Climate Change and Zoonoses: Overview (Audio Transcription)

1. (a/v) Welcome to the Climate Change and Zoonoses Overview. I am providing this summary to you in my capacity as a Professor at the Department of Epidemiology and Biostatistics in the University at Albany’s School of Public Health. However, my work is also informed by my 33 years as an epidemiologist and public health veterinarian with the New York and New Mexico departments of health, and the Centers for Disease Control and Prevention as an Epidemic Intelligence Service Officer. As we get ready to move into the presentation, I’m letting you know that I will use audio only for most of the rest of these slides so you can focus on the slide content.

2. The primary objective for this slide set is to provide a short overview of zoonotic diseases, climate change, and the potential impact of climate change on health.
   • This includes humans and non-human animals. Unlike the common perception that humans are not animals, we actually are part of the animal kingdom! In public health, and in life, we tend to be human-focused, so much of the work related to climate change and health emphasizes human health. However, non-human animals will be briefly mentioned in this overview, even though there has been much less research on how they will be impacted by climate change. More information specific to non-human animals will be provided in a separate slide set.
   • Despite the perception in some circles that there is insufficient evidence to draw any conclusions about climate change and health, there is actually a huge body of evidence on this topic. It will be impossible for me to present it all, particularly in this one slide set.
   • This presentation will provide only an overview and introduction to the topic. In this overview, we will briefly define zoonotic diseases, climate change, the potential impact of climate change on human and non-human animal health, including zoonotic diseases, the types of vulnerable populations we’re concerned about, and then some ways to address these risks through the One Health approach, mitigation, and adaptation.
   • I will not provide detailed summaries related to particular types of diseases and populations in this presentation, but instead will have separate slide sets on specific types of diseases.
   • Scientific studies published in peer-reviewed journals must be the bedrock for any conclusions. Using search engines like PubMed and others is highly recommended to see those articles. However, the full text of a journal article often is not available unless working with a library that can order it for you. So I will primarily provide information and sources in the slide notes that are readily accessible to everyone. These will be websites that provide summaries based on the original journal articles. I have deliberately chosen a wide variety of websites so you can become familiar with different places to get information on the topic.
   • Some of those key sources are listed in the final slides of the presentation, but many of them are under each slide in the slide notes. Thus I highly recommend after reviewing these slides that you download the separate pdf version, which includes the slide notes.

3. Let’s begin with a very brief introduction to Zoonoses, or Zoonotic Diseases.
   • Slightly different definitions are used for zoonoses at different times, depending on how broad or narrowly we wish to define the term. But all the definitions include at their core the infectious diseases which are transmitted from animals to people.
   • This transmission can be direct, such as rabies from the bite of an infected animal.
• Many zoonotic diseases are spread by vectors. The term ‘vector’ also can have a broad
definition to include anything, including objects, that serves as a source of exposure to
the disease organism. But most often when we talk about disease vectors, we’re talking
about mosquitoes, ticks, fleas, and flies. On the slide we have a photo of the infamous
_Aedes aegyptii_ mosquito implicated in transmission of Zika virus.
• Spread can also occur if the environment is contaminated. For example, animals can shed
_Salmonella_ bacteria into soil or water, and people or other animals can then breathe in or
swallow the bacteria.
• Please note this second primary bullet, which indicates that zoonotic diseases can spread
from people to non-human animals. These diseases are called reverse zoonoses, or
anthroponoses, meaning from people. You may have heard of MRSA, which stands for
methicillin resistant _Staph aureus_. This is a very dangerous human form of _Staph_
infection, and we are increasingly seeing cases where people have spread it to their pets
or horses.
• Related to the final primary bullet: It’s important to understand that zoonoses include an
extremely broad group of diseases, due to infection from every known type of pathogen.
This includes viruses, bacteria, parasitic organisms and prions. Again, we won’t in this
presentation get into any of those in detail, but will describe them more fully in
subsequent presentations.

4. Why should we care about zoonoses?
• There are a number of very important reasons. First, as I implied at the end of the last
slide, there are literally thousands of different zoonotic diseases world-wide, which are
impacting diverse human and non-human animal populations.
• Most importantly, almost all of the most dangerous potential bioterrorism disease agents
are zoonotic. The government has three different categories of disease agents depending
on their level of risk for BT disruption. The primary disease organism on the list which is
_not_ zoonotic is smallpox, but the others can be transmitted to people from animals, or the
organisms can be taken from the animal, environment, or a lab and manufactured for
direct human transmission. An important example is anthrax, as illustrated by this note
that was sent on Sept. 11, 2001 with anthrax in envelopes, shortly after the World Trade
Center was demolished. Subsequent investigation eventually implicated a prominent
American lab scientist who was pretending to be an Islamic terrorist.
• The final reason we should care about zoonotic diseases is that they represent
approximately three-quarters of the emerging pathogens. These are disease organisms
that are newly discovered or are popping up in new areas of the world.

5. This slide provides a map showing some of these emerging or re-emerging infections.
• The spiky colored circles represent where these diseases first appeared. The colors on this
map are a bit confusing because the colors on the printed names of the disease don’t
match the colors of the spiky circles those names are associated with. So disregard the
colors of the names, and focus instead on the colors of the circles in classifying these
emerging diseases.
• The yellow circles represent arthropod borne diseases. Arthropods are insects and ticks.
Viruses spread by arthropods are called arboviruses. Examples of arboviruses on this
slide include West Nile virus that suddenly appeared in the New York area in 1999,
related to mosquito transmission. DHF is an abbreviation for Dengue Hemorrhagic Fever
which is also spread by mosquitoes throughout much of the world. VEE is an
abbreviation for Venezuelan Equine Encephalitis, which is a mosquito-borne infection of the brain in horses and people. An example of an arboviral brain infection spread by ticks rather than mosquitoes is TBE or tick-borne encephalitis, here shown in Japan but also present in other parts of the world.

- The red circles represent rodent-borne diseases. Examples include the Sin nombre hantavirus first discovered in New Mexico in 1993, related to mouse transmission.
- I was working for the state health departments during the U.S. discoveries of hantavirus in New Mexico and West Nile virus in New York, so I can attest to how exciting and rewarding state health department work can be.
- The purple circles represent other vectors including bats, which have been implicated as potential sources of many new diseases including Ebola virus first in Africa, Nipah virus in Southeast Asia, and Hendra virus in Australia.

6. There are several terms which are used to refer to the animals which have these diseases and then ultimately transmit them to humans.
- Two terms you will see most often are “reservoir” and “host”. These terms can be used in many ways, including issues unrelated to zoonotic diseases.
- But in general, for zoonotic diseases the animal reservoir is a population of animals where the disease organism is permanently maintained, and from which the infection can be transmitted to other populations. Depending on the complexity of the disease, there can be more than one type of animal reservoir.
- Ultimately to eliminate risk of transmission to people, the disease control must be directed at the reservoir. Certainly methods can be taken to interrupt transmission. But until the disease is eliminated from the reservoir or host species, the disease will remain a risk. That makes zoonotic diseases much more challenging to control, compared to diseases that are person-to-person only.

7. This diagram from the CDC illustrates the chain of infection broadly.
- As we can see on the left, there can be human, non-human animal, or environmental reservoirs harboring the disease agent, and then capable of transmitting it to people or other animals.
- The middle part of the diagram shows the different transmission methods, including direct contact, vectors, vehicles like contaminated food products, and airborne or droplet spread.
- Finally the chain of infection requires a susceptible host, either human or non-human animal, and various portals of entry for the organism. Portals of entry can include the eyes, nose, mouth, skin, injection through the skin (including bites for rabies), or sexual contact.

8. (a/v) That concludes the extremely brief overview of zoonotic diseases. As I indicated earlier, I will have separate slide sets that will delve into some of these diseases more fully. For this initial overview related to climate change and zoonoses, let’s switch gears now and provide a short summary of climate change. These photos illustrate some of the major factors which are changing, including heat, mosquitoes in new areas, hurricanes, and extreme weather like flooding.

9. Here are two terms that are important to learn. Climate change is the broader concept, referring to any significant changes in climate lasting for an extended period of time. Global warming is a component of climate change, and refers to rising temperatures. There’s a lot
more we could say about these topics, so please download the pdf at the end and look at the references.

10. What are the causes of climate change? These fall into three categories.

- The overwhelming consensus of scientific evidence indicates that the current climate changes are anthropogenic or human caused. These changes are linked to what we have been doing since the Industrial Revolution, by burning fossil fuels for power, leading to greenhouse gases.
- However, over the history of the planet, there have been climate changes caused by natural internal processes of the earth, including air and sea interactions.
- There also have been what’s called external forcing influences, including solar flares and other influences around the planet. Volcanic eruptions are included in this category, although they could also be viewed as a natural internal process.

11. This diagram summarizes what’s happening with greenhouse gases. Multiple human activities can release certain gases into the atmosphere. These activities include using gasoline or oil in our homes, vehicles, and powerplants. When these gases build up in the atmosphere, they become like a greenhouse that we would build out of glass or plastic, to keep in the heat in the winter for the plants we’re trying to grow when it’s too cold outside. The atmosphere with the greenhouse gases acts like a greenhouse or blanket, keeping radiation in instead of escaping. That warms the earth, both land and sea.

12. This figure shows how the concentrations of greenhouse gases have increased from the year 0 (the time of Christ) to now. You may wonder how they know what the greenhouse gas concentrations were in early time, but they’re able to check them in the lab from core ice samples, where they drill down into layers put down thousands of years ago. The three greenhouse gases diagrammed here are carbon dioxide, methane, and nitrous oxide. We can see that all three take a big jump around the time of the Industrial Revolution in the late 1800s.

13. This slide focuses on the rise of the greenhouse gases just since 1970. What’s particularly alarming is that the rate of increase is changing. On average the greenhouse gases were increasing 1.3% per year between 1970 and 2000. In the next decade from 2000 to 2010, the rate of increase became greater, averaging 2.2% per year. These observed increases are then used to make projections or predictions about the future. It can be challenging to make predictions for the future, so usually various scenarios making different assumptions are used. There can be a best case and worst case scenario, depending on any changes we might make and other factors.

14. The effects of this current and potential future increase in greenhouse gases can be tracked with a number of different indicators. Some indicators for tracking can be increasing, and others can be decreasing. This slide provides a summary of the indicators that are increasing in a warming world.

- In the upper left corner, there are 7 different data sets graphed, which have remarkable consistency. We can see how the average world air temperature is dramatically increasing in recent years, as measured near the surface in the lowest atmospheric level, the troposphere.
- Below that, 3 sets of data are graphed, and we can see how the specific humidity is increasing overall across the world. In any of these graphs, and particularly the humidity one, we can see that year to year, there can be increases and decreases. However, what’s more important is the overall trend that appears to be indicating a fundamental change.
In the bottom left corner, 7 sets of data are graphed showing an increase in ocean heat content.

In the upper right corner, 6 sets of data are graphed showing an average sea level rise worldwide.

Below that is a graph of 6 sets of data showing that, since about 1900, the sea surface temperature has been increasing.

Under that graph is a similar graph of 5 sets of data showing how the air temperature over the oceans has been increasing.

And finally in the bottom right corner, there are 4 sets of data graphed showing specifically the increases in air temperatures over just the land surfaces.

15. This map summarizes some of the climate trends we’re seeing in the U.S. One of the take-home messages from this map is that climate change affects different areas differently. Some areas will be impacted more than others, and the impacts can be very diverse. This is an illustrative diagram as opposed to an actual map. So the map highlights areas that are particularly experiencing these trends, but these impacts could occur in other parts of the country, and of course the world.

- A big change for the west where I come from are the heat waves. In Tucson Arizona where I grew up, there were be a couple of days per year where the temperature was over 100 degrees. Now there can be week after week of temperatures that high, starting in the spring.
- Drought is another big change. The main river that used to flow by downtown Tucson for hundreds of years permanently disappeared during my lifetime.
- Wildfires did occur but were infrequent. Now, in many summers people in the west are having to evacuate their homes not only from fire threat, but also because the smoke and poor air quality leads to high risks for those with respiratory problems such as asthma.
- Towns like Charleston South Carolina and Miami Florida now have sea water in some neighborhoods and yards with some of the incoming tides.
- The Northeast has been particularly hard hit with extreme precipitation associated with storms like Hurricane Irene, Tropical Storm Lee, and Hurricane Sandy.

16. Let’s start to look at some of these climate change impacts one at a time. The major impacts are all listed here. They include increased temperatures, changes in precipitation, extreme weather events, and increased sea level. We’ll highlight each one individually, and start with increased temperatures.

17. The different colored lines on this graph represent different data sets, but each shows how the temperature, averaged across the entire globe including air and sea surface, has been increasing since 1850. As we can see, this average goes up and down from year to year, but particularly since about 1960 the average has been increasing dramatically. Based on the greenhouse gas information, the conclusion is that humans are likely the dominant cause of this warming that we are observing since the mid-20th century.

18. This world map shows how it is still theoretically possible for us to make a difference in this warming trend. The slide introduces the term ‘mitigation’ which means reducing greenhouse gas emissions to prevent warming.

- The colored line under the two world maps is a temperature gauge, starting on the left with the purple area where the average temperature would decrease on average 2 degrees centigrade when comparing the 1986-2005 period with the 2081-2100 period.
• The right side of the colored line is red corresponding to an average 11 degrees centigrade increase in temperature between those two time periods.

• As you can see in both maps, it doesn’t look like there’s any chance of the earth cooling at all during that time period. However, the left map shows a smaller rise in average temperatures, anywhere from 0 to 3 degrees Centigrade, if we can start substantial mitigation to reduce greenhouse gases.

• The right map illustrates the anticipated temperature increases without any additional mitigation, and that’s when you see really extreme temperature increases.

19. Now we will talk about changes in precipitation, which could be increased in some areas and decreased in others. There can be impacts and health problems related both to an increase in precipitation and a decrease in precipitation, depending on how extreme they are.

20. This map shows the estimated change in yearly precipitation between now (2016) and 2080.

• The blue areas are predicted to have increases in precipitation up to 5 cm for the southwest.

• The dark brown areas may have 25 centimeters of reduced precipitation. This will influence risk of wildfires, which last summer were particularly intense in the northwest states of Montana, Idaho, Washington, Oregon, and down into California.

21. The issue of heavy downpours is somewhat separate from the average precipitation levels. Heavy downpours refers to the number of extreme precipitation events. As we can see in this map, our northeast area is experiencing the largest percentage increase in heavy downpours between 1958 and 2011, at 74% increase.

22. Now we’ll focus on some of these extreme weather events more, and I’ve added wildfires to the list.

• Not only do we need to worry about the average temperature increasing as we’ve previously discussed, but a major concern for health are the specific times when there is a spike in temperature from a heat wave. Heat waves are even more deadly than an overall average increase in temperature, because our bodies have not had a chance to adapt to the changed temperature.

• We previously mentioned overall changes in precipitation, including reduced precipitation. These reductions can become so extreme as to result in drought. These droughts can have major health impacts if people and other animals are no longer able to live in certain geographic areas. There’s also evidence that drought leads to more concentration of people, wildlife and vectors around the limited water supplies, which is conducive to the spread of disease. In 2011, the heat and drought in Texas and Oklahoma contributed to more than $10 billion in direct losses to agriculture alone. Shortages in food supplies is one indirect health impact of climate change.

• Extreme storms also appear to be linked to climate change. On many measures, the Atlantic hurricane activity has become more serious since the early 1980s. These include measures of intensity, frequency, and duration, as well as the number of the strongest (Category 4 and 5) storms.

• Finally for wildfires, of the 10 years with the largest acreage burned in the U.S., nine have occurred since 2000. This period coincides with many of the warmest years on record nationwide.

23. This map shows some of the extreme weather events that occurred around the world in 2014. Some were believed linked to climate change, and others were concluded to be unrelated
• In the United States, the overall probability of California wildfires has increased due to climate change. Hawaii had unusual tropical cyclones.
• The southeastern Canadian plains experienced heavy rains and flooding related to climate change and land use patterns.
• In South America, Argentina had a heat wave at the end of 2013 and early 2014, which was concluded to be five times more likely because of human-induced climate change.
• In Europe, record annual mean warmth was concluded to be related to climate change, as was the extreme rainfall in southern France.
• The drought in East Africa was made more severe because of climate change.
• Extreme heat events in Korea and China were linked to climate change.
• Devastating floods such as those that occurred in Jakarta in 2014 are becoming more likely due to climate change.
• Meteorologic conditions associated with an extreme Himalayan snowstorm have increased related to climate change.
• The New York State Department of Health and multiple other agencies were fortunate to receive funding for studies in 2014 and 2015 of the impact of Hurricane Sandy which occurred in 2012. Those federally-funded studies were designed specifically to document health impacts from weather-related disasters like Hurricane Sandy, including lessons learned to increase resiliency in the future. The link to a special journal issue publication for some of these research studies is provided in the notes for this slide.

24. Finally, let’s look at increased sea level due to melting of snow and ice. Most of us are aware that polar bears have less sea ice that they use for hunting. But the impact is much broader than that.
• Winter ice coverage has decreased by 63% in the Great Lakes since the 1970s.
• One reason for even higher temperature increases near the North and South Poles is that a vicious cycle is established. As more ice melts, the dark water absorbs more heat from the sun than white reflective ice, leading to more warming.
• Humans who have based their winter transportation on reliable fresh water and ocean ice cover can become more isolated from civilization and resources. There have been deaths from people trying to cross previously frozen bodies of water that no longer are consistently strong enough for people or vehicles.

25. These 3 graphs show indicators that are decreasing in a warming world, as represented by the large black arrows facing down.
• As you can see, the snow cover in the Northern Hemisphere for March and April has been slowly decreasing, particularly in the last 2 decades.
• Dramatic decreases have also been seen for glacier mass and the extent of the Arctic sea ice in September.

26. This photo compares the size of an Alaska glacier between 1941 on the left and 2004 on the right. Think about this difference multiplied by all the glaciers around the world that are draining into the ocean. All that melted ice needs to go somewhere, and it contributes to rising sea levels. The temperature changes are even more extreme closer to the North and South Poles, which makes glacier melting even worse.

27. One of the biggest worries about rising sea levels is the melting of the Antarctic ice, because there is so much of it.
In this series of maps, we see the blue ice pack over the land surface in the upper left corner, and the ice pack remains stable without melting if we could stop greenhouse gas emissions.

Moving to the right, if we could leave 95% of the fossil fuels underground, unburned, and keep the average temperature increase under 2 degrees Centigrade, then there would be some melting of ice and exposing the underground continent, but you can see it’s limited to smaller areas. If we leave 90% of the fossil fuel underground, then more ice melts.

We can continue in the next row of maps, seeing that if we burn all the remaining fossil fuels, almost all of the Antarctic ice cap would melt.

28. There are a number of good sites you can use to look at how various parts of the world would be submerged depending on sea level rise.

- With decay of just the West Antarctic ice sheet, the sea level is estimated to rise 4-10 feet.
- This particular application, for which the URL is in the slide notes, allows you to adjust the blue bar on the lower left to compare the impact of sea level rise by the number of feet. I used the application for Boston because it is a fairly compact city and we could see the impact of sea level rise more easily.
- To make the potential impact more visible, I set the bar to the maximum estimated rise of 10 feet with decay of the West Antarctic ice sheet. Remember that if there was decay of more of the Antarctic ice sheet, the sea level rise could be even greater than 10 feet.
- The blue color on the map indicates the areas that would be submerged within a 10 foot sea level rise.
- As you can see, most of the main part of Boston and Cambridge, including Logan airport, would be submerged.

29. I mentioned with an earlier slide that the impacts of climate change can be different for different areas. The take-home message is that the risks related to climate change need to be examined at the local level. The local jurisdictions can also determine how to prioritize those risks for adaptation activities, which are those activities which need to be implemented to adapt to climate change, if the mitigation doesn’t work to prevent it. I’ll provide a couple of examples for New York State, where I’m giving this presentation from. This photo illustrates the damage that was associated with Hurricane Sandy that hit the New Jersey and New York coasts in late October, 2012.

30. These maps show how we can see different climate trends even within one state, if it’s a large and geographically diverse one like New York.

- The map in the upper left corner pictures the number of cool nights between 1900 and 2008. Areas along the eastern Hudson Valley and far west had a warming trend as indicated by the red color, when there were fewer cool nights. In contrast, a few areas of the state as indicated by the blue color had a cooling trend with more cool nights.
- Below that map in the lower left corner, the number of warm nights is shown. The pattern is somewhat similar, but not exactly the same. The eastern Hudson Valley again had a warming trend with an increase in the number of warm nights, and other areas had a cooling trend with a decrease in the number of warm nights.
- The right two maps show precipitation trends. In the upper right corner, the darker green areas are those with increased total precipitation on wet days. The yellow or orange areas are drier.
• The bottom right map demonstrates a daily intensity index for precipitation, where the annual total precipitation is divided by the number of wet days in the year. This index indicates a larger area of the state that is becoming dryer.

31. In the previous slides, I’ve provided a very quick overview of climate change and indicators of it. Now we’ll start to look more specifically at the impact of climate change on health. There are many studies and sources of information. But there are two sources listed here that help pull together a lot of information.
• The first is a special report on climate and health in the U.S. which was released in 2016, and is available on the internet.
• The second is a book published in 2015 by Dr. George Luber of the CDC and his coauthor, which is available for purchase.
• These two resources are highly valuable, but there is so much research going on that even these two great resources immediately start to become outdated once they’re published. So it’s important to keep monitoring sites and scientific journals for new information.

32. This diagram from the World Health Organization provides a summary of how climate change can impact human and non-human animal health.
• Starting on the left, climate change can cause human and non-human animal exposures to regional weather changes, including heat waves, extreme weather, temperature, and precipitation. These weather changes can lead directly to health effects, as illustrated by the top red arrow that goes across directly to various health effects.
• Or the climate factors can lead more indirectly to health effects by modulating various intermediate factors. Those intermediate factors can include different contamination pathways, such as the land or water bodies, transmission dynamics for the organism or vector species, changes in agro-ecosystems and hydrology which influence food crops, and socioeconomic and demographic disruptions including the large scale movement of people from areas that are no longer habitable due to sea level rise or drought.
• The final column on the right briefly summarizes the type of health effects that can occur either directly or indirectly through changes in these modulating factors. These health effects include temperature-related illness and death, and extreme weather-related health effects including injuries, drownings, or freezing to death.
• Air-pollution is increased with climate change, which worsens asthma and other respiratory conditions. This also includes increased growth of plants that cause allergies.
• Water- and food-borne diseases can increase as water and food gets more pathogen contamination.
• Vector-borne and rodent-borne diseases can increase as the animal reservoirs spread into new areas, or the climate change increases the multiplication of the organism.
• Food and water shortages can impact the young, old, and medically frail.
• Finally, there are other important health effects including mental health, reduced nutrition, and increased risk of infectious diseases in general. For example, extreme weather can disrupt access to medical care, and even to food sources.

33. In the last slide I briefly mentioned some vulnerable populations. Adaptation to climate change is such a huge task that we need to prioritize those who are most vulnerable. This slide summarizes some of them.
• For humans, we particularly worry about older adults, because of their decreased regulation of body temperature. Older adults can think that they’re coping with hot temperatures, and want to save money by not turning on air conditioning. They also don’t
want to be dependent on others, so they sometimes will not ask for help or leave the familiarity and comfort of their homes to go to cooling centers.

- People with underlying health problems are a vulnerable population, and one example is cardiovascular disease deaths associated with heat waves.
- Pregnancy can lead to vulnerability to heat exposures, with resulting lower birth weights and birth defects.
- Those living in certain geographic locations are vulnerable to extreme weather, like flooding.
- People working in certain occupations, like seasonal farmworkers, are more vulnerable to heat and vector-borne disease exposures.
- In our planning, we tend to be human focused and think just about the human vulnerable populations. However, the emergency weather events like hurricanes have helped us recognize the heavy toll they take on our domestic animals, both pets in the home and horses and livestock in the fields. If we’re not prepared to deal with the impact to these animals, we sometimes risk humans as well who don’t want to leave their animals. Fortunately, big events like Hurricane Katrina helped with the development of County Animal Response Teams (or CARTS), and the deployment of veterinarians to disaster areas. Rules have been modified to allow people to bring some animals to shelters.
- Wildlife are also impacted by a changing climate due to impacts on ecosystems. This has sometimes led to wildlife in closer proximity to humans and domestic animals, leading to spillover of viruses like influenza, Hendra, and Nipa.

34. Let’s provide a brief snapshot of the impact of climate change on zoonoses.

- We’ve been reviewing the climate effects of temperature change, precipitation change, extreme weather events, and increased sea level.
- These various climate effects can impact zoonotic diseases first by increasing the reproduction rate of the disease pathogen. Increased temperatures can shorten the extrinsic incubation period (EIP), which is the time required for the pathogen, the organism causing disease, to multiply between vector feedings. A shortened EIP was demonstrated for Dengue virus in mosquitoes held at warmer temperatures. After introduction of West Nile virus into the western hemisphere in 1999, another variant recognized in Texas 2 years later had a shorter EIP and so came to dominate the U.S by 2003.
- Climate change can alter the habitat of reservoirs and vectors in ways that facilitate maintenance of the disease. For example, ticks that spread Lyme Disease have increased egg hatching success with warmer temperatures. Warmer temperatures support overwintering of mosquitoes which spread West Nile virus.
- Climate change may influence the transmission rate of the pathogen. For example, there is extensive research into the complex effects of diurnal temperature fluctuations on malaria transmission. Diurnal temperature fluctuations refer to the variations between high and low temperatures within a day.
- Climate change can impact movement of the reservoir populations to bring the pathogen to new geographic areas. For example, models indicate that suitable habitat for vampire bats will likely expand in parts of South America, leading to an increased risk of exposure to the vampire bat strain of rabies. There is also concern that global warming will lead to geographic spread of raccoon dogs in northern Europe, which are a competent host of the fox strain of rabies.
• However, the challenge in understanding the impact of climate is that there are other factors which are also influencing these disease risks. For example, there are changes in human land use patterns which can be very important in bringing reservoir populations and uninfected populations closer together, separate from any climate changes. So research is focusing on how all these factors are inter-related, to identify areas for prevention.

35. To summarize this brief overview of climate change and zoonoses, numerous indicators show us that climate change is happening now in our lifetime, and will continue into our children’s lifetime. The only uncertainty is whether worst case scenarios or more optimistic scenarios will occur, and that will depend on human actions as well as the meteorologic changes.

• Climate change is having an impact on public health, including both human and animal health. People who are young, old, ill, or economically or socially marginalized will be particularly impacted. When people can no longer afford to care for their animals, or wildlife ecosystems are impacted, non-human animals will be severely affected. Groups in the western U.S. are already mobilizing to determine the impact on wildfires on wildlife.

• The full impact on individual diseases, including zoonoses, is still being evaluated, and we particularly need to understand the relative contribution of climate versus other factors. The Institute of Medicine in 2008 issued a report about infectious diseases related to global climate change and extreme weather, with the reference provided in the slide notes. This report included climate and weather as one of 13 factors which influence emerging infectious diseases, and climate can influence the other factors as well to amplify its effect.

• Finally, we need to improve our disease surveillance systems to be able to detect new occurrences and act on them quickly. There are a number of systems that seek to pick up and share information about new disease occurrences more quickly. One is ProMed-mail, which is an online system developed by the International Society for Infectious Diseases to share early indicators of disease outbreaks, in hopes of identifying their scope and finding potential sources more quickly. Another is HealthMap, first developed by Boston Children’s Hospital. This is a global mapping system to help identify patterns of disease outbreaks.

• The one health model can be beneficial to better understanding and preparation for climate change health impacts, and we’ll discuss this model more in subsequent slides.

36. The artist for this picture asked the question: When the tiger meets the crocodile—what can we do? His philosophy related to the competitive and even predatory relationship among these species. His answer to the conflict was to learn about our neighbors. This means taking a broad approach which includes other creatures and the environment.

37. Here is a summary of the One Health model. The model says that optimal health involves three components, human, animals, and the environment.

• To address health problems, we need to recognize the role of these components and address each one.

• Thus the One Health model requires a collaborative approach among human health care providers, veterinarians, biologists and others working with animals, and scientists addressing the environment.
• There are a number of groups working with the One Health model, including the American Veterinary Medical Association and the Centers for Disease Control and Prevention.

38. I mentioned mitigation briefly earlier. These are measures to reduce greenhouse gases and the subsequent climate effects. These include actions that we can take as individuals, and within our communities and larger societies. They include:
• More efficient use of energy
• Greater use of low-carbon and no-carbon energy
• Improved carbon sinks to get the carbon out of the atmosphere and back into the earth. Forest management and carbon capture and storage are two aspects of this.
• Finally, lifestyle and behavioral changes are critically important to reduce burning of fossil fuels, increased greenhouse gases, and climate change.

39. Adaptation refers to the type of activities that those of us working in health can do to help our communities adapt to the climate change and health risks. This slide lists just a few of the projects that are underway. There are links to all of these projects in the slide notes which you can download after the presentation.
• Robert Wood Johnson Foundation funding is supporting a number of projects.
• New Jersey is working with their local municipalities on action plans.
• There is a grant program for coastal community resilience in the Gulf Coast area.
• There is help for hospital and medical offices to reduce their environmental footprint and protect patients and health care workers.
• Buenos Aires has been working to curb electricity consumption in public buildings during summer heat waves.
• Connect4Climate has supported the development of global citizen videos related to climate change.
• The last activity of eliminating standing water to reduce mosquito breeding specifically addresses risk of zoonoses like West Nile or Zika virus. More examples will be provided in separate slides when we discuss those specific diseases. This is an example of the type of adaptation activity that we would want to be doing anyways to reduce risk, even without the influence of climate change factors.

40. This slide lists some of the adaptation activities that are underway in New York State.
• We have a central website where many of the local health departments list their cooling centers.
• There is a Climate Smart Communities initiative coordinated by our Dept. of Environmental Conservation, where local jurisdictions can learn about adaptation and incorporate those activities to meet goals.
• We have a number of short courses, webinars, and lectures available online through our state’s Learning Management System.
• These efforts were featured in a spring 2016 NYS success story authored by the American Public Health Association.

41. The Centers for Disease Control and Prevention is funding 18 climate ready states and cities to identify, prioritize, and implement adaptation activities in support of their local communities.
• You can go to the CDC website that will be in the slide notes for the contact information to get in touch with these programs and find out what adaptation activities they have developed.
• Every program is extremely active. The funding is being renewed for five years in 2016, and the emphasis will be on implementation and evaluation of adaptation activities. The diversity of climate and health threats in these areas will allow development of numerous innovative approaches.
• Depending on the federal budget, CDC hopes to extend funding soon to more of these states and key cities.

42. One final aspect to consider when we are choosing mitigation and adaptation activities are their co-benefits and conflicts.

• Co-benefits are the added benefits we get when do mitigation or adaptation activities, above and beyond the direct benefits of a more stable climate. One example is policies to encourage the creation of walkable cities. This is a mitigation activity, because we are reducing the use of fossil fuels and so also reducing greenhouse gas emissions. But having more walkable cities also increases the health benefits from exercise, so this is a co-benefit.
• Conflicts are the trade-offs between climate policy and other objectives, including any negative impacts from switching to more climate friendly options. One example is wind turbines. Their use can reduce greenhouse gases, but depending on where they are sited, they can have negative visual impacts and noise. There have also been some concerns raised about possible health impacts if living close to them.

43. A few of the key publicly available resources are listed in these next two slides.

• This slide emphasizes some of the more science oriented information sources, including the Centers for Disease Control and Prevention, the World Health Organization, and the National Centers for Environmental Information.
• The National Climate Assessment was released in 2014.
• The Intergovernmental Panel on Climate Change and the U.S. Government Accountability Office have many documents.
• New York has information on its state health department website.
• The NYS Department of Environmental Conservation which is the lead agency for coordinating climate change activities within New York State has links to many other groups and activities within New York.

44. This slide emphasizes some of the more education and communication resources.

• These include the American Public Health Association, Climate for Health, the Public Health Institute, the White House, the Climate Action Campaign, 350.org, and Climate Access.

45. (a/v) To wrap up this overview slide set, I’ll mention some academic courses that address these issues.

• This slide set was developed first for a 3 credit fully online class on Zoonoses that I teach at the University at Albany, and the course is open to nonmatriculated students, which are those who enroll just for a single class.
• Our University also offers a new Global climate change class using Dr. Luber’s text book, but it is not online.
• Emory University is where Dr. Luber presents his own class in-person.
• There are probably other institutions featuring this topic that you can check into.
Finally, I’d like to acknowledge the following people who contributed ideas or content to previous versions of these slides.

- Danielle Abraham and Kathy Clancy are two former NYS Dept. of Health staff who have helped us develop slide sets.
- Dr. Asante Shipp Hilts is our current state climate and health project director, and there are numerous others at the NYS Dept. of Health and our School of Public Health working on climate and health issues.
- The students in my Zoonoses course every year develop some great updated summaries of these zoonotic disease risks related to climate change.
- Please download the pdf of this slide set after the talk, particularly to have the references and sources on the slides and within the slide notes.
- I will be working on additional presentations that will focus in more detail on some of these zoonotic diseases and climate change.
- Thank you for the opportunity to share this complex topic with you, and hopefully encourage you to pursue it further.