# Is there a correlation between deforestation and the rise of malaria in sub-Saharan Africa?

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Malaria is the most common and deadliest vector-borne disease in sub-Saharan Africa, infecting 300-500 million people a year and causing 2-3 million deaths per year in this region (WHO, 2000). Unprecedented increase in human population growth and little socio-economic movement leads to high levels of poverty and underdevelopment in rural areas. As a result, the uninhibited exploitation of resources in sub-Saharan Africa, especially forests, has led to severe environmental, ecological and public health problems. How can this be linked to an increase in vector-borne diseases like malaria? What factors influence mosquito, specifically the *Anopheles gambiae*, habitat and vector transmission capabilities with respect to changing environments? These questions and more will be answered in this analysis of scientific literature concerning the impacts of rising malaria cases in connection to human influence on changing environments.

Sub-Saharan rainforests are being deforested at rates that are unsustainable and will greatly impact future generations. Forests bestow the basic foundations of ecological functions by means of regulating climate and water resources, and providing habitats for animals and plants. A typical course for deforestation in sub-Saharan Africa begins when loggers chop down and remove the large, valuable trees. Then, low-input low-output agriculture farmers come to farm the land where after only several cycles will leave the land ravaged and nutrient-poor. At the moment, 1.5 billion hectares of land are being used for crops, and estimates say there is nearly twice that much left despite being locked up in other valuable resources (FAO, 2008). The increase in crop production has increased 35% in sub-Saharan Africa (FAO, 2008). Factors that cause this are expansion of arable land, increase in cropping intensity, and improvements in yield (Rose, 2013). In this case, expansion of arable land is due to the clearing of forests, increasing in cropping intensity is due to swelling populations that turn to farming for work, and improvements in yield is due to advances in technology—all of which are negatively affecting the sub-Saharan rainforest ecosystem. Clearing forests completely changes every aspect of the environment's microclimate including soil and aquatic conditions, and the ecology of local flora and fauna such as malaria vectors (Uneke, 2008). A study done in the Peruvian Amazon found that A. darlingi, closely related to *A. gambiae*, is 278 more times likely to bite a human in a deforested area than in a predominately-forested area (Vittor, 2006). The study concluded that there is significantly higher human-biting activity in *A. darlingi* in deforested and developed areas (Vittor, 2006). Disappearing forests result in overgrazed farmlands and the conversion of grasslands and wetlands to crop agriculture, meaning diminished resilience of the ecosystem. The clearing of forests for cropland has given rise to more breeding sites for *A. gambiae*, which prefers to lay eggs in deep water surrounded by short vegetation. Generally, primary growth forests are heavily shaded with a substantial layer of organic matter that acts as a sponge to absorb water and increase its acidiity, whereas cleared land is more susceptible to pooling water with a more neutral pH (Patz 2000). When the necessary root systems are not present to uptake rainwater, the entire water cycle is thrown off balance; the rainwater will accumulate in some areas, while runoff in others will cause erosion. More water will accumulate where there are no trees or plants to absorb the water, and a puddle will form the perfect breeding ground for A. gambiae. Since people in sub-Saharan Africa are expanding to deforested areas at extremely high rates, that leaves plenty of food for mosquitoes. *A. gambiae* was originally a zoophilic and sylvatic feeder, but has now adapted to feeding on humans and livestock due to ever-increasing abundance (Gottwalt, 2013).

*A. gambiae* is the vector for the parasite that infects humans called Plasmodium falciparum, the most dangerous of the four human malaria parasites. In regions where malaria is highly endemic, residents build up a protective semi-immunity to P. falciparum during the first 10-15 years of life, explaining why the majority of malaria-related deaths happen in young children (Riley, 1994). When an infected mosquito bites a human, the parasite travels to the liver where it develops through several stages and multiplies asexually along the way. Then merozoites, the blood-stage parasites, invade and rupture the red blood cells. Soon after, the host exhibits symptoms of the disease. On the other hand, when a mosquito bites an infected human, the human's blood contains gametocytes that evolve into a zygote in the insect's gut. The zygote turns into an ookinete, able to spontaneously move throughout the gut and eventually pass through the wall of the gut to form a sporozoite-filled oocyst. Once the oocyst has attached to the outside of the mosquito's gut, it bursts, and the sporozoites make their way to the mosquito's salivary gland to repeat the process (Wirth, 2002). The parasite goes through a series of morphological transformations, which may enable it to circulate throughout the bloodstream undetected by filtering mechanisms located in the spleen (Dearnley, 2012). The unusual crescent shape of P. falciparum allows for increased virulence and transmission of the parasite (Dearnley, 2012). There was an estimated 207 million cases of malaria in 2012. Doctors and scientists have intervened to save approximately 3.3 million lives since 2000 with the use of mosquito nets, insecticide, and quick diagnoses with more access to artemisinin-based therapies (WHO, 2013). However, the increasing prevalence of global climate change is combating intervention methods.

Climate change, at this rate, is on course to cause longitudinal and latitudinal temperature increases, which in turn will affect mosquito vectors and their ability to transmit disease. Arthropods rely on ambient temperatures for survival and proper development, directly restricting their distribution range (Afrane, 2012). In areas like the highlands of Africa where the ambient temperature is low, the ability for Anopheles mosquitoes to survive is quite limited. Yet, when the climate warms or factors such as deforestation alter the microclimate, it allows Anopheles the capability to thrive in areas otherwise unsuitable. When malaria cases spread to higher altitudes in the highlands, human mortality rate is particularly high due to the lack of protective immunity in the region (Baum, 2013). It is well supported that increased precipitation and humidity increases availability of larvae habitat as well as habitat productivity (Afrane, 2012). As water temperature rises Anopheles mosquito larvae mature faster, allowing for increased offspring potential (Beck-Johnson, 2013). Not only does larvae mature faster—the increase in ambient temperature accelerates the digestion process in the

*This author wrote the paper as a part of BIOL133: Biology Inquiry: Tropical Forest Biology under the direction of Dr. Westley adult mosquito and results in more human bites and faster parasite transmission, which equals increased disease efficiency (Paaijmans, 2013). A study in western Kenya looked at how changing microclimate is affecting the *A. gambiae* gonotrophic cycle, the period between blood meal until oviposition or egg laying. The study found that in deforested areas the gonotrophic cycle was shortened by 1.7 days (Afrane, 2005). Instead feeding on humans once every five days, to the mosquitoes feedonce every three days, again leading to increased disease efficiency. Ambient temperature change may affect malaria transmission in respect to vector quantity, mosquito biting rate, vector survival rate, and parasite reproduction rate.

Many different factors can be attributed for the increase of malaria in sub-Saharan Africa: deforestation, effectiveness of parasites, and global climate change. Scientists have researched the connection between forest cover, deforestation, and its relationship to malaria transmission. The clearing of forests in sub-Saharan Africa has devastating impacts on local ecosystems, specifically vector-borne diseases. By transforming microclimates, habitats are positively changed for the *A. gambiae* by providing areas with less shade, more holding precipitation, and changing humidity levels among other factors. *P. falciparum* is the most deadly malaria parasite due to its virulent behavior and unique host cycle. Global climate change is allowing Anopheles to thrive in areas generally too cool to support their species. Increased temperatures benefit Anopheles by increasing reproductive fitness, speeding up the gonotrophic cycle, and larvae development.



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