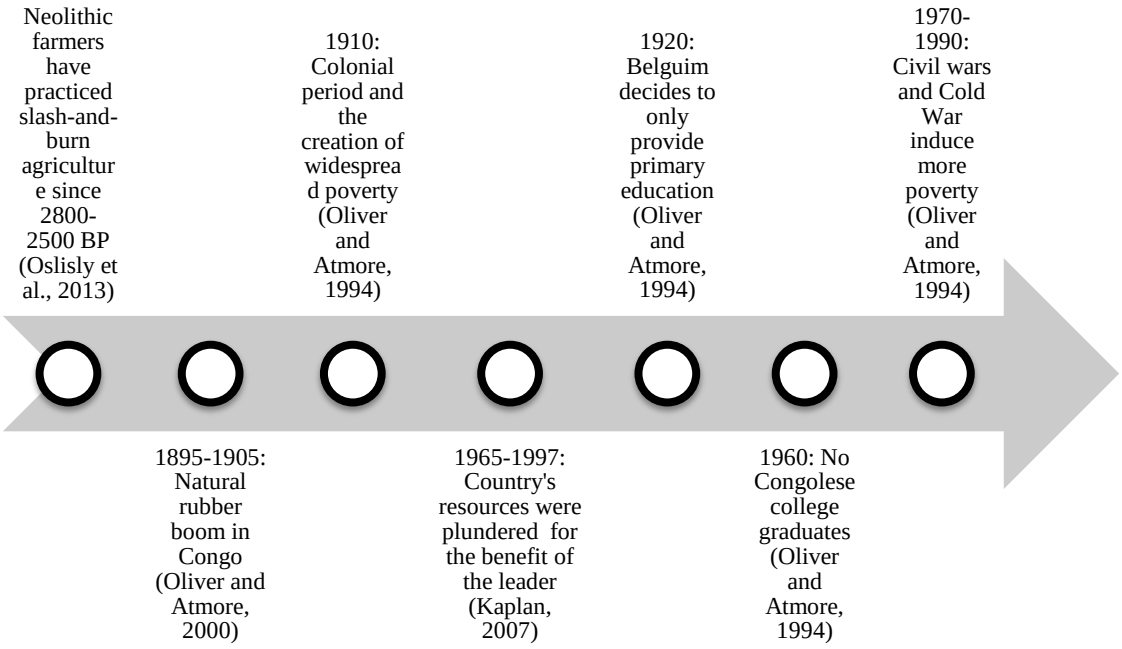

Figure 8: Timeline of major cultural events driving deforestation in the Lake Télé-Lake Tumba Landscape

outside of agriculture and non-timber forest products (Oliver and Atmore, 2000). Economic poverty became inescapable when market prices valued forest timber over the non-timber products that communities rely on while concomitantly practicing exclusion in the management and benefits of timber sales.

Marginalization was further woven into the culture from 1895 to 1905 when Congolese were coerced into working for minimal wages during the rubber boom to pay for expenses of government and modern communication that was not accessible to them, financially nor socially (Figure 8). Congo Free State became the Belgian Congo, yet policies still marginalized the Congolese greatly. French and German colonies began focusing on education in their colonies around 1925. Belgium decided it was only necessary to focus on primary education, "in order to bring the inhabitants of the colony up at a uniform pace" (Oliver and Atmore, 2000). Belgium's colonial policies on education left the country with extremely low education rates, apparent in the zero college graduates at independence and very few effective leaders to run the government in comparison to other newly independent colonies.

Table 7: Cultural drivers influencing deforestation in the Lake Télé-Lake Tumba Landscape

	Specific Activities	Evidence
Public attitudes, values, and beliefs	Public concern or lack of support for forest protection and sustainability	Country's resources were plundered for the benefit of the leader (Kaplan, 2007)
	Low morale/education	One year before Belgium pulled out, there were only three African civil servants among the country's 4,600 top officials and no African doctors, dentists, pharmacists, lawyers,

		engineers, or even veterinarians (Kaplan, 2007)
	Dominant frontier mentality	
	Prevailing attitudes of modernization, development, nation-building	Promotion of International policies
	Belief in the sacredness of nature and future generations	High among local populations (Survey Data)
	Beliefs about forest values	Low among government and political elite
Individual household behavior	Unconcern of individuals	Culture of political elite
	Rent-seeking behavior	Surrounding access and rights to natural resources (Survey Data)
	Non-profit orientation	
	Tradition, imitation	Practice of slash-and-burn agriculture

High cultural dependence is a driver of deforestation in the landscape. Cultural imitation of slash-and-burn agriculture is an inherited land-use practice. Based on the survey data it is practiced because the communities believe that forests are the best places to practice agriculture and their ancestors left forestlands to them for this use. Governmental cultural dependence on forests is for economic growth and stability of the country and its citizens. However, the corrupt organizational culture that exists among government officials and institutions has led to the unfair and illegal granting of concessions and siphoning of funds for a very long time now.

Money made from the sale of the country's natural resources, acquired via concessions, taxes, investments, and bribes made available through formal and informal policies, went to line the pockets of individual elites, rebels, Mobutu, and Leopold (Table 5). Country revenue tripled from 2000-2005, yet only minimal payments were transferred

to the provinces, or those living outside of Kinshasa (Marysse, 2004). Shekhawat (2009) estimated that between 60% and 80% of customs revenues have been embezzled. Governing bodies and institutions historically have had poor administrative and fiscal policies and a poor-performance track record of protecting their citizens and forests. From my surveys of local populations in the landscape, it is clear that public perception of various governing bodies is low. Community members cite corruption, theft, and greed, as the sources of their lack of confidence. Thus, a cyclical culture of corruption persists among individual household and institutional behavior.

Survey Results: Pressures causing deforestation

According to my survey results, there are five persistent pressures causing deforestation in the LTLT Landscape: agriculture, poverty, commercial concessions, temporary camps, and conflict. Of these five pressures, the results from the landscape rank analysis show the top three perceived population pressures causing deforestation were agriculture, determined to adversely impact forest cover across the landscape the most with a 38% majority population agreement, poverty 37%, and commercial concessions 21% (Table 8). Even though agriculture was determined to be the most salient driver of deforestation across the landscape, it is important to note that there are differences between the two lakes. At Lake Tumba, agriculture (34%) was ranked second to poverty (48%).

Table 8: Frequency ranking of proximate pressures causing deforestation in the Lake Télé-Lake Tumba Landscape

		Total Landscape	**Lake Mai Ndombe**	**Lake Tumba**
Categories	Variables	Population N=322	Population N=172	Population N=150
Agriculture Expansion	*Agriculture*	38%	41%	34%
Social Triggers	*Poverty*	37%	27%	48%
	Over Fishing	1%	1%	1%
	*Conflict**	40%	37%	43%
Infrastructure Extension	*Roads*	1%	2%	1%
	Waterways	1%	2%	1%
	*Temporary Camps**	39%	41%	37%
Wood Extraction	*Commercial Concessions*	21%	27%	15%

The results from the village cluster analysis show that there are five persistent pressures causing deforestation in the landscape (Table 9). Of these five, agriculture and poverty were both ranked as most important by 44% of villages. Within the landscape, the village cluster analysis also highlight that there is seemingly much difference between the lake communities. At Lake Mai Ndombe, 41% of villages cite agriculture and 38% cite temporary camps as major pressures, whereas at Lake Tumba 67% of villages cite poverty and 42% cite conflict as highly pressuring forests. Using the same rank scale, only 16% or 4 villages identified commercial concessions as a salient pressure causing deforestation within the landscape.

Table 9: Frequency ranking of pressures causing deforestation in the Lake Télé-Lake Tumba Landscape based on villages

		Total Landscape	Lake Mai Ndombe	Lake Tumba
Categories	Variables	Villages N=25	Villages N=13	Villages N=12
Agriculture Expansion	*Agriculture*	44%	41%	33%
Social Triggers	*Poverty*	44%	27%	67%
	Over Fishing	0%	1%	0%
	*Conflict**	32%	37%	42%
Infrastructure Extension	*Roads*	0%	2%	0%
	Waterways	0%	1%	0%
	*Temporary Camps**	32%	38%	25%
Wood Extraction	*Commercial Concessions*	16%	27%	0%

Table 10: Frequency of multiple-proximate factor causation

Agro, Ag = Agriculture Expansion Social = Social Triggers Pov = Poverty Wood = Wood Extraction Infras = Infrastructure Extension	Total Landscape		Lake Mai Ndombe		Lake Tumba	
	N=25		N=13		N=12	
Agro-Wood	19	76%	10	77%	9	75%
Agro-Infras	14	54%	9	69%	5	42%
Agro-Pov	22	88%	10	77%	12	100%
Agro-Social	12	48%	6	46%	6	50%
Wood-Infras	8	32%	7	54%	1	8%
Wood-Pov	16	64%	7	54%	9	75%
Wood-Social	6	24%	2	15%	4	33%
Pov-Social	11	44%	5	38%	6	50%
	3-factor term of causation					
Ag-Wood-Infra	8	32%	7	54%	1	8%
Ag-Wood-Pov	16	64%	7	54%	9	75%
Ag-Wood-Social	6	24%	2	15%	4	33%
Ag-Infras-Social	3	8%	2	15%	1	8%
Wood-Infras-Social	1	4%	1	8%	0	0%
	4-factor term causation					
All	13	52%	7	54%	6	50%

The results from the interlinkage among pressures analysis show that agriculture-poverty is the most salient pressure tandem that individuals view as affecting forest cover in the landscape, accounting for 88% of 2-factor cases. However, this slightly changes at the lake level where pressure tandems further validated the divide between the lakes

(shown in Table 10). At Lake Mai Ndombe 77% (10 of 13) of communities identified the agriculture-wood and the agriculture poverty pressure tandems and at Lake Tumba 100% (12 of 12) of communities identified the agriculture-poverty pressure tandem. This validates agriculture and poverty as the two main pressures acting in the landscape.

Mixed Methods Results: Driver-pressure Tandems causing deforestation

Political and institutional factors are driving agriculture expansion, wood extraction, infrastructure extension and social triggers

Political and institutional factors have a strong influence on proximate causes. Formal policies are often established but never enacted. Administrative authority and fiscal decentralization are not actualized, which limits institutional capacity. Informal policies, such as corruption and clientelism, are ingrained into the culture of governmental organizations. And property rights regimes continue to undermine authority because of land tenure insecurity and long-term marginality of local forest dwelling populations. Political and institutional factors account for 23% of cases and impact all five identified pressures. See Table 11.

Table 11: Driver frequency analysis results

	Absolute	Relative	Cumulative
Political/Institutional Factors	42	23%	23%
Economic Factors	42	23%	46%
Technological Factors	38	20%	66%
Cultural Factors	34	18%	84%
Demographic Factors	30	16%	100%
Total Cases	186	100%	

Agriculture: Long-term marginality of local forest-dwelling populations established in the original land race is further driven by property rights regimes that continue to undermine and promote land tenure insecurity. Administrative authority and fiscal decentralization are also not actualized. Formal policies are often established but never enacted. This limits institutional capacity, incentivizes corruption, promotes clientelism, and becomes ingrained into the culture of governmental organizations and officials. Failed policies, poor performing institutions, and corrupt public administrators cause deforestation by creating high inflation and inability to rely on government for help or provisions, drive local populations to use forests as safety nets. This same argument is true on a larger level, seen in how the political elite treats the 'common good' of forests as banks for personal use. The multiple levels of government failures equate the DRC as a failed state because this is a system that never meets its obligations.

Poverty: Failed policies have created high and fluctuating inflation, large national debt, and economic poverty for citizens; see Table 2 and Appendix B. Economic poverty is most felt at the community level; as resources do not trickle down, communities turn to forests to sustain their livelihoods and therefore use forest as their only means of collateral.

Commercial Concessions: Weak institutional capacity caused by clientelism has created an illegitimate culture among political and government entities. Because there are no effective sanctions for misconduct, concessions are granted by whomever whenever (see Political and Institutional Factor Timeline above). During the forestry reform in 2002, a review of 285 logging contracts that covered 43.5 million hectares of

rainforest was conducted. The initial review only assesses payment of taxes and canceled 163 contracts covering 25.5 million hectares of rainforest (Debroux, 2007). Forest loss drives environmental poverty while the lack of economic equity in concessionary profits continues the cycle of economic poverty, leaving communities trapped in a harmful cycle of trade-offs.

Temporary Camps: The lack of effective policies and policy implementation allows for exploitation and thereby overexploitation of the country's natural resources. "Too much of a good thing" theory applies here, where opportunistic exploitation causing deforestation eventually creates diminishing returns. Temporary camps are usually filled with those individuals who have access to resources; resources equate to hard currency or the ability to acquire tools and materials. These individuals are able to capture resources at faster rates than impoverished community members, thereby furthering the cycle of economic and environmental poverty.

Conflict: Authoritarian rule that restricts constitutional rights and privileges causes' conflict. Privatization of free and independent press similarly generates conflict. Failed governance crafts national and also local level conflict. Politics is the study of who gets what and why, and those who are left out of the political pie can be major contributors to conflicts and unrest. National conflicts in DRC and local conflicts within provinces follow these trends where both contribute to deforestation by more people using more resources to increase livelihood and financial stability.

Economic factors are driving agriculture expansion, wood extraction, infrastructure extension, and social triggers

Nationally- and internationally-led economic policies have caused an unstable economy, uneven economic development, and high foreign debt. Economic structures, price variables, and market growth are ways in which economic factors drive deforestation at the proximate-pressure level. Broadly, both formal and informal economic structures and policies have led to illegal wood extraction and a large economically marginalized and impoverished population. In the LTLT Landscape, economic factors drive 23% of deforestation cases and impact four of five pressures (Table 9).

Agriculture: Economic poverty at the local level drives agriculture expansion as a function of destitution because forest conversion is seen as the best method contributing to livelihood security. Clearing forestland for new agricultural plots fuels a cycle of environmental-economic poverty.

Poverty: The lack of economic structure, poor fiscal control and administration, and failure to effectively practice fiscal decentralization has created impoverished constituents within the landscape. This is apparent in that the DRC leads the race to the bottom on almost every indicator on the UN Human Development Index List.

Commercial Concession: At the national level, forest conversion is seen as the best way to promote development. Granting of credits, subsidies, concessions, and other investments is how development is practiced. However, the culture within governmental organizations and among public officials is that they are unconcerned about holistic provisions of these forests. This is seen in the frequent granting of illegal concession

titles, which directly cause forest loss and do not take into account cultural or economic values of non-timber forest products.

Conflict: The different ideologies on fiscal decentralization are having detrimental effects on natural resources. Accumulations of wealth rooted in greed have historically been the catalyst of conflict in the DRC and other Congo Forest Basin countries. Countries that experienced short or long periods of conflict during political independence left a poverty-stricken underclass of citizens totally reliant on forests. Provincial economic powerhouses historically were uninterested in fiscal socialism. At independence, Moise-Kapenda Tshombe, leader of the Katanga province, with the support of President Joseph Kasavabu, wanted to set up a loose federal system, where power would be centralized at the provincial level and among tribal groups (Oliver and Atmore, 2000). Patrice Lumumba, the country's first prime minister, had a vision for the importance of a single, national party, while promoting the idea of fiscal decentralization and unity of the country. These conflicting ideologies fueled poverty present from the historical marginalization and it can still be seen today. This is important, because as political leaders in the country changed over time, forests and the country's natural resources continued to be plundered. This is evident in that power and money continue to remain concentrated in the hands of an elite few, instead of trickle down economic policy structures that exist on paper.

Temporary Camps: Economic drivers such as rent-seeking behavior practiced by individuals and groups contribute to deforestation through the tragedy of the commons theory. This view is persistent throughout the landscape and mainly surrounding

agriculture and fishing activities. There is a positive relationship between deforestation, resource degradation, and opportunistic behavior. Deforestation increases as profits from forests resources increase.

Demographic factors are driving agriculture expansion, wood extraction, and social triggers

Demographic factors drive 21% of cases and affect four of five pressures. Population growth underlies agriculture expansion, poverty, and other social triggers in causing deforestation by pressuring environmental and social thresholds and in some cases surpassing them, e.g. conflict.

Agriculture: Population growth means more people, more food required, and thereby more land use to practice slash-and-burn agriculture.

Conflict: A lack of means and limited space can create conflict. At Lake Tumba there is conflict over fishnet size usage. Smaller size catch nets, such as mosquito nets supplied by well-meaning but misguided non-profit organizations (Brooks et al., 2011), have been at the center of many problems concerning catch size and fishing rights. Conflict produces refugees, for example the Dongo conflict over fishing rights had approximately 2,700 casualties and 150,000 refugees (Sanguma, 2012). Refugees contribute to deforestation because they use the forest ecosystems as the sole resource for rebuilding since leaving behind their homes, standing crops, seeds, and tools (Biswas and Quiroz, 1993; Oliver and Atmore, 2000).

Poverty: Population growth drives poverty because historically these populations were born into circumstance created impoverished conditions. Poverty is amplified by

land scarcity and become cyclical because of the pressures placed on forests from overusing ecosystem services. This increases migrant behavior in quest for livelihood support.

Temporary Camps: Temporary camps are a result of commercial concessions and soldier camps. Population growth increases as a result of proximity to camps and this drives deforestation through pressures related to quest for livelihood support under limited resources and competition from rent-seeking behavior.

Technological factors are driving agriculture expansion, infrastructure extension, and social triggers

The lack of technology in agriculture production, such as the use of fertilizers and machinery, drives plot extension in search of more productive lands. This cycle increases poverty amongst the population here, creating a cycle of environmental-poverty driven by the need to deforest. However, access to technology can also diminish ecosystem health. For example, some fishing communities in the landscape are experiencing diminishing returns because of fine net usage and a lack of respect for traditional fishing laws and policies. Technological factors account for 21% of cases and drive four of five proximate-pressures on the ground (See Table 9).

Agriculture: Individuals and the communities at-large lack access to agro-technology products, such as fertilizers and other tools that can be used to intensify soil fertility. Without such plot intensification tools, plots are extended in order to account for loss in productivity of soils.

Conflict: On a larger political scale, access and limitation of access, cause conflict. Conflict has a history of causing deforestation in DRC from refugees alone, not to mention the deforestation that occurs from the illegal sector that thrives during conflict (Oliver and Atmore, 2000; Biswas and Quiroz, 1993). Within the landscape, access to technology drives conflict over resource usage and rights. Conflict has ensued around deforestation at both lakes and specifically around fishing rights at Lake Tumba.

Temporary Camps: Access to technology drives opportunistic migrant workers in the landscape. Workers reduce bushmeat and fish stocks and cause deforestation through new land settlers' support. Support is defined by increased resource usage needed to sustain the increase in population, and guns and weapons provided to locals by military for hunting.

Poverty: A lack of technological inputs was proven to contribute to deforestation through land-use extensification. Land extensification is practiced because there are low technological inputs due to the lack of economic capacity. Low technological inputs force farmers to extend their fields in search of more productive soils. This creates the cycle of environmental poverty. Environmental poverty becomes a cycle because the fertility of the environment for which the community depends on for their livelihood is reduced with use; however survival is dependent on use.

Cultural factors driving agriculture expansion, wood extraction, and social triggers

The corruptive organizational culture of government officials and institutions in the wood and infrastructure sectors drives deforestation. Cultural marginalization creates poverty and leads to environmental degradation and from the lack of basic government

provisions. Deforestation in these instances is driven by cultural related poverty conditions. These factors drive 14% of cases and affect three of five proximate-pressures.

Agriculture: Traditionally, cultural imitation, for example, slash-and-burn agriculture, causes deforestation through the conversion of forest to agricultural plots (Kull, 2009). Within the landscape, survey responses captured that forests are the best place to practice agriculture activities and because forestlands were left to them by their ancestors to practice these activities.

Poverty: A culture of marginality and impoverishment that was initially developed during the era of King Leopold was further developed under the rule of Presidents Mobutu and Kabila. Low education and morale that was established in the pre-colonial and colonial period define the social poverty that exists among communities that rely on forests. Initially created in the institutional shift from an agrarian to a market economy, the over extension on the margins of the natural resource market economy and the lack of spending restraint created overall country-level poverty. There was large national foreign held debt created by the absence of fiscal decentralization and the presence of corruption. This triggered individual poverty and destitution because of the established culture of poor performance and disregard for the sole entity in which these populations can rely on for their basic health and wellbeing. Therefore, as poverty increases and more individuals become entirely reliant on forests resources for their survival, they will contribute greatly to deforestation.

Conflict: “The state of war in contemporary Africa should [in fact] be conceived as general cultural experience that shapes identities, just as do the family the school and other social institutions” (cited in Benduce, 2006).

Discussion

National Policy Drivers

Political conditions in Central African states have a long history of cultural, political, and environmental marginalization, making the drivers of deforestation particularly powerful and highly responsible for the conditions that persist on the ground. Rudel (2013) uses conditions within political boundaries of Central African states as indicators for assessing driver-pressure tandems effects on forest cover change. Political boundaries of the DRC and the conditions within the state are useful indicators for determining anthropogenic forest cover change. Forestry policies have failed to protect forestlands, and have failed to do so since the European discovery of the wealth and abundance of natural resources here (Hochschild, 1998; Oliver and Atmore, 2000; Conrad and Murfin, 2010).

Nation-states exist for the purpose of providing political goods to constituents within their borders and will succeed or fail based on the strength or weakness of their methods for achieving those goals (Rotberg, 2003). Congo has time (Leopold era), and time (Mobutu era), and time (Kabila eras) again failed local constituents in the provision of quality and equitable services. This demonstrates a pattern of failed policies being drivers of the deforestation persisting in DRC, across the region, and in other tropical rainforests globally (Geist and Lambin, 2001).

The DRC is a failed state because national government officials continue to practice harmful policies that lead to an unstable economy. Special price variables and other economic structures have influenced markets in the DRC such that there is high urban and peri-urban deforestation, supporting the Dutch Disease hypothesis (Rudel et al., 2013). DRC is experiencing urbanization without industrialization unlike some neighboring countries. For example, in DRC, a shift to cities is not happening at a rate fast enough to account for rural deforestation that is also occurring. Therefore, both rural and urban deforestation are persistent, highlighting a possible reversal of Dutch Disease.

Even after years of peace processing, negotiations, and signed accords, security in rural areas rarely improves (Virunga, 2015). Beneduce (2006) argues that a culture of war influences one just as one's family would. He argues that conflict in the Congo has been used to reshape structures of opportunity at the grassroots level and also stems from the motivation from perpetual negative or violent experiences. This is likely because political conditions improve on paper; however, citizens are still experiencing the harsh realities from the breakdown of the political system on the ground. These realities are seen in the practices of extortion and kleptocracy, catalyzed by minimal economic activities, forced taxes, killings, detentions, executions, and systematic sexual violence against women and girls. Opportunity in forests increases competition and concomitantly limits rewards. Too much competition for the same or limits on rewards creates conflict. Conflict over resource scarcity is stated to occur within communities in the landscape.

Provision of political goods and services are only possible when security measures are sustained and sustained without coercion or arms. However, Congo has a

history of violence, which magnifies the historical and cultural marginalization of forest-dwelling communities and intensifies their poverty. Rotberg (2003) argues when countries fail in the wake of internal violence it leaves the state unable to administer the provision of goods and services to citizens. When such violence has exploded throughout the country, services and provisions that were barely delivered before become non-existent during times of conflict. Consequently, as the state loses legitimacy from conflict itself, it, too becomes illegitimate to constituents because of administrative disruptions. Once a state loses legitimacy, the response of the government is to 'restore faith' in the system demonstrating the system is functional in order for the system to be viable. This has not been the case in the DRC where security in the region has hardly improved as a result of policies created.

Foreign Policy Drivers

Numerous international policy indexes point to Congo being among the worst of worst. The DRC is ranked as a failed state for the past five years by the Fund for Peace, a fragile state by the World Bank and the IMF, and many others. However, international stakeholders continue to play a large role in perpetuating conditions that exist in the DRC today. The general consensus of DRC being a failed state is based on the argument that nation states fail because internal violence creates the inability to provide political goods to inhabitants. Political goods are described by Rotberg (2003) to be health and medical care, schools and knowledge, roads and railways, and other types of physical infrastructure. Also mentioned are financial and banking institutions, access, and the promotion of civil society.

The DRC cannot supply its citizens with basic goods and services because it is supplying the world with raw materials to stock cell phones and other wants. The historical trend of the DRC supplying the world with natural resources is not new, beginning with the rubber trade during the 1880's and 1890's, the materials siphoned from the country and forced labor to repay the debt of King Leopold in Belgium, a man who never stepped foot in the DRC, to supply materials for the Atomic bomb used in Hiroshima, and more recently for the highly sought conflict minerals of tin, tantalum, and tungsten, and gold also known as 3TG (Malcolm X and Breitman, 1992; Hochschild, 1998; Fleckner and Avery, 2011; Manhart and Schleicher, 2013). Natural resource industries make profits in the billion, yet the people of the DRC still live in extreme poverty[5].

Numerous whistle blowing attempts have been made to explicitly call out conditions in the Congo since the latter 1800s. The first of such whistle blowers was George Washington Williams, an African American politician and historian, who was the first to report atrocities in Congo to the World through an open letter address to King Leopold. Next was Reverend. Dr. William Henry Sheppard an African American missionary from the Presbyterian Church who produced firsthand accounts of the human rights violations. E. D. Morel, a British journalist wrote about the vast amount of natural resources like rubber and ivory leaving the Congo matched by only guns and ammunition coming into the country. Others included Prime Minister Patrice Lumumba, who was murdered, dismembered, and burned because even dead his body was still a considered

[5] http://www.worldbank.org/en/country/drc/overview

threat, and Malcolm X, who was assassinated less than 4 months after speaking out about the deplorable conditions imposed upon Congolese citizens by colonial powers. Thus, it is important to demonstrate that explicit acknowledgement of policy drivers have a history of being silenced.

By examining the narrative of foreign policy in the DRC, it is clear global perspectives harmfully outweigh local accounts and histories. Narratives, unlike market models and measurement instruments, have the ability of capturing the subjective nature of political realities (Stone, 2002), and as a methodology, narratives are used in many disciplines for reporting connected events in a story-like manner (Jones and McBeth, 2010). For the purpose of highlighting the political influence of condition still persistent today, it is important to introduce the thoughts of the first prime minister of the DRC, Patrice Lumumba. On the day of independence, June 30, 1960 six months before his assassination Lumumba stated "….we are deeply proud of our struggle, because it was just and noble and indispensable in putting an end to the humiliating bondage forced upon us. That was our lot for the eighty years of colonial rule and our wounds are too fresh and much too painful to be forgotten. We have experienced forced labor in exchange for pay that did not allow us to satisfy our hunger, to clothe ourselves, to have decent lodgings or to bring up our children as dearly loved ones" (Lumumba, 1960).

Narrative Policy Framework studies conditions and communications through two levels, micro and meso. Micro-level analysis is a valuable persuasive insight into specific user-groups but limited by its implications and narrow scope. Meso-level analysis is useful for explaining how policy narratives influence policy outcomes. Cook (2010)

argues that American administrations favored the narrative of genocide over the plunder and land grab of the natural resources of the DRC. He supports this claim by highlighting Washington[6] ignores economic sub-factors as the reasons for insecurity in the country and in the region; citing strong states perform well in these categories, whereas weak states are failing. Thus, social scientists use narratives as a way to present empirical information because policy problems follow a similar structure to that of a narrative in that they have a beginning, middle, end, climax, a change or transformation, heroes, villains, victims, and evil forces are pitted against good ones. And, overall narratives are strategic in portraying stories and shifting value dimensions of a debate to restructure political coalitions (Jones and McBeth, 2010).

Public Administration Drivers

The absence of actualized fiscal and administrative decentralization supported by fiscal transfers is a main driver of the informal society that exists among low-level civil servants, such as police and military personnel. This highlights that administrative failures happen long before violence erupts and can play a significant role in causing inner-country conflict. Administrative failures are linked to un-actualized formal policy, such as the lack of transfer payments from the central government to regional governments. Lumumba articulated for a unity state with redistributive fiscal decentralization, a view opposed by Moise Tshombe, Belgium, and other international powers. True fiscal decentralization according to Lumumba meant the wealth of the country remains in the country and for the people.

[6] Washington, District of Columbia, USA

Decentralization as an international foreign policy measure put forth by the World Bank and IMF called Structural Adjustment Programs (SAPs). This reinforces the notion of foreign policy driving forest cover change and highlights implicit scales of influence present within driving forces. Thus the failures of formal policies are the beginning of the breakdown in the system. This happens because formal policies need money transfers for administrative actualization, policy implementations, and for salary payments. The system will not function if public administrators are not paid for services rendered and thus system failures are because of the reliance on informal collection methods for subsistence. Poor administration impedes an organization's ability to effectively implement policies. Limited implementation efforts and poor administration factors are persistent responses recorded by LTLT community members.

Pressures

Agriculture

Slash-and-burn agriculture is cited the primary cause of deforestation in the landscape. The majority of deforestation in the landscape occurs around Lakes Tumba and Mai Ndombe, respectively (OSFAC, 2010). It has been assumed that this type of agriculture is the biggest threat to forests by scientist and policy experts who cite numerous rationales. The most notable is the book *The Soil Under Shifting Cultivation* published by Nye and Greenland in 1961, which references timeframes for sustainable fallow thresholds. However, my findings show communities living adjacent to lakes practice agriculture to become food secure, citing the forest resources as the foundation of their livelihoods. And, that agriculture practices vary based on area, crop, tools,

households, financial resources, and even among fields within the same household. Results from other field studies in the Congo Forest and West African agroforestry communities found little convincing data to show that fallow length has declined in tropical Africa (Ickowtiz, 2004; 2006). And, even though evidence used to support the breakdown in sustainability of shifting cultivation are debatable at best, more important is the rationale put forth by communities because of their quest for food security. Thus, if fallow periods have always varied, then it must be the introduction of new forest pressures, e.g. commercial concessions, temporary camps, conflict, and poverty which stem from anthropogenic drivers, e.g., failed governance, economic poverty, and cultural marginalization that are the gross determinants of deforestation and stress to the state of the ecosystem.

Poverty

The only place in the world where urbanization is associated with negative economic growth is Sub-Saharan Africa (Harsch, 2001). Monetary poverty was created by the installation of the market society and further propelled by the lack of government provisions, concern, and access to participate in such market has engineered the reversed the Dutch Theory. Market factors and conditions set at the national and international levels have not allowed for a surplus felt at the local level. In fact, economic conditions actually place greater pressures on forest communities, seen in their increased reliance on forests, equating to deforestation detectable by satellite and by local communities.

Poverty is the second most salient pressure causing deforestation in LTLT and the most persistent pressure identified by Lake Tumba communities. The results of poverty

are evident in these communities, especially when comparing Lake Mai Ndombe to Lake Tumba. At Lake Tumba there are specific requests for fertilizer and help with increasing soil fertility, which are attributed to the perception of high forest loss and diminishing agricultural returns. At Lake Mai Ndombe, poverty exists but concerns regarding changes are less drastic here and are expressed indirectly rather than drastic and explicit changes mentioned at Lake Tumba. It is also useful to highlight that the use and access to primary forest symbolize wealth and fertility and around Lake Tumba, the majority of those surveyed use secondary forests for livelihood activities.

Under the 2002 Forestry Codes, laws tasked wood-extraction concessionaires with creating management plan to help contribute to poverty alleviation. The assumption is urbanization will decrease rural deforestation, mostly occurring from slash-and-burn agriculture because companies will come and provide employment. This assumption coincides with the Dutch Disease where Rudel (2013) tested various independent driver variables to prove this case for many other Congo Basin Forest countries. However, although some deforestation patterns in DRC follow the Dutch Disease, what is occurring in the LTLT Landscape disproves this hypothesis for conclusively depicting the entire country. There is not enough employment to account for reduced rural deforestation, thus communities continue to cut. And, as policy discussion e.g. the Dodd-Frank Wall Street Reform and Consumer Protection Act, continually focus on the bottom line of global corporations, millions of impoverished local constituents, stewards, and historical owners of the land in DRC are left in the balance. Thus, forest loss seen in rural communities can be explained by extreme and persistent poverty.

Infrastructure extension chain-logically drives forest loss by opening forestlands for new agricultural fields via opportunity (Geist and Lambin, 2002). Using newly cleared lands cleared by roads or concessions introduces opportunity for communities to gain access to forest. The original deforestation alters the environmental state creating environmental poverty but the opportunity gained by local communities creates short-term food security and thus continues the impact cycle. This is especially true in LTLT where such driver cycles have created poverty and have prompted more use of forest by local populations. These cycles, which are ultimately a positive feedback between environmental and economic poverty, is further perpetrated by the lack of education, lack of rights to land, and a lack of access to alternative means, in particular financial ones.

Income and wealth impacts the choices of techniques used in resource extraction in the landscape. The average individual living in surveyed forest communities does not have access to resources outside the forests. I observed very little man-made trash in the major market hubs of Inongo and Bikoro. Trash sightings decreased as the distance from such hubs increased, becoming non-existent in most communities outside a 15 km radius. A man living in the Kesenge village around Lake Mai Ndombe saw an opportunity to sell a tree on his lands that fell after a storm event. The wood could be used to make desks for the school being erected by ERA and WLW. Because he did not have a chainsaw, his plan to sell the wood before it rotted had to be good enough to obtain an advance in salary to acquire the tools and material for extraction; ultimately the log was not used. This reinforces the notion of situational poverty created by the lack of money and opportunity. A study conducted in Cameroonian forests community's notes that the range

in access and ability of agroforestry practices went from the capability to purchase or rent chainsaws to being able to hire outside labor (Ickowtiz, 2006). Thus, those individuals who are privileged can extract resources at higher rates to obtain the biggest bang for their buck, e.g. logging concessions and temporary camps.

Temporary camps increase access to resources for campers and also communities. Camps are not present in all communities within the landscape, however, where camps do exist, the impacts are well seen. Temporary camps are associated with soldiers who provide community members with weapons for bushmeat hunting. Temporary migrants are also associated with opportunistic fishermen in the landscape who used unsustainable fishing techniques to maximize yields such as the use of mosquito nets. Inogwabini (2014) study also notes that people come to remote areas from major towns and have lots of time, energy, and money to invest in fishing. This is not the case for local fishermen, who find difficulties purchasing hooks, nets, and who more so rely on traditional fishing techniques. These findings highlight that temporary camps and other modern pressures occurring are problems of forest gentrification. Continued stress from gentrification pressures, e.g. concessions, roads, rent seeking migrant workers, are causing deforestation at unsustainable rates and the access created by these pressures fuels traditional slash-and-burn agricultural practices of forest dwelling communities.

Accordingly, the use of modern technology in forest resources extraction has caused economic and environmental poverty for local communities, as they do not benefit from the sale of resources nor the condition of the environment after extraction. Local communities are aware of the conditions in which they live and they acknowledge

that without the forest they will suffer, starve, and die. In the same breadth, forest dwelling communities have limited control over political conditions and rights to the land in which they live. Thus, the lack of transferred payments as well cycle of environmental degradation has created a survival-of-the-fittest mentality. This ultimately leaves forest dwelling communities trapped in a cycle of environmental-economic deprivation.

Conclusion

The complexities that exist among tragedy of the commons battles are best captured in strategic language and portrayed via narrative. Narratives are well suited for measuring causal relationships if the structure of the narrative is based on a model that can then be tested. In the DRC, narrative roles have been well defined by history and well portrayed in literature. Heroes are synonymously associated with aid and givers of aid; citing also nuns, persists, and missionaries who predate modern development workers. This ideology is well portrayed and analyzed in The White Man's Burden by William Easterly. Villains are heavily associated with logging and extractive industries and also local populations in their use of forests, whether sustainable or unsustainable. Victims include animals, particularly large megafauna' species that can be the face of conservation, such as the panda or bonobo. Local populations are also seen as victims of the problem of deforestation as their livelihoods are often affected by changing conditions in the environment. And lastly, evil forces in the case of natural resources can ultimately be broken down to mean those controlling the allocation of money, which is heavily associated with power and greed. The terminology of hero or villain is a representation similar to the analogy of planners and searchers used by William Easterly

(Easterly, 2006). Planners are those who plan to give, plan to do, while searchers are those who are actively engaged in finding ways to reach the targeted audience.

Recommendations

Research is needed to assess changes to the state of the forest as a result of forest loss caused by driver-pressure tandems. As it stands, the majority of the population practices agriculture for a living. If ecosystem services are reduced as an impact of deforestation, then livelihood security is in jeopardy for millions. If livelihood security is in jeopardy, then forests will not be sustained. Alternative livelihood support and training focused on soil fertility and poverty alleviation should be the focus of relieving pressures placed on forests. Thus, to relieve pressures and address state changes, management strategies should target ground level and focus on tackling agriculture expansion.

In order for management strategies implemented at the landscape-level to work, forest managers must also focus on addressing underlying drivers at the national and international levels for best results. These strategies should focus on good governance and policy creation that promote and actualize the prevention of future unsustainable forest destruction and that also provide services to forest communities. Alternative livelihood support should be tested as an indicator to reverse the Dutch disease hypothesis. Therefore, it will also be important to understand to what extent is external livelihood support provided currently to these communities. Most important is that future policies and implementation strategies seek to correctly address the driver piece of deforestation, because as deforestation increases, ecosystem services will decrease for all people.

CHAPTER 4: IMPACTS OF DEFORESTATION ON ECOSYSTEM SERVICES, WILDLIFE, AND HUMAN HEALTH IN THE NORTHWEST DEMOCRATIC REPUBLIC OF CONGO

Introduction

The Democratic Republic of Congo (DRC) contains the largest block of the second largest tropical rainforest in the world (de Wasseige et al., 2012). The Congo Basin Forests is also the least-known wetland in the world (Keddy et al., 2009). Forests within the political boundaries of the DRC have averaged one percent deforestation per decade for the past 30 years (Potapov et al., 2012; Hansen et al., 2013). The Lake Télé-Lake Tumba (LTLT) Landscape, which also covers a small part of the Republic of Congo, is the largest wetland on the African continent and considered to be the largest wetland of international importance identified by the Ramsar Convention (de Wasseige et al., 2012).

Approximately 60 million Congolese in DRC are directly reliant on proper functioning of forests for basic provisions such as food, water, foliage, shelter, recreation, medicinal properties, and cultural attributes. It is important to determine the impacts resulting from driver-pressure tandems, as they are important indicators of ecological health. The reluctance to integrate human societal views into ecology conversations, studies, and action have been challenging because of the role humans play in stressing the environment (Rapport et al., 1989; MEA, 2005). Conversely, degraded environments

stress human health. The threat of disease moving to humans from animals is central to this argument citing the recent Ebola outbreaks in West Africa (Muyember-Tamfun et al., 2012). Threats are heightened by environmental degradation, e.g., forest destruction, which displaces animals and human communities and increases epidemics.

Ecological health is by extension the health of an ecosystem and its inhabitants (Aguirre et al., 2002). Thus, ecosystem health is the sum of interactions between human health, animal health, and plant health, which converge to determine ecological health of the system (Figure). Over time there have been challenges associated with conserving ecosystems because of the specificity of disciplines and the barriers associated with integrating these disciplines (Rapport et al., 1998; Aguirre et al., 2012). However, individually and concomitantly, changes in one component impact anther component, resulting in an altered ecological healthy state. Therefore the ecological state is always changing and long-term trends must be understood in order to better predict shorter-term fluctuations.

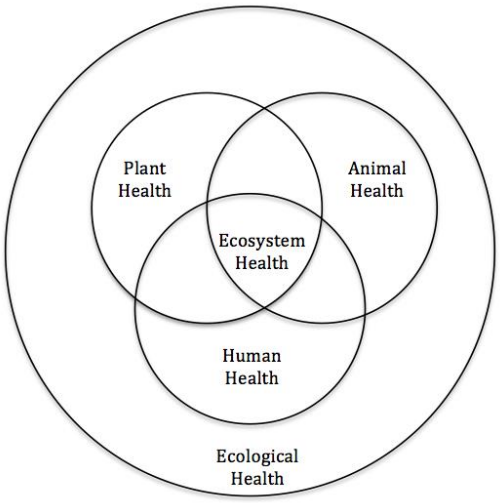

Figure 1: Expansion of ecological health spheres concepts used in efforts to discriminate conservation medicine in Brazil (Aguirre et al. 2012)

For centuries, communities living in the Congo forest have balanced forest destruction and food security through the practice of slash-and-burn agriculture (Malhi et al., 2013). However, changes in urban environments have benefitted external citizens from a certain environment at the expense of existing residents (Smith, 2002; Atkinson and Bridge, 2004). The gentrification of forests has increased pressures and displaced residents by allowing additional activities that result in their destruction. For example, the addition of modern pressures such as commercial wood extraction and poverty occurring concomitantly with historical deforestation activities has resulted in a harmful cycle of forest loss. Deforestation has adverse impacts on ecosystem services, which can also adversely impact the health of human communities and wildlife; therefore the ecological integrity of the LTLT landscape is in question. There are many measurement frameworks that effectively assess the impacts of stress on human, animal, and plant health

collectively (Rapport et al., 1985, 1998; Aguirre et al., 2002, 2012). The objective of this chapter is to evaluate the ecological health of the LTLT landscape by assessing the impacts to the state of human health, forest health, animal health, and lake health as a result of forest loss using a questionnaire, GIS data, and weather data.

Hypothesis:

1. The ecological health of the LTLT landscape is in a state of decline and is affecting forest communities including changes in food security, public health, and environmental resilience.
2. The ecological health of the landscape is interconnected; then human health, animal health, lake health, and forest health, cannot be compartmentalized.

Alternative Hypotheses:

1. If ecosystem services decrease as a result of forest loss, then the health of local communities, wildlife and ecosystems will also decrease.
2. If weather patterns are altered, then forest resilience will decline.
3. If local knowledge is used as a tool for determining environmental change, there are greater possibilities of assessing ecological health.

Materials and Methods

Study Site

LTLT (2°35’2’’N – 2°41’27’’S; 16°16’15’’E – 20°19’35’’E) is characteristic of flooded and floodable forests, covering 126,440 km2 an area larger than Uganda, Guyana, and Senegal (Devers and Vandeweghe, 2006). It is the world’s second largest swamp forest; the first is located in the Amazon (Vandeweghe, 2004). The landscape

regulates hydrological conditions in the Congo Basin and the climate of Central Africa (Devers and Vandeweghe, 2007; Bangwoy et al., 2013). It is a biologically diverse endemic botanical and zoological region, with many of its species threatened or endangered (de Wasseige et al, 2012). The DRC portion of the LTLT is approximately 80,000 km^2, representing more than 75% of the entire landscape. This region experienced a 2% forest loss from 1990 to 2010 (Chapter 2). This is the most overharvested area for wood in DRC because it is the only place where the economically valuable Wenge or black wood (*Mellitia laurentii*), is found. Deforestation in the landscape is more intense around the lakes, approaching 86% of the total deforestation of LTLT from 2000-2010.

Survey Collection

There are approximately 90-100 villages adjacent to these lakes, 60±5 around Lake Mai Ndombe and 30±5 around Lake Tumba. Communities were identified based on deforestation occurring adjacent to their villages, which was classified using satellite data and verified via ground truthing. The study was conducted between October 2013 and May 2014 in 25 villages, representing 25% of the communities living in LTLT. Using a community-based cross-sectional survey, selected households of pre-identified communities surrounding both lakes were sampled randomly. Surveys included villages experiencing a mosaic of low, moderate, and/or high deforestation rates. For more detailed methods of community selection, see Chapter 2 of this dissertation.

Surveys consisted of semi-structured questionnaires. This included open, closed, and ranking questions. Data collected were used to obtain local perception of forest attributes, changes, and management. Surveys also obtained data on local community

perceptions of ecosystem functions and services, frequency of use of goods and services, and perceived impacts to these services caused by deforestation (see full survey attached in Appendix A).

Weather Data Collection

Weather data were collected from the Mabali Scientific Reserve (MSR) located on a 1,900ha scientific reserve on the east bank of Lake Tumba (Devers and Vandeweghe, 2006; de Wasseige et al., 2009). Research technicians at the facility have continuously collected temperature, rainfall, humidity and lake-level data since 1970 (Inogwabini et al., 2006). Instruments used were rain gauges, thermometers, anemometers, and hygrometers, which were frequently calibrated to ensure accuracy. Data were collected at fixed times throughout the day in the following manner: air temperature was collected daily and also aggregated into monthly means. Precipitation data were collected per day and presented in monthly means and number of rainy days per month. Lake level was measured five times per month. Lastly, humidity was collected four times per day and presented in relative percent.

Weather pattern changes from 1970 to 2014 were determined by analyzing data collected from MSR. Trends in climate variables were used to determine if climate change was occurring in correlation to forest loss. Temperature (ºC) was analyzed by summing daily means. The amount of rainfall (mm) was summed to provide a daily total. Humidity (%) data was summed to provide daily means. Lake level was measured using a fixed 8m scale at the lakeshore near the research station. Trends of change were tested for significance using Pearson's R and t-test statistics.

Remotely Sensed Data Collection

Landsat Satellite images were used from the Monitoring the Forest of Central Africa (FACET in French) using remotely sensed data sets. FACET is a comprehensive, high-resolution (60m) wall-to-wall map of forest cover loss for the entire Congo Basin. FACET used the Decision Tree Approach for the wall-to-wall methodology (Potapov et al., 2013). The FACET data set was created using 8,881 30m resolutions Landsat Enhanced Thematic Mapper Plus (EMT+) images for three time periods: 2000, 2005, and 2010. The best available pixels of the compositing periods were selected to create mosaicked composites for the entire country. A final mosaic was produced for all classes: primary, secondary, and woodland (OSFAC, 2010).

Land cover changes from 2000 to 2005 and from 2005 to 2010 for block of forest around LTLT were determined digitally using previously categorized FACET map images by converting from raster to vector format. ArcGIS was used to determine areas experiencing high, moderate, and low amounts of primary and secondary deforestation. Highlighted results of deforestation areas for Lakes Mai Ndombe and Tumba were mapped to include water bodies, roads, villages, tributaries, and commercial concessions. Lake Tumba and Lake Mai Ndombe deforestation rates were then compared and contrasted.

Survey Analysis

Survey data determined which food products are most important to the communities living in the landscape. To do this, community members were asked to identify all sources of food they consume. I used quartiles and descriptive statistics to group and code collected data. To determine if food sources were impacted by

deforestation, community member were asked to identify how frequently they consume various food products. Environmental changes were determined by assessing change in human behavior using distance proxy questions to quantify stress on ecosystem services. Chi square (χ^2) tests were used to determine significance between change in acquisition time of the ecosystem good or service and the population's perception of the impact that deforestation has on that good or service. If the relationship was proven to be significant, then stress is considered to be occurring.

Community medical resources were identified by survey data. Community members were asked to identify if new diseases were occurring within the area and to list medicinal plants and their associated cures. To determine if medical resources were impacted by deforestation, a χ^2test was used to determine a correlation between the changes in collection time required to collect a forest resource and the community members' and perceived impact of forest loss; significant correlations were defined as stress. Stress was determined if correlations were significant. Lastly, survey data coded community member's recollections of changes in water and climate cycles as a result of deforestation. Coded responses were quantified and presented in percentages.

Mixed Method Analysis

To determine the impacts resulting from the diminishing forest health, a framework was created using LTLT as a case study, for assessing the deforestation impacts on local communities and ecosystem services in the Congo Basin. I began by identifying anthropogenic adaptations resulting from environmental change. This was accomplished by mixing qualitative and quantitative methods that combined empirical

data collected from surveying forest communities in the study area; weather data acquired from MSR; and remotely sensed map images of the study area acquired from the FACET report. Below are detailed steps of the analyses components. By triangulating data sources, mixed method analysis demonstrated ecological variables within forests were interconnected.

Remote Sensing and Weather Results

Remote sensing analysis results show the landscape experienced 1% of forest loss per decade between 1990 and 2010. And, 86% of the forest loss occurred around Lakes Tumba and Mai Ndombe, respectively. Weather analysis demonstrated that temperature and precipitation have remained constant since 1970. Whereas lake water levels have declined since 2001, humidity has increased since 1970, and, a majority of community members surveyed perceived that ecosystem services in the LTLT landscape are decreasing as a result of deforestation. Perception is forest loss is high, food supplies reduced, public health reduced, and changes in seasonal calendars may be occurring. Below, detailed results are presented for each specific weather parameter.

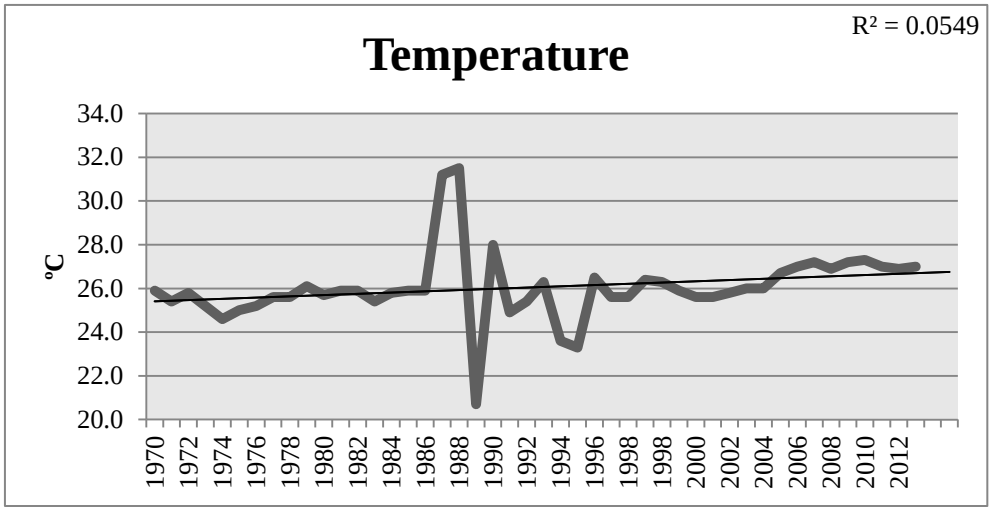

Figure 2: Yearly temperature averages

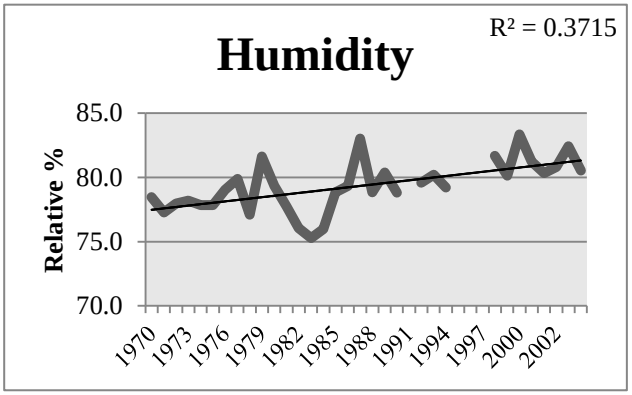

Figure 3: Yearly humidity averages

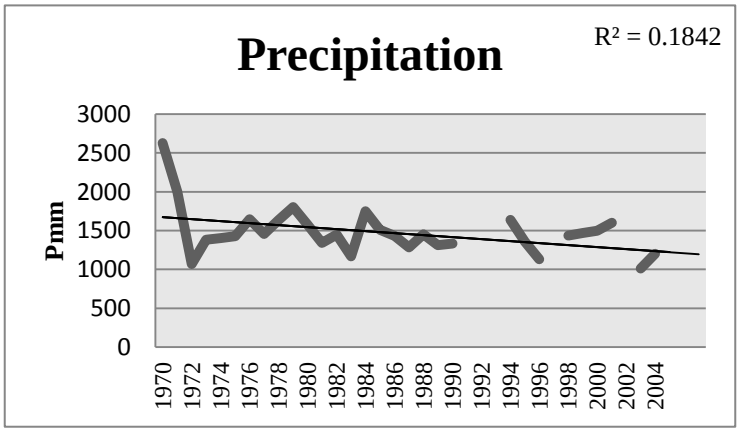

Figure 4: Yearly rainfall averages

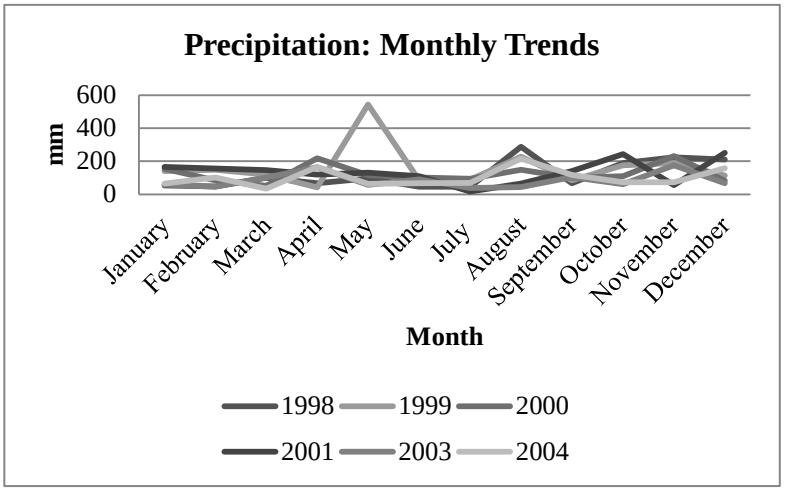

Figure 5: Monthly rainfall trends depicted by year from 1998-2004. 1999 was a moderately strong La Nina year for this region.

Temperature and humidity: Overall, the temperature and humidity within the landscape show an upward trend, however, the increase in temperature was not considered statistically significant (*p=0.72).* Temperature has remained constant since 1970 (Figure 2) and humidity has increased (Figure 3). In 1988 and 1989, temperatures in the area had extreme highs and lows, which are correlated with strong El Niño Southern Oscillation and La Niña events during those years that affected the African Continent.

Precipitation: Variables dependent on precipitation have remained constant (Figure 4). Precipitation increased in May of 1999 (See Figure 5) and this is correlated with a La Niña cycle over the region during that year. Data was not collected in 1997 citing the passing of Rwandese through the research area. There was also limited data collected in 1991, 1995, and 2002 for reasons unknown and thus those averages were omitted. However, because there is a high degree of variance occurring in precipitation

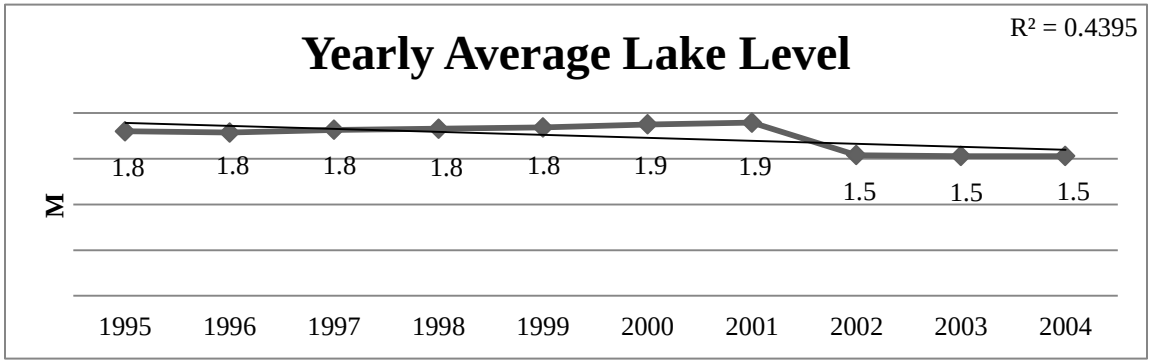

Figure 6: Yearly lake level fluctuation from 1995 to 2004

since the 1970s, the difference in the amount of rainfall in 1970 to 2004 was significant (*p=0.042).* Therefore, relative variance within the system has increased over the 34-year period; depicted in the fluctuating changes over a shorter period of time.

Lake level: Yearly precipitation trends have been constant between 1970 and 2004 in the landscape, even though monthly trends show significant variance. Because 75-95% of the water that falls over the Congo Basin is recycled, it is expected that lake level will decline under reduced rainfall; however, yearly water level changes in Lake Tumba were found to be insignificant (Figure 6). Similarly, monthly lake trends show greater fluctuations over time. Decreasing trends were found to persist during the following months: January, August and December declines were significant and February declines were not significant. Increasing trends were found to persist during April, May, June, July, October and November (Figure 7). This demonstrated that the first dry season beginning in January peaking in February has become drier, and the second dry season beginning in July ending in September has become wetter, particularly in July.

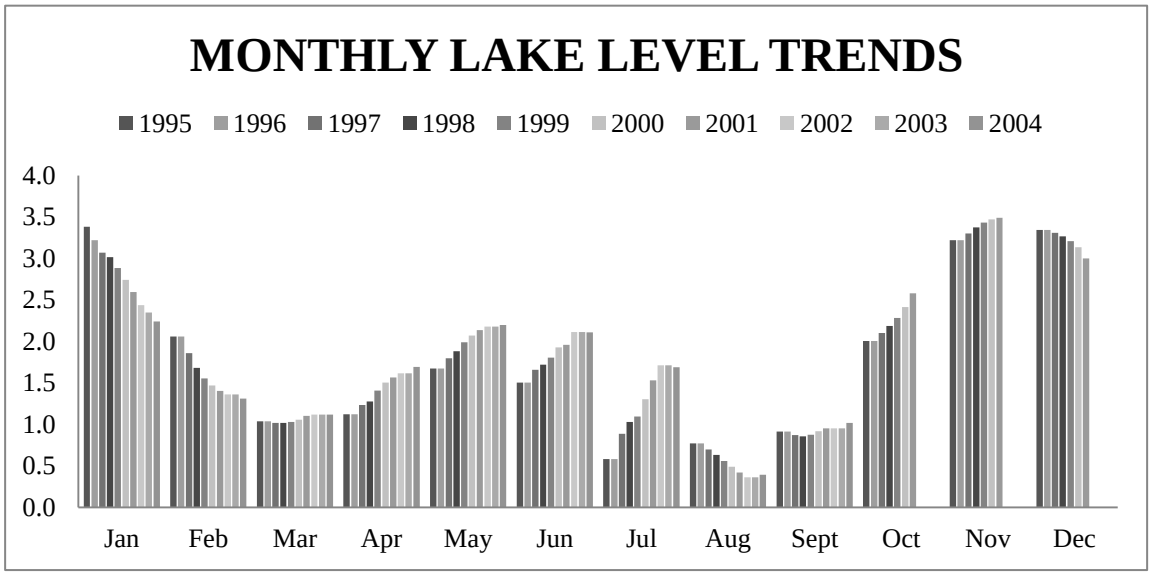

Figure 7: Monthly lake level fluctuation from 1995 to 2004

Survey Results

Forest loss: A 51% majority of individuals surveyed in the landscape perceive forest loss to be high. This is not consistent at the lake scale, where 57% of individuals living around Lake Mai Ndombe perceive deforestation to be high and the majority of individuals here are using primary forests and 45% of individuals living around Lake Tumba also perceive deforestation to be high but the majority of individuals here are using secondary forests. At Lake Mai Ndombe, 56% of those surveyed use primary forest for agriculture activities but at Lake Tumba 94% of those surveyed use secondary forest for agriculture activities.

Nutritional sources: Consumption of fish and bushmeat were declining in the landscape and populations articulated they were malnourished. Findings from the quartile

analysis conducted on bushmeat showed that the most frequently consumed species were monkeys, kulupas (*Cephalophus dorsalis*), mbegeles (*Cephalophus nigrifrons*), antelopes, and pambis (*Cephalophus nigrifrons*) and foxes, frogs, lions, leopards, and bats where the least consumed species. Findings from the quartile analysis conducted on non-timber forest products (NTFPs) demonstrated that the least utilized products in the landscape were rattan cane and the most utilized were caterpillars. Although 69% (N=322) of individuals in the landscape-scale consumed fish daily and 40% consumed bushmeat 1-2 days a week, there were differences between the two lakes. At Lake Mai Ndombe, 56% of the population (N=172) consumed fish daily compared to 83% at Lake Tumba (N=150). Also, at Lake Mai Ndombe, 67% of the populations also consumed bushmeat on a weekly basis, whereas at Lake Tumba, 49% of the populations consumed bushmeat only on a monthly or yearly basis and 19% did not eat bushmeat at all. The high reliance on caterpillars and less reliance on rattan cane may point to the productivity of the primary forests in their ability to provide high nutritional and economically valuable NTFPs.

In the landscape, 76% of those surveyed perceived that they spent more time in the forest acquiring bushmeat and 43% perceived that the impact of deforestation on bushmeat is high. The relationship between the perception of forest cover and the perception of time spent in the forest to acquire bushmeat was significant. However, individuals living in communities surrounding Lake Mai Ndombe perceived that the deforestation impact on bushmeat was low whereas at Lake Tumba the majority of the population described it as high.

In the landscape, 70% spent more time fishing and 43% reported that fishing impact on lake stocks was high. This relationship between the perception of forest cover and the perception of time spent acquiring fish was significant. In the landscape, 61% of those surveyed spent more time in forests acquiring NTFPs and 37% reported that the impacts on NTFPs were high. A total of 43% spent more time in forests collecting NTFPs.

Public Health: Public health was perceived to be decreasing in the landscape. That is, 72% at Lake Mai Ndombe (N=172) and 5% at Lake Tumba (N=150) reported that new diseases were occurring and malnutrition, anemia, and malaria were the most frequently mentioned. Communities associate anemia with deforestation, warmer temperatures and other changes in climate, and a lack of high protein food sources such as fish, bushmeat, and caterpillars. Anemia was often reported concomitantly with malnutrition. Malaria was associated with stagnant waters and temperature increases. At the landscape level, 37% noted a negative impact of deforestation on medicinal plants, with 47% reporting that medicinal plants were found deeper in the forest. There was a significant relationship between the perceived that impact of deforestation and distance required to obtain plants with medical properties. However, at Lake Mai Ndombe, an 18% majority reported that the deforestation was low and medicinal plants were found deeper in forest, whereas at Lake Tumba 28% perceived that deforestation to be high and medicinal plants also found deeper in forests. The majority of medicinal plants listed were to cure hemorrhoids, malaria, anemia, and fever. Medicinal plants to cure diarrhea and constipation were also frequently mentioned.

Temperature and humidity: In the landscape 62% of those surveyed (N=322) perceive that temperature is increasing and an overwhelming majority perceive that warming occurs in the dry season (see Appendix C for recalled dates of change). Very few respondents, mostly at Lake Tumba, mention that temperature increases during the rainy season and that hot temperatures persist through the night. Individuals living in the Ikita community (N=10) at Lake Mai Ndombe and the Nkoso community (N=10) at Lake Tumba state there has been an increase in humidity associated with rain events. Community accounts of increasing humidity are consistent with what is occurring in recorded weather patterns.

Precipitation: At Lake Mai Ndombe (N=172), 41% of respondents surveyed believe that there has been an increase in precipitation occurring in the month of May and flooding and violent storms in December. A respondent from the Lohenge community specifically noted that precipitation has been increasing "…. since 2003." Still, 29% of respondents here also noted that there is less precipitation now than before and an overwhelming majority those individuals who believed there was less precipitation also stated there was a drought during the 2013 dry season. Some even stated there was no rain for three months during this period. Droughts and decreased precipitation were stated to be occurring during the dry season, while increases in violent rains and storm events were reported throughout the year. At Lake Tumba (N=150), the majority of respondent's state that precipitation has increased during the small dry season occurring from January to March, while very few reported rain decreases in May.

Lake Levels: At Lake Tumba, the communities' perceive the lake is not as a deep as it once was, it is getting close to homes because of erosion, and a respondent from the Mpenda community recalls that every 20 years there is a big flood. Findings demonstrate that as people moved across the lake in 2002 and 2003 there were many accidents. Other observed changes here state that the water level is decreasing, pulsing is occurring slower, and sometimes not at all. Respondents also note there are strong and violent waves during the month of October because of storms. Observed water levels at Lake Mai Ndombe are also decreasing according to survey findings, particularly during the dry season. There are reports of storm events creating high and low water level extremes and there are claims that water levels in the lake were so low that people were able to "…walk across the lake on foot in 2002."

Discussion

Climate Findings

Climate changes still remain at the center as the most heated debates around the world. The effects of climate change are becoming more and more common, yet it still remains difficult to convince policy makers and common citizens of the urgency of the changes we see happening. The geographical setting of the LTLT area has been known for its constant climate parameters: little temperature variation, stable rainfall intensities, and low levels of water changes (Malier, 1966). Recent changes in weather patterns in the LTLT Landscape demonstrate that deforestation causes adverse land-climate interactions through the alteration of local climate parameters. From 2005 onwards, temperature has been increasing according to monthly trends and local perceptions. These findings are

consistent with global trends of rising temperatures where the last 10 years have been the hottest on record (NASA, 2015). Our findings on rain intensities and altered lake depth demonstrate a drying trend in the region. These findings are consistent with previous accounts from communities and civil society organization reporting high amounts of erosion around lake riparian areas (Inogwabini et al. 2006).

Remote Sensing Findings

Remote sensing has been used to quantify forests and its attributes for decades. Landsat satellite images and MODIS have been particularly useful for determining forest cover and loss within the Congo Basin because it is able to capture the small-scale deforestation that is persistent in these forests. The FACET report has identified forest cover and loss for the entire basin from 2000-2010. According to the DRC FACET report, the Equateur Province is considered to be one of three provinces that lost the most forested area in the DRC from 2000 to 2010; losing 2.5% of forest cover, whereas the neighboring Bandundu Province for the same time period lost 2.2%, which is not considered to be among the highest (OSFAC 2010). Per our survey findings, Lake Tumba residents are mainly using secondary forests for agriculture activities and at Lake Mai Ndombe residents are mainly using primary forests. This is consistent with the FACET report findings, which concluded deforestation is occurring at higher rates in the Equateur Province where Lake Tumba is located, than in comparison to the Bandundu Province where Lake Mai Ndombe is located. Environmental changes described by communities from this study can be corroborated with remotely sensed satellites and weather data, proving that deforestation causes adverse land-climate interactions. Being the largest

international wetland of importance, the significance of the area for regional climate, and the importance of this area to climate in the mid-west U.S.A thus global climate, makes changes seen extremely important for multiple reasons.

Community Health Findings

Human communities in this study have been able to identify and articulate the variance within the system because their livelihoods are dependent on these functions that have been reduced. The majority of individual's surveyed living around these lakes practice agriculture for a living. Because of deforestation and its subsequent impacts there is a widespread increase in food insecurity as ecosystem services decrease. Findings from survey analysis indicate that reduced forest functions have adversely impacted community health and food security by reducing essential goods and services such as bushmeat supplies, fish stocks, NTFPs, medicinal plants, and increasing disease and induced weather variability.

At Lake Mai Ndombe, deforestation and community impacts are reportedly lower than at Lake Tumba following the evidence that deforestation is higher around Lake Tumba. Agricultural activities are mainly practiced in primary forests at Lake Mai Ndombe because their access to this type of forest is greater, productivity is ideal, and therefore individuals living here do not use home gardens and are seemingly more food secure than those residing around Lake Tumba. Those living around Lake Mai Ndombe consume fish and bushmeat on a daily to weekly basis, whereas at Lake Tumba consumption patterns range from daily to yearly, highlighting the difference in food availability and indicating a scale for depicting food insecurity. Residents living around

Lake Tumba are engaged in aquaculture, animal husbandry, and home gardens in order to provide diversity of where their food comes from because the environmental conditions are highly variable citing significant change in the traditional agriculture calendar and reduced ecological resilience.

The culture of the people living in the LTLT forest is significant to sustaining forest resilience. Culturally, forest-dwelling communities have high amounts of environmental literacy, but as forests are degraded and destroyed, the culture that has been highly marginalized and therefore left untapped will also be lost. This is significant as human populations in this region have a long history living and conserving these forests (Malhi et al. 2013). The culture of stress and reduced elasticity or resilience is not new and is discussed in great detail by ecologist such as Odum and Rapport in the 1970s and 1980s. Stress is documented in the overfishing occurring in Lake Tumba because mosquito nets provided to households to prevent malaria were used as fishing nets instead (Kantu 2009).

Low fish stocks can be explained by altered climate and lake parameters at Lake Tumba where our findings demonstrate that diminished ecosystem services and diminished forest cover are positively related and that if current impact trends continue, greater effects are likely to occur in LTLT and adjacent forest ecosystems in varying degrees. Thus, as discussions continue surrounding the concept of "empty forests" (Bennett et al. 2002; Nasi et al. 2011; Wilkie et al. 2011), a forest void of megafauna, attention must be paid to the ethnosphere (Davis, 2003; Aguirre et al. 2012), or forests will be empty of all life. Many believe deforestation to be the physical act of destroying

forests, seen in previous classifications of blame for the state of forests on the small-scale farmer, however, any activity that results in the destruction of a connected forest component causes deforestation, and drivers and pressures causing deforestation have been proven to have varying scales of influence (Cuvelier et al. 2014; Parker and Vadheim 2014; Slade 2015). Thus, whether that activity is over fishing, mining, or policy, and applied by animal, plant, or humans, can cause destruction to a forest component that adversely impacts the ecological health of forests and thus resilience capabilities.

Currently, the majority of communities within the landscape are consuming moderately high-level trophic species and are gathering mostly high-in-protein NTFPs e.g. caterpillars and kola nuts. These species are not predator or keystone species such as lions and elephants nor lower-level species such as frogs, foxes, bats, rattan cane, and edible vines. The larger regional and global security implications regarding stress in these forests are climate refugees and a host of infectious diseases. Because African rainforests have a lower threshold of rainfall viability, making them more susceptible to retreat under drier conditions (Malhi et al. 2013), these findings are indeed significant because of the direct relationship that exists between local populations, the state of forest, and the various ecosystem services the forest provides. In the future we are likely to see that moderately-high trophic species that are currently consumed e.g. pambi (*Cephalophus nigrifrons*), kulupas (*Cephalophus dorsalis*), mbegeles (*Cephalophus nigrifrons*), run low, the least consumed species e.g. frogs, bats, and foxes will be threatened as they will be the only source of food for these communities. Even bonobos (*Pan paniscus*) are

mentioned as a source of food for communities, despite their ancestral ties being the closest human primate species. This shows that food choice decisions are being made out of desperation.

The consumption of bats and primate species has larger implications for controlling future food and water borne disease outbreaks (Aguirre et al. 2012). The same implication can be applied to NTFPs because as primary forests are reduced, secondary forests and its products become the foundation of primary production, such as increased rattan cane that has been documented to grow well in secondary forests (Panayotou and Ashton, 1992). As this shift happens, communities will be forced to rely more on secondary forests products, which have been proven to be less productive. A shift in food consumption patterns are similar to the gentrification experienced in cities (Cunningham 2000; Loewen 2013); citing the numerous urban areas deemed food deserts because of the reduced supply of healthy, nutritious, and accessible food (Smoyer-Tomic et al. 2006; Kwate 2008). The same fate is to come of forests as gentrification of forests continues, except what is to come for these communities will be worse because of limitation placed on migration.

Conclusions and Recommendations

Ecosystem services are diminishing across the landscape because of deforestation and the severity of results varies at individual lake-scales. The reduction of ecosystem services has environmental and anthropogenic impacts, both of which cause ecological degradation. Culture is reduced as perturbation increases because forests are not only places where forest populations practice cultural traditions, human culture in this region

are dependent on properly functioning forests for survival. Thus, without the forests, the identity of these people will forever be lost. An implication of this is an increase in lesser desirable food sources, denoting that this is already persistent at Lake Tumba where communities eat less fish because their lake is overfished and there are reported lower agricultural yields due to secondary forest use. Little attention has been paid to land-climate interactions at local and regional scales in Africa and the lack of information has huge implications for the regulation of climate parameters essential to the survival of LTLT communities. The lack of information on this critical region is detrimental as there are urgent needs to monitor the severity of climate change and its impacts here.

Grasping a better understanding of the relationship between forest communities and ecosystem services can provide valuable insight on how to sustainably manage forest. Historically, forest functions are influenced by changes in global climate and the African forests too, have shifted based on these changes. For example, forest cover in the Congo Basin has been influenced by these shifts, seen in the vast reduction of forestlands during drier periods. The focus on the future of global climate changes often neglects the fact that local climate changes are currently being experienced in these communities.

Further research is needed to assess responses to the omni-directional impacts of deforestation. As it stands, an overwhelming majority of the population living in the forest practice agriculture for a living, thus it will be important to understand the viability of conserving forest ecosystems from the perspective of local communities. And, because forest loss has caused ecosystem services to decline such that livelihood security has also been reduced, future studies should seek to assess community adaptations to deforestation

impacts and management's adaptive responses to deforestation impacts. Forests must be looked at for more than just timber, more than global climate security, but as the livelihood security for millions of humans living in them. Therefore, there is a need to equip local African communities to collect, analyze, and present weather data of local and global significance.

CHAPTER 5: EVALUATION OF REDD+ STRATEGIES FOR CONSERVING FORESTS: A CASE STUDY USING THE LAKE TÉLÉ-LAKE TUMBA LANDSCAPE IN THE DEMOCRATIC REPUBLIC OF CONGO

Background

Sustainable forest management was introduced in the early 1990s after a movement of international conferences and writings in the early 1980s focused on the concept of sustainability (von Gadow et al., 2000). In June 1992 the United Nations Conference on the Environment and Development (UNCED) initiated a world process for the sustainable management, conservation, and development of forest and forest resources. This approach to forest management looked beyond forests as trees and thereby as resources for extraction. The new approach sought to acknowledge all of the benefits that forests provide. However, there is still no universally agreed upon definition for sustainable forest management (SFM) (GEF Website, 2015).

The United Nations Forum of Forests (UNFF) has composed the most globally accepted definition of SFM, calling it "…a dynamic and evolving concept that aims to maintain and enhance the economic, social, and environmental values of all types of forests for the benefit of present and future generations." This approach of viewing forests holistically is in stark contrast to a previous theory, the wake theory, where the focus was timber above all other forest functions (von Gadow et al., 2001). This shift was timely as the role that forests play as major carbon reservoirs has catapulted these ecosystems to the forefront of global climate change discussions.

Introduction

Forests are highly significant in addressing multiple global challenges for the sustainable development of all countries. However, forest communities are still greatly marginalized, receiving very little if any benefit from either national or global-scale forest policies or transactions (Marysee, 2004). Transactions are occurring and payments are being made within the DRC; the country has been one of the top 10 recipients of humanitarian aid nine of the last 10 years[7]. Human communities living in forests are attempting to become food and economically secure, but, without the inclusion of the individual and collective voices of the 1.6 billion people who live in and directly rely upon these forests, management will not be sustainable. Slash-and-burn agriculture, for example, is occurring rapidly because individuals are seeking food and financial security for themselves and their families yet, at the same time, deforestation increases these insecurities.

Rainforest plants and animals serve as important sources of food for human communities. Two-thirds of terrestrial plant and animal species are found in forests (Pimm and Raven, 2000). Forests also provide clean air, shelter, medicines, spirituality properties, a host of other ecosystem services that are essential to the welfare and survival of humans, plants, and animals (UNMEA, 2005). From a local perspective, forests are a source for over 5,000 commercially traded products, both timber and non-timber (Janisheyski et al., 2008; SCBD, 2009; Mebrat and Gashaw, 2013; Aguirre et al., 2012). From a global perspective, forests serve as carbon sinks for current and future sources

[7] http://www.globalhumanitarianassistance.org/countryprofile/democratic-republic-of-congo

(Dixon et al., 1994). However, the destruction of forests inhibiting the long-term provision of necessary ecosystem services on which 1.6 billion people depend.

Local impacts of deforestation demonstrate an alter the ecological state of forest ecosystems seen in local land-climate interaction changes detectable by satellites (Chapter 2), in weather trends (Chapter 4), and articulated by communities living in forests (Chapter 3). National policy and economic failures increase the local reliance on forests and fuel the deforestation cycle. The exclusion of the local voice in the context of larger policy directives on forests is not only unsustainable for livelihood security of forest communities and the forests for global security reasons.

Payment for Ecosystem Services

The promotion of payment for ecosystem services (PES) in forests is increasing in popularity and has emerged as the main international strategy for mitigating climate change through alteration of land-use practices in developing countries (Angelsen et al., 2009). PES offers incentives for developing countries to reduce deforestation (UN, 2010). At the 2005 United Nations Convention on Climate Change (UNFCCC) Conference of Parties (COP) 11 in Montreal, the Coalition of Rainforest Nations proposed a compensation reduction mechanism plan to account for deforestation. This proposal was later turned into a campaign for reducing emissions from deforestation and forest degradation (REDD) by the United Nations. REDD plus the payments for ecosystem services (REDD+) was established under the 2007 Bali Action Plan under the UN Framework Convention on Climate Change (UNFCCC) as the primary mechanism to support forest conservation in developing countries. REDD+ Pilot countries in Africa

included the DRC, Tanzania, and Zambia; in Asia and the Pacific: Indonesia, Papua New Guinea, and Viet Nam; in Latin America and the Caribbean: Bolivia, Panama, and Paraguay. The purpose of creating the international framework of REDD+ was to create financial value for the carbon stored in forests through the pricing of carbon sequestration in order to make payments for the conservation of forests.

PES approaches to SFM were established to build the capacity of forest communities in order to conserve forests, utilizing standing forests to capture carbon. Pilot programs were launched in seven countries called REDD Readiness to prepare nations to implement REDD+ Demonstration Projects (UN, 2005). A multitude of actors at various scales have become involved in the provision of REDD+ programs and project activities (Cerbu et al., 2009). REDD+ Demonstration Projects accomplish SFM through programming implementation that provides co-benefits. REDD+ activities include, but are not limited to, poverty alleviation, economic growth, and other responses to drivers of deforestation, all of which are often insufficiently understood (Corbera and Schroeder, 2011).

Payment for Ecosystem Services in Africa

Africa has numerous REDD Readiness projects. Although Readiness investments are equally distributed across tropical rainforest regions, African projects are unequally distributed compared to Asia and South America (Cerbu et al., 2011, Wildlife Works, 2012). Demonstration Projects are financed by external agencies that formally base funding upon biodiversity benefits; however, an unofficial criterion for selection is based on previous relationships within the country.

Findings from a global survey on REDD+ projects showed that demonstration project investments exhibited a trend of funding good governance, past experience, and co-benefits (e.g., profits), often having little to do with climate change or sustainable economic development within the host country (Cerbu et al., 2009; ERPIN, 2014). This is significantly different than countries choosing to opt-in, like what took place in UN-sanctioned REDD+ Readiness projects. Likewise, only 18 REDD+ Demonstration Projects exist in Africa, compared to 40 in East Asia and the Pacific, 31 in the Amazon, and two in South Asia (Cerbu et al., 2009, 2011; IPCC, 2015). The lack of investments in Africa means that emissions reductions are not being maximized.

Payment for Ecosystem Services in the Democratic Republic of Congo

The DRC is the second largest country in Africa and holds two-thirds of the world's second largest tropical rainforest. A national coordination committee, CN-REDD, and the government agency MECNT (Ministry of Environment, Conservation of Nature and Tourism), are responsible for implementation of REDD+ in the DRC based on the Emission Reduction Program Idea Note (ERPIN), established in March 2014. The Department of Forest Management (DIAF) in the DRC is under the direction of MECNT. DIAF, along with the support of FAO and UN-REDD has been leading the development of the national measurement, reporting, and verification (MRV) system for REDD+ since 2009. The Direction de Development Durable (DDD), under direction of MECNT, coordinates REDD+ project activities and program policies for emission mitigation. The Congolese civil society organizations are organized into a platform of the Climate Task Force REDD+ (GTCR) with one of the organizations, Observatoire de la Gouvernance

Forestiere (OGF), dedicated to the independent monitoring of forest activities and Observatoire Satellital des Forets d'Áfrique Centrale (OSFAC) is collaborating with WWF and the University of Maryland College Park on the DRC's Carbon Map and Model Project to provide high-resolution emissions factor data via airborne LiDAR (Light Detection and Ranging).

The Forest Carbon Partnership Facility (FCPF) ERPIN for the Democratic Republic of Congo (DRC) confirmed what Cerbu (2009) highlighted that Readiness investments have often neglected weak governance and high deforestation countries that could ultimately benefit from the increased capacity of implementing REDD. REDD+ Demonstration Projects are mostly financed by external funders with a preference for high performance tracking, according to findings from Cerbu (2011). This is undoubtedly harmful to nations like the DRC, where failed policies, lack of decentralized fiscal authority, and overall poor governance and performance records likely discourage investments.

Despite acknowledged high levels of corruption, theft, and embezzlement, there are established REDD+ projects that can be assessed in the DRC. As of 2009, the DRC had four national REDD+ Readiness programs, 18% of the total Readiness Programs in Africa, and three REDD+ Demonstration Projects in the country, accounting for 16% of the total demonstrated projects on the continent and 3% of total global REDD+ Demonstration Projects (Cerbu et al., 2011). Currently, REDD+ Demonstration Projects (henceforth denoted to as RDPs) in the country include: (1) the Isangi project in the Orientale province, implemented by Jadora International; (2) the Mai Ndombe project in

the Bandundu province, implemented by Wildlife Works Carbon; (3) the Mai Ndombe/Lac Tumba jurisdictional program also in Bandundu province, implemented by World Wildlife Fund; (4) the Luki reserve project in the Bas-Congo province, implemented by WWF; (5) the Equateur (Mbandaka and Gemena) project in the Equateur province, implemented by Woods Hole Research Center; and (6) the Eco-Makala project in the North and South Kivu provinces, implemented by WWF.

Problem Statement

Current management responses are not addressing all the problems of deforestation in the DRC. The Congolese people have been exploited for their land, labor, and natural resource capital, where profits obtained by the individual and the corporations are linked to a mass cover-up of human rights violations that have been committed. Thus, it is imperative that REDD+ goals and objectives focus on community development, working in collaboration with existing local policies, rules of law, and culture within a given location (Geist and Lambin, 2002; Car et al., 2009). However, responses to address deforestation are greatly focused on global climate change mitigation, often ignoring the effects of climate change on local communities.

Key information is lacking regarding the creation and structure of the REDD+ policy framework at multiple scales, leaving REDD+ management strategies fragmented vertically and horizontally. Regulations governing afforestation, reforestation, and the role that indigenous groups play in providing information in the process have remained largely unexplored (Corbera and Schroeder, 2011). UN language specifically highlights the benefits of climate change mitigation for global communities, yet there is a failure to

explicitly include degradation reduction benefits for local communities (Seymour, 2008; Okereke and Dooley, 2010; Dooley et al., 2011). In addition, national level coordination is not greatly understood and the exclusion of civil society organizations has created great concern amongst local populations and groups regarding their benefits from participation in REDD+. DRC has been involved in REDD+ for 10 years and has been in the active Readiness phase since 2009. The implementation of emissions reduction plans and mobilization of funds are fundamental for local communities to receive benefits.

The premise of this study follows that if forest policies to reduce emissions are created to benefit individuals living in forest communities, then the creation and implementation of such policies should address relevant conditions persisting within the local arena in order to be effective. This study builds off the Geist and Lambin (2001) meta-analysis of drivers of tropical deforestation to test whether indirect and direct factors influencing forest cover are locally of globally based. Specially, I seek to determine the relevancy and effectiveness of response to deforestation in forests of the Congo Basin by asking: (1) What responses are used to reduce deforestation, and increase food security for forest-dwelling communities? (2) Do individuals living in forests perceive these to be effective responses to address the causes and effects of forest loss in their communities?

Methods

Study Area

The Central Africa Regional Program for the Environment (CARPE) is USAID's largest land management program in Africa. It was initially authorized in 1995 as a 20-

year, three-phase regional initiative to conserve the ecological integrity of the Congo Forests[8]. CARPE is headquartered in Kinshasa, DRC, but works throughout the six Congo Basin countries: the DRC, Republic of Congo (ROC), Central African Republic (CAR), Cameroon, Gabon, and Equatorial Guinea. CARPE has the strategic mission to protect the ecological integrity of the Congo Basin Forest for biodiversity and climate security.

The majority of CARPE funds are allocated for planning and management activities within 12 delineated Landscapes (Yanggen et al., 2010). The landscape management model is a strategy for understanding, developing, and implementing conservation at various scales within a designated political boundary. It provides a wide-range of sustainable management strategies that consider the social, economical, and environmental aspects of conservation. Congo Basin Forest stakeholders choose the landscape management model as a planning tool to address the larger issues faced, more than any single protected area. Most DRC RDPs were based in CARPE-delineated landscapes because of the advantages of designated political boundaries a wealth of biological and socioeconomic information, and previously contacted communities.

The Lake Télé-Lake Tumba (LTLT) Landscape is located in the heart of the Congo Basin and is centered on Lake Télé in the ROC and Lake's Mai Ndombe and Tumba in the DRC. The LTLT Landscape is the largest Ramsar freshwater wetland of international importance, the world's largest swamp forest, and the world's second largest wetland area (Seyler et al., 2010). This landscape is divided into three types of

[8] http://carpe.umd.edu/about/index.php

management strategies: community based natural resource management (CBNRM), extraction zones (ERZ), and protected areas (PAs). Most of the planning that has occurred within the landscape has happened on the ROC side of the landscape (de Wasseige et al., 2009, 2010, 2012; 2014), even though the DRC side comprises 57% of the landscape's land area.

The LTLT Landscape currently hosts two RDPs. The first RDP was established by WWF in communities surrounding Lake Tumba, located in the Equateur Province. WWF is an international non-profit conservation organization with a regional office, the Central Africa Region Program Office (CARPO), located in Kinshasa, DRC. WWF CARPO manages forests in various strategic capacities in order to conserve biodiversity and contribute to livelihood support and local autonomy. The second RDP is a 300,000ha of forests located in the Mai-Ndombe District of the Bandundu Province established by Ecosystem Restoration Services (ERA) and Wildlife Works (WLW) in communities surrounding Lake Mai Ndombe (Wildlife Works, 2012). ERA is an owned subsidiary of Offsetters Climate Solutions focused on developing large-scale carbon projects. Wildlife Works is a limited company based in San Francisco, California, USA, that has established REDD+ programs in Kenya. Both of these organizations subscribed to REDD+ goals and objectives by providing technical support and making payments to communities for not deforesting lands adjacent to Lake Mai Ndombe. Payments are made to local chiefs from the sale of carbon credits. Therefore, monitoring and evaluation of projects and current management can be based on the landscape boundary within a

specific country to determine the successes and failures associated with established projects.

Data Collection

Literature Review

The literature review will be used to determine if the organizations working in LTLT were responding to all DPSIR categories. A literature review was conducted using REDD+ project documents. This included governmental reports, UN reports, scholarly articles, and company reporting documents. Obtained UN-REDD+ goals and objectives were used as the guide on what SFM should seek to achieve in REDD pilot countries. National level REDD+ goals and objectives were used as the guide to what SFM strategic implementation seeks to achieve in landscapes. This information was used to establish a baseline of what SFM has set out to accomplish for the RDPs in the LTLT Landscape.

Surveys

Surveys were used to collect information on forest dynamics from the forest dwelling populations living in the landscape and also from key informant stakeholders working on forest management in the Congo Basin (see Appendix A for surveys). The local population sample was determined by using remotely sensed satellite images to detect areas experiencing varying levels of forest loss within the landscape (Chapter 2). Communities living adjacent to deforested areas were identified as areas to conduct survey questionnaires. The managerial population sample set was open to all individuals working on issues related to the forests of the Congo Basin. This included individuals working at the international, national, and landscape levels and that also come from diverse occupational backgrounds and organizations.

During the course of this study, 322 men and women living in 25 villages located within the DRC portion of the LTLT Landscape were surveyed using a confidence level of 95%. In order to obtain a representative sample, individuals were selected from households in LTLT communities determined by the population of the village (Creswell, 2013). Individuals were also sampled in market places and from gatherings around consent meetings with local chiefs. The only criterion was that individuals had to be at least 15 years old. Selective sampling was applied to include marginalized and underrepresented populations such as the Twa and women, as their perspectives are often lost in majority and highly patriarchal societies such as those found in much of this region (Lewis, 2012; Giblin, 2014). The margin of error for the local population survey results is 5.45% with a 50% response distribution. At Lake Mai Ndombe, 172 people were surveyed in 13 villages. At Lake Tumba, 150 people were surveyed in 12 villages.

During the course of this study, 20 managerial level stakeholders were interviewed and surveyed. The managerial sample included field-level technical experts, policy makers, administrators, private sector executives, and government officials working on forest conservation. These individuals worked for various governments, non-profit, and for profit organizations focused on the conservation and maintenance of the Congo Basin. The sample was determined by an existing network and by using the snowball technique to gather more participation (Farquharson, 2005; Trost, 1986). Open ended responses were coded for quantification and presented with closed responses using descriptive statistics.

Analysis

The Driver-Pressure-State-Impact-Response framework created by European Environmental Agency as the way to strategically respond to Integrated Environmental Assessments via an environmental reporting mechanism (Kristensen, 2004). DPSIR analysis is conducted by chain-logically linking variables and also determining responses to those variables, see Figure 1. DPSIR will incorporate the aggregated impacts of local, informal responses on drivers, pressures, state, impacts, and effectiveness of responses using findings from previous chapters of this dissertation on the state of the LTLT (Chapter 2), the most salient drivers and pressures occurring in the LTLT (Chapter 3), the persistent impacts resulting from a change in state in LTLT (Chapter 4), and current literature review and survey results to determined responses effectiveness.

A scale of influence model was created for assessing the problems of deforestation vertically within the horizontal structure of the DPSIR framework. The vertical dimension consists of a hierarchy triangle where the direction of the triangle explains the implicit bias or the controlling force of the particular DPSIR category being reviewed. The scale is based on a three-tier service delivery model: local or landscape level, national or country level, and global or international-level. The vertical scale accounts for human actors who play a role over time in influencing forest cover. The horizontal structure of DPSIR accounts for socio-political-ecological causes and effects over time which, have an influence on forest cover. By applying the vertically scaled influence model to the horizontal structure, the DPSIR framework holistically assesses the frequency and effectiveness of responses.

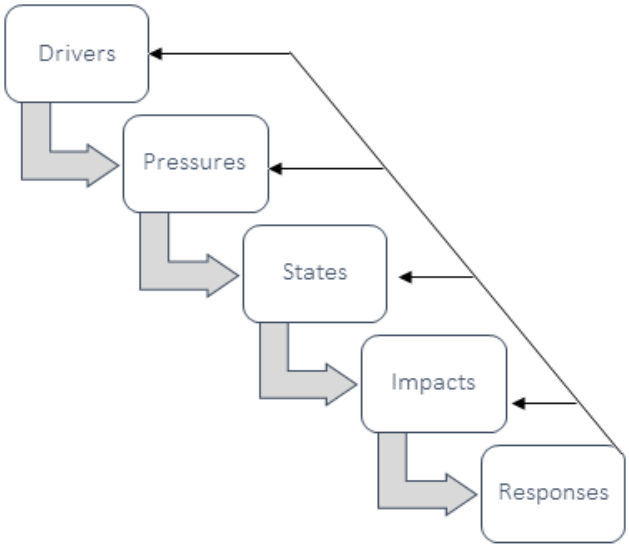

Figure 1: Driver-Pressure-State-Impact-Response Framework

Triangulation was applied using all sampled data sources (local population, managerial survey, and literature review) to check for consistency regarding the most salient factors for each DPSIR variable. After consistency was demonstrated among local and managerial stakeholders and the management responses to DPSIR variables were determined, the local population survey data were used to support or refute claims of effectiveness. This information was coded into broad categories and presented in percentages (Geer, 1991). Underlined words were used as code to quantify open-ended response. An evaluation checklist was created using the UN-REDD goals and objectives; the WLW project goals and objectives; and the WWF CARPO project goals and objectives for determining how effectiveness should be measured. The checklist included creating a financial value for the carbon stored in forests, offering incentives for

developing countries to reduce emissions from forested lands, and invest in low-carbon paths to sustainable development.

Results

Sustainable Forest Management Influences and Responses

The DRC ERPIN confirms that WWF and WLW Carbon Ltd. are implementation partners of the RDP in LTLT. National REDD+ responses found in the ERPIN are aligned with international UN-REDD+ goals and objectives, as illustrated in Figure 2. And, based on the DRC ERPIN, forest managers aim to address drivers, pressures, and impacts resulting from changes to the state of forests through various strategic responses including : (1) Emission Reduction Activities - which directly produce emission reductions; and (2) Enabling and Non Carbon Activities - which provide the basis for these emission reductions but do not directly produce the reductions.

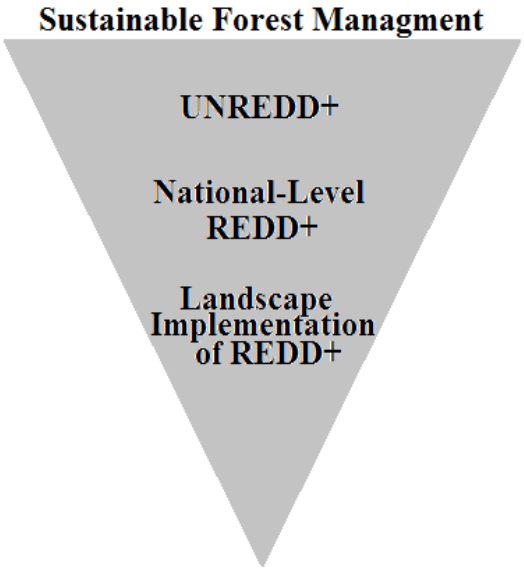

Figure 2: Direction of influence in the creation of SFM policies

Figure 3: Direction of influence of the most salient drivers causing deforestation in LTLT

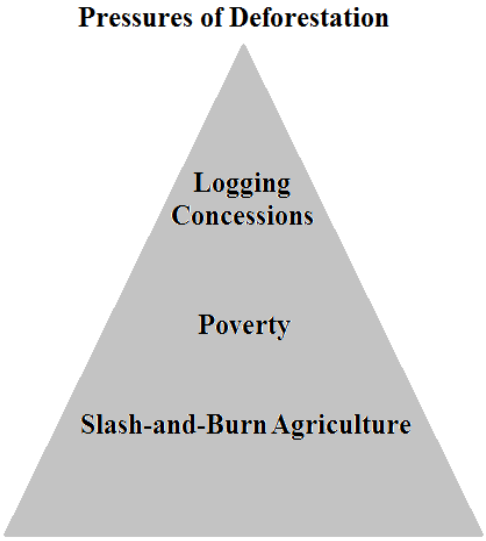

Figure 4: Directional influence of the most salient pressures causing deforestation in LTLT

Political and institutional factors and economic factors were ranked by local- and managerial-stakeholders as the most influential drivers affecting forest cover. Forty-seven percent of the local population stakeholders perceive that pressures are caused by political and economic drivers, and 61% of the managerial population stakeholders perceive that government policy and economic failure have a high influence on forest cover.

There was consistency among community and managerial stakeholders in the identification of drivers causing deforestation in the LTLT Landscape. Communities in the study area ranked the following drivers in order from most to least impactful: (1) political and institutional factors, (2) economic factors, (3) technological factors (4) cultural factors, and (5) demographic factors (Table 12). And, because political factors concomitantly affect all other driver categories (Chapter 3), it will be considered the most salient even though evenly ranked with economic factors. Managerial stakeholders ranked the following drivers in order from most impactful to least: (1) political and institutional factors, (2) economic factors, (3) technological factors and (4) cultural factors, (Table 2). These findings show that manager's rate government corruption, economic gain, and the lack of government provisions equally high (61%) as local communities (66%). These findings indicate that forests are controlled by top level individuals who have power and access to influence policy. Figure 3 depicts a model of the hierarchy of influence that stakeholders have over the driver process, using the most salient driver factors as examples.

Table 12: Local stakeholder ranking of drivers occurring in the landscape

N=20

	# of cases	Relative %	Cumulative %
Political/Institutional Factors	42	23%	23%
Economic Factors	42	23%	46%
Technological Factors	38	20%	66%
Cultural Factors	34	18%	84%
Demographic Factors	30	16%	100%
Total Cases	186	100%	

Table 2: Managerial stakeholder ranking of drivers occurring in the landscape

(N=20)		
Drivers		% Rank of driver as high
Political/Institutional Factors	Government corruption	61%
	Political instability	44%
	Limited regulation	44%
Economic Factors	Economic gain	61%
	Areal markets	6%
Technological Factors	Industrialization/ urbanization	33%
Cultural Factors	Lack of means provided by the government	61%

Local stakeholder ranking and managerial stakeholder ranking of pressures show there is consistency in the identification of pressures causing deforestation in the LTLT Landscape. Slash-and-burn agriculture is cited by both groups as the most influential pressure causing forest destruction in the landscape. Communities in the study area ranked the following pressures in order from most impactful to least: (1) slash-and-burn agriculture; (2) poverty and other social triggers; (3) commercial concessions; (4) roads,

(5) waterways, and (6) overfishing, see Table 313. Similarly, managerial stakeholders ranked the following pressures in order from most impactful to least: (1) slash-and-burn agriculture; (2) poverty; (3) commercial concessions; (4) overfishing, (5) waterways, and (6) roads; see Table 14. Pressures, like drivers of deforestation, can persist as single factors and as tandems. Within the landscape, slash-and-burn agricultural is considered the most salient pressure but often persists in tandem with poverty. The managerial population survey results and DRC ERPIN cite logging and poverty as pressures impacting forest cover, validating both local and managerial survey responses. Figure 4 depicts the most salient pressures causing forest lost in LTLT and the scale of stakeholder influences.

Table 313: Percentage of local stakeholders ranking specific pressures by the study location

		Lake Mai Ndombe	Lake Tumba	Forest Managers	Total Landscape
PRESSURES		Villages N=13	Villages N=12	N=20	Villages N=25
AGRICULTURE EXPANSION	*Agriculture*	41%	33%	50%	44%
SOCIAL TRIGGERS	*Poverty*	27%	67%	33%	44%
	Over Fishing	1%	0%	11%	0%
	*Conflict**	37%	42%	-	32%
INFRA-STRUCTURE EXTENSION	*Roads*	2%	0%	6%	0%
	Waterways	1%	0%	11%	0%
	*Temporary Camps**	30%	25%	-	32%
WOOD EXTRACTION	*Commercial Concessions*	27%	0%	28%	16%

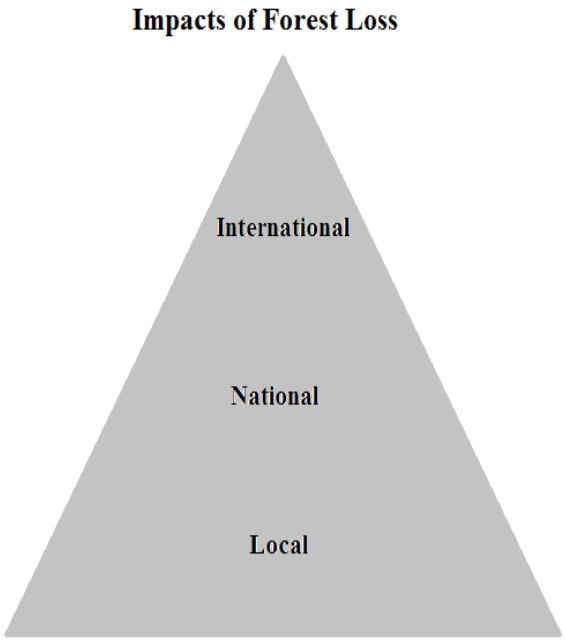

Figure 5: Directional influence of how impacts are portrayed

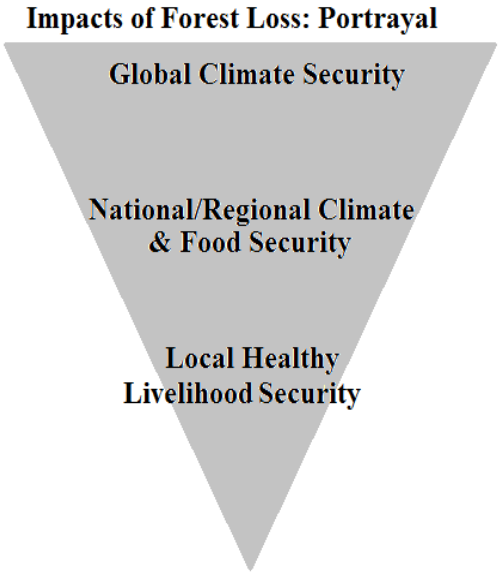

Figure 6: Directional influence of how impacts should be portrayed because of the reality on the ground

There is consistency in the identification of impacts, i.e. reduction in ecosystem services, as a result of forest loss. For example, Figure 5 depicts the hierarchy associated with how impacts of forest loss are portrayed, whereas Figure 6 depicts the hierarchy associated with the risk factors associated with the impacts of forest loss. Sixty-nine percent of the sample population perceive there are changes in the water cycle and 74% perceive there are changes in climate patterns because of deforestation. Community members articulated detailed descriptions of major shifts in the seasonal agricultural calendar. Locally, 72% of those surveyed state that deforestation adversely impacts their livelihood, indicating that forest loss affects every aspect of life for forest dwelling communities. In LTLT, communities are experiencing reduced food security from diminished bushmeat, fish, and non-timber forest product supplies. More than 50% of individuals sampled at both lakes believe that the impacts of deforestation on food supplies are high to moderate. Fifty-two percent state they spend more time in the forest than before acquiring medicinal plants; 41% state that more diseases are occurring now than there had been previously.

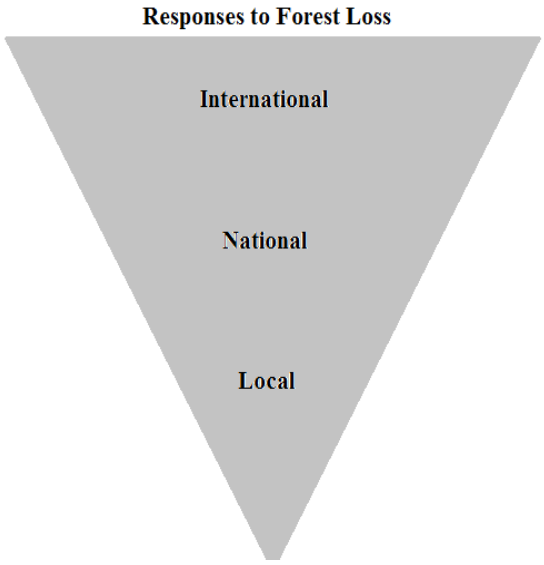

Figure 7: Directional influence of responses to deforestation in LTLT

There are implicit biases associated with responses to forest loss.Figure 7 depicts the hierarchy associated with how responses are determined and applied. The most unified response for addressing deforestation and its impacts in LTLT is the application of REDD+ SFM strategies. The international framework on REDD+ lists two objectives for reaching reduction goals: (1) help developing countries "get ready" for participation in a future REDD mechanism and (2) support the development of guidance and standardized approaches based on sound science. The DRC ERPIN states that all projects in the emission reduction program area are aligned with national and international REDD+ strategies. The implementation of the Emission Reduction (ER) plan includes the following five objective areas to achieve by 2020: (1) climate, (2) biodiversity, (3) rights and customs, (4) livelihoods, and (5) finance and governance. The implementation of REDD+ is by facilitating partners, who state that their goal is "to develop a model

provincial green development program that provides alternative and rewards performance to address the changes of climate change, poverty reduction, natural resource conservation and protection of biodiversity." Lastly, community responses to how they might adapt to increased forest loss were: (1) allow the forest to regenerate, (2) use forests more in order to live, (3) use of adaptive techniques such as aquaculture and animal husbandry, and (4) believe that God will provide. Therefore, there is consistency across scales in the identification of broad REDD+ policy language, however the specificity of implementation varies at scale.

Effectiveness of SFM approaches used in LTLT

In the LTLT Landscape, many stakeholders work on forest conservation and management. Forty-six percent correctly identified ERA and WLW, hence forth referred to as WLW only, as the organization working at Lake Mai Ndombe; 26% of those surveyed identified WWF as the correct organization working Lake Tumba. At Lake Tumba, there were individuals in all communities that articulated the presence of WWF, whereas at Lake Mai Ndombe the communities that did not note the presence of WLW were those communities located outside the WLW project area.

Sixty-two percent of the LTLT populations perceive that traditional management as the most effective, while less than 40% perceive that NGOs, national, and regional government to be effective. Ten of twelve communities around Lake Tumba state that the NGO working in their community is ineffective and 100% of residents who mention NGOs being ineffective say this is because there is no presence of the organization on the ground, NGOs are ignorant about local lives and conditions locals face, and that there is

no action or implementation of programs. Ten of thirteen communities around Lake Mai Ndombe state that that the organization working to conserve forest in their area is ineffective. Here, approximately 84% of residents feel management practices are not effective because new techniques are not implemented; programs are good but they do not last, lack of transparency; lies and a lack of trust; no programming or irrelevant programs; and because the soil and subsoil belong to the state.

Communities living around Lake Mai Ndombe are more knowledgeable about REDD than communities living around Lake Tumba. Fifty-six percent of residents at Lake Mai Ndombe stated they know about REDD whereas only 7% at Lake Tumba stated they know about REDD. At Lake Tumba individuals who identified knowing about REDD were only able to articulate that REDD meant they had to stop their agriculture activities in the forest. Those who identified being familiar with REDD at Lake Mai Ndombe could clearly articulate that REDD was reducing emissions from deforestation and degradation pressures. However, neither community is well informed about the community benefit of REDD, shown by only 8% of residents at Lake Mai Ndombe know about the plus aspect of REDD and no residents at Lake Tumba know about REDD+.

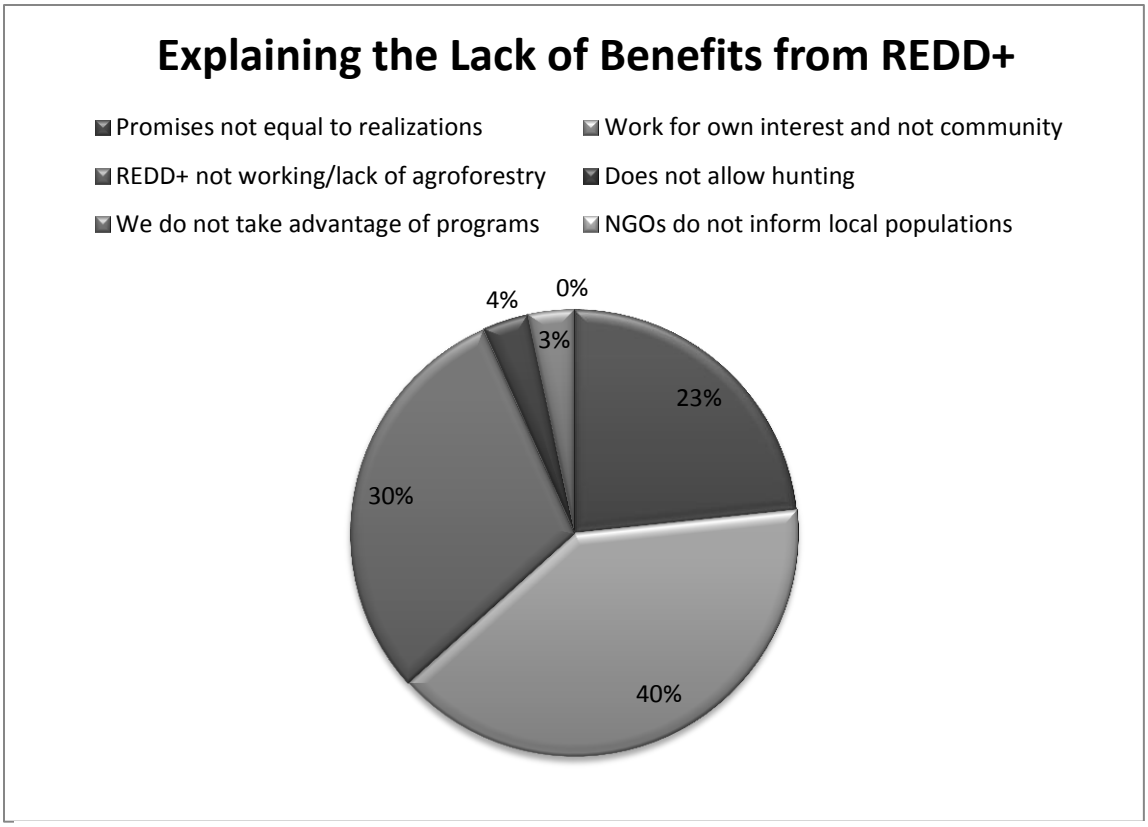

Figure 8: Survey results from Lake Mai Ndombe residents explaining the lack of benefits they receive from the implementation of REDD+ programing in their communities.

Sixty-seven percent of individuals living in communities around Lake Mai Ndombe stated REDD+ programs were occurring in their communities. (The Kolobeke, Inongo, and Mpanza communities do not have on-going REDD+ programing at Lake Mai Ndombe). At Lake Tumba, 93% of individuals stated that REDD programs were not occurring in their communities. At Lake Mai Ndombe, 79% of those who stated REDD programs were occurring also perceived that the community benefits from these programs, whereas 100% of individuals at Lake Tumba who identified REDD programs were occurring perceived there are no benefits received by the community. Benefits from REDD+ surround infrastructure development and provision of services. Lake Mai

Ndombe communities identified infrastructure projects as the building of schools while services include mobile clinics, agroforestry capacity building, and school supply distribution. Individuals also identified why REDD+ programs were not working to benefit the community (Figure 8). Forty percent of individuals across the landscape discussed concerns that organizations work for their own interest and not for the interest of the community. Thirty percent stated that REDD+ programs are not working because agroforestry practices are not enough to sustain communities and that slash-and-burn agriculture must still take place. And, 23% perceive that REDD+ programs as ineffective for communities because promises are not materializing.

Discussion

Responses to deforestation do not address all aspects of the DPSIR framework. Communities living around Lakes Mai Ndombe and Tumba consider forest management and conservation ventures ineffective because forest policies that respond to forest loss are created at international and national scale without the input of local voices. For example, my findings show that the populations living around Lake Tumba perceive that management as non-existent while at Lake Mai Ndombe benefits expressed are said to be superficial. Responses to deforestation have garnered millions of dollars in LTLT, yet the money distributed to local communities is marginal. This is a common critique of REDD+ policies by civil society and local communities (Carr et al., 2007).

Some scholars articulate biases when surveying human communities because responses may be tailored in order to receive greater benefits (Creswell, 2013). However, these biases do not distort the reality of the circumstances on the ground, which is that

wealth is still largely only captured by a few while most of the population remains economically impoverished, culturally marginalized, and thus left destitute with the forest as their only source of collateral (Clark, 2012).

Drivers of forest loss operate unchecked within political and governing bodies in DRC and, at the same time, there is a refusal to acknowledge that this cycle is occurring at various scales (Carr et al., 2009). My findings show that the perception of the policy climate of the country is filled with corruption, embezzlement, and patronage such that the informal sector has overrun the formal sector, becoming a dominant force in decision-making processes. Formal policies were found to have a history of top-down approaches lacking equity and inclusion of local stakeholders (McFerson, 2010). For example, property rights regimes have been muddled since land granting contracts were established under the order of King Leopold of Belgium in 1887 (Oliver and Atmore, 2000). These contracts unethically and illegally transferred land ownership away from local communities (Hochschild, 1998). Moreover, findings here suggest that these policies lack sufficient relevance to local forest users. In 2014, local communities still poorly understood forestry laws and rights to land. These findings suggest that the problems are cyclical and related to the original history of how land, labor, and capital were acquired here.

Slash-and-burn agriculture is the most persistent pressure causing forest loss according to local communities and forest managers, although all pressures reduce food security for forest-dwelling communities. Drivers of forest loss and responders to forest loss constantly apply political checks to the pressure of slash-and-burn agriculture

through laws such as the Forestry Code and polices such as the DRC ERPIN and REDD+ policy. Pressures have checks to balance their input into the forest system; however, checks imposed on pressures are biased, as they are controlled by the drivers of forest change, which have previously been determined to have large informal and corruptive implications. A study conducted on fuel wood harvesting worldwide concluded that only about 27-34% is unsustainable; sustainability is based on whether or not annual harvesting exceeds incremental re-growth (Bailis et al., 2015). Remote sensing results from this study indicates that in some instances fuel-wood collection can pressure forests greatly; however, in many instances fuel-wood collection was a by-product of forests previously cut or degraded from previous activities. Therefore, investigating drivers that pressure forests, e.g., logging concessions, are needed, however, this has a history of not occurring.

There is a lack of trust between constituents and governing bodies regarding the implementation of relevant forest policies that effectively and equally address all pressures as well as the receipt of payment from profitable pressures. Money made from unchecked pressures is captured by an elite few heightening economic poverty for local communities. Therefore, slash-and-burn will continue, as long as it is the community's only form of collateral.

Researchers state that the practice of slash-and-burn agriculture is no longer sustainable (Nye and Greenland, 1961). Therefore, managers are attempting to reduce emissions by restricting cutting and selling carbon credits on the open market in order to make payments to communities (Wildlife Works, 2012). This is seemingly problematic

for two reasons: first, funders, managers, and scholars are calling for the reduction of some pressures while not others; Restrictions are placed on cutting forests to grow food yet the aid given to increase food and livelihood security is not reaching communities. Reduced food security in local communities fuels environmental poverty globally. Second, the transfer of payment is not guaranteed based on the track record of performance in the country, which is known and articulated by community members per my findings. Thus, deforestation will continue as communities seek food secure situations for themselves and their families.

Forest cover in the LTLT Landscape is in decline; however, often the quantifiable state of forest cover fails to explain the qualitative rationale behind the numbers. My findings show that communities cut forests because they are attempting to become food secure. This is their home and this is also their culture. To these communities, the forests are comparable to Wal-Mart, a one-stop shop for all livelihood essentials. A fully stocked Wal-Mart in the USA is thus comparable to a fully functioning forest in the DRC, where more people shopping equates to less available supplies. Forests and Wal-Mart must be replenished in order to be sustainable. Items are restocked in Wal-Mart based on consumer demand. Thus, the conversation of restocking and replenishing forests must capture and include more information from the population of people who essentially live and die based on the state of forests and the goods and services provided by that healthy state.

The impacts from deforestation occurring in LTLT extend beyond the removal of standing trees and global climate change; deforestation impacts animals, aquatic

ecosystems, and human communities within the forest. Because of the omni-directional impacts of forest loss, the global nature of forest policies, and the history of failing to recognize and value local knowledge, impacts are largely unknown beyond the local scale. The identification of impacts occurring in local communities are considered last, even though numerous studies have argued that this needs to be first (Geist and Lambin, 2002; Carr et al., 2007; Bailis et al., 2015).

Recommendations

To improve responses to deforestation, it would help for management to focus on ensuring that voices from local communities are the driving forces of change in the system. For too long, the narrative remained that the past histories of the Congo are unconnected to the present events which are occupying the front pages of headlines today. This can be accomplished by fostering a larger commitment that pushes for local citizen engagement in forest communities. More local participation is likely to increase the understanding of reality for responders and thus improve responses. By the same token, this also means that local managers working in the landscape need more autonomy to earmark and administer funds. At all levels, actualized fiscal decentralization is required in the allocation, administration, and distribution of items that equate to financial capital or the resource curse will continue.

I recommend this study, along with the driver-pressure, state, and impacts studies from this dissertation, be placed into the larger context of DPSIR. The implications of using this holistic framework rooted in local responses will be most important for improving how the world understands life in these forests. The historical discounting of

local voices and the gentrification of their homes increases the vulnerability of these human communities to sustain their livelihoods and livelihood insecurity reduces the ability of forests to stabilize climate for local ecosystem service provisions as well as global provisions. Increasing the size, distribution, and urgency of delivery of management and conservation endeavors that are adaptive to conditions at the landscape level, can help to maintain forest resilience. Considering a holistic view of the timeline of all events should provide recommendations that speak to the uniquely complex political-ecological-historical context that explain deforestation in the Congo Basin, with an especially particular focus on the DRC. These recommendations should be targeted towards academia, government, and management and that seek to explore ways to provide operational and applied strategies to address One Health.

Conclusion

There cannot be a continued assessment of and negative association attached to the sprouting seeds, without assessing the quality and degradation of the soil. This Evidence from the empirical analysis that confirmed responders, identified responses, and determined response effectiveness suggests responses to deforestation need greater local relevance and foci. Rather than providing support for dominant narratives of response to tropical deforestation in DRC (war-torn, impoverished, failed state), analysis of these case studies show forest loss is occurring because there is a lack of a detailed understanding of the complex set of drivers and pressures affecting forest cover changes within LTLT. Responses are controlled by the same entities that implicitly control drivers and thus very little of what is invested reaches local communities here. This leaves

communities in an environmental and economic poverty trap, practicing slash-and-burn agriculture and relying on diminishing forests returns for food security. The most salient drivers occurring in LTLT are political and economic drivers and slash-and-burn agriculture and poverty pressures. Local tandem synergies further challenge single factor causation explanations where blame was mostly placed on slash-and-burn. Rather, this analysis reveals that both drivers and responses largely fluctuate based upon national and international institutional and economic factors, e.g. both drivers and responses are controlled by national and international bodies. Locally, pressures causing deforestation, for example slash-and-burn, which are amplified because of poverty and forest gentrification are caused by historical, political, and economic marginalization in turn created by international and national political bodies. And, although analysis suggest that even though delivery of management in LTLT overall is critiqued as ineffective, at Lake Mai Ndombe communities expressed receiving benefits from REDD+ programing; highlighting increased success with presence on the ground. Therefore, major implications of this mixed method case study reveal the usefulness of on-the-ground presence in responding to deforestation. Since a detailed understanding of the complex drivers and pressures are poorly understood, local presence is required to inform policy responses and for intervention to be adaptive and effective.

CHAPTER 6: USING DPSIR AS A TOOL FOR COMMUNICATING THE ECOLOGICAL HEALTH OF FOREST IN THE DEMOCRATIC REPUBLIC OF CONGO

Overview

The Forests of the Congo Basin are endangered because, despite being the world's second largest tropical forest, the overall commitment to their maintenance has been shoddy at worst and ineffective at best. The history of atrocities in the Congo has remained largely untold or greatly dismissed (Malcolm X and Breitman, 1992; Hochschild, 1998; Conrad and Murfin, 2010). Beginning before the European colonial land grab of Africa, Leopold held the DRC as his personal slave state killing over an estimated 10 million Congolese (Hochschild, 1998; Conrad and Murfin, 2010). During the colonial period, the DRC was plagued by the natural resource curse, leaving the ecological health of the Congo Forests in a constant state of decline (Hochschild, 1998, Oliver and Atmore, 2000; McFerson, 2010; Malhi et al., 2013; Hansen et al., 2013; Potapov et al., 2012). And since managers do not use an inclusive framework for assessing the state of forests, sustainably managing these forests will only become harder with increased environmental variation that is also likely to have adverse impacts on social dynamics.

Forests in Central Africa have supported human communities for millennia through the provision of ecosystem services (Malhi et al., 2013). Forest-dwelling communities depend on these services for their livelihoods. Nowadays, forests are

targeted for their climate mitigation properties (UNMEA, 2005). However, the failure to account for decades of unsuccessful policies raises serious questions and concerns regarding relevancy and direction of current sustainable forest management, its intervention strategies, development plans, and, most importantly, equity. The relatively small numbers of individuals who effect driving forces are standing at the top of the governance hierarchy in their ability to address the root causes of environmental change in LTLT communities, and they are also those who are able to, through responses, address pressures and changes to the state as well (Carr et al., 2007). There has been a flock of investors, both public and private, looking to curb greenhouse gas emissions and also to profit from their ventures in forests. However, traditional knowledge and management is still greatly marginalized, seen as inferior to western and modern styles (Vansina, 1990).

The Driver-Pressure-State-Impact-Response (DPSIR) framework was created by the European Environmental Protection Agency to provide structure for better understanding Integrated Environmental Assessments (Kristensen, 2004). DPSIR is a conceptual framework useful for understanding and communicating causal changes around the state of the environment to audiences at varying levels, a tool extremely useful for bridging the gap at the science-policy interface (Bell, 2012). This framework, when applied to transdisciplinary studies, addresses the complexities of horizontal and vertical management practices, articulating to diverse audiences a relevant, easily digestible message, helping to ensure accountability and transparency. It has successfully been used in Ghana to present complex environmental information to policy-makers (Agyemang et

al. 2007), in Brazil in the Guanabara Bay to integrate natural and socio-economic indicators (Bidone and Lacerda, 2004), and as a problem structuring method for ecosystem-based management (Gregory et al., 2013).

DPSIR is a useful tool for understanding where we are in the system and where we are heading in the future if business as usual is continued (Tscherning et al., 2012) because it provides a structure to assess the problem, agents who play active roles in causing the problem, and the adaptiveness of the solutions in addressing problems. However, Carr et al. (2007) conclude that is not an effective environmental reporting framework for assessing large-scale sustainable development projects because it requires careful consideration of how the framework organizes development goals and environmental problems. They continue stating that in order for DPSIR to be useful in assessing sustainable development goals at scales, a method must be established that incorporates aggregated local and informal responses on drivers, pressures, state, impacts, and adaptation responses. Thus, in order for DPSIR to be completely useful, studies must question those who are privileged by the categorizations created by the DPSIR framework.

Recommendations from the Carr et al. (2009) call for the merging of qualitative and quantitative data in order to reformulate thinking about the hierarchies persistent in development. Their premise was that this would provide a foundation for challenging hierarchies and practices related to collection of qualitative data such as interviews, observations, and policy frameworks created to aggregate and organize such data. Therefore, DPSIR can also be used as an evaluation tool. The objective of this paper is to

present recommendations of findings from a transdisciplinary case study using DPSIR (Chapters 2-5) to better understand holistically the political-ecological implications of deforestation in the Lake Télé-Lake Tumba Landscape in the Democratic Republic of Congo.

Study Site

The Lake Télé-Lake Tumba forests provide essential omni-directional ecosystem services. This USAID and partner recognized site is the largest Ramsar site in the world, the largest wetland of international importance, and the largest body of freshwater on the continent of Africa (de Wasseige et al., 2014). Locally, food security for forest dwellers is dependent on viable agriculture and animal protein, both of which are in decline. Nationally, economic prospecting is mostly notable in logging concessions and other commercial ventures such as mining (de Wasseige et al., 2014). Globally, standing forests are also highly sought because of their function in carbon mitigation (UN, 2010; Avissar and Werth, 2005; Werth and Avissar, 2005). However, the longevity of forest dwelling populations in the Congo are important to the ecological integrity of the forests ecosystem, as altered human health affects animal health and plant health (Aguirre et al., 2012).

Methods

Using the Lake Télé-Lake Tumba Landscape in the northwestern Democratic Republic of Congo as a case study for examining the problems associated with deforestation survey questionnaires were proctored to local populations and managerial populations. Historical, political, economical, geographical, and ecological data was

gathered from the literature review. Environmental data collected to determined weather pattern changes and geographical changes were gathered via rain gauges, thermometers, and Landsat satellite images. Narrative policy analysis was used on information obtained from the literature review. Survey data were coded and analyzed for trends using descriptive (Chapter 2), inferential (Chapter 3), and chi squared statistics (Chapter 4). Weather data were analyzed using t-test and Pearson's R statistic (Chapter 4). Satellite images were analyzed using remote sensing analysis in ArcGIS 10.1 (Chapter 2).

Local populations were selected from communities experiencing a mosaic of primary and secondary forest loss, ranging from high, moderate, and low amounts. Forest loss was determined by satellite detectable images showing deforestation rates by decade. Communities living in forests were also able to articulate deforestation's impact on a scale on (1) being low to (3) being high. Weather data collected at the Mabali Scientific Reserve located at Lake Tumba were averaged and presented in yearly trends. This included temperature in °C, humidity in relative %, rainfall in mm, and lake level in meters. Land cover data were collected from FACET reports and used to determine forest cover loss around Lake's Mai Ndombe and Tumba from 2000 to 2010. Qualitative and quantitative data were analyzed in combination using triangulation. The role differentiation between disciplines is defined by the needs of the situation rather than by discipline-specific characteristics. Therefore, assessment, intervention, and evaluation are carried out jointly and results produce multidirectional causal relationship connections between DPSIR categories.

Results

A summary of findings from the transdisciplinary analysis assessing the political-ecological implication of deforestation occurring in the Lake Télé-Lake Tumba Landscape using the DPSIR framework is presented in Table 1. As detailed in Chapters 2-5, there is consistency among all stakeholders in the identification of drivers, pressures, the state of the forests within the landscape, and impacts occurring from the change in forest's ecological health. However, there are disagreements between how managerial populations focus response efforts and priorities. There is a disconnect between what is written at national and international levels and how it is implemented within landscapes. This disconnect is highlighted in these findings, where landscape managers implement culture and health programs, while national and international focus is on broadly funding economic and livelihood support, (Table 14). Therefore, current SFM responses are not entirely effective in addressing the omni-directional threats of deforestation. This is due to the disconnect that exists between policy creation and implementation on the ground, and between the relevance of applied policy in relation to what is actually needed on the ground. Below I present policy recommendations based on these findings.

Table 14: DPSIR Results for the LTLT Landscape

Drivers	1. Political and institutional factors 2. Economic factors 3. Technological factors 4. Cultural factors 5. Demographic factors
Pressures	1. Slash-and-burn agriculture

	2. Poverty 3. Commercial concessions 4. Conflict 5. Temporary Camps 6. Access 7. Overfishing		
State	2% forest loss from 1990-2010		
Impacts	1. Reduced livelihood security 2. Reduced public health 3. Reduced climate security 4. Reduced economical profitability		
Responses	1. Land extensification 2. Home plots 3. Aqua culture 4. Animal husbandry	1. Culture 2. Health	1. Economic 2. Livelihood 3. Culture
DPSIR Categories	Local Population N=322	Landscape Managerial Population N=3	National Managerial Population N=10

Recommendations

Transdisciplinary research methods should be used for studying the political-ecological dynamic of the forest loss in DRC using DPSIR. By crossing disciplines, "transdisciplinarity" or transdisciplinary thinking employs perspectives and methods that transcend traditional disciplines, and engage both researchers and practitioners in addressing real-world problems (Aguirre and Gonzalez-Astudillo, 2014). Transdisciplinary thinking requires that team members share roles and systematically cross discipline boundaries. The primary purpose of this approach is to pool and integrate the team expertise so that more efficient and comprehensive assessment and intervention services may be provided in a determined field. Transdisciplinary thinking brings

together academic experts, field practitioners, community members, research scientists, political leaders, and business owners among others to solve some of the pressing problems facing the world today (Aguirre and Wilcox, 2008). The communication style in transdisciplinary thinking involves continuous give-and-take among all members on a regular, planned basis. The role of differentiation between disciplines is defined by the needs of the situation rather than by discipline-specific characteristics. Assessment, intervention, and evaluation are carried out jointly.

Sustaining forests must occur at the science-policy interface, which is best accomplished by crossing disciplines and through breaking down past hierarchies. Breaking past hierarchies is no small feat; however, it should begin by openly acknowledging the past atrocities and the false classifications of the people in the Congo as brutes, savages, and uneducated war lords. Having open conversations about the mass killings, enslavement, colonization, and now blame for the state of affairs after decades of oppression cannot heal all wounds but acknowledging these things exist the hope is that transparency will foster change at the table where resources a monetized and divided.

This dissertation should be used as a tool for applied political and ecological development and management. Thus, this document is not solely for technical purposes, academic purposes, or managerial purposes, but should be used as a mechanism to obtain funding, increase knowledge, promote growth, understand lessons learned, provide input, garner feedback, and foster transparency in forest management in the Congo Basin, the DRC, and in the LTLT Landscape. Recommendations below speak to the transdisciplinary nature of this work and outline a plan of action (POA) for forest

constituents, managers, and also academia that address drivers, pressures, state impacts, and responses to forest loss. Within these recommendations, I will focus on information gaps within the current system and how to address these gaps based on findings of this dissertation.

Recommendation for drivers causing deforestation in the Lake Télé-Lake Tumba Landscape:

- ❑ *Local populations must be given a voice in the creation of policies and the structuring of institutions that respond to deforestation and forest conservation*

Research findings: Historically, indigenous knowledge in the LTLT forests has been dismissed or unused, however, per my findings, these communities are extremely environmentally literate and this information should be considered. All stakeholders are in agreement in ranking the most salient drivers (Chapters 3 and 5). Narrative policy analysis of historical data show drivers of forest loss in the study are failed administrative policies, poor economic planning, constant corruption, and poor governance review. However, there is a failure of explicitly identifying drivers due to the implicit biases associated with economic power and privilege within the structure of all DPSIR variables.

Recommendation: Addressing political and economic driver of deforestation are inclusive decision-making should be based on evidence from an extensive group of stakeholders where all evidence is available, accessible, and in meaningful forms. More on-the-ground engagement is needed so that realistic localized evidence is introduced into the system to help increase transparency, legitimacy, and also contribute to equity. Therefore, SFM should seek to create a citizen knowledge collection bank program by empowering citizen scientist to participate in data collection for climate studies and historical studies.

Recommendation for pressures causing deforestation in the Lake Télé-Lake Tumba Landscape:

- ❑ *Efficient payment streams must be made to individuals in local communities in order for SFM REDD+ to be effective*

Research findings: Analysis shows a majority of all stakeholders are in agreement that slash-and-burn agriculture and poverty are the two most salient pressure of deforestation, respectively (Chapters 3 and 5). Slash-and-burn is an ancient practice used to sustain life. Thus the most salient pressures of deforestation in LTLT are occurring because forests are sources of food security. These findings are consistent with literature and international policies and narratives on this matter (FAO, 2012, Wildlife Works, 2012; UN, 2010).

Recommendation: To reduce pressures causing deforestation in LTLT, forest management and implementation strategies must increase the standard of living. The LTLT Landscape should serve as a case study where compensation is made in exchange for collecting transdisciplinary data use for to track change over time. Receiving payment for tracking change over time increases livelihood security through the creation of paying jobs. The implementation of the citizen knowledge collection data programs increases education by promoting new ways of sharing knowledge and can work to debunk false truths by dismantling barriers that previously restricted this flow of information. And, because there is limited capacity on the ground in regards to current landscape management presence, communities are ideal candidates for receiving payments for this work because of their environmental literacy and location already on the ground.

Adaptation measures being used the Lake Tumba should be tested for viability at Lake Mai Ndombe and vice versa. Seed dispersal programs, agroforestry workshop, animal husbandry, and aquaculture are adaptation measures and management strategies in use that have been successful within the LTLT landscape. These programs, along with food demonstration programs and workshop should be tested and applied in LTLT communities to begin to help shift community practices and increase food security and with the high reliance on the forest. By helping to shift communities to home gardens, less intensive forest crops, and cultural shifts through consumable demonstrations, economic surplus might allow for less forest reliance and reduced food diversity will mean less food choice and increase the amount of malnourished communities. It is important the workshops and training account for domestic animals and home garden plots and also the spread of diseases and vectors.

Recommendation for the state of the forests in the Lake Télé-Lake Tumba Landscape:

- ❑ *A baseline of climatic change needs to be established to better manage for future climate change scenarios*

Research findings: There is consistency among stakeholders in identifying the declining state of the LTLT forest (Chapters 2 and 5). Remote sensing analysis findings show that deforestation is occurring in a mosaic pattern and losses are relatively low in comparison to other tropical forests but high in relation to other provinces in the country.

Recommendation: A soil core sample study conducted in LTLT to better understand long term trends in soil properties and climate properties is needed. Soil science research can tell us climate patterns over longer periods of time, compared to the weather data used in this study. By collecting soil core samples, many land-climate interaction analyses can be conducted, such as determining soil moisture properties. Soil studies can help determine ways to better establish efficient shifting patterns and for agroforestry techniques. Ultimately, the increased flow of information from the citizen collection program and soil studies will increase the knowledge of what occurs in this region regarding the land-climate interactions and preservation of soil fertility for forests and agriculture.

Recommendation for responding to deforestation's omni-directional impacts occurring in the Lake Télé-Lake Tumba Landscape:

- ❑ *Economic value must be placed on non-timber forest products in LTLT in order to make relevant payments for ecosystem services*

Research Findings: Findings show weather patterns are changing and impacting the traditional agricultural calendar (Chapter 4). Survey findings show there is consistency in impacts identified by all stakeholders (Chapter 5). However, impacts are skewed towards highlighting global climate change rather than local weather variation and ecological and human welfare changes. Therefore, impacts are often discussed at high levels leading to compartmentalized discussions that are not inclusive of local perspectives, creating limited synergy in how policy seeks to address impacts resulting from forest loss.

Recommendation: An economic valuation assessment is needed in the LTLT forests because there is much ambiguity with regards local forests goods and services and their subsequent impacts. A valuation of ecosystem services in the LTLT forests is needed in order to effectively make payments for the sustainable use and conservation of these services. This would also confirm the relevancy of existing payments and help provide a framework for how to make future payments.

Recommendation for deforestation responses to forests in the Lake Télé-Lake Tumba Landscape:

- ❑ *Value must be placed on local lives, knowledge, adaptions, and impacts to meet SFM goals*

Research Findings: These findings demonstrate a lack of understanding of the historical make-up of the DRC, making responses to deforestation shallow and irrelevant to realities on the ground. Environmental changes are occurring because of deforestation and that forest managers are broadly managing for livelihood and climate changes with little accountability and presence on the ground (Chapter 5). Without an on the ground presence, policies created and implemented were found to be irrelevant and sparely applied.

Recommendation: Awareness and funding campaign is needed to bring attention to the real story of Congo. Therefore, my recommendations for addressing the disconnect of false realities of the Congo and of Africa is by holding a series of events called "*Redefining the Perception of Africa through Art"*. Through these events, individuals can use various forms of art to express their positive view of the Congo and of Africa in order to redefine the false and negative narratives of a place so rich in land, natural resources, and culture to name a few. By redefining the perception of Africa in developing nations will hopefully begin to change attitudes and long held beliefs that will ultimately help DRC forest communities. If people know then they can be held accountable, if they remain ignorant, then it is by choice and highlights the point of privilege.

Overall, DPSIR is useful for compartmentalizing the individual pieces of causes and effects of forest loss. DPSIR is also able to provide a complete picture of the entire problem at local, regional, and global scales. The practicality in managing multiple sets of transdisciplinary data through categories and subcategories for a case study on one of the hardest countries in the world to work in have been extreme fruitful in highlighting the need for more local studies that address climate change awareness and perception, payment for ecosystem services that reach local communities, and successful adaptions reduction strategies for increased sustainable forest management that can extrapolated and applied within other landscapes.

APPENDIX A

Local Population Interview Questions

Select area of deforestation:
- Lac Mai Ndombe
- Lac Tumba

Correlation # to area of deforestation:
Select interview type:
- Adult
- Minor

Date:

Demographic Information

A. Age:
B. Sex:
    a. Male
    b. Female
C. Ethnicity:
    a. Bantu
    b. Pygmy
D. Marital Status:
    a. Single
    b. Married
    c. Divorced
    d. Widowed
E. Occupation:
    a. Hunter
    b. Student
    c. Farmer
    d. Fishermen
    e. Teacher
    f. Nurse
    g. Trader
    h. Government
    i. Medicine man
    j. Security
    k. Other
F. Education Level:
    a. 0 – early childhood education
    b. 1 – primary education
    c. 2 – lower secondary education
    d. 3 – upper secondary education
    e. 4 – post secondary, non-tertiary education
    f. 5 – short-cycle tertiary education
    g. 6 – bachelors or equivalent
    h. 7 – masters or equivalent
    i. 8 – doctoral or equivalent
G. How many people live in your household?
H. How long have you lived in this area?
I. Has the population in this area grown larger or smaller in your lifetime?
    a. Larger
    b. Smaller
    c. Same

Driver-Pressure Relationship (D-P)

1. Please rank the following 6 pressures of deforestation according to their severity in this area:

.	Logging concession/mining concessions
.	Swidden fallow agriculture/ slash-and-burn agriculture
.	Over fishing
.	Roads
.	Waterways i.e. lakes and rivers
.	Poverty

2. Is the local government here corrupt?
    a. Yes
    b. No
3. Are temporary camps, e.g. concession worker camps, solders-persistent in this area?
    a. Yes
    b. No
4. Who in your household practices agriculture?

a. The woman
b. The man
c. The children
d. The man and woman
e. Woman and children
f. Man, woman and children
g. Do not practice agriculture

5. Where is agriculture practiced most frequently?
    a. Around your house
    b. Primary forest
    c. Secondary forest
    d. Savannah
6. Why was this area chosen for agriculture?
7. Does proximity to lakes and rivers help to facilitate the ease of transporting goods?
    a. Yes
    b. No
        i. If yes, do you feel this increases deforestation?
            a. Yes
            b. No
8. In this area, which of the following is used more to transport forest goods?
    a. Road
    b. Waterways (e.g. lakes, rivers)

People-Forest Relationships (S)

9. Do you feel deforestation in this area is high, low, or moderate?
    a. High
    b. Low
    c. Moderate
10. How do you view the forest and the resources it provides? *Check all that apply.*
    - o Home
    - o Source of income
    - o Place of recreation
    - o Source of food and building materials
    - o Source of medicine
    - o Source of water
    - o Other? Please list
11. What is the significance of the forest to your culture?

Knowledge of Forest Management (R)

12. If I am from the area and need land for economic activities, to whom would I go to get permission?
13. If I am not from this area and need land for economic activities, to whom would I go to get permission?
14. Who owns the forest in this area?
    a. Land chief
    b. Family
    c. Community
    d. NGO/Private
15. Do you know any organization working on forest management in this area?
    - o Yes
        - ✓ If you can please name them?
        - ✓ Do you feel this/these organization address all aspects of deforestation and its management, particularly areas of significance to your culture, economic activities, livelihoods, and health?
            a. Yes
            b. No
    - o No
        - ✓ Are there traditional/cultural management strategies in place?
            a. Yes
            b. No

16. Are you satisfied with the following entities' work in current forest management?
    - Traditional
        - ✓ Yes
        - ✓ No
        - ✓ Somewhat
            i. Why are you not satisfied?
    - Regional
        - ✓ Yes
        - ✓ No
        - ✓ Somewhat
            i. Why are you not satisfied?
    - National
        - ✓ Yes
        - ✓ No
        - ✓ Somewhat
            i. Why are you not satisfied?
    - NGO/Civil Society
        - ✓ Yes
        - ✓ No
        - ✓ Somewhat
            i. Why are you not satisfied?
17. Are there mechanisms in place that address community concerns regarding forest management at the local and national levels?
    a. Yes
        - Do you feel policy and management opinions from the local level are being introduced into actual management strategies?
            a. Yes
            b. No
    b. No
18. Do you know about the constitution?
    a. Yes
        i. If yes, what do you know about it regarding the forest?
    b. No
19. Are there mining and or logging companies working in this area?
    a. Yes
    b. No
20. Do you know what company (ies) is/are doing logging or mining activities here?
    a. Yes
        i. If you can, please name them?
    b. No
21. How long have they been here?
22. Are they employing local labor?
    a. Yes
    b. No
23. What are the main activities they are doing here? *Please select all that apply.*
    a. Charcoal production
    b. Mining
    c. Logging
    d. Poaching
24. Do you believe they are working according to the laws of the state?
    a. Yes
    b. No
    c. Unsure
25. Do you believe these activities to play a large or small role in deforestation and degradation?
    a. Large role
    b. Small role
    c. Unsure
26. Are you familiar with REDD and REDD+?
    a. Yes
        i. What do you know about it?
    b. No

27. Do REDD and/or REDD+ programs currently exist in this area?
    a. Yes
    b. No
    c. Unsure
28. Are these programs working and benefiting the community?
    a. Yes
        i. How are they benefiting the community?
    b. No
    c. Unsure
        i. Why are these programs not working or benefiting the community?
29. Would you like to receive payment for the ecosystem services of your area?
    a. Yes
    b. No

Ecosystem Services (I)

30. Do you notice deforestation and/or degradation affecting water cycles in this area?
    a. Yes
    b. No
    c. Unsure
31. If yes, how so, what have you noticed? Can you provide information on when these events occurred?
32. Do you notice deforestation and/or degradation affecting climate?
    a. Yes
    b. No
    c. Unsure
33. If yes, how so, what changes? Can you provide information on when these events occurred?
34. What importance does the forest have to you? *Select all that apply*
    a. Provisioning Services – basic survival goods and services
        - Water
        - Fish
        - Bushmeat
        - Charcoal
        - Fiber
        - Building materials
        - Herbs
        - Insects
        - Medicine
        - Viable agriculture
    b. Regulating Services – those services which help to maintain balance
        - Flood protection
        - Purification of air and water
        - Waste absorption
        - Disease control
        - Climate regulation
        - Water cycling
    c. Supporting Services – those services necessary for the production of all other ecosystem services
        - Soil formation – good soils
        - Nutrient cycling
        - Photosynthesis – creating oxygen
        - Carbon capturing
        - Crop pollination
    d. Sociocultural Services – cultural and spiritual services
        - Ecotourism
        - Spiritual attachments
        - Indigenous/traditional knowledge and practices
        - Recreation
35. Under increased deforestation, how will these identified ecosystem services be affected?

36. What type of bushmeat do you consume? *Select all that apply*
    - Monkey
    - Lion
    - Leopard
    - Forest rat
    - Sitatuga
    - Dwarf crocodile
    - Wild hog
    - Antelope
    - Porcupine
    - Fox
    - Bonobo
    - Kulupa
    - Mbengele
    - Pambi
    - Mountain Gorilla
    - Bat
    - Snake
    - Elephant
    - Pangolin
    - Frog
37. How often do you consume bush meat on weekly basis?
38. How often do you consume fish per week?
39. What NTFPs do you gather from the forest? *Select all that apply.*
    - Bushmeat
    - Caterpillars
    - Fish
    - Rattan cane
    - Mushrooms
    - Palm wine
    - Edible vines
    - Kola nuts
    - Fruits
    - Pomme d'acajou
    - If others, write here:
40. What is the impact of deforestation has on the following? *Select one option for each.*
    a. Bushmeat:
    High Moderate Low
    b. Fish stocks:
    High Moderate Low
    c. Non-timber forest products:
    High Moderate Low
41. Have you noticed a change in length of time it takes to gather the following?
    Select one option for each.
    a. Bushmeat
    More time Less time Same time
    b. Fish
    More time Less time Same time
    c. NTFPs
    More time Less time Same time
42. Do you believe this change is a consequence of deforestation?
    a. Yes
    b. No

Livelihood and Sociocultural Changes (I)

43. Does deforestation impact livelihoods in this area?
    a. Yes
    b. No
44. How has the community adapted to deforestation, for example, what changes have been made in daily life?
45. How might you adapt in the future?
46. Will you migrate (move to a new area) as a result of deforestation?
    a. Yes
    b. No
47. Is there conflict in this area?
    a. Yes
        i. Does this conflict stem from deforestation?

a. Yes
b. No

b. No

48. Are there new diseases happening now?
    a. Yes
    b. No
49. If yes, can you name some of the new disease or their symptoms?
    - ✓ Do you know where these diseases are originating?
        a. Yes
        b. No
            - If yes, where?
50. Is the disease Konzo persistent in this area?
    a. Yes
    b. No
        i. If yes, when do you notice Konzo occurring the most? *Select only one.*
            a. During time of war
            b. Low bushmeat availability
            c. Low fish availability
            d. Lack of time to process cassava
            e. Unsure
51. Do you purchase medicine from local pharmacies or rely more heavily on traditional medicines gathered from the forests?
    a. Pharmacy
    b. Traditional medicines gathered from forests
52. Can you list the medicinal plants gathered from the forest and their uses/cures?
53. Are there changes in medicinal plants availability? *Select only one.*
    a. Found deeper in the forest
    b. Not always available
    c. Completely gone
    d. No change
54. What suggested solutions could you provide to the following stakeholders to help them provide management strategies that improve your livelihood and wellbeing?
    - National
    - Provincial
    - Community
    - Traditional
    - International
    - Private Sector

Managerial Population Interview Questions

1) Date:
2) If I have follow up questions regarding your responses, and it is okay for me to contact you, please provide your email address or phone number.
3) What organization do you work for?
4) What type of organization is this?
    a) Government
    b) NGO
    c) Civil society
    d) Banking institution
    e) Other
5) What is your job title?
6) How long have you worked for this organization?
7) How long has your organization been working on forest management in DRC?
8) How long have your worked on forest management in the Congo Basin?
9) Do you feel deforestation is high, moderate, or low in DRC?
10) Why do you feel this way?

11) Do you feel deforestation is high, moderate, or low in the Lake Tele-Lake Tumba Landscape?
12) How does your organization view the forest of the Congo Basin?
    a) Conservation area
    b) Community development area
    c) Resource extraction
    d) Other
13) Please rank the following, 1 being highest priority, 7 being lowest, regarding your organizations targeted management strategy
    a) A home a source of income
    b) As recreation
    c) A source of food
    d) As building material
    e) A source of medicine
    f) A source of water
14) Please rank the following 6 drivers of deforestation according to their severity, 1 being highest and 6 being lowest:
    a) Logging concession/mining concession
    b) Swidden fallow agriculture/slash-and-burn agriculture
    c) Over fishing
    d) Roads
    e) Waterways
    f) Poverty
15) Where would you rank climate change in the above list of drivers?
16) Is this list of drivers of deforestation complete or do you have any you would like to add?
17) Please rate the importance of these pressures causing deforestation, high, moderate, or low:
    a) Political instability
    b) Economic gain government corruption
    c) Lack of education
    d) Urbanization/industrialization
    e) Areal markets
    f) Limited regulation
    g) Lack of means provided by the government
18) Where do you spend most of your time physically working?
    a) International office
    b) National office
    c) Landscape level

Landscape Managers

19) At which lake do you work?
    a) Lake Mai Ndombe
    b) Lake Tumba
20) What roles does your organization play in forest management in the Lake Tele-Lake Tumba landscape?
    a) Funder
    b) Conservation of forests and forest resources
    c) Restoration of forests
    d) Resource extraction
    e) Other
21) What are your organization management strategies?
    a) How could those that you rated low or medium be improved?
22) Does your organization have mechanisms in place that address community concerns at the local level?
23) Does your organization have mechanisms in place that address community concerns at the national level?
24) Does your organization have mechanisms in place that address community concerns at the international level?
    a) For those in which your answered yes please explain and for no please explain why this is and how it can be changed?
25) Does your organization integrate indigenous knowledge and resource

management into management strategies and forest policies?
   a) For yes please give an example, for no please explain why not.
26) What benefit(s) does your organization receive from working in these forests?
   a) How would deforestation impact these benefits?
27) Do you feel there is a disconnect between the following management and implementation levels?
   a) International to national
   b) National to landscape
   c) Partners working within the same landscape
      i) For all those for which you selected yes, please explain why you think this is.
28) How does your perspective differ being on the ground (e.g., landscape level) compared to being at the national or international level with respect to
   a) Resources for project implementation
   b) Strategies
   c) Targets
      i) Is there a disconnection between trying to achieve these three things?
      ii) Please explain why you feel there is a disconnect between achieving those three things?
29) Do you believe your organizations location at the landscape level allows you to take into account the complexities of forest management at the national and international level?
30) What role do budget allocations (Congressional, organizational, etc.) have on management priorities at the ground level?
31) Do you feel your organization addresses all aspects of deforestation and its management, particularly areas of significance to the culture, economic activities, livelihoods and health of forest dwelling populations?
   a) Please explain how each of the previous (culture, economic activities, livelihoods and health) is or is not addressed.
32) What information (management, science, laws, policies, etc.) do you feel is currently lacking in the Lake Tele-Lake Tumba Landscape?
33) What research or information do you feel will be useful to filling this gap?
34) How could my particular research benefit your organization?
35) Does your organization employ local staff at the landscape level?
36) Does your organization employ local staff at the national and/or international levels?
37) What are the main activities your organization does at the landscape level?
38) Is your organization working in accordance to the laws of the state?
39) What benefit(s) does you organization receive from working in these forests?
40) Will deforestation impact these benefits?
41) How might your organization adapt to these changes?

National and International Managers

42) What roles does your organization play in forest management in Lake Tele-Lake Tumba?
   a) Funder
   b) Conservation of forests and forest resources
   c) Restoration of forests
   d) Resource extraction
   e) Other
43) What are your organizations management strategies?

a) How could those that you rated low or medium be improved?

44) Does your organization have mechanisms in place that address community concerns at the local level?
45) Does your organization have mechanisms in place that address community concerns at the national level?
46) Does your organization have mechanisms in place that address community concerns at the international level?
    a) For those in which your answered yes please explain and for no please explain why this is and how it can be changed?
47) Does your organization integrate indigenous knowledge and resource management into management strategies and forest policies?
    a) For yes please give an example, for no please explain why not.
48) Do you feel there is a disconnect between the following management and implementation levels?
    a) International to national
    b) National to landscape
    c) Partners working within the same landscape
        i) For all those for which selected yes, please explain why you think this is?
49) How does your perspective differ being on the ground (e.g., landscape level) compared to being at the national or international level with respect to
    a) Resources for project implementation
    b) Strategies
    c) Targets
50) Do you believe your organizations location at the national or international level allows you to take into account the complexities of forest management at the landscape level?
51) What role do budget allocations (Congressional, organizational, etc.) have on management priorities at the ground level?
52) Do you feel your organization addresses all aspects of deforestation and its management, particularly areas of significance to the culture, economic activities, livelihoods, and health of forest dwelling populations?
    a) Please explain how each of the previous (culture, economic activities, livelihoods and health) is or is not addressed.
53) What information (management, science, laws, policies, etc.) do you feel is currently lacking in the Congo Basin as a whole as well as the Lake Tele-Lake Tumba Landscape?
54) How could my particular research benefit your organization?
55) Does your organization employ local staff at the national or international level?
56) Does your organization employ local staff at the landscape level?
57) What are the main activities your organization does at the landscape level?
58) Is your organization working in accordance with the laws of the state?
59) What benefit(s) does your organization receive for working in these forests?
60) How would deforestation impact these benefits?
61) How would your organization adapt to these changes?

All Managers

62) What do you see can be done to get more funders involved?

63) Do you believe that increased awareness will encourage more funding?
    a) Why do you believe this?
64) What do you see that could be done to create more awareness and involvement in your constituent base on conservation and preservation of the Congo Basin Forests?
65) Would you like to receive a copy of the dissertation results and findings?
    a) Please provide your email address.

APPENDIX B

Table 1B: Results from analysis of economic impacts of business as usual practices

-Uneven economic development	1980: GDP = $14,922 million (Marysse, 2004)*
	1984-1986: real GDP ↑ 3.3%
	1987-1989: real GDP ↑0.6% a year (Nachega, 2005)
	1987: Real GDP 3x higher than official GDP (Verhaegen and Vale, 1993)
	1998: GDP ↓ -1.7% (Marysse, 2004)**
	1999: GDP ↓ -4.3% (Marysse, 2004)**
	1999: GDP = $5,200 million (35% of 1980 GDP) (Marysse, 2004)*
	2000: GDP ↑ -6.9% (Marysse, 2004)**
	2001: GDP ↑135% (Marysse, 2004)**
	2002: GDP ↑ 16% (Marysse, 2004)**
	2003: GDP ↑ 8% (Marysse, 2004)**
	2003: GDP ↑ 4.4% (Nachega, 2005)
	2005: GDP growth of 7% (Shekhawat, 2009)
	2010: GDP = $20.5 billion (World Bank)
	2013: GDP = $31 billion (World Bank)
-High and fluctuating inflation	1965-1973: Inflation average 21% per year (Nachega, 2005)
	1980s = high inflation, 1990s = hyperinflation (Nachega, 2005)
	1983: Inflation 77% (Nachega, 2005)
	1984-1985: Inflation averaged 24% (Nachega, 2005)
	1987: Inflation = 126% (Nachega, 2005) *calculated from '88, '89 and averaged 3 years
	1988: Inflation = 100% (Nachega, 2005)
	1989: Inflation = 56% (Nachega, 2005)
	1990: Inflation ↑ 265% (Nachega, 2005)
	1991-1994: Inflation averaged 5,422% (Nachega, 2005)
	1995: Inflation 23,000% (Kaplan, 2007)
	1998: Inflation ↑ = 134.8% (Marysse, 2004; Nachega,

	2005))**
	1999: Inflation ↑ =483.3% (Marysse, 2004)**
	2000: Inflation ↑ =511.2% (Marysse, 2004; Nachega, 2005)**
	2001: Inflation ↓ 217% of GDP (Nachega, 2005)
	2002: Inflation ↑ = 16% (Marysse, 2004)**
	2003: Inflation ↑ = 8% (Marysse, 2004)**
-Heavy Debt	1980: Government expenditures = $3,870 million (26% of GDP) (Marysse, 2004)*
	1999: Government expenditures = $260 million (5% of GDP) (Marysse, 2004)*
	1990: Money growth = ↑ 189% (Nachega, 2005)
	1991-1994: Money growth averaged 3,594% (Nachega, 2005)
	1990: Investments 13% (Kuditshini, 2008)
	1993: Income levels ↓ 35% pre-indepence levels (Kaplan, 2007)
	2000: Investment = 4.4% (Kuditshini, 2008)
	2000-2005: National revenues tripled (Shekhawat, 2009)
-Heavy foreign debt	1976: 1st Structure adjustment loan $27 million (Shekhawat, 2009)
	1977: Long term debt $2,900 million (Shekhawat, 2009)
	1987: Long-term debt $23.7 billion (Shekhawat, 2009)
	1990: IMF halts financial aid (Shekhwat, 2009; Nachega, 2005)
	1990: Fiscal deficit 11% of the GDP (Nachega, 2005)
	1991-1994: Fiscal deficit = average 19% (Nachega, 2005)
	1995: Foreign debt $14 billion (Kaplan, 2007)
	1995: Fiscal deficit reduced to 6.8% of GDP (Nachega, 2005)
	2006: AID increased, 56% of national budget (Shekhwat, 2009)

APPENDIX C

Table 1C: Respondents recall of changes in water and climate cycles due to forest loss

Summary of specific dates mentioned
1970-1980 fish were many in the lake i.e. tilapia, and now it does not rain much
Since 1985 – climate has changed and temperature has increased
Since 1997 climate has changed
High temperature and irregular rains during 2013 seasons
Rain in February and high temperatures in May
Strong winds in April and October
1992 – heavy precipitation a boat sank
1994 – Boat sank
October/November 1994 – Accident on the lake
Since 2003 rains increased
November 11, 2003 – There was an accident on the lake
November 25, 2003 Accident on the lake
2008 – Violent storm
2009 and 2010 – Boats sank
2011 – Flood in December
April 2012 usual changes in climate
April 2013 usual changes in climate
October – there are strong waves, rain, and violent waves

REFERENCES

Abramovitz, J. (2001). Unnatural disasters (Worldwatch Paper No. 158). *Worldwatch Institute*. Washington, D.C.

Adger, W. N., Kelly, P. M., Winkels, A., Huy, L. Q., & Locke, C. (2002). Migration, Remittances, Livelihood Trajectories, and Social Resilience. *AMBIO: A Journal of the Human Environment*, *31*(4), 358–366.

Advisory Group on Finance Collaborative Partnership on Forests. (2012). Study on Forest Financing. *United Nations.*

Afolayan, T. A. (1980). A Synopsis of Wildlife Conservation in Nigeria. *Environmental Conservation*, *7*(03), 207.

Aguirre, A. A., & González-Astudillo, V. (2014). Achieving transdisciplinary EcoHealth education in early professional development. *EcoHealth*, (2), 1–2.

Aguirre, A. A., Ostfeld, R., & Daszak, P. (2012). *New directions in conservation medicine: applied cases of ecological health*. OUP USA.

Aguirre, A. A., Ostfeld, R. S., Tabor, G. M., House, C., & Pearl, M. C. (Eds.). (2002). *Conservation medicine: ecological health in practice*. Oxford University Press.

Aguirre, A., & Wilcox, B. A. (2008). EcoHealth: envisioning and creating a truly global transdiscipline. *EcoHealth*, *5*(3), 238–239.

Agyemang, I., McDonald, A., & Carver, S. (2007, August). Application of the DPSIR framework to environmental degradation assessment in northern Ghana. In *Natural Resources Forum* (Vol. 31, No. 3, pp. 212–225). Blackwell Publishing Ltd.

Aldrich, R. (1968). Remote sensing and the forest survey—Present applications' research, and a look at the future. *Proc. 5th Symp. Remote Sensing of Environ.[Univ. Mich., Ann Arbor,* pp. 357–372.

Angelsen, A., Brown, S., & Loisel, C. (2009). Reducing emissions from deforestation and forest degradation (REDD): an options assessment report.

Arora, V. K., & Montenegro, A. (2011). Small temperature benefits provided by realistic afforestation efforts. *Nature Geoscience*, *4*(8), 514–518.

Atkinson R., and Bridge, G., (Eds.). (2004). Gentrification in a global context. Routledge, 2004.

Avissar, R., & Werth, D. (2005). Global Hydroclimatological Teleconnections Resulting from Tropical Deforestation. *Journal of Hydrometeorology*, *6*(2), 134–145.

Avissar, R. (1995). Recent advances in the representation of land-atmosphere interactions in general circulation models. *Reviews of Geophysics*, *33*, 1005.

Avissar, R. (2002). The Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA): Insights and future research needs. *Journal of Geophysical Research*, *107*(D20).

Balick, M. J., & Mendelsohn, R. (1992). Assessing the economic value of traditional medicines from tropical rain forests. *Conservation biology*, 128–130.

Bailis, R., Drigo, R., Ghilardi, A., & Masera, O. (2015). The carbon footprint of traditional woodfuels. *Nature Climate Change*, *5*(3), 266–272.

Barnes, R. F. W. (2002). The bushmeat boom and bust in West and Central Africa. *Oryx*, *36*(03).

Barrow, E., & Fabricius, C. (2002). Do rural people really benefit from protected areas - rhetoric or reality? *Pakrs*, *12*(2), 67–77.

Bartlett, J., Kotrlik, J., & Higgins, C. (2001). Organizational research: Determining appropriate sample size in survey research appropriate sample size in survey research. *Information Technology, Learning, and Performance Journal*, *19*(1), 43.

Baumgardner, M., Kristof, S., Johannsen, C., & Zachary, A. (1969). Effects of organic matter on the multispectral properties of soils. *Proceedings of the Indiana Academy of Science*, *79.* pp. 413–422.

BBC. (2009, November 20). "Many flee" Congo fishing clashes. *BBC*. Retrieved from http://news.bbc.co.uk/2/hi/africa/8370875.stm

BBC. (2014, September 16). Democratic Republic of Congo profile. Retrieved October 6, 2014, from http://www.bbc.com/news/world-africa-13283212

Bell, S. (2012). DPSIR= A problem structuring method? An exploration from the "Imagine" approach. *European Journal of Operational Research*, *222*(2), 350–360.

Beneduce, R., Jourdan, L., Raeymaekers, T., & Vlassenroot, K. (2006). Violence with a purpose: Exploring the functions and meaning of violence in the democratic republic of Congo. *Intervention*, *4*(1), 32–46.

Bennett, E. L., Milner-Gulland, E. J., Bakarr, M., Eves, H. E., Robinson, J. G., & Wilkie, D. S. (2002). Hunting the world's wildlife to extinction. Oryx, 36(04), 328–329.

Berbet, M. L. C., & Costa, M. H. (2003). Climate Change after Tropical Deforestation: Seasonal Variability of Surface Albedo and Its Effects on Precipitation Change. *Journal of Climate*, *16*(12), 2099–2104.

Bidone, E. D., & Lacerda, L. D. (2004). The use of DPSIR framework to evaluate sustainability in coastal areas. Case study: Guanabara Bay Basin, Rio de Janeiro, Brazil. *Regional Environmental Change*, *4*(1), 5–16.

Biswas, A. K., & Quiroz, C. T. (1996). Environmental Impacts of the Rwandan Refugees on Zaire. *Springer on Behalf of Royal Swedish Academy of Science*, *25*(6), 403–408.

Blackstone, B., Stamouli, N., & Forelle, C. (2015, June 28). Greece Orders Banks Closed, Imposes Capital Controls to Stem Deposit Flight. Retrieved July 27, 2015

Blaser, J. (2009). *Forest law compliance and governance in tropical countries Forest Carbon Asia*. FAO and ITTO.

Bonan, G. B., Pollard, D., & Thompson, S. L. (1992). Effects of boreal forest vegetation on global climate. *Nature*, *359*(6397), 716–718.

Bonan, G. B. (2008). Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests. *Science*, *320*(5882), 1444–1449.

Bonham, C. A., Sacayon, E., & Tzi, E. (2008). Protecting imperiled "paper parks": potential lessons from the Sierra Chinajá, Guatemala. *Biodiversity and Conservation*, *17*(7), 1581–1593.

Brinkmann, W. L. ., & Ribeiro, M. N. G. (1971). Air temperatures in Central Amazonia !! - The effect of near-surface temperatures on land-use in the Tertiary region of Central Amazonia. *Instituto Nacional de Pesquisas Da Amazonia*, 6.

Brooks, E. G. E., Allen, D. J., & Darwall, W. R. T. (2011). *The status and distribution of freshwater biodiversity in central Africa*. IUCN.

Brown, H. C. P. (2009). *Institutional Dynamics and Climate Change in the Congo Basin Forests of Cameroon Report of Preliminary Findings* (Preliminary Findings). Ontario, Canada.

Brovkin, V., Sitch, S., von Bloh, W., Claussen, M., Bauer, E., & Cramer, W. (2004). Role of land cover changes for atmospheric CO_2 increase and climate change during the last 150 years. *Global Change Biology*, *10*(8), 1253–1266.

Bruner, A. G. (2001). Effectiveness of Parks in Protecting Tropical Biodiversity. *Science*, *291*(5501), 125–128.

Bultot, F. (1974). *Climatic Atlas of Zaire basin. Part Four: Atmospheric pressure, surface wind and altitude, temperature and humidity of the air at altitude, cloud cover and visibility, chemical properties of air and precipitation and classifications Cl.* Brussels: I.N.E.A.C: 193 maps

Burgess, R., Hansen, M., Olken, B., Potapov, P., & Sieber, S. (2012). *The political economy of deforestation in the tropics* (No. Working Paper No. 79). Grantham Research Institute on Climate Change and the Environment.

Büthe, T. (2002). Taking temporality seriously: Modeling history and the use of narratives as evidence. *American Political Science Review*, *96*(03), 481–493.

Butler, R. A. (2008). Deforestation in the Amazon. *Mongabay. com. http://www. mongabay.com/brazil.html*.

Bwangoy, J. B., Hansen, M. C., Roy, D. P., Grandi, G. D., & Justice, C. O. (2010). Wetland mapping in the Congo basin using optical and radar remotely sensed data and derived topographical indices. *Remote Sensing of Environment*, *114*(1), 73–86.

Bwangoy, J. R. B., Hansen, M. C., Potapov, P., Turubanova, S., & Lumbuenamo, R. S. (2013). Identifying nascent wetland forest conversion in the Democratic Republic of the Congo. *Wetlands ecology and management*, *21*(1), 29–43.

Campbell, D. (2005). The Congo River basin. *The World's Largest Wetlands: Ecology and Conservation. Cambridge University Press, Cambridge*, 149–165.

Carneggie, D. M. (1970). Remote sensing. *Miscellaneous Publication*, (1147), 165.

Carneggie, D. M., & Lauer, D. T. (1966). Uses of multiband remote sensing in forest and range inventory. *Photogrammetria*, *21*(4), 115–141.

Carr, E. R., Wingard, P. M., Yorty, S. C., Thompson, M. C., Jensen, N. K., & Roberson, J. (2007). Applying DPSIR to sustainable development. *International Journal of Sustainable Development & World Ecology*, *14*(6), 543–555.

Cerbu, G., Minang, P., Swallow, B., & Meadu, V. (2009). Global survey of REDD projects: what implications for global climate objectives? ASB Policy Brief No. 12. ASB Partnership for the Tropical Forest Margins, Nairobi, Kenya.

Cerbu, G. A., Swallow, B. M., & Thompson, D. Y. (2011). Locating REDD: A global survey and analysis of REDD readiness and demonstration activities. *Environmental Science & Policy*, *14*(2), 168–180.

Chapin III, F. S., Zavaleta, E. S., Eviner, V. T., Naylor, R. L., Vitousek, P. M., Reynolds, H. L., & Díaz, S. (2000). Consequences of changing biodiversity. *Nature*, *405*(6783), 234–242.

Chase, T. N., Peilke Sr., R. A., Kittel, T. G. F., Nemani, R. R., & Running, S. W. (1999). Simulated impacts of historical land cover changes on global climate in northern winter. *Springer-Verlag*, 13.

Cifuentes A, Miguel, Izurieta V, Arturo, Faria, H. H. de, & World Wildlife Fund. (2000). *Measuring protected area management effectiveness: Forest Innovations Project*. Turrialba, Costa Rica: WWF: IUCN; GTZ.

Clark, T. (2008). We're Over-Researched Here! 'Exploring Accounts of Research Fatigue within Qualitative Research Engagements. *Sociology*, *42*(5), 953–970.

Clark, M. (2012). Deforestation in Madagascar: Consequences of population growth and unsustainable agricultural processes. *Global Majority E-Journal*, *3*(1), 61–71.

Claussen, M. (2002). *Does landsurface matter in climate and weather? In Vegetation, water, humans and the climate: a new perspective on an interactive system*, (Synthesis No. Part A). IGBP Core Project.

Cleaver, K., & Schreiber, G. (1993). The Population, Environment and Agriculture Nexis in Sub-Saharan Africa. In J. P. Srivastava & H. Alderman (Eds.), World Bank, *Agriculture and Environmental Challenges* (p. 310). Washington, D.C: World Bank.

Clément, J. A. (2004). The Democratic Republic of the Congo: Lessons and challenges for a country emerging from war. *Postconflict Economics in Sub-Saharan Africa: Lessons from the Democratic Republic of the Congo, 2*, 6.

Climate Law & Policy. (2014). *Unpacking the "Warsaw Framework for REDD+". The requirements for implementing REDD+ under the United Nations Framework Convention on Climate Change* (No. Briefing note).

Conrad, J., & Murfin, R. C. (2010). *Heart of darkness*. Macmillan.

Corbera, E., & Schroeder, H. (2011). Governing and implementing REDD+ *Environmental science & policy*, *14*(2), 89–99.

Correll, D. L. (1997). Buffer zones and water quality protection: general principles. In H., Nick International Conference on Buffer Zones (Ed.), *Buffer zones: their processes and potential in water protection : the proceedings of the International Conference on Buffer Zones, September 1996*. Harpenden, England: Quest Environmental.

Creswell, J. W., and Clark, V. L. P. (2007). Designing and conducting mixed methods research.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Croon, G. W., McCullough, D. R., Olson Jr, C. E., & Queal, L. M. (1968). Infrared scanning techniques for big game censoring. *The Journal of Wildlife Management*, 751–759.

Daly, M. C., Lawrence, S. R., Diemu-Tshiband, K., & Matouana, B. (1992). Tectonic evolution of the Cuvette Centrale, Zaire. *Journal of the Geological Society*, *149*(4), 539–546.

Davis, W. (2003). Dreams From Endangered Cultures. *Lecture presented to TED, February*.

Debroux, L., Topa, G., Kaimowitz, D., Karsenty, A., Hart, T., Abdon, A., et al. (2007). Forests in post-conflict democratic republic of Congo: Analysis of a priority agenda. *Selected Books, 1*

DeFries, R. S., Houghton, R. A., Hansen, M. C., Field, C. B., Skole, D., & Townshend, J. (2002). Carbon emissions from tropical deforestation and regrowth based on satellite observations for the 1980s and 1990s. *Proceedings of the National Academy of Sciences*, *99*(22), 14256–14261.

DeFries, R. S., Rudel, T., Uriarte, M., & Hansen, M. (2010). Deforestation driven by urban population growth and agricultural trade in the twenty-first century. *Nature Geoscience*, *3*(3), 178–181.

Delire, C., Ngomanda, A., & Jolly, D. (2008). Possible impacts of 21st century climate on vegetation in Central and West Africa. *DGVM Responses to the Latest IPCC Future Climate Scenarios*, *64*(1–2), 3–15.

"Democratic Republic of Congo - Global Humanitarian Assistance."*Global Humanitarian Assistance*. Development Initiatives. Web. 29 July 2015.

Det Norske Veritas. (2012). *CCB final validation report: era and wildlife works' Mai Ndombe REDD project in the democratic republic of Congo* (Validation Report).

Devers, D., and Vandeweghe, J. (2006) The forest of the Congo basin: state of the forest 2006.

de Wasseige, C., Devers, D., de Marcken, R., Eba'a Atyi, R., Nasi, R., & Mayaux, P. (2009). The Forests of the Congo Basin: State of the Forest 2008.

de Wasseige, C., Devers, D., & de Marcken, P. (2010). *The forests of the Congo basin: State of the forest 2008* Publications Office of the European Union.

de Wasseige, C., de Marcken, P., Bayol, N., Hiol-Hiol, F., Mayaux, P. H., Desclée, B., & Atyi, E. A. (2012). *The forests of the Congo basin: state of the forest 2010* (p. 276p). Publications Office of the European Union, Luxembourg.

de Wasseige C., Flynn J., Louppe D., Hiol F., Mayaux Ph. (2014). *The forests of the Congo basin: state of the forest 2013* Weyrich. Belgium. 328 p. Legal deposit:

de Wit, M., Guillocheau, F., & de Wit, M. C. (Eds.). (2015). *Geology and Resource Potential of the Congo Basin*. Springer Science & Business Media.

Dirmeyer, P. A., and Shukla, J. (1994). Albedo as a modulator of climate response to tropical deforestation. *Journal of Geophysical Research*, *99*(D10), 20863.

Dirmeyer, P. A., Fang, G., Yadav, P., & Milton, A. (2014). Climate change and sectors of the surface water cycle in CMIP5 projections.*18*, 5317.

Dixon, R. K., Solomon, A. M., Brown, S., Houghton, R. A., Trexier, M. C., & Wisniewski, J. (1994). Carbon pools and flux of global forest ecosystems. *Science*, *263*(5144), 185–190.

Dooley, K., Griffiths, T., Martone, F., & Ozinga, S. (2011). *Smoke and mirrors. A critical assessment of the Forest Carbon Partnership Facility*. Forest Peoples Programme.

Donald, P. F., Sanderson, F. J., Burfield, I. J., & van Bommel, F. P. J. (2006). Further evidence of continent-wide impacts of agricultural intensification on European farmland birds, 1990–2000. *Agriculture, Ecosystems & Environment, 116*(3-4), 189–196.

Draulans, D., & Van Krunkelsven, E. (2002). The impact of war on forest areas in the Democratic Republic of Congo. *Oryx, 36*(1), 6.

DRC ERPIN (2014). *Forest Carbon Partnership Facility Carbon Fund Emission Reductions Program Idea Note*

Dudley, N., Gujja, B., World Wide Fund for Nature, & International Union for Conservation of Nature and Natural Resources. (1999). Challenges for Protected Areas in the 21st Century. In S. Stolton (Ed.), *Partnerships for protection: new strategies for planning and management for protected areas*. London: Earthscan.

Duveiller, G., Defourny, P., Desclée, B., & Mayaux, P. (2008). Deforestation in central Africa: Estimates at regional, national and landscape levels by advanced processing of systematically-distributed Landsat extracts. *Remote Sensing of Environment, 112*(5), 1969–1981.

Eastaught, C. (2008). *Adaptations of forests to climate change: a multidisciplinary review*. Vienna: IUFRO Secretariat.

European Environmental Agency (EEA). (2007). *Halting the loss of biodiversity by 2010: proposal for a first set of indicators to monitor progress in Europe, EEA Technical Report no. 11/2007* (No. 11/2007). Copenhagen: European Environmental Agency.

Eltahir, E. A. B., & Bras, R. L. (1994). Sensitivity of regional climate to deforestation in the Amazon basin. *Advances in Water Resources*, *17*(1–2), 101–115.

Ernst, C., Mayaux, P., Verhegghen, A., Bodart, C., Christophe, M., & Defourny, P. (2013). National forest cover change in Congo basin: Deforestation, reforestation, degradation and regeneration for the years 1990, 2000 and 2005. *Global Change Biology, 19*(4), 1173–1187.

Essayas, N. A. (2010, November). *Applying the DPSIR Approach for the assessment of alternative management strategies of Simen Mountains National Park Ethiopia*. University of Natural Resources and Life Sciences (BOKU), Vienna, Austria.

Evans, K. (2012). Brave new world: the global trends changing the future of deforestation. *Center for International Forestry Research*. Doha, Qatar.

FAO Expert Consultation on the Role of Forestry in Combating Desertification, & Food and Agriculture Organization of the United Nations. (1989). *Role of forestry in combating desertification: proceedings of the FAO Expert Consultation on the Role of Forestry in Combating Desertification, held in Saltillo, Mexico, 24-28 June 1985*. Rome: Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/docrep/T0115E/T0115E00.htm

FAO. (1997). *Wildlife and food security in Africa*. (Y. Ntiamoa-Baidu, Ed.). Rome: Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/docrep/w7540e/w7540e00.htm#Contents

FAO. (2001). *Conservation agriculture: Case studies in Latin American and Africa*. Rome: FAO. Retrieved from http://www.fao.org/docrep/003/Y1730E/y1730e00.htm#P-1_0

FAO. (2007). *Land Degradation Assessment in Drylands (LADA)* (Biophysical Indicator Toolbox (Pressure/State) No. Technical Report 2) (p. 87).

FAO. (2010).*Global forest resources assessment 2010: Main report*. Food and Agriculture Organization of the United Nations.

Farquharson, K. (2005). A different kind of snowball: identifying key policymakers. *International Journal of Social Research Methodology*, *8*(4), 345–353.

Fisher, B., Turner, R. K., & Morling, P. (2009). Defining and classifying ecosystem services for decision making. Ecological economics, 68(3), 643—653.

Fitzherbert, E., Struebig, M., Morel, A., Danielsen, F., Bruhl, C., Donald, P., & Phalan, B. (2008). How will oil palm expansion affect biodiversity? *Trends in Ecology & Evolution*, *23*(10), 538–545.

Fleckner, M., & Avery, J. (2011). Congo Uranium and the Tragedy of Hiroshima. *University of Copenhagen.[Electronic] http://www. docstoc. com/docs/59168425/Congo-Uranium-and-the-Tragedy-of-Hiroshima Last Visited*, 05-21.

Fogarty, B. J., & Wolak, J. (2009). The effects of media interpretation for citizen evaluations of politicians' messages. *American Politics Research*, *37*(1), 129–154.

Foley, J. A. (2005). Global Consequences of Land Use. *Science*, *309*(5734), 570–574.

Food and Agriculture Organization of the United Nations. (2012). *State of the world's forests, 2012*. Rome: Food and Agriculture Organization of the United Nations.

Forest Monitor. (2006). Political, social and economic framework. Retrieved from http://www.forestsmonitor.org/en/reports/540539/549940

Fraser, A. I. (1998). Social, Economic and Political Aspects of Forest Clearance and Land-Use Planning in Indonesia. In B. K. Maloney (Ed.), *Human Activities and the Tropical Rainforest* (Vol. 44). Dordrecht: Springer Netherlands.

Frayssinet, F. (2013, June 20). Straightening Out Accounts on Deforestation in the Brazilian Amazon. *Inter Press Service News Agency*. Rio De Janeiro.

Garg, T. (2014). Public Health Effects of Ecosystem Degradation: Evidence from Deforestation in Indonesia. *Cornell University*, 48.

Gari, J. (2001). Biodiversity and indigenous agroecology in Amazonia: The indigenous people of Pastaza. *Etnoecologica*, *5*(7), 21–37.

Geer, J. G. (1991). Do open-ended questions measure "salient" issues? *Public Opinion Quarterly*, *55*(3), 360–370.

Geist, H. J., & Lambin, E. F. (2001). *What Drives Tropical Deforestation?* (Meta-analysis No. 4). Brussels: University of Louvain.

Geist, H. J., & Lambin, E. F. (2002). Proximate Causes and Underlying Driving Forces of Tropical Deforestation Tropical forests are disappearing as the result of many pressures, both local and regional, acting in various combinations in different geographical locations.*BioScience*,*52*(2), 143–150.

German Government. (2006, February 9). National Forest Inventory. Retrieved September 9, 2014, from http://www.bundeswaldinventur.de/enid/a9.html

Giblin, J. (2014). Political and Theoretical Problems for the Archaeological Identification of Precolonial Twa, Tutsi, and Hutu in Rwanda. *Ethnic Ambiguity and the African Past: Materiality, History, and the Shaping of Cultural Identities*, *65*, 217.

Giles-Vernick, T. (2002). *African Studies Review*, *45*(3), 85–87.

Gong, C., & Eltahir, E. (1996). Sources of moisture for rainfall in West Africa. *Water Resources Research*, *32*(10), 3115–3121.

Gough, A. D., Innes, J. L., & Allen, S. D. (2008). Development of common indicators of sustainable forest management. *Ecological Indicators, 8*(5), 425–430.

Gregory, A. J., Atkins, J. P., Burdon, D., & Elliott, M. (2013). A problem structuring method for ecosystem-based management: The DPSIR modelling process.*European Journal of Operational Research,227*(3), 558–569.

Green, R. E. (2005). Farming and the Fate of Wild Nature. *Science, 307*(5709), 550–555.

Haken, N., Messner, J. J., Hendry, K., Taft, P., Lawrence, K., & Umaña, F. (2013). *Failed states index IX2013* No. 06L) The Fund for Peace.

Hansen, M. C., Roy, D. P., Lindquist, E., Adusei, B., Justice, C. O., & Altstatt, A. (2008). A method for integrating MODIS and Landsat data for systematic monitoring of forest cover and change in the Congo basin. *Remote Sensing of Environment, 112*(5), 2495–2513.

Hansen, M., Moore, R., Hancher, M., & Potapov, P. (2013a). *Global forest change* University of Maryland.

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., & Townshend, J. R. G. (2013). High-resolution global maps of 21st-century forest cover change. Science,342(6160), 850–853.

Hansen, M. C., Stehman, S. V., & Potapov, P. V. (2010). Quantification of global gross forest cover loss. *Proceedings of the National Academy of Sciences, 107*(19), 8650–8655.

History. (2009). Hurricane Mitch. Retrieved October 9, 2014, from http://www.history.com/topics/hurricane-mitch

Hoare, A. L., & Rainforest Foundation UK. (2007). *Clouds on the horizon: the Congo Basin's forests and climate change*. London: Rainforest Foundation.

Hochschild, A. (1998). *King Leopold's ghost: A story of greed, terror, and heroism in colonial Africa* Houghton Mifflin.

Hosonuma, N., Herold, M., De Sy, V., De Fries, R. S., Brockhaus, M., Verchot, L., et al. (2012). An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters, 7*(4).

Huggins, C. (2005). *Conflict in the Grewat Lakes Region: How is it Linked with Land and Migration?* (No. Natural Resource Perspectives No. 96). London: Overseas Development Institute.

Hughes, R. H., Hughes, J. S., & Bernacsek, G. (1992). *A directory of African wetlands* IUCN.

Human Rights Watch. (2005). *The Curse of Gold* (p. 13). Retrieved from http://www.hrw.org/reports/2005/06/01/curse-gold

Hurni, H., & Ludi, E. (2000). Reconciling Conservation with Sustainable Development A Participatory Study Inside and Around the Simen Mountains National Park, Ethiopia. *Centre for Development and Environment (CDE) University of Bern, Bern*.

Ickowitz, A. (2006). Shifting cultivation and deforestation in tropical Africa: Critical reflections. *Development and Change*, *37*(3), 599–626.

Ickowitz, A. (2006). Shifting cultivation and deforestation in tropical Africa: Critical reflections. *Development and Change*, *37*(3), 599–626.

Inogwabini, B., & Ndunda, M. (2006). A dramatic decline in rainfall regime in the Congo Basin: Evidence from a thirty-four year dataset from the Mabali Scientific Research Centre, Democratic Republic of Congo. *International Journal of Meteorology*,*31*(312), 278-285.

Inogwabini, B., Matungila, B., Mbende, L., & Abokome, M. (2007). Great apes in the Lake Tumba landscape, Democratic Republic of Congo: Newly described populations. *Oryx*, *41*(04), 532-538.

Inogwabini, B. I. (2014). Bushmeat, over-fishing and covariates explaining fish abundance declines in the Central Congo Basin. *Environmental Biology of Fishes*, *97*(7), 787–796.

Indian Institute of Forest Management. (2013). *National Forest Policy Report: India*. Retrieved from ftp://ftp.fao.org/docrep/fao/005/AC921E/AC921E04.pdf

Intergovernmental Panel on Climate Change. (2008). *Climate change 2007 : synthesis report*. (L. Bernstein, R. K. Pachauri, & A. Reisinger, Eds.). Geneva, Switzerland: IPCC.

International Rescue Committee. (2006). Refugee children & youth backgrounders. *www.The IRC.org retrieved on*,*19*(05), 2013.

IPCC, 2012: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.* A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F.

Stocker, D. Qin, D.J. Dokken, K.L. Edi, M.D. Mastrandea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA 582 pp.

IPCC, 2014: Summary for Policymakers. In: *Climate Change 2014: Impacts Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Firth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.N., V.R., Barros, D.J., Dokken, K.J., Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1–32.

ITTO. (2005). *Status of Tropical Forest Management: India*. International Tropical Timber Organization.

IUCN. (2004). The Durban Action Plan. Presented at the 5th IUCN World Parks Congress. Retrieved from http://cmsdata.iucn.org/downloads/durbanactionen.pdf

Jacks, G. V., & Whyte, R. O. (1939). The rape of the earth: A world survey of soil erosion. *The Rape of the Earth: A World Survey of Soil Erosion.*

Janishevski, L., Noonan-Mooney, K., Gidda, S. B., & Mulongoy, K. J. (2008). Protected areas in today's world: their values and benefits for the welfare of the planet. *CBD Technical Series*, (36).

Jiang, H. (2009, July 29). China's Great Green Wall Proves Hollow Tree planting damages environment in northern China. *The Epoch Times*.

Jones, M. D., & McBeth, M. K. (2010). A narrative policy framework: Clear enough to be wrong? *Policy Studies Journal*, *38*(2), 329–353.

Kadima, E., Delvaux, D., Sebagenzi, S. N., Tack, L., & Kabeya, S. M. (2011). Structure and geological history of the Congo basin: An integrated interpretation of gravity , magnetic and reflection seismic data. *Basin Research*, *23*(5), 499–527.

Kaplan, S. (2007). The wrong prescription for the Congo. *Orbis*, *51*(2), 299–311.

Keddy, P. A., Fraser, L. H., Solomeshch, A. I., Junk, W. J., Campbell, D. R., Arroyo, M. T., & Alho, C. J. (2009). Wet and wonderful: the world's largest wetlands are conservation priorities. Bioscience, 59(1), 39–51.

Knipling, E. B. (1970). Physical and physiological basis for the reflectance of visible and near-infrared radiation from vegetation. *Remote Sensing of Environment, 1*(3), 155–159.

Kristensen, P. (2004). *The DPSIR Framework*. Presented at the Workshop on a comprehensive / detailed assessment of the vulnerability of water resources to environmental change in Africa using river basin approach. UNEP Headquarters, Nairobi, Kenya.

Kuditshini, J. T. (2008). Global governance and local government in the Congo: The role of the IMF, World Bank, the multinationals and the political elites. *International Review of Administrative Sciences, 74*(2), 195—216.

Kull, C. A., & Laris, P. (2009). Fire ecology and fire politics in Mali and Madagascar. In *Tropical Fire Ecology* (pp. 171-226). Springer Berlin Heidelberg.

Kull, C. A. (2013). Air photo evidence of historical land cover change in the highlands: Wetlands and grasslands give way to crops and woodlots. *Madagascar Conservation & Development, 7*(3), 144–152.

Kull, C. A. (2005). Historical landscape repeat photography as a tool for land use change research.*Norsk Geografisk Tidsskrift,59*(4), 253–268.

Lambin, E. F. (1994). Modeling deforestation processes.

Ledec, G. (1985). The political economy of tropical deforestation. *The Political Economy of Environmental Abuse in the Third World. Holmes and Meier, New York, NY,*

Lewis, J. (2012). Technological Leap-frogging in the Congo Basin, Pygmies and Global Positioning Systems in Central Africa: What has happened and where is it going?

Lindquist, E., Hansen, M., Roy, D., & Justice, C. (2008). The suitability of decadal image data sets for mapping tropical forest cover change in the Democratic Republic of Congo: Implications for the global land survey. *International Journal of Remote Sensing, 29*(24), 7269–7275.

Long, C. (2011). Land rights in the Democratic Republic of Congo: a new model of rights for forest-dependent communities. *Land struggles and civil society in Southern Africa. Africa World Press, Trenton*.

Lumumba, P. (1960, June 30). Proclamation of Congolese Independence.

Luney, P. R., & Dill, H. W. (1970). Uses, potentialities, and needs in agriculture and forestry. *Remote Sensing with Special Reference to Agriculture and Forestry*, 1–34.

Malcolm, X., & Breitman, G. (1992). *By any means necessary*. New York: Pathfinder.

Malcolm, X. (1964). The ballot or the bullet. *April*, *3*, 23 –44.

Malhi, Y., Adu-Bredu, S., Asare, R. A., Lewis, S. L., & Mayaux, P. (2013). African rainforests: past, present and future. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *368*(1625).

Malthus, T. (1998). *An Essay on the Principle of Population*.

Manhart, A., & Schleicher, T. (2013). *Conflict Minerals: An Evaluation of the Dodd -Frank Act and Other Resource-related Measures*. Öko-Institut.

Mannion, A. M. (2003). *The Environmental Impact of War & Terrorism.* University of Reading.

Mapa, R. B., & Kumaragamage, D. (1996). Variability of soil properties in a tropical alfisol used for shifting cultivation. *Soil Technology*, *9*(3), 187–197.

Martin, G. H. G. (1983). Bushmeat in Nigeria as a Natural Resource with Environmental Implications. *Environmental Conservation*, *10*(02), 125.

Marysse, S. L. (2004). *Decentralization issues in post-conflict Democratic Republic of the Congo (DRC)* University of Antwerp. Institute of development policy and management (IDPM-UA).

Mayaux, P., Bartholomé, E., Fritz, S., & Belward, A. (2004). A new land-cover map of Africa for the year 2000. *Journal of Biogeography*, *31*(6), 861–877.

Mayaux, P., Pekel, J. F., Desclee, B., Donnay, F., Lupi, A., Achard, F., et al. (2013). State and evolution of the African rainforests between 1990 and 2010. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *368*(1625).

McFerson, H. M. (2010). Extractive industries and African democracy: Can the "Resource curse" be exorcised? *International Studies Perspectives*, *11*(4), 335—353.

McMichael, A. J., Patz, J., & Kovats, R. S. (1998). Impacts of global environmental change on future health and health care in tropical countries. *British Medical Bulletin*, *54*(2), 475–488.

Mebrat, W., & Gashaw, T. (2013) Threats of woody plant species diversity and their conservation techniques in Ethiopia.

Megevand, C. (2013). *Deforestation trends in the Congo basin: Reconciling economic growth and forest protection* World Bank Publications.

Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Mkwalo, A. C. (2011). Assessment of potential and impacts of afforestation in the Letaba catchment, Limpopo Province, South Africa.

Moran, E. F. (1994). The Law, Politics, and Economics of Amazonian Deforestation. *Indiana Journal of Global Legal Studies*, *1*(2).

Mputu, A. (2013). *Aquatic Assessment in the Lake Tumba Landscape, DRCongo* (Licentiate These). Swedish University of Agricultural Science, Uppsala.

Muyembe-Tamfum, J. J., Mulangu, S., Masumu, J., Kayembe, J. M., Kemp, A., & Paweska, J. T. (2012). Ebola virus outbreaks in Africa: past and present. *Onderstepoort Journal of Veterinary Research*,*79*(2), 06–13.

Nachega, M. J. (2005). *Fiscal dominance and inflation in the Democratic Republic of the Congo (EPub)* International Monetary Fund.

Nasi, R., Taber, A., & Vliet, N. V. (2011). Empty forests, empty stomachs? Bushmeat and livelihoods in the Congo and Amazon Basins. International Forestry Review, 13(3), 355—368.

Naughton-Treves, L., Holland, M. B., & Brandon, K. (2005). The role of protected areas in conserving biodiversity and sustaining local livelihoods. *Annual Review of Environment and Resources*, *30*(1), 219–252.

Nelson, A., & Chomitz, K. M. (2011). Effectiveness of Strict vs. Multiple Use Protected Areas in Reducing Tropical Forest Fires: A Global Analysis Using Matching Methods. *PLoS ONE*, *6*(8).

Ngonghala, C. N., Pluciński, M. M., Murray, M. B., Farmer, P. E., Barrett, C. B., Keenan, D. C., & Bonds, M. H. (2014). Poverty, Disease, and the Ecology of Complex Systems. *PLoS Biology*, *12*(4).

Nkem, J., Idinoba, M., & Sendashonga, C. (2008). *Forest for climate change adaptation in the Congo Basin: Responding to an urgent need with sustainable practices* (Environmental Brief) (pp. 2–6). CIFOR.

Nkem, J. N., Somorin, O. A., Jum, C., Idinoba, M. E., Bele, Y. M., & Sonwa, D. J. (2013). Profiling climate change vulnerability of forest indigenous communities in the Congo Basin. *Mitigation and Adaptation Strategies for Global Change*, *18*(5), 513–533.

Nye, P. H., & Greenland, D. J. (1961). The soil under shifting cultivation.*Soil Science*, *92*(5), 354.

Oates, J. F. (1999). *Myth and Reality in the Rain Forest: How Conservation Strategies are falling in West Africa* (Illustrated.). University of California Press.

Odum, E. P., Finn, J. T., & Franz, E. H. (1979). Perturbation theory and the subsidy-stress gradient. BioScience, 29(6), 349–352.

Odum, E. P. (1985). Trends expected in stressed ecosystems. *Bioscience*, *35*(7), 419-422.

Okereke, C., & Dooley, K. (2010). Principles of justice in proposals and policy approaches to avoided deforestation: towards a post-Kyoto climate agreement. *Global Environmental Change*, *20*(1), 82–95.

Oliver, R., & Atmore, A. (2000). *Africa since 1800*. Cambridge University Press.

OSFAC, P. pour les F. du B. du C. (PFBC), European Commission Observatoire des Forêts d'Afrique Centrale, Wasseige, C. de, & Joint Research Centre. (2007). *The forests of the Congo basin: state of the forest 2006*. Luxembourg: EUR-OP.

OSFAC. (2010). In Observatoire Satellital des forêts d'Afrique centrale (OSFAC), South Dakota State University (SDSU), University of Maryland (UMD). (Ed.), *Monitoring the forests of central Africa using remotely sensed data sets. Forest cover and forest cover loss in the democratic republic of Congo from 2000 to 2010.* Brookings: South Dakota State University.

Oslisly, R., White, L., Bentaleb, I., Favier, C., Fontugne, M., Gillet, J. F., et al. (2013). Climatic and cultural changes in the west Congo basin forests over the past 5000 years. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *368*(1625).

Parker, C., Mitchell, A., Trivedi, M., & Mardas, N. (2008). *The Little REDD+ Book: An updated guide to governmental and non-governmental proposals for reducing*

emissions from deforestation and degradation (third.). Oxford: Global Canopy Programme.

Parker, D. C., & Wolff, M. F. (1965). Remote sensing. *Science and Technology,* (43)

Phelps, J., Friess, D. A., & Webb, E. L. (2012). Win–win REDD+ approaches belie carbon–biodiversity trade-offs. *Biological Conservation*, *154*, 53–60.

Pielke, R. A., Marland, G., Betts, R. A., Chase, T. N., Eastman, J. L., Niles, J. O., Running, S. W. (2002). The influence of land-use change and landscape dynamics on the climate system: relevance to climate-change policy beyond the radiative effect of greenhouse gases. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *360*(1797), 1705–1719.

Pimm, S. L., & Raven, P. (2000). Biodiversity: extinction by numbers. *Nature*, *403*(6772), 843–845.

Posa, M. R. C., Wijedasa, L. S., & Corlett, R. T. (2011). Biodiversity and conservation of tropical peat swamp forests. *BioScience*,*61*(1), 49–57.

Potapov, P. V., Turubanova, S. A., Hansen, M. C., Adusei, B., Broich, M., Altstatt, A., et al. (2012). Quantifying forest cover loss in Democratic Republic of the Congo, 2000–2010, with landsat ETM+ data. *Remote Sensing of Environment*, *122*(0), 106–116.

Pottier, J., University of London, & School of Oriental and African Studies. (2003). *Fevered imaginings: "the Congo" in popular culture, globalisation, conflict and diplomacy*. London: School of Oriental and African Studies, University of London.

Porter-Bolland, L., Ellis, E. A., Guariguata, M. R., Ruiz-Mallén, I., Negrete-Yankelevich, S., & Reyes-García, V. (2012). Community managed forests and forest protected areas: An assessment of their conservation effectiveness across the tropics. *Forest Ecology and Management*, *268*, 6–17.

Rapport, D. J., Costanza, R., & McMichael, A. J. (1998). Assessing ecosystem health. *Trends in Ecology & Evolution*, *13*(10), 397–402.

Rapport, D. J., Regier, H. A., & Hutchinson, T. C. (1985). Ecosystem behavior under stress. *American Naturalist*, 617–640.

Ravindranath, N. H., Chaturvedi, R. K., & Murthy, I. K. (2008). Forest conservation, afforestation and reforestation in India: Implications for forest carbon stocks. *Current Science*, *95*(2), 216–222.

Radio Okapi. (2009, July 31).

Redford, K. H. (1992). The Empty Forest. *BioScience*, *42*(6), 412–422.

Roy, S. B., Walsh, P. D., & Lichstein, J. W. (2005). Can logging in equatorial Africa affect adjacent parks? *Ecology and Society*, 11.

Rose, A. L. (2002). Conservation must pursue human-nature biosynergy in the era of social chaos and bushmeat commerce. *Cambridge Studies in Biological and Evolutionary Anthropology*, 2008–239.

Rudel, T. K., Coomes, O. T., Moran, E., Achard, F., Angelsen, A., Xu, J., et al. (2005). Forest transitions: Towards a global understanding of land use change. *Global Environmental Change, 15*(1), 23–31.

Rudel, T. K., Defries, R., Asner, G. P., & Laurance, W. F. (2009). Changing drivers of deforestation and new opportunities for conservation. *Conservation Biology, 23*(6), 1396–1405.

Rudel, T. K. (1995). When Do Property Rights Matter? Open Access, Informal Social Controls, and Deforestation in the Ecuadorian Amazon. *Human Organization, 54*(2).

Rudel, T. K. (2013). The national determinants of deforestation in sub-Saharan Africa. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *368*(1625), 20120405.

Sala, O. E. (2000). Global Biodiversity Scenarios for the Year 2100; *Science, 287*(5459), 1770–1774.

Samba, G., Nganga, D., & Mpounza, M. (2008). Rainfall and temperature variations over Congo-Brazzaville between 1950 and 1998. *Theoretical and Applied Climatology, 91*(1-4), 85-97.

Sample, V., Johnson, N., Aplet, G., & Olson, J. (1993). *Defining Sustainable Forestry*. Washington, D.C: Island Press.

Sanguma, W. (2012). Re-evaluating peacebuilding in the democratic republic of Congo: A case study in Dongo.

Samyn, Jean-Marie, Gasana, James, Pousse, Emmanuel, Pousse, Fabien. "The Forest Sector in the Congo Basin Countries: 20 Years of AFD Intervention." *Agence Française De Development* (2012). ADF. Web.

Sato, D., Yasui, D., & Byamana, M. (2000). Follow-Up Survey of Environmental Impacts of the Rwandan Refugees on Eastern D. R. Congo. *AMBIO: A Journal of the Human Environment*, *29*(2), 122–123.

Secretariat of the Convention on Biological Diversity. (2009). Sustainable Forest Management, Biodiversity and Livelihoods: A Good Practice Guide. Montreal.

Secretariat of the Convention on Biological Diversity. (2008). *Protected areas in today's world their values and benefits for the welfare of the planet*. Montreal, Quebec, Canada: Secretariat of the Convention on Biological Diversity.

Seyler, J., Thomas, D., Mwanza, N., & Mpoyi, A. (2010). *Democratic Republic of Congo: Biodiversity and tropical forestry assessment (118/119)* No. Final) USAID/ Democratic Republic of the Congo.

Seymour, F. (2010). *Forests, climate change, and human rights: Managing risks and trade- offs* (p. 207). Cambridge University Press.

Shames, S., Wollenberg, E., Buck, L. E., Kristjanson, P., Masiga, M., & Biryahwaho, B. (2012). Institutional innovations in African smallholder carbon projects.

Sharma, N., & Rowe, R. (1992). Managing the World's Forests. *Finance & Development*, *29*(2), 31.

Shekhawat, S. (2009). Governance crisis and conflict in the Democratic Republic of Congo. *University of Mumbai, Working Paper*, (6), 7–17.

Slade, S. 2015. Dodd-Frank at 5: How Financial Reform Led to Bloodshed in the Congo, Retrieved July 23, 2015 from http: //reason.com/blog/2015/07/21/dodd-frank-at-5-how- financial-reform-led.

Smith, N. (2002). New globalism, new urbanism: gentrification as global urban strategy. Antipode, 34(3), 427–450.

Solberg, B., Brooks, D., Pajuoja, H., Peck, T. J., & Wardle, P. A. (1996). *Long Term Trend in World Supply and Demand for Wood and Implications for Sustainable Forest Management: A contribution to the CSD Ad Hoc Intergovernmental Panel on Forests (IPF), Draft Paper*. Joensuu, Finland: European Forest Institute and As, Norway: Norwegian Forest Research Institute.

Snyder, P. K. (2004). Analyzing the effects of complete tropical forest removal on the regional climate using a detailed three-dimensional energy budget: An application to Africa. *Journal of Geophysical Research*, *109*(D21).

Stone, Deborah. 2002. *Policy Paradox: The Art of Political Decision Making, Revised Edition,* 3rd ed. New York: W. W. Norton.

Szott, L., Palm, C., & Buresh, R. J. (1999). Ecosystem fertility and fallow function in the humid and subhumid tropics. *Agroforestry Systems, 47*(1-3), 163–196.

Tallis, H., Kareiva, P., Marvier, M., & Chang, A. (2008). An ecosystem services framework to support both practical conservation and economic development. *Proceedings of the National Academy of Sciences*, *105*(28), 9457–9464.

Thompson, B., Cohen, M. J., & Meerman, J. (2012). World Food Insecurity and Malnutrition: Scope, Trends, Causes and Consequences. In B. Thompson & M. J. Cohen (Eds.), *the Impact of Climate Change and Bioenergy on Nutrition* (pp. 21–41). Dordrecht: Springer Netherlands.

Tilman, D. (2001). Forecasting Agriculturally Driven Global Environmental Change. *Science*, *292*(5515), 281–284.

Toham, A. K. et al., (2006). *A vision for biodiversity conservation in central Africa: Biological priorities for conservation in the guineo-congolian forest and freshwater region.* World Wide Fund for Nature.

Trost, J. E. (1986). Statistically nonrepresentative stratified sampling: A sampling technique for qualitative studies. *Qualitative sociology*, *9*(1), 54–57.

Tscherning, K., Helming, K., Krippner, B., Sieber, S., & y Paloma, S. G. (2012). Does research applying the DPSIR framework support decision making? *Land Use Policy*, *29*(1), 102–110.

Turner, B. L. (1990). *The earth as transformed by human action: Global and regional changes in the biosphere over the past 300 years* CUP Archive.

Turner, B., Meyer, W. B., & Skole, D. L. (1994). Global land-use/land-cover change: Towards an integrated study. *Ambio-Stockholm-*, *23*, 91–91.

Tylianakis, J. M., Didham, R. K., Bascompte, J., & Wardle, D. A. (2008). Global change and species interactions in terrestrial ecosystems. *Ecology Letters*, *11*(12), 1351–1363.

Tyukavina, A., Stehman, S., Potapov, P., Turubanova, S., Baccini, A., Goetz, S., et al. (2013). National-scale estimation of gross forest aboveground carbon loss: A case study of the Democratic Republic of the Congo. *Environmental Research Letters*, *8*(4), 044039.

UNMEA. (2005). Synthesis report.*Island, Washington, DC*.

United Nations. (2013). UN-OHRLLS: Least Developed Countries - About LDCs. Retrieved from http://www.unohrlls.org/en/ldc/25/

UN. (2010, July 15). Supporting REDD Readiness in UN-REDD Partner Countries. Retrieved July 9, 2015, from http://www.un-redd.org/NewsCentre/Supporting_REDD_Readiness/tabid/4826/Default.aspx

Vandeweghe, J. P. 2004. Forests of Central Africa: Nature and Man. Ecofac, Lamono Publishers, Tielt, Belgium.

Vansina, J. M. (1990). Paths in the rainforests: toward a history of political tradition in equatorial Africa. University of Wisconsin Pres.

Verhaegen, B., & Vale, M. (1993). The temptation of predatory capitalism: Zaire under Mobutuism. *International Journal of Political Economy*, 109–125.

Verissimo, D., MacMillan, D. C., & Smith, R. J. (2011). Toward a systematic approach for identifying conservation flagships. *Conservation Letters*, *4*(1), 1–8.

Virunga [Motion picture]. (2014). Netflix.

Vlassenroot, K. (2013). Land Issues and Conflict in Eastern DRC. Publication. *SSRC*.

von Gadow, K., Pukkala, T., & Tomé, M. (2000). *Sustainable Forest Management*. Dordrecht: Springer Netherlands.

Wallace, K. J. (2007). Classification of ecosystem services: problems and solutions. Biological conservation, 139(3), 235–246.

Walker, R. T. (1987). Land use transition and deforestation in developing countries. *Geographical Analysis*, *19*(1), 18–30.

Watson, R. T., Noble, I. R., Bolin, B., Ravindranath, N. H., Verardo, D. J., & Dokken, D. J. (2000). *Land use, land-use change and forestry: a special report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Watts, J., & correspondent, A. environment. (2009, March 11). China's loggers down chainsaws in attempt to regrow forests. *The Guardian*.

Werth, D., & Avissar, R. (2005). The local and global effects of African deforestation. *Geophysical research letters*,*32*(12).

Wildlife Works Department of Carbon Development. (2012). *The Mai Ndombe REDD+ project* Wildlife Works.

Wilkie, D. S., Bennett, E. L., Peres, C. A., & Cunningham, A. A. (2011). The empty forest revisited. Annals of the New York Academy of Sciences, 1223(1), 120–128.

Williams, C. A., & Hanan, N. P. (2011). ENSO and IOD teleconnections for African ecosystems: evidence of destructive interference between climate oscillations. *Biogeosciences*, *8*(1), 27–40.

Wibowo, D. H., & Byron, R. N. (1999). Deforestation mechanisms: a survey. *International Journal of Social Economics*, *26*(1/2/3), 455–474.

Westover, R. H. (2011, April 27). US Forest Service Reforestation Efforts a Win-Win for Healthy Forests.

World Bank. (2000). *Brazil: forests in the balance: challenges of conservation with development*. (U. J. Lele, Ed.). Washington, D.C: World Bank.

World Bank. (2011). *Reforestation Projects Bring Carbon Revenues and Co-Benefits To Poor Communities* (Press Release No. 2012/006/SDN). Marrakesh.

World Food Programme. (2014). Hunger. Retrieved October 9, 2014, from

Wrong, M. (2001).*In the footsteps of Mr. Kurtz: Living on the brink of disaster in Mobutu's Congo*. New York: HarperCollins Publishers.

Xia, J., Liang, S., Chen, J., Yuan, W., Liu, S., Li, L., et al. (2014). Satellite-based analysis of evapotranspiration and water balance in the grassland ecosystems of dryland East Asia. *PloS One*, *9*(5), e97295.

Yanggen, D., Angu, K., & Tchamou, N. (Eds.). (2010). *Landscape-Scale Conservation in the Congo Basin: Lessons Learned from the Central African Regional Program for the Environment (CARPE)*. IUCN.

Yale School of Forestry and Environmental Studies. (2015, January 22). Surprising insights into effects of wood fuel burning. *Science Daily*. Retrieved February 21, 2015

Zhao, M., & Running, S. W. (2010). Drought-Induced Reduction in Global Terrestrial Net Primary Production from 2000 through 2009. *Science*, *329*(5994), 940–943.

BIOGRAPHY

Ashley D. Milton graduated from Vanden High School, Fairfield, California, in 2006. She received her Bachelor of Science from Florida Agricultural and Mechanical University, Tallahassee, Florida, in 2009 and her Master of Public Administration from American University, Washington, D.C., in 2011. She was a Fulbright Scholar in the Democratic Republic of Congo and for 2013-2014. Ashley has worked for the U.S. Department of State, the U.S. Agency for International Development, and the Ocean Foundation, to name a few.