Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.8, No.11, 2018

The Trend of Forest Cover Removal: Case Study of Tonkolili District, Northern Sierra Leone

Morie Sam[1] Zhang Zhiqiang[2]
1.College of Environmental Science and Engineering, UNE-Tongji Institute of Environment for Sustainable Development (IESD)
Tongji University Sipping Road, Yanpu district, Shanghai, China
2.College of Environmental Science and Engineering, Tongji University, Sipping Road, Yanpu district, Shanghai, China

Abstract
Tonkolili district, been a major district for fuel wood timber production in Sierra Leone has some environmental consequences as a result of poor forest management due to lack of updated forestry policies and regulations. This study focused on the changing trend of the forest in Tonkolili district for the pass twenty eight years since the district serves as a source of bioenergy for more than half of the population living in Freetown the capacity of Sierra Leone.
The study also made a comparison using satellite imageries between 1990, 1995 ,2011 and 2012 to visualized the level at which the forest have been depleted over the course of the study period. Different data sources from government Ministries, department and agencies were analyzed using origin pro 8.5 to practically showcase the trend in form of graphs and tables.
Keywords: Agency, Department, Deforestation, Forest cover, Satellite imagery, Strategies, Trend,

Introduction

As human population and per-capita spending is growing in Sierra Leone, there is an increasing pressure on forests for timber, food and bio-fuels such as fire wood and charcoal that increases pressure on the natural forest(Akiwumi 2014). In line with this includes the expansion of the urban cities in Sierra Leone as many forests are cut down to built houses and other infrastructures(Thorn 2017). The national demand for forest timber is becoming strong, as a result of growing timber markets in Europe, Asia and other developed countries(Kanazawa 2017). Deforestation enthused by industrial logging is especially relevant for the conservation of biodiversity because it represents the penetration and economic development of the forest (Brandt 2016), with critical implications for wildlife protection and human resolution patterns.

Forest cover removal can have a negative impact on the environment; the most dramatic impact is a loss of habitat for millions of species, drastically promotes climate change(Shafroth 2017). The Earth's land animals and plants exist in forests, and many cannot survive the deforestation that destroys their homes(Soulard 2017). Deforestation/forest cover removal also drives climate change such as drought, accelerated sea level rise and more intense heat waves. Forest soils are damp, but without protection from sun-blocking tree cover, they quickly dry out(Papanastasis 2017). Trees also help maintain the water cycle by returning water vapour into the atmosphere. Without trees to fill these roles, many former forest lands can quickly become barren deserts(Soussan 1991).

Removing trees deprives the forest portions of its canopy, which blocks the sun's rays during the day, and holds in heat at night(Severson 2017). This disruption leads to more extreme temperature swings that can be harmful to plants and animals(Norgaard 2012). Trees also play a significant role in absorbing the greenhouse gases that fuel global warming(Leverkus 2017). For example, European ash is an important species in biodiversity protection of forest environment and in financial terms, which does not only endow with habitat for many fauna and flora, but also timber for the building and furniture industries(TerebaAnna Stephen Woodward 2017). Fewer forests mean larger quantity of greenhouse gases entering the atmosphere and increased hustle and severity of global warming(Hosonuma 2012).

The most practicable solution to deforestation is to carefully manage forest resources by eliminating clear-cutting to make sure forest environments remains intact in the ecosystem. The cutting that should occur should be balanced by planting young trees to replace older trees felled out for any purpose(Yang 2017).

Sustainable forest management, the process of managing permanent forest land for timber production without dropping inherent values and future efficiency will be viewed as one of the key mechanism of forest protection, biodiversity preservation, income enhancement and minimizing the natural deserters such as flooding, erosion and landslides in Sierra Leone's ecosystem(Vacchiano 2017).

Sierra Leone's forestry and wildlife sector guiding principle has been inadequate in addressing modern issues in forestry governance and management (Sierra Leone Biodiversity Strategic Action Plan). The forestry act of 1988 remains the principal legislation guiding the administration and regulation of forestry and forest reserves in Sierra Leone (Sierra Leone forestry policy 2010). The environmental management practices by the

environmental protection agency (EPA) and other related environmental protection organisations are faced with number of challenges due to the lack of modernized forestry acts and modern technological environmental management apparatus(Schettino 2017). According to a study done by Dr. Sari Pitkanen from the University of Eastern Finland in Burkina Faso and Sierra Leone, 'causes of deforestation have been as a result of the expansion of agriculture, over exploitation of wood resources, population growth and bad land use policies' (info cards from Biodev. Project)

The human actions in the environment has shown a significant negative impacts on the forest due to economic grade, most evidently over the last 2800 years(Feurdean Angelica 2017). This is not an exceptional in Sierra Leone, as the residents in the country mainly depend on biomass as their primary energy supply (Morie Sam 2018). Considerable variability in fire episodes can be explained by the dominant forest species and post fire-responses, as most rural people engages in the cutting of trees either for charcoal production, timber logging or for farming and mining activities in the district(Pietron 2017).

One of the problems of forest cover removal and intensive timber harvesting in Tonkolili district is that it unavoidably reduces the stabilizing influence of the forest on the biosphere and, hence, has a negative impact on the normal environment(Paul 2009). In the northern region of Sierra Leone, where 60% of the cattle and small ruminant population is concentrated, over 8,300 sq km of land has been left bare due to overgrazing. There are no attempts at any form of range for pasture management; bush fires continue to impinge on about 200,000 hectares of savannah woodlands annually(Krause 2017). Thus, overgrazing and annual bush fires have caused an apparent natural change from savannah woodland to grassland in the cattle rearing areas specifically Port Loko district, Kambia district Bombali district and some part of Kionadugu and Tonkolili districts.

Clear cut of trees result in a decrease of forest envelop in virgin forest, and an increase of young conifers and secondary small leaf tree species(Onuchin 2017). Due to intensive forest harvesting, the vegetation of northern Sierra Leone has experienced considerable transformations over the past several decades. Human-caused changes in the forest cover formation are reflected in the ratio between evapo-transpiration and water yield, the two major water balance components.

Understanding current trends and patterns of forest disturbances in Sierra Leone is necessary for monitoring and predicting the degree of forest cover loss or gain, fragmentation, and ecological change across a range of geographic scales(Severson 2017).

To effectively regenerate the forest in the northern part of the country, several biotic or abiotic factors may persuade the natural regeneration establishment; e.g. competition, herbivore, soil substrate quality, light and water availability, and trampling by animals as this part of the country is also known for cattle rearing.

Although changes in forest formation do occur, compared to conventional logging, reduced impact logging management may be more profitable if practice in the South-Eastern part of Sierra Leone which is considered to be the tropical rain forested of the country, due to reducing the environmental impact on forest stands and soils, and especially for minimizing damage to residual trees and soil compaction while also reducing biodiversity vanished in the country.

Large-scale charcoal production, primarily in sub Saharan Africa including Sierra Leone, has been a growing concern due to its intimidation of deforestation and biodiversity slaughter, land dilapidation and climate change impacts. It is cited as the most environmentally devastating phase of this traditional energy supply chain, and despite increasing per capita income, higher electrification rates, and significant renewable energy potentials, charcoal and firewood still remains the dominant supply of cooking and heating energy for eighty percent of households in Sub Saharan Africa (Brieland Jones, University of Michigan).

Forest management in Sierra Leone is giving the impression to be less care about due to lack of proper and updated forest management regulations. As a result, rural community residents in the north and south part of Sierra Leone have engaged in commercial fire wood and charcoal burning as a main source of income for their daily survival.

Reduced impact logging, have being looked as a premeditated and carefully controlled management of the forest for timber production purpose(Klauberg Carine 2017). This may cause attack by non-commercial tree species, grasses and lianas, therefore increasing the beauty of the natural surroundings with valuable species. These assessments are critical for land managers charged with balancing the economic and environmental penalty of timber harvest. Researchers continue to tussle with the question of how best to acquire precise, timely, and dependable overviews of forest change, condition, and extent.

Incorporating land transform information into a historical evaluation requires an analysis of the factors that persuade the rates and patterns of each land change process(Soulard 2017). This system may sound good in Sierra Leone's environmental monitory and management process. Mining actions, particularly in the eastern and southern regions, have also left vast areas deforested and degraded. It is estimated that between 80,000 and 120,000 hectares have been mined in different parts of the country with minimal efforts at reclamation or remediation of the forest. The unrestrained exploitation of mineral resources, attached with the very few mitigating policies and conservation programs over the years, and poor enforcement of those existing policies

has resulted in devastating environmental consequences. There is a consensus from all actors that deforestation is occurring, but the perceptions of where it is happening, who is to blame (for causing and preventing it) and how it can be stopped' vary deeply

Aim of the study

The aim of this study is to assess the trend of forest cover removal in Tonkolili district, northern Sierra Leone and evaluate the current trend of the best environmental management practices in the district.

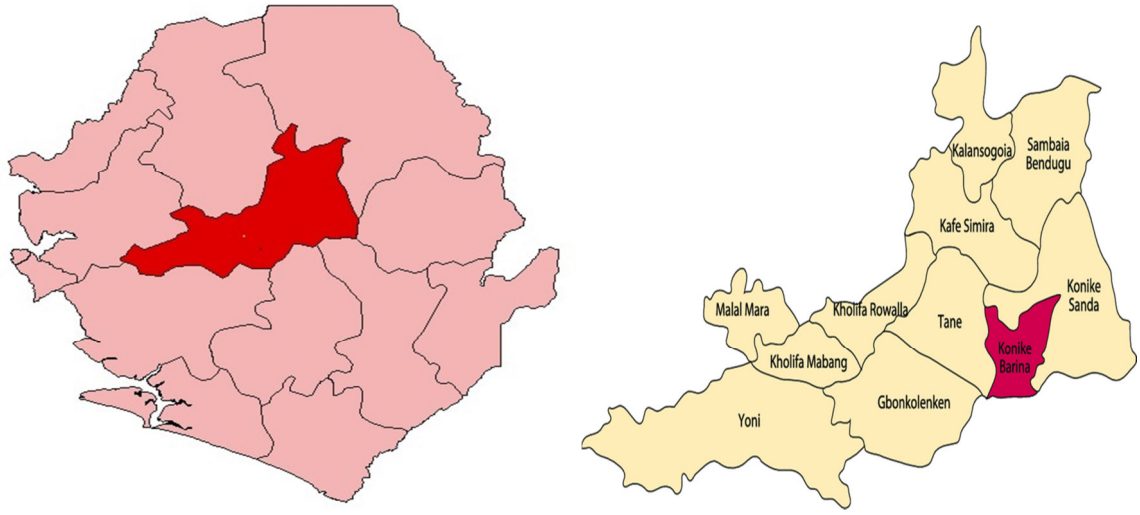
Materials and Methods

Description of the study area

The district comprises eleven chiefdoms, with Magburaka as the capital, and Mile 91, the commercial centre with an estimated total inhabitant of 530,776. The populations of the district are predominantly Muslim by religion, with a Christian minority. Tonkolili district is strategically positioned in the north of Sierra Leone with a terrain space of 7,003 km2 (2,704 sq miles), and is crossed by many rivers including the Pampana River and Sierra Leone's longest river, the Rokel. The district has both highlands and lowlands. The highlands rise up to 700 feet, and are the highest in Sambaia Bendugu chiefdom. It is from these hills that the major rivers in the district have their sources. The rest of the district is lowland which occupies a greater part of the district and is appropriate for agricultural invention. In the past, the district was covered with thick forests, but due to increased farming and bio-energy activities and the use of slash and burn methods of cultivation, the forests have gradually given way to grass lands.

Figure 1

Map of Sierra Leone indicating the study area in red and Map of Tonkolili district, showing all the chiefdoms in the district



Dataset

An open face to face interview and discussions were carried out with the stakeholders responsible for environment such as the Environment Protection Agency (EPA), Ministry of Agriculture, Forestry and Food Security (MAFFS) and Ministry of land, Environment and Country planning (MLECP) in order to capture the trend of the environmental management strategies in Tonkolili district. Raw data were provided according to the set criteria for this study.

The secondary data such as the satellite images were downloaded from the United States Geographical Survey (USGS) website between the years 1990 to 2017. Twenty-eight (28) years data significantly show an increase and decrease in the forest cover on the study area, Tonkolili district. This includes photographs of the GPS coordinate points by random selection of months and days within each year.

Random selection of twenty communities within the Tonkolili district to serve as a research ground followed with a simple random sampling selection of the community people within the selected communities in the district was done to be the respondents of the questionnaires and the focus groups.

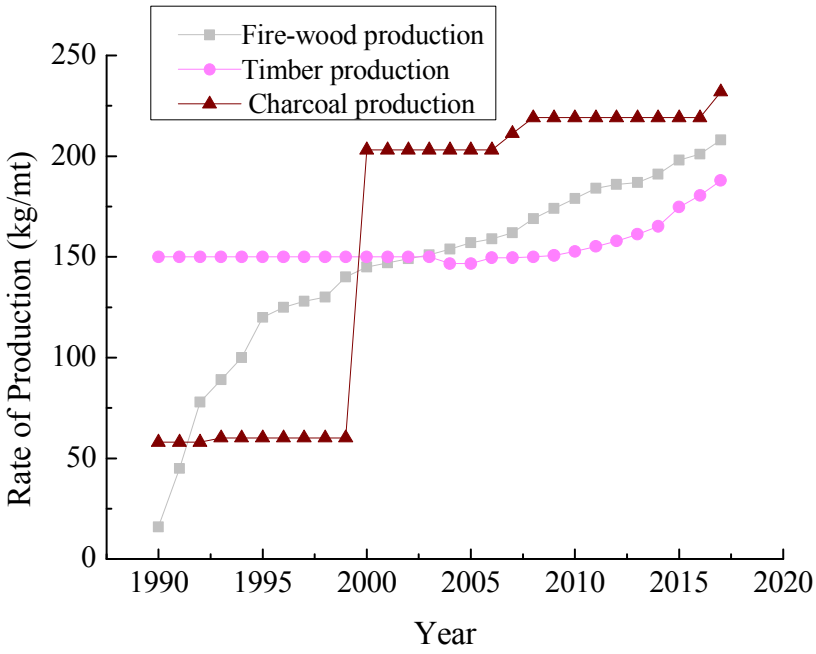
Satellite data

Satellite searching was followed using the following data sets: Landsat 7 Enhanced Thematic Mapper plus Collection 1 Level-1, Landsat 4-5 Thematic Mapper Collection 1 Level-1 and Landsat 1-5 Multispectral Scanner Collection 1 Level-1. Area of interest was within the Coordinate 1: 8.7389, -11.7980.

Results

Figure 2

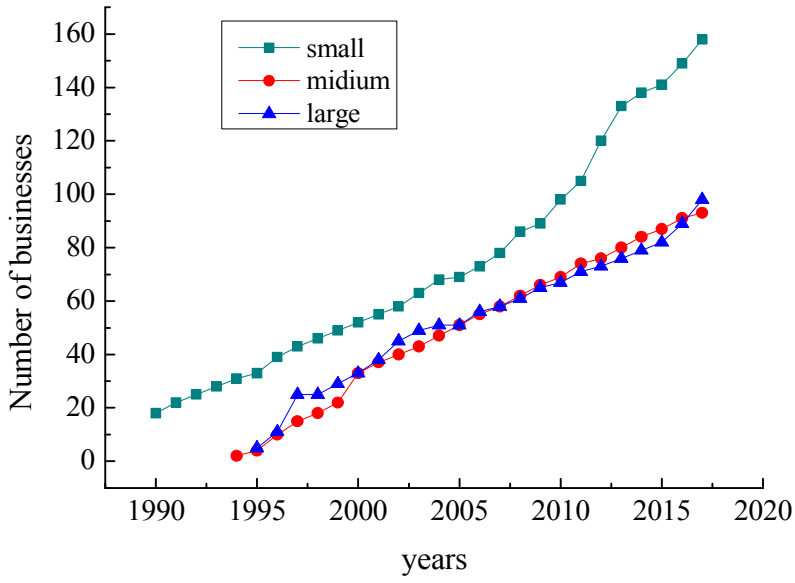
Rate of production of fire-wood, timber and charcoal in the district as of 1990 to 2017



An increased in fire-wood, charcoal and timber production in the district has given ways to various land degradation due to forest cover removal, timber extraction with a forwarder and power saw and transporting with a trucks contribute by trampling the young trees in the forest(Lijewski 2017). Land covers change in forest catchments force water balance and accordingly, river flow due to the high level exposure of the water bodies to the direct sunrays. Unplanned selective logging for timber, charcoal and firewood is a common practice in tropical forest of Tonkolili district, a high priority ecosystem for biodiversity conservation at the national scale(Ortiz-Colin 2017). As this is not a healthy phenomenon not only for the forest ecosystem, but also for the endanger species in the forest.

Scale of charcoal and firewood enterprises from 1990 to 2017

Figure 3



Due to the high rate of charcoal, timber and firewood production in the district, the market for these forest

products are massively increasing.

Mining activities in the district

Mining activities in the district have increased significantly over the past twenty years, which its activities in the forest have coursed a drastic reduction on forest cover. Tropical forests are fundamental in terms of biodiversity and ecosystem services, but the mining operations are sometimes not in confirmative of this idea(Burivalova 2017). However, mining also provides humans with basic needs but not satisfying the environmental conservation thought.

Iron Ore Mining Site in Tonkolili District

Figure 4
Increase of Mining Sites in Tonkolili District

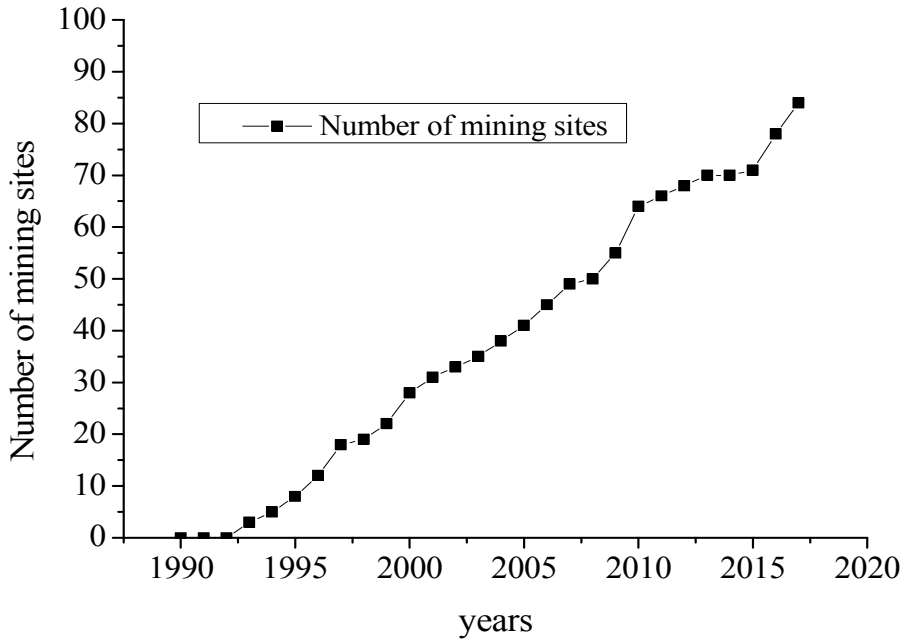


Table 1

Energy Use in the Tonkolili district (1990 – 2017)

years	Biomass Fuel (kg/mt)	Diesel Fuel (L/mt)	Kerosene (L/mt)
1990	5,144	9,012	480
1991	5,120	9,354	908
1992	5,021	9,849	1,184
1993	5,869	10,110	1,581
1994	7,440	10,123	1,898
1995	9,122	10,163	1,705
1996	10,901	10,214	3,264
1997	12,783	10,283	3,842
1998	14,673	10,202	3,870
1999	15,869	11,015	4,196
2000	16,494	10,482	1,781
2001	17,821	10,454	2,110
2002	19,148	10,476	2,350
2003	20,475	10,334	2,338
2004	21,803	10,247	2,310
2005	23,130	9,731	
2006	23,130	9,632	
2007	23,130	9,587	
2008	23,130	9,533	
2009	23,130	9,500	
2010	23,130	9,452	
2011	24,123	9,394	
2012	23,901	9,318	
2013	23,783	9,226	
2014	23,873	9,114	
2015	23,869	8,885	
2016	23,984	9,090	
2017	23,903	9,334	

source; Ministry of Energy, Sierra Leone

Figure 5
Energy use and equivalent CO2 emission from biomass

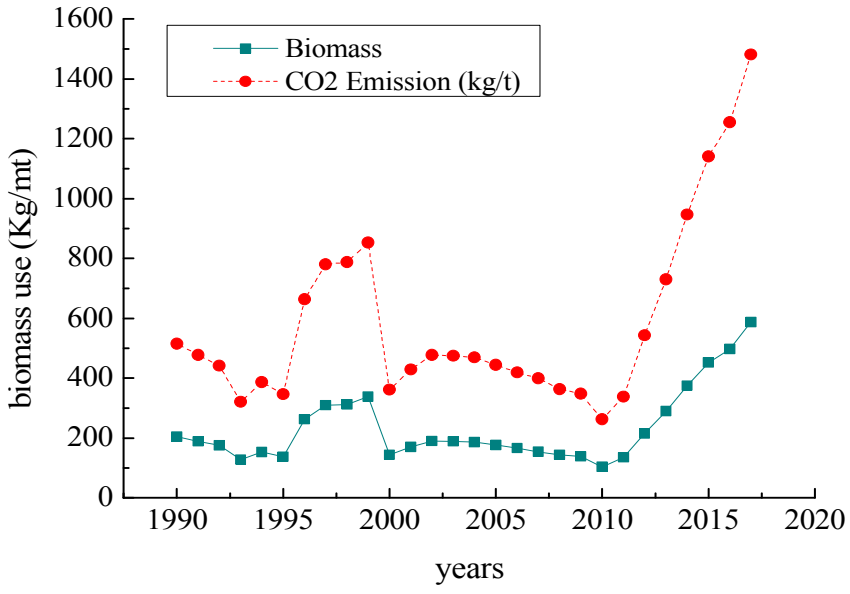


Figure 6
Fossil fuel used for domestic purposes and the equivalent CO2 emission

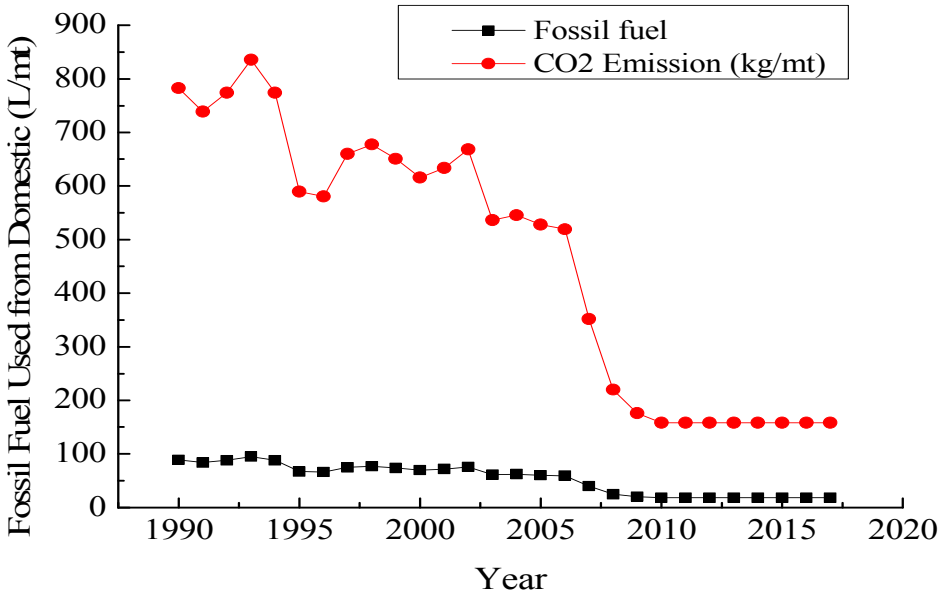


Figure 7
Emission from enterprises

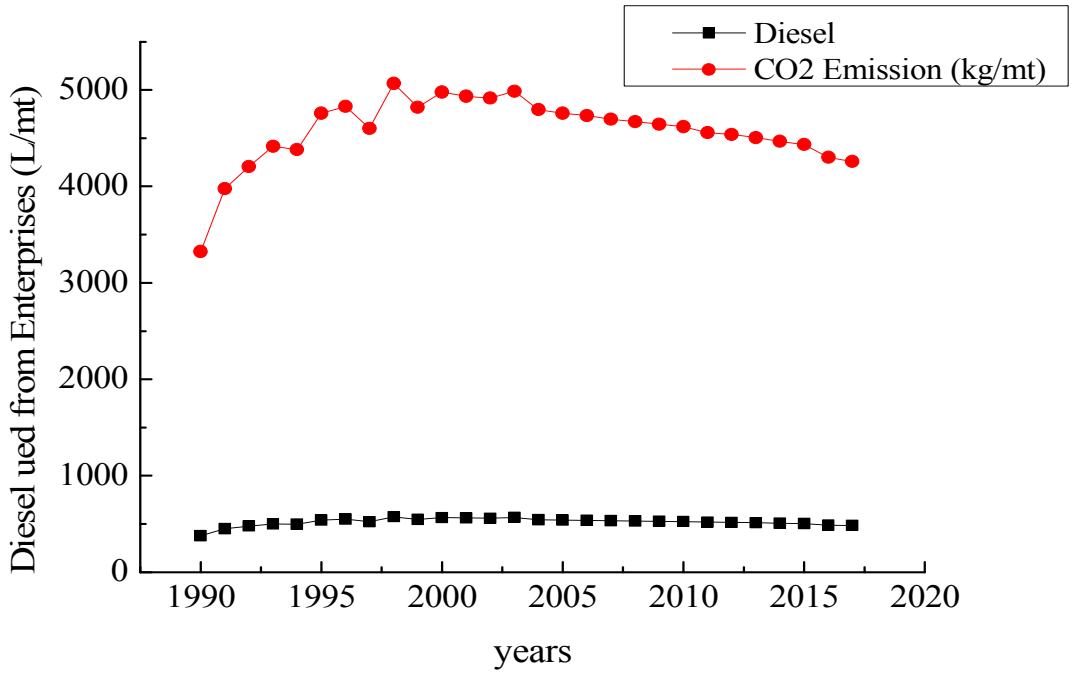
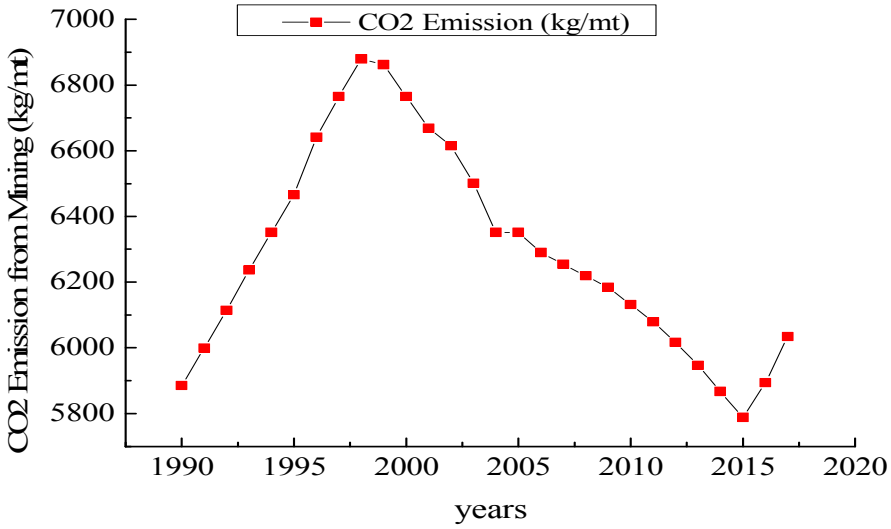


Figure 8
CO2 Emission from the mining sites



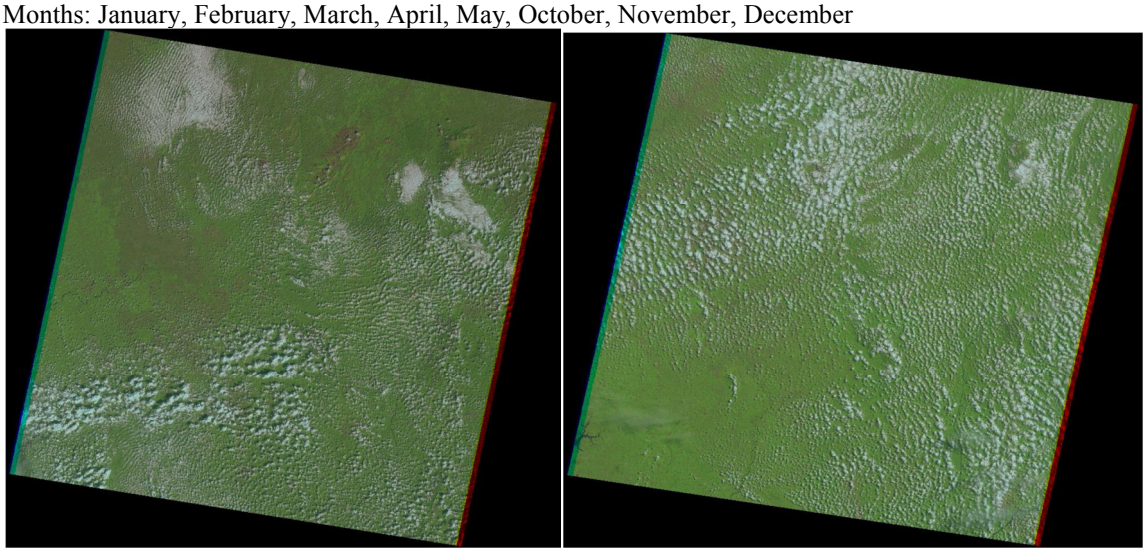
From the graph, there was a rapid increase of CO2 emission form 1990 to 2000 which maybe to the civil war as mining companies were unregulated; however, there was a smooth decrease of the emission level around 2001 to 2015 after peace was restores in the country.

Satellite images spotted to show the decreasing trend of forest cover removal and the searching were based on the following criteria:

Start Date: 01/01/1990

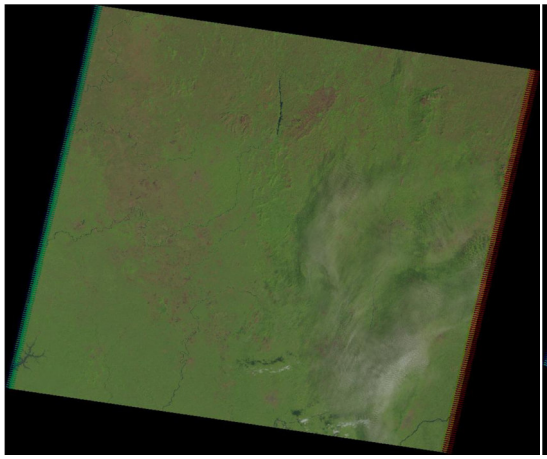
End Date: 12/31/2017

Months: January, February, March, April, May, October, November, December

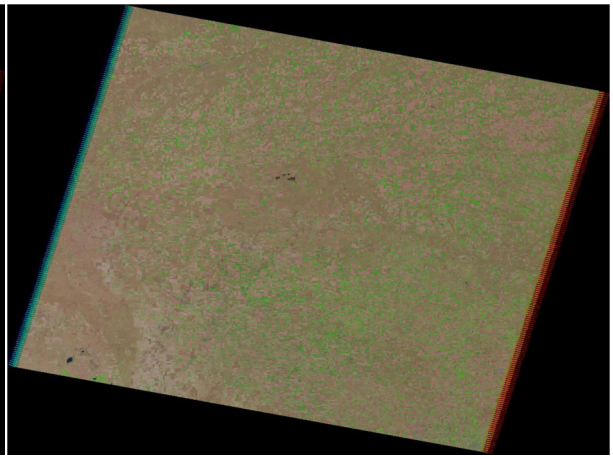


Data acquisition 1990/12/09 *Data acquisition 1995/05/29*

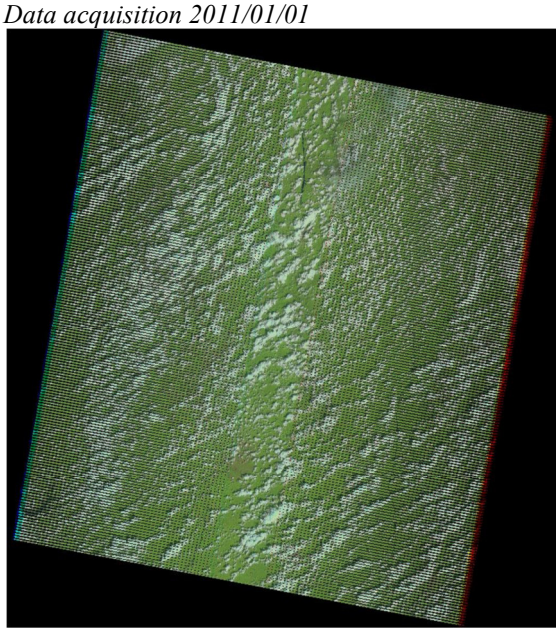
Satellite imageries of one of the communities in the study area (Mabang community) showing dense state of the forest at the early years between 1990 and 1995



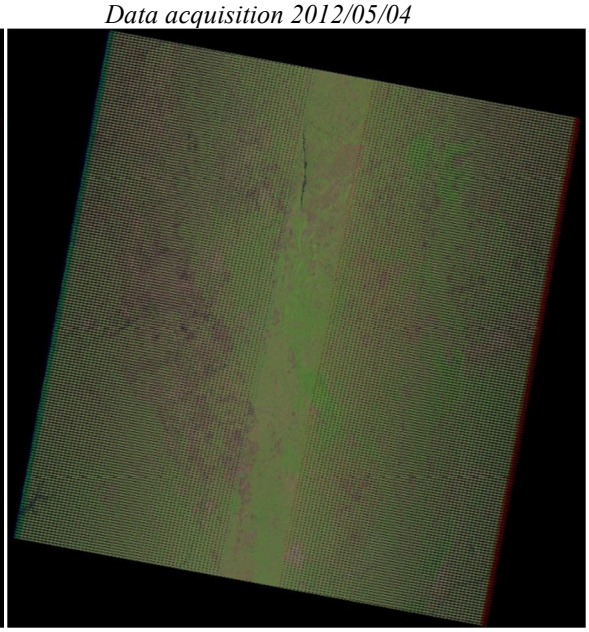
Data acquisition 2011/01/01



Data acquisition 2012/05/04



Data acquisition 2017/10/24



Data acquisition 2016/03/11

Satellite images of six different years are chosen to graphically show the significant decrease of the forest between the study periods. However, due to data acquisition from 1990 to 1995, there is no different in the satellite photographs, which means that the forest was under total ordered and in stable and natural state.

Landsat 8 data acquisition in 2011 and 2012 show a tremendous decreased of the forest cover, which means that high level of forest activities have been undergoing over the period of ten to eleven years. But significant increases of the forest reappear starting from 2016 to 2017 which may be due to some environmental regulations implementation.

Discussions and recommendation

Forests serve as a home for millions of species in the ecosystem and as a medium of atmospheric gas purification mechanism on earth. Forests provide many benefits to man and other organism such as provision of shades, holding soil particles together through trees roots, giving out oxygen to the atmosphere which human beings inhale in exchange with carbon dioxide and provision of economic forest products. The most highly benefits that forests provide on a balanced scale for both human and other lower organisms are; provision of suitable environment for the stabilisation of biodiversity in the ecosystem and the prevention of natural disaster factors; such as flooding, mud slides and soil erosion and overall climate change.

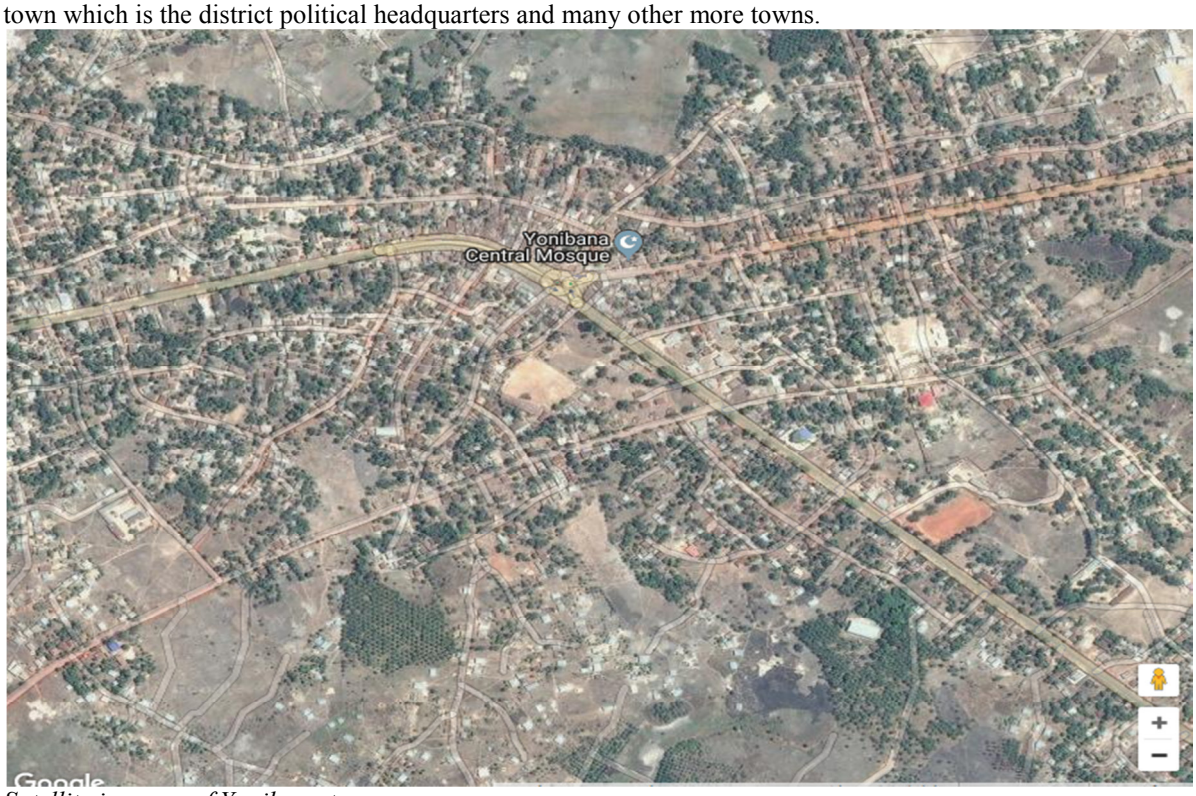
From the data analysis, concerns for air quality is one of the basic environmental thoughts that is of interest, since the consumption of biomass and diesel is top the list of the energy usage in the district, and the graphs showing a remarkable increase of the CO2 emission from these energy usage. Despite the air quality concerns, the physical appearance of the nature forest can be seen that there is a reduction in structure and its natural state, based on the satellite images shown above from 1990 to 2017. This means that there is a need for urgent attention of the government for proper monitoring and implementation of forestry regulations in the district.

Reasons for decrease of forest in Tonkolili district

There are reasons for the drastic decrease of forest cover in Tonkolili district which requires an urgent call to adherence and possible scientific and engineering solutions.

1. **unplanned urbanization**

Like many other towns in Sierra Leones, the major towns in Tonkolili district are undergoing rapid unplanned urbanization. These include the Yonibana town which serves as the economic centre for the district, Magburaka town which is the district political headquarters and many other more towns.



Satellite imagery of Yonibana town

Satellite imagery of Magburaka town

The unplanned settlements of residents in these towns have coursed a tremendous destruction on the forest

and hence its regeneration has been affected.

2. Economic activities

The economic activities of the residents in the district for their daily survival have significantly coursed environmental depletion. Due to the energy poverty rate in the district, majority of the residents depends on sales of forest products such as burning charcoal and firewood, despite the high increase in the mining activities in the district, those under the poverty line still depends on such enterprises. Timber logging and mining operations are heavily controlled by international mining companies, which operate directly with the central government and paying little attention to the local residents.

Bags of charcoal and abandon charcoal production sites around Yonibana chiefdom in Tonkolili district

Uncontrolled production of charcoal and firewood in Tonkolili is of the major economic activities undertaken by the residents

Table 2

Average Energy Consumption from 1990 - 2017

Biomass Fuel (tone)	Diesel Fuel (tones)	Kerosine (tones)
17,639	9,790	2,254

Table 2 shows the three main energy sources in Tonkolili district

Conclusion

Forest management is a relevant and dedicated discipline which needs a serious attention as the fight against climate change and climate resilient in the world is becoming a global fight. From the study, more management principles need to be implemented in the district to combat the rate of forest cover removal. This can be done through the implementation of sustainable renewable energies for domestic utilization that can replace charcoal and firewood for heating and cooking, enterprises and industrial energy needs, community engagement on the reforestation by implementing more forestry projects and sustainable timber logging.

As figure 8 indicated the reduction of CO2 emission from mining, utilization of sustainable renewable energy either from hydro or solar power, can further reduced the air pollution in the district and increase good health status of the community people. This can also reduce the dependent on firewood and charcoal for

domestic energy needs, as women and children suffer most from the carbon emission of firewood and charcoal during cooking. As table 2 confirm that biomass shows the highest number for energy consumption in the Tonkolili district during the study duration. This is mainly from firewood and charcoal for domestic purposes.

Considering the efforts that the United Nations is putting forward by formulating goals that can be achieve by 2030, goal number thirteen, climate action which clearly set out its major target as 'Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning' this target should focus on the aspect of forest cover removal to raise awareness of its impact to climate change. Another important goal of the sustainable development goals is goal number fifteen which is seriously concerns with Protection, restoration and promoting sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. The target for this specifically stress on the protection of forest and the restoration of the disturb ecosystem. The target state that, 'By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and dry lands, in line with obligations under international agreements' this means a total stakeholder involvement in forest management by formulating and implementing appropriate forest policies that can compliment goal number fifteen of the sustainable development goals.

Biodiversity can only be restore in Tonkolili district by firm and continuous forest management by reducing the number of forest activities and embark on remediation process most especially the abandon mining sites, previous charcoal and firewood production areas and deforested regions in the district. Enhanced planned urbanization and promote the use of renewable energy by all local residents, enterprises and big energy consuming companies present in the district. Through this, environmental problems such as air pollution, land degradation, and probably water pollution will be restored and biodiversity will be restored as well.

Acknowledgement

Thanks and appreciations to the college of Environmental Science and Engineering, UNEP-Tongji Institute of Environment for Sustainable Development(IESD) Tongji University for giving me the supports necessary to carry out this work.

Special thanks to Wang Zidi for being a Kind international student's coordinator in IESD office.

References

Akiwumi, F. A. (2014). "Strangers and Sierra Leone mining: cultural heritage and sustainable development challenges." Journal of Cleaner Production **84**: 773-782.

Brandt, J. S. N., Christoph Agrawal, Arun (2016). "Deforestation and timber production in Congo after implementation of sustainable forest management policy." Land Use Policy **52**: 15-22.

Burivalova, Z. H., F. Y. oh, L. P.Garcia, C. and Putz, F. (2017). "A Critical Comparison of Conventional, Certified, and Community Management of Tropical Forests for Timber in Terms of Environmental, Economic, and Social Variables." Conservation Letters **10**(1): 4-14.

Feurdean Angelica, G. F., Boris Vannière, Ioan Tant, Robert B. O'Hara, Mirjam Pfeiffer, Simon M. Hutchinson, Mariusz Gałka, Magdalena Moskal-del Hoyo and Thomas Hickler (2017). "Fire has been an important driver of forest dynamics in the Carpathian Mountains during the Holocene." Forest Ecology and Management **389**: 15–26.

Hosonuma, N. H., Martin De Sy, Veronique De Fries, Ruth S. Brockhaus, Maria Verchot, Louis Angelsen, Arild and Romijn, Erika (2012). "An assessment of deforestation and forest degradation drivers in developing countries." Environmental Research Letters **7**(4): 044009.

Kanazawa, K. (2017). "Sustainable Harvesting and Conservation of Agarwood: A Case Study from the Upper Baram River in Sarawak, Malaysia." Tropics **25**(4): 139-146.

Klauberg Carine, E. V., Carlos Alberto Silva, Andrew Thomas Hudak Manuela Oliveira and Pedro Higuchi (2017). "Short-Term Effects of Reduced-Impact Logging on Copaifera spp. (Fabaceae) Regeneration in Eastern Amazon." Forests **8**: 257.

Krause, A. P., T. A. M. Bayer, A. D. Doelman, J. C. Humpenoder, F. Anthoni, P. Olin, S. Bodirsky, B. L. Popp, A. Stehfest, E. and Arneth, A. (2017). "Global consequences of afforestation and bioenergy cultivation on ecosystem service indicators." Biogeosciences **14**(21): 4829-4850.

Leverkus, A. B. a. C., J. (2017). "An ecosystem services approach to the ecological effects of salvage logging: valuation of seed dispersal." Ecological Applications **27**(4): 1057-1063.

Lijewski, P. M., J. Fu, P. Ziolkowski, A. Rymaniak, L. and Kusiak, W. (2017). "Fuel consumption and exhaust emissions in the process of mechanized timber extraction and transport." European Journal of Forest Research **136**(1): 153-160.

Morie Sam, A. S. a. S. S. M. (2018). "Availability, Accessibility and the Road Map for Clean, Affordable, Effective and Efficient Energy for Sierra Leone; A six years Analysis from 2006 to 2011." International

Journal of Scientific and Research Publications **8**(5): 543-553.
Norgaard, T. E., M. and Dacke, M. (2012). "Animal or Plant: Which Is the Better Fog Water Collector?" Plos One **7**(4).
Onuchin, A. B., T. and Pavlov, I. (2017). "Hydrological Consequences of Timber Harvesting in Landscape Zones of Siberia." Environments **4**(3).
Ortiz-Colin, P. T.-A., T. Lopez-Barrera, F. and Gerez-Fernandez, P. (2017). "Can traditional selective logging secure tree regeneration in cloud forest?" Iforest-Biogeosciences and Forestry **10**: 369-375.
Papanastasis, V. P. B., S. Chouvardas, D. Mantzanas, K. Papadimitriou, M. Mayor, A. G. Koukioumi, P. Papaioannou, and A. Vallejo, R. V. (2017). "Comparative Assessment of Goods and Services Provided by Grazing Regulation and Reforestation in Degraded Mediterranean Rangelands." Land Degradation & Development **28**(4): 1178-1187.
Paul, M. G. (2009). "Deforestation: constructing problems and solutions on Sierra Leone's Freetown Peninsula." Journal of Political Ecology **Vol. 16,**.
Pietron, J. C., S. R. Chalova, A. S. Alekseenko, A. V. and Jarsjo, J. (2017). "Extreme spatial variability in riverine sediment load inputs due to soil loss in surface mining areas of the Lake Baikal basin." Catena **152**: 82-93.
Schettino, S. M., L. J. Bermudes, W. L. Cacador, S. S. and Souza, A. P. (2017). "Ergonomic study of timber manual loading in forestry fomentation areas." Nativa **5**(2): 145-150.
Severson, J. P. H., C. A. Maestas, J. D. Naugle, D. E. Forbes, J. T. and Reese, K. P. (2017). "Effects of conifer expansion on greater sage-grouse nesting habitat selection." Journal of Wildlife Management **81**(1): 86-95.
Shafroth, P. B. S., K. J. Gomez-Sapiens, M. Lundgren, E. Grabau, M. R. Ramirez-Hernandez, J. Rodriguez-Burgueno, J. E. and Flessa, K. W. (2017). "A large-scale environmental flow experiment for riparian restoration in the Colorado River Delta." Ecological Engineering **106**: 645-660.
Soulard, C. E. W., J. J. and Griffith, G. E. (2017). "Forest Harvest Patterns on Private Lands in the Cascade Mountains, Washington, USA." Forests **8**(10).
Soussan, M. D. E. a. J. (1991). Fuelwood Problems and Solutions. Journal of Ecology. **105, 111–121:** 8.
TerebaAnna Stephen Woodward, A. K., Małgorzata Borys and Justyna Anna Nowakowska (2017). "Analysis of DNA profiles of ash (Fraxinus excelsior L.) to provide evidence of illegal logging." Wood Sci Technol **51**: 1377-1387.
Thorn, S. B., C. Svoboda, M. and Muller, J. (2017). "Effects of natural disturbances and salvage logging on biodiversity - Lessons from the Bohemian Forest." Forest Ecology and Management **388**: 113-119.
Vacchiano, G. G., M. Lingua, E. and Motta, R. (2017). "Forest dynamics and disturbance regimes in the Italian Apennines." Forest Ecology and Management **388**: 57-66.
Yang, S. a. M., G. (2017). Forest dynamics in the US indicate disproportionate attrition in western forests, rural areas and public lands. Plos One. **12**.