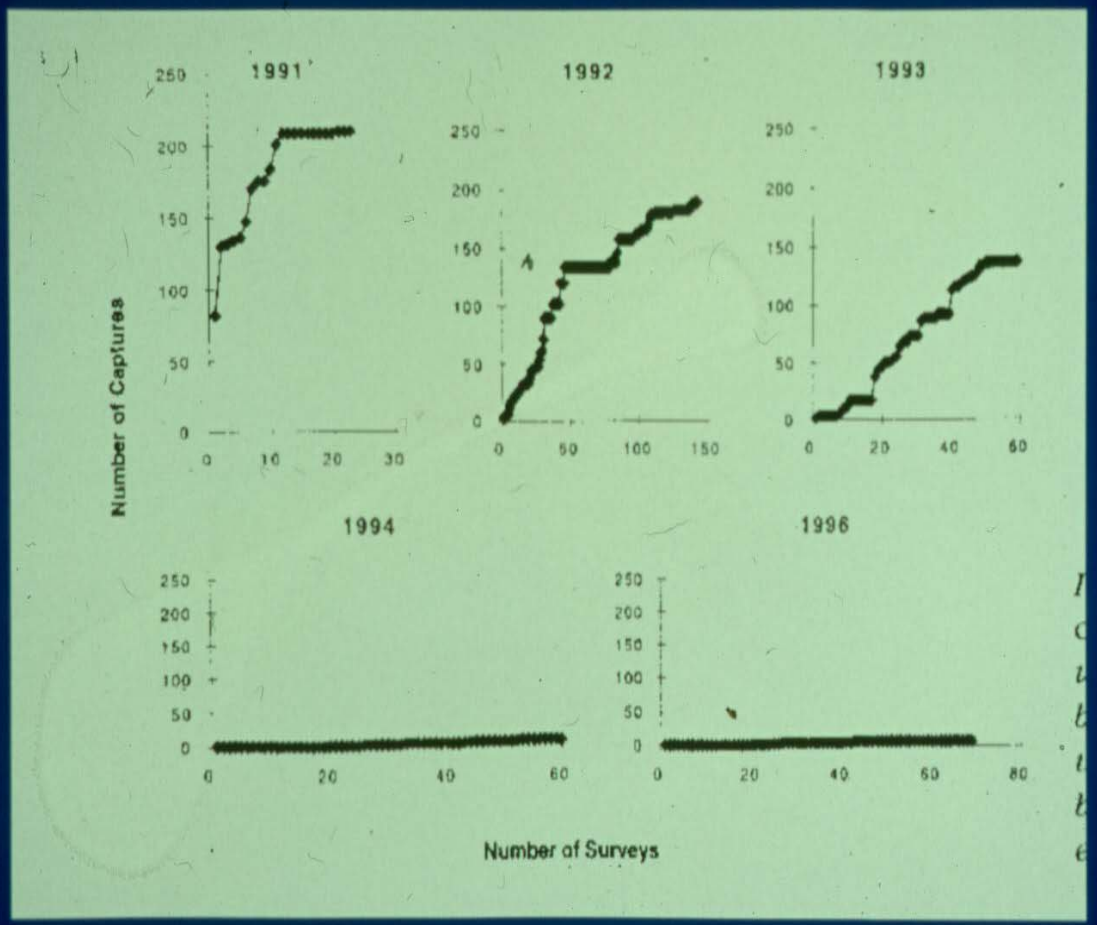
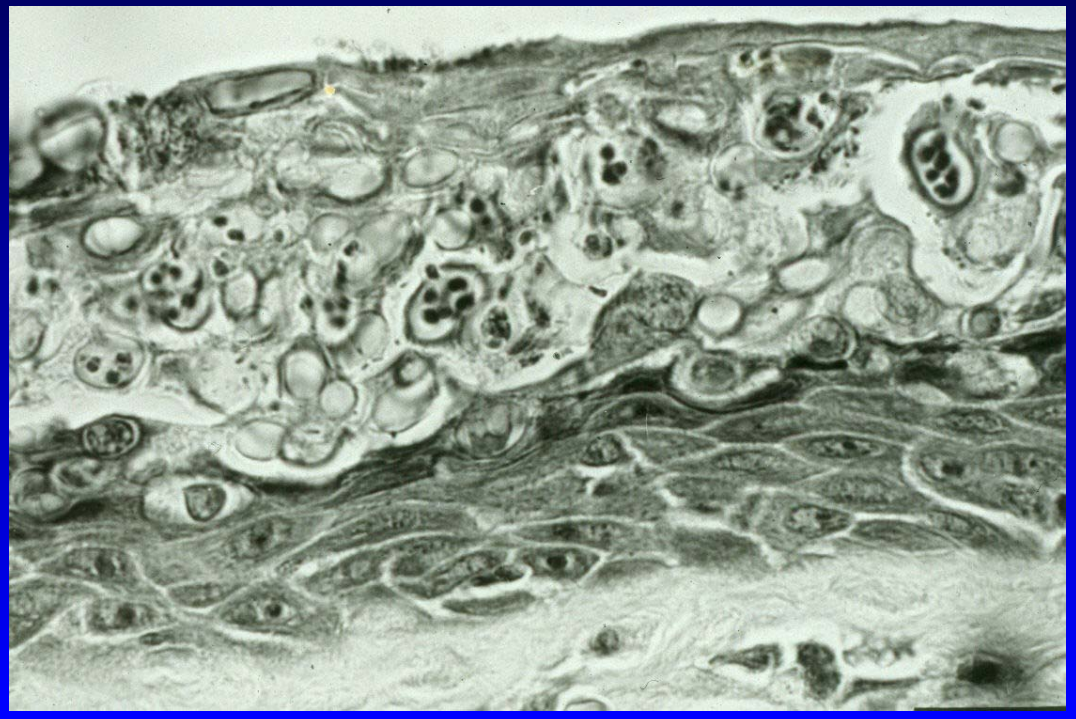
Amphibian Declines

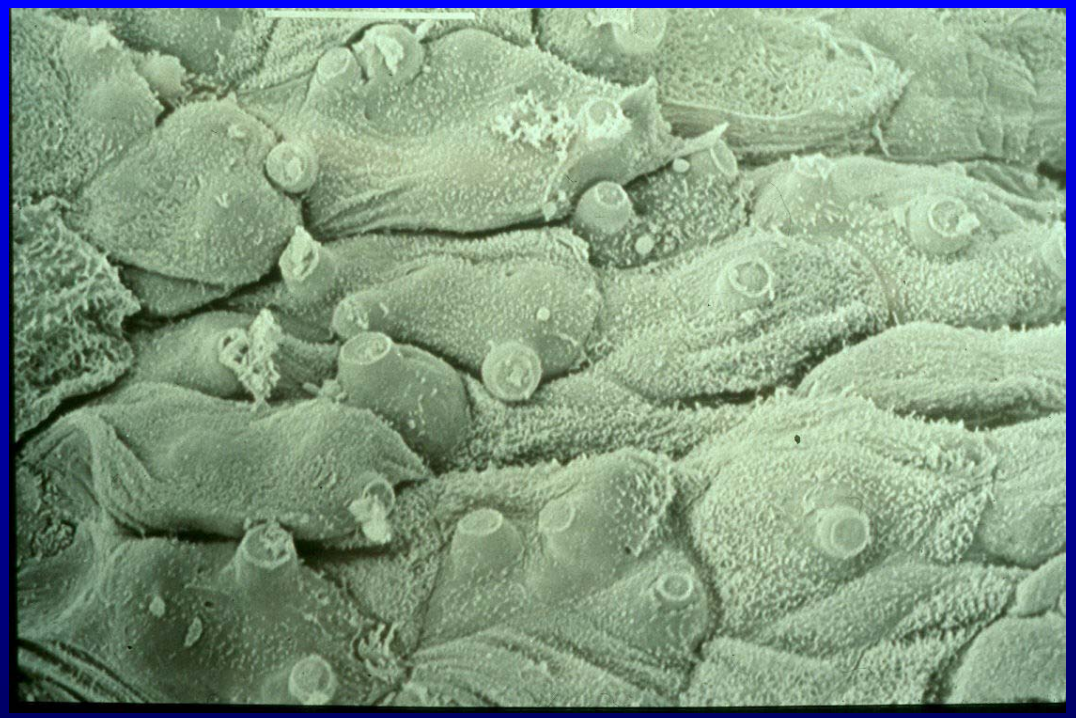
- Global population declines since 1970s
- Major declines and extinctions in tropical montane rainforests



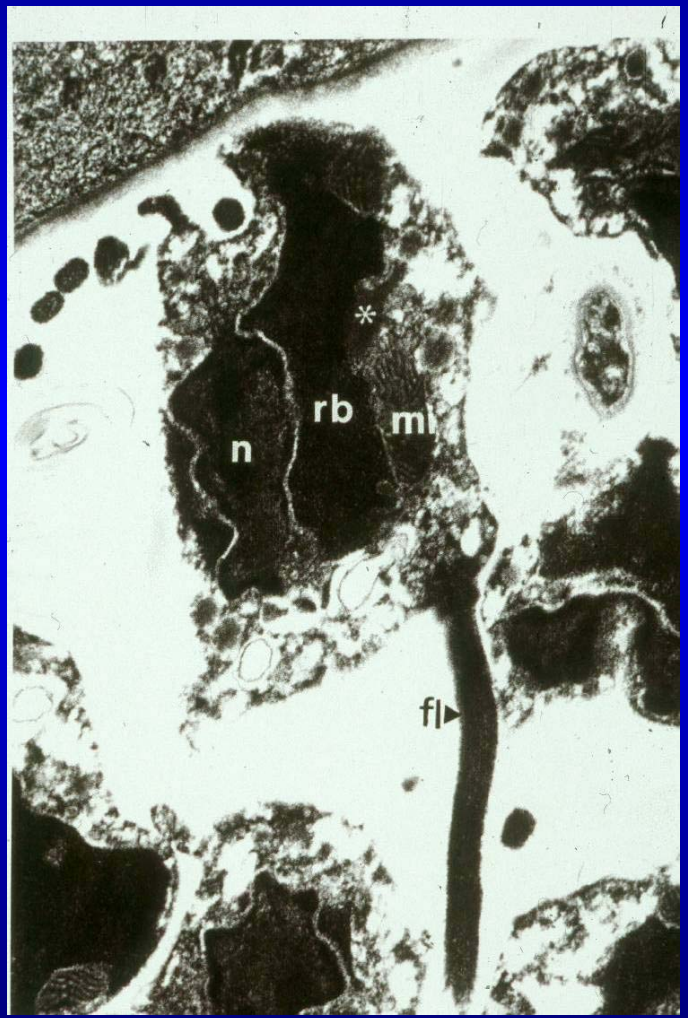
Chytridiomycosis

- Discovered in 1998
- Fungal infection of keratinized epidermis
- Hyperplasia, hyperkeratosis
- Cause of death by unknown mechanism





- **Zoosporic fungal agent isolated in culture and Kochs postulates proven**
- ***Batrachochytrium dendrobatidis.***
- **New genus, first chytrid infecting a vertebrate**



Origins?

Two Hypotheses

1. **Endemic disease. Emerged due to global changes (UV-B, climate, pollution) increasing virulence or decreasing host immunity**

2. **Panzootic. Emerging due to anthropogenic introduction**

Methods

PCR with fungal specific primers. Rapidly mutating ITS region

TA clone and sequence

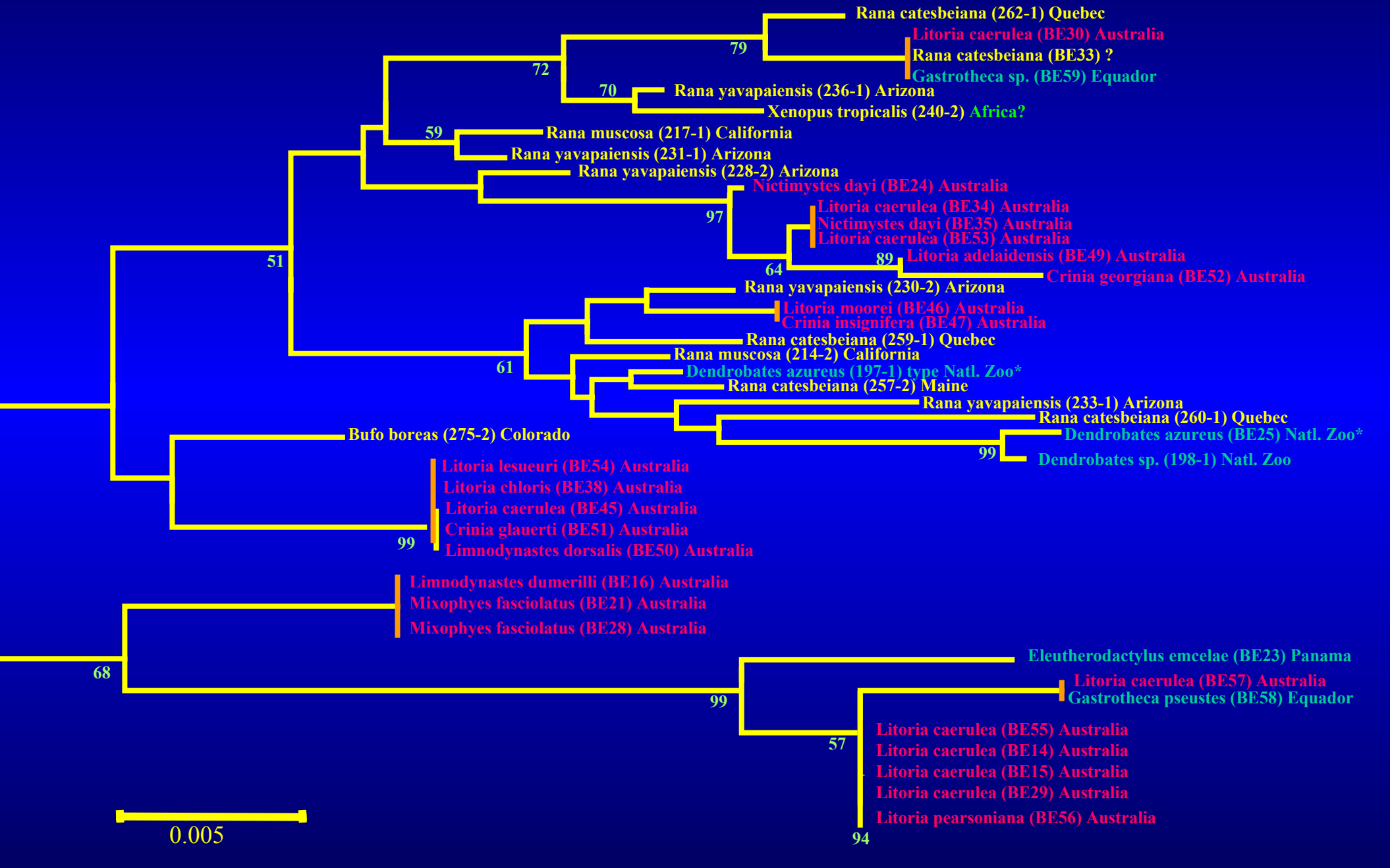
Align sequence and construct trees

- **Phylogeographic signal present**
  - **supports endemic chytrid co-evolution and global climate stress**
- **Phylogeograhic signal absent**
  - **supports panzootic epidemic via introductions**

Sequence Variation

	#aligned bases	variable sites	informative sites
18s rRNA (partial)	54	0	0
ITS 1	202	54	29
5.8s rRNA	156	2	1
ITS 2	138	56	56
28s rRNA (partial)	34	4	3
Total	584	116	89

Neighbor-joining Tree

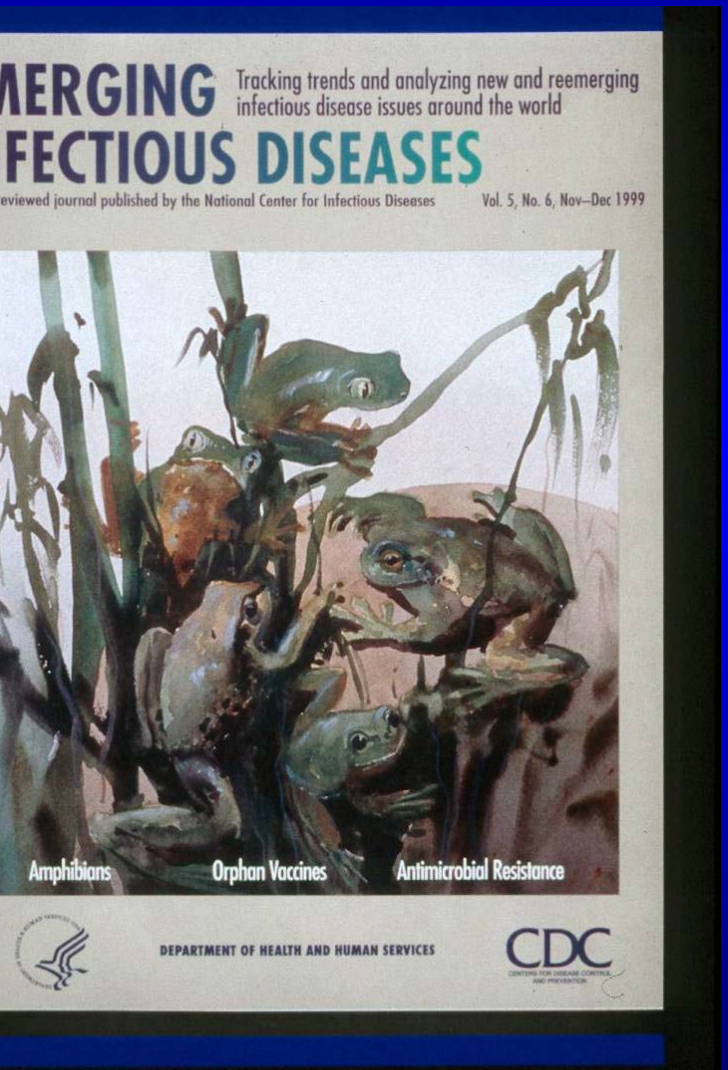


Anthropogenic spread

Chytridiomycosis confirmed in:

- **Pet trade**
- **Food trade (> 1 million p.a. USA)**
- **Lab animal trade**
- **Zoos**
- **Introduced species**

An emerging disease of wildlife?



- **Rapid increase in geographic range**
- **Increased impact**

A unique wildlife EID

- **Species extinctions**
- **Global emergence**
- **Threatens a class of vertebrates**

Emerging Wildlife Diseases

Local, epizootic

- Bacterial diseases of coral, Florida *Nature* 392: 557
- *Mycoplasma* in songbirds, U.S.A. *Emerg. Infect. Dis.* 1: 107
- Canine distemper, black-footed ferret, U.S.A. *Conserv. Biol.* 2: 66

Panzootic

- Rinderpest, Africa 19thC
- Morbilliviruses, marine mammals *Nature* 338: 209
- Aspergillosis of sea fans, Carribean. *Nature* 394: 137
- Amphibian chytridiomycosis *PNAS* 95: 9031

Implications for Wildlife: Extinction by Infection

- Gastric brooding frogs, Australia

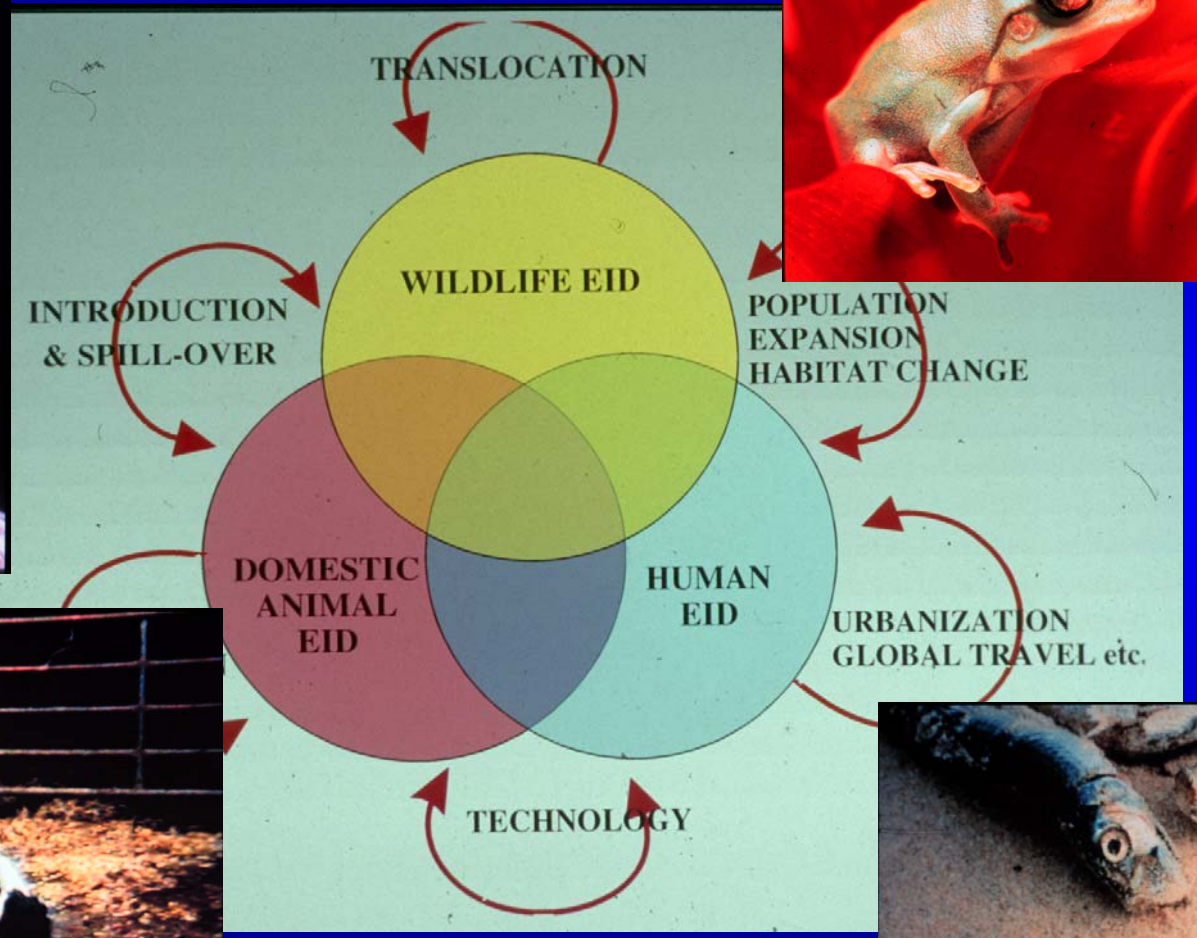
2 unique species now extinct due to fungal disease

- Hawaiian birds

Over one third of original fauna lost to avian malaria and pox

- Partula tree snails

First definitively proven case of extinction due to disease


TRANSLOCATION
WILDLIFE EID
INTRODUCTION
& SPILL-OVER
POPULATION
EXPANSION
HABITAT CHANGE
DOMESTIC
ANIMAL
EID
HUMAN
EID
URBANIZATION
GLOBAL TRAVEL etc.
TECHNOLOGY

Environmental Drivers of Emergence

Human populations

- International Travel
- Climate
- Population Growth
- Agricultural Changes
- Disease Introduction

Wildlife populations

- Animal Translocations
- Climate
- Encroachment
- Pathogen spill-over from agriculture
- Disease Introduction

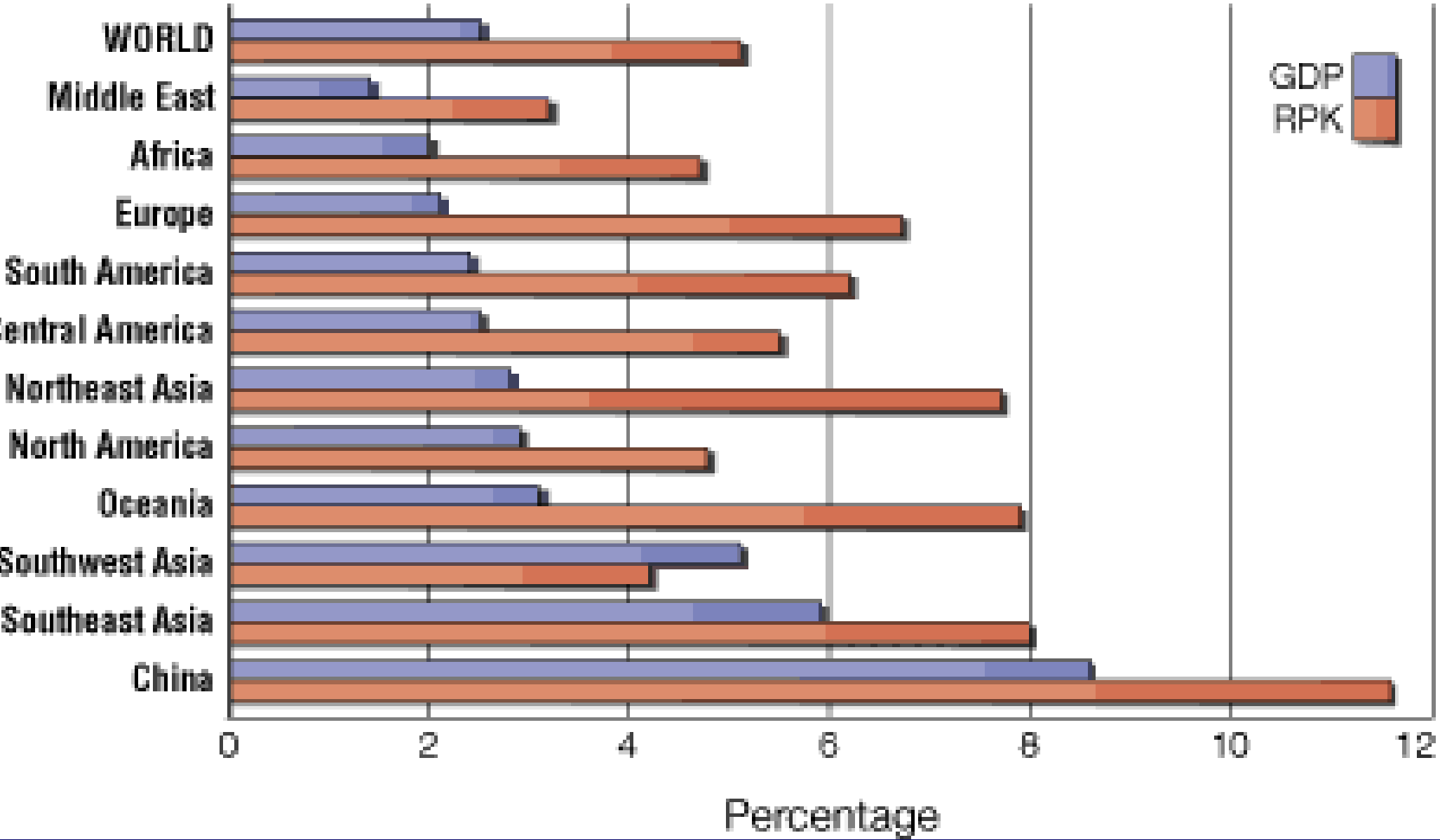
Pathogen pollution

Anthropogenic introduction of hosts and/or pathogens to new areas

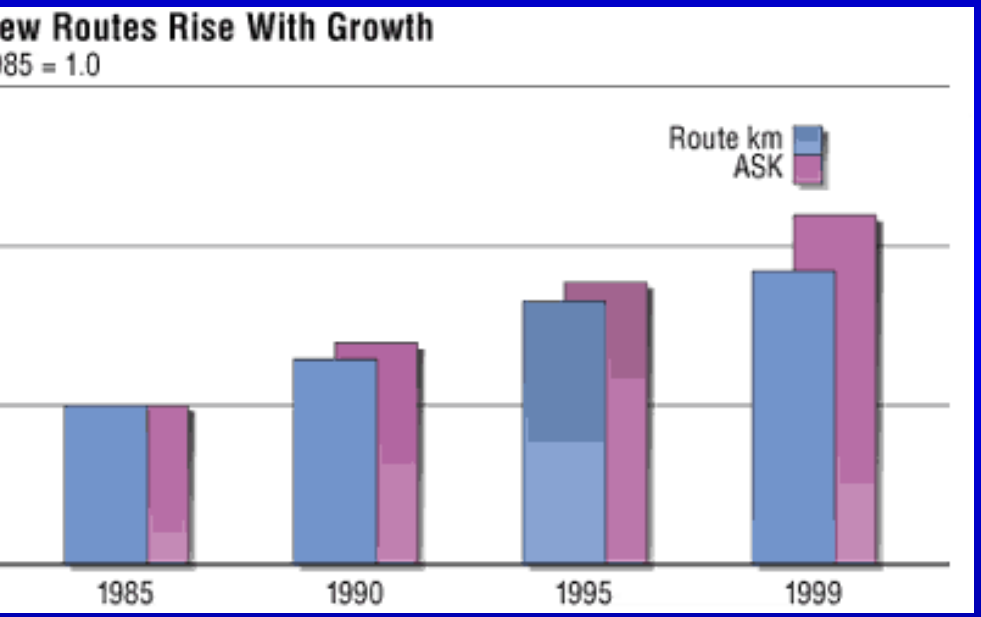
- **Rinderpest – Africa**
- **Crayfish plague - UK**
- **Infectious Salmon Anemia - UK, USA**
- **Bovine TB, Brucellosis - globally**
- **Rabies, Canine Distemper – globally**

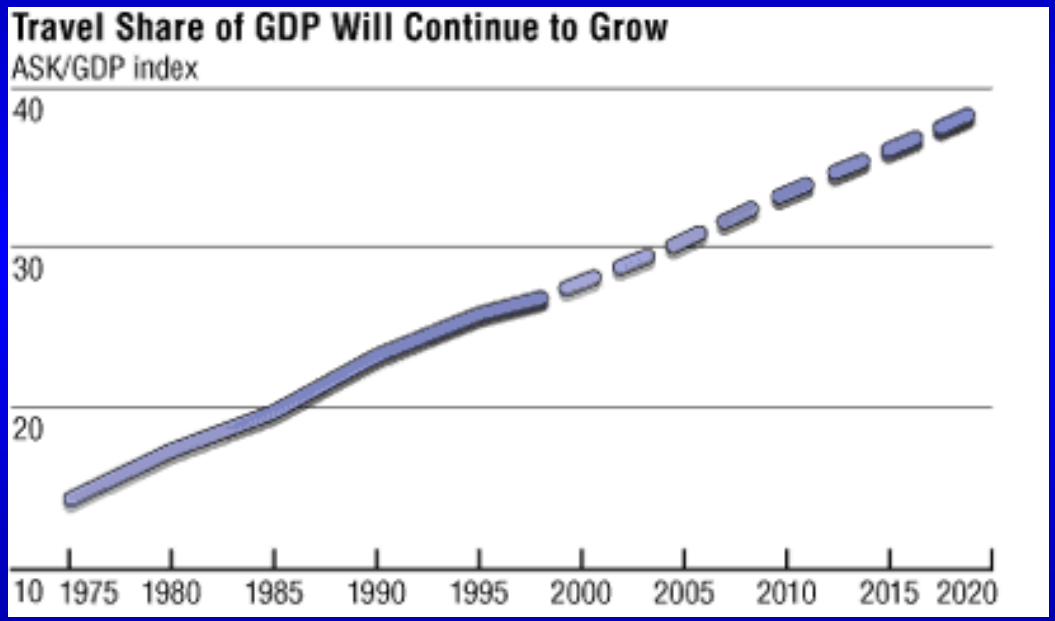
Growth Varies by Region

Annual growth by domicile, 1986–1999



Rate of Globalization is increasing





Zoonotic Skew

- **1709 Human Pathogens 49% zoonotic**
- **156 Emerging human pathogens 73% zoonotic**

Emerging pathogens 3 x more likely to be zoonotic.

Taylor & Woodhouse, ICEID 2000

Nipah virus emergence

- Lack of epidemiological data.
- Multiple reservoir hosts Transmission dynamics not understood
- Complex ecological factors driving emergence: Encroachment, habitat loss (deforestation), exploitation for food, urbanization

Malaysian Agricultural Development 1961-2001

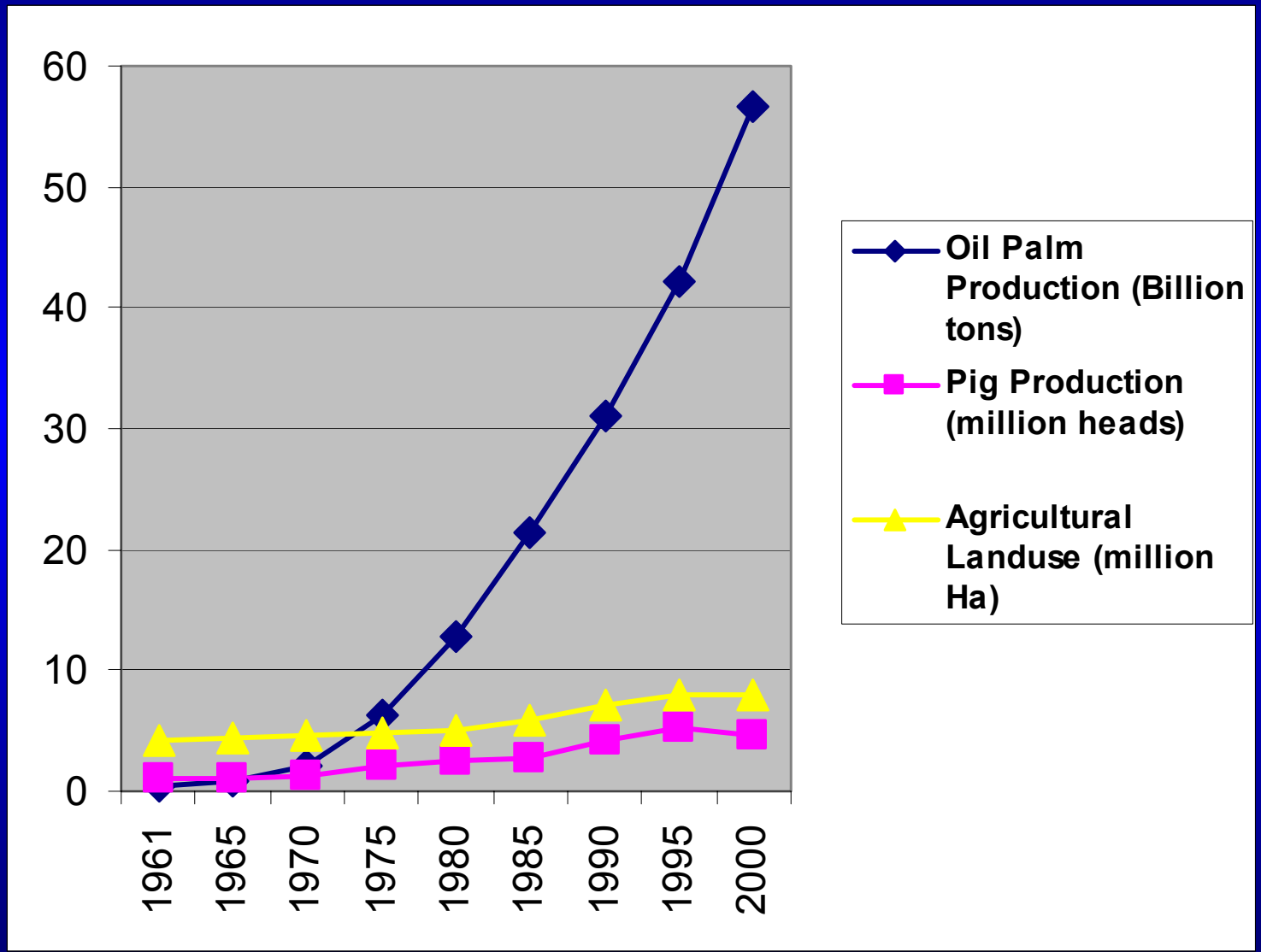
Data from FAO

Deforestation:

Total forest cover

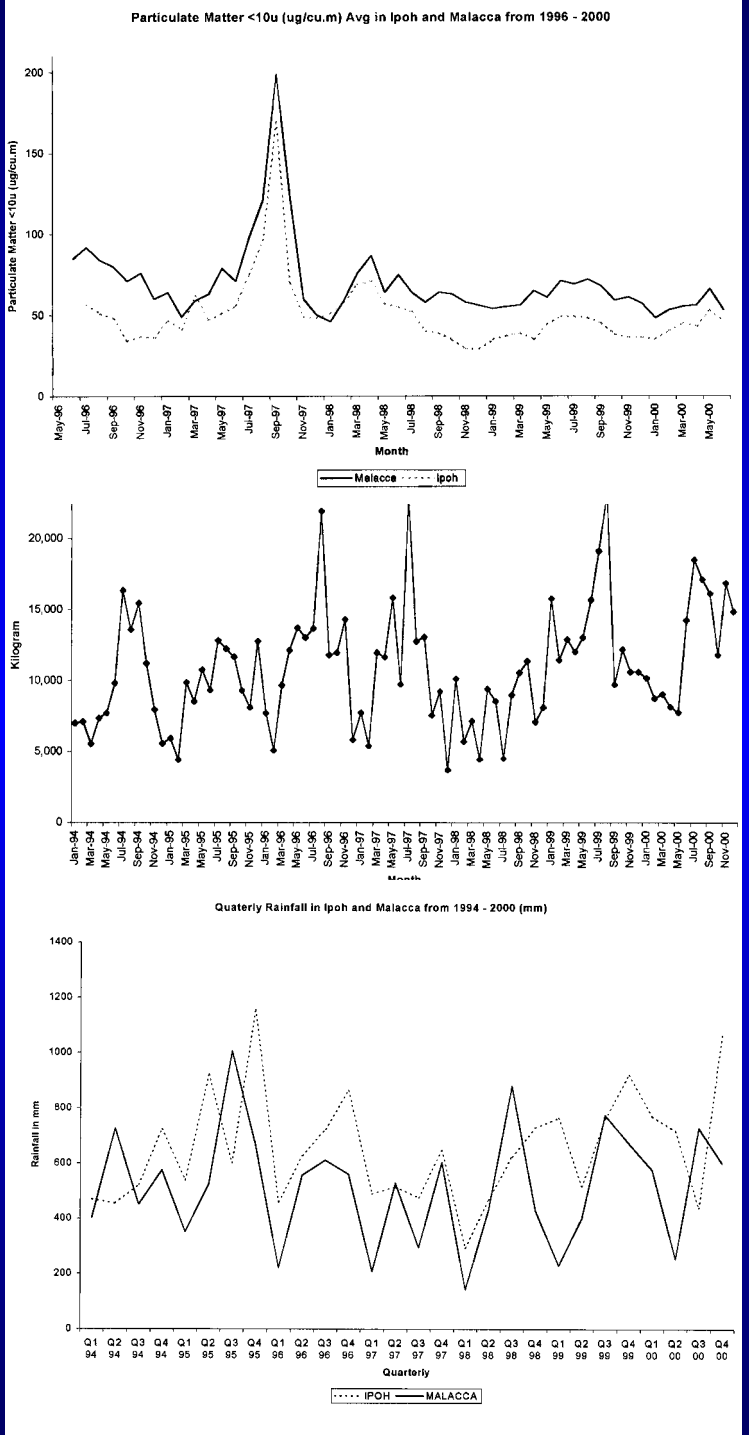
1979 49%

1992 45.3%



Nipah virus complexity

- Extreme ENSO event prior to emergence
- Unprecedented haze due to slash & burn deforestation and drought
- Fruiting trees fail
- Change in bat migration patterns?



New Anthropogenic Factors

• Habitat loss	Lyme Disease
• Fragmentation	Lyme Disease
• Biodiversity loss	Lyme Disease
• Overexploitation	Phocine distemper
• Encroachment	Nipah, Hendra
• Climate change	Vector-borne diseases
• Introduced species	Pathogen pollution
• Deforestation	Oropouche virus
• Pollution	Marine mammal morbilliviruses

Collaboration

The Consortium for Conservation Medicine

- Harvard Med
- Tufts School of Vet Med.
- USGS National Wildlife Health Center
- Wildlife Trust – a conservation NGO

- Think-tank approach
- Linking diverse disciplines
- Investigating anthropogenic changes that drive EIDs

USGS
science for a changing world
National Wildlife Health Center