ESRM 350

Parasitism and disease

Autumn 2016

“Dr. Costa then offered important clues to differentiate the syndrome from polio. In tick paralysis there is no fever, the spinal fluid is normal, the knee jerk and other reflexes are lost early, the patient is passive and apathetic, and, of course, the child has had a recent tick bite, or an attached tick is found.”

- Pamela Nagami, *Bitten: True Medical Stories of Bites and Stings*

Parasitism

- Consumption of part of another animal, the **host**, without killing it
  - Host is sort of like habitat, though it can fight back with immune response
- Every animal has parasites
  - most are host-specific
- Almost 50% of all species on earth estimated to be parasites!
- Have shaped the course of human history
  - e.g., the protozoan *Plasmodium* (malaria) during the Revolutionary War*

*Mann CC, *1493: Uncovering the New World Columbus Created*

Kinds of Parasites

- Endo-
  - live inside the body of the host
  - e.g., flukes, tapeworms, fungi, bacteria, viruses, and protozoa

A liver fluke (trematode) extracted from a human

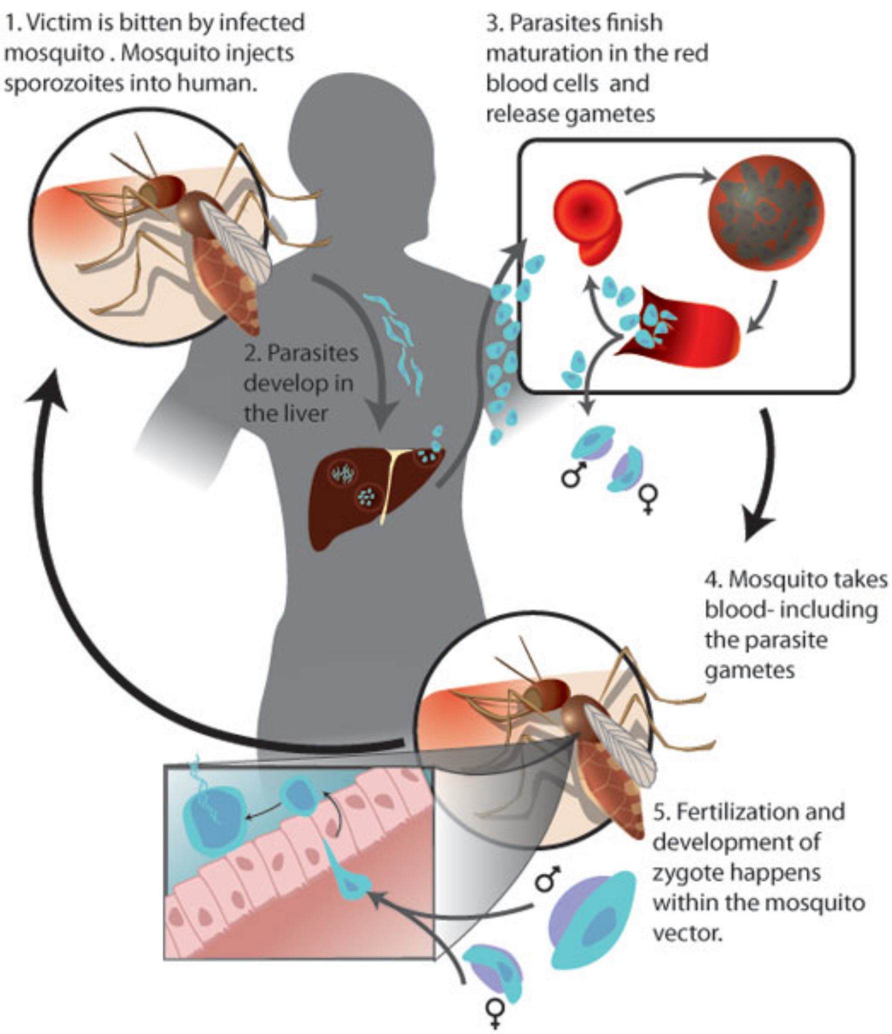
- Ecto-
  - Live and feed on the outside of the body of the host
  - e.g., ticks and lice, protozoa, bacteria, and fungi

A paralysis tick from Australia

Parasite Transmission

- Direct transmission
  - Host to host contact required
  - e.g., bacteria and viruses
- Indirect transmission
  - host to 3^{rd} party to host
  - requires **vectors:** carry parasites in daily activities
    - e.g. blood sucking insects
  - Sometimes involves **intermediate hosts**
    - Secondary host in which parasite must spend time to complete its life cycle

The *Plasmodium* Life Cycle



Humans – **primary host** (development, maturation, release of gametes)

Anopheles mosquito – **secondary host** (fertilization and development of zygote)

The Parasite-Host Interaction

- The parasite-host interaction represents a balance between parasite virulence and host defenses
  - immune system of host can recognize and disable parasites
  - but parasites may multiply rapidly before an immune response can be deployed

Ecological Effects of Parasites

- Reduce survival and reproduction of hosts
  – low-quality individuals, more susceptible to parasites, not selected as mates
  – parasites may want host killed to be transmitted (parasites may control host behavior!!)
    - e.g., *Toxoplasma gondii*

T. gondii – single celled parasite that infects rats but needs to be inside a cat's digestive system to reproduce.

Parasite affects rats' brains such that they lose their fear, and are even sexually attracted to, cat urine!

Parasitized rats are rendered more likely to be eaten by cats, giving *T. gondii* a better chance to complete its life cycle.*

*House et al. (2011) *PLoS One*

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Can the common brain parasite, *Toxoplasma gondii*, influence human culture?

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The latent prevalence of a long-lived and common brain parasite, *Toxoplasma gondii*, explains a statistically significant portion of the variance in aggregate neuroticism among populations, as well as in the 'neurotic' cultural dimensions of sex roles and uncertainty avoidance. Spurious or non-causal correlations between aggregate personality and aspects of climate and culture that influence *T. gondii* transmission could also drive these patterns. A link between culture and *T. gondii* hypothetically results from a behavioural manipulation that the parasite uses to increase its transmission to the next host in the life cycle: a cat. While latent toxoplasmosis is usually benign, the parasite's subtle effect on individual personality appears to alter the aggregate personality at the population level. Drivers of the geographical variation in the prevalence of this parasite include the effects of climate on the persistence of infectious stages in soil, the cultural practices of food preparation and cats as pets. Some variation in culture, therefore, may ultimately be related to how climate affects the distribution of *T. gondii*, though the results only explain a fraction of the variation in two of the four cultural dimensions, suggesting that if *T. gondii* does influence human culture, it is only one among many factors.

Keywords: personality; nations; masculinity; neuroticism; uncertainty avoidance

Ecological Effects of Parasites

- May reduce population growth
  - intensity of parasitism increases with crowding (density-dependent)
  - Large populations tend to be heavily parasitized
    - parasitized individuals have lower fitness (survival and reproduction)
    - e.g., parasite-induced vulnerability to predation in snowshoe hares (*Lepus americanus*)

Hares parasitized by helminths (worms) are more likely to fall prey to lynx and other predators

Helminth parasitism is density dependent.

Thus, when hares are abundant, helminth parasitism enhances predation, drives down population size.*

*Ives and Murray (1997) *J Anim Ecol*

Disease

- A disturbance to the normal structure or functioning of an animal
  - effects range from discomfort to death
- Many parasites do not cause disease
  - those that do are called pathogens (e.g., protozoans, bacteria, fungi, viruses)
- Diseases caused by parasites are communicable
  - transmission increases with density
  - also, selective pressure against disease severity reduced with density
    - you can cause diseases that kill swiftly if new hosts are close by

Sylvatic Plague

- Bacterial disease, *Yersinia pestis*
  - **primary host:** wild rodents
  - **vector**: fleas
  - **symptoms**: sever infection of the lymph nodes (bubonic), blood (septicemic), or lungs (pneumonic)
- Humans are a “dead end” host
  - bubonic plague (Black Death)
  - pandemic of 1346-1351; most victims dead in 3-4 days
  - minimum 20 million dead in Europe; estimates up to 50-70 million and 150-220 million worldwide (global population of 500 million)
  - still around, but treatable with antibiotics (72% fatal without treatment)

*http://www.nwhc.usgs.gov/disease_information/sylvatic_plague/

Sylvatic Plague and Black-Footed Ferrets

- Sylvatic plague
  - inadvertently introduced to North America in early 1900s
  - affects prairie dogs, has wiped out entire colonies (> 90% mortality rate)
  - Why so lethal?

*http://www.nwhc.usgs.gov/disease_information/sylvatic_plague/publications/protecting_black-footed_ferrets.pdf

Sylvatic Plague and Black-Footed Ferrets

- Plague outbreaks in prairie dog colonies a conservation concern because
  - black-footed ferrets (*Mustela nigripes*), one of the world's most endangered mammals, are prairie dog specialists
    - prairie dogs critical for food, shelter (burrows)
  - ferret recovery requires protecting prairie dogs, and ferrets, from plague (vaccine-laden oral baits)

*http://www.nwhc.usgs.gov/disease_information/sylvatic_plague/publications/protecting_black-footed_ferrets.pdf

Brucellosis

- Bacterial disease, *Brucella abortus*
  - **Host:** most common in domestic cattle; also affects wild ungulates
  - animal-to-animal transmission (oral); vector not needed
  - **symptoms**: commonly induces abortion during latter half of gestation; can also cause chronic infections of the bones and joints*

*http://www.michigan.gov/dnr/0,4570,7-153-10370_12150_12220-26503--,00.html

Brucellosis and Bison

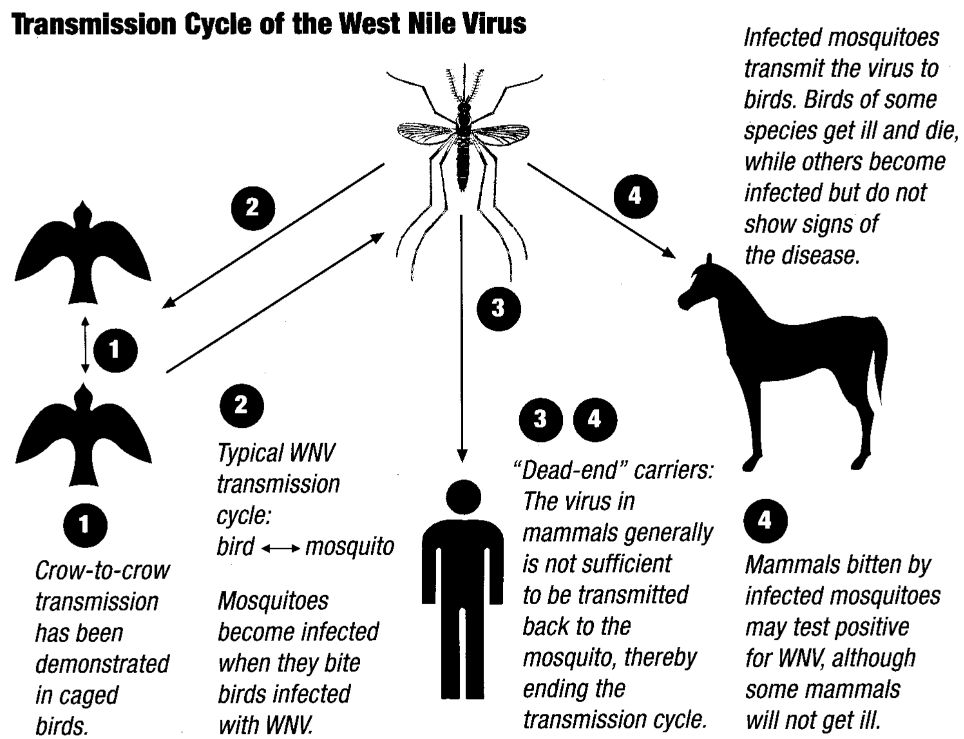
- The conservation concern…
  - transmission between bison and livestock in greater Yellowstone region*
  - Consequently, bison are prevented from leaving Yellowstone NP
    - wild bison from park not known to transmit infection to livestock
  - An ironic twist
    - *Brucella* bacteria arrived with European cattle brought to USA

Bison bison

*http://www.nps.gov/yell/naturescience/bison.htm

West Nile Virus

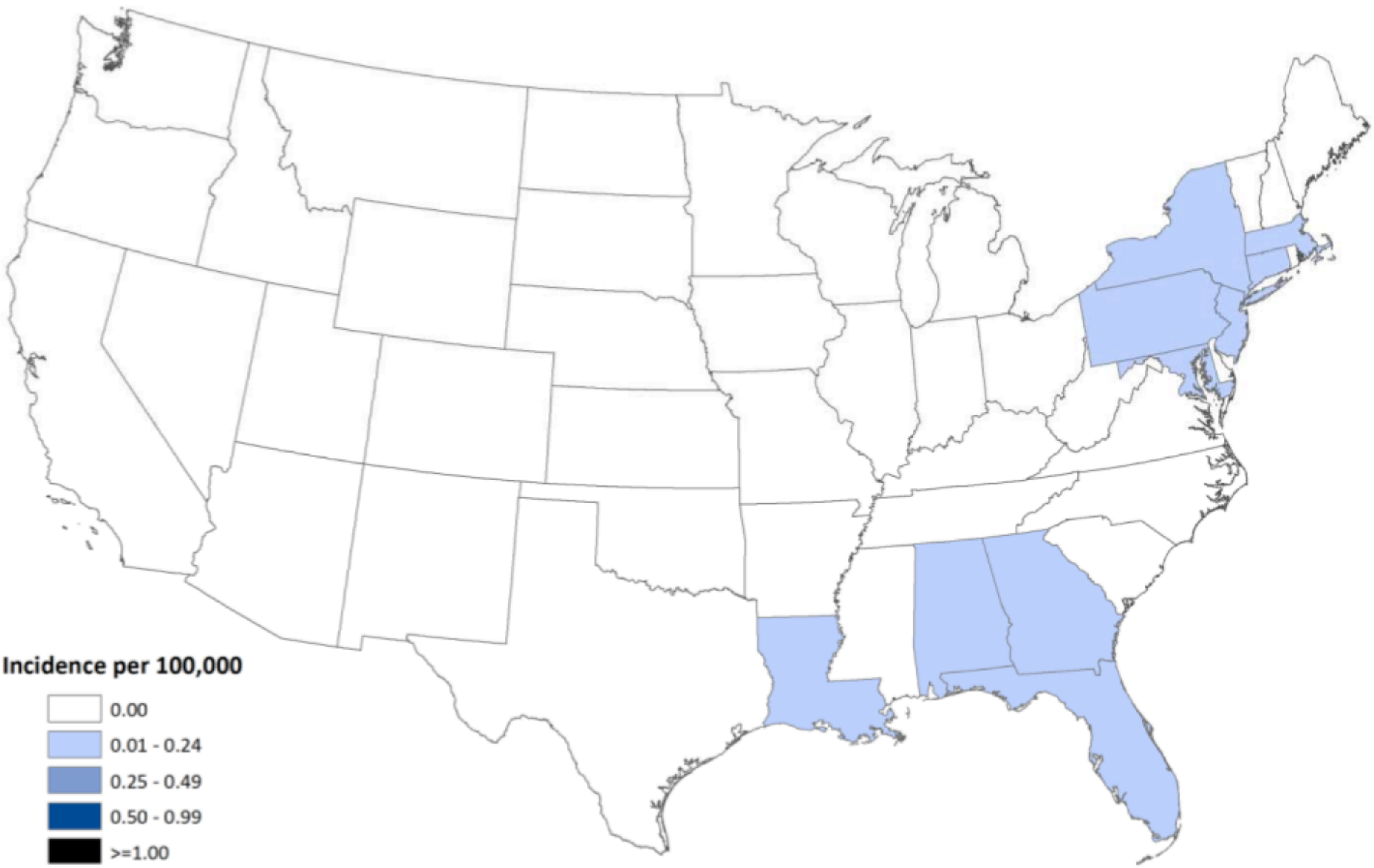
- Arthropod-borne virus
  - **primary host**: birds (225 species)
    - impacts on bird populations unknown
  - **vector**: mosquitoes
  - causes encephalitis and meningitis (inflammation of brain and surrounding tissue)
- Humans are "dead end" carriers
  - Only 1 in 5 are symptomatic*
  - < 1 % develop serious neurologic illness
    - 10% fatal
  - first outbreak: summer 1999



*http://www.cdc.gov/westnile/faq/genQuestions.html#what

West Nile virus neuroinvasive disease incidence reported to ArboNET, by state, United States, 1999

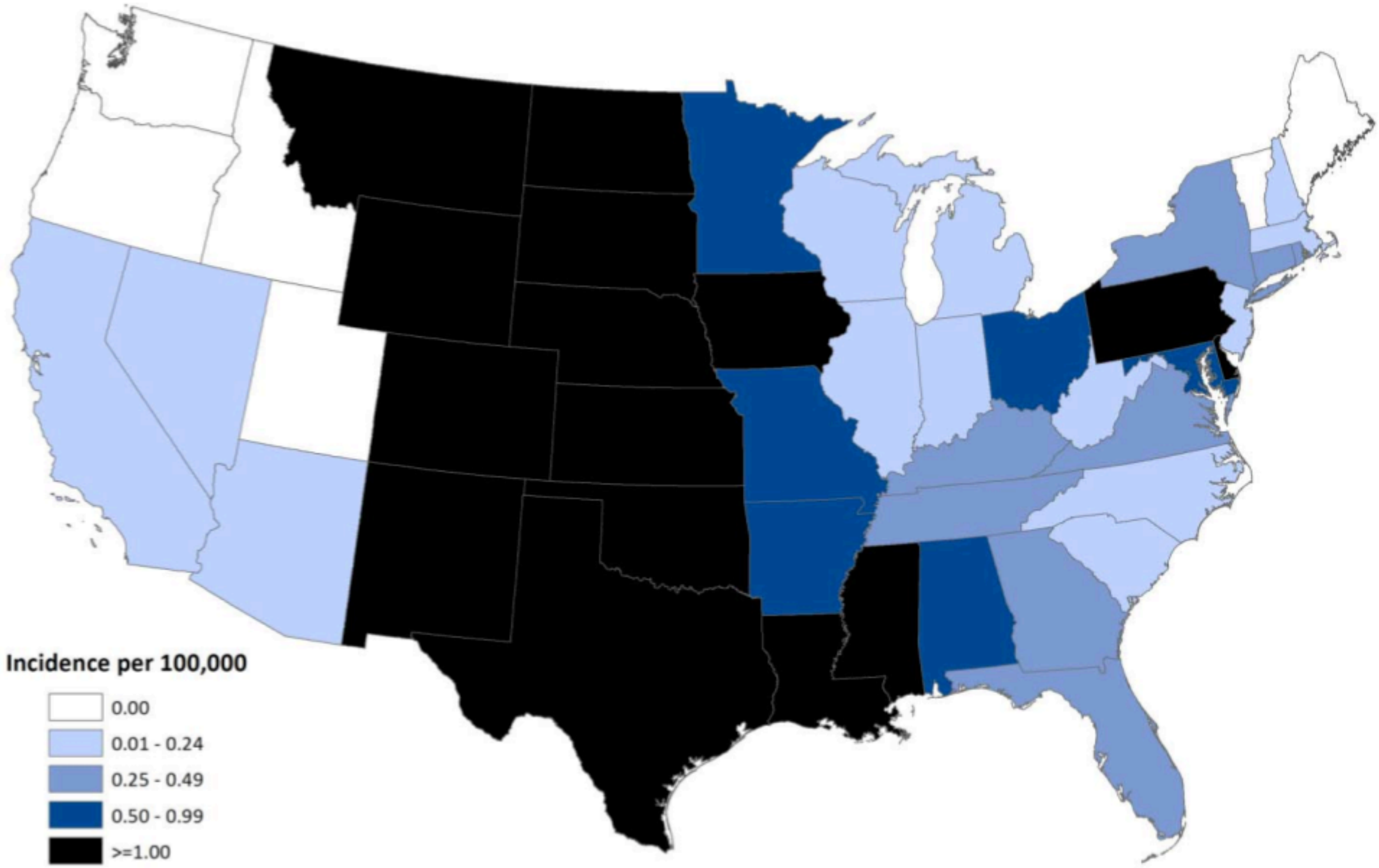
West Nile virus neuroinvasive disease incidence reported to ArboNET, by state, United States, 2001



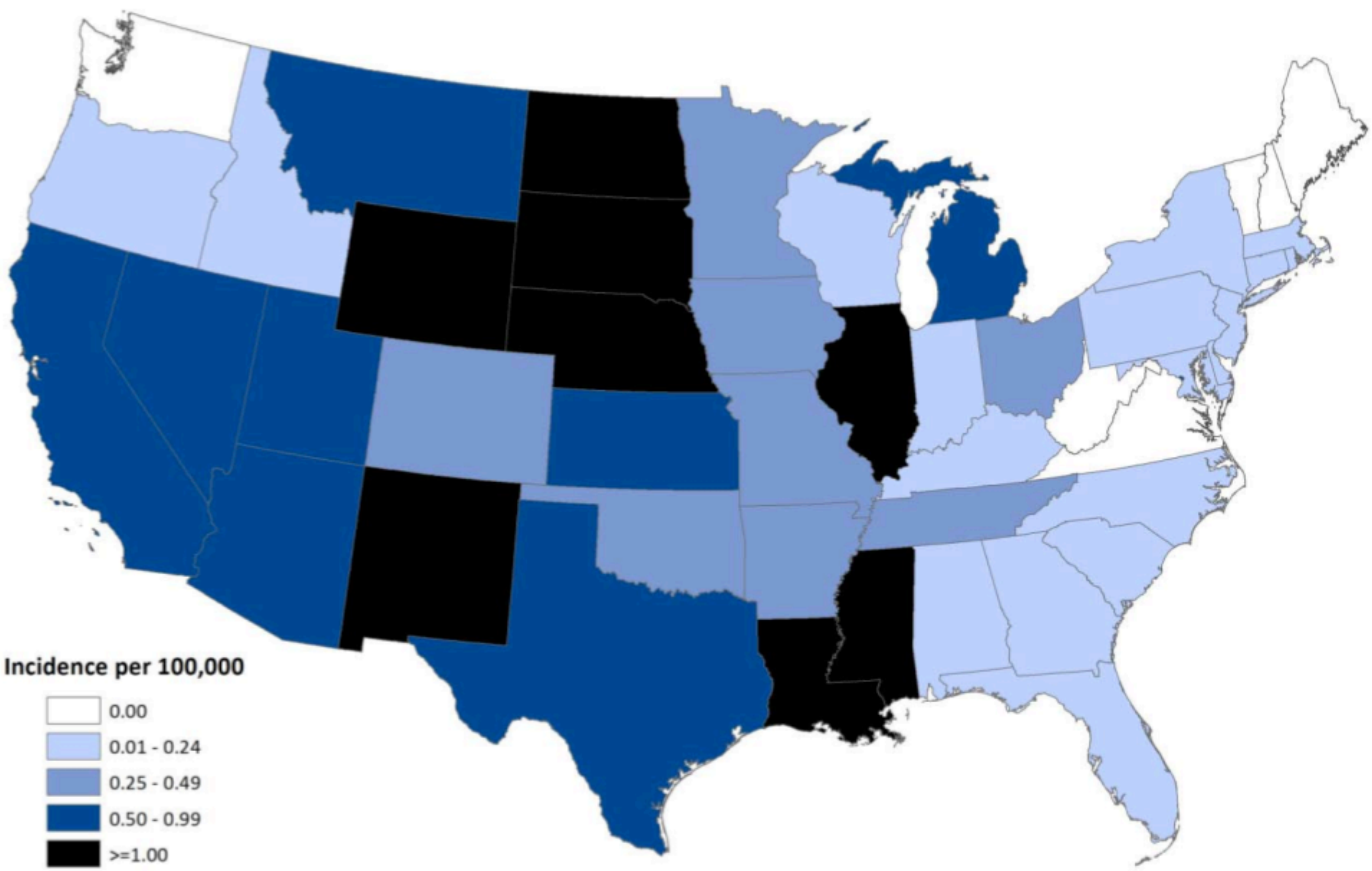
Incidence per 100,000

- 0.00
- 0.01 - 0.24
- 0.25 - 0.49
- 0.50 - 0.99
- >=1.00

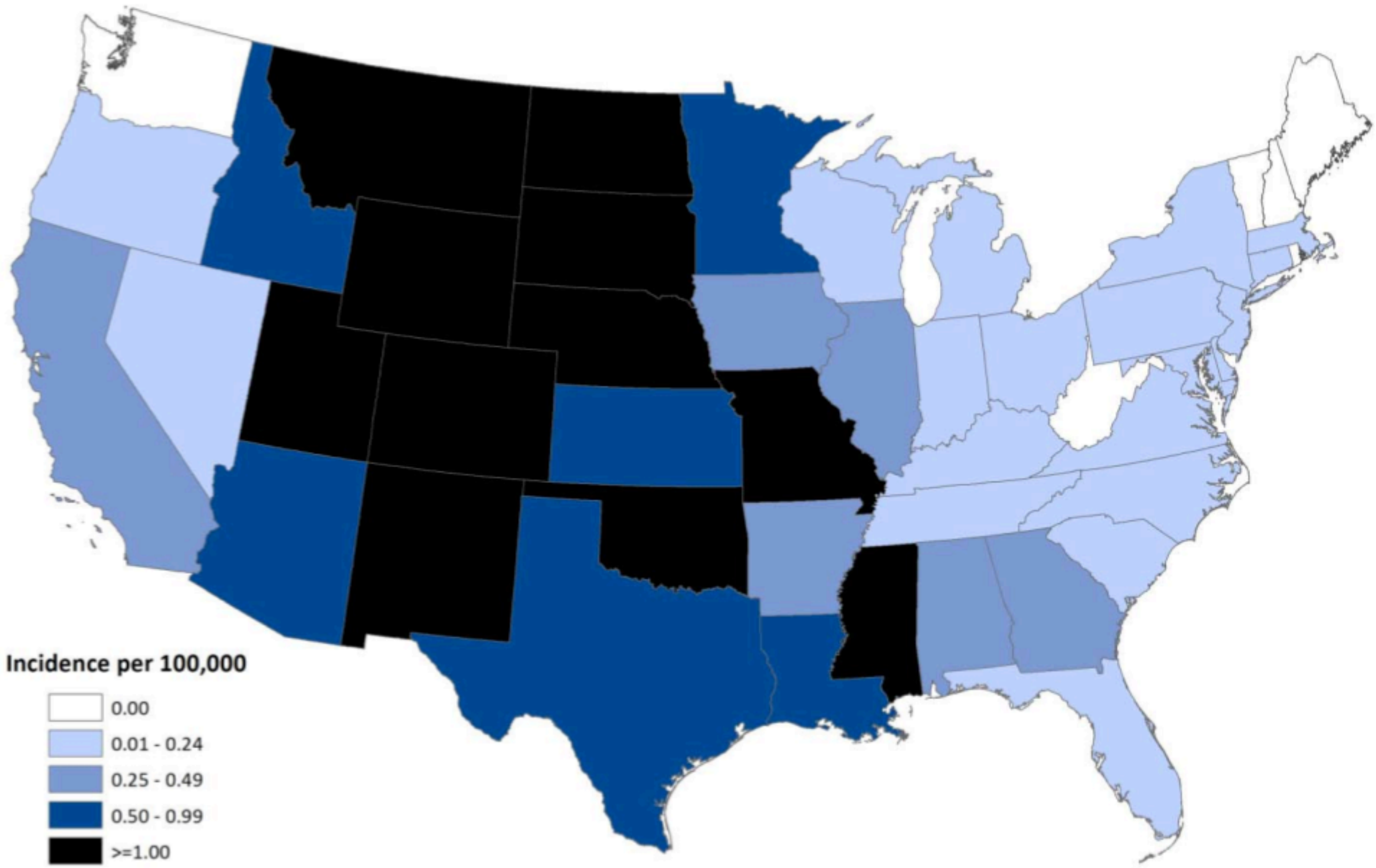
West Nile virus neuroinvasive disease incidence reported to ArboNET, by state, United States, 2003



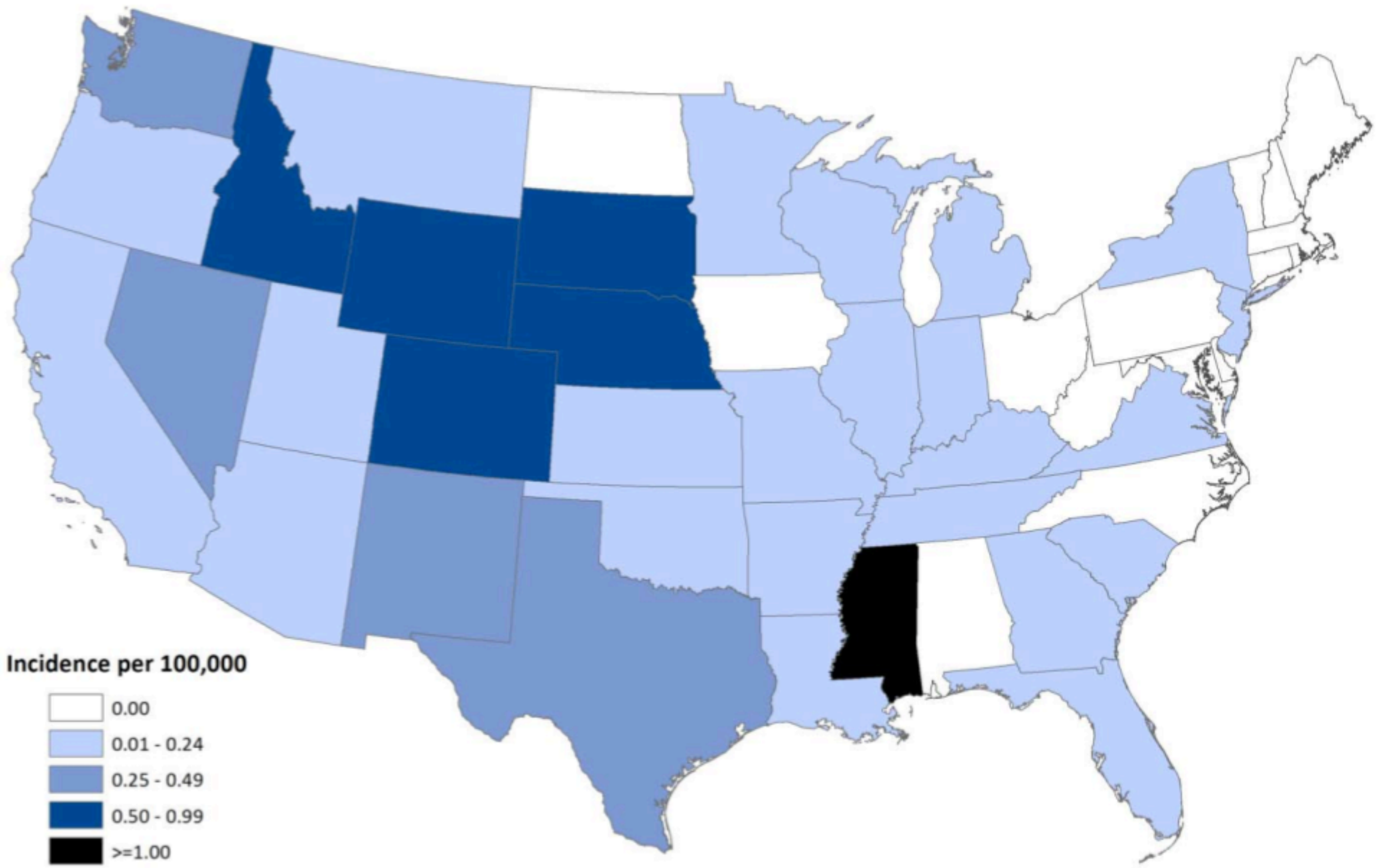
West Nile virus neuroinvasive disease incidence reported to ArboNET, by state, United States, 2005



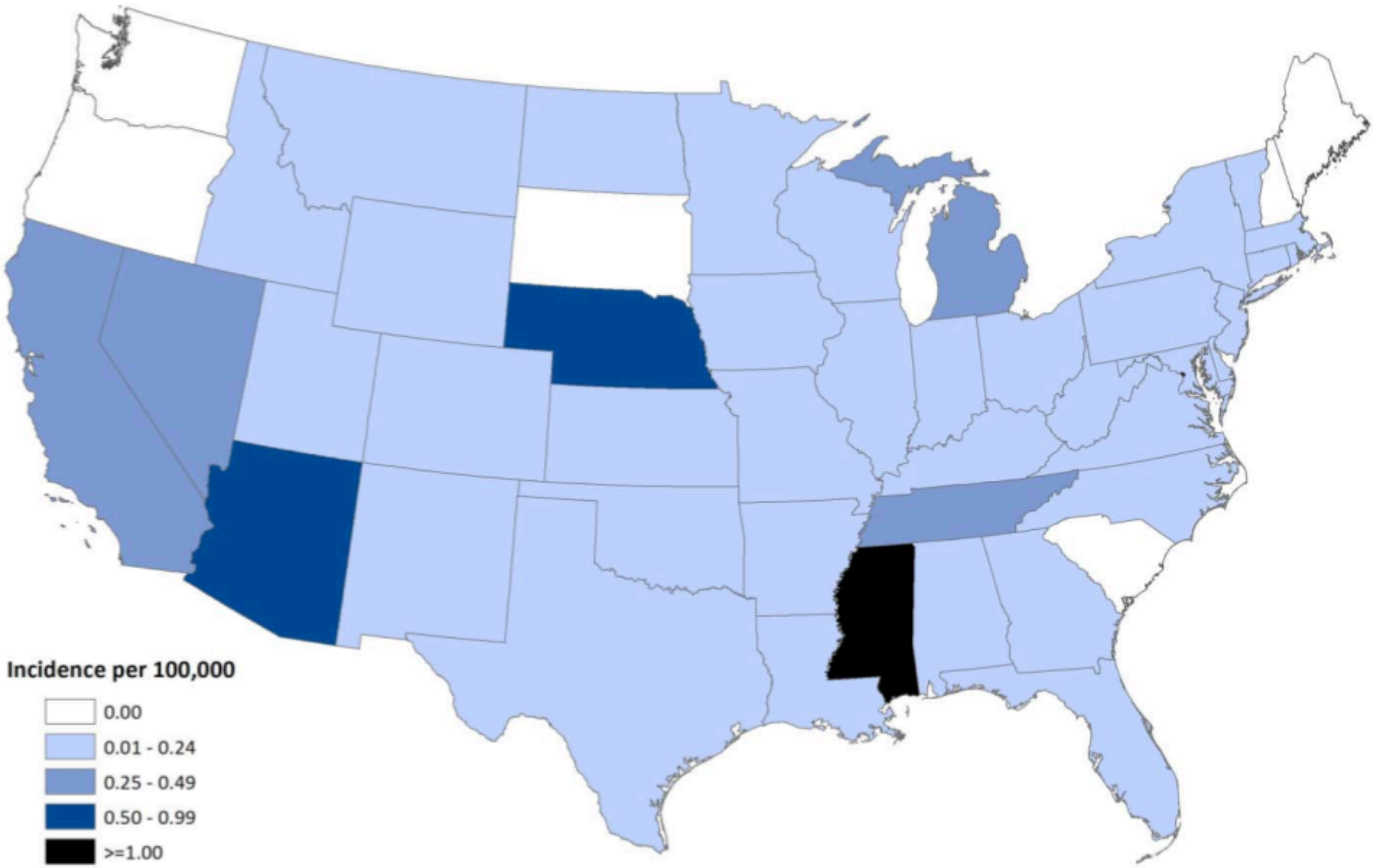
West Nile virus neuroinvasive disease incidence reported to ArboNET, by state, United States, 2007



West Nile virus neuroinvasive disease incidence reported to ArboNET, by state, United States, 2009



West Nile virus neuroinvasive disease incidence reported to ArboNET, by state, United States, 2011



West Nile virus neuroinvasive disease incidence reported to ArboNET, by state, United States, 2012