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**Climate Change
and Zoonotic Diseases: Impacts on
Ecosystems and Human Health. Case
study Rift Valley Fever, South Africa**

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The logo for Cuyahoga County Board of Health (CCBH) is a dark green square with the white text "CCBH" inside.

Definitions

- Zoonosis – zo-o, animal, and nosos (Greek), a disease communicated to **man** from **lower** (order) **animals** (Chambers Twentieth Century Dictionary). Infection or disease transmissible from **animals** to **humans** under **natural** conditions (Merriam-Webster).
- Zoonotic – adjective from zoonosis; disease spread by a **virus** that lives in **non-human animals** in **natural surroundings**, and transmitted to humans, it **will mutate** and spread starting a **chain of infection**.

Problems with Definitions: Basic Concepts + Anthropocene

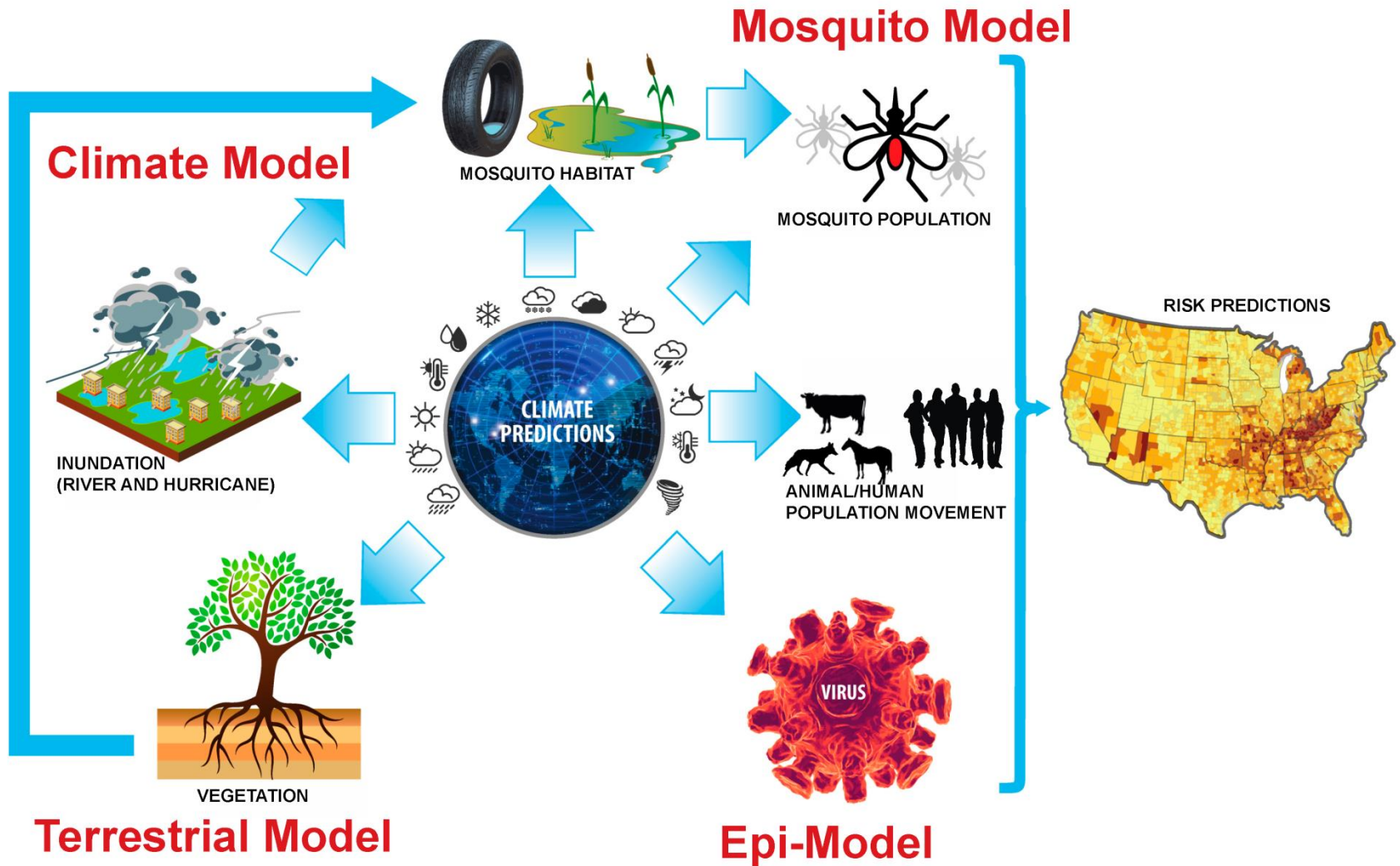
- **Words** profoundly *influence behaviour*.
- **Natural Conditions**: No longer apply in *Post-human* age. Zoonosis is the result of ecosystem destruction and imbalance.
- **Animals** and *humans*. Implying humans are *not* animals, something different, 'higher' than 'mere' animals.
- **Man**: generic use for humanity, *excludes females* who equal 50% of humans.

Zoonosis:

Causes of Increasing Infections

- **High impact diseases** tend to be **zoonotic**, emerge from wildlife; HIV, SARS, COVID-19.
- Zoonotic transfer of pathogens to humans **increasing destruction of natural ecosystems** for global food production, raw materials; timber, mining and urban development.
- E.G.'s: Road construction: Africa; bushmeat, mining. Asia; wetmarkets, Palm oil plantations. Brazil; clearing rain forests, beef production.
- **Increasing humans contact with wild animals**, the **reservoir of novel viruses**.

Climate impacts, Zoonosis, Human Health

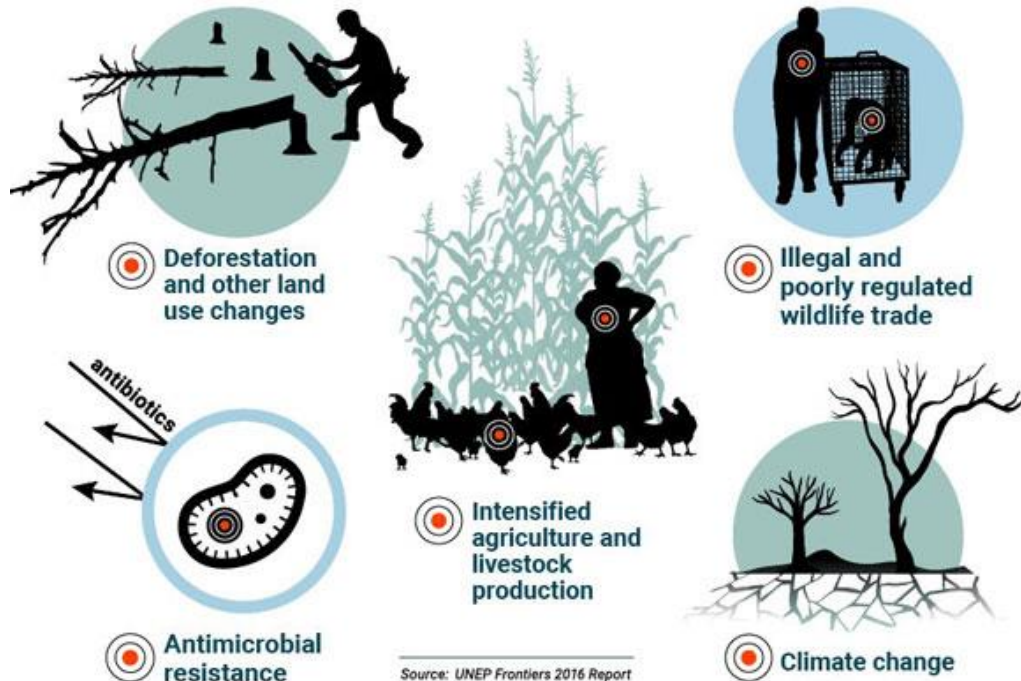


Zoonosis Transfer

- ***Viral transfer*** primarily within 6,495 ***mammals***: wild and domestic herbivours; goats, sheep, cattle, camels, pigs, rats, bats, primates.
- Other ***vertebrate animals***; fish, amphibians, reptiles and birds. Bird flu is an exception.
- Rabies best-known and most feared of all zoonotic diseases – (prior to COVID!). Infections route unknown, but zoonotic transmission from pigs suggested.

Climate Change > Ecosystem + Human Health > Zoonosis

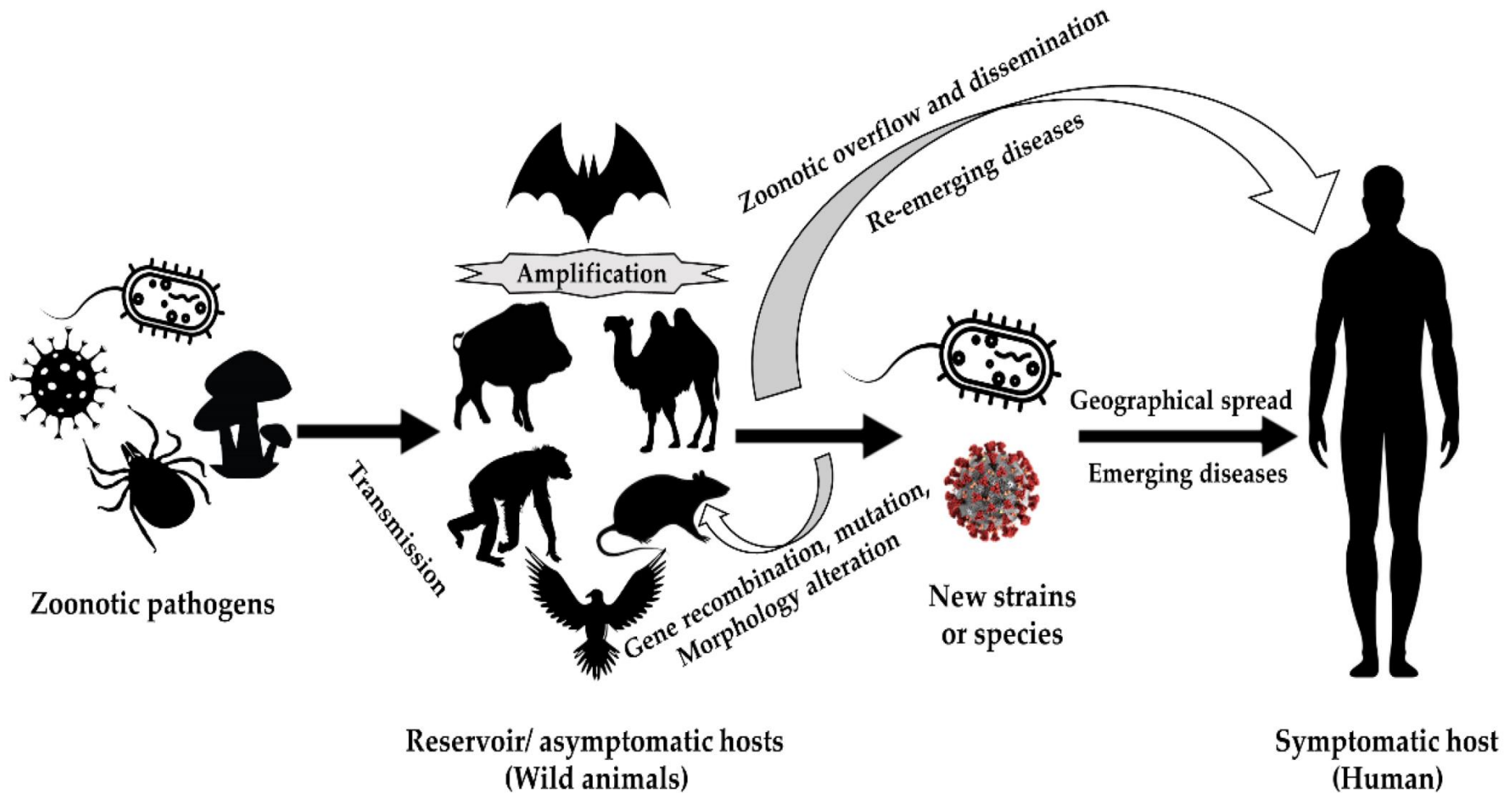
What factors are increasing zoonosis emergence?
(Diseases transmitted from animals to humans)



#COVID19

UN
environment
programme

Zoonotic Disease Transmission



Zoonotic transfer to Human

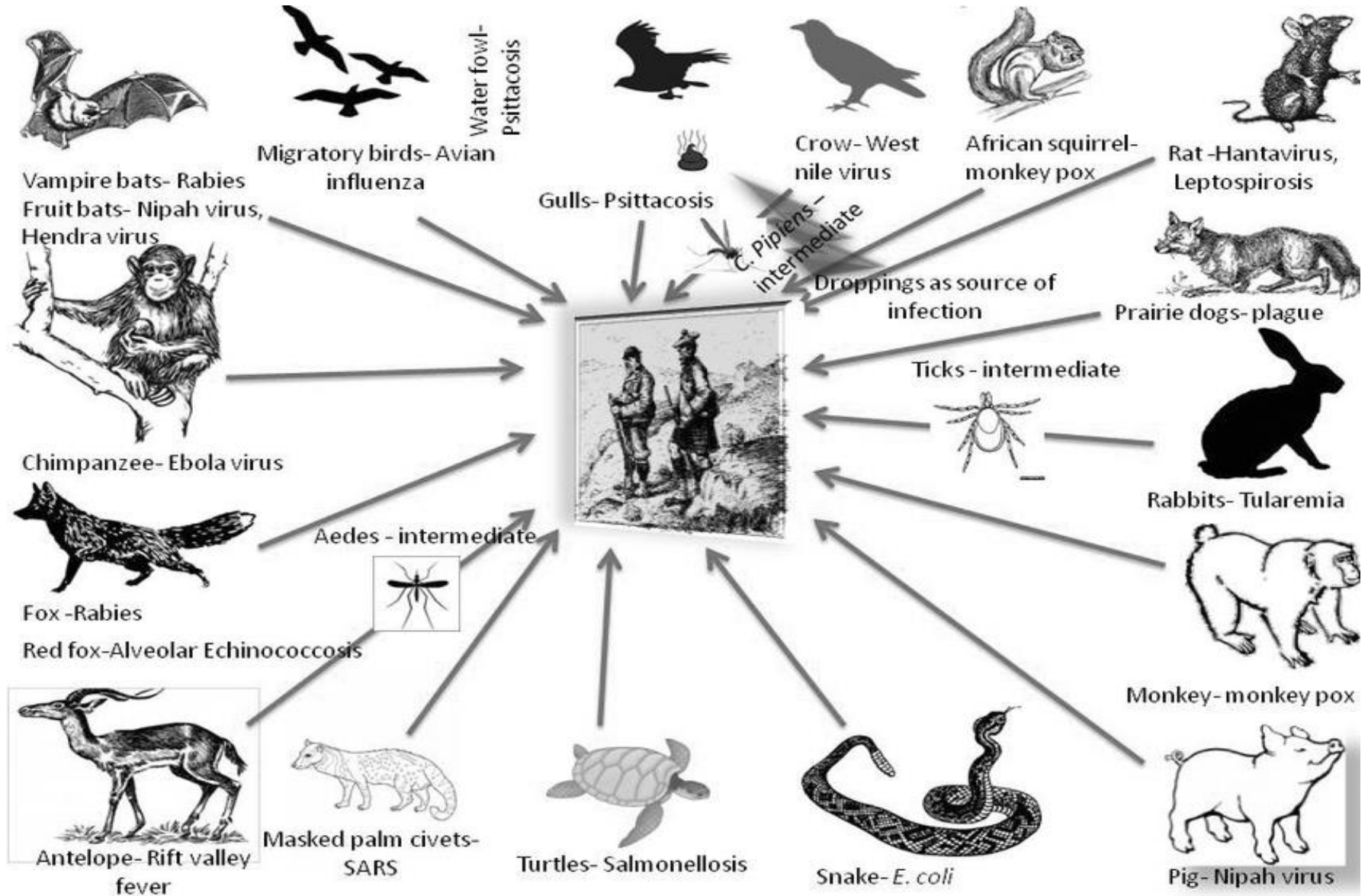


Image: Microsoft Bing, zoonotic disease transmission. Accessed 18th February, 2021

Zoonotic Diseases in the US

Of major national health concern.

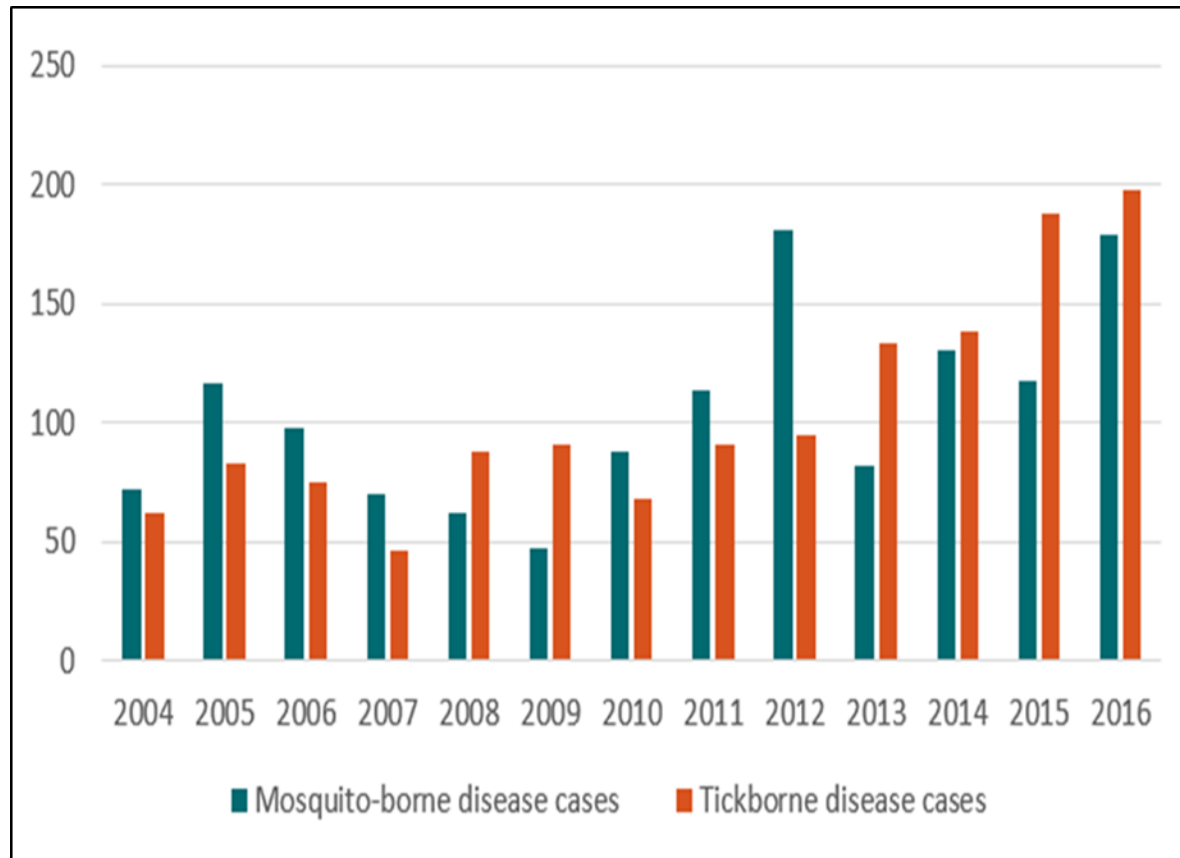
- Vector-borne diseases tripled from 2004 to 2016
- Nine new pathogens introduced since 2004
- US has 14 fourteen vector-borne diseases
- Six are spread by ticks
- Seven by mosquito
- One by fleas – the plague

Examples of tick, mosquito-borne diseases

- Rocky Mountain Spotted Fever (RMSF)
- Lyme disease
- West Nile virus
- malaria
- Zika
- Dengue fever

Ohio and Cuyahoga: Zoonotic Disease Increase

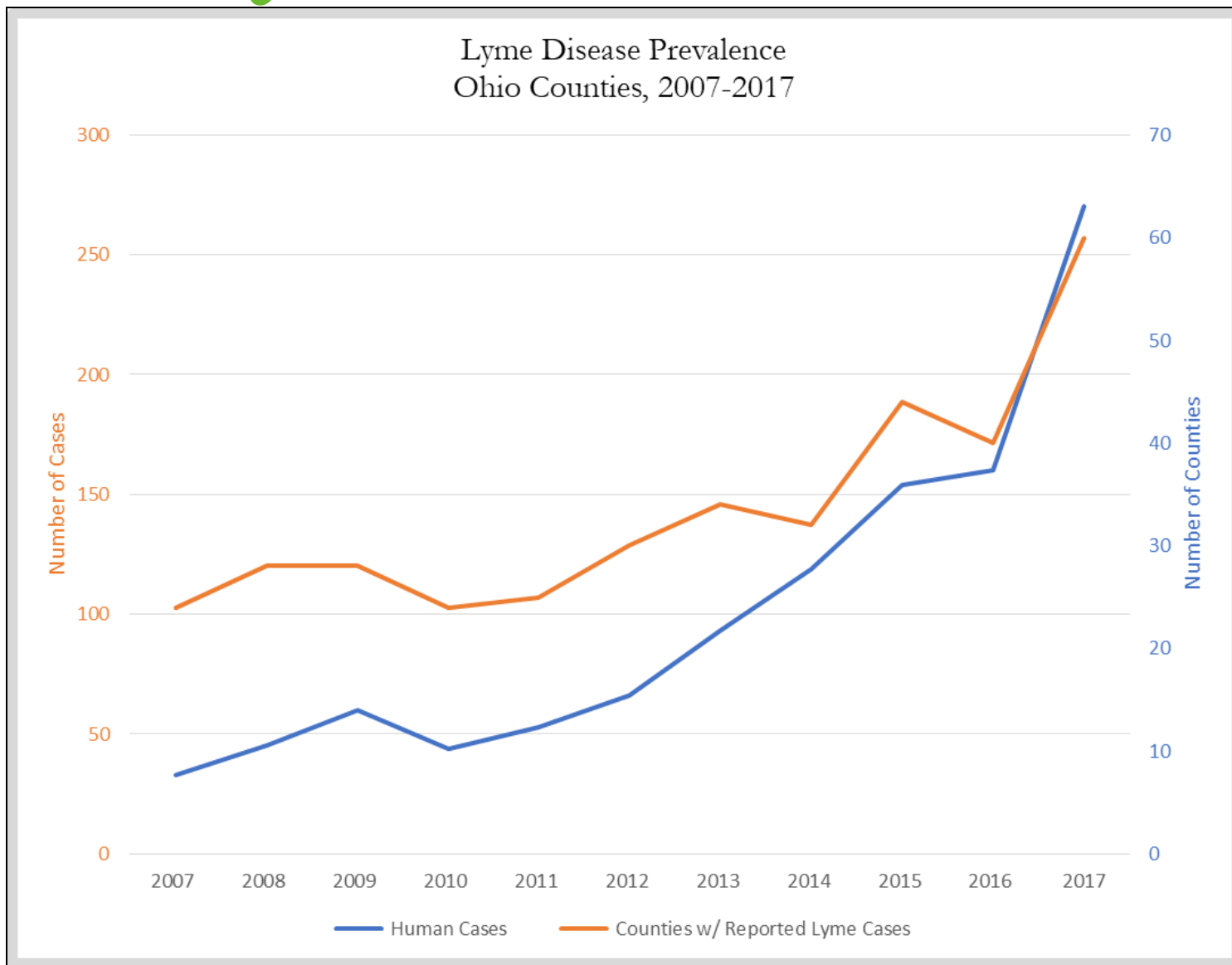
Mosquito-Borne and Tick-Borne Disease Cases in Ohio (2004-2016)



CCBH

About the data: Centers for Disease Control and Prevention. National Notifiable Diseases Surveillance System, Annual Tables of Infectious Disease Data. Atlanta, GA. CDC Division of Health Informatics and Surveillance, 2005-2017.

Lyme Disease



Source: Ohio Department of Health

Climate Change & Zoonosis, link? Rising CO₂

- CO₂: Pre-2000 < 400 ppm. 2020 > 416 ppm
- More heat days - Longer growing seasons
- Fewer freezing days killing invasive, non-indigenous, pathogenic species
- Deforestation and land clearing, decreases natural ecosystems
- Decreases albedo, increases temperature
- Built/urban development creates, novel habitats, increase breeding sites for vectors

Zoonotic Diseases in Ohio

Cuyahoga/Ohio Vector-borne diseases 2017

- Malaria (56), LaCrosse encephalitis (4), Jamestown Canyon (2), Unspecified California (11).

Travel-associated mosquito-borne diseases; Ohio (2018)

- Chikungunya virus – 3
- Dengue Fever – 3 most wide-spread global disease, found in 125 countries.
- Zika – 4
- West Nile Virus – (27 cases)
- Cattle, sheep farming in arid US states possible infection route for **Rift Valley Fever (RVF)** vectors



Zoonosis, A Personal Account: Understanding Rift Valley Fever



Zoonotic Research in South Africa: The Puzzle of Rift Valley Fever

- **Highly complex:** Field Work: vegetation, botany, geology, soils, climatology, weather, rain, mosquito. Laboratory Analysis; virology, veterinary, entomology, epidemiology, sample & data analysis plus curation.
- **Numerous Partners;** Local, National, International.
- **Expensive** > 1 Meg \$ 000's annually.
- **Long-term;** 5 years minimum.
- **Non-scientists:** Farmers, farm labourers, politicians, administrators, interested public, business.
- **Many meetings, workshops and symposia.**
- **Education:** Presentations & pamphlets in suitable language; Afrikaans, Sesotho, Setswana, Tswana.

Partners



The project depicted is sponsored by the U.S. Department of Defense, Defense Threat Reduction Agency. The content of the information does not necessarily reflect the position or the policy of the federal government, and no official endorsement should be inferred.



A One Health Approach: Ecological and Epidemiological Understanding of Rift Valley Fever Virus (RVFV)

RVF remains a mysterious virus.

Confined to Africa and Arabian.

Outbreaks, rarely predicted, sporadic, large, occur in non-human animals.

Close association with heavy rainfall and flooding.

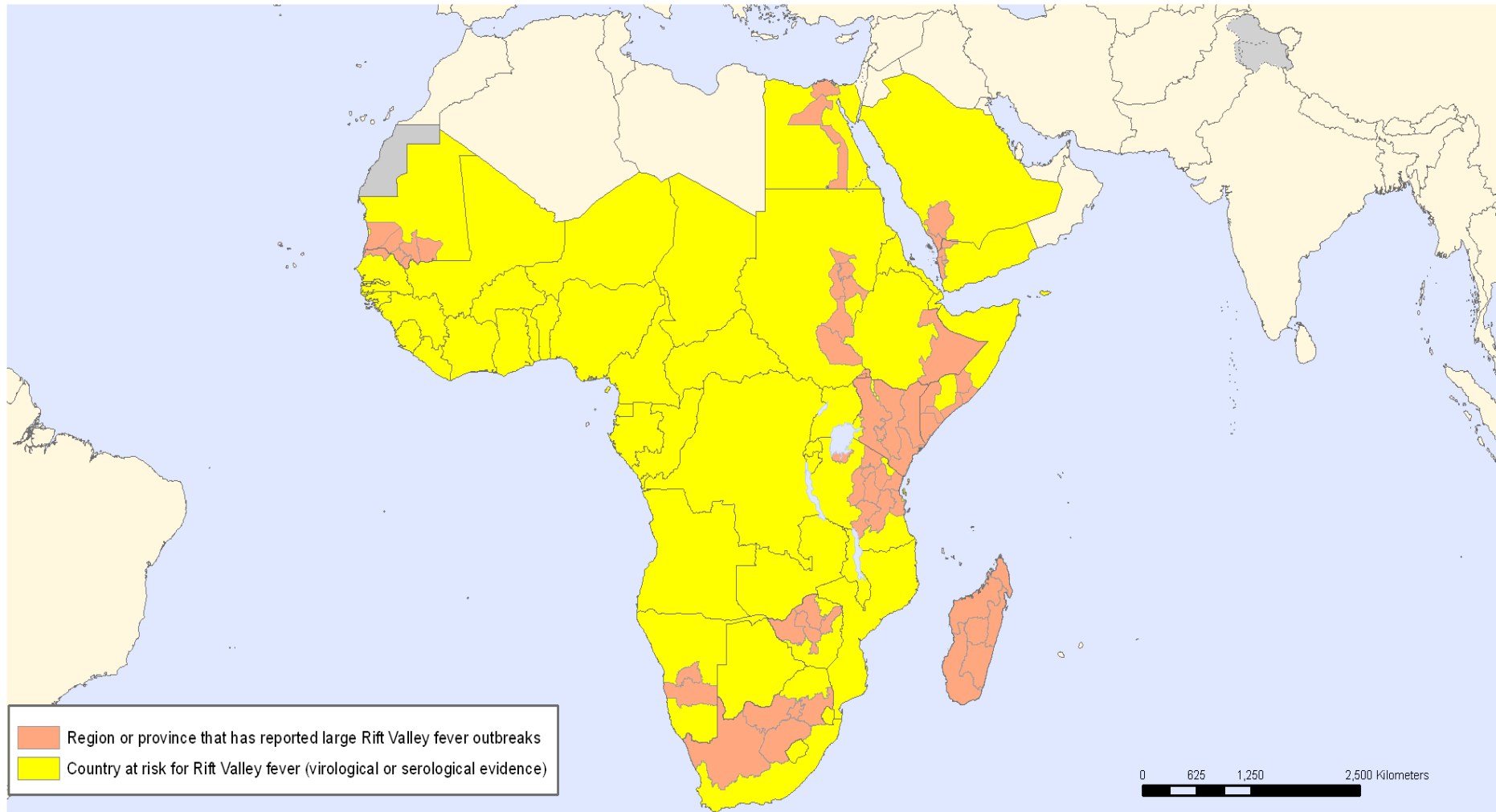
The 2010-2011 outbreak infected 300 human, in close contact with blood or meat from infected sheep and cattle.

Infected 800 cattle, 700 goats, & 16,500 sheep.

Virus infects wild antelope and buffalo but affects are largely unknown.



Geographic distribution of Rift Valley fever outbreaks



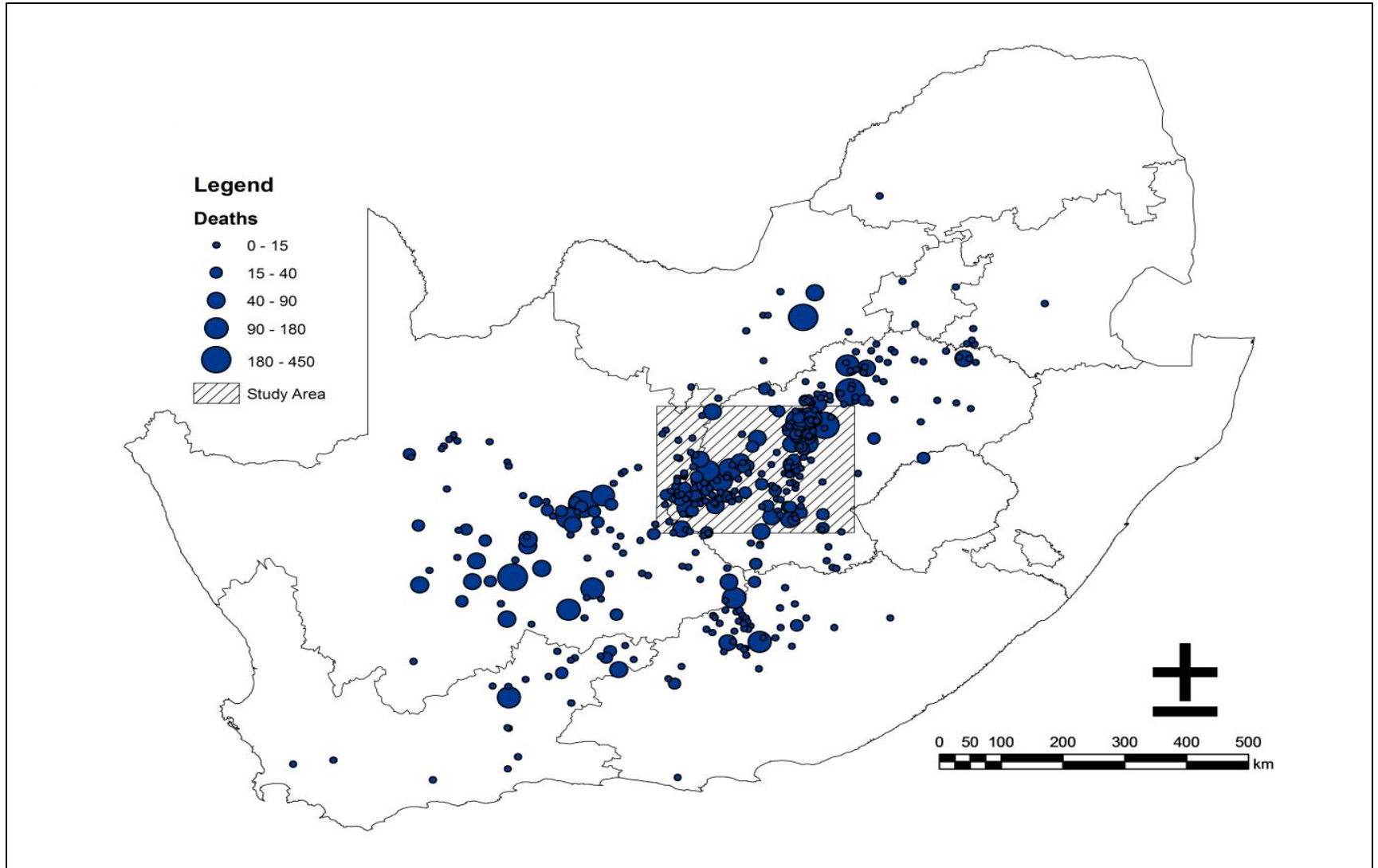
The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: Global Alert and Response Department
World Health Organization
Map Production: Public Health Information
and Geographic Information Systems (GIS)
World Health Organization

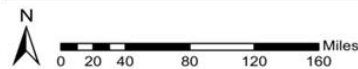
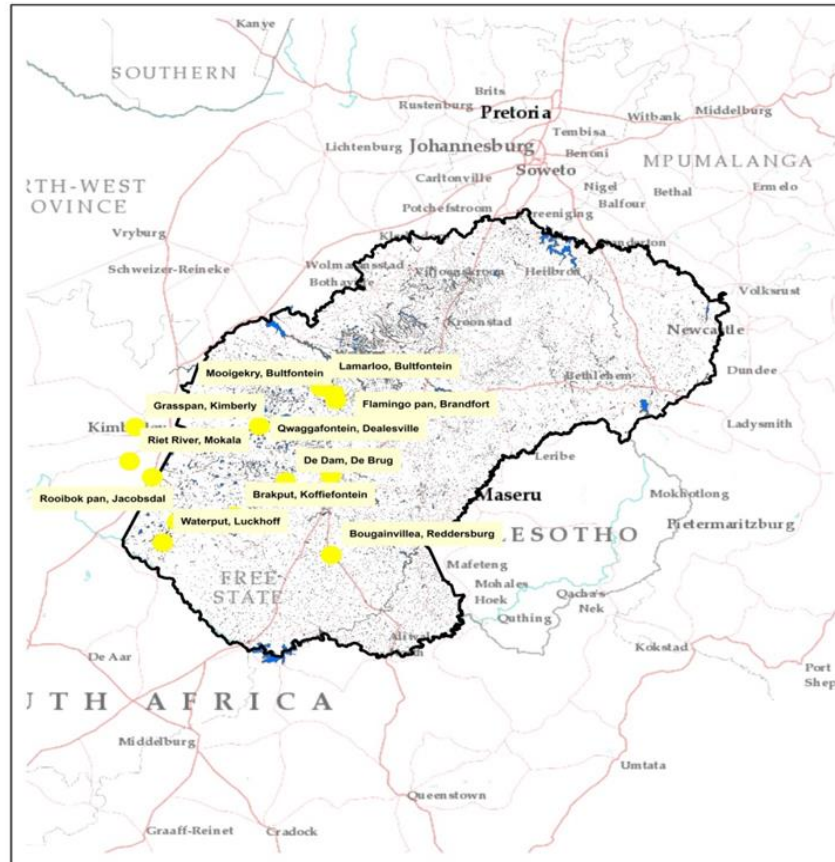


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Free State study area for 2010 Rift Valley Fever outbreak, South Africa



Assess > 50 farms on 40 000 km² Select 15 - 22 study sites



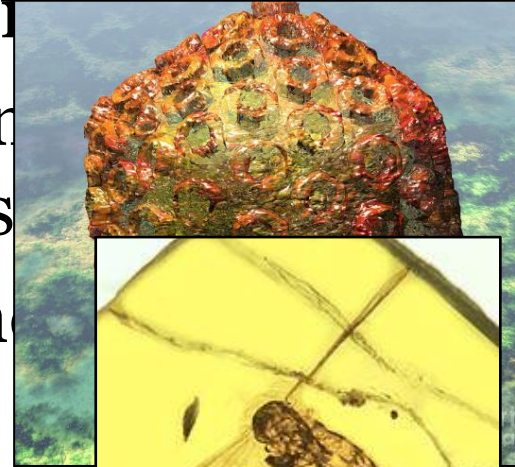
Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
False Easting: 0.0000
False Northing: 0.0000
Central Meridian: 0.0000
Standard Parallel 1: 0.0000
Auxiliary Sphere Type: 0.0000
Units: Meter

Service Layer Credits: Sources: Esri,
DeLorme, USGS, NPS

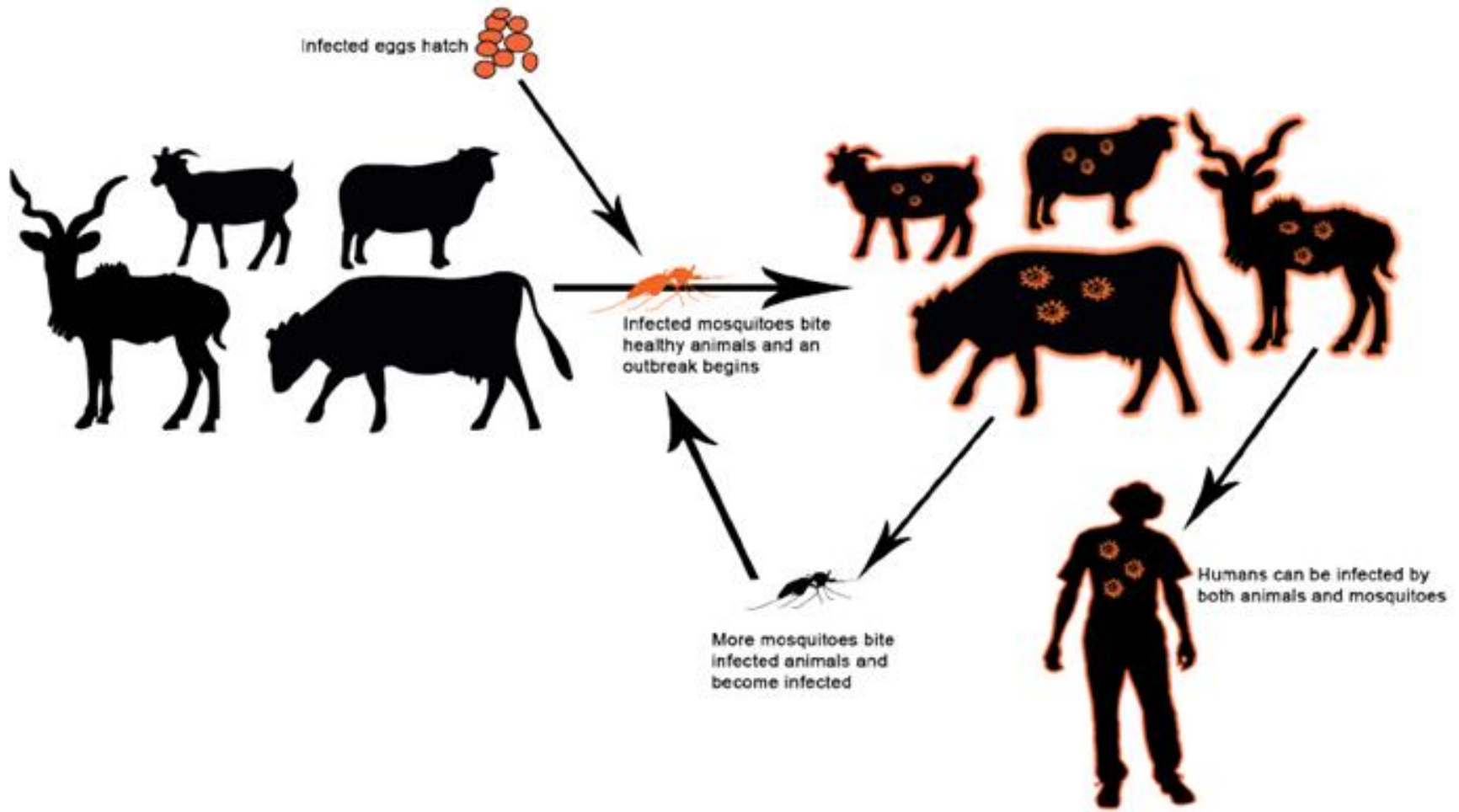


What is Rift Valley Fever?

- First identified in the Rift Valley, Kenya
- **Arbovirus** - arthropod-borne Zoonotic disease
spread by *Aedes* mosquitoes > 700 species
Culex amplifying vector > 1000 sp.
- Mosquitoes 200 Mil years old, in amber
- Phlebovirus genus, cause disease in domestic
wild ruminants spread to humans, causing
Haemorrhagic fever, retinitis, hepatitis, neurological
disease and death.
- Up to 100% abortions in ewes.
- Outbreaks every 20 years; 3 in South Africa
1950-51, 1974-5, 2010-2011



Rift Valley Fever Zoonosis; Cycle of infection via vector



Ecology of RVF virus during inter-epidemic periods poorly understood

- Outbreaks correspond with the warm phases of the **El Niño**/Southern Oscillation, **increase rain**.
- Primarily spread by infected *Aedes* mosquito bite 4-5 species, & *Culex* as secondary vector.
- Herbivours grazing in wetlands, *Aedes* habitat, fly 300m only. *Culex* fly 5 km, amplify.
- Second method; Virus spread transovarially, **desiccation resistant** eggs survive long enough to maintain the virus between outbreaks.
- Low level of RVFV transmission occurs during inter-epidemic periods in wildlife, livestock.

Context for the ecology and wetland vegetation study in South Africa

- **Cost** of RVF 2008–2010: R 295.3 million >\$60 mil.
- Total **deaths**: 8877 farm animals+ 24 humans
- Total outbreaks on **489 farms**, widespread.

Species	Susceptible	Cases	Deaths	Destroyed
Sheep	265 080	13 117	8 078	512
Cattle	70 445	738	448	7
Goats	5 993	157	86	11
Goats/sheep	5 163	269	204	1
Wild species	9 344	52	52	0
Camelidae	227	5	5	0
Buffaloes	146	4	4	0
Totals	356 398	14 342	8 877	530

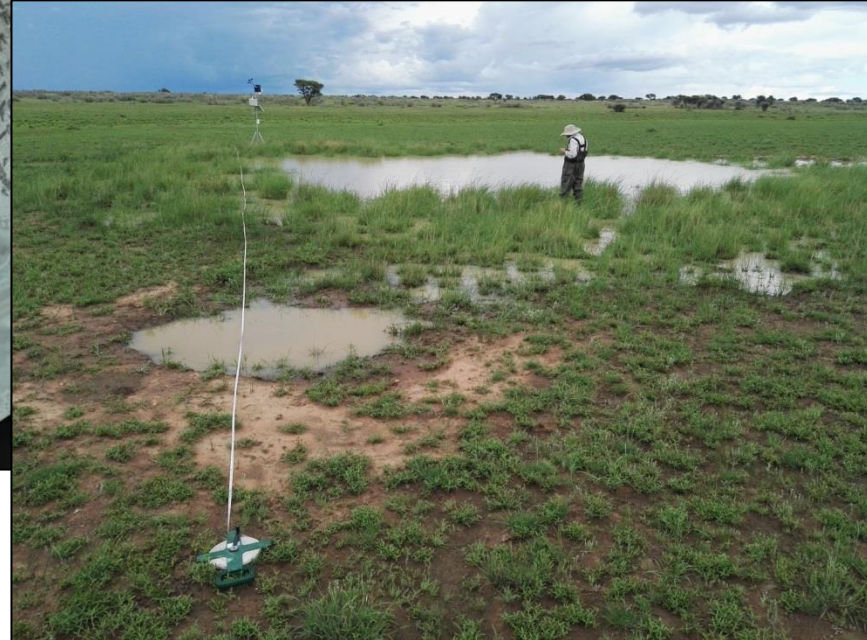
Data derived from RSA, OIE Report 17, pp. 98.



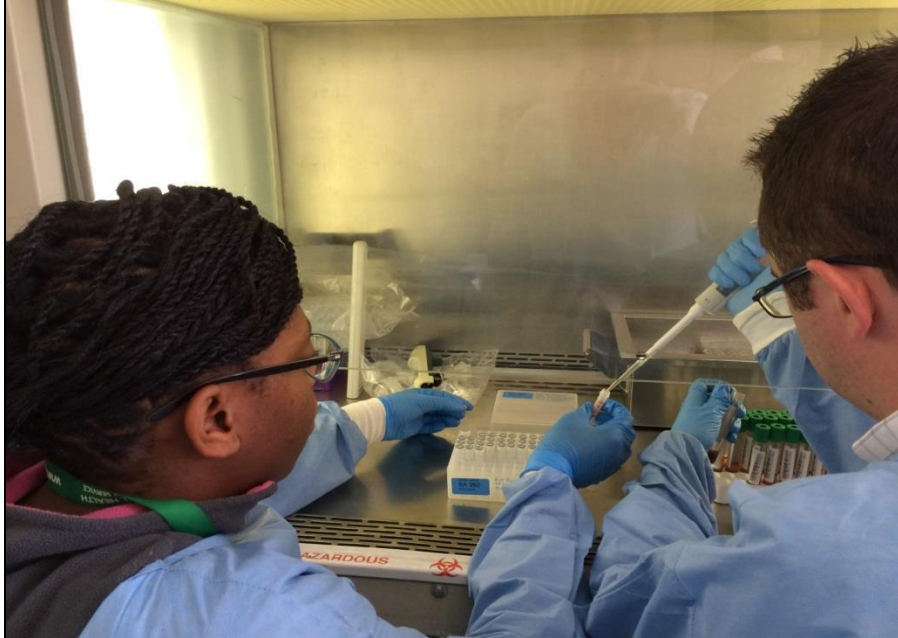
Assess 22 Wetlands & 132 relevés Collect 200 Plants



Mosquito; 115000 collect, 5000 identified. 22 Weather Stations installed



Blood sampling; livestock, 6458, antelope/buffalo, 2475, human serology, 1247 Lab work; 10180 analysed



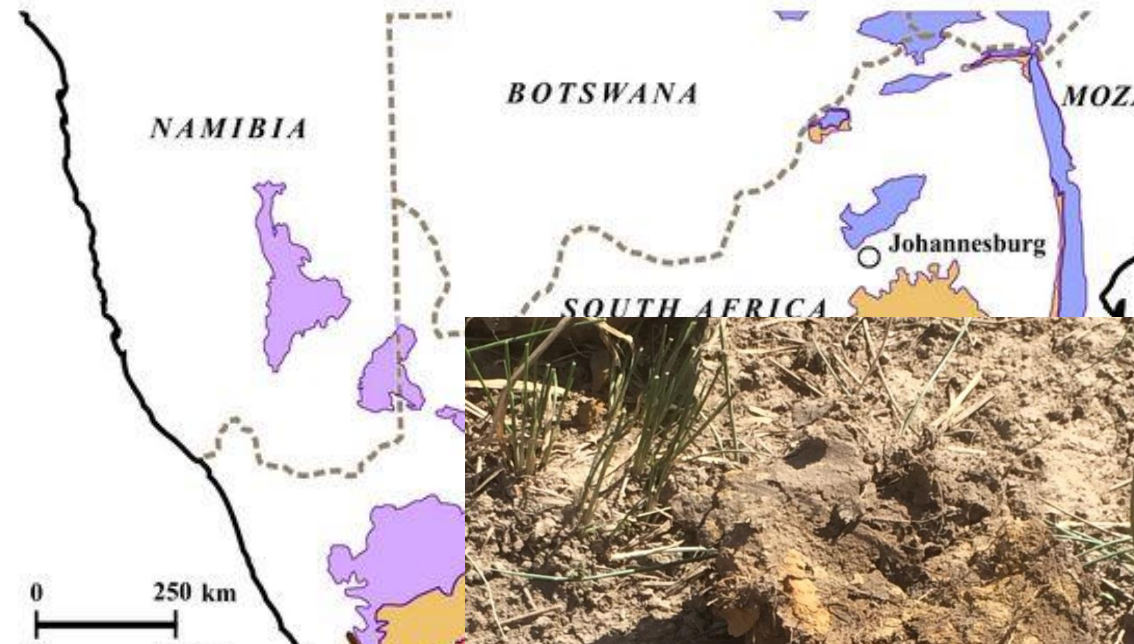
RFV Data Collected

- 22 sites & 132 relevés assessed over 40,000 km².
- > 200 plants identified, described and vouchered.
- **± 120 soil samples** collected and analysed.
- >115000 mosquitoes collect & 5000 identified.
- **Publications:** peer reviewed: 7, and others: 6
- International **seminars:** 6, **workshops:** 4
- Bloodwork: livestock, 6458; antelope/buffalo: 2475.
- Numbers of humans tested for serology: 1247
- 22 weather stations installed at sites.
- **Student degrees:** 5 (+2 US) masters, 1 (+3 US) PhDs produced – 5 undergrad students.



Results Ecological

- Geology: Ecca.



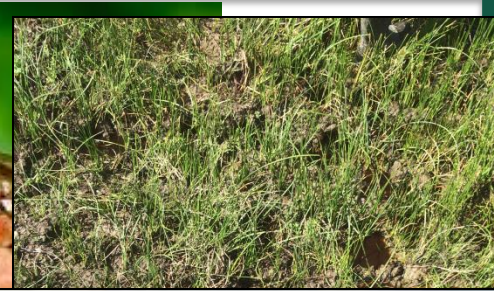
Survival of mosquito eggs and Virus

Survival factors: Virus may aestivate during inter-epidemic periods

1. Clay soils
2. Vegetation matrix
3. Wetlands

Hypothesis for survival


1. Extra-cellular nucleic acids in aquatic + soil sediments
2. Transformed by >40 species able to modify host physiology to absorb and integrate DNA into their genomes
3. Possible mechanisms of integration
4. Wetland birds may ingest eggs on legs, feathers, or bodies



Conclusion: Climate Change Impact on Zoonosis & RFV.

- More frequent and intense outbreaks.
- Better Understand environmental parameters.
- **Build resilience** – develop affordable vaccine.
- **Change behaviour** – more information.
- **Education** via papers & workshops - farmers, workers, scientists, students, media.
- Develop management **policy** – Governments, Veterinarians, Healthcare workers, public.
- Ongoing monitoring, evaluation, reassessment.

US and Globally; What's Needed for Ecosystems & Human Health?

- Zoonosis increase in intensity & frequency.
- Policies needed – ecosystem + human health.
- Collaboration – regional, national, international.
- Protection of indigenous biodiversity.
- Resources are limited – Earth is finite.
- Limits to (human) population growth – Malthus 1798 biological population growth curve.
- Population & Economics – Ricardo 1821. 
- Economics; Alvin Toffler 1970 'Limits to Growth'

Climate Change & Zoonosis: Importance for Health Care Workers? What can You Do?

- Increased extreme weather as CO₂ levels rise
- Increase in people with zoonotic disease.
- This is; You, family, friends, patients!
- Provide Health Care knowledge on zoonosis.
- Importance of Education; self, others.
- Steps you can take: reduce consumption.
- Women's rights to reproductive health.
- Reduce human impact on ecosystems.

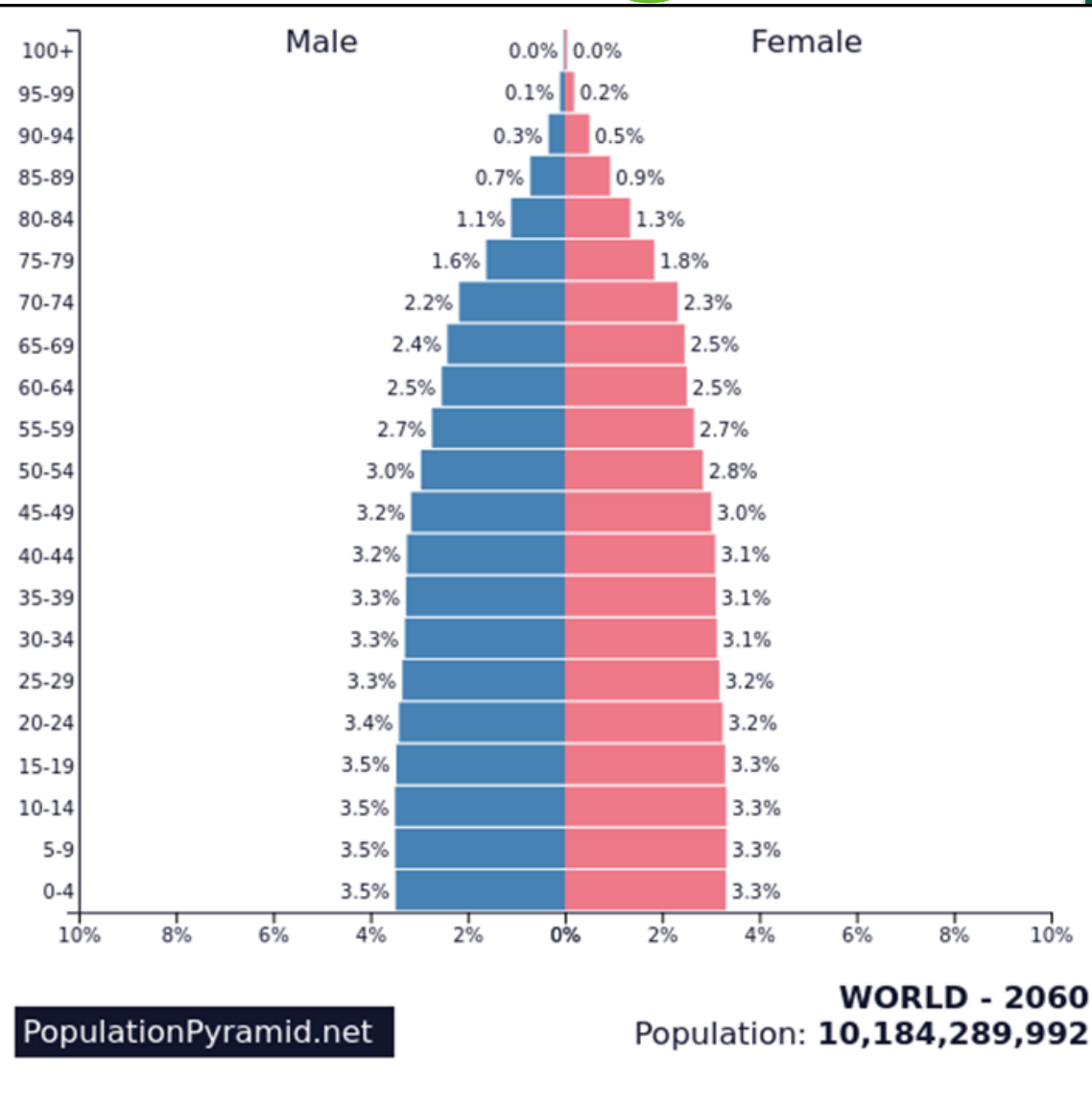
Human Population 2060, when you retire at age 65!

Climate Change and Zoonosis World population 2060

10,184,289,992

2100 ±11 Gig

- Habitat destruction
- Urban development
- Agriculture Increase
- Raw materials
- Industry demands
- Greenhouse Gases



Questions?

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