Alexandra Cosmatos

Global Climate Change

The Effects of Climate Change on Vector Born Diseases (Malaria) in Cyprus

Background Information

There is now clear and convincing evidence that anthropogenic climate change is occurring, and at an alarming rate. Within the last 10 years we have experienced in influx in extreme weather conditions, from the destructing hurricane Katrina in North America to the detrimental tsunami in Indonesia. The Earth's surface has warmed by more than 0.8 °C over the past century, and by approximately 0.6 °C in the past three decades.[1] The predictions that scientists are giving us right now describe a very bleak future. From rising sea levels that could drown entire cities, to an ice age that can cause huge amounts of species extinction, we know that without a great amount of social reform, the world as we know it will become a very different place. The drastic changes in our global climate will cause serious repercussions to every aspect of human life including the economic and social systems that societies rely on.

When discussing the most pressing impacts of Global Warming many scientists agree that along with a serious increase in global temperatures, a rise in sea levels will have dire consequences, specifically in areas such as Cyprus. The increase in temperatures worldwide will allow for much of the frozen ice sheets currently on land to melt and seep into the ocean. This will disrupt not only the global conveyer belt of the world's oceans, but will obviously increase sea level. For area's such as Cyprus the increase in sea level can engulf many coastal areas, including cities such as Limassol, Paphos and even things such as the Larnaca Airport. Cyprus with a one meter increase in sea level will not be the same Cyprus as we know it today.

Furthermore, we know that with the temperature increases worldwide serious droughts will occur. Cyprus has already started to feel the effects of water shortages over the past few years,

---

[1] *Surface temperature analysis: analysis graphs and plots.* NASA: Goddard Institute for Space Studies; 2007. Available from: http://data.giss.nasa.gov/gistemp/graphs/

forcing Cyprus to rely on neighboring countries such as Greece for water. In time, the availability of water will decrease tremendously, making it hard for agriculture to survive. With all of these changes, current projections make drought and famine seem inevitable and site them as a major cause of death in years to come. Unfortunately, however, these will not be the only sources to increase the number of deaths; with all of these changes in the global climate, many suspect that there will be a radical increase in the number of deaths due to vector born diseases. "The influence of climate and the environment on infectious diseases has been a subject of debate, speculation, and serious study for centuries," according to Shope in the 1991 article **"Global Climate Change and Infectious Diseases."**[2] Shope refers to Jacob Henle's 1840 treatise *On Miasmata and Contagia* in which Henle contends that "Heat and moisture favor the production and propagation of the infusoria and the molds, as well as the miasmata and contagia, therefore miasmatic-contagious diseases are most often endemic in warm moist regions and epidemic in the wet summer months." [3]

Vector Born Diseases

A disease that is transmitted to humans or other animals by an insect or other arthropod is called a *vector-borne disease*. Arthropods may infect humans directly via by bites, stings, or infestation of tissues, or indirectly through disease transmission. Several genera of arthropods play a role in human disease, but mosquitoes and ticks are the most notable disease vectors. The most significant mode of vector-borne disease transmission is by biological transmission by blood-feeding arthropods. According to the Encyclopedia of Public Health, there are 4 key components that determine the occurrence of vector-borne diseases: (1) the abundance of vectors and intermediate and reservoir hosts; (2) the prevalence of disease-causing pathogens suitably adapted to the vectors and the human or animal host; (3) the local environmental conditions,

---

[2] Shope, R. E. 1992. Impacts of global climate change on human health: Spread of infectious disease. Chapter 25 of *Global climate change: Implications, challenges and mitigation measures*, ed. S. K. Majumdar, L. S. Kalkstein, B. Yarnal, E. W. Miller, and L. M. Rosenfeld, 363-70. Easton, PA: The Pennsylvania Academy of Science.

---

[3] http://www.ciesin.columbia.edu/TG/HH/veclev3b.html

especially temperature and humidity; and (4) the resilience behavior and immune status of the human population.[4]

Global climate change has the ability to affect all four key components of vector borne disease transmission. First off, increases in extreme weather events, especially those that trigger flooding, could create excellent breeding conditions for mosquitoes by creating more shallow pools of stagnant water. Secondly, with the recent increase in pesticide resistance, the prevalence of disease causing pathogens has increased significantly. Furthermore, with an overall increase in global temperatures, there will be longer and warmer springs and summers which could increase mosquito reproduction and development, and also increase the tendency of mosquitoes to bite. The last component of vector borne diseases depends on the immune status of the population. Unfortunately, as we have previously discussed, future conditions may be ridden with drought and famine, thus will causing a decrease in much of the population's natural immune system, allowing them to be much more susceptible to disease.

As we can see as attached in Graph 1, there a number ways in which climate could effect vector borne diseases, including temperature, wind patterns precipitation and even changes in humidity. The WHO's report Tropical Diseases[5] provides the most up-to-date estimates of the number of people infected by the most serious vector-borne diseases: malaria, 270 million; schistosomiasis, 200 million; lymphatic filariases, over 90 million; onchocerciasis, nearly 18 million; leishmaniasis, 12 million; dracunculiasis, 1 million; and African trypanosomiasis, 25,000 new cases per year (1990b). WHO indicates the available data are generally considered to underestimate the prevalence of these diseases in human populations. Any impacts of climate change on vector-borne diseases may first occur at the margins of their current distribution. A 1993 *Lancet* article, "Global Health Watch: Monitoring Impacts of Environmental Change,"[6] with contributions by Freier et al., suggests how specific diseases may shift poleward, rise to

---

[4] http://www.enotes.com/public-health-encyclopedia/vector-borne-diseases
[5] World Health Organization (WHO). 1990b. *Tropical Diseases* 1990. TDR-CTD/HH 90.1. Geneva: World Health Organization.
[6] Freier, J. E., D. J. Rogers, M. J. Packer, N. Nicholls, and J. Almendares. 1993. Vector-borne diseases. In *Global health watch: Monitoring impacts of environmental change*, by A. Haines, P. R. Epstein, and A. J. McMichael. *Lancet* 342: 1464-69.

higher altitudes, and spread beyond areas where they are traditionally endemic. Others may be eliminated entirely due to extreme heat or dryness.

Dobson and Carper thoroughly illustrate the parasite-host population dynamics and the response to long-term climatic changes in the "Global Warming and Potential Changes in Host-Parasite and Disease-Vector Relationships"[7] chapter of their 1992 book *Global Warming and Biodiversity*. They point out that the extent to which long-term climatic changes affect the prevelance and distributions of different parasites and pathogens. According to Dobson and Carper, the specific disease and vector characteristics, such as place of reproduction, size, duration of infection, and the degree of immune response stimulated in human hosts, as well as other attributes of their life cycles is what will be the most effected by climatic changes. Dobson and Carper also suggest that climatic changes such as an increase in temperature will effect the disease transmission, for example the heat may also hasten the parasite's development and cause rapid population growth. Many fear that an increase in overall temperatures, along with flooding and humidity will create a more suitable environment for malaria carrying mosquitoes, creating a malaria epidemic.

Malaria is currently one of the planet's most deadliest diseases and one of the leading causes of sickness and death in the developing world. According to the WHO:

Malaria remains the most important of the tropical diseases - widespread throughout the tropics, but also occurring in many temperate regions. The disease exacts a heavy toll of illness and death - especially amongst children in endemic areas. It also poses a risk to business travellers, tourists and immigrants, and imported cases of malaria are increasingly seen in nonendemic areas such as Europe and North America. Epidemics are frequent in rural areas experiencing intense economic development. Treatment and control have become more difficult with the spread of drug resistant strains of malaria, and insecticide resistant strains of the mosquito vectors[8].

---

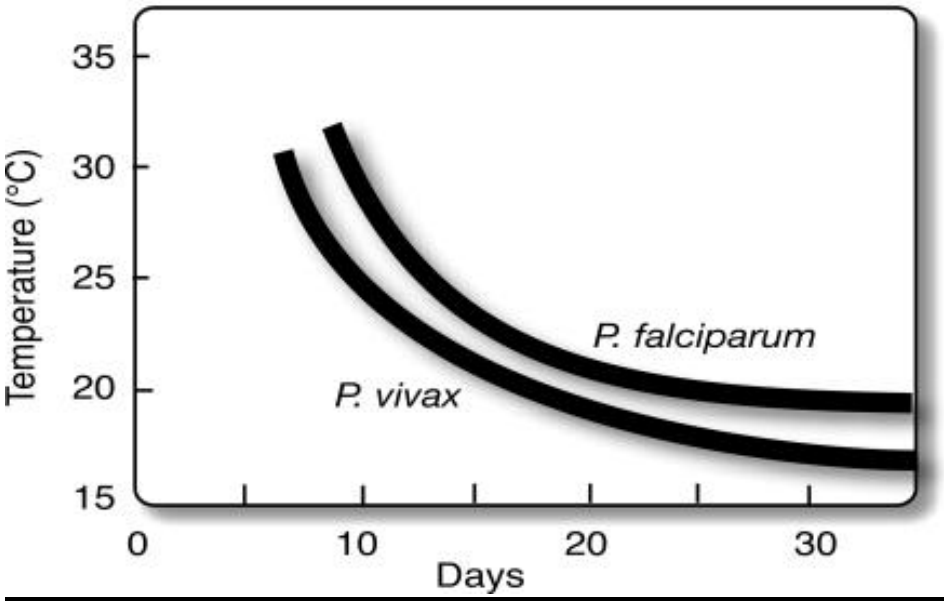
[7] Dobson, A., and R. Carper. 1992. Global warming and potential changes in host-parasite and disease-vector relationships. In *Global warming and biodiversity*, ed. R. L. Peters and T. E. Lovejoy. New Haven, CT: Yale University Press.

[8] World Health Organization (WHO). 1990b. *Tropical Diseases* 1990. TDR-CTD/HH 90.1. Geneva: World Health Organization.

Annual disease statistics calculated by the World Health Organization suggest that there are 300 to 500 million clinical cases of malaria each year resulting in 1.5 to 2.7 million deaths. Although malaria has been thought to have been nearly or completely eradicated in many parts of the world, malaria has been on the rise in some highland regions and desert fringes. In 2006 the National Academy of Sciences conducted a study to determine the reasoning behind the recent increase in incidence rate. The study concluded that because the life cycle of the mosquito that transmits malaria and the microorganism that causes the disease are extremely sensitive to changes in temperature, the rising average temperatures may be making conditions more favorable for mosquitoes and pathogen development, leading in turn to the surge in malaria cases.

Figure One

Relationship between temperature and malaria parasite development time inside the mosquito ("extrinsic incubation period" or EIP). EIP shortens at higher temperatures, so mosquitoes become infectious sooner. Note the nonlinear response to temperature, as well as relative threshold limits for malaria parasite development (≈18°C and 15°C for P. falciparum*, and* P. vivax*, respectively)*

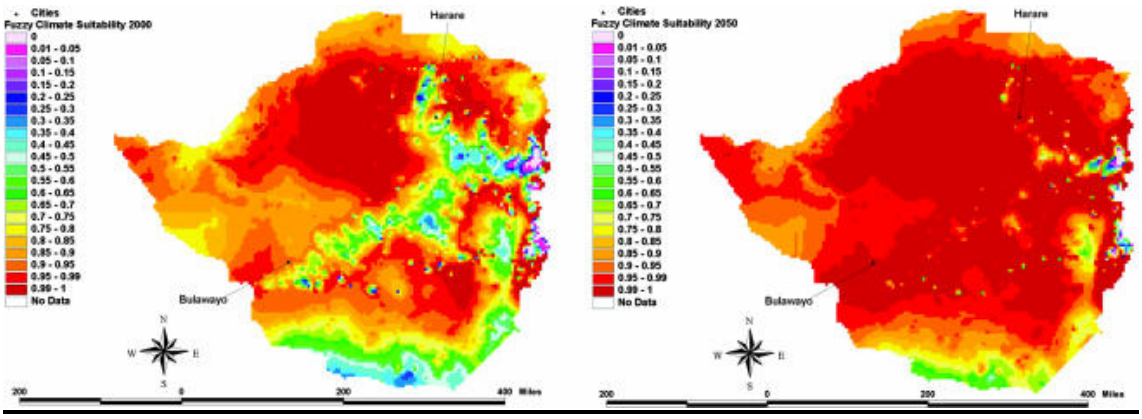


[9]

Further data collected from the study illustrated how rapidly the climate was changing in places such as Zimbabwe, thus making it more suitable for malaria transmission. This rapid progression can be alarming to neighboring African countries as well as the southern Mediterranean. Many scientist suggest that due to global climate change, the environmental characteristic of Zimbabwe will soon be mirrored in Cyprus. Therefore, using geographical models of vector distribution that match environmental characteristics with vector populations and/or disease outbreaks we can assume that there is a strong possibility of a malaria epidemic making it's way to Cyprus and other regions similar in climate, such as the surrounding Mediterranean and even southern United States. In summary, the suitable conditions for Malaria that are currently being developed in Zimbabwe may soon also exist in Cyprus.

Figure 2

[9] Jonathan A. Patz* and Sarah H. Olson. Malaria risk and temperature: Influences from global climate change and local land use practices. Proc Natl Acad Sci U S A. 2006 April 11; 103(15): 5635–5636. Published online 2006 April 4. doi: 10.1073/pnas.0601493103. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1458623



*Climate suitability for stable malaria transmission across the diverse topography of Zimbabwe, determined by fuzzy logic analysis and based on United Kingdom Meteorological Office (UKMO) global climate scenarios for year 2000 (*Left*) and with warming to the year 2050 (*Right*). Orange-red colors indicate more suitable climate conditions for malaria transmission.*

According to UNEP data, there have been no recent deaths in Cyprus due to malaria. However, malaria did plague Cyprus for many years. It was only in 1946 when a well organized Anopheles eradication campaign started. Until 1949 this Service worked on Mosquito Eradication. An official announcement about the success of this Campaign was made on January 10th, 1950.[10] Future climatic changes however, can bring malaria back to the small island. Furthermore, Cyprus's location also makes it more vulnerable for another epidemic. The estimated annual number of malaria cases is about 14 million, out of which 95% occur in four countries: Afghanistan, Somalia, Sudan and Yemen. After the Gulf war however, malaria was spreading over the boarders into Turkey and the Eastern Mediterranean. According to an article released by the WHO ,Cyprus is threatened; since importation of malaria to the northern part of the island from Turkey has been documented. In practical terms, there is a need for co-ordination of antivectorial activities and standardization of control methods between the countries with strong programmes and relatively intense transmission in border areas.

Currently little action is being done to prevent any malaria outbreaks in Cyprus. I believe that most people believe that since malaria has been completely eradicated from the island that it poses no further threat. Unfortunately, due to all the climate changes we have dealt with,

---

[10] Constantinou, K. Parassitologia. 1998 Jun;40(1-2):131-5.

alongside the new pesticide resistant strains of mosquitoes, malaria can theoretically pose a huge threat in Cyprus.

Current Studies

Just this year, the Cyprus Public Health Service has released a report about it's mosquito surveillance program in the Republic of Cyprus conducted over the past 10 years. "Twenty-three species belonging to 6 genera and 10 subgenera have been recorded to date, including species documented from earlier surveys. As a result of this program, new mosquito species for Cyprus have been recorded, including *Anopheles marteri*, *Culex theileri*, *Cx. impudicus*, *Culiseta subochrea*, and *Uranotaenia unguiculata*. Importantly, mosquito species previously considered eradicated have reemerged (*An. sacharovi*). Monitoring and identification of mosquito species is an important component of the Public Heath Service's commitment to protecting the health of residents and preventing the spread of vector-borne diseases."[11]

This information could be useful in ascertaining which, if any, strains of mosquitoes could potentially pose a threat in Cyprus. A good contact regarding this information is Marios Violaris, of the Medical Entomology Laboratory, Medical and Public Health Services, Ministry of Health, 19 Campou Street, Strovolos, Nicosia CY 2030, Cyprus.

From the governmental side there seems to not be much action regarding the increase of vector borne diseases secondary to global warming. Even on the webpages of both the Ministry of Health and the Ministry of Public Health there is no information what so ever about malaria in general. One step in the right direction would to be to perhaps contact theses members (healthservices@mphs.moh.gov.cy) and discuss the serious implications that global climate change can have on the spread of disease.

Since Cyprus is such a small island, perhaps the best idea would to be to reach out to other experts in the field and ask for their suggestions. Andrew Dobson is a specialist in his field and published a book titled *Global Warming and Potential Changes in Host-Parasite and*

---

[11] Marios Violaris[1], Marlen I. Vasquez[1], Anna Samanidou[2], Margaret C. Wirth[3], and Andreas Hadjivassilis. Journal of the American Mosquito Control Association 25(2):199-202. 2009
doi: 10.2987/08-5793.1

Disease-Vector Relationships. His insights in the topic can perhaps awaken the Cypriot Ministries of health about the alarming issue at hand, as well as give some strategic planning. Andrew Dobson is currently a Professor of Politics at Keele University, United Kingdom; in the School of Politics, International Relations and the Environment (SPIRE), and in the Research Institute for Law, Politics and Justice. Andrew Dobson can be reached via email Andrew@AndrewDobson.com.

Similarly, Janice Longstreth (**tigrr98@comcast.net**) was a co-author in writing *The Potential Impact of Climate Change on Patterns of Infections Diseases in the United States.* Janice is currently working at The Institute for Global Risk Research, in Bethesda, Maryland. Her knowledge of the environmental impacts on geographically oriented diseases can also be of aid in determine what the next best strategic step is for Cyprus. In Mrs. Longstreth's book, she concluded that "the greatest threat to controlling potential outbreaks from vector-borne diseases due to climate change was the decrease in funding and support of public health programs responsible for disease surveillance and vector abatement. They recommended the creation of multidisciplinary expert teams charged with developing effective programs to cope with anticipated changes in the incidence and distribution of vector-borne diseases."[12]

Conclusions

---

[12] Longstreth, J. D., and J. Wiseman. 1989. The potential impact of climate change on patterns of infectious disease in the United States. In *The potential effects of global climate change on the United States: Appendix G Health*, ed. J. B. Smith and D. A. Tirpak for the Office of Policy, Planning, and Evaluation, U.S. Environmental Protection Agency. Washington, D.C.: U.S. Environmental Protection Agency.
[13] WHO Task Group. Potential health effects of climate change. Geneva: WHO, 1990: 58.
[14] Freier, J. E., D. J. Rogers, M. J. Packer, N. Nicholls, and J. Almendares. 1993. Vector-borne diseases. In *Global health watch: Monitoring impacts of environmental change*, by A. Haines, P. R. Epstein, and A. J. McMichael. *Lancet* 342: 1464-69.
[15] Epstein PR, Rogers DJ, Sloff R. Satellite imaging and vector-borne disease. Lancet 1993; 341: 1404-06.
[16] Shope, R. E. 1992. Impacts of global climate change on human health: Spread of infectious disease. Chapter 25 of *Global climate change: Implications, challenges and mitigation measures*, ed. S. K.
[17] Haines, A., P. R. Epstein, and A. J. McMichael. 1993. Global health watch: Monitoring impacts of environmental change. *Lancet* 342: 1464-69.

[18] Longstreth, J. D., and J. Wiseman. 1989. The potential impact of climate change on patterns of infectious disease in the United States. In *The potential effects of global climate change on the United States: Appendix G Health*, ed. J. B. Smith and D. A. Tirpak for the Office of Policy, Planning, and Evaluation, U.S. Environmental Protection Agency. Washington, D.C.: U.S. Environmental Protection Agency.

As we can see the health impacts of climate change are potentially huge. A specific WHO task group has been established to calculate and monitor the increasing threat of vector borne diseases due to climate change. The WHO task group identified several vector-borne diseases that might be influenced by climate change[13]. Examples are malaria, lymphatic filariasis, African trypanosomiasis, dengue and yellowfever. [14]

One step to help monitor the ever changing weather and terrain conditions is with the use of salittle imagery. Surveillance is critical to predict potential outbreaks of vector-borne diseases. The US National Aeronautics and Space Administration is sponsoring research on the use of satellite information for vector-borne disease monitoring and control.[15] Improved surveillance systems should be incorporated within the next generation of earth observation platforms. Shope recommends that more studies, both in the field and the laboratory, examine the disease agent's ability to adapt to changing climatic conditions to allow prediction of which pathogens might migrate and their potential destinations.[16] Similarly, Haines, Epstein, and McMichael, reiterate the importance of low-cost continuous-field monitoring of disease incidence and recommends the use of remote sensing to detect changes in terrestrial ecosystems, the habitats for animal hosts and vectors.[17]

From these experts we can see how important the use of monitoring and prevention will be in conquering this future battle with vector borne diseases. Field studies have been done but they must be kept going indefinitely. Scientists have determined that the greatest threat to controlling potential outbreaks from vector-borne diseases due to climate change was the decrease in funding and support of public health programs responsible for disease surveillance and vector abatement. This is quite dangerous in countries such as Cyprus were the dangers of malaria have been forgotten. The US EPA recommends the creation of multidisciplinary expert teams charged with developing effective programs to cope with anticipated changes in the incidence and distribution of vector-borne diseases.[18] With increasing monitoring and knowledge hopefully countries such as Cyprus can prepare for the worst, instead of merely hoping for the best.

Graphs

Graph 1: Examples of Effects on Vector Borne Diseases

World Health Organization (WHO). 1990. Potential health effects of climatic change. Geneva: World Health Organization.

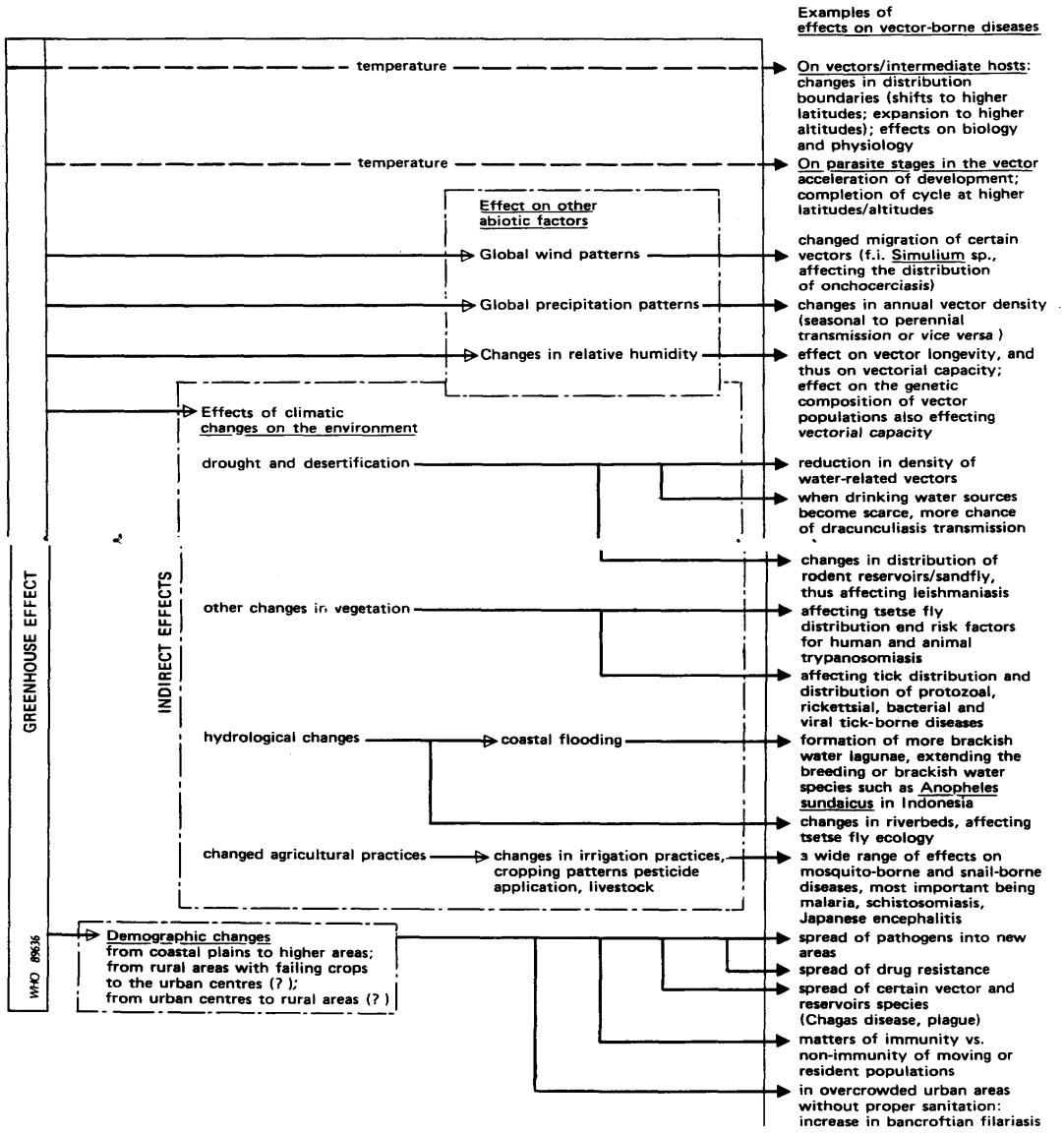
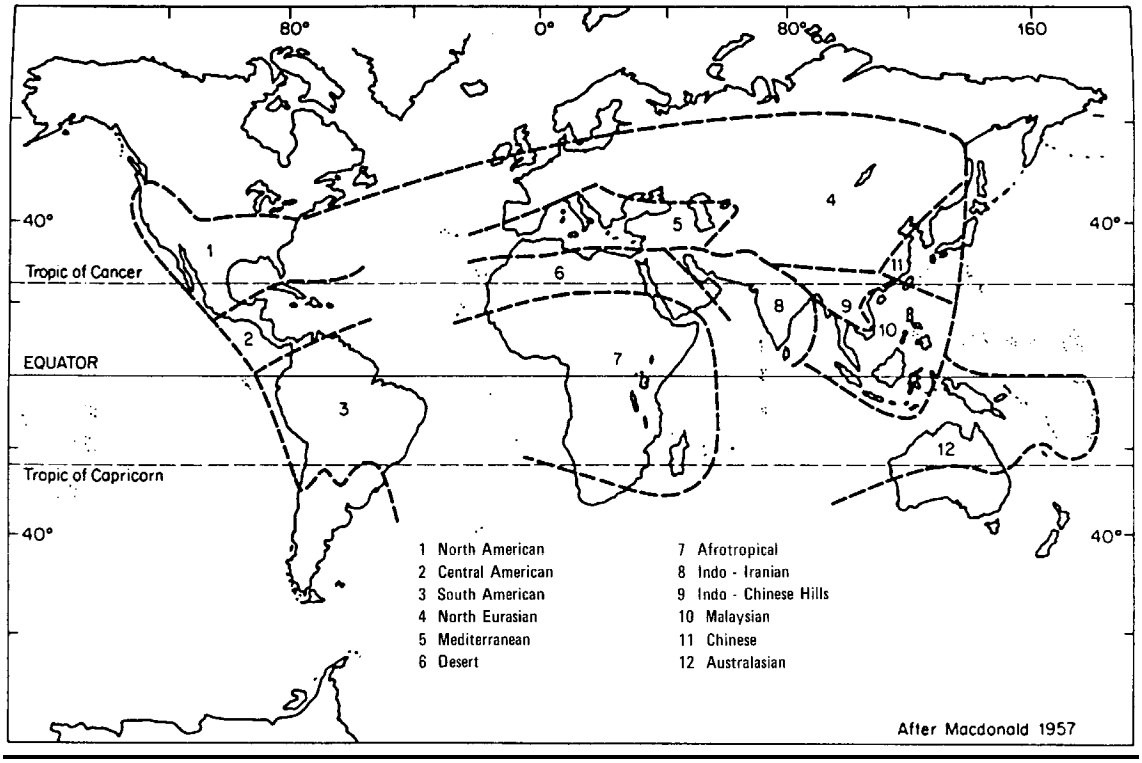


Fig. 5. Possible effects of climatic change due to the greenhouse effect on vector-borne disease epidemiology.

[19] World Health Organization (WHO). 1990. Potential health effects of climatic change. Geneva: World Health Organization.

Zones of Malaria

Map 2 **The Zones of Malaria Epidemiology**



Bibliography

[1] *Surface temperature analysis: analysis graphs and plots.* NASA: Goddard Institute for Space Studies; 2007. Available from: http://data.giss.nasa.gov/gistemp/graphs/

2. Shope, R. E. 1992. Impacts of global climate change on human health: Spread of infectious disease. Chapter 25 of *Global climate change: Implications, challenges and mitigation measures*, ed. S. K. Majumdar, L. S. Kalkstein, B. Yarnal, E. W. Miller, and L. M. Rosenfeld, 363-70. Easton, PA: The Pennsylvania Academy of Science.

3. Robert S. Chen. The Center for International Earth Science Information Network . Columbia University. Available Online: http://www.ciesin.columbia.edu/TG/HH/veclev3b.html

4. Encyclopedia of Public Health. Vector Borne Diseases. Available Online: http://www.enotes.com/public-health-encyclopedia/vector-borne-diseases

5. World Health Organization (WHO). 1990b. *Tropical Diseases* 1990. TDR-CTD/HH 90.1. Geneva: World Health Organization. Available Online: http://www.ciesin.columbia.edu/docs/001-614/001-614.html

6. Freier, J. E., D. J. Rogers, M. J. Packer, N. Nicholls, and J. Almendares. 1993. Vector-borne diseases. In *Global health watch: Monitoring impacts of environmental change*, by A. Haines, P. R. Epstein, and A. J. McMichael. *Lancet* 342: 1464-69.

7. Dobson, A., and R. Carper. 1992. Global warming and potential changes in host-parasite and disease-vector relationships. In *Global warming and biodiversity*, ed. R. L. Peters and T. E. Lovejoy. New Haven, CT: Yale University Press.

8. World Health Organization (WHO). 1990b. *Tropical Diseases* 1990. TDR-CTD/HH 90.1. Geneva: World Health Organization Available Online: http://www.ciesin.columbia.edu/docs/001-614/001-614.html

9. Jonathan A. Patz* and Sarah H. Olson. Malaria risk and temperature: Influences from global climate change and local land use practices. Proc Natl Acad Sci U S A. 2006 April 11; 103(15): 5635–5636. Published online 2006 April 4. doi: 10.1073/pnas.0601493103. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1458623

11. Constantinou, K. Parassitologia. 1998 Jun;40(1-2):131-5.

12. Marios Violaris[1], Marlen I. Vasquez[1], Anna Samanidou[2], Margaret C. Wirth[3], and Andreas Hadjivassilis. Journal of the American Mosquito Control Association 25(2):199-202. 2009 doi: 10.2987/08-5793.1

13. Longstreth, J. D., and J. Wiseman. 1989. The potential impact of climate change on patterns of infectious disease in the United States. In *The potential effects of global climate change on the United States: Appendix G Health*, ed. J. B. Smith and D. A. Tirpak for the Office of Policy, Planning, and Evaluation, U.S. Environmental Protection Agency. Washington, D.C.: U.S. Environmental Protection Agency.

14. WHO Task Group. Potential health effects of climate change. Geneva: WHO, 1990: 58.

15. [1] Freier, J. E., D. J. Rogers, M. J. Packer, N. Nicholls, and J. Almendares. 1993. Vector-borne diseases. In *Global health watch: Monitoring impacts of environmental change*, by A. Haines, P. R. Epstein, and A. J. McMichael. *Lancet* 342: 1464-69.

16. Epstein PR, Rogers DJ, Sloff R. Satellite imaging and vector-borne disease. Lancet 1993; 341: 1404-06.

17. Shope, R. E. 1992. Impacts of global climate change on human health: Spread of infectious disease. Chapter 25 of *Global climate change: Implications, challenges and mitigation measures*, ed. S. K.

18. Haines, A., P. R. Epstein, and A. J. McMichael. 1993. Global health watch: Monitoring impacts of environmental change. *Lancet* 342: 1464-69.

19. World Health Organization (WHO). 1990. Potential health effects of climatic change. Geneva: World Health Organization.