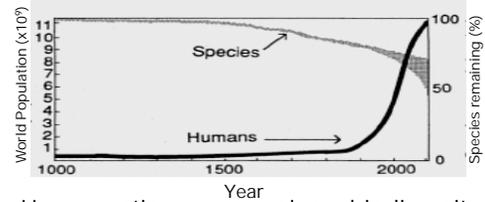


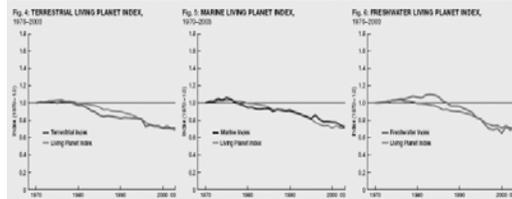
Joe Roman, PhD  
 AAAS Environmental Policy Fellow  
 Located at the  
 U.S. Environmental Protection Agency

## The Biodiversity Crisis

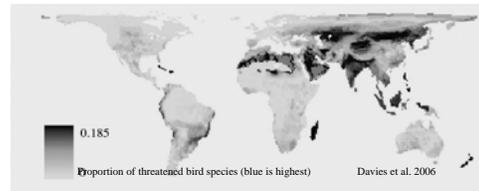


- Human actions are causing a biodiversity crisis, with species extinctions up to 1000 times higher than background rates  
 –Pimm et al. 1995

## Biodiversity Loss Is Accelerating



## Global Decline



- Best predictors of extinction risk are human impacts, such as population density and agricultural activity.
- Conservation priorities should focus on areas of high human density as well as best remaining habitat.

## Ecosystem Services

As Provided by the Diversity of Life on Earth

- Provisioning services
  - Food
  - Freshwater
  - Wood and fiber
  - Fuel
  - Clean air
  - Medicines

## Ecosystem Services

As Provided by the Diversity of Life on Earth

- Regulating services
  - Climate regulation
  - Flood regulation
  - Disease regulation
  - Water purification

## Ecosystem Services

As Provided by the Diversity of Life on Earth

- Cultural services
  - Aesthetic
  - Cultural
  - Recreational
  - Spiritual

## Ecosystem Services

As Provided by the Diversity of Life on Earth

- Supporting services
  - Nutrient cycling
  - Primary production
  - Soil formation

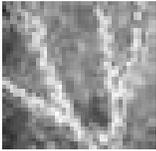
## Chemical Diversity: The Imaginative Leap

- Natural molecules selected by evolution have unbeatable potencies as therapeutic agents
  - 60% of cancer drugs from natural compounds
  - 75% of drugs for infectious diseases from natural compounds

## Chemical Diversity: The Imaginative Leap

- Michellamine B
  - African liana  Ancistrocladus korupensis produces a novel anti-HIV compound
  - Significant amounts needed for preclinical investigation

## Chemical Diversity: The Imaginative Leap

- Bryostatin
  - The bryozoan Bugula neritina has anticancer properties 
  - Oceans may be the medicine cabinet of 21st century

## Chemical Diversity: The Imaginative Leap

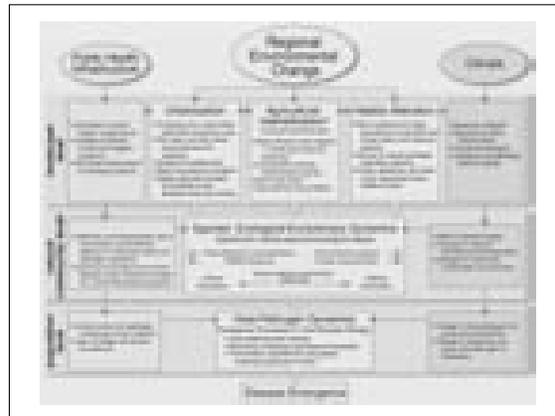
Vacina de sapo

- Campinas Indian Reserve, Acre, Brasil. Shamans administered the kambô remedy, known as vacina de sapo or frog vaccine 
- Potential applications include hypertension, strokes, and other illnesses



## How Changes in Biodiversity Affect Human Health

- Potential mechanisms include changes in:
  - Host and pathogen density and relative abundance
  - Contact, exposure, and transmission
  - Landscape heterogeneity
  - Human susceptibility

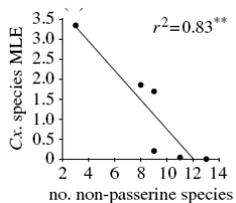


## Biodiversity and West Nile Virus

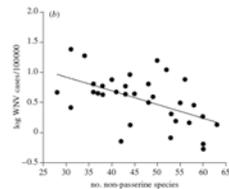
- Vector-borne diseases, with much of their life cycle outside of the human host, may be most sensitive to change in environment
- Mosquito-borne West Nile virus detected in US in 1999
- Wild birds serve as the primary reservoir hosts

## Biodiversity and West Nile Virus

- Factors accounting for variation in WNV prevalence are poorly known
- Ezenwa et al. (2006) examined the diversity of bird reservoirs in association with WNV infection in mosquitoes across SE Louisiana



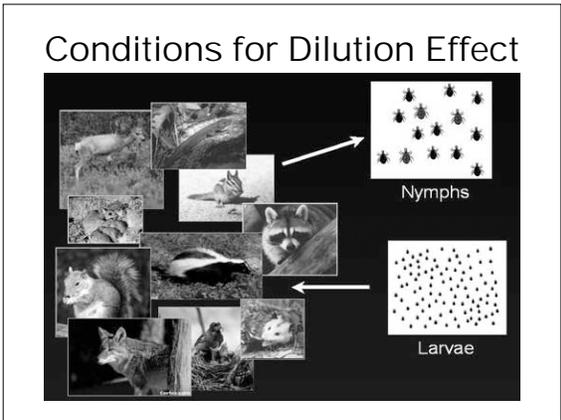
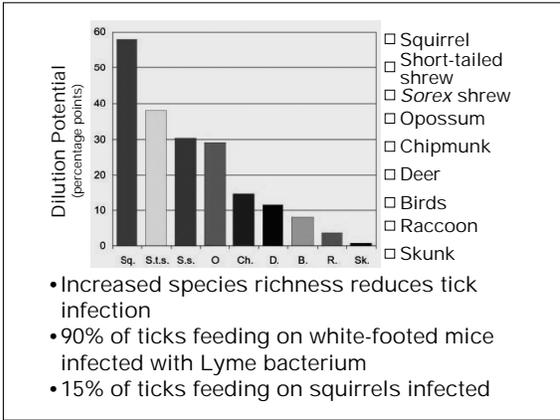
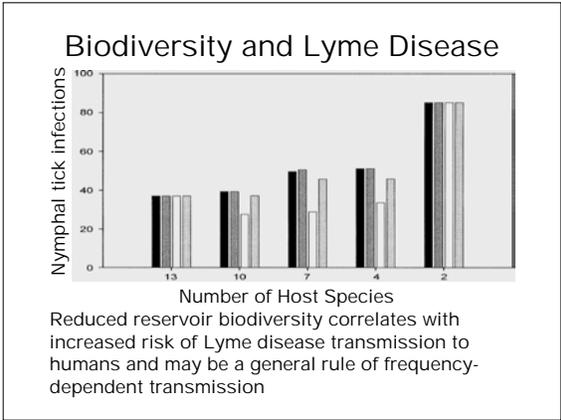
Infection rates of *Culex* mosquitoes declined with increase of nonpasserine species richness



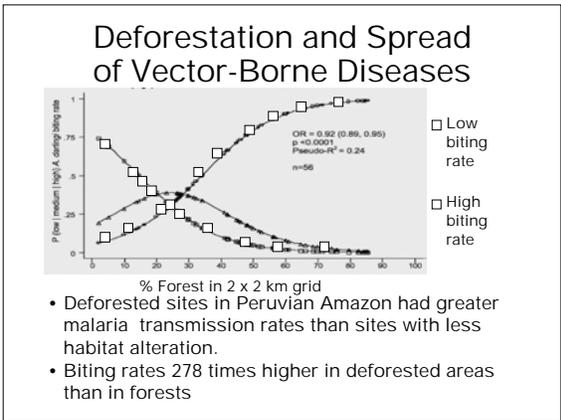
Lower infection rates correlated with lower numbers of human cases of WNV

Links between high biodiversity and reduced disease risk may help account for distribution patterns





- ### Conditions for Dilution Effect
- Generalist vector
  - Horizontal transfer of pathogen
  - Variation in reservoir competence among hosts
  - Positive correlation between reservoir competence and percentage of tick meals supplied by hosts in the community



- ### Forest Fragmentation and Disease Transmission
- Biodiversity loss increases frequency of interspecific interactions, increasing pathogen transmission.
  - Intensity of gastrointestinal parasite infection is elevated in red colobus monkeys inhabiting forest fragments with reduced plant biodiversity and high rates of human encroachment.

## Host Shifts in Forest Systems

- Deprived of their primary food sources vampire bats seek alternative hosts: humans.
- In rural areas, shift occurred when pigs and cattle were eliminated.
- Massive attacks occurred in gold mining camps of Amazon when food sources were depleted because of overhunting and noise.
- More attacks increased likelihood of rabies transmission.

## Wildlife Trade and Disease Emergence

- Consumption of wild animal meat
  - Central Africa: more than 1 billion kg per year
  - Amazon Basin: 67-164 million kg per year approximately 6.4 to 15.7 million animals
  - Outbreaks, including SARS, have caused hundreds of billions of dollars of economic damage globally

## Invasive Species

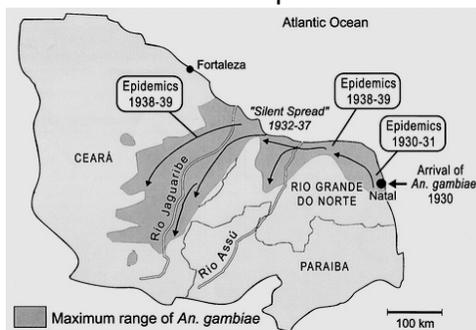
- Invasive species, along with over hunting and habitat degradation, is one of the top three causes for species extinctions.



## Invasive Species

- Decline and extinction of Hawaiian birds
  - Common house mosquito, *Culex quinquefasciatus*, first transported to Maui by whaling ship in 1826
  - Later invasions of *Plasmodium relictum* resulted in decline of many native birds.
  - Thirteen species of Hawaiian honeycreepers have gone extinct since Europeans arrived.

## Invasive Species

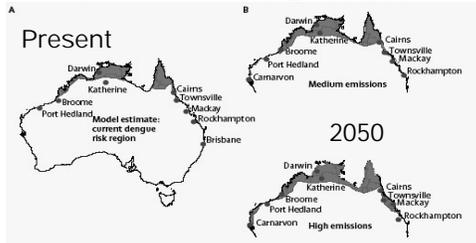


## Invasive Species

- Human-aided transport is responsible for arrival and spread of most invasive vectors, such as fleas, lice, kissing bugs, and mosquitoes.
- Nonindigenous vectors have fomented epidemics of human diseases, such as malaria, yellow fever, typhus, and plague.



## Global Warming and Spread of Infectious Disease



Projected spread of *A. aegypti* in Australia by 2050

## Global Warming and Spread of Infectious Disease

- Warmer climates have led to increased algal blooms, creating favorable conditions for *Vibrio cholerae*.
- Changes in temperature and humidity increased reproduction of malaria vectors.

## Biodiversity-Health Research at US Environmental Protection Agency

<http://es.epa.gov/ncer/biodiversity/>

- Exploratory research funding
  - How do anthropogenic drivers of changes in biodiversity directly affect the transmission of human disease?
  - What are the mechanisms that connect these issues?
  - Multidisciplinary approach to exploring root causes of disease emergence and spread to assist in prevention and mitigation.

## Workshop on Biodiversity and Human Health

- Sept. 14-15, 2006, held at Smithsonian Institution Washington, DC
  - Interdisciplinary workshop of researchers, practitioners, and decision makers in ecology, public health, social sciences, and remote sensing to discuss
    - The state of the science and research priorities
    - Risk analysis and creation of monitoring and forecasting network
    - Types of data and models needed to map the relationship between biodiversity decline and EIDs
- <http://www.yale.edu/yibs/biodiversity.html>

## Partners and Collaborators

- Institute of Ecosystem Studies
- Asia-Pacific Institute of Tropical Medicine and Infectious Diseases
- National Oceanic and Atmospheric Administration (NOAA)
- NASA Ames Research Center
- World Conservation Union (IUCN)
- World Federation of Public Health Associations
- American Public Health Association (APHA)
- World Health Organization (WHO)
- Smithsonian Institution
- Yale Center for EcoEpidemiology

## Protecting Biodiversity, Protecting Human Health

- Environmental factors contribute to emerging diseases and environmental approaches can reduce their burden:
  - Develop new tools to integrate data for improved understanding of relationships between biodiversity and human health.
  - Use earth observation and field data to track and analyze global relationships between habitat alteration, biodiversity loss, vector ecology, and the emergence and spread of infectious disease.

## Protecting Biodiversity, Protecting Human Health

- Environmental factors contribute to emerging diseases and environmental approaches can reduce their burden:
  - Inform decision making to benefit society.
  - Develop new constituency and new approaches for conserving biodiversity.