# Emerging and re-emerging viral diseases: what are the threats and challenges

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# Post-Ebola: what are the viral threats and challenges?

- **The most recent clinical cases of Ebola were diagnosed in Guinea on 17 March; the last case in Sierra Leone was discharged from hospital on 4 February 2016, and country is in a 90-day enhanced surveillance period until 25 June; and Liberia is in an enhanced surveillance period until 10th April.**
- **The scale of the Ebola outbreak over the past 2 years has galvanised the world to develop a new Global Health Security Framework and Workforce to ensure a rapid and effective response to new global health threats. Under intense pressure from Member States, UN, World Bank and other international donors, WHO has initiated a reform process - this has taken the form of a new 'Outbreaks and Health Emergencies Cluster' which has been established under an interim Executive Director.**
- **It is important to recognise that outbreaks of infectious diseases of all sizes will continue to occur in all parts of the world, some well-known, some completely novel, but there is now a fear of 'over-kill'!.**
- **In equatorial Africa, this includes outbreaks of viral haemorrhagic fevers – such as Ebola, Marburg, Congo-Crimean haemorrhagic fever, yellow fever, dengue, Lassa, and possibly other as yet unknown viruses, as well as cholera and other epidemic diseases.**
- **In the rest of the tropical and sub-tropical world, it includes dengue, chikungunya, as well as other epidemic zoonotic diseases, and most recently, Zika virus.**

# Post-Ebola: what do we need to do to meet these challenges?

- The challenge now is how we can we learn from the past and be prepared for the next outbreak – it is essential that outbreaks are detected and identified rapidly so that appropriate responses can be mounted.
- The earlier a potential outbreak is recognised, the greater the opportunity to prevent further spread.
- Huge strides have been made in laboratory diagnosis in Africa and elsewhere, and a new African Centre for Disease Control (CDC) is being established in Addis Ababa.
- Most other areas (not necessarily countries) of the world have effective and highly capable diagnostic laboratories and access to reference laboratories, but detection and alert can be a problem, particularly in remote areas where pubic health and medical care is limited – as seen regularly in mining areas.
- These diagnostic needs are essential for the rapid detection of novel infectious agents which could become public health emergencies of international concern; a central plank of the new International Health Regulations.

# Emerging diseases: the definition

- New diseases which have not been recognised previously.
- Known diseases which are increasing, or threaten to increase, in incidence or in geographic distribution.
- The terms ‘re-emerging or resurgent diseases’ are also used – usually to describe diseases which we had thought had been controlled by immunisation, antibiotic use or environmental changes, but which are now reappearing.

- How and from where do novel or emergent disease agents arise or expand?  (ie: where do they come from??)

# How and where do novel or emergent diseases arise?

Most emergent viruses have been around for millennia, either as:

(a) known diseases which are spreading geographically to new areas or which are increasing in incidence, or

(b) unknown agents which exist in specific niches and which are then 'discovered' during investigations of:

- Syndromes which we suspect may have an infectious aetiology; -
- Clusters of unusual cases with no known aetiology ;
- 'Stamp-collecting' – seeking novel agents from wildlife using standard isolation methods – but they are not necessarily pathogenic for humans; or
- Genetic scanning of wildlife samples for sequences indicative of specific families of microbes, but again with no indication of human pathogenicity.

Other agents may become pathogenic through mutation and/or selection, including the acquisition of antibiotic resistance and genetic reassortment of genetic segments and selection resulting in new pandemic influenza strains or in the evolution of new Bunyavrises.

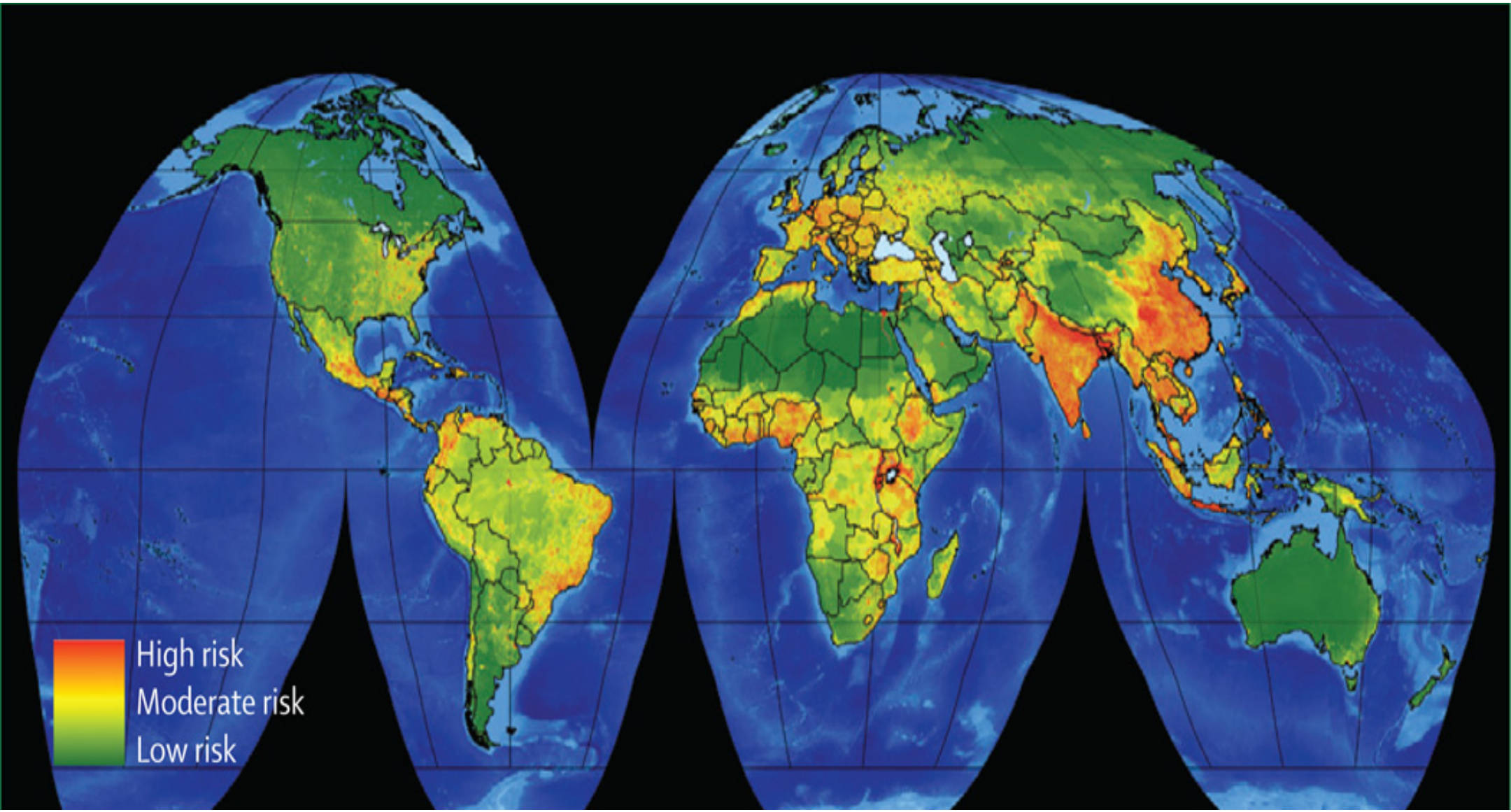
# Emerging diseases – the importance of animal reservoirs

- Over 74% of all novel emerging diseases over the past two decades, most of which were viruses, have been zoonotic (transmitted from an animal source);

- Most of these have come from either bats (particularly fruit bats), rodents or birds – for others, the hosts have yet to be determined;

- Thus the importance of understanding animal diseases and the role of wildlife in disease emergence cannot be understated, and there is strong belief that wildlife diseases should be a major component of global surveillance strategies.

# Global hotspots for emerging diseases that originate in wildlife




From Morse et al (2012) Lancet 380:1956-65

# EMERGING/RE-EMERGING VIRUSES: RECENT EXAMPLES

2015 - ZIKA VIRUS (Brazil)
- *VARIEGATED SQUIRREL BORNAVIRUS (Germany)
- *HUMAN PEGIVIRUS -2 (USA)
- *AKHMETA POXVIRUS (Georgia)
- *ITAYA VIRUS (Peru)

2014 - *SOSUGA VIRUS (Bats; South Sudan/Uganda)
- *BOURBON VIRUS (USA)
- EBOLA VIRUS (West Africa)

2013 - *INFLUENZA (H7N9) (China)
- ZIKA VIRUS (Pacific Islands)
- CHIKUNGUNYA VIRUS (Caribbean)

2012 - *MERS CORONAVIRUS (camels; Saudi Araba)
- *BAS-CONGO VIRUS (Congo)

2011 - *SFTS BUNYAVIRUS (China)

2010 - *TITI MONKEY ADENOVIRUS (USA)

2009 - *KLASSEVIRUS 1 (Australia, USA, Spain)
- *LUJO VIRUS (South Africa/Zambia)
- *HEARTLAND VIRUS (USA)
- *EV104 ENTEROVIRUS
- *INFLUENZA H1N1 Pandemic Influenza

2008 - *KAMPAR VIRUS (Malaysia)
- *CHAPARE VIRUS (Bolivia)
- *HUMAN COSAVIRUS (Pakistan)

2007 - ZIKA VIRUS (Yap)
- *DANDENONG VIRUS (Australia, ex Balkans)
- *MELAKA VIRUS (Malaysia)
- *BUNDIBUGYO EBOLA VIRUS (Uganda)
- *KI POLYOMAVIRUS
- *SAFFOLD VIRUS

2006 - CHIKUNGUNYA (SW Indian Ocean, East Africa, India, Sri Lanka, Indonesia)
- WEST NILE (Argentina)
- *NEW HUMAN RHINOVIRUS (USA)

2005 - *HUMAN BOCAVIRUS

2004 - INFLUENZA (H5N1) (Thailand, Vietnam,)
- *HUMAN CORONAVIRUS NL63

2003 - *SARS CORONAVIRUS

2001 - *HUMAN METAPNEUMOVIRUS
- NIPAH VIRUS (Bangladesh, India)

2000 - RIFT VALLEY FEVER (Mid. East)

1999 - *NIPAH VIRUS (Malaysia)
- INFLUENZA H9N2 (HK)
- WEST NILE VIRUS (USA)

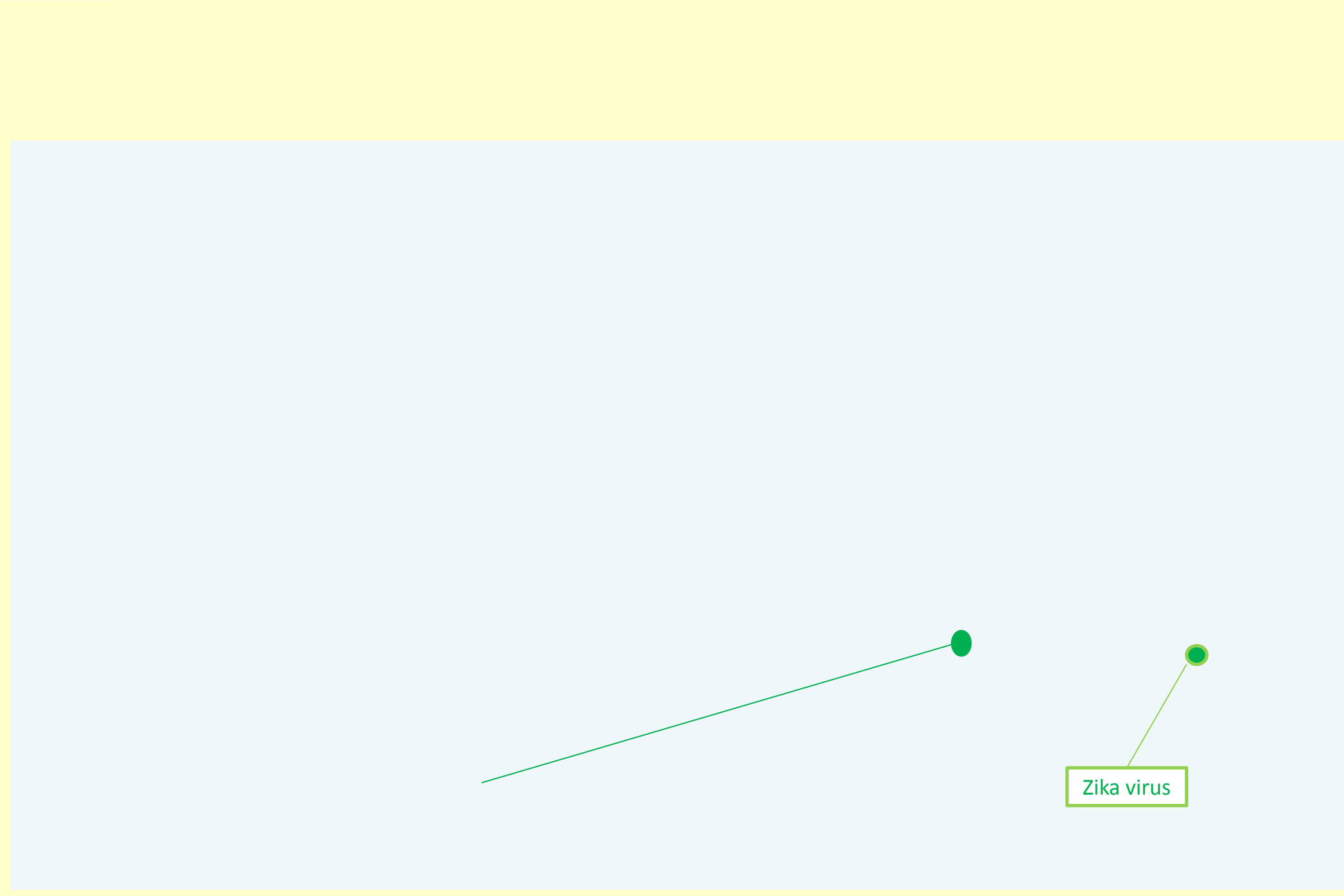
1998 - *SEN VIRUS (Italy)

1997 - *ALKHURMA VIRUS (Saudi Arabia)
- *MENANGLE VIRUS (Australia)
- INFLUENZA H5N1 (HK)
- *RABENSBURG VIRUS
- *TT VIRUS (Japan)

1996 - *AUSTRALIAN BAT LYSSAVIRUS

White = zoonosis, transmitted from animals; Yellow = initial zoonotic event; Red = Human to human.
* = a novel virus which has not been seen previously.


SFTS bunyavirus
MERS
coronavirus


Zika virus

# Animal-Human Interface

- Thus the animal-human interface is crucial in zoonotic disease emergence, providing the stepping stone for the agent to spread from an animal reservoir to humans.
- It may be ‘domestic’, where people live in close proximity with their domestic animals, or with wildlife.
- Those most at risk from contact with wildlife are hunters, traders in bush meat or at animal markets, but the risks are increasing as natural habitats shrink and animals seek food closer to human habitation, often encroaching into peri-urban or even urban areas.

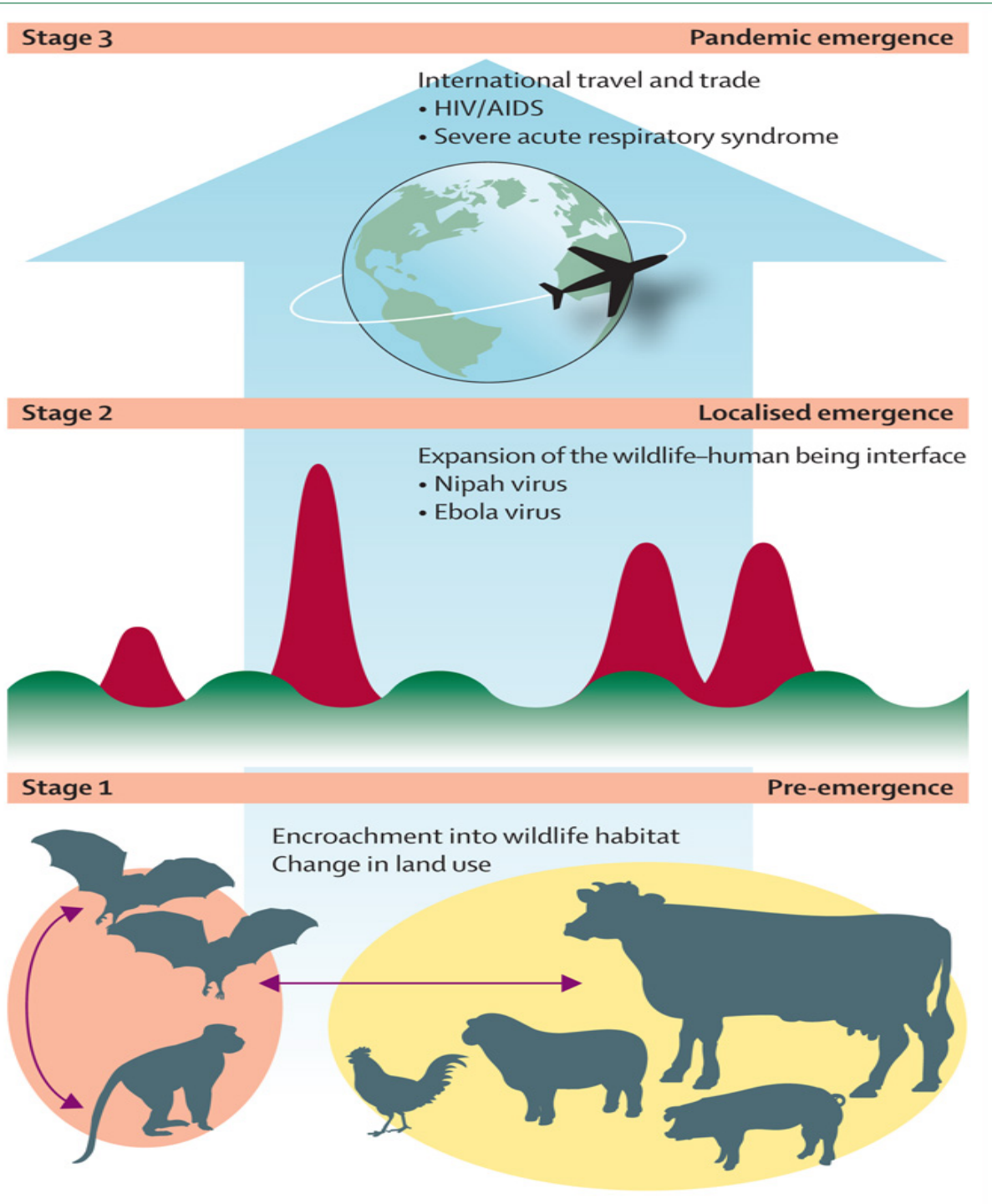
Photo: Hume Field

Photo :Paul Gibbs

Chatou market, Guangzhou, China, May 2003

# The animal-human interface: bush meat – a major source of risk for disease emergence, both through consumption and collection – and of course in international trade.

Photos by courtesy of Hume Field and Peter Daszak




Pandemic emergence requires a move from animal-to-human transmission to the capacity for high frequency of human-to-human transmission cycles, combined with rapid dissemination through travel and/or trade

Localised emergence requires increased spill-over events, human susceptibility and cross-species transmission at the wildlife/livestock – human interface. Exacerbated by urbanisation, human behaviour, etc

Pre-emergence requires the means for cross-species transmission, through encroaching into wildlife habitat, changes in land use, water impoundment, and is some instances, changes in climate.

Morse et al (2012). Lancet 380:1956-65

- What drivers precipitate the emergence and spread of viruses?

# The importance of human intervention and human activities in disease emergence, and the important role played by biodiversity

- Many drivers or factors can be responsible for, or contribute to, emergence, either singly or in concert.
- Perhaps, the single most important component of emergence, which is common to most of these drivers, is the role of human intervention or human activities.
- Some of the drivers are influenced by environmental conditions.
- But it must also be understood that *biodiversity* provides the 'source', or the biological environment or milieu, from which new diseases emerge.
- Of particular importance for mosquito-borne viruses is the spread and establishment in new areas of mosquito vectors – particularly *Aedes albopictus* and *Aedes aegypti* – largely spread by trade!

# Drivers Responsible for Emergence, Resurgence and Increased Spread of Infectious Diseases

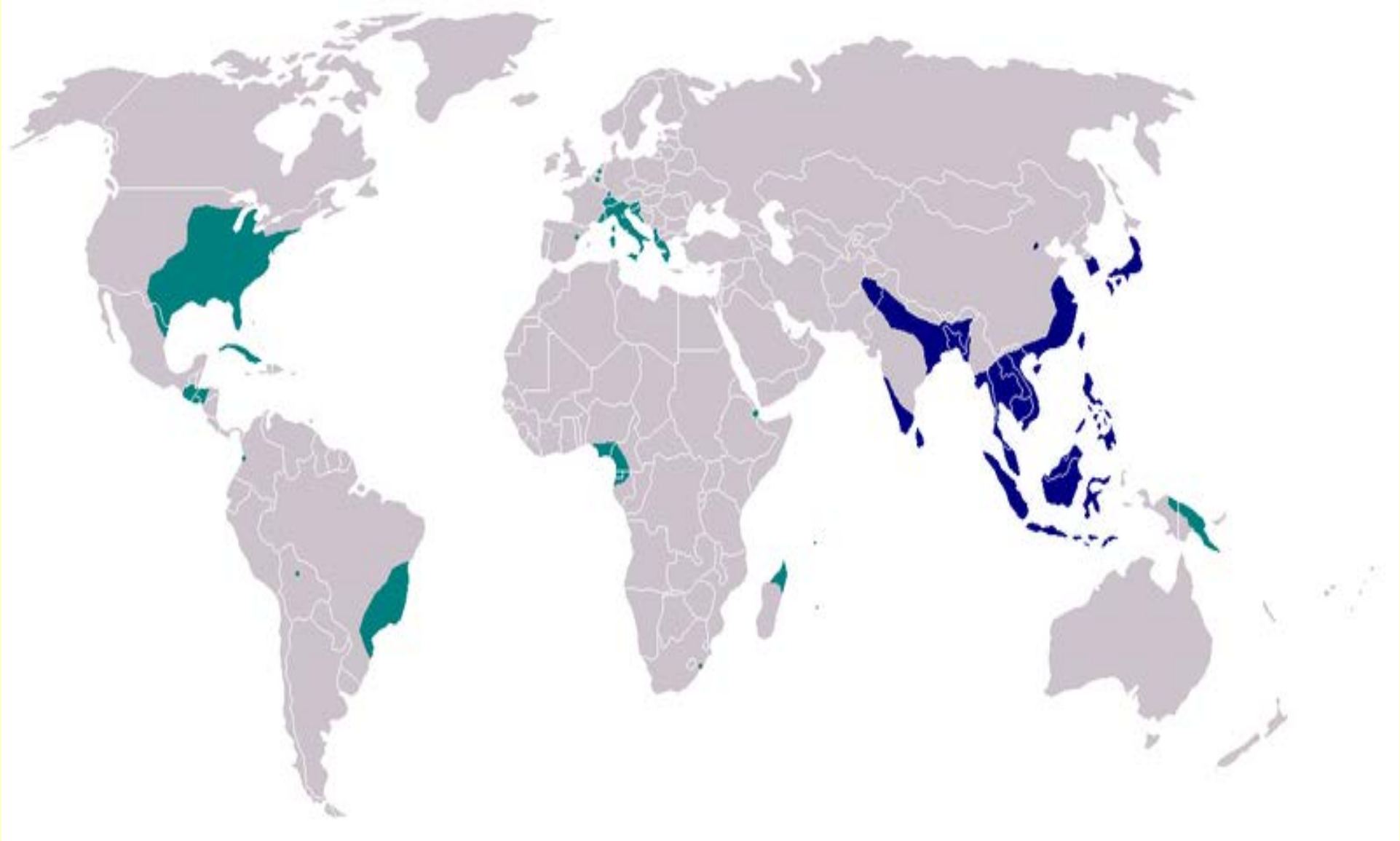
## (a) Human activities:

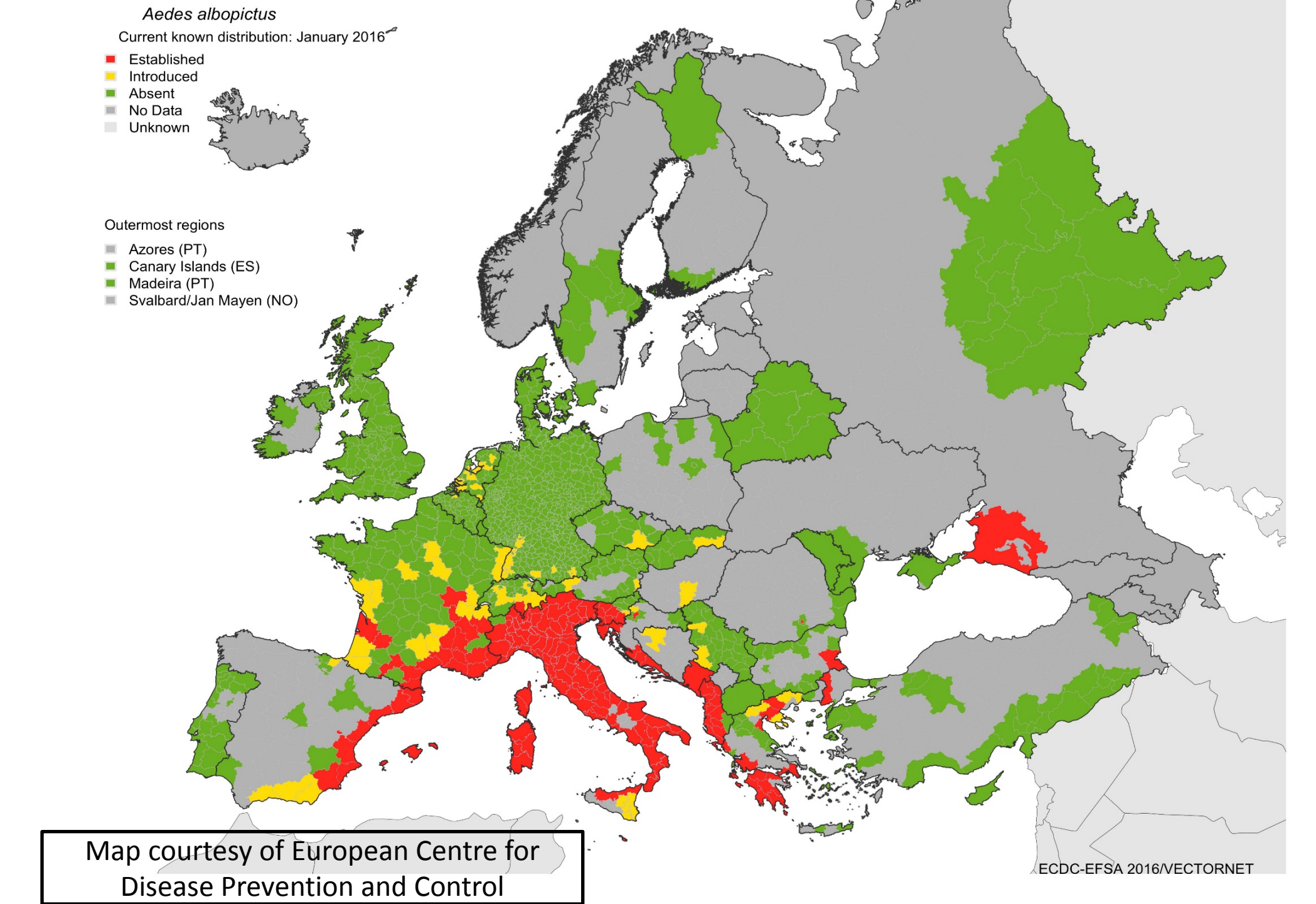
- Changes in human demographics or behaviour:
  - Population growth and migration; Urbanisation
  - War/civil conflict/bioterrorism;
  - Human behaviour - sexual behaviour/intravenous drug use
- Changes in technology & industry:
  - Globalisation of food supplies; Changes in processing; use of antibiotics as food supplements
  - New technologies; eg Organ/tissue transplantation; factors in food safety
- Economic development and land use:
  - Changes in land use and agricultural practices; Intensive agriculture; food safety; interactions with wildlife
  - Dam building; Increased irrigation
  - Deforestation/reforestation;
- International travel & commerce:
  - Worldwide movement of people and goods;
  - Transport of mosquitoes and other vectors, and establishment in new geographic areas.
- Microbial adaptation and change:
  - Microbial evolution;
  - Response to environmental selection.
- Breakdown in public health:
  - Reduction in prevention programmes;
  - Inadequate sanitation; inadequate vector control.

## (b) Natural Occurrences:

- Climate
- Vertebrate host movement, such as migratory bird movements
- Natural disasters

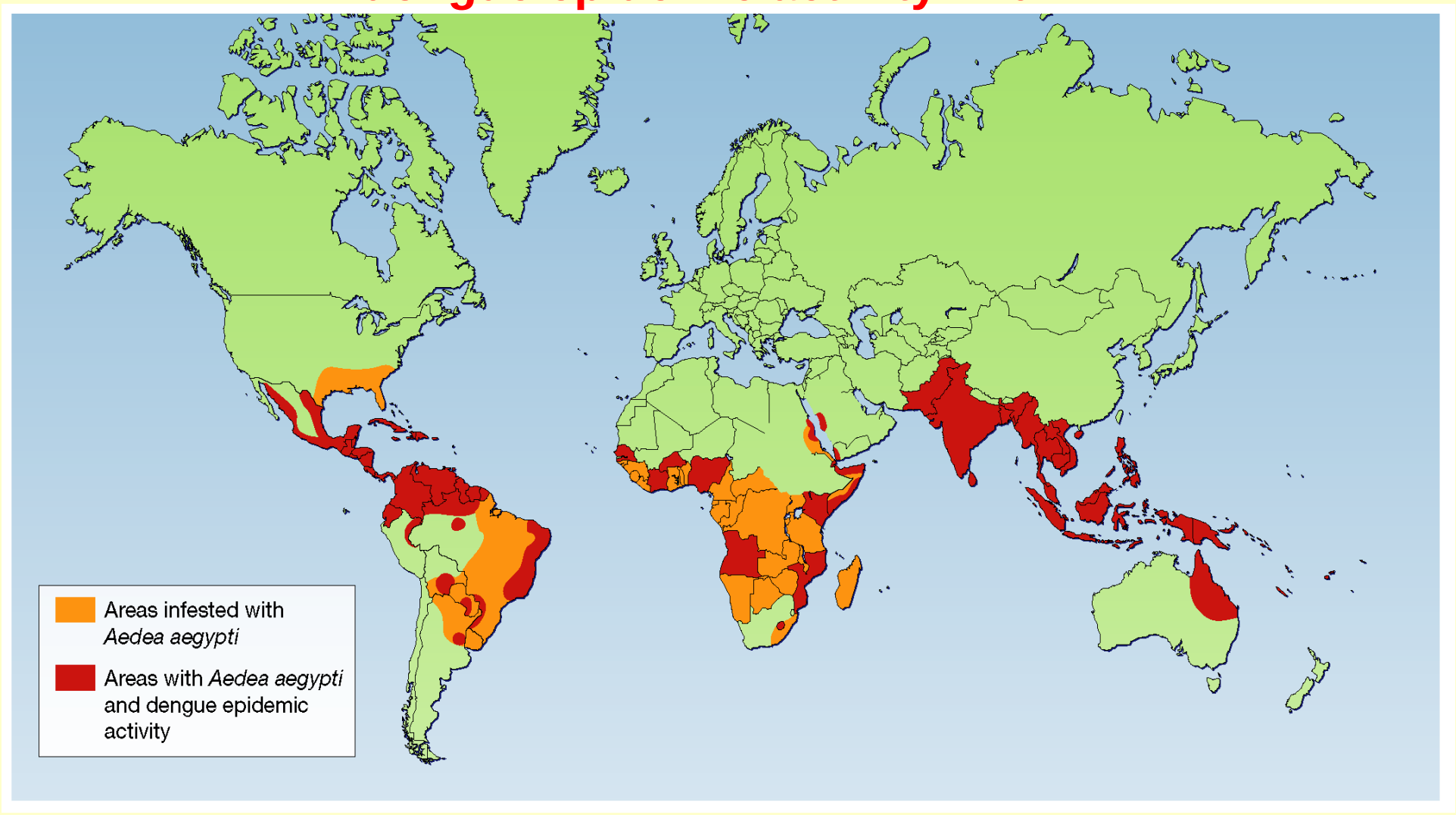
# Distribution of *Aedes albopictus* as at 2007






Map courtesy of European Centre for Disease Prevention and Control

# Areas infested with Aedes aegypti, and with dengue epidemic activity - 2011




**Based on Mackenzie, Gubler & Petersen (2004) Nature Med 10(12): S98-S109**

# How many viruses are there which could represent a threat??

## Vertebrate species:

| | |
|---|---|
| Birds | 9,956 |
| Mammals | 5,416 |
| Amphibians | 6,199 |
| (Fish | 30,000) |

## Invertebrate species

| | |
|---|---|
| Insects | 950,000 |

If each Mammalian and bird species has 10 species-specific viruses, then this would total in excess of 150,000 viruses.

Thus there are many possible viruses which could potentially cross the species barriers.

In sea water, there estimated to be several million viruses per millilitre of sea water, and all different! Luckily most are phages and not of any potential risk, but there are significant numbers that infect eukaryotic phytoplankton, invertebrates, and vertebrates. Thus prawn virues, finfish viruses, and viruses of seals, sealions and cetacans.

# Possible virus threats – or are we paranoid?

## Arthropod-borne viruses

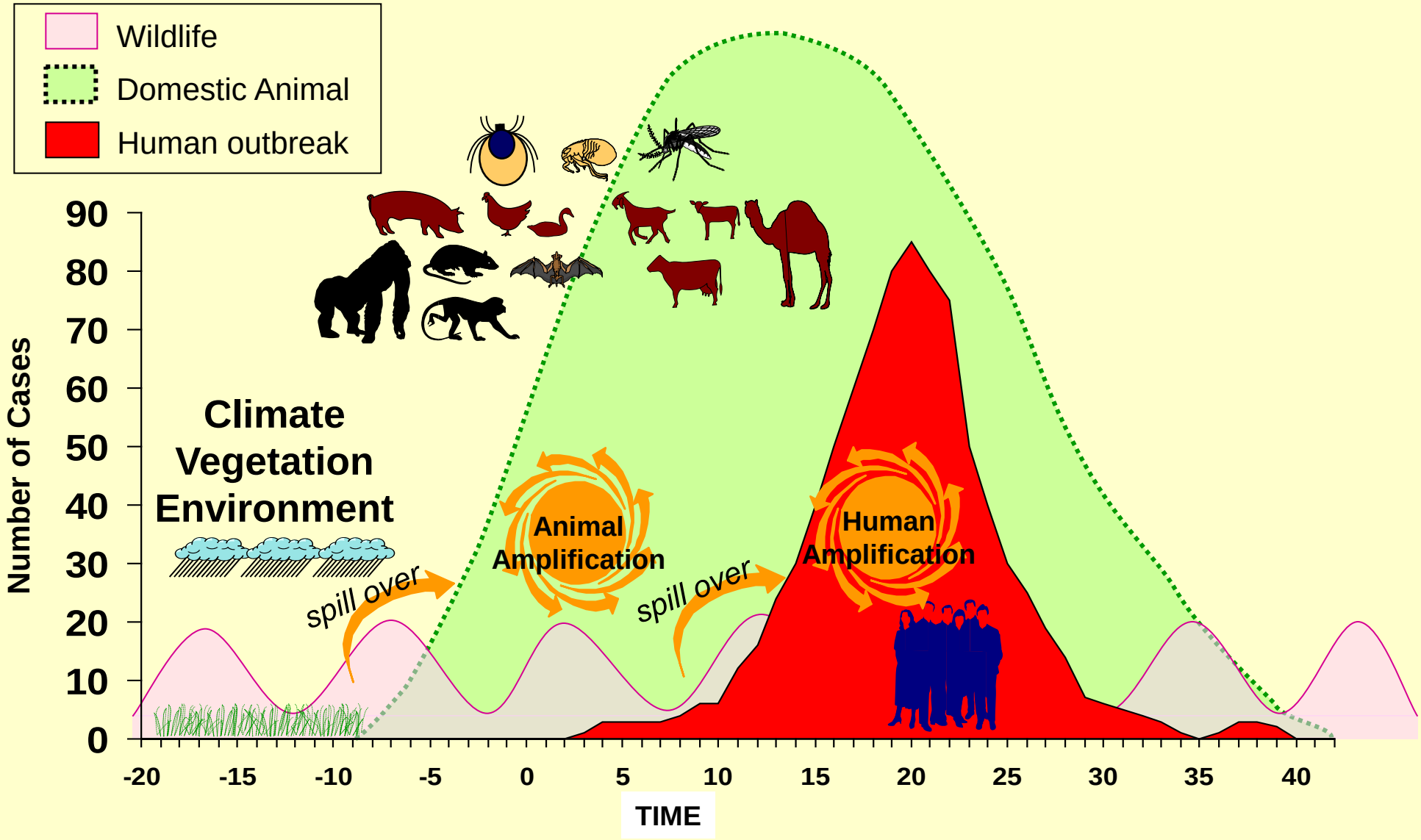
- **Sepik virus** – a flavivirus and the closest known to yellow fever
- **Baiyangdian virus** - a flavivirus found in east Asia causing egg drop and ovary/oviduct disease in ducks
- **Sitiwan virus** – a flavivirus causing encephalitis and retarted growth in chicks.
- **Usutu virus** – an African flavivirus spreading in Europe, fatal in avian species, causing mild human disease.
- **Itaya, Caraparu, Ngari, Wyeomyia viruses, et al –** Some of the Bunyaviruses causing human disease

## Other viruses

- **Highly pathogenic avian influenza –** H7N9, H5N6 or H9N2??
- **MERS –** lessons learnt from Korea should be taken on board!
- **Lloviu virus -** a novel filovirus detected in bats in Spain
- **Bas-Congo virus** – a novel rhabdovirus causing haemorrhagic fever
- **Ebola Reston virus** – an Ebola virus species in Asia – and are there others?
- Various Orthoviridae [Melaka virus and Kampar

Early detection and a rapid response response is really crucial to respond to potential emerging threats

# Emerging Infectious Disease outbreak alert and response




Slide kindly provided by Pierre Formenty, WHO

# Outbreak Response challenge


No single institution
has all the capacity!


Bringing international partners together to rapidly focus global resources on a problem

# The Global Outbreak Alert and Response Network (GOARN) – network to assist in response

One mechanism to assist in responding to emerging disease outreaks is GOARN - a partnership of technical institutions to:

- Provide and coordinate rapid technical support to countries by providing best available expertise for outbreak response.
- Its members range from large organisations such as MSF, US-CDC, PHE, Red Cross-Red Crescent, to the very small, such as University departments, all providing specialist expertise at no cost.
- It is semi-autonomous, but with a secretariat embedded in WHO, and a Steering Committee which maintains oversight on outbreak activities.
- Its activities have been largely in outbreak response, but are now increasingly being directed to 'Alert' functions as well.
- Alert may be from many different mechanisms – a country health department, WHO Country Offices, international press, social media, etc, but also potentially from private companies.

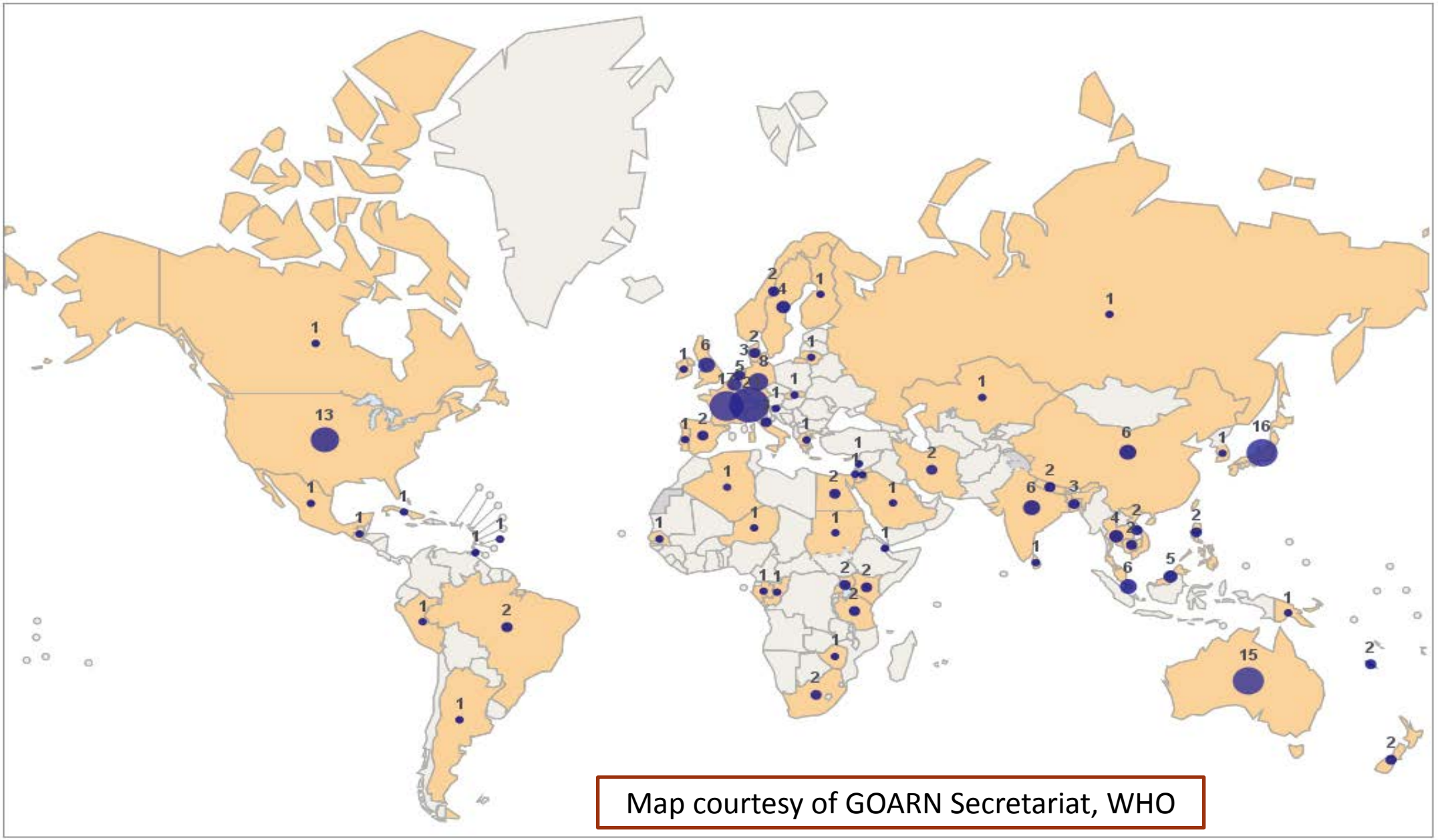
# GOARN: 15 years on:

- In 2000: 67 partners

  In 2012: 153+ Partners and 37 Networks (providing a further 355 partners)
- Over the past 15 years -

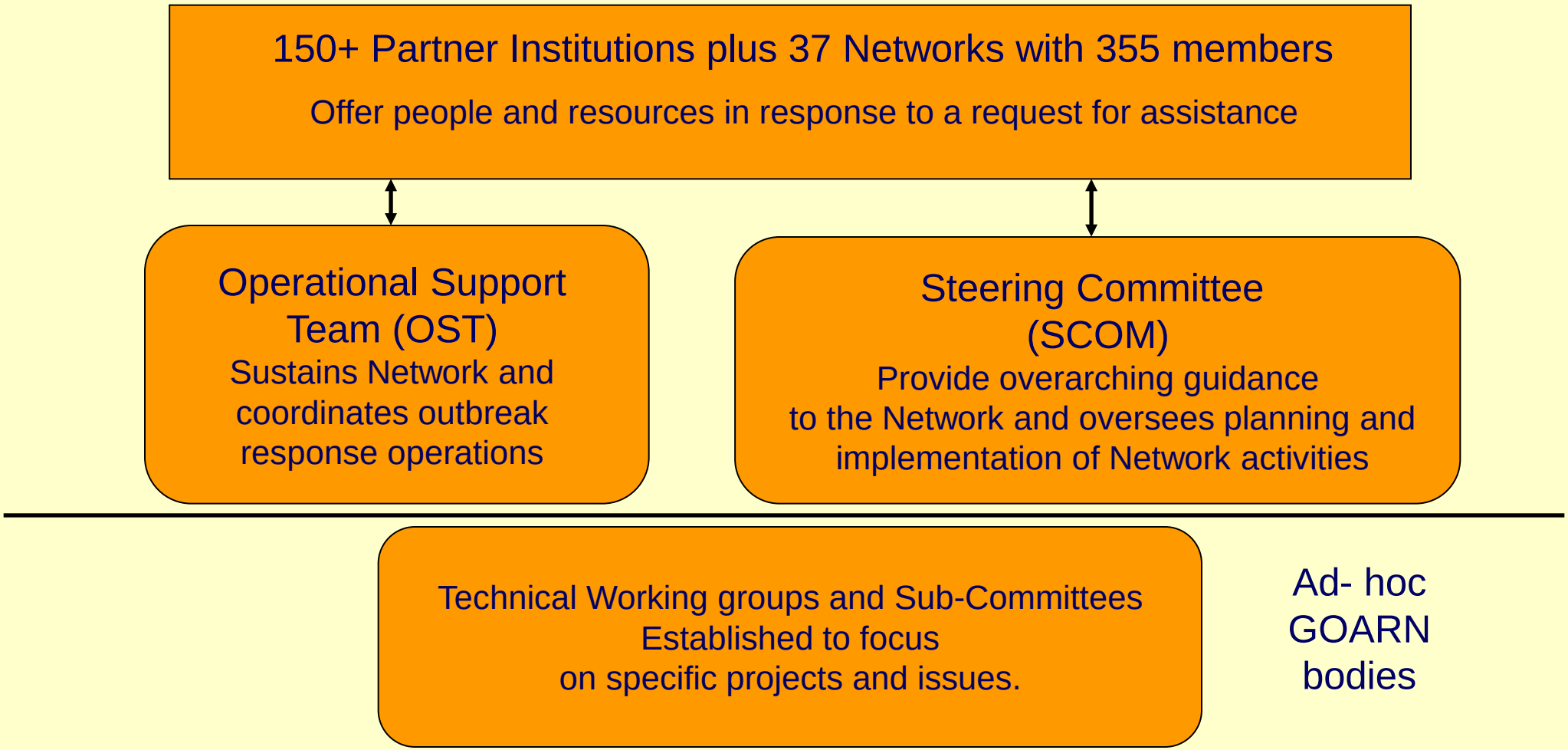
  200+ missions in 82 countries, and over 1600 experienced staff for surge capacity if needed for widespread deployment.
- GOARN has a strong ‘branding’ but new challenges will better define its role in the next decade.
- GOARN will continue to play a crucial role in the new Outbreaks and Health Emergencies Cluster of WHO.

# GOARN Membership: Partners and Network hubs N=205



Map courtesy of GOARN Secretariat, WHO

# GOARN's current structure



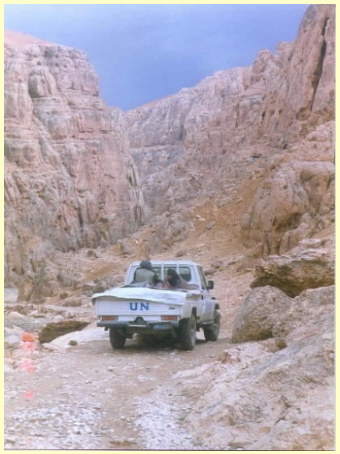
# Deploy multidisciplinary teams

- Field epidemiology
- Laboratory science
- Clinical management
- Infection control
- Environmental health
- Health education
- Medical anthropology
- Risk communication
- Outbreak Logistics
- Veterinarians, etc

# Field Operations: 2000-2016

Afghanistan, Algeria, Angola, Argentina, Armenia, Azerbaijan, Bangladesh, Belize, Bolivia, Burkina Faso, Cambodia, Cape Verde, Chad, Chile, China, Côte d'Ivoire, Democratic Republic of Congo, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Fiji, French Polynesia, Gabon, Georgia, Ghana, Guatemala, Guinea, Haiti, Honduras, Hong Kong SAR, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kenya, Kosovo, Laos, Lebanon, Liberia, Former Yugoslav Republic of Macedonia, Madagascar, Mali, Mexico, New Caledonia, Nicaragua, Niger, Nigeria, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Qatar, Republic of Congo, Saudi Arabia, Senegal, Sierra Leone, Singapore, South Sudan, Sri Lanka, Sudan, Switzerland, Syrian Arab Republic, Tanzania, Timor Leste, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United States of America, Vietnam, West Bank and Gaza Strip, Yemen






# GOARN and Specialist Networks –