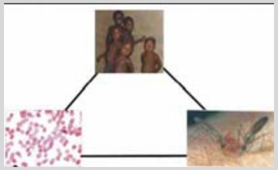

Figure shows the disease interaction triangle: human host, *Anopheles* vector, and *Plasmidium* parasite (shown in human blood sample), taken from *A model structure for estimating malaria risk* by MB Hoshen and AP Morse, 2005, Netherlands

Climate Change and the Spread of Malaria

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Photo of *Plasmodium dalciparum* cells, taken from *Mechanism of Malaria "hide and seek" Coming into View* by Tara C. Smith, University of Iowa, USA

INTRODUCTION

Malaria, otherwise known as *Plasmodium falciparum*, is an infectious disease most commonly found in Africa, Asia, the Mediterranean region, and some Pacific Islands. Malaria is spread to the human body via the *Anopheles* mosquito; a relatively immature from of the disease incubates in the mosquito, and upon biting human flesh, the disease is transported to the human body where it continues to mature. The most common symptoms of malaria are alternating periods of fever and chills that can last several hours and occur quite frequently. If malaria goes untreated in the human body, several organs may become enlarged, anemia develops, and death is usually quick to follow. Although exact statistics are difficult to obtain, an estimated 2.7 million lives are claimed by malaria each year, and the number of people afflicted by the disease reaches into the hundreds of millions.

In order to fully understand the seriousness of the disease, our attention must be focused towards the harbingers of the disease: the *Anopheles* mosquito. Through studying the habitats of these mosquitoes, several scientists have theorized that climate change may have a significant impact on the lives of the mosquitoes, which in turn will affect the spread of the malaria virus among humans.

GETTING TO KNOW THE CULPRIT

Photo of *Anopheles* Mosquito taken from Center for Disease Control and Prevention, Atlanta, USA

Of the several hundred different species of the *Anopholes* mosquito, only about thirty are actually capable of carrying the vector that causes malaria in humans. These insects are cold-blooded (which explains why they thrive in warm, tropical environments) and usually only live for 1-2 weeks after reaching full adult form. Eggs are laid directly on top of the water in ponds or other such "breeding pools", and the hatching rate varies depending on the temperature (under warm temperatures, it takes just a few days for eggs to hatch). The insects can reach full adult form in as little as six days, and then they begin to prey on blood from humans and cattle. Female adults usually lay their eggs within three days of constant feeding.

DIRECT EFFECTS OF CLIMATE CHANGE ON MOSQUITO HABITATS

Scientists at the front of the climate change issue have enumerated several ways in which the habitat of the *Anopheles* mosquito will change in response to global warming. There is debate surrounding many of the issues, but there are two direct effects that construct the foundation of the link between climate change and the spread of malaria.

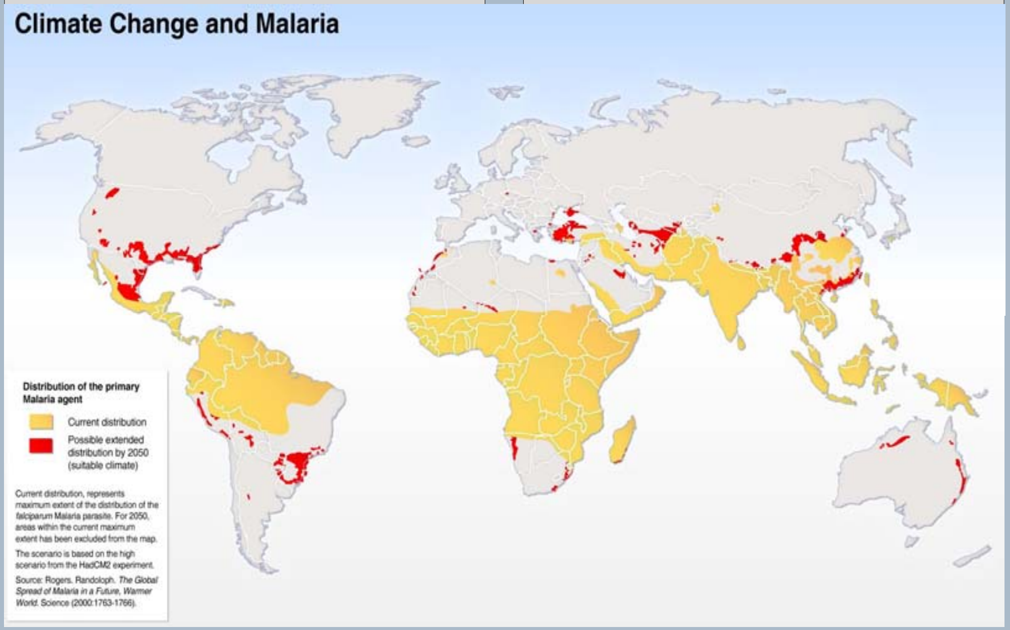
1. Increase in Temperature and Precipitation Rates

There are two direct effects of an increase in temperature on mosquito populations – increase in mating rates and the speeding up of the maturation process (from larval form to adult form). Increased precipitation causes a rise in the number of possible breeding pools.

2. Extension of Malaria Endemic Regions

As is displayed by the figure below, current scientific models suggest that increases in temperatures will allow mosquito populations to extend farther North and South from the equator. Though malaria is usually equated with developing countries such as Africa and the Pacific Islands, the possibility of suitable habitat extension poses a serious threat to developed nations such as the USA and Australia.

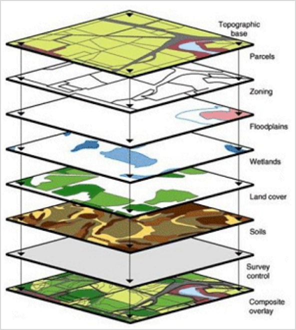
Figure below taken from Rogers and Randolph, Science 2000, cartography done by Hugo Ahlenius, *UNEP-GRID/Arendahl*



HOW DO SCIENTISTS MODEL THESE CHANGES TO MOSQUITO HABITATS?

The most effective way that scientists have been able to highlight specific ecological changes in mosquito habitats is with the help of an extremely powerful computer-mapping program called a geographic information system (GIS). The spatial data computed by the program helps scientist measure flight paths and model landscape architecture. Flight path measurement aids scientists quantify the geographical distance that mosquitoes are willing to fly in order to feed – which will help in the process of evaluating malaria risk as it continues to spread to new areas. Modeling landscape architecture provides insight as to what types of breeding grounds the mosquitoes prefer, which can be of great help in deciding which type of preventative measure (such as larval source control) will be most useful.

Figure to the right shows the layers of a typical GIS model. Models such as these will be extremely helpful in monitoring the exact changes that occur in mosquito populations. Figure taken from The Guide to Geographic Information Systems Online



PREVENTATIVE MEASURES

The prospect of malaria becoming more abundant on our planet begs the question: What preventative measures must we take? The Center for Disease Control and Prevention lists three key methods that have been effective in controlling the spread of malaria:

•ITN's – Insecticide Treated Bed Nets

Bed nets form a physical barrier between the human and the mosquito during the nighttime hours, decreasing the frequency of mosquito bites.

•IRS – Indoor Residual Spraying

Process in which all the foundational structures of a household are sprayed with a pesticide that kills mosquitoes on contact. *This method does not actually decrease the frequency of bites, it merely kills the insects that land during the digestion and feeding process*

•Larval Source Control

Filling potential waterbeds, draining swamps, and creating ditch systems in an attempt to prevent the buildup of standing water (in which the mosquitoes breed).

Photos of ITN's taken from the Center for Disease Control and Prevention, Atlanta, USA

WHERE DO WE GO FROM HERE?

If climate change will indeed hold a significant impact on mosquito habitats and the spread of malaria, efficient counteractive action must be taken. However, the location of high-risk areas in underdeveloped countries compounds the problem due to the unavailability of funds, poor healthcare systems, and substandard living conditions. If the models predicting the extension of mosquito populations into first world countries are correct, there is sure to be a rapid response from the economically superior regions. Until then, however, climate change and its effect on the spread of malaria assumes a role at the center of the discussion between global responsibility and humanitarian aid.

CONTACT INFORMATION

This poster was developed as an assignment for Honors 295, Fall 2007, *Population, Environment, and Sustainability - Ethics for Living into the Future*. References can be obtained by contacting the author.

For more information: Center for Disease Control and Prevention at www.cdc.gov/malaria and *Environmental Change and Malaria Risk* by Bogers, Martens, and Takken online at http://library.wur.nl/ojs/index.php/frontis/issue/view/202