

Global biogeography of human infectious diseases - agents of change



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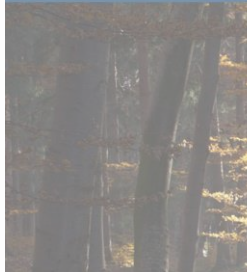
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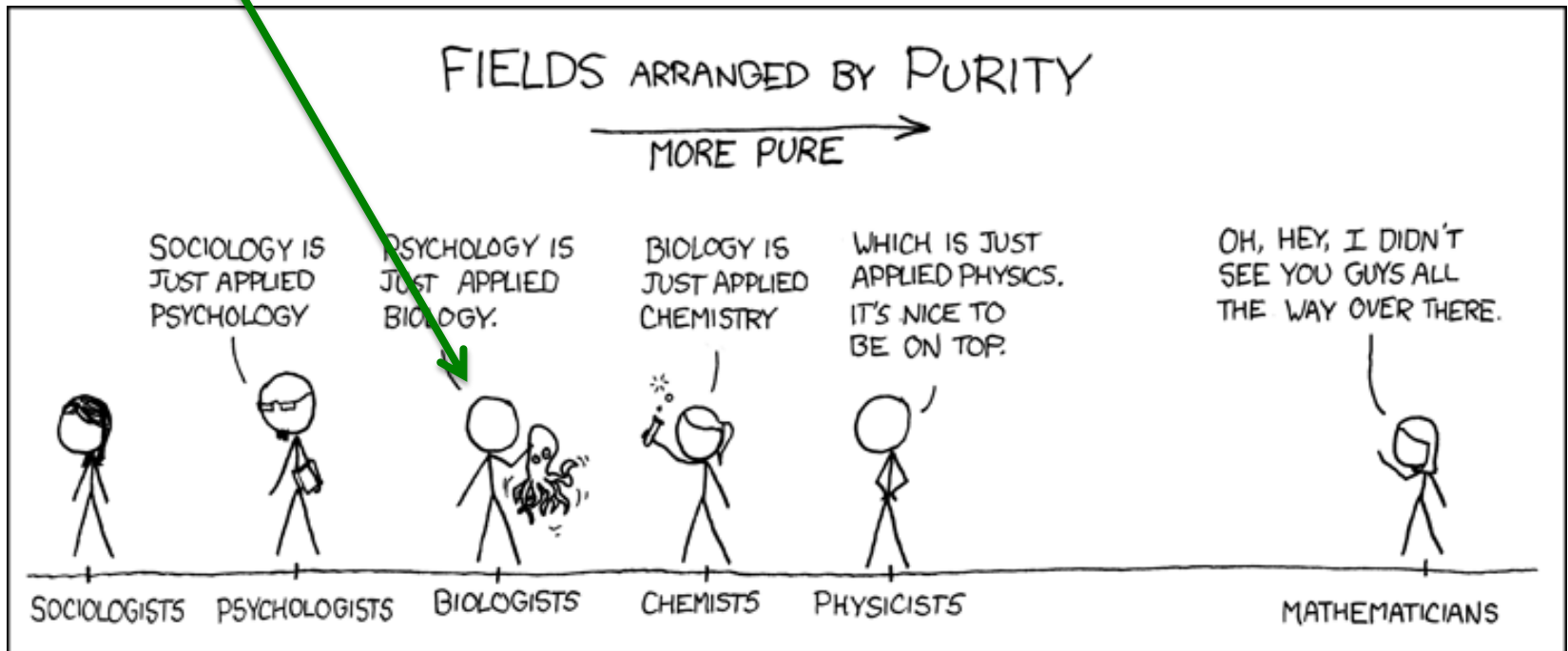


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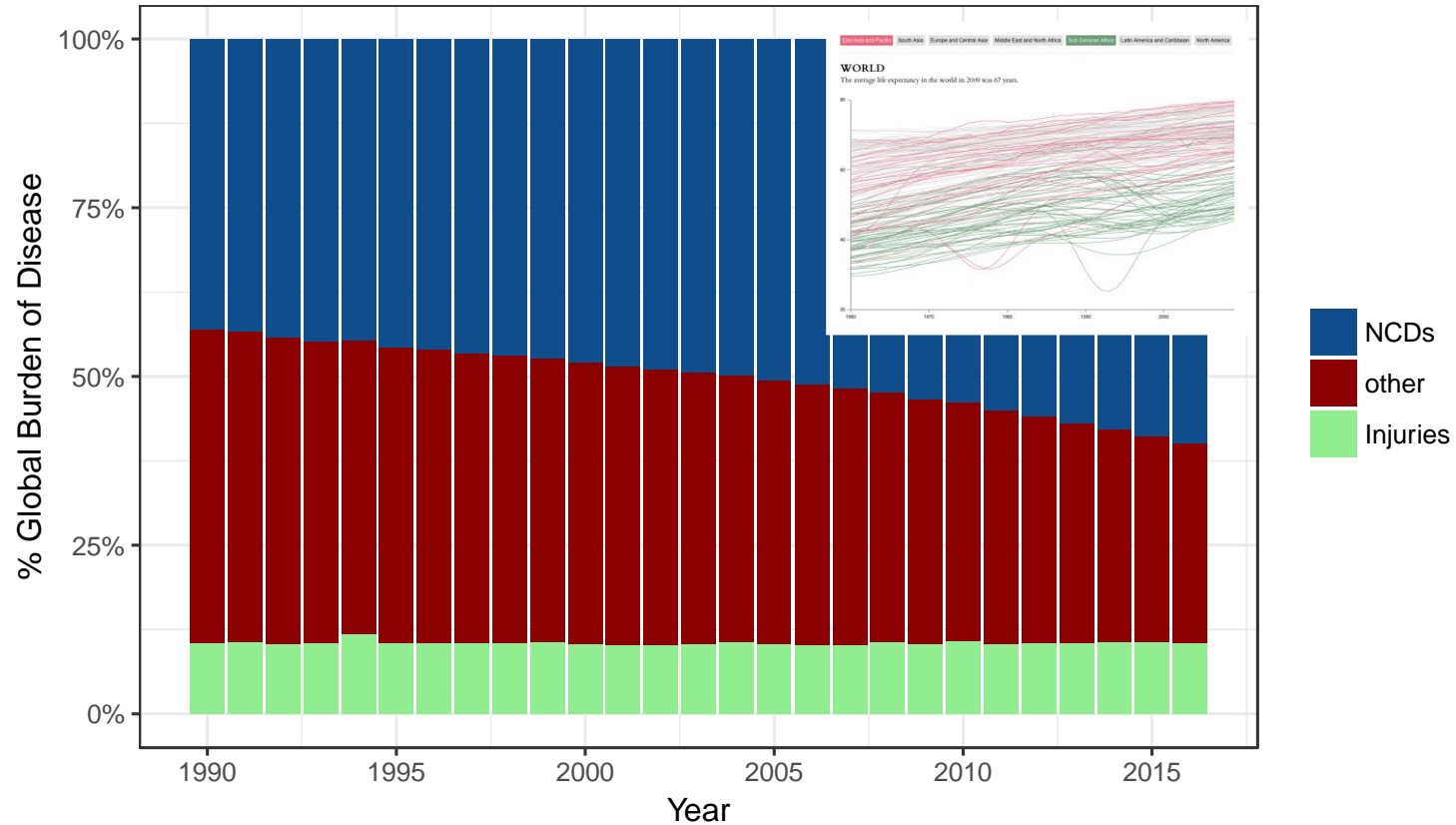
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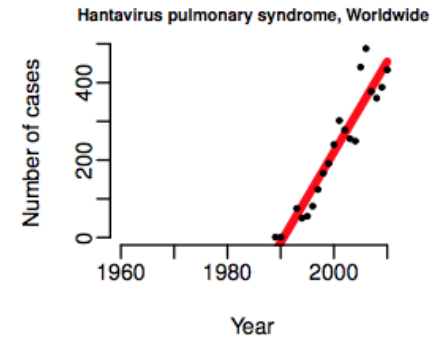
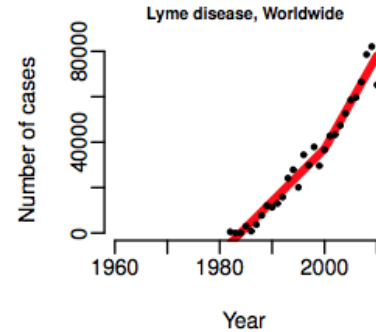
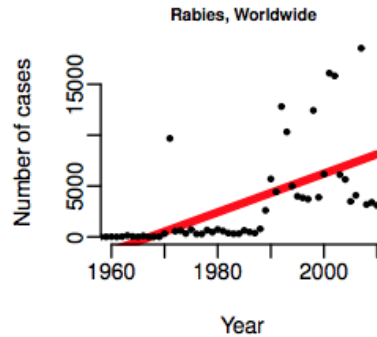
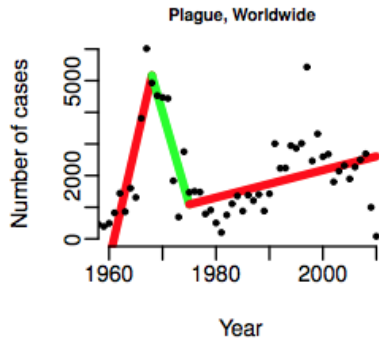
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- Major successes in health in past 50-100yrs
- Particularly burden from infectious diseases



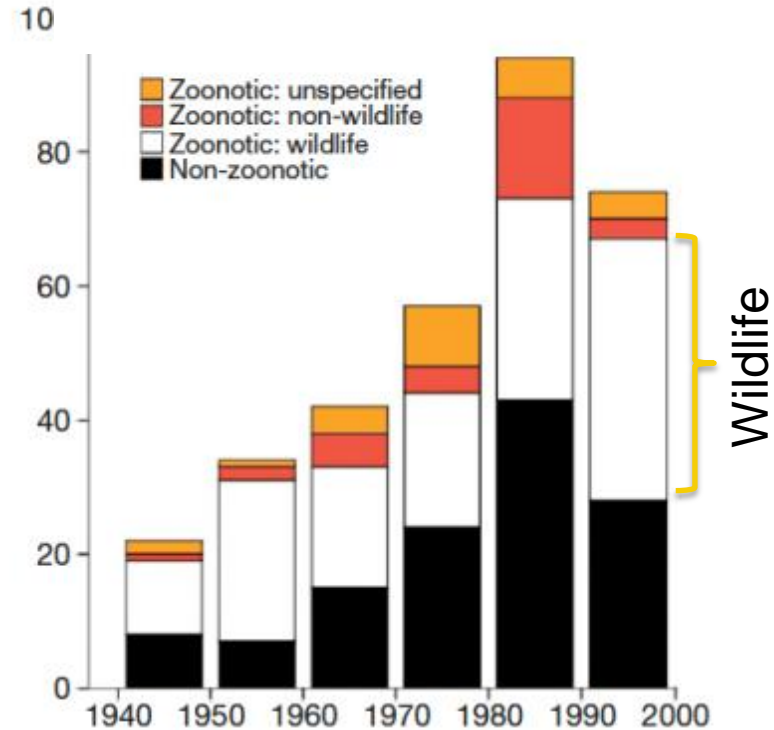
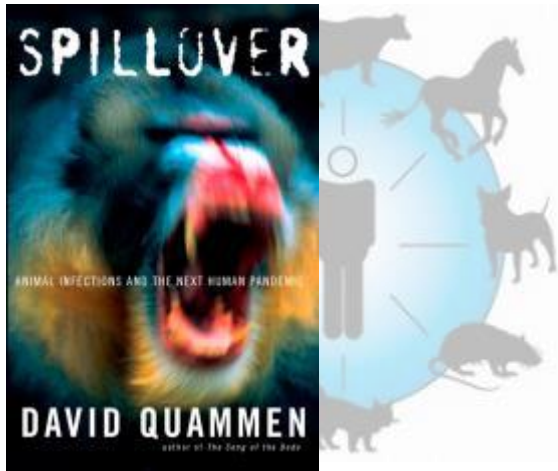
Emerging infectious diseases (EIDs)



Funk et al. 2013

Emerging infectious diseases (EIDs)

- EIDs on the rise globally
- ~60% from animals (“zoonotic”)
- Mostly wildlife



Jones et al. 2008

Infectious diseases: the role of animals

Most known human infectious diseases are shared with animals



Rabies, Influenza A, Ebola, SARS, Q Fever, Toxoplasmosis, Salmonella, Brucellosis, Hendra, Echinococcosis, Anthrax, ~~Zoonosis~~ Nipah, Psittacosis, ~~Plague~~ Plague, Bas Congo, Monkeypox, Rift Valley, Leptospirosis, Schistosomiasis, Leishmaniasis, Chagas disease, Hantavirus, Japanese B encephalitis.....



■ Shared with animals (61%)

■ Not known to be shared (39%)

Resulting in over 1,000,000,000 human cases every year

Climate change impacts - organisms to ecosystems

Temperature

As temperature increases...

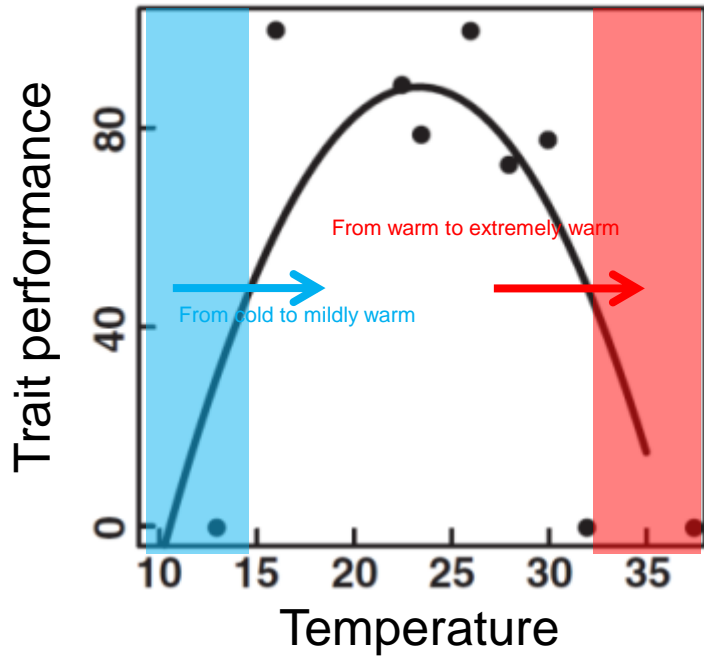
--> atoms speed up...

--> enzymatic reactions speed up

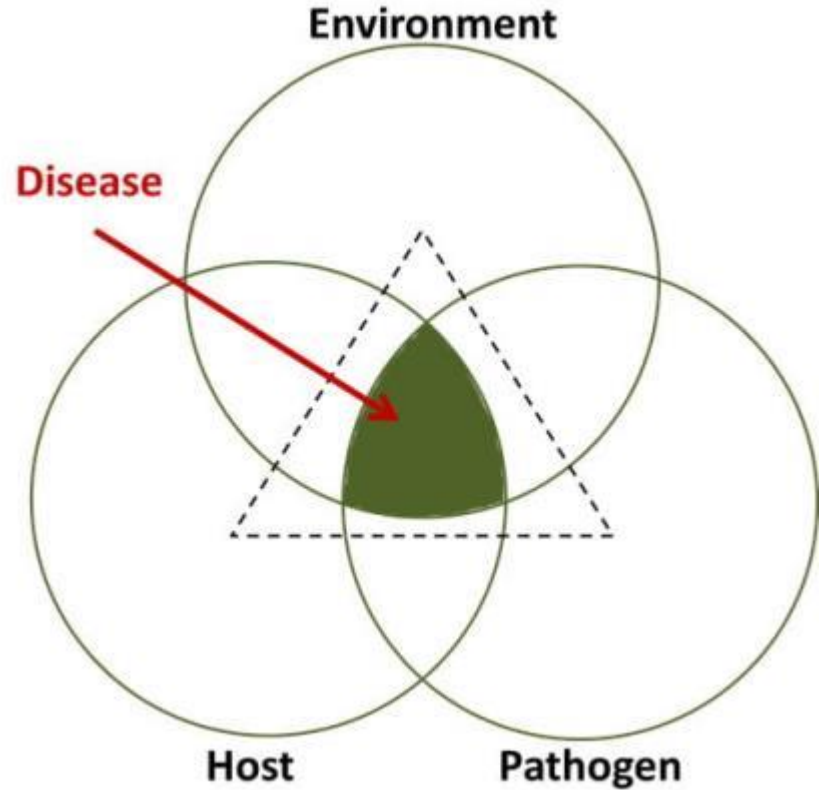
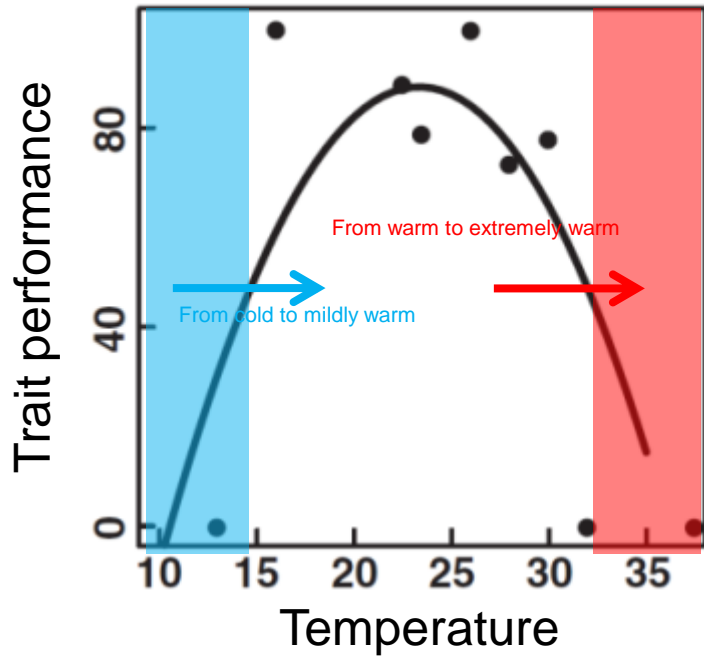
ectotherms



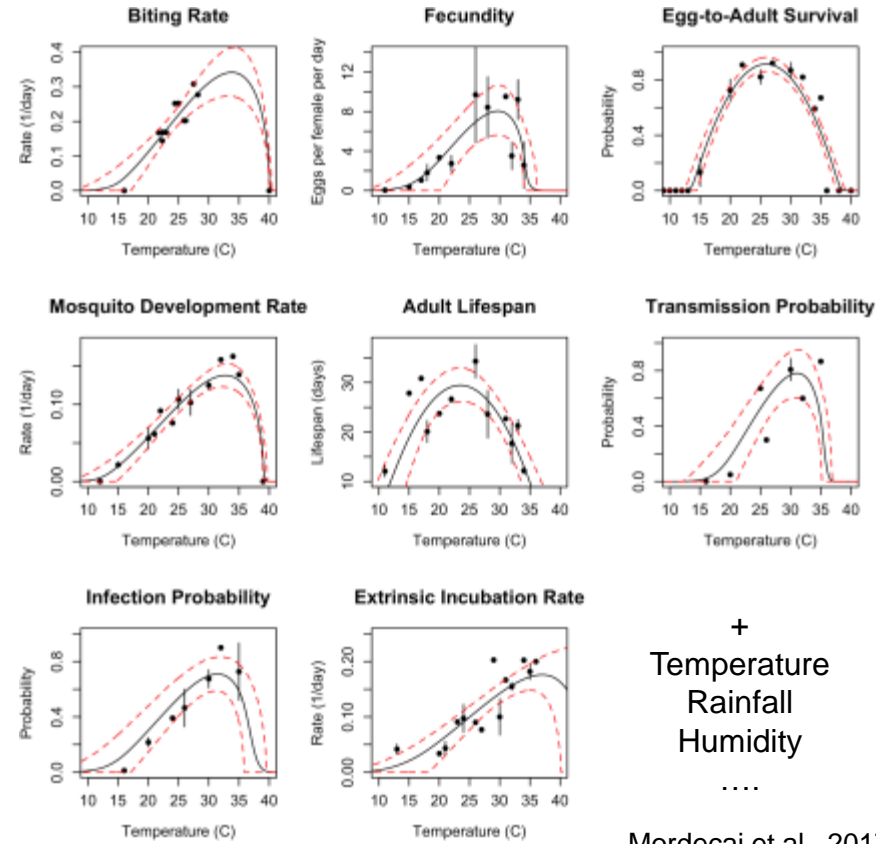
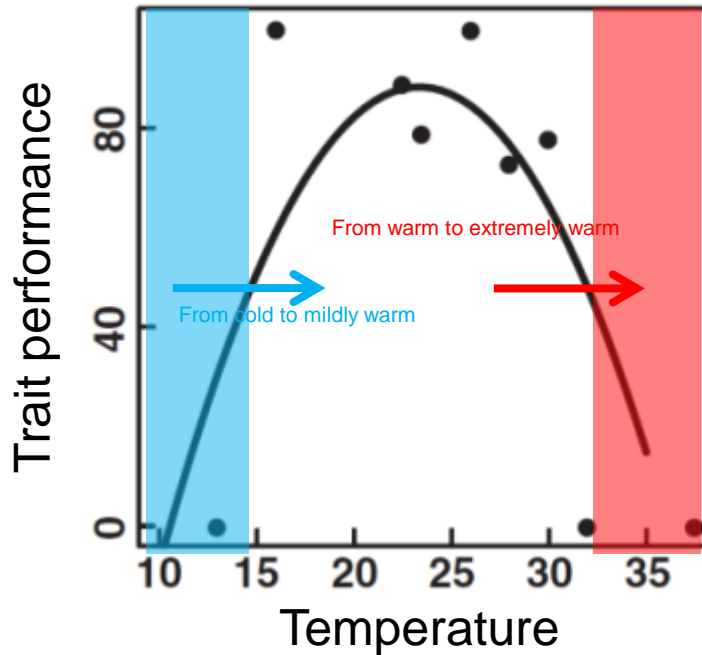
Trait performance



Trait performance



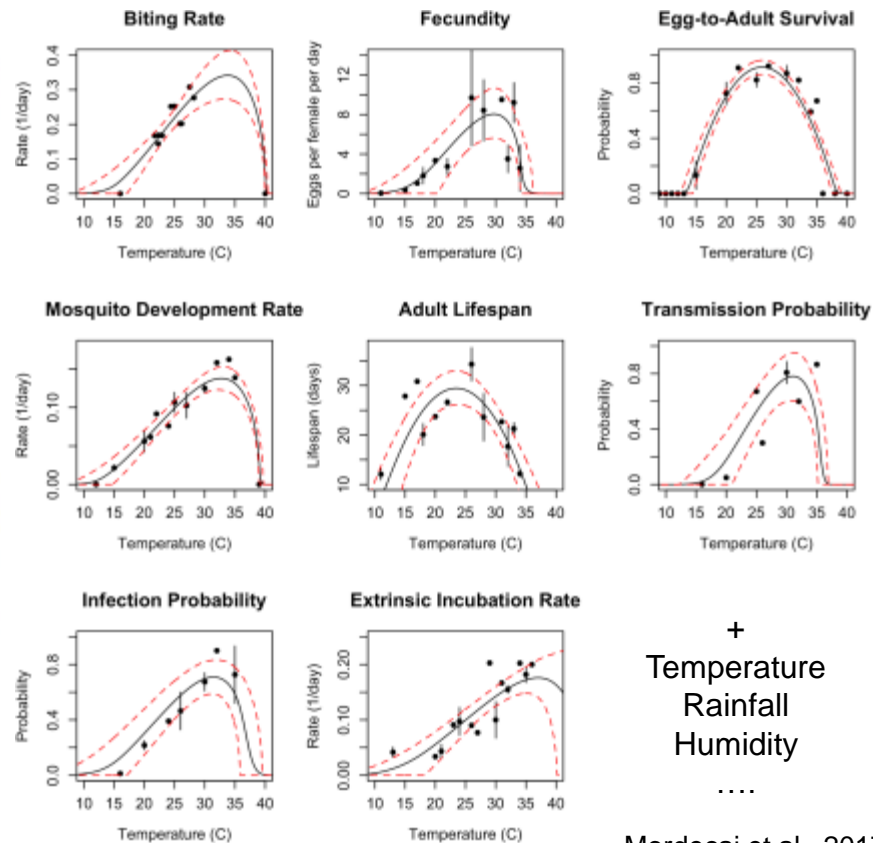
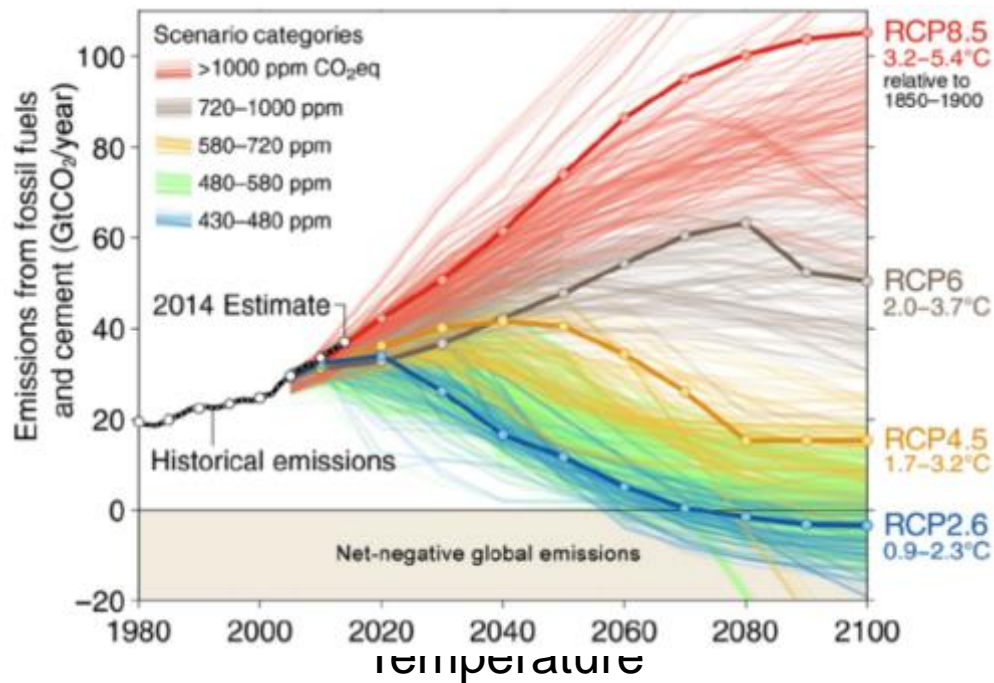
Trait performance



+
Temperature
Rainfall
Humidity



Trait performance

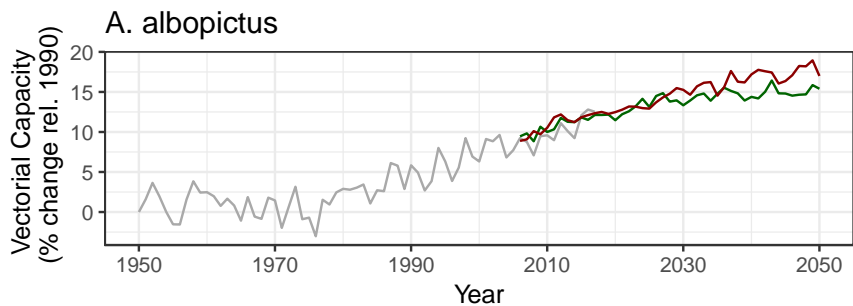


+
Temperature
Rainfall
Humidity
...

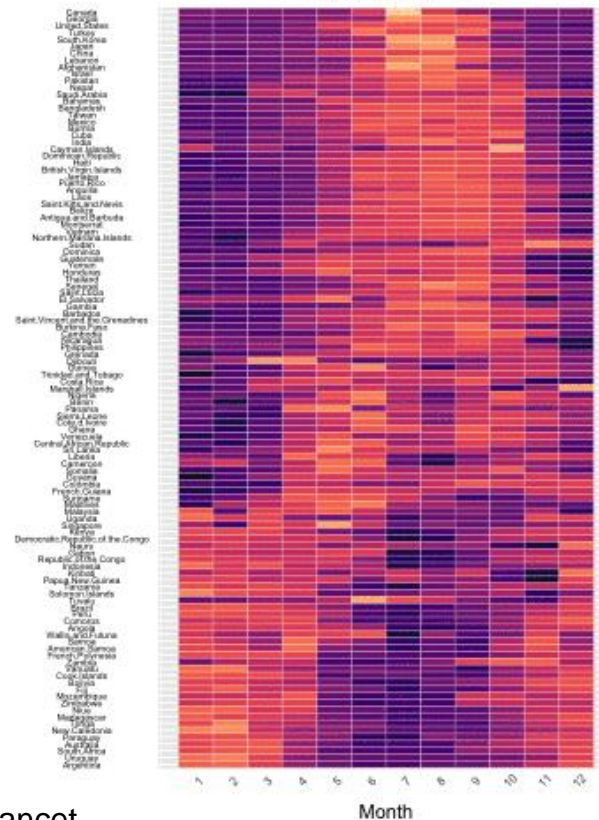
Vectorial capacity

$$VC = \frac{ma^2 b_h b_m e^{-\mu_m n}}{\mu_m}$$

a = vector biting rate,
 b_h = vector to human transmission per bite
 b_m = human to vector infection per bite,
 n = extrinsic incubation period – EIP,
 μ_m = vector mortality rate,
 m = female vector-to-human population ratio



Seasonal profiles 1950



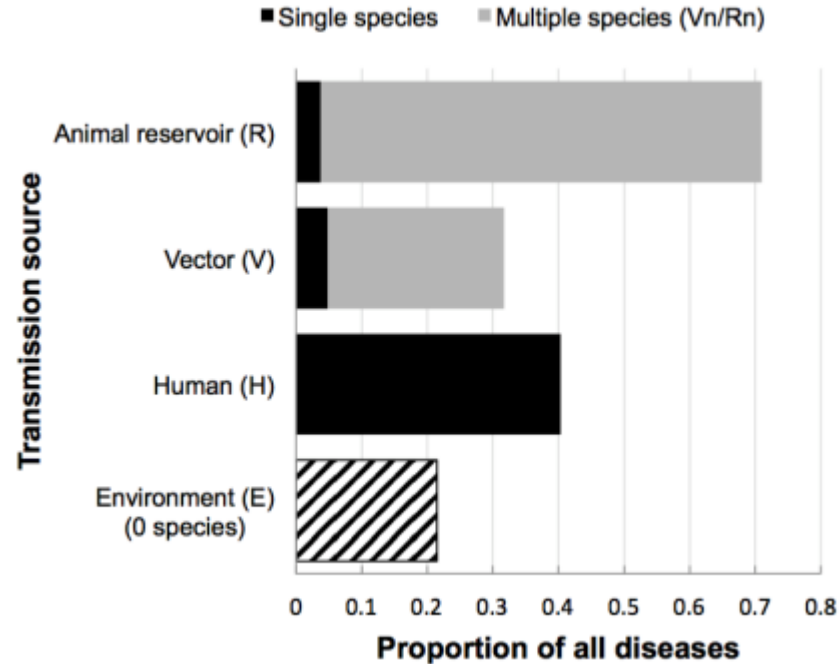
Pathodiversity

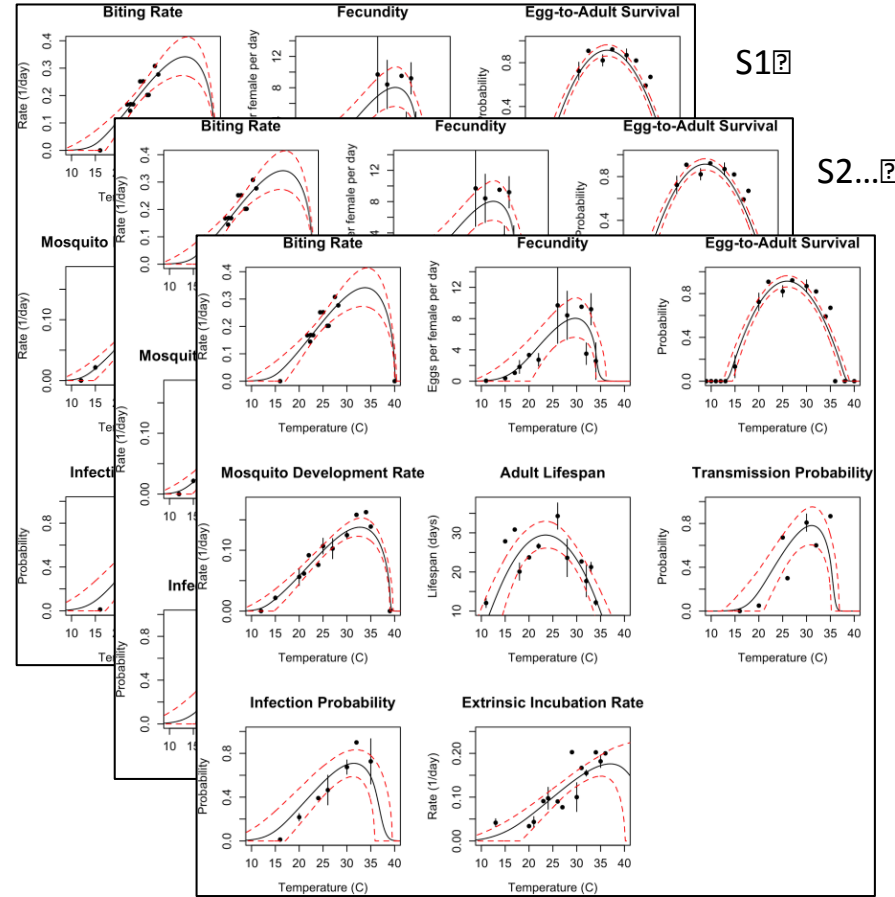
2107 pathogens in humans (Wardeh et al. 2015)

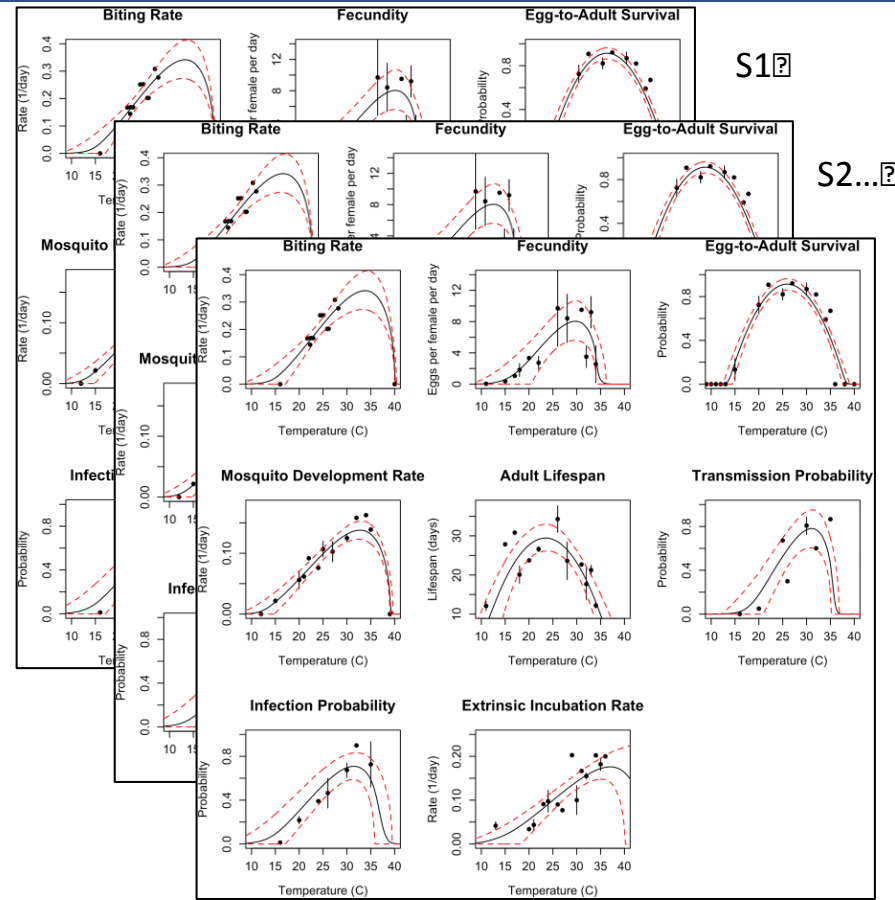
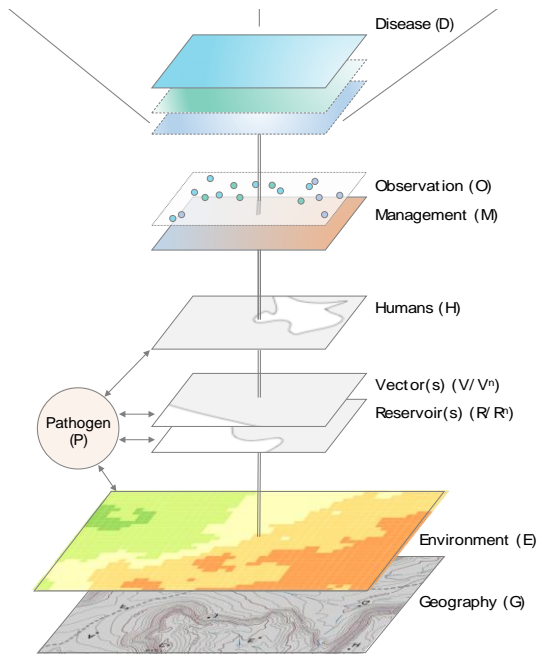
- 274 viruses
- 1003 bacteria
- 447 fungi
- 82 protozoa
- 301 helminths

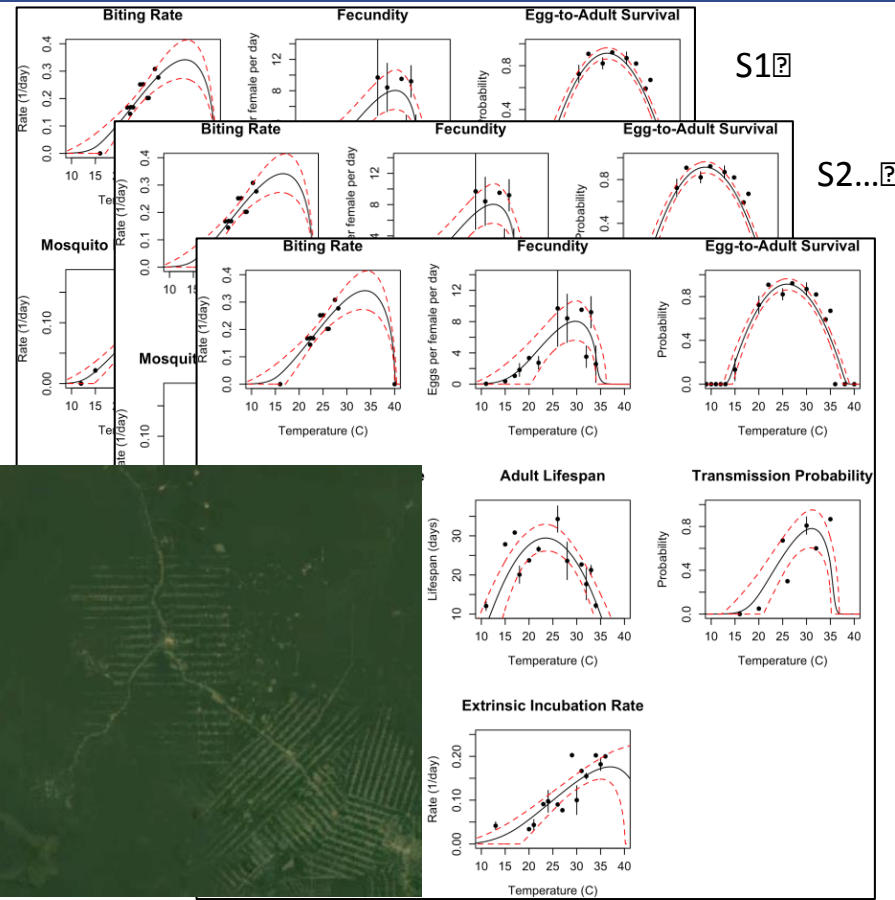
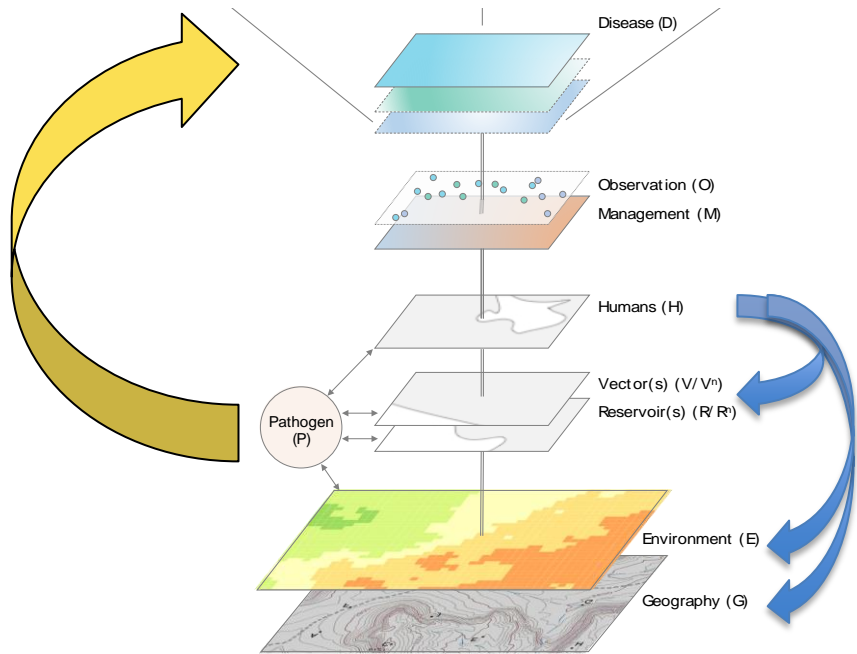
Majority:

- Zoonotic
- Multiple zoonotic hosts
- If vector-borne, then multiple vectors



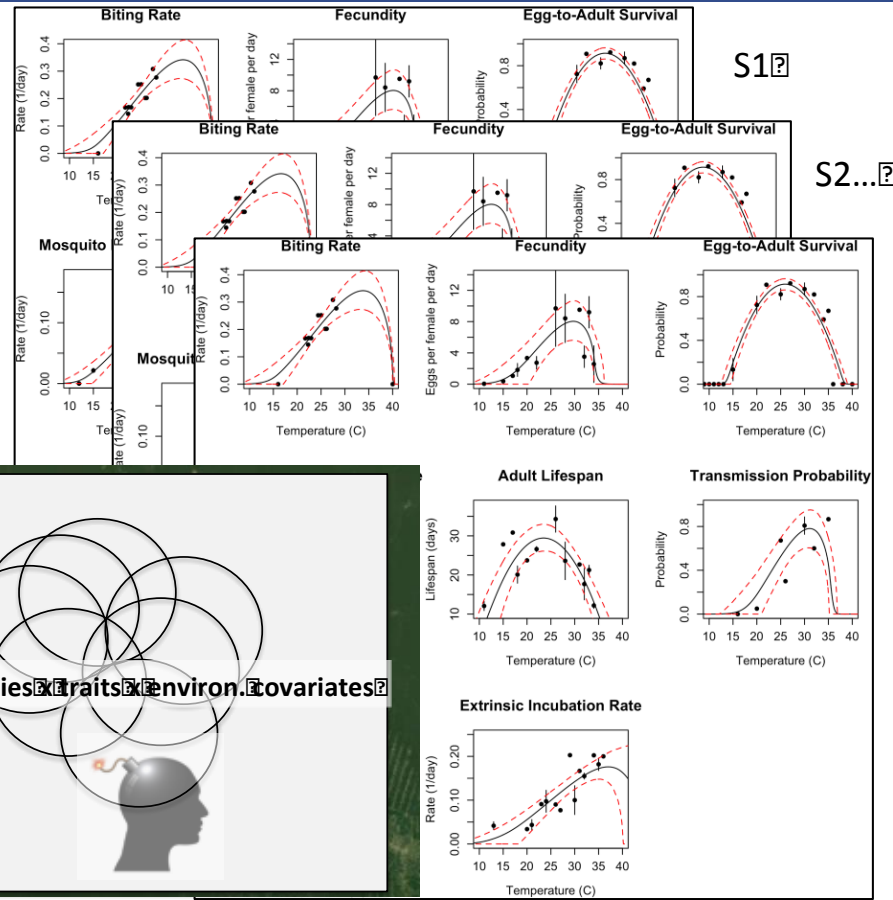
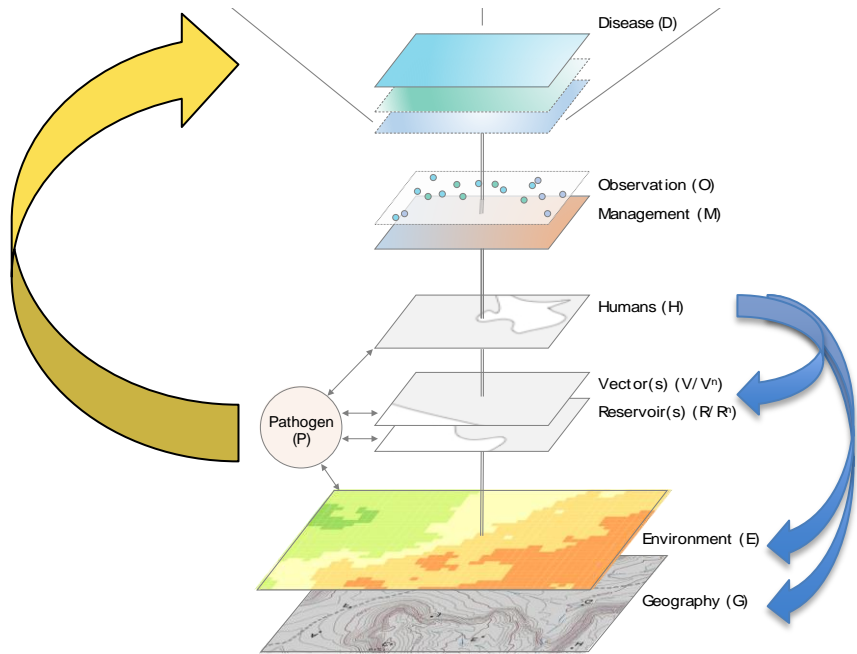






S1?

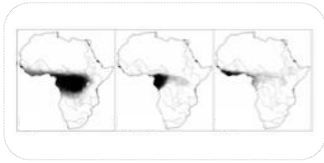
S2...?



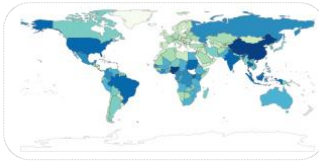
Pathogeography

Multi-disease biogeographic patterns

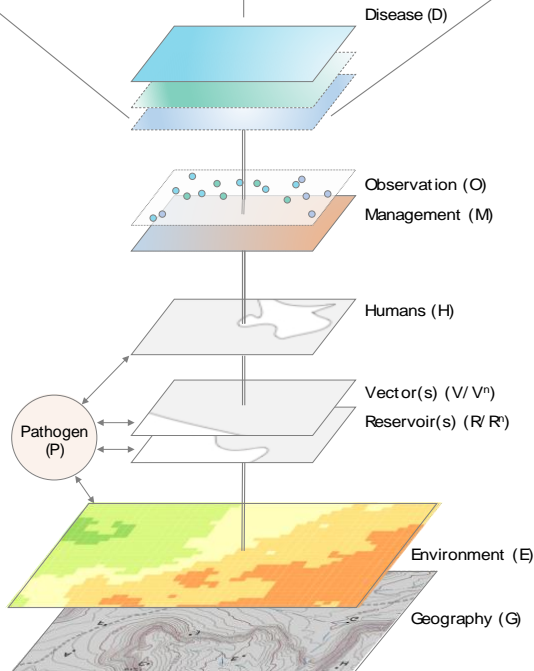
e.g. Chorotypes



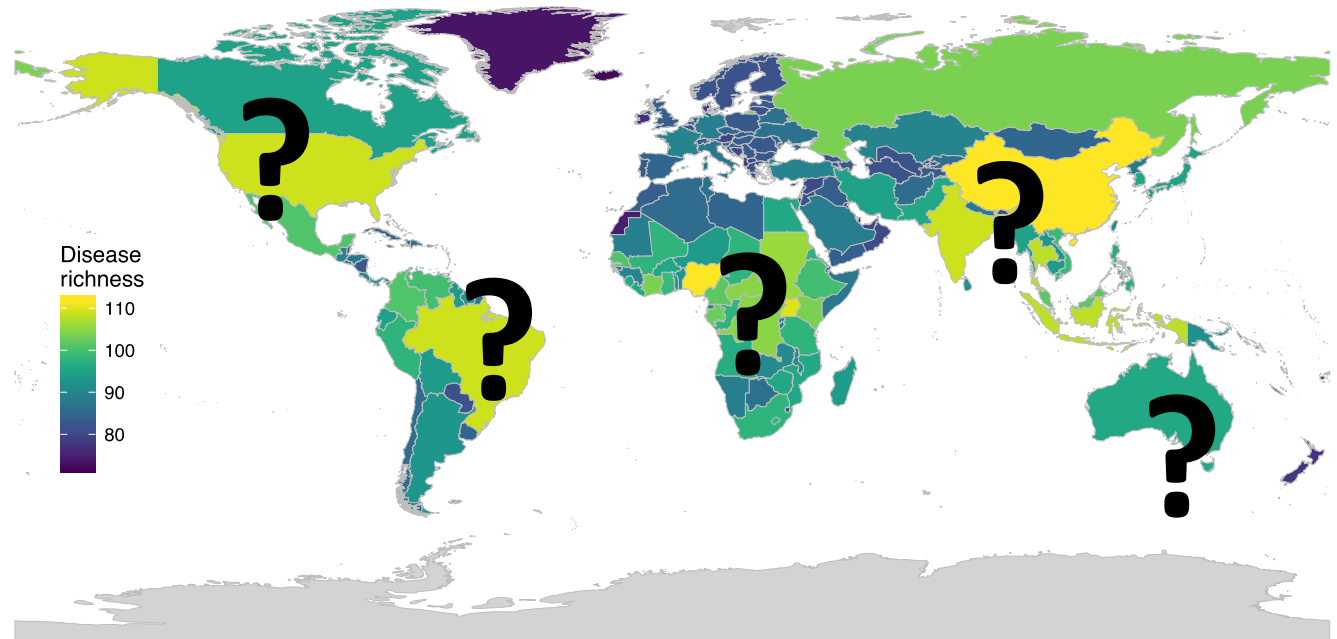
e.g. Richness patterns



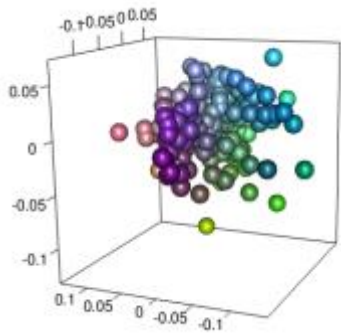
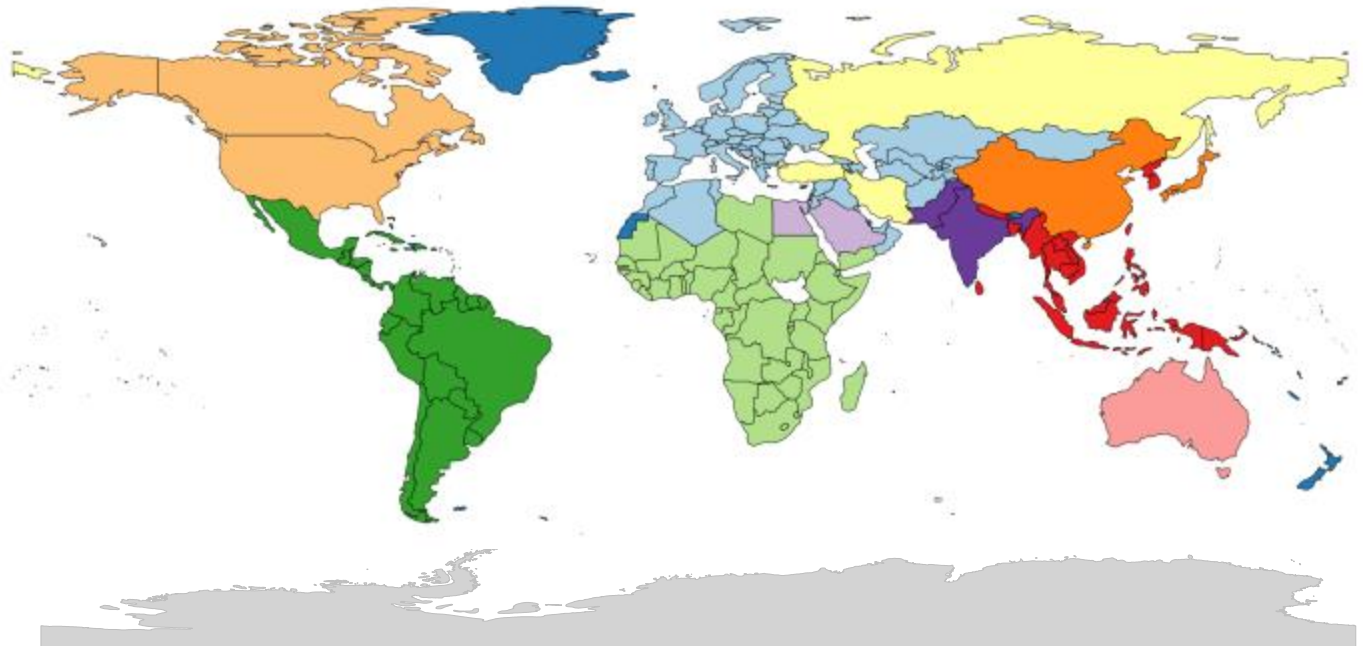
e.g. Bioregionalisation



Disease identity (which diseases where?)



Regionalisation



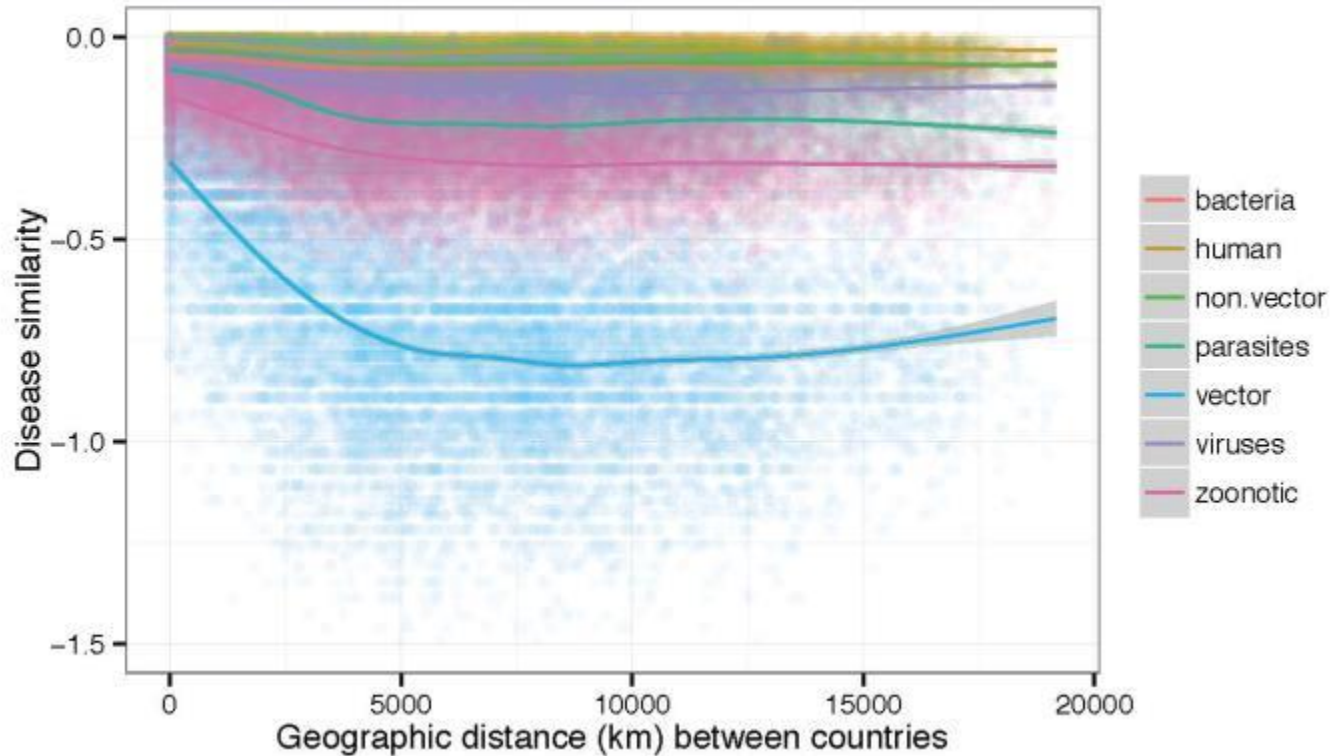
Pathogeography

Regionalisation



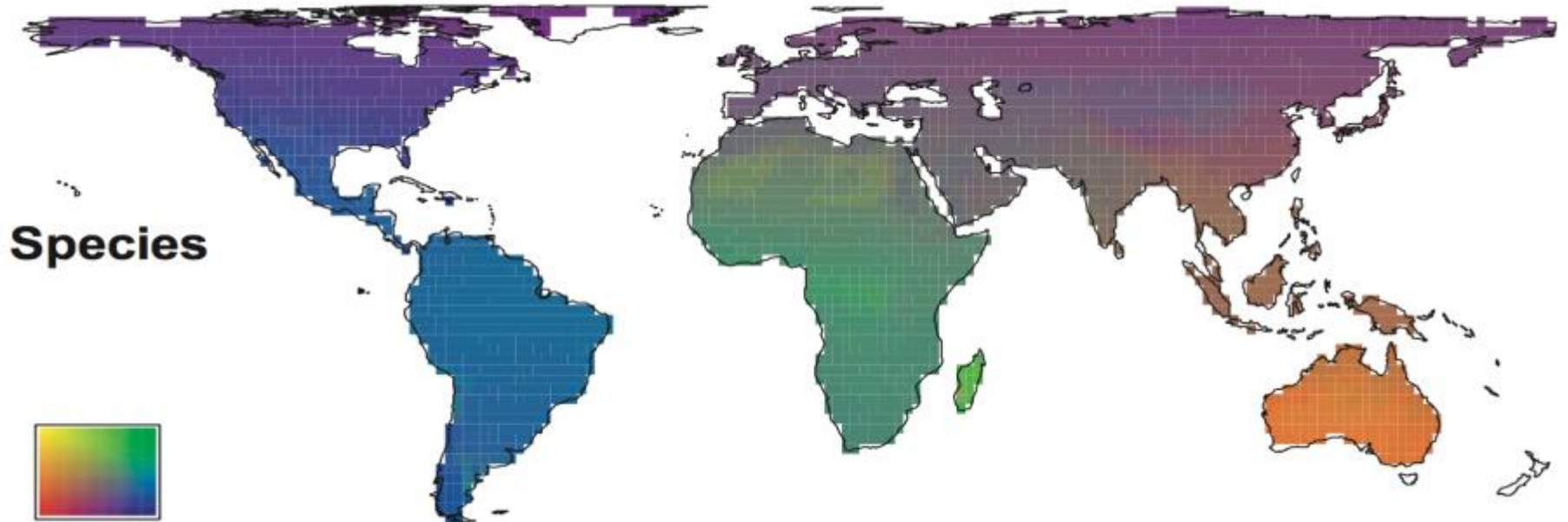
Pathogeography

Distance



Pathogeography

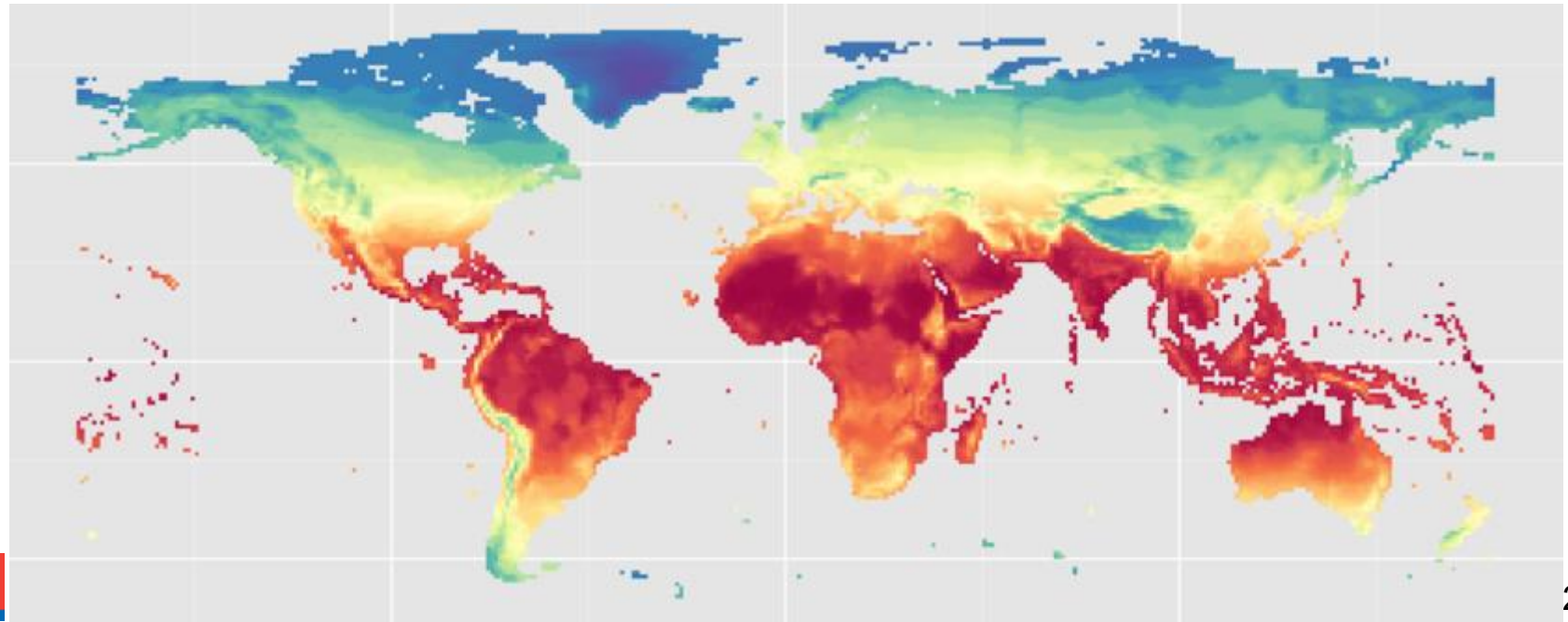
Biodiversity



Species



Climate



Connectivity

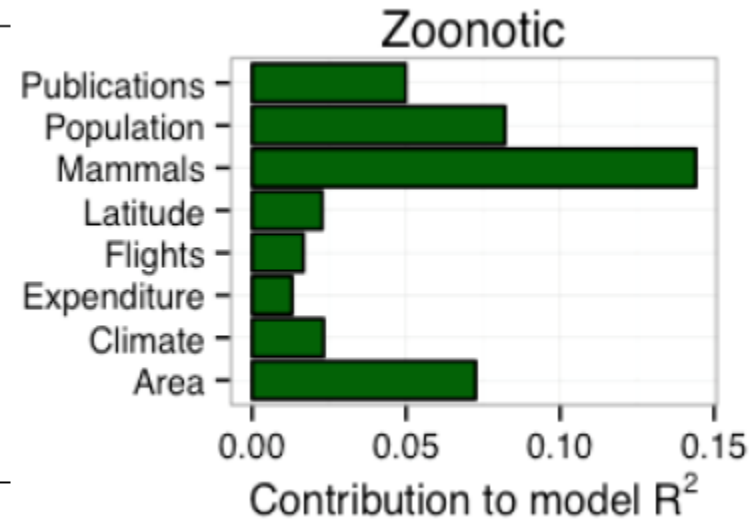


Pathogeography

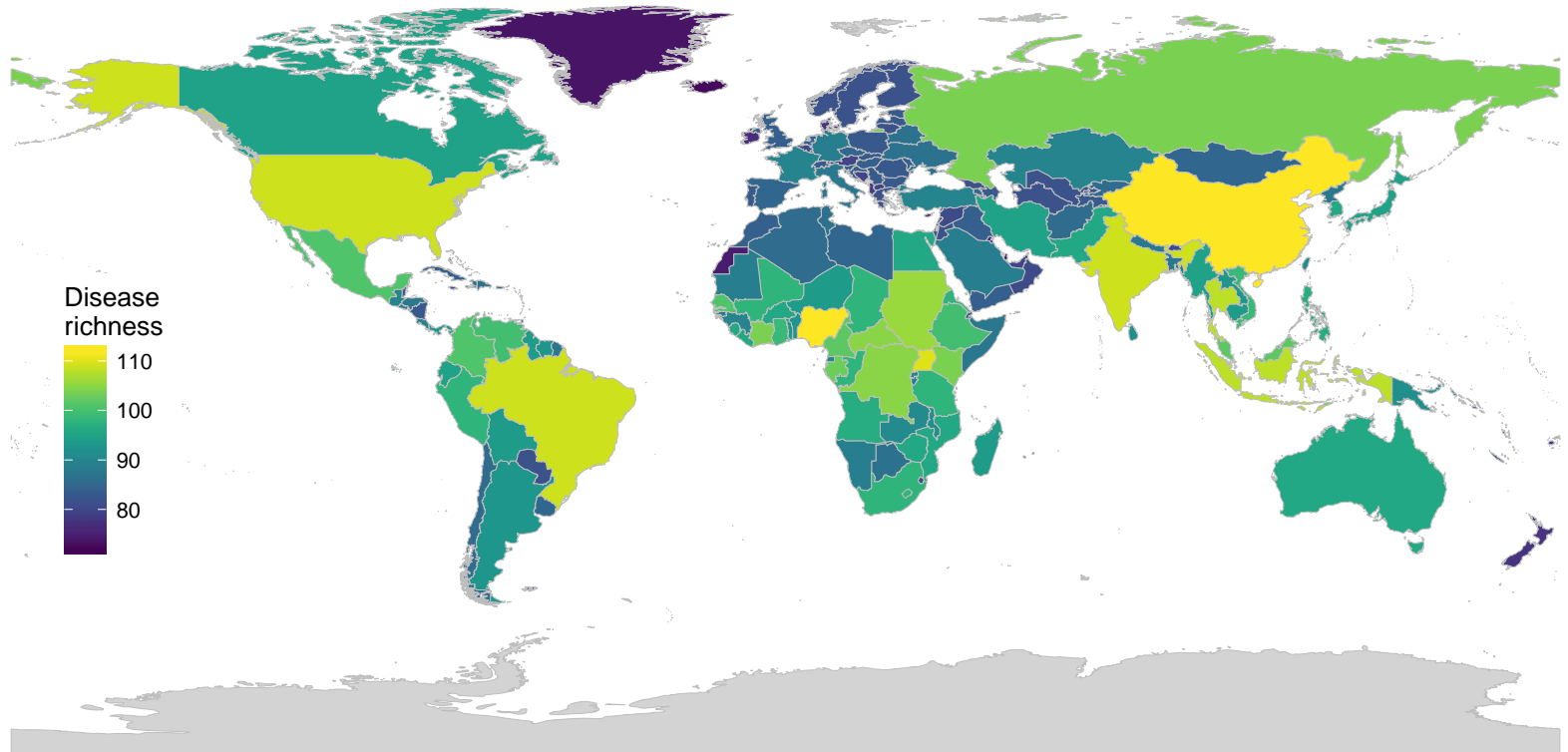


Variable	Coefficient	<i>p</i>	
Mammal biodiversity	0.018	0.001	***
Flight Traffic	0.001	0.034	*
Climate	-0.002	0.002	**
Publications	-0.002	0.004	**
Land Area	-0.005	0.001	***
Health Expenditure	0.000	0.710	
Population size	-0.007	0.001	***
Latitude	0.001	0.208	

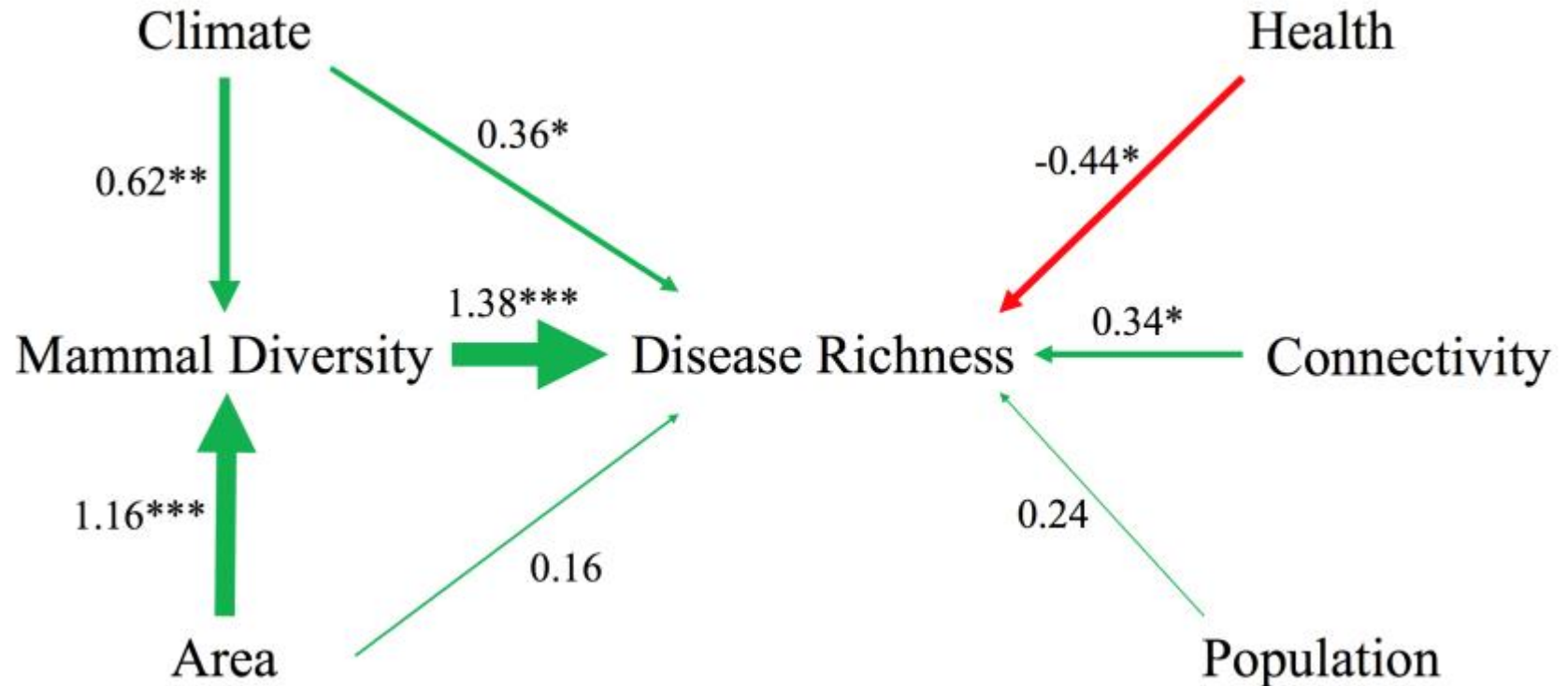
Model $R^2 = 0.54$



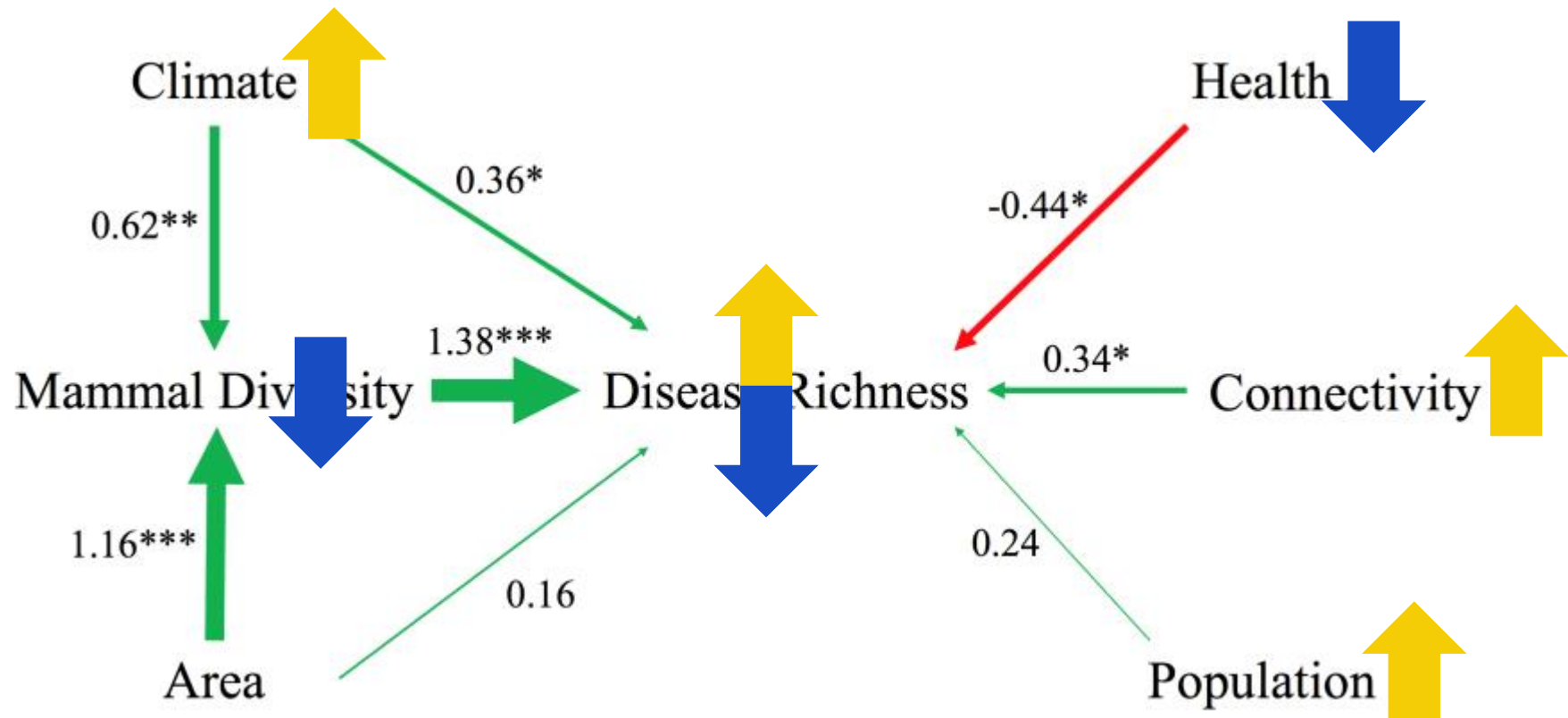
Pathogeography



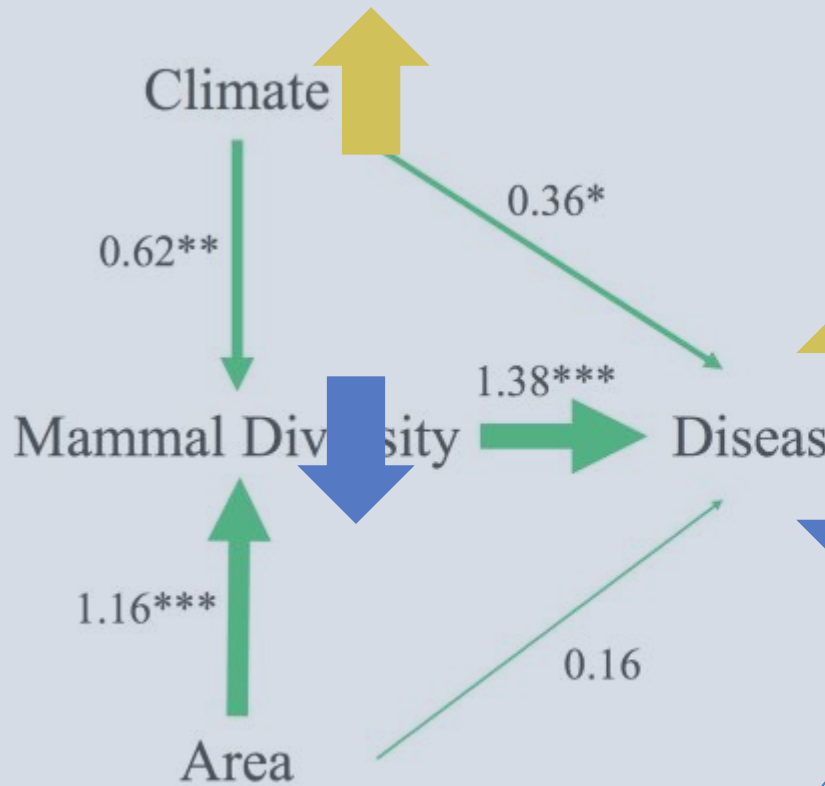
Pathogeography



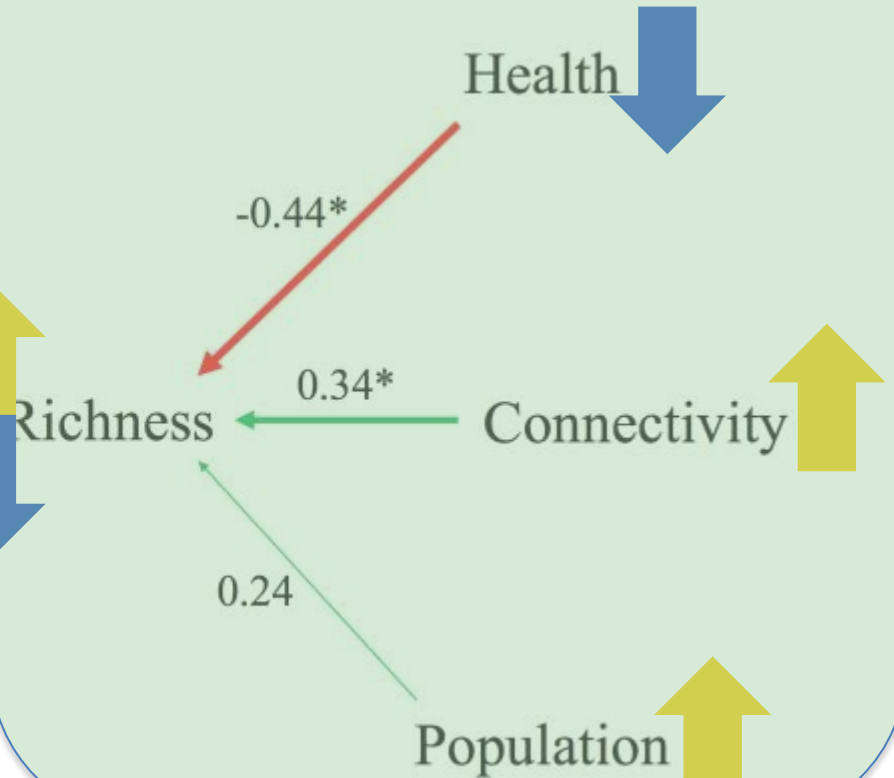
Pathogeography



Human influence Little control

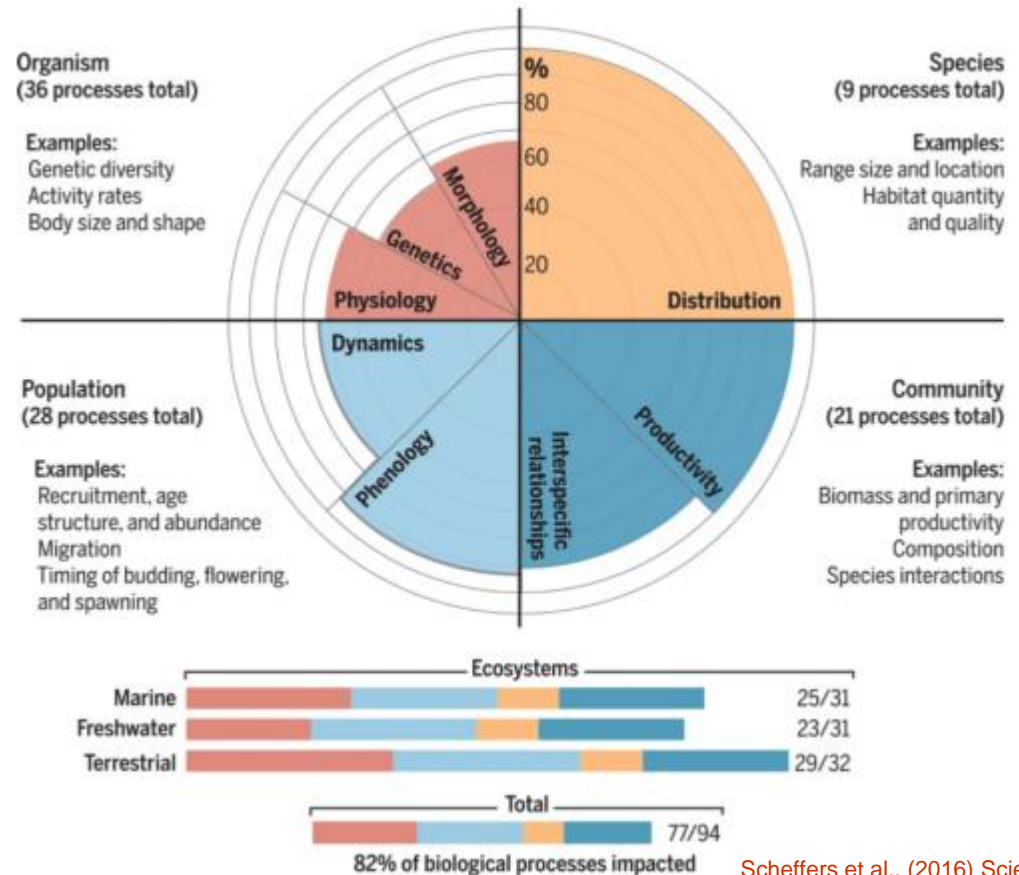


Human influence Some control




Climate change impacts - organisms to ecosystems

- 82% of 94 processes
- 1° C average warming so far
- Conservative estimates
- Processes are connected!



Conclusions

- Most human infectious diseases are zoonotic
- Zoonoses are **complicated** - difficult to map, predict
- Zoonoses = **biodiversity * habitats * land-use * dispersal * climate**
- ...
- **Increases AND decreases in risk** due to climate change
- Host/pathogen traits  global disease diversity
- Global scale disease diversity is controlled by factors that **we affect but don't control**
- **Systems approaches** required
- Public health + conservation policies = **co-benefits**

Merci!

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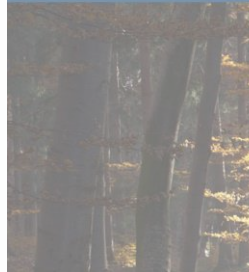
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