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MALARIA IN MICHIGAN

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By

David Charles Nutter

A THESIS

Submitted to Michigan State University in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Department of Geography

ABSTRACT

MALARIA IN MICHIGAN

By

David Charles Nutter

During the 19th century malaria was the most common ailment in Michigan. Malaria, or ague -- as it was known then, was so prevalent that it was not even perceived to be a disease. Following the discoveries of the plasmodium by Laveran and Ross in the late 1890's one would expect a marked decline in prevalence. Curiously, malaria declined well before these discoveries in Michigan. The aims of this study are to determine the routes by which malaria came to Michigan, to note the prevalence of the disease in the state, and most importantly, the reasons for its decline.

Unfortunately, the data collection for this theses was very difficult. Because malaria was so common, morbidity statistics were not recorded. Mortality statistics were first recorded in 1867, but only following 1873 were these statistics compiled annually by the Michigan State Board of Health. Mortality statistics were divided into many different diseases because of the lack of understanding with regards to the nature of the disease. For example, malaria was listed, in part, under some of these causes of death: typho-malarial diseases, remittent fevers, aque, and malarial fevers.

In order to identify a reasonable set of variables that might have contributed to the decline, the historical-cultural backdrop was reconstructed to help in the search for clues. Present-day epidemiological and clinical knowledge also helped to bring some of these variables to light. Some of these variables are: deforestation and drainage, screening of windows and doors, better diagnosis, and a slowing of the influx of a non-immune population into the state. The list of variables is not, however, exhaustive, because of the lack of morbidity statistics, and specific local variation.

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Chapter 1 Introduction

The most common of all maladies in Michigan before the twentieth century was ague (malaria). Until the land was partially drained, and the timber depleted, ague was the most widespread of all diseases. "As late as 1881 malaria was still believed to constitute over fifty percent of the total sum of illness in the state."¹ Every summer with the onslaught of the heat of June and July, ague became evident.

As long as man has kept written records, malaria has been mentioned. Hippocrates wrote, "Hot winds cause poor appetite, derangement of the digestive organs, flabby physique; in women they lead to fluxes and barreness; in children, to asthma, epilepsy and convulsions; in men, to dysentery, diarrhea and ague, with pleurisy and pneumonia rare."^E

Today, malaria is an endemic disease in parts of Africa, Asia, Central and S. America, where environmental factors, including temperature, humidity, and standing water, support the breeding of mosquitoes and where there is close contact between the mosquitoes and man. During the settlement of Michigan, particularly during the 19th century, malaria was endemic. The residents of Michigan had no idea that the ague-shake originated

¹Michigan History Magazine, vol. 25, (1941)

[₽]Winslow, E.E.A. <u>The Conquest of Epidemic Disease</u>, pg. 65.

with the mosquito, but instead believed that this plight was related to marshy wet lands; a notion that had been held since antiquity.

Chapter 2 Review of Literature

Malaria posed the greatest threat to health for the residents of Michigan in the seventeenth and eighteenth centuries. While the disease was seldom fatal, nearly every family had at least one member who was afflicted with fever, chills and shakes. Malaria was so prevalent that, for a time, it was not even considered a disease. "He's ain't sick, he's just got the ager!" was a common remark.

From our present vantage point, we know that malaria is spread by an infected anopheline mosquito population which is, in turn, infected by an infected animal -- perhaps human -population or vice versa. This paper analyzes the arrival of malaria in Michigan, and the decline of malaria in the state. This "decline" is of pivotal importance to this thesis because this decline came about before the discoveries by Laveran and Ross in 1898 which finally separated the disease from those caused by "germs" and identified malaria as one spread by the presence of a microorganism; a plasmodium which is spread from human to human with the help of the anopheline vector.

Malaria has long been regarded as a disease of the marshes and low country where foul air (mal'aria -- Italian) rises to strike the people with its toxic vapors. Many have written concerning malaria about specific regions of the world. Hackett wrote a book about the historic malaria situation in Europe which

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had an impact upon the New World colonies. Today, malaria is largely endemic in tropic and subtropic regions; therefore, present epidemiological articles deal directly with these areas. Since this study focuses upon Michigan, it is important to utilize primarily those works that were written with regard to North America, because the American spatial, historical and entomological parameters are the most similar to the events that occurred in Michigan.

Perhaps the earliest significant work about malaria in North America was <u>A Systematic Treatise on the Principle Diseases of</u> <u>the Interior Valley of North America</u> by Daniel Drake, M.D. which was published in 1850. Drake walked all over the Interior Valley -- the Mississippi watershed -- of North America, and he recorded his observations in this very valuable work. He noted housing types, clothing, diets, insect populations, drainage patterns and much more. Drake subscribed to the theory that malaria was spread by way of microscopic insects -- a theory that was not embraced by his contemporaries.

After Ross' discovery of the plasmodium in 1898, a flurry of interest in the decline of malaria took place because this decline predated the discovery of the plasmodium. Childs (1940) described the rise and fall of malaria prevalence in the Carolina Low Country in the 17th and 18th centuries. Childs linked the prevalence to the African slave trade and to the cultivation of rice. (p. 264) Of these two factors, the slave trade from Africa contributed to the coming of malaria into Michigan only in a

small way. The most pertinent study for the examination of malaria in Michigan would be that by Erwin H. Ackerknecht titled Malaria in the Upper Mississippi Valley 1760-1900. In this work Ackerknecht examines and compares the histories of the northern states that border on the Mississippi River. He concludes that the malaria in these areas was none other than "pioneer malaria." Many nonimmunes would move into a malarious area and this would fuel successive epidemics and leave the land in a state of endemicity. This form of malaria contrasts with the malaria that is found in the third world tropic and subtropic countries today, because the malaria in these lands is caused by a more virulent Plasmodium; usually Plasmodium falciparum. These regions remain in a state of edemicity accompanied by periodic epidemics without requiring a heavy emigrant influx in order for the disease to survive because of their tropic and subtropic locations. These regions receive far greater precipitation than the mid-latitudes and the temperature remains warm enough for the mosquito and parasite to live.

As the 19th century came to a close, so too did malaria in Michigan. This decline occurred without any conscious effort by the settler to affect the decline of the disease. The fall of malaria prevalence can not be attributed to any given factor, but rather many factors. Ackerknecht cited 12 reasons why malaria left the Upper Mississippi Valley. This list is probably the most concise with regards to a large region. These factors will be discussed in Chapter 8.

Following World War II concern arose with regards to the returning GIs from malarious lands because these men could possibly re-infect the mosquito population. In February of 1946, Michigan State College published a research article by Curtis Sabrosky, an entomologist, titled: "Occurrence of Malaria Mosquitoes in Southern Michigan." Sabrosky took samples from standing water in 31 Lower Michigan counties in an attempt to assess the <u>Anopheles</u> populations in the state. The study had its limitations because it was impossible to sample every marsh, pool, ditch etc. for anopheline mosquitoes. Sabrosky also admitted that he was unfamiliar with the study area. The study did confirm that the <u>Anopheles quadrimaculatus</u> composed 75.09% of the larvae population.

Ernest Carroll Faust has written a series of articles concerning the morbidity and mortality of malaria in the United States. In his paper titled: "Clinical and Public Health Aspects of Malaria in the United States from a Historical Perspective," Faust hypothesized where malaria originated, how it spread in North America, and speculated on reasons for the decline. In the closing paragraphs of his study he discussed procedures that would reduce "the level of natural propagation." These steps are for the prevention of malaria; the last and best step for disease control.

 Reduction of <u>Anopheles quadrimaculatus</u> and <u>A.</u>
<u>freeborni</u> breeding in hyperendemic foci to a point where the chances of man-mosquito-man development of the life cycle are very frequent.
Continued, more extensive consciousness of malaria in patients appearing for consultation and treatment,

not only in highly endemic territory but in areas of milder endemicity and in non-malarious regions. з. Increased blood film diagnosis. 4. Treatment of all malaria patients with adequate amounts of antimalarial drugs until a cure is effected. 5. Inquiry by all physicians consulted by veterans, merchant seamen or civilians, who have been overseas, recarding a history of malaria, and notification to local health authorities of potential malaria carriers. 6. A minimum food ration for the poorer elements of our population, which is quantitatively adequate to produce resistance to disease. (Frequently actual cure can not be effected until bodily resistance has been built up to destroy the malaria parasites in the foci outside red blood cells.) 7. Serious consideration of the advisability of instituting suppressing antimalarial therapy to populations in hyperendemic foci which remain resistant to reduction by other practical methods.³

Clearly these steps are for present-day malaria control, and could not be implemented during the studied time frame of this thesis. However, since malaria in the United States has been, for all intents and purposes, eradicated, these rules need to be strictly enforced so as to thwart any future outbreaks of the disease.

³⁷Faust, E. C. 1945. Clinical and public health aspects of malaria in the United States from an historical perspective. Am. Jour. Trop. Med. 25:199-200.

Chapter 3 Malaria -- the disease

Epidemiology

Malaria is a three factor human disease. It, therefore, requires three factors in order to survive: man, the mosquito, and the protozoa. Areas without any one of these ingredients simply are not malarious.

Malaria was endemic to the mid section of North America during the 18th and 19th centuries. As the masses of settlers landed in the New World and moved westward they entered malarious lands. Cecil's <u>Textbook of Medicine</u> states: "Through the centuries the most impressive effects of malaria have been recorded during the time of war when large numbers of nonimmunes are placed in malarious lands."⁴ Though the settlements were not a result of wars, the vast majority of these emigrants could be considered nonimmunes. Even in the 17th century in the Carolinas this fact was known; "Many immigrants were from the north of Ireland and were "highly vulnerable to malaria.""⁵

[&]quot;Wyngaarden, James B. and Smith Lloyd H. 1982. <u>Cecil</u> <u>Textbook of Medicine</u>. 17th ed. Philadelphia: W.B. Saunders Co. p. 1716.

⁵⁵Childs, St. J.R. 1940. <u>Malaria and the Colonization of the</u> <u>Carolina Low Country, 1526 - 1696</u>. Baltimore [Johns Hopkins Univ. Studies in Hist. and Polit. Science, Series LVIII, No.1].

<u>Manifestations</u>

The victim of an infected Anopheles mosquito begins to experience chills and fever accompanied by a frontal headache myalgia. Cecil states: "In the early period of the illness and the fever may be persistent for several days before developing into a synchronous periodicity, the hallmark of tertian and quartan malaria. When the typical pattern has been established, the patient has a chill, a rise in temperature to 40 to 41°C, headache and myalgia. This is followed in several hours by diffuse sweating and a fall in temperature."⁶ These clinical manifestations become important when considering the socioeconomic aspects of the disease. Although these symptoms appear momentarily disabling, they were synchronous, therefore leaving the victim feeling fatigued but otherwise healthy in between attacks. This relative health also led many to believe that the ague was not a disease but a state of normality; after all, everyone was afflicted.

Diagnosis

"The diagnosis of malaria must be suspected in every patient with fever, coma, or shock who has lived or traveled in a malarious area, has received a blood transfusion, or may be a drug addict. The only (sic) technique for confirming the clinical suspicion of malaria is the identification of plasmodia

[&]quot;Wyngaarden and Smith, p. 1719.

in fixed, stained blood smears."⁷ Therefore, any continued or periodic fever in 19th century Michigan should have been first regarded as malaria. Unfortunately, for the residents of Michigan and the rest of the endemic lands, malaria was not well defined which led to many misdiagnoses.

The Anopheles Mosquito

Four species of the <u>Anopheles</u> mosquito exist in Michigan, <u>A.</u> <u>quadrimaculatus</u>, <u>A. barberi</u>, <u>A. walkeri</u>, and <u>A. punctipennis</u>. In Michigan <u>A. quadrimaculatus</u> is the most efficient as a vector. It falls well short of the tropical and subtropical varieties, but is regarded "as the most dangerous species and chief vector of malaria in eastern North America."⁶

The mosquito goes through four stages in its life: the egg, the larvae, the pupae and finally the adult. The larval stage is crucial to the survival of the mosquito during the cold Michigan winters because the larva sinks to the bottom of the pool when the water temperature drops below 12° C or 13° C. There the larvae remain in a dormant state until the water warms up.⁷

Mosquito populations are revitalized very quickly every year following the spring thaw. "One female mosquito depending on her

"Horsfall, William R. 1955. Mosquitoes. p. 140

[&]quot;Ibid., p. 1720.

[©]Sabrosky, C.W. 1946. The occurrence of malaria mosquitoes in southern Michigan. Tech. Bull. 202, Michigan State College Agric. Exp. Stn. pg. 40.

species and environment may lay from a little less than 50 to about 500 eggs in her first brood, slightly fewer in each subsequent delivery, of which there may be eight or ten before she dies. Taking 200 eggs as an average clutch and assuming half of these will hatch out females, then the theoretical progeny from a single insect in five generations would be twenty million. As each life cycle from egg to egg takes under good conditions something like two weeks, those twenty million could be the produce of one favorable North American summer."¹⁰

The resting place of the mosquito requires three elements: 1) the site must be convenient to the oviposition site; 2) the resting spot must be in close proximity to the possible blood meal; and 3) the climate must be favorable.¹¹ In the following chapter concerning the physiography of Michigan, the state will be analyzed with regards to a favorable oviposition environment.

The Protozoan Life cycle

When an infected individual enters an area that is inhabited by the <u>Anopheles</u> mosquito, the possibility arises that this individual could infect the entire <u>Anopheles</u> mosquito population. This would be accomplished by a host of mosquitoes taking blood meals from this individual, and in turn taking blood meals from

¹^oHarrison, Gordon 1978. <u>Mosquitoes, Malaria and Man</u>. New York p. 141-2.

¹¹Horsfall, p. 146.

other human victims after the <u>Plasmodium</u> has become established within these respective mosquitoes.

The female <u>Anopheles</u> mosquito is the primary focus of attention because the female must take a blood meal before she can lay her eggs. The male feeds off plants rather than animals, as does the female when animals are scarce. As the female withdraws her blood meal, she takes with it both female and male gametocytes of the protozoan which form a zygote in the stomach.

After fertilization, the zygote becomes a motile ookinete, penetrates the stomach wall, and multiplies in an enlarging oocyst. Rupture of this cyst allows the release of sporozoites which are distributed throughout the mosquito and accumulate in the salivary During the process of feeding, the mosquito gland. injects fluid from the salivary glands. Sporozoites may be released with the salivary fluid if the mosquito ate a blood meal two to four weeks previously which contained male and female malaria gametocytes. The sporozoites enter the circulation immediately, and a transient parasitemia occurs which lasts less than one hour. During this period the sporozoites enter hepatic parenchymal cells, initiating the preerythrocytic stage of plasmodium infection by forming a primary hepatic schizont. The duration of the preerythrocytic stage is usually short in the P. <u>falciparum</u> (5.5 to 7 days) and <u>P. vivax</u> (6 to 8 days) but somewhat longer in <u>P. ovale</u> (9 days) and <u>P.</u> malariae (13 to 16 days). Merozoites are then released from the hepatic cells and enter circulating erythrocytes. Occasionally, when the number sporozoites inoculated is very low, the period from infection to onset of erythrocyte infection lasts for months or even years. In falciparum malaria the tissue phase terminates at the beginning of the erythrocyte cycle; in vivax and ovale malaria, the hepatic forms This species variation necessitates different persist. therapeutic approaches in treating malaria. The species also differ in the number of merozoites released after primary hepatic schizogony: P. falciparum, about 40,000 from each infected cell; P. ovale, 15,000; P. vivax, 10,000; and P. malariae,

2,000. The large number of merozoites released into the circulation in **P. falciparum** may contribute to the high levels of parasitemia seen in this infection and perhaps to the increased frequency with which erythrocytes are observed to contain multiple organisms. The merozoite attaches to specific receptors on the red blood cell and then enters by inducing erythrocyte endocytosis, and the organism begins to develop within a vacuole in the erythrocyte. The organism increases in size, partially filling the red blood cell; this is termed late trophozoite. Later the nuclear material is segregated by schizogony, and the red blood cell becomes filled with the cytoplasm, and the multiple nuclei of the schizont. The erythrocyte cycle is completed when the red blood cells rupture, releasing the merozoites formed from the schizont, which then invade other erythrocytes. Symptoms of fever and chills coincide with the release of merozoites; hence the clinical descriptions of tertian malaria (fevers on days one and three) and quartan (fevers on days one and four). The number of merozoites formed during erythrocyte schizogony is helpful in species diagnosis. Examination of a mature schizont of P. malariae will reveal 6 to 12 developing merozoites, P. ovale 6 to 16, and P. vivax 12 to 24. By mechanisms which remain unknown, some merozoites do not continue the cycle of schizogony but develop into female and male gametocytes. These first appear in the peripheral blood several days after the onset of the erythrocytic cycle, and they may persist for weeks after schizogony has been suppressed. During the blood meal of an Anopheles mosquito, the gametocytes are indested.12

Thus, the life cycle of the protozoan is complete. This process

is revealed in this diagram:

¹^eWygaarden and Smith, p. 1716-17.



Life cycle of Plasmadium in mosquino and man. (Adapted from Alverado CA, Bruce-Chivan LI: Scientific American, Vol 206, May, 1962. Cupyright ** 1%2, by Scientific American, Inc. All rights reserved.)

The Protozoa

<u>A. quadrimaculatus</u> has been established above as the chief vector of malaria in North America. With the exclusion of specific temperature parameters, the <u>A. quadrimaculatus</u> can host any of the following protozoa: <u>P. cynomolgi</u>, however the <u>A.</u> <u>freeborni</u> is a better host for this plasmodium;¹³ <u>P.</u> <u>bastianelli</u>,¹⁴ <u>P. ovale</u>, the <u>A. quadrimaculatus</u> is a poor host for this particular plasmodium;¹⁵ <u>P. malariae</u> stands up well in the <u>A. quadrimaculatus</u> stands under experimental conditions;¹⁶ <u>P. berghei</u>: rare oocysts have been discovered in the <u>A.</u> <u>quadrimaculatus</u>;¹⁷ <u>P. relictum</u>: the development of the parasite

¹³Malaria Parasites, p. 179

¹⁴ ¹⁴Ibid, p. 205

- ¹⁵⁵Ibid. p. 218
- ¹⁶Ibid. p. 261
- ¹⁷Ibid. p. 433

takes longer in the <u>A. quadrimaculatus</u> than other parasites;¹⁰ <u>P. gallinaceum</u> and <u>P. fallax</u> are transmitted much better by the <u>Aedes</u> species.¹⁷ The two most important protozoa in North America are <u>P. vivax</u> and <u>P. falciparum</u>.

With regards to Michigan the <u>P. vivax</u> is of greater importance than the <u>P. falciparum</u> because <u>P. vivax</u> can withstand lower temperatures. Both of these plasmodia can be present in the <u>A. quadrimaculatus</u> depending on the temperature of the environment.^{eo} The northern parameter of malaria in Michigan would then be that of the <u>P. vivax</u> because "the adult <u>Anopheles</u> will survive higher and lower temperatures than the developmental forms of the malaria parasite which infect this insect."^{e1} The difference of warmer and cooler air is crucial to the protozoa. In fact, the warmer the environment, the faster the sporogony can occur within the gut of the female anopheline. Temperatures below 15°C to 16°C are hostile to any form of malaria within the mosquito.^{ee} Below is a table revealing the relative lengths of time that sporogony requires depending upon temperature of the <u>P.</u>

<u>vivax</u>:

¹⁰Ibid. p. 525. This plasmodium is the agent of "bird malaria."

¹⁹Ibid. p. 644

^e◦Horsfall, pp. 154-5.

²¹Stratman-Thomas, Warren K. "The Influence of Temperature on P. vivax" American Journal of Tropical Medicine, V. 20. p. 715.

22Pampano, Emilio 1969. Malaria Eradication 2ed. London:Oxford University Press. p. 45.

Temperature in C°	Whole Process duration in days
16	55
17	38.5
18	29
19	24.5
20	19
21	17
22	15
23	12.5
24	11
25	10
26	9
27	8

This table was derived from Pampana's table.²³ The figures in this table were calculated by the method of Oganov-Rayevski, 1947. This table is illustrated graphically below.



As seen, the sporogony process takes varying amounts of time in order to be accomplished. Since constant temperatures do not occur in nature, these statistics are only rough estimators for

²³Ibid., p. 46.

reality. Since Michigan is located at a relatively high latitude malaria had a lower incidence²⁴ than in the warmer, lower latitudes, with the completed sporogony cycle occurring in the mid to late summer. The late summer in Michigan tends to be well above the minimal 16°C (60.8°F). This means that all of Michigan could support the sporogony process as far as temperature is concerned. However, the northern lower peninsula and the upper peninsula were unlikely locations for successful sporogony because of their relative locations to the mean jet stream. Any slightly anomalous shift would produce a hostile environment to the parasite.

^{$e_4} The form of malaria that existed in Michigan was also <u><math>P_{\cdot}$ </u> <u>vivax</u> malaria which has less severe clinical manifestations than <u> P_{\cdot} falciparum</u> malaria.</sup>

Chapter 4 Data Assembly

Researching malaria in Michigan is a formidable task because it was not considered a disease, but rather a state of normality. Every year with the onset of the summer heat, the inhabitants of Michigan would begin to have periodic shakes and fevers. Until Michigan State Board of Health was organized in 1870, no specific form of medical data gathering existed. When the State Board of Health was created, legislation was introduced which would make reporting of diseases to the State Board of Health compulsory.²⁰ This legislation now made the gathering of data mandatory. From this point records were kept by the State.

Misdiagnoses also plague historical research in the area of malaria. These misdiagnoses may either be the result of simple

^{es}Act No. 81, Section 2. states: "The State Board of Health shall have the general supervision of the interests of the health and life of the citizens of this State. They shall especially study the vital statistics os this State, and endeavor to make intelligent and profitable use of the collected records of deaths and of sickness among the people; they shall make sanitary investigations and inquiries respecting the causes of the disease, and especially of epidemics; the causes of mortality, and the effects of localities, employments, conditions, injestia, habits and circumstances on the health of the people. They shall, when required, or when they deem it best, advise officers of the government, or other State boards, in regard to the location, drainage, water supply, disposal of excreta, heating, and ventilation of any public institution or building. They shall from time to time recommend standard works on the subject of hygiene for the use of the schools of the State. 1873 Laws of Michigan.

error, or they could be the result of a lack of medical training. The Supreme Court in Michigan during the 1860's stated that "a doctor was anyone calling himself such."" A common disease that was both mistaken for malaria, and malaria for it, was typhoid. In the First Annual Registration Report of Michigan in 1868, a doctor wrote, "many Physicians , especially the young and the ignorant, in order to magnify their own professional importance, magnify the importance of the diseases which they treat, and they are very prone to call any continued fever typhoid fever.""? This problem of distinguishing between typhoid and malaria was compounded by the fact that both typhoid and malaria had fevers with some degree of periodicity. The epidemiology of typhoid is considerably different from malaria. "Typhoid bacillus is a classic food- and water-borne pathogen. The major routes of passage are by the five F's: flies, fingers, food, feces, and fomites. Salmonella typhi is extremely hardy and can survive for extended periods in polluted waters, contaminated foods, and soiled bed clothes."28 Upon autopsy one also finds marked similarities. Both diseases produce enlarged spleens and livers.

Both of these diseases were prevalent in Michigan during the 19th century. In an effort to separate these diseases this map was produced.

^{ee}Ackerknecht, p. 11.

First Annual Registration Report of Michigan, Lansing, Michigan. 1868.

^{≥⊖}Wygaarden and Smith, p. 1507.



Not only does this map reveal information about typhoid and malaria mortality, it also indicates population by county by implementing the cartogram which increases the size proportionately with the different population of each county. The northern counties were exaggerated in order that they not be "swallowed up" or perhaps vanish into the ground of the map.

These counties in the north of Michigan most likely were populated even though the census recorded no one.

Upon examination, one county -- Lapeer -- immediately appears anomalous. Lapeer county is found in the "thumb" area of the lower peninsula. Lapeer is shaded light greenish blue as opposed to the "brown" counties that surround it. The lower incidence of typhoid deaths may indicate a doctor or doctors of a more professional nature; doctors who could discern between the two diseases. This does not imply, however, that the anomaly is correct. It is the opinion of this author, that both malaria and typhoid were ubiquitous in Michigan during the last century; although malaria was not as deadly as typhoid. Ground water contamination was more likely to be the rule than the exception because of a lack of knowledge concerning the proximity of the privy to the well.

It seems likely, then, that the southern three tiers of Michigan counties should be equally malarial and typhoidal. Therefore, these three tiers of counties should not vary from the top right corner of hues on the color grid. The fact that there are counties that do vary from these three colors suggests that diagnostic error was great.

Chapter 5 The Physiography of Michigan

The last episode of glaciation receded from the two peninsulas of Michigan over 10,000 years ago. Today this land is covered primarily with unconsolidated glacial debris that has been distributed in a ground moraine with a gentle undulating surface. The lack of gradient, especially noticeable on the lower peninsula, has left the landscape with poor drainage. Swamps, ponds and lakes are common in the lower peninsula, making favorable breeding grounds for the mosquito.

The drainage basins of the lower peninsula of Michigan are central to this paper for two reasons: the rivers provided forms of transportation and they tend to follow the lowlands, which are naturally more prone to swamps. Ackerknecht refers to this in his book <u>Malaria and the Upper Mississippi Valley</u>: "In the wooded country of Western Missouri in the valley of the Missouri River malaria was plentiful during the late sixties and early seventies. Nearly everybody along the river bottoms suffered from it, but the hill country was spared..."^{E9} The river areas were more malarious than the hill country in between.

Aside from the prevailing westerlies that pick up moisture from Lake Michigan, the majority of the available moisture is advected into this area from the Gulf of Mexico and even from the

[≥]Ackerknecht, p. 34.

Pacific Ocean. Michigan lies in a "battle zone" between the cool dry air from Canada, and the warm moist air from the south. Ackerknecht noted that "The wet years of 1849-51 in Iowa were followed by terrible out breaks of malaria."³⁰ It appears that the incidence values are correlated strongly with the amount of precipitation that an area receives. This also held true for Michigan. "Because of the abundance of rain, the marshes were full of water, and in June people began to come down with the ague, chills and fever until there were hardly any well people enough to take care of the sick."³¹

Vegetation has long been known to be a habitat for mosquitoes, but even earlier governing bodies recognized a correlation between vegetation and disease. During the 17th century, "The legislators [of the Carolinas observed that "vegetation and malaria flourished together." Therefore, it was decried that bushes, stumps, young pines and weeds were to be removed from the communities."³²

It seems that Michigan, then, is an ideal location for the <u>Anopheles</u> mosquito. "As far back as record extends mosquitoes were pestiferous. In an expedition to Detroit [1793] by Lindley Moore and Paxon, it is recorded: "Last night the musquetoes

^{ae}Childs, p. 228.

^{@0}Ibid., p. 39.

³¹Burr, C.B. 1930. <u>Medical History of Michigan</u>. 2 vols. Minneapolis. p. 685.

[sic] exceeded anything of the kind I have ever

experienced...""33

The settlers were constantly under attack by the <u>Anopheles</u> as remarked in the <u>Medical History of Michigan</u>: "The pioneers built "smudges" to drive away the mosquitoes, and swatted them while they "murdered sleep." Mosquito bars were hung over the beds of a few of the wealthy ones -- that is to say, those whose property was free from mortgage and whose superannuated teapot contained a number of jingling coins -- but window screens were unknown. In the daytime food on the table was protected by covering with a wire woven contraption. Flies ruled by day and anopheles (sic) by night."³⁴

³³Burr, p. 692. ³⁴Burr, p. 691.

Chapter 6 The Spread of Malaria to Michigan

Four plausible routes of the spread of malaria to Michigan will be considered here: malaria as an endemic disease familiar to Michigan, the slave trade, a route by which the disease originated in Africa and then spread to North America, the French and the English as the purveyors of malaria, and the spread of malaria within the continent.

The first systematic enquiry regarding malaria, would be to consider whether malaria was endemic; not only in Michigan, but in North America in general. If the disease were endemic in one part of the land, then certain <u>Anopheles</u> habitats would be infected. From the first accounts of visits by Europeans to the North American shores, malaria is not mentioned. Ackerknecht maintains that the Indians -- the indigenous population -- were not infected. "It is likely that the Indians were not malarious because an "expedition like the one of DeSoto in 1541, would have been quickly destroyed...""³⁵ After the arrival of the Europeans some noticed that the Indians also suffered from malaria. "Mrs. Dr. L. W. Lovell of Climax informs me that she has seen an Indian have the ague which shook him as it did the white man.""³⁶

⁹⁵Ackerknecht, p. 59. ⁹⁶Burr, p. 682.

The generally accepted theory concerning the origin of malaria is that it arrived with the slave trade. The taking of slaves by Europeans began in 1434 when "Antonio Gonzales, a Portuguese captain, landed on this coast [Guinea], and carried away with him some negro boys, whom he sold to one or two Moorish families in the south of Spain."³⁷ The slave trade on the North American continent started in 1620; about the same time that the pilgrims landed at Plymouth, when a Dutch vessel brought slaves to Jamestown, Virginia.³⁸ Africa, the home of the slaves sold in North America, has long been known to be malarious. The west coast of Africa was named "the white mans grave." It only seems natural to blame the arrival of malaria in North America on the slave trade; after all, the highest incidence of malaria in the seventeenth century appeared to be in the Carolinas. "In the tobacco-growing colonies, Maryland, Virginia, and North Carolina, slaves constituted a third part or more of the population. In South Carolina, where rice was the principle produce, they were still more numerous, decidedly outnumbering the [white] inhabitants."³⁷ By 1715 the ratio of black slaves to the white population was as follows:

³⁸Ibid., p. 370. ³⁹Ibid., p. 381.

³⁷Blake, W. D. 1861. <u>The History of Slavery and the Slave</u> <u>Trade</u>, Columbus, Ohio. p. 95.

	<u>Whites</u>	Negroes
New Hampshire	9,500	150
Massachusetts	94,000	2,000
Rhode Island	8,500	500
Connecticut	46,000	1,500
New York	27,000	4,000
New Jersey	21,000	1,500
Pennsylvania and Del.	43,000	2,500
Maryland	40,700	9,500
Virginia	72,000	23,000
North Carolina	7,500	3,700
South Carolina	6,250	10,50040

Although the South claimed the largest share of the slave population, ample slaves also lived in the North. These people could have easily infected the anopheline population, thereby starting a malaria epidemic.

African slaves were not the only origins of malaria in North America. Malaria also existed in Western Europe. As the Europeans began to settle on the North American shores they brought with them chronic ailments that were common to their homelands.

The French began exploring the inland waters for an alternate route to the Orient in the early 1600's. Although this group of men was largely transitory, a few forts and towns were established. The French community with the greatest impact was Detroit which was built by Cadillac above the Detroit River in 1701. It is quite probable that the French brought malaria to Michigan because the lands were considered very malarious at the close of the eighteenth century. "When General Wayne reached Detroit, he was suffering from a malarial fever which he had

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40Ibid. p. 378.

contracted during his journey. The western territory was notorious for its fevers and agues and Detroit did not escape their ravages."41

Warshaw points out that certain groups of colonists were malarious and others were not. The role of the European in bringing malaria to the New World is neatly demonstrated by the experiences of the English settlers in Virginia. The first colonists, sent out by Sir Walter Raleigh, made their headquarters on Roanoke Island and spent almost a whole year exploring the adjacent mainland. These colonists were recruited from Raleigh's native country of Devon, a part of England then free of malaria. As a result, these men remained relatively healthy throughout their stay in what was subsequently proven to be rather ideal territory for the development of malaria.

The experience of the Jamestown colony, established some twenty-two years later, was strikingly different. These settlers, largely recruited from London, then a focus of malaria, arrived at Jamestown on May 13, 1607. Until the beginning of July, all of the 105 colonists enjoyed good health. Suddenly, an epidemic of ague broke out which progressed so rapidly that only a handful remained on their feet and by September, almost half of the settlers had died. From that time on the presence of malaria gave Jamestown the reputation of being an unhealthy place and it was largely responsible for the removal of the capitol from Jamestown to Williamsburg in 1699.⁴^m

This example illustrates that colonists from Devon were spared from malaria when they arrived at the New World, while their

⁴¹Bald, F. Clever General Wayne visits Detroit Michigan History Magazine 26:4 p. 445.

⁴^eWarshaw, Leon J. 1949. <u>Malaria. The Biography of a</u> <u>Killer</u>. New York. p. 26.

London counterparts were plaqued by malaria in Jamestown, all because their particular homelands were either malaria-free or malarious. By moving the capitol to Williamsburg, the colonists were leaving the swampy tidal flats of Jamestown behind and moving inland. This does not mean that an <u>Anopheles</u> population did not exist around Williamsburg. The inhabitants probably continued to suffer, but less than in Jamestown. The colonists were probably infected with P. vivax malaria which would cause less severe outbreaks in the following three or four years; assuming no great influx of new non-immunes. Faust concurs when he writes that "It is entirely probable that some of the British explorers and settlers suffered from malaria, since the disease was at that time endemic in the Fen counties..."43 Since malaria likely also arrived with the British (see above, Devon and London as sources), it stands to reason that all of the British settlements along the eastern coasts of North America would be malarious; provided that the Anopheles mosquito also existed in those areas. This being the case, New England would also be prone to malaria attacks. "Although the colder climate made it more difficult for malaria to take a foothold, New England was not spared. The early history of the Massachusetts colonies contains descriptions of disastrous epidemics."44

""Warshaw, pg. 27.

⁴³Faust, Ernest C. 1945. Clinical and public health aspects of malaria in the United States from an historical perspective. Am. Jour. Trop. Med. 25:185-201. p. 185.

E. C. Faust provides a possible theory as to the diffusion of malaria in North America:

Even before the Federal Government had been established pioneers began a westward trek for new land and by the beginning of the nineteenth century this migration had measurably increased. In this way malaria was carried up the river valleys of the Atlantic coast, across the Appalachian divide into Western New York and Pennsylvania and into the Ohio river valley.

From the more southern Atlantic Coast States it was spread into Kentucky, Tennessee, Alabama, Mississippi, Arkansas and northern Louisiana. Meanwhile, French settlers brought malaria directly to Mobile, New Orleans and Natchez, while Spanish immigrants from Mexico and other countries to the south introduced the disease into Texas and the Gulf Coast.45

Faust does not discuss how the malaria in the south may have spread northward to fortify the already existent malaria in New England.

New England is a crucial area in regards to the settling of Michigan. As the Erie Canal opened, coupled with the establishment of steam ship lines on Lake Erie, many New Englanders left the rocky soils of the northeast for optimistic futures in Michigan. Michigan was the most popular destination for the emigrant in the 1830's.⁴⁴ This verse, titled "Emigrant's Song" describes this interest in Michigan:

[&]quot;⁵Faust, E. C. p. 186.

⁴⁶Dunbar, Willis F. 1980. <u>Michigan</u>. Grand Rapids:Eerdmans Pub. Co. p. 194.

Come all ye Yankee Farmers, Who'd like to change your lot, Who've spunk enough to travel Beyond your native spot, And leave behind the village Where Pa' and Ma' do stay, Come follow me and settle In Michigania.

What country ever growed up So great in little time, Just popping from the nurs'ry Right into like its prime; When Uncle Sam did wean her, 'Twas but the other day, And now she's quite a Lady, This Michigania.

Then come ye Yankee Farmers, Who've mettle hearts like me, And elbow-grease in plenty, To bow the forest tree; Come take a "Quarter Section," And I'll be bound you say, This country takes the rag off, This Michigania.47

It thus appears, then, that malaria was not found in North America prior to the coming of the Europeans. It would be impossible to limit the route of malaria from one specific land to North America because most of the colonists and explorers including the French and the Spanish were from malarious lands. The Spanish played a minor role in comparison to the British, and perhaps the French with regards to Detroit and French Town, in that they were not interested in settling the land, but rather were interested in the exploitation of this New World.

[&]quot;⁷Dunbar, p. 193. This verse originally appeared in a Detroit paper in 1831

Chapter 7 Malaria in Michigan

Before the white man arrived on these shores, Michigan was occupied by the Chippewa, the Ottawa, the Huron and the Potawatomi. The French were the first Europeans to set foot on Michigan soil when Brulé stopped in the area that is now Sault Ste. Marie in 1620. Three settlements existed in Michigan into the 19th century. During these years the French, the British and the Americans fought for control with the Americans winning the lands through the Jay treaty of 1796 and later through the treaty of Ghent at the close of the War of 1812 in the year 1815.

As discussed above, it was unlikely that malaria existed in Michigan prior to the coming of the white man. Records concerning malaria in Michigan begin around the turn of the nineteenth century. This does not mean though, that malaria did not exist in Michigan before that time. Cadillac established the community of Detroit on a high spot above the Detroit River in 1701. It is likely that malaria existed there because, as we have seen, the French most likely brought the initial malaria to this region. Morse's <u>Geography</u> of 1805 states, "The prevailing diseases of the lower part of the Ohio, on the Mississippi and through the Floridas are bilious fevers. In some seasons they are mild, and are little more than common intermittants; in others they are highly malignant and approach the genuine yellow

fever of the West Indies."⁴⁰ As has been shown above, malaria was also well entrenched in Michigan at this time.

Although Michigan did not enter statehood until 1837, the American period of Michigan's history began with the Treaty of Ghent in 1815. The American period is the focus of this paper. During that time the incidence of malaria steadily rose until the 1870's and '80's and the health records and medical understanding were constantly being improved. The Americans, whether or not they were to blame for bringing malaria to Michigan, inherited the most malarious period.

Following the Black Hawk War of 1832, Michigan enjoyed a a great boom in population. Ships were built to meet the demand for ferrying the emigrants to the state. Detroit became the "dropping off point for the new settlers who were entering the region. "No other town in Michigan approached Detroit in size or importance. In fact, it was the only incorporated city in Michigan when the state was admitted to the Union in 1837.

The bulk of the emigrants who came to Michigan arrived first in Detroit where they purchased horses, a wagon and whatever else they needed before leaving for the frontier. These pioneers would have traveled by one of the existing roads: the Chicago Road, the Territorial Road or the Grand River Road. These three roads were laid in the first three tiers of Michigan's counties.⁴⁹ Fifteen villages sprang up along these roads and

4[©]Dunbar, pp. 191-5.

^{4⊕}Ackerknecht, p. 16.

were incorporated by 1837: Monroe (1827), Ypsilanti (1832), Ann Arbor(1833), Niles, Adrian, Pontiac, St. Joseph, Tecumseh, Centreville, Constantine, White Pigeon, New Buffalo, Marshall, Mount Clemens, and Coldwater."50

This ingredient of incoming non-immunes combined with high annual precipitation totals sets the stage for malaria epidemics. In 1836 there was a great surge of emigrants which was noted in the Medical History of Michigan: "Of the "great immigration of 1836" a settler in Van Buren County remarked, "I've known the time when the rush at Dodge's was so great and the demand for lodging so pressing that travelers offered as high as a dollar for the privilege of leaning against a post."⁵¹ The large amounts of flying insects as recorded here was perhaps indicative of large rainfall amounts which created a larger vector habitat during the period following the large emigration: [1837]""flies, gnats and mosquitoes" were so numerous that the sky was completely darkened."⁵² The following year marked one of the worse malaria outbreaks ever in Michigan. In Palmyra, Michigan in the fall of 1838 a settler remarks: "I do not exaggerate when I say with us there were three sick persons to every well one."⁵⁹

Michigan's vegetation patterns changed considerably because of the logging industry. As the forests were depleted and

⁵³Ibid., p. 685.

^{©o}Dunbar, p. 211.

⁵³¹Burr, p. 119.

^{™&}lt;sup>2</sup>Ibid., p. 123.

primary and secondary growth of underbrush and aspens had taken over, the habitat for the mosquito was greatly enhanced. Many areas that were once considered low lands had suddenly become wet lands. As these wet lands were produced the incidence for malaria increased. The logging industry also provided a greater population that could come into contact with the Anopheles habitat. The woods and malaria have long been correlated: "In the wooded country of Western Missouri in the valley of the Missouri River malaria was plentiful during the late sixties and early seventies. Nearly everybody along the river bottoms suffered from it, but the hill country was spared... malaria becan to diminish in a marked decree in the late seventies."⁵⁴ Before the Civil War malaria was beginning to stabilize in the Upper Mississippi Valley, but the war brought higher incidence back into the area. "The wholesale movement of populations brought about by the war, the necessity of bringing thousands of susceptible soldiers of both sides into malarious regions, and the great hardship and devastation consequent to the military campaigns were conditions conducive to an explosive epidemic."55 Around 1870, malaria reached it's high watermark. Immediately following 1870 malaria sharply declined as can be seen in this graph below.

^{\$\$4}Ackerknecht, p. 34.

[&]quot;"Warshaw, p. 31.



The decine of malaria in Michigan. Source: Michigan Vital Statistics 1871-1916

In the next section the many reasons for this decline will be discussed.

Chapter 8 Conclusions: the decline of malaria in Michigan

The study of the decline of malaria in Michigan has been a complex problem because it happened before the plasmodia had actually been discovered. Before the discussing the factors that led to the disappearance of malaria, we should remember again the factors that made this area malarious. These are:

1) the existence of the plasmodium

2) an existing anopheline population

3) a suitable human population.

Since the eradication of malaria can be on any of these three fronts, many possibilities that might affect the decline are possible.

Ackerknecht cites twelve reasons for this decline:

1) population movement 2) railroad, steamship and steam regulation 3) clearing, cultivation and drainage 4) prosperity 5) housing 6) screening 7) education 8) food cattle breeding 9) 10) mosquitoes 11) quinine 12) weather and climate⁵⁶

It is conceivable that some of these factors may not apply to Michigan. Ackerknecht's decline factors will therefore be individually examined in the light of the Michigan situation.

Other possibilities with respect to Michigan might be:

- 1) forest fire
- 2) the State Board of Health
- 3) urbanization

Malaria is a disease of a region that must be dealt with in a epidemiological or social manner along with the clinical approach, in order that it be handled satisfactorily. These individual notions are dealt with below.

Population Movement

This is, perhaps, the most important aspect in regards to the decline of malaria. As the population increased so did the total number of malaria cases. As the population movement decreased so fell the total number malaria cases. Malaria epidemics are fueled by bringing large nonimmune populations into malarious areas.⁵⁷ When the population movement decreases, so do the morbidity and mortality rates.

Dunbar noted that between 1830 and 1837 that Michigan was the most popular destination of those moving westward.

The boom peaked in 1836, when sales of approximately one-ninth of Michigan's total land area -- 4,189,823 -- acres brought in \$5,241,228,70, more than a fifth of the total receipts for the entire country.⁵⁰

By the 1870's the number of emigrants arriving in the state had diminished remarkably.

>>>Wyngaarden and Smith, p. 1716.

⁵⁹⁰Dunbar, p. 193.

The auto industry blossomed around the turn of the twentieth century as a result of the acquired capital from the logging industry. Henry Ford's innovations in production required a large population of unskilled laborers. This new form of labor did lead many new people into Michigan, but they settled in the urban areas rather than in the country. This phenomenon not only protected these new people from the malarious areas, it also served to reduce the habitat of the <u>Anopheles</u> mosquito by building urban areas where wet lands once existed.

Railroad, steamship and steam regulation

Ackerknecht destinguishes between population movement and the modes of transportation that provided the masses with the means of reaching different regions. Improved transportation technology resulted in a greater number of nonimmunes arriving in malarious areas.

As far as Michigan is concerned the railroad served to open up the state for logging in the remote areas. The railroad also provided transportation between all of the larger metropolitan areas within the southern part of the state. With the aid of therailroad, the small towns were able to grow economically as well as in population. The steamships that brought multitudes of nonimmunes into Michigan resulting in the malaria epidemics of the 1830's began to have less of an appeal for the traveler as the railroad linked the state with Ohio and points beyond.

<u>Clearing</u>, cultivation and drainage and the decrease of the vector

The clearing of the land brought about an initial rise in morbidity and mortality in Michigan. As the primal forest was depleted, undergrowth was then permitted to grow which turned out to be a more favorable habitat for the mosquito. As the agricultural industry blossomed in the state much of this undergrowth was also cleared away. In 1871 Dr. Lathrop noticed that "the disappearance of malaria is due to the cultivtion of lands around the city."⁵⁹ Along with the depletion of the undergrowth, drainage of wetlands curbed the habitat of the Anopheles. This was probably one of the most important factors leading to the decline and eradication of malaria in Michigan. A Dr. Wilson of Flint, Michigan, in a letter to Dr. Kedzie, wrote in April 1874, "that in all cases [drainage] modifies malarial diseases and diminishes the number of cases, and to a great extent prevents their occurrence. Drainage in this country has reduced malarial fever fifty per cent and has improved the general health to the same extent. 60 Although malaria was misdiagnosed and totally misunderstood, the physicians of the day realized that a relationship between flooded lands and malarial fevers, along with the general well-being, existed.

"Michigan History Magazine, Vol. 25, No. 1, p. 61.

"'Lyster, Henry F. 1875. Draining for Health Second Annual Report of the Secretary of the State Board of Health 1875. p. 51.

Prosperity, housing and screening

The logging industry brought a great deal of capital into Michigan. As the wealth increased, the living standards also improved. The old log cabins, which were nearly always in a state of disrepair⁶¹, were replaced by more permanent dwellings made of clap board. The old log homes provided the settlers with a lower standard of living than the homes that the logging industry would facilitate. The log cabins were also economic indicators with far reaching ramifications: "Low standards of living mean that health and education services are poorly developed and inadequate; under-nutrition and malnutrition cause debility and increase susceptibility to disease."⁶²

As Michigan was plagued by myriads of flying insects, screens were seen as a godsend because they offered relief from the pests of the outdoors. Fresh air had long been thought to be very healthy. In a paper delivered in Kalamazoo, Michigan at the Sanitary Convention on 1 & 2 June 1886, Victor Vaughn stated: "Every room should have direct sunlight and not be dependent upon that which is diffused through another room. The windows should extend well towards the ceiling and be hung so as to lower from the top as well as raise from the bottom in such a manner that they are easily opened. In no part of the house should they be

Prothero, R. Mansell 1965. <u>Migrants and Malaria</u>, London:Longmans. p. 123.

⁶¹Drake, D. 1854. <u>A Systematic Treatise on the Principal</u> <u>Diseases of the Interior Valley of North America</u>. Vol. 1 Cincinnati, 1850, vol. 2, Cincinnati. p. 681.

kept closed during the day."⁶³ Having the windows open during the day would most likely mean that man coexisted with many insects inside of his house all of the time. Screening is especially important because it prohibits the mosquito from taking blood meals from sleeping victims. This is when the victims are especially prone and the mosquitoes most active. During the daytime one can stay relatively free of mosquito bites.

Screening windows, unfortunately, was not widespread until the second, or perhaps the third decade of the 20th century. This does not mean that the idea for screens did not exist earlier. "There is evidence that wire screens were manufactured in this country as early as 1817 probably by a tedious hand weaving process."⁶⁴ These screens were not, however, used for screening windows. "The first recorded sale of wire cloth for window screens was made to Johnson and Brother, Washington D.C. on 30 January 1861."⁴⁶⁵ Production of window screens would not begin for another twelve years: "In 1873, Wickwire Brothers, Inc. of Cortland New York converted a carpet loom to wire weaving, and finally succeeded in the production of woven wire

[∞][∞]Ibid. p. 1186.

[☆]SVaughn, Victor C. Healthy Homes. A paper delivered at the 13th Sanitary Convention in Kalamazoo in 1886. p. 38.

⁶⁰*Boyd, Mark F. ed. 1949. <u>Malariology</u>. Philadelphia:W.B. Saunders Co. p. 1186.

cloth suitable for window screens."⁶⁶ Even though window screens were available and even utilized, many used the screens improperly or allowed the screens to fall into disrepair. "In a survey in the 1930's covering typical counties in 46 states, no screens were reported for 26.8 per cent of all farm houses; and they were reported as poor for an additional 20.0 per cent, and as just fair in the case of 21.8 per cent more."⁶⁷ Screening, although an effective and logical approach to the relief of malaria -- even daily relief from mosquitoes, can not be associated with the withdrawal of malaria from the state. Adequate and thorough screening occurred well after the decline of the disease had begun.

Education and the State Board of Health

In 1873, the Michigan State Board of Health was organized in an attempt to thwart many of the health problems in the state. As medical knowledge increased, the people became familiar with the correlation between poor sanitation and the higher prevalence of disease. As noted above, the duties of the State Board of Health included the reporting of diseases; especially epidemics. Malaria was most likely a disease that was missed because <u>P.</u> <u>vivax</u> malaria is rarely fatal but very common. The State Board

⁴⁰⁰ Ibid. p. 1186.

of Health was, and is only as effective as its knowledge base. Ventilation in living quarters, for example, was thought of as a healthful practice, but open windows mean easy prey for mosquitoes -- especially at night. The State Board of Health made great inroads in the area of drainage of wetlands as discussed above.

Cattle Breeding and the mosquito

Very little is mentioned about cattle during the settling of Michigan in the pioneer accounts. It seems likely that most farmers owned a cow -- more for dairy purposes than meat -- along with other livestock. Cattle are discussed briefly in this small quote about Detroit in the 18th century: "Agriculture was carried on profitably, and supplies were exported quite early from that settlement, consisting of corn and wheat, and possibly beans and peas. Cattle, horses and swine were raised in considerable numbers, but salt was so expensive that very little, if any, meat was salted for sale."⁴⁶⁹ Cows were also thought of as an economic indicator: James Birney "was a third owner in the former Saginaw Bay company's lands and his enlightened policy and liberal dealings with early purchasers did much toward starting the growth of the town on a solid basis, and his importation of

[⊕]Michigan Pioneer Collection, Vol. 2, p. 102.

blooded stock was a great benefit in improving the breed of cattle..."

Although Texas and the West were famous for their cattle drives, Michigan also had a few drives. "In 1831, Mr. Sutton brought from Ohio a large drove of cows and oxen to sell to the new comers who settled in this neighborhood [Plymouth Corners... near Ann Arbor]. In 1832 and 1833 of each year, he drove herds of cattle from the Sangamon valley, in Illinois, for this market..."

As the cattle herds increased in Michigan, the mosquitoes possibly changed their feeding habits from man to the easier victim. Mosquitoes have been known to suddenly change feeding habits, of which this might be an example.⁷⁰

Quinine

Quinine is derived from the bark of a tree and has been referred to as "peruvian bark" or "Jesuite's bark." Quinine has been used for, centuries in the treatment of malarial symptoms. "Empirical treatment of malaria with extracts of the cinchona tree (indigenous in certain regions of South America) probably dates back several centuries, although the first written record of its use appeared in 1633. In 1820 Pelltier and Caventou

"Ribbands, p. 237.

isolated quinine as one of the active alkaloids in the crude extracts, and the use of quinine became widespread thereafter."⁷¹

"Quinine does not avoid (sic) infection; quinine does not sterilize (sic) the carrier. Quinine, therefore, can not have a direct effect on the eradication of malaria from a community. Whoever tries to link quinine directly with the disappearance of malaria because quinine is the most direct antimalarial measure is pleading a lost cause."7²² This does not mean that quinine did not help in the eradication of malaria in an indirect way. The lands that were malarious may never have been opened up to settlement had it not been for this form of treatment. Upon the opening of these lands, the lands were deforested, cleared and drained. Cities began to spring up which, in turn, pushed the malaria endemic areas back and out. This topic will be covered later.

Faust believed that the drop in price of quinine from \$4.50 to \$.25 per ounce in 1913 also contributed to the decrease in clinical malaria and malaria mortality because this new price brought quinine within the reach of the common folk.73

⁷⁷⁹Faust, p. 189

[&]quot;Wyler, David J. 1984. The Ascent and Decline of Chloroquinine. JAMA, May 11, 1984. 251:18. p. 2420.

[&]quot;PAckerknecht, pp. 126-127."

Forest fires

The notion of forest fires as an agent contributing to the decline of malaria in Michigan is weak at best because the killing frosts of Autumn would accomplish the same results as a cauterizing fire. Since the fires destroyed such great areas including forests, towns and villages, a great deal of the mosquito's natural habitat was destroyed.

The first major fire in Michigan was the fire that began on the west coast of Michigan and spread all the way across the state on October 8, 1871. This was the very same day of the Great Chicago Fire and the Peshtigo Fire in Wisconsin. The summer had been excessively dry and the swamps were all but dried up. Over two million acres were burned in that fire. Almost exactly ten years later another fire broke out burning only about half of the acreage, however this fire was far more deadly since it burned through the small towns in the "Thumb." Many people of White Rock literally fled into Lake Huron in order to survive the blaze."⁴

The effect of these fires on the decline of malaria could only be indirect. Older homes that offered little protection from the mosquitoes were destroyed in the wake of this disaster (along with the good homes...). The dry summers of 1871 and '81 probably aided this malaria decline more than the fires themselves.

24Holbrook, Stewart H. 1944. <u>Burning an Empire</u>. pp. 95 -107.

<u>Urbanization</u>

As many of the cities in Michigan grew, a decrease in malaria incidence could be expected because the natural habitat of the mosquito would be decreased. With the onset of the automobile industry in the early twentieth century -- a result of the capital that was produced by the logging industry and the abundance of nearby mineral wealth -- urbanization boomed because of the need for many nonskilled laborers. Rather than spark another wide spread epidemic, this influx of workers created larger metropolitan areas that pushed the countryside and the Anopheles habitat back. This would produce a decrease in the anopheline habitat. Ribbands concurs with this point. "No evidence has yet been adduced to show that the number of human hosts is normally an important limiting factor in the determination of the size of an anopheline population, and it may be supposed that the total number of anophelines will be more closely related to the capacity of their breeding places than to the number of their human hosts. This factor will help to decrease the malaria risk in crowded communities."75

Ribbands, C.R. 1949. Studies on the attractiveness of human populations to anopholines. Bull. Ent. Res. 40: 227-238. p. 236.

Chapter 9 Closing Remarks

I have combined many of these reasons for the decline of malaria because I feel that they are so interrelated that they can not be separated. Since malaria was on the decline well before knowledge of the plasmodia/anophelines was disseminated, I believe that all of these factors were important. Perhaps others, yet to be discovered, also played important roles.

Probably the most important conclusion concerns the route by which malaria came to the Michigan peninsulas. Although the North American malaria stronghold was in the south because of the slaves who were brought from the west coast of Africa, direct infection of Michigan from this region was unlikely. It has been pointed out that malaria was also endemic in parts of Europe and England during this period of settlement in North America. Malaria was also evident in the New England settlements during the 17th, 18th and 19th centuries. As land became more crowded and the stories of western lands circulated, many New Englanders settled in western New York. From there many went on to Michigan. This is not to say that the trade between the seaboard colonies could not have spread malaria from the southern settlements. Very little trade existed, however, between Michigan and the southern settlements because of the existing transportation routes were east-west rather than south-north.

Boyd et al. suggest that malaria and agriculture are negatively correlated.⁷⁶ Most likely, when man has reshaped the landscape; be it for agriculture or municipality, malaria has declined. Whether drainage of the land for increased arable area, or the growth of towns, the result, as far as the mosquito habitat is concerned, the same; the mosquito habitat is reduced in size or eliminated.

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