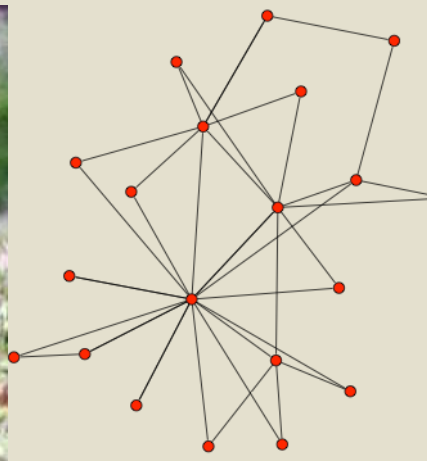


Understanding pathogen transmission at the wildlife/domestic animal interface

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Outline

1. Multihost pathogens & identification of maintenance population
2. Intervention case study: CDV & rabies in Serengeti Ecosystem
3. Modeling: useful tool - but rarely used. Why?
4. Other gaps/challenges

Multihost pathogens

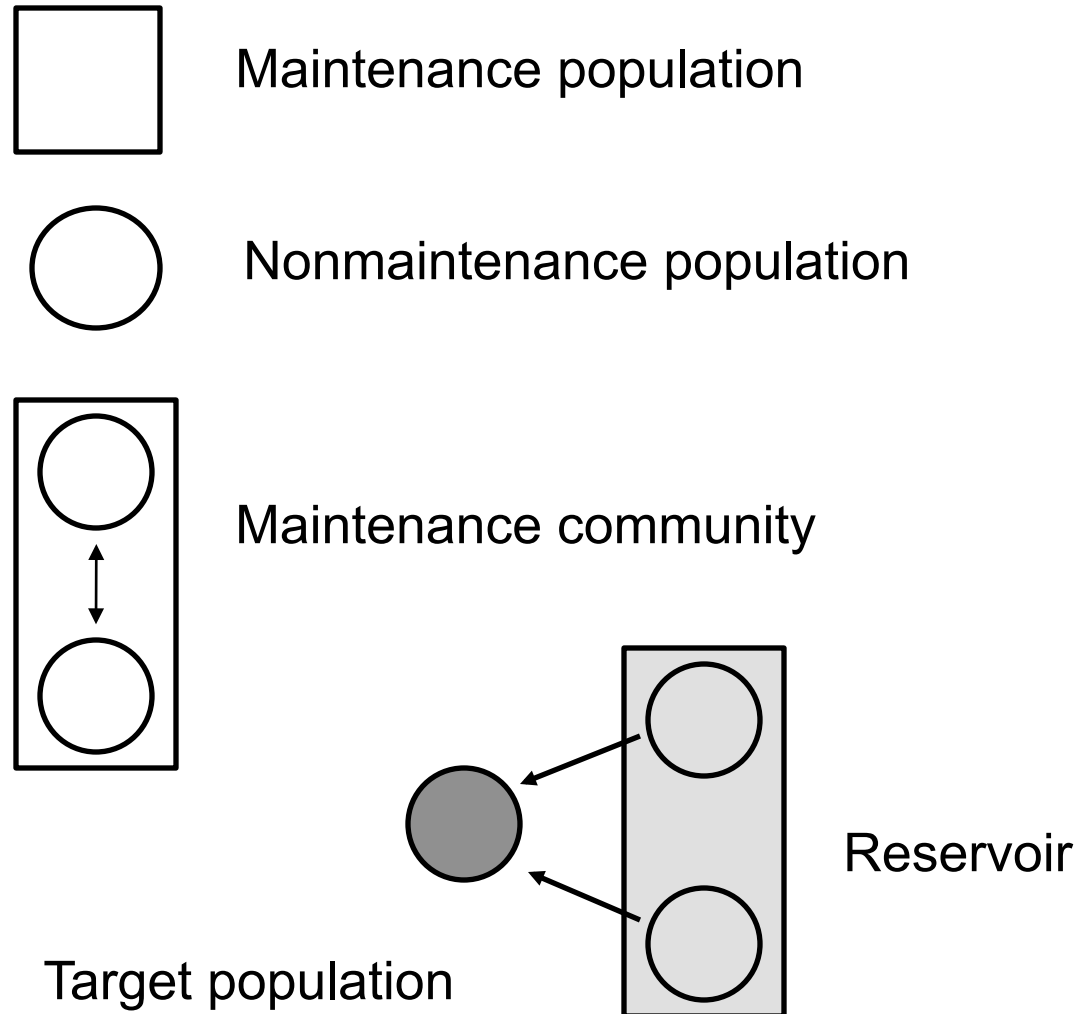
Why are these important?

- Humans- Emerging infectious disease
- Wildlife- Biodiversity
- Livestock & domestic animals- Welfare, regional & global economics, and livelihoods

How do we control these pathogens?

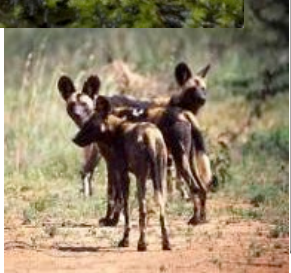
- Identification of maintenance population

Identifying reservoirs in multihost populations



Multihost pathogens affect biodiversity

(Cleaveland *et al* 2002)



Threatened population	Pathogen	Maintenance population
Chimpanzee	Polio	Humans
Rainforest toads	Chytridiomycosis	Cane toads
African wild dog	Rabies, canine distemper virus	Domestic dogs

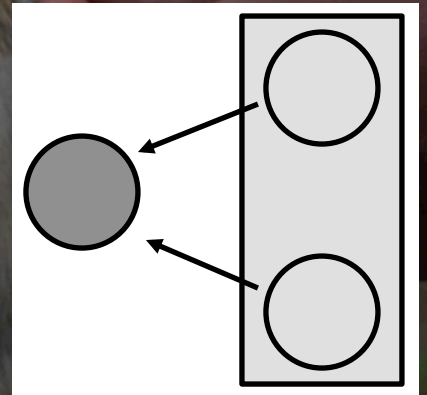
Maintenance population

– species (group of species) in which pathogen *persists*

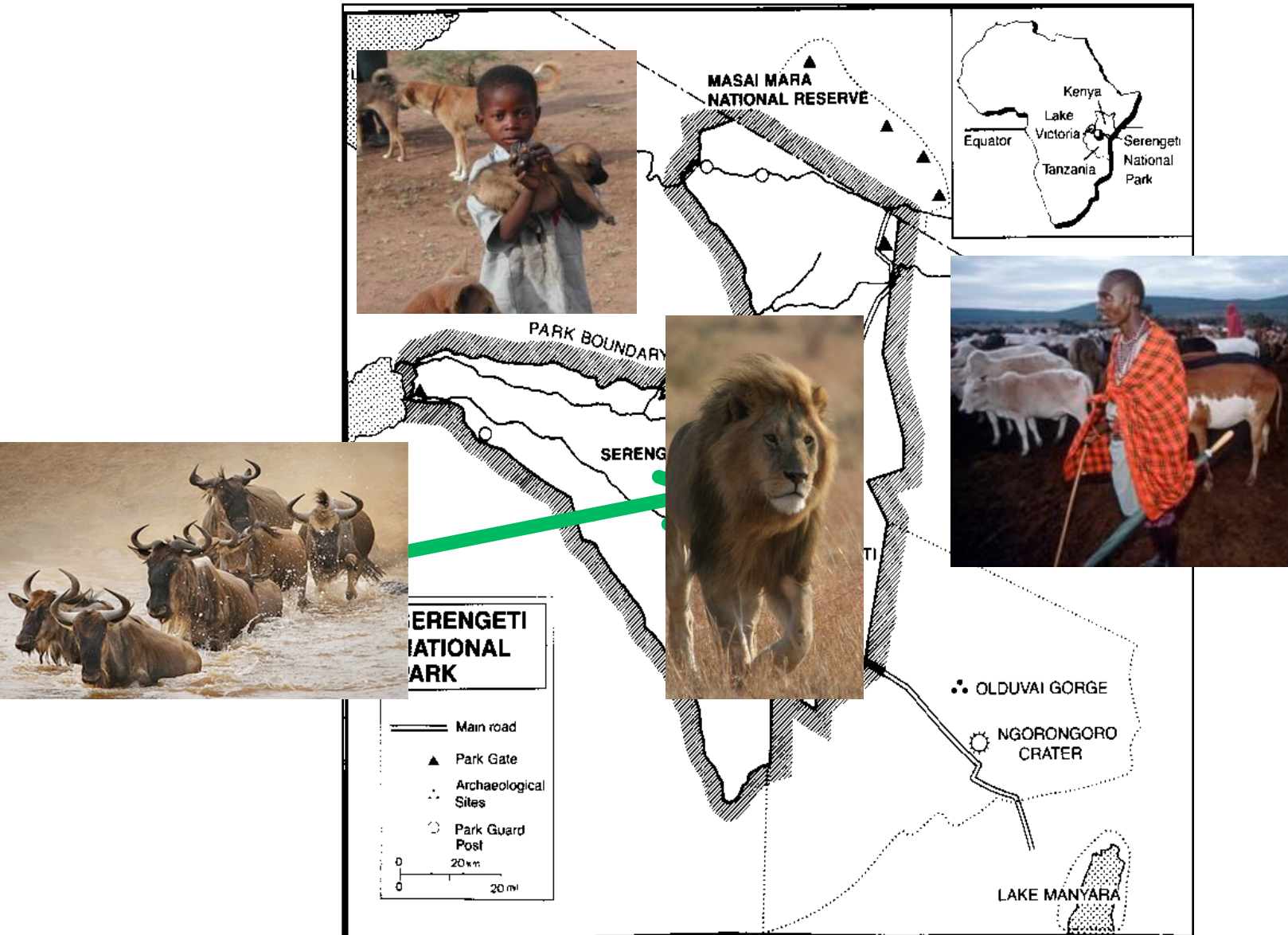
Can make the same table for humans or domestic animals

Intervention options

- Focus on maintenance population
- Prevent interactions between reservoir/target
- Control target populations



Serengeti as example of intervention

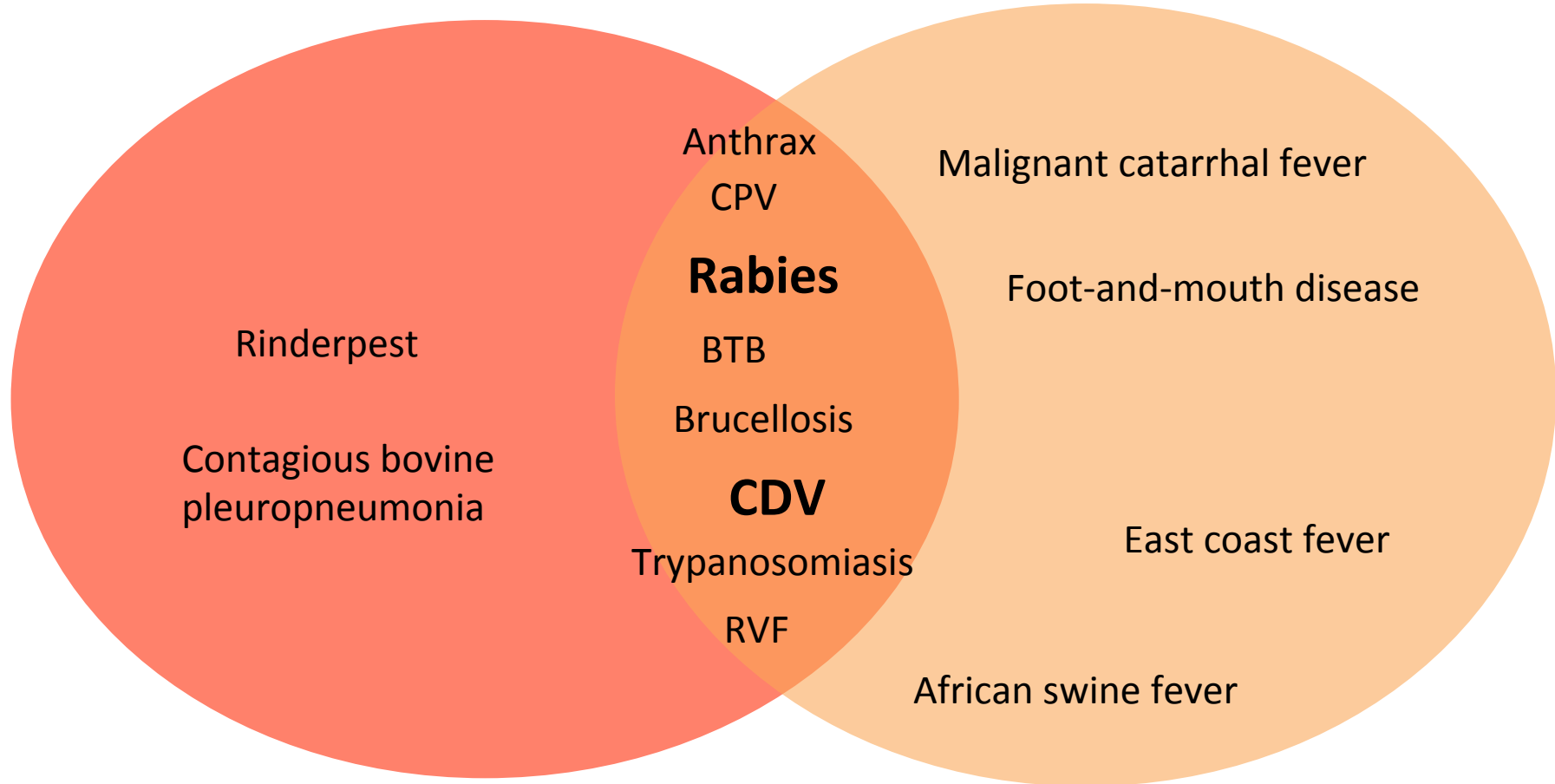


Why should we care about identifying reservoirs?

In Serengeti...

Maintained by domestic animals

Maintained by wildlife





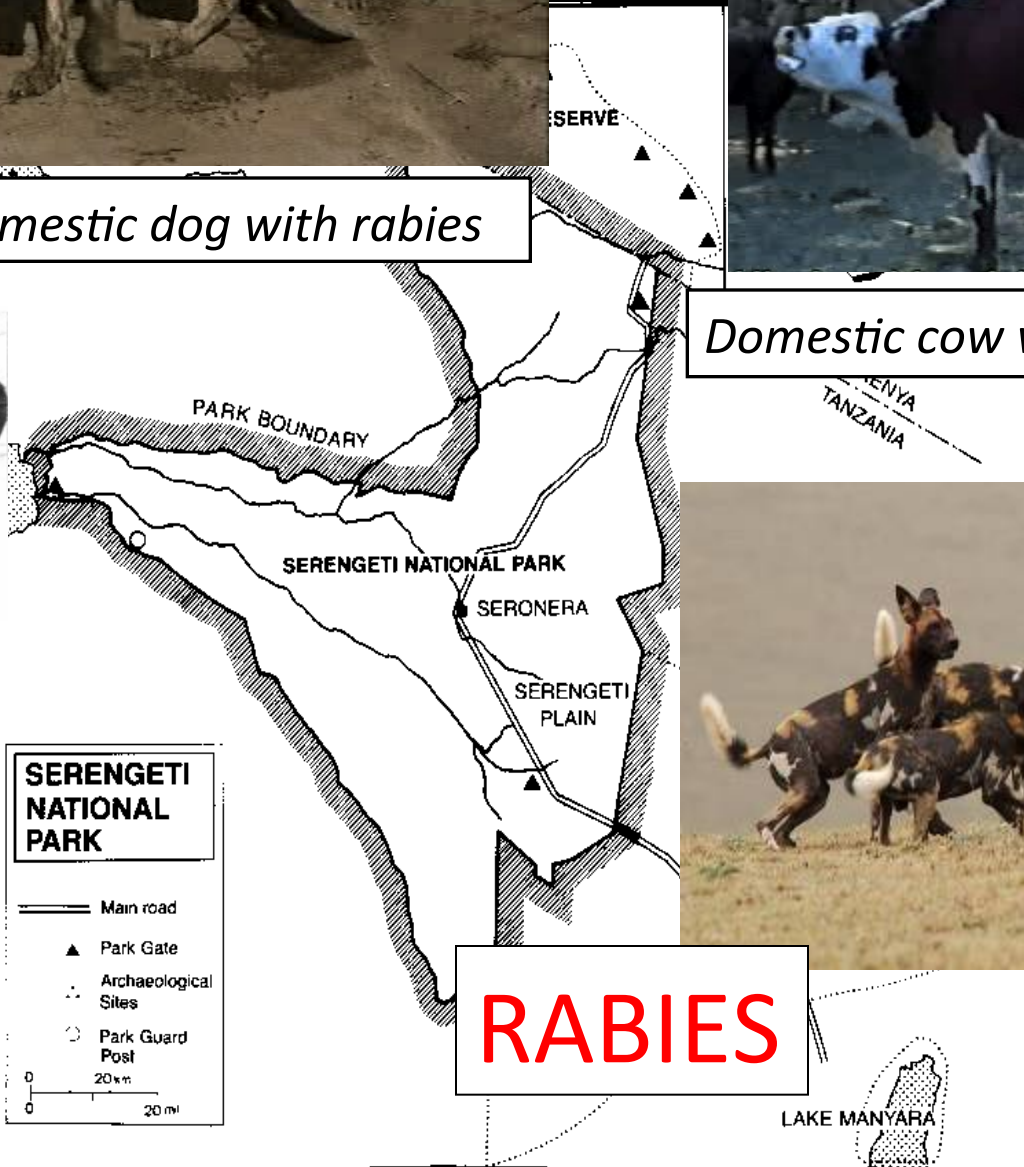
Domestic dog with rabies



Domestic cow with rabies



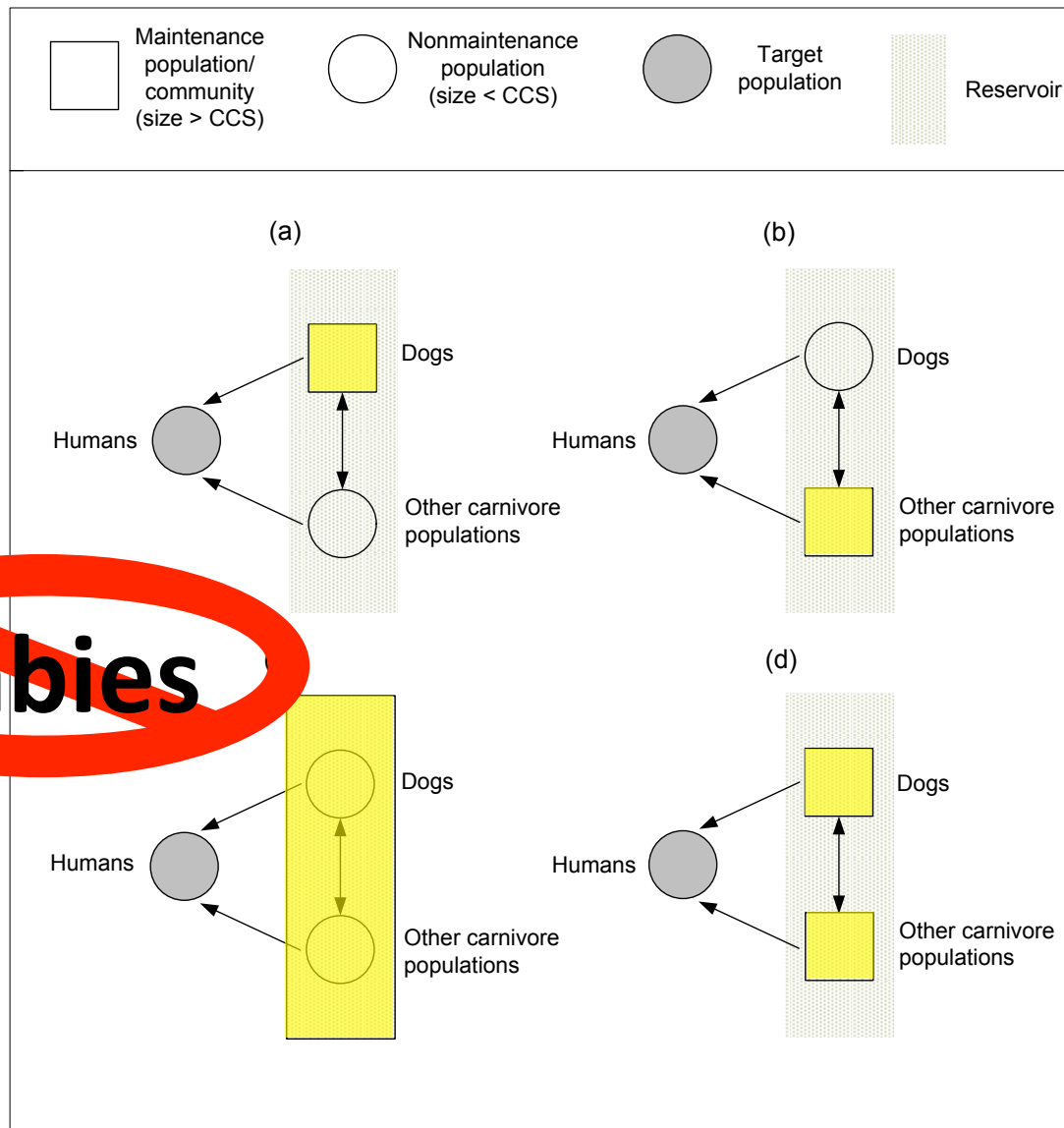
Human with rabies



RABIES

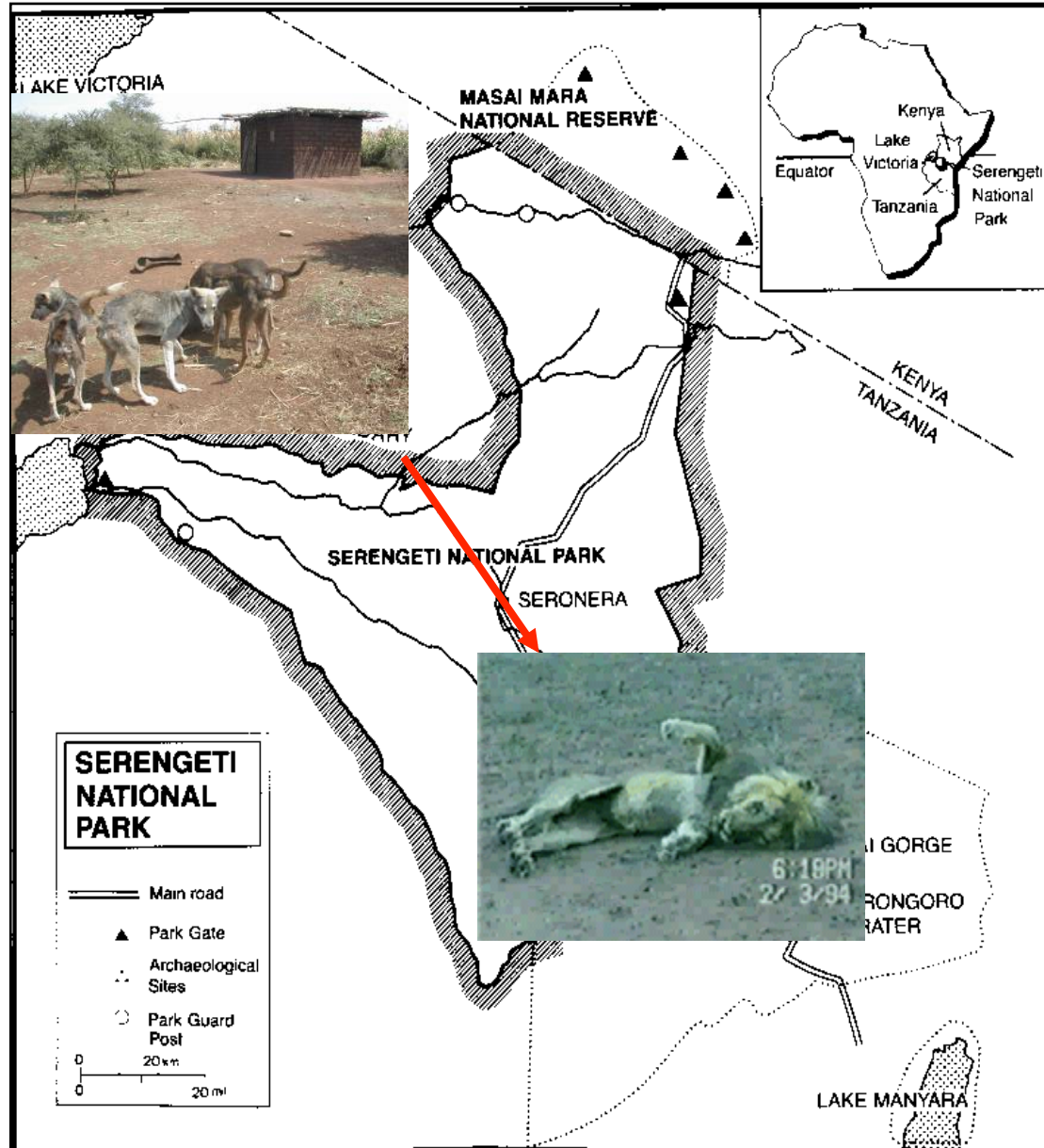


Potential rabies reservoir systems

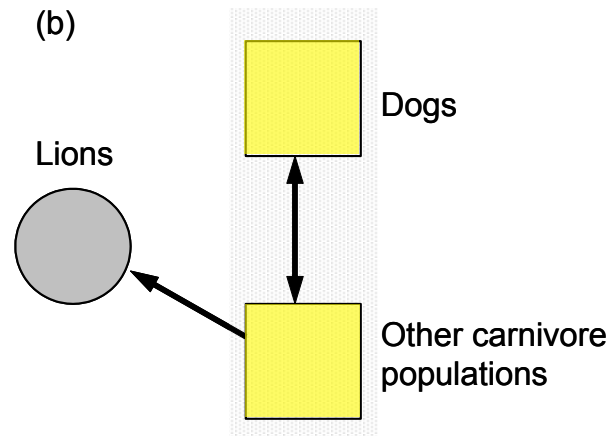
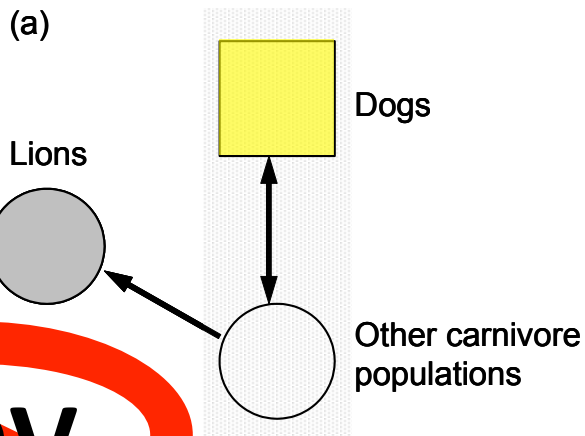
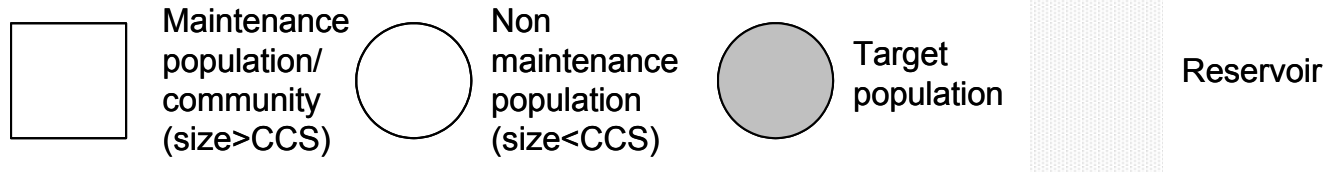


~~Rabies~~

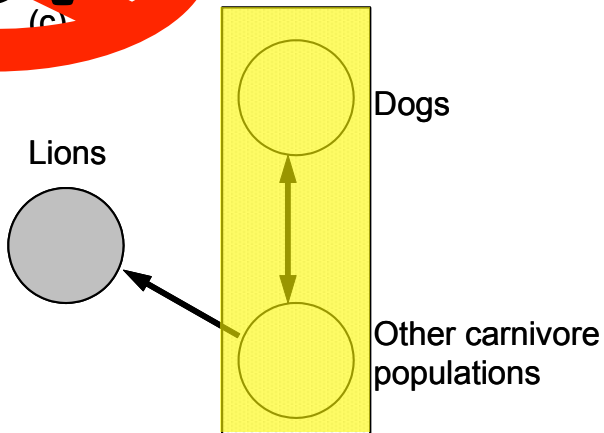
Canine Distemper Virus



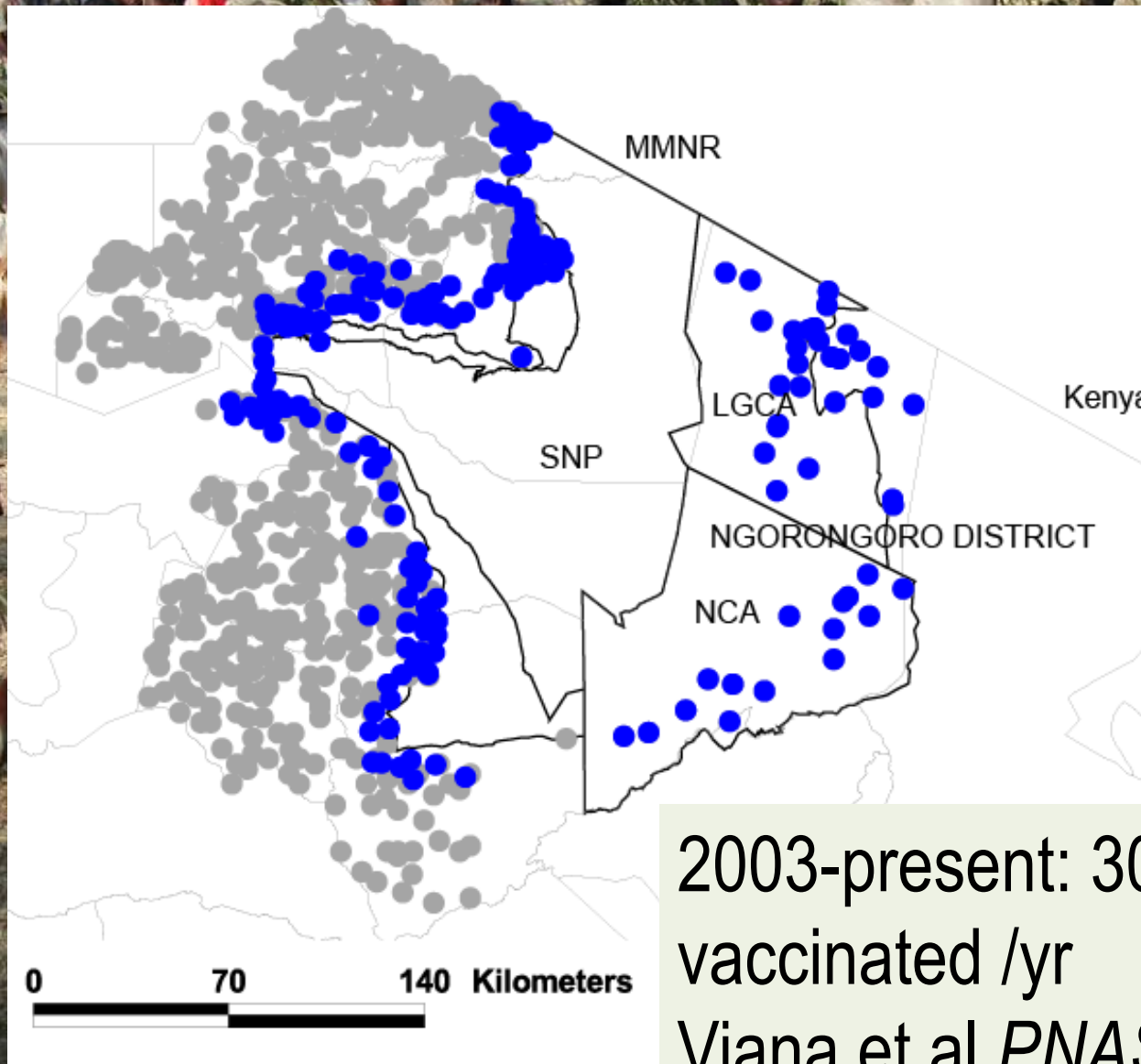
Potential CDV reservoir systems



~~CDV~~



Intervention trial: Mass dog vaccination



2003-present: 30- 50,000 dogs vaccinated /yr
Viana et al *PNAS*, 2015

Rabies results

- Vaccination works and is affordable!

(Hampson et al., *PLoS Bio* 2009, Kaare et al., *Vaccine* 2009)

- “Spillover” from dogs to other hosts

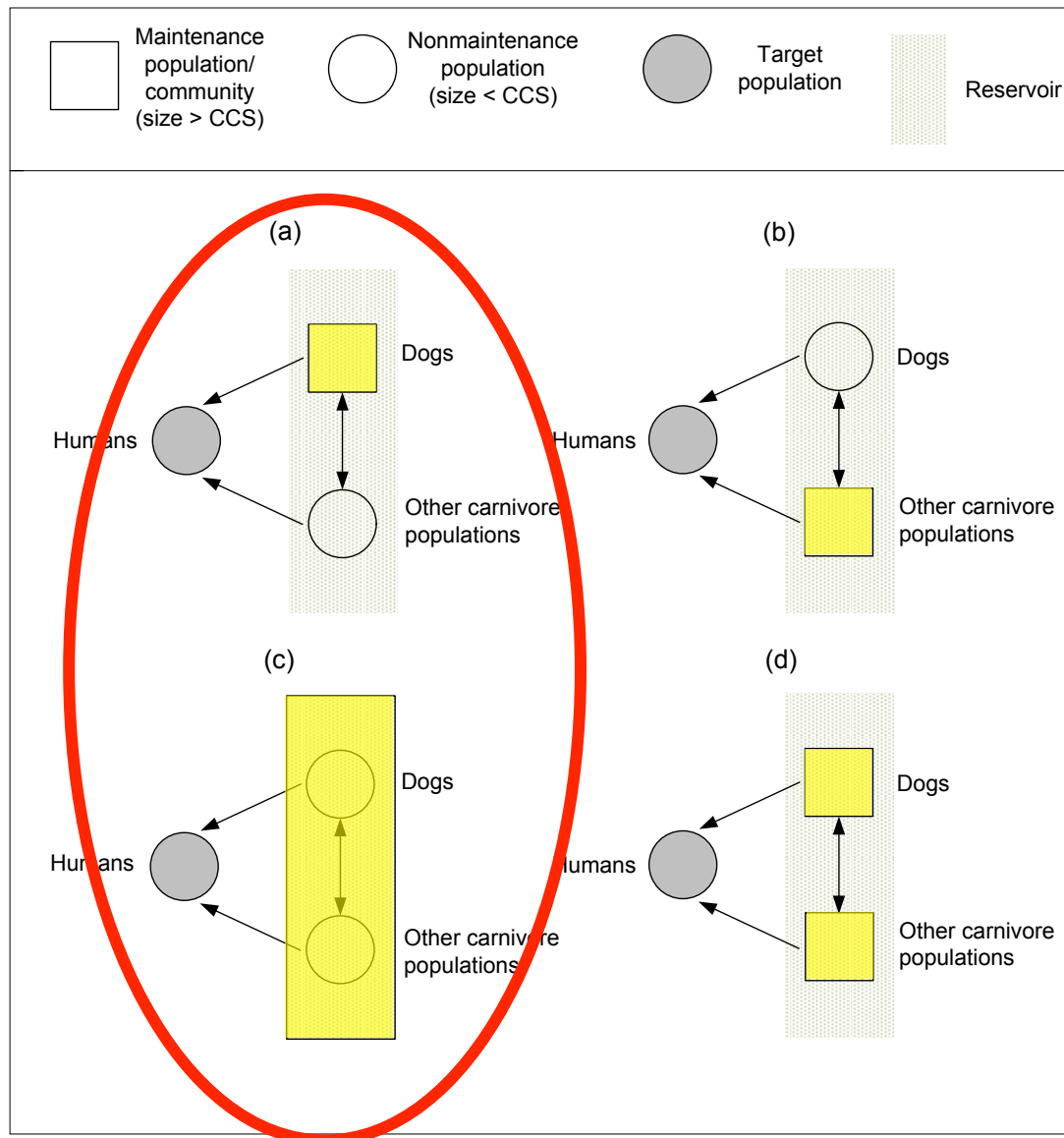
(Lembo, Hampson, Haydon, Craft et al., *J Appl Ecology* 2008)

- Rabies is controllable; each rabid animal only infects ~ 1.2 others.

(Hampson et al., *PLoS Bio* 2009)



Rabies results



CDV results

- Lions not maintenance population

(Craft et al *ProcRoySocB* 2009)

- Multiple wild hosts needed to replicate 1994 fatal outbreak

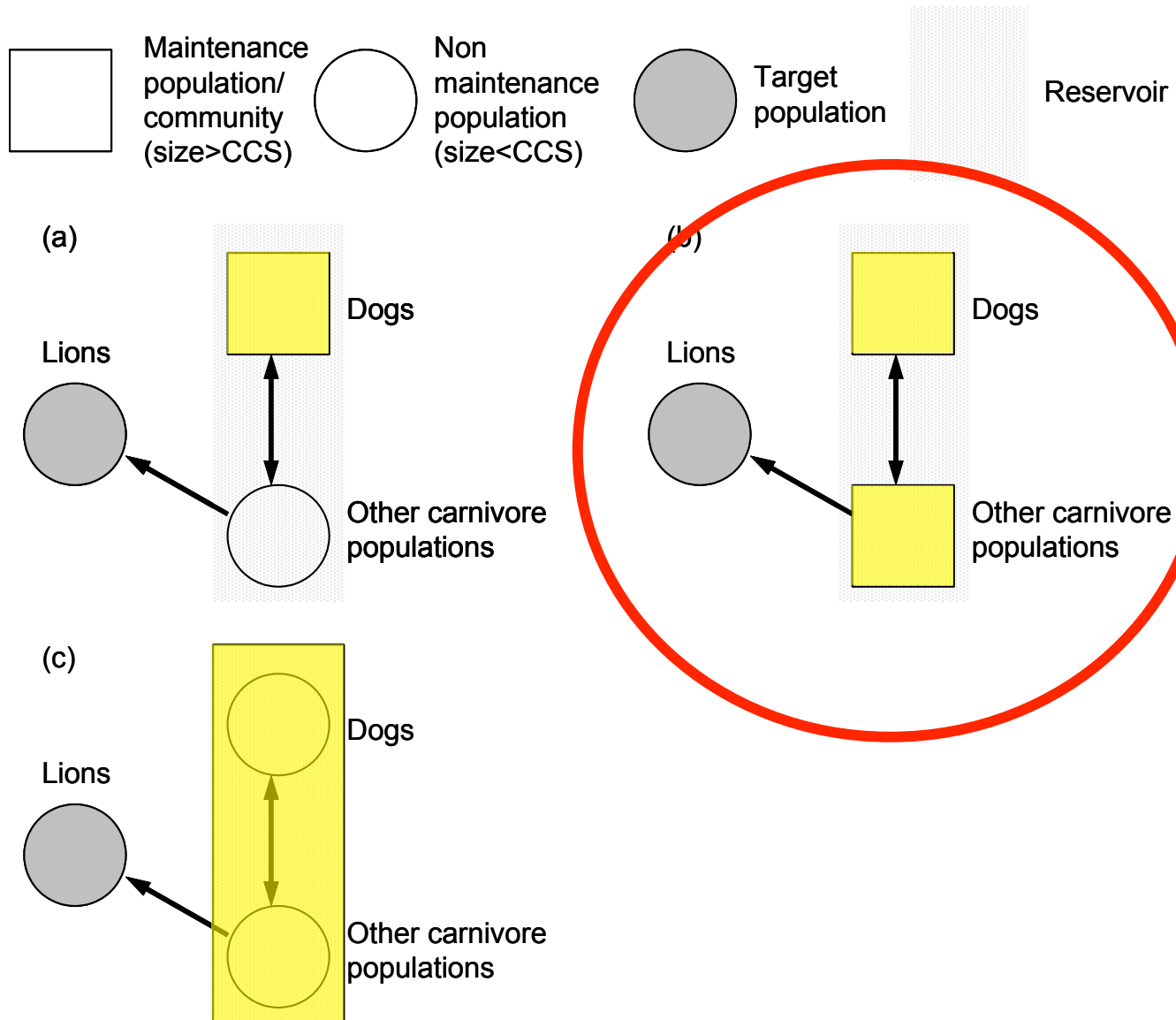
(Craft et al *Journal of Animal Ecology* 2008)

- Virus may be maintained by broader carnivore community

(Viana et al *PNAS* 2015)

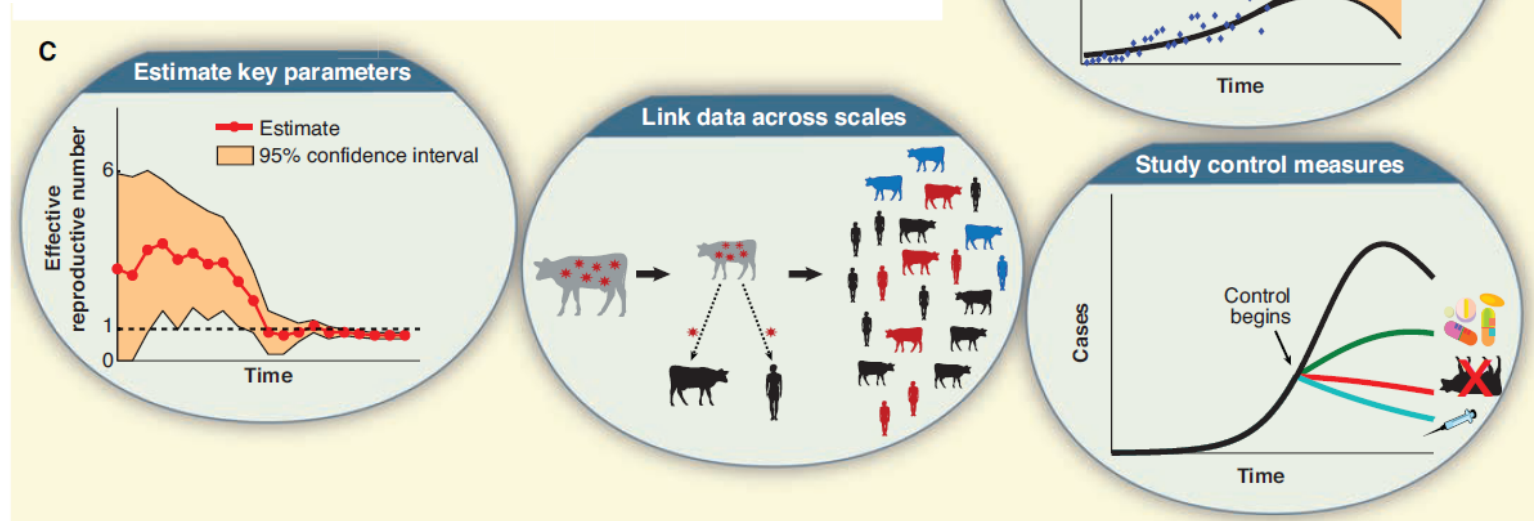


CDV results



Modeling: Dynamic disease models

- Ask questions that are ethically or logistically unfeasible
- Conduct 'what if' experiments
- Inform data collection



Lit. search: dynamic models of disease transmission

How clustered are different disciplines?

How unified are modeling approaches?

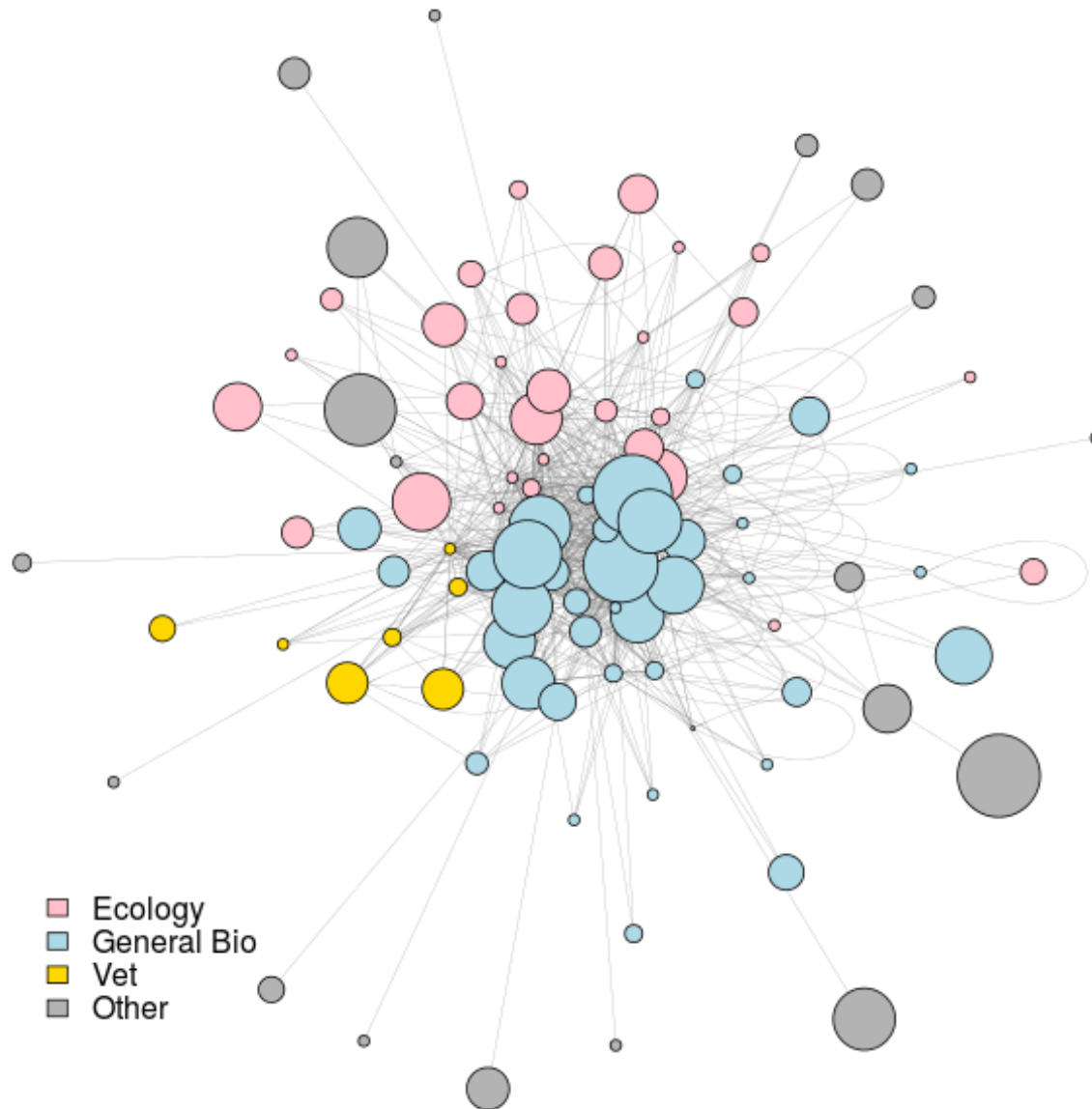
Any change through time with the “One Health” approach?

- 2258 papers, then eliminated those not directly referencing disease transmission
- 1605 papers remained, from 108 journals, 4219 authors

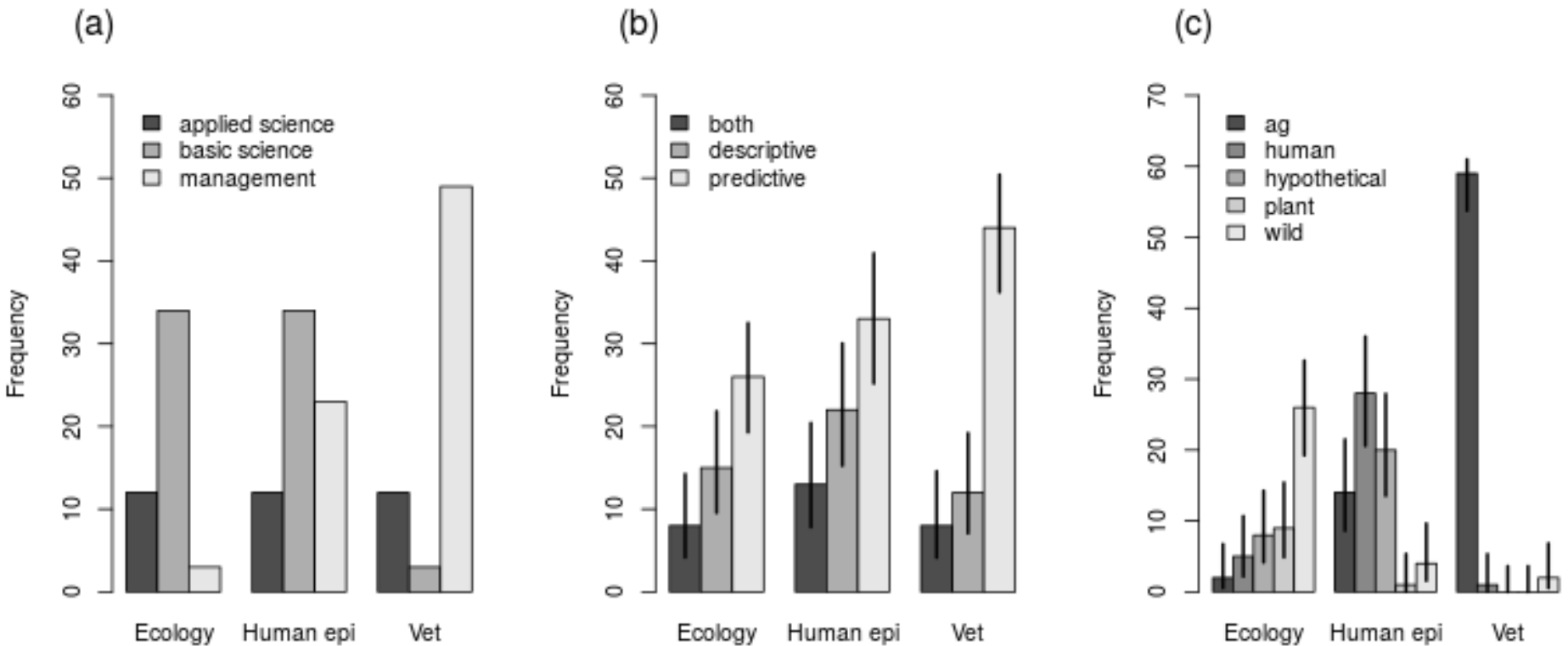
Network construction & community structure

- Constructed paper citation network (which journals cite which journals)
- Identified community structure and found 3 communities with clear disciplinary structure: veterinary journals, ecological journals, and general biology/public health journals.

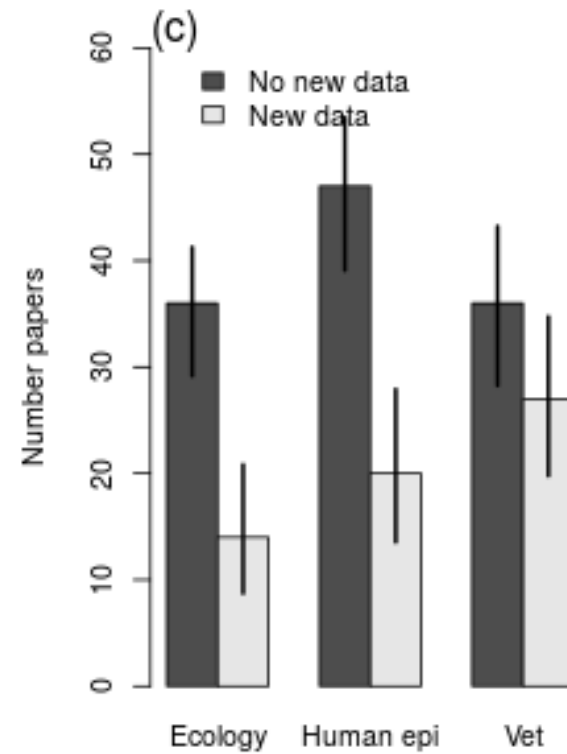
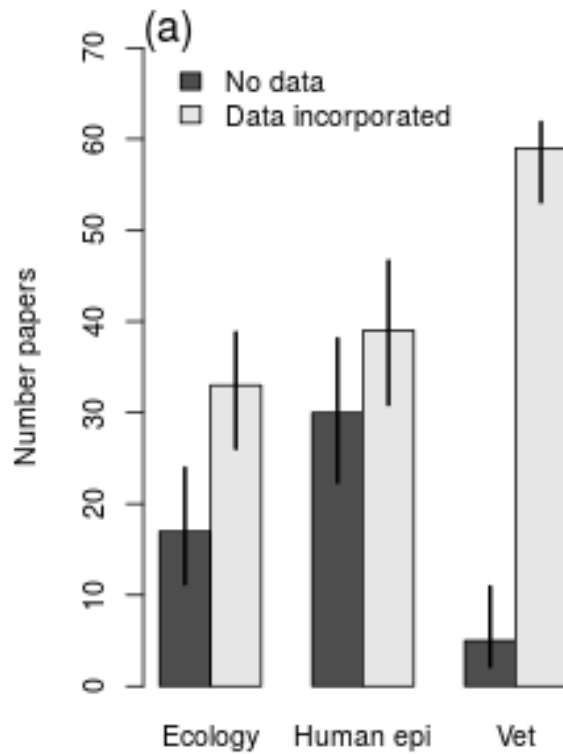
Journal Communities



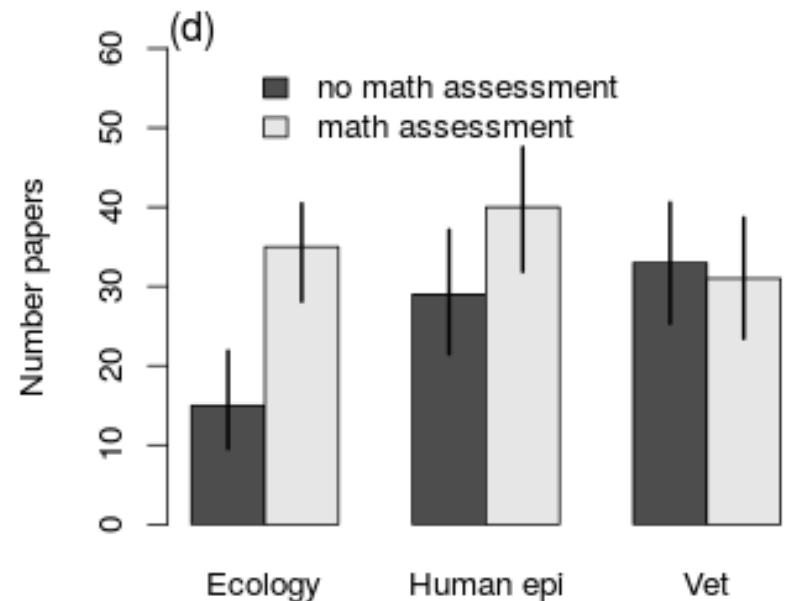
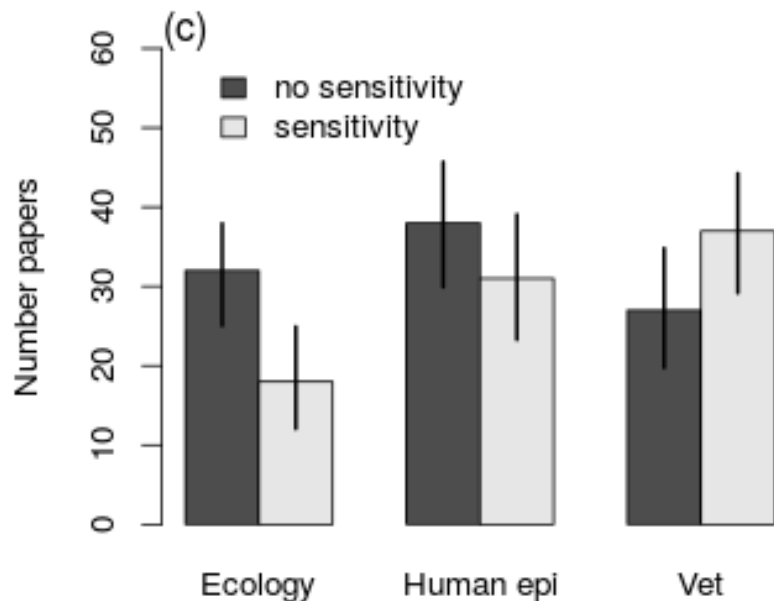
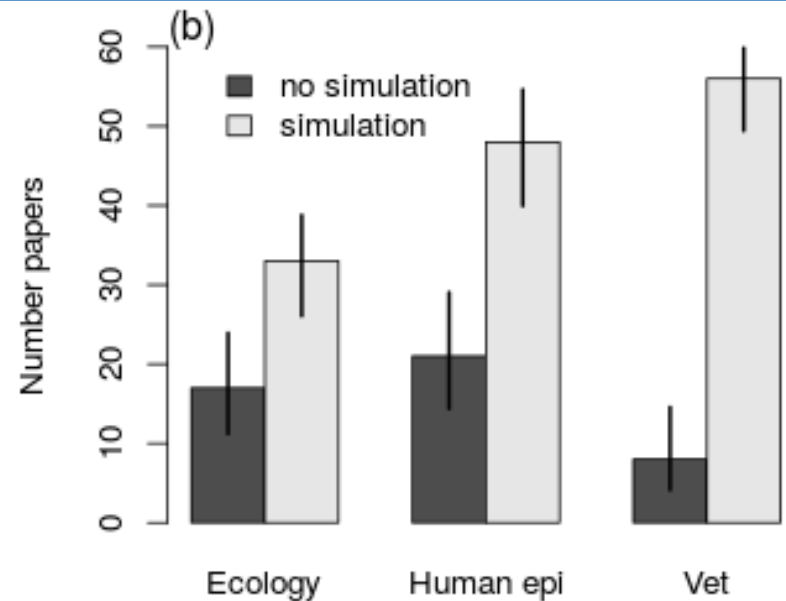
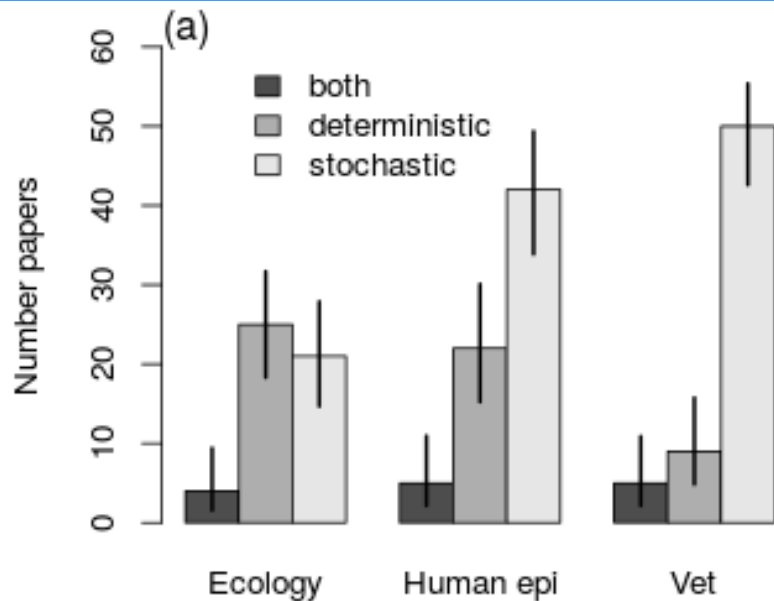
Differences: study system



Data incorporation



Model implementation



Journal Communities

Community	Number of Journals	Number of Papers	Median Number of Authors (2.5th, 97.5 th quantiles)	Most common lead author affiliation (%)	Citations within community / citations between communities	Citations to Human-focused epi	Citations to Ecology	Citations to Vet
Human-focused Epidemiology	42	1043	4, (1, 15)	Math / Stat / Epi (48.2%)	2504 / 421	NA	251	170
Ecology	30	310	4 (1, 12.275)	Ecology / Evolution (55.9%)	378 / 366	352	NA	14
Veterinary	7	198	4 (1, 9.075)	Veterinary / Animal Health (63.6%)	311 / 120	106	14	NA

Wildlife/Livestock interface implications?

- Concerning that vet and ecology communities are pretty isolated from each other
 - Do not generally cite (read?) each other
 - Different model objectives and approaches
- What challenges does this pose for working together?
- Or solving challenges at the wildlife/livestock interface?

Other gaps/challenges

- knowledge of host range and distribution (WL)
- diagnostic assays that apply to pathogen systems at the interface
- the dynamics of pathogen transmission at the interface
- host population impacts of interface diseases (WL)
- appropriate mitigation efforts
- New tools (beyond interventions and modeling)?

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 - Dan Haydon, Sarah Cleaveland, Tiziana Lembo, Katie Hampson, Andy Dobson, Craig Packer, Eblate Ernest, Magai Kaare
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