Land use change, Biodiversity and Infectious Diseases

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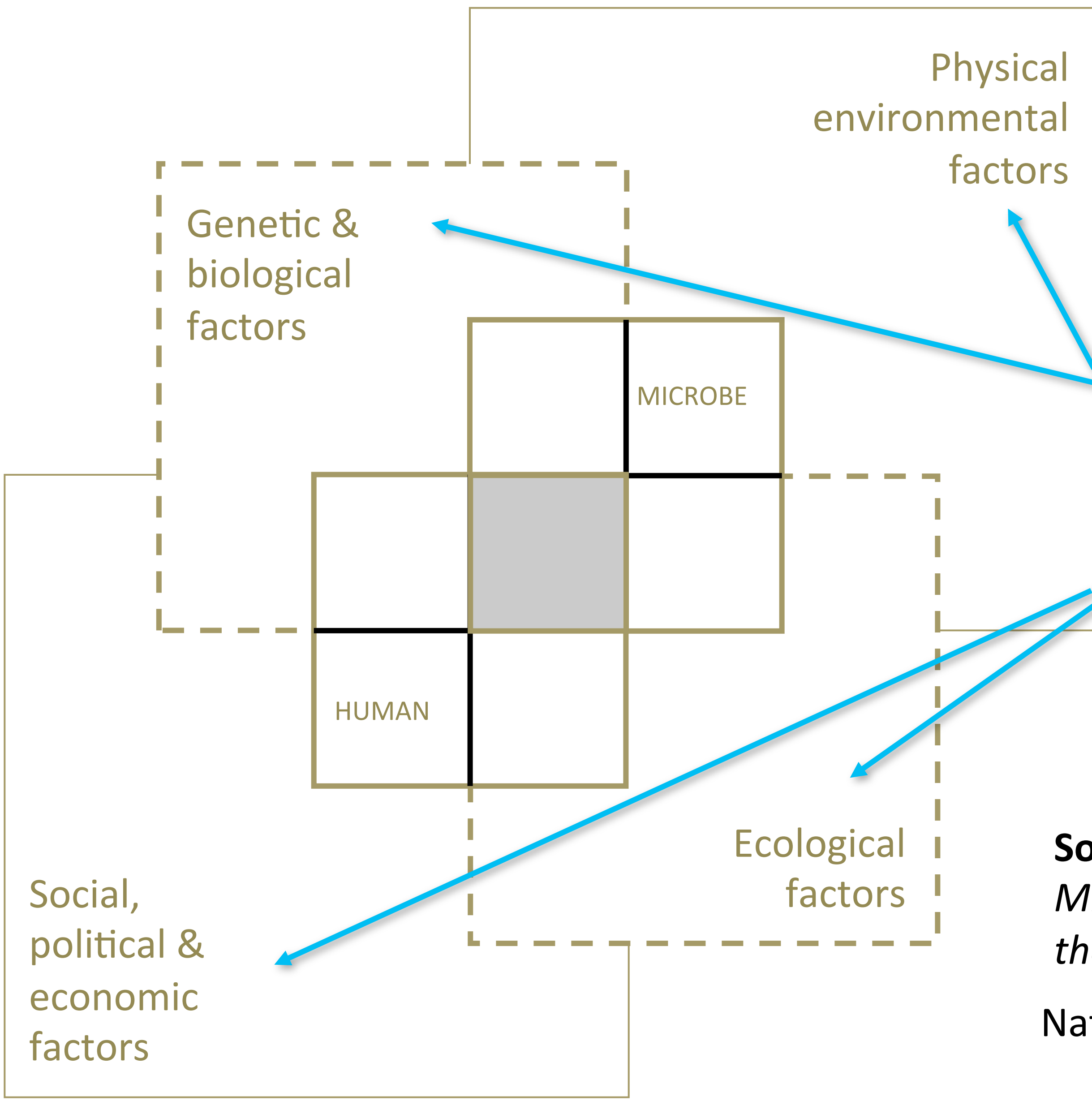
Convergence Model – Emergent Diseases



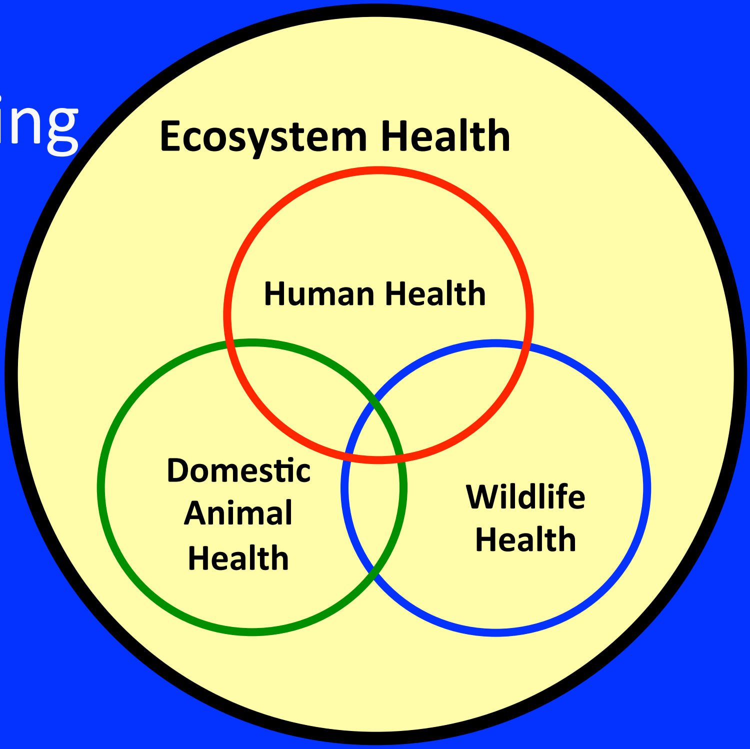
Challenge is to predict these underlying root determinants

Source: IOM, *Emerging Microbial Threats to Health in the 21st Century*, 2004.

National Academy of Sciences

Ecosystem Health Approach

- Expanded research in wildlife disease epidemiology, disease ecology and ecosystem health
  - Need increased understanding of the drivers of emerging diseases to more effectively prevent and control wildlife and zoonotic diseases
  - Prevention is key!



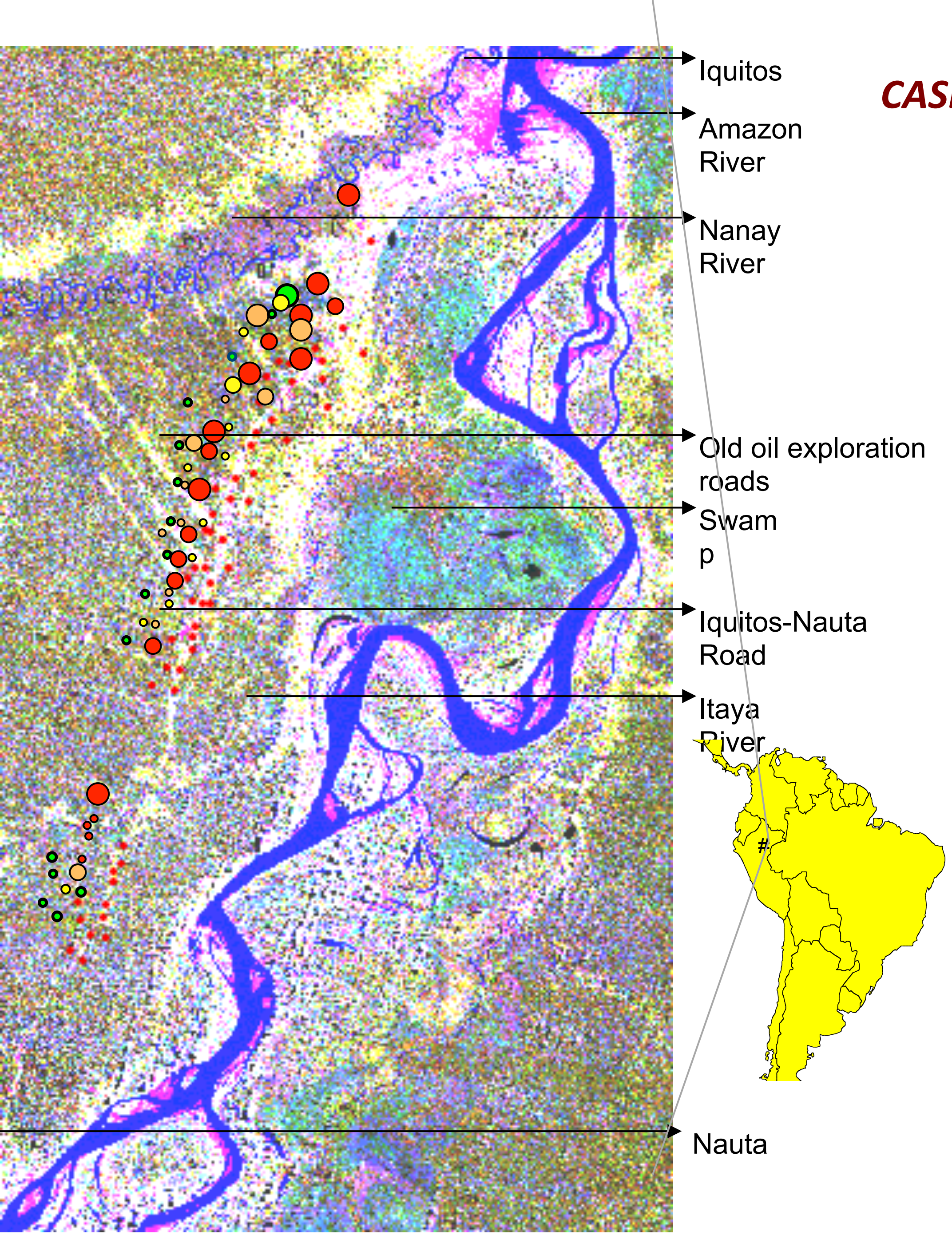
Predictive models for emerging diseases?

Mechanisms of Disease Emergence

- ***Altered habitat,*** which can lead to changes in the number of vector breeding sites or in disease reservoir host distribution.
- ***Biodiversity change,*** including loss of predator species and changes in host population density.
- ***Niche invasion*** or host-shifting by pathogens.
- ***Human-induced genetic changes*** in disease vectors or pathogens, such as mosquito resistance to pesticides or the emergence of antibiotic-resistant bacteria
- ***Environmental contamination*** by infectious disease agents, such as fecal contamination of source waters.

Millennium Ecosystem Assessment, 2005

CASE STUDY: Deforestation and Malaria



Peruvian Amazon study site

Landsat image shows road from Iquitos to Nauta. 56 sampling sites indicated per key below:

Scale: 1:800,000

- ○ 5.0 – 22.9 mean *A. darlingi*/6-hrs/person
- ● high deforestation (54%), low forest (3%)
- ○ 0.5 – 4.9 mean *A. darlingi*/6-hrs/person
- ● medium deforestation (25%), medium forest (20%)
- ○ 0 – 0.4 mean *A. darlingi*/6-hrs/person
- ● low deforestation (5%), medium forest (35%)
- ● low deforestation (6%), high forest (76%)

Vittor et al. 2006

Anopheles mosquitoes

~ 422 species of *Anopheles*, 60 to 70 of which can act as malaria vectors

Therefore, many *Anopheles* species are harmless to humans, incapable of allowing *Plasmodium* to develop into sporozoites that reside in the salivary glands.

Some species will harbor *P. vivax* sporozoites, but not *P. falciparum* sporozoites.

Service, 1993

Species	Vegetation type: Village (n=255) Total†	Village Mean	Deforested** (n=191) Total	Deforested Mean	Shrub / secondary growth (n=191) Total	Shrub Mean	Forest (n=250) Total	Forest Mean	Total no. collected (mean biting rate)
Subgenus Nyssorhynchus									
A. triannulatus	86	0.3	450	2.4	5137	26.9	1941	7.8	7614 (8.6)
A. darlingi	2050	8.0	459	2.4	45	0.2	92	0.4	2646 (3.0)
A. benarrochi	328	1.3	496	2.6	180	0.9	288	1.2	1292 (1.5)
A. oswaldoi	41	0.2	327	1.7	598	3.1	300	1.2	1266 (1.4)
A. rangeli	74	0.3	289	1.5	98	0.5	5	0.0	466 (0.5)
A. nuneztovari	33	0.1	81	0.4	17	0.1	13	0.1	144 (0.2)
A. (N) spp*	157	0.6	170	0.9	188	1.0	159	0.6	674 (0.8)
Subgenus Anopheles									
A. mediopunctatus	61	0.2	170	0.9	436	2.3	164	0.7	831 (0.9)
A. mattogrossensis	54	0.2	136	0.7	18	0.1	4	0.0	212 (0.2)
A. punctimacula	11	0.0	0	0.0	18	0.1	44	0.2	73 (0.1)
A. peryassui	15	0.1	3	0.0	0	0.0	0	0.0	18 (0.0)
A. neomaculipalpus	0	0.0	0	0.0	2	0.0	1	0.0	3 (0.0)
A. (A) spp*	12	0.0	25	0.1	22	0.1	14	0.1	73 (0.1)
Subgenus Lophopodomyia									
A. squamifemur	9	0.0	0	0.0	1	0.0	3	0.0	13 (0.0)
Total *Anopheles*	**2931**	**3.3**	**2606**	**2.9**	**6760**	**7.6**	**3028**	**3.4**	**15325 (17.3)**
Culicines	69960	274	67917	357	72985	382	73045	292	283907

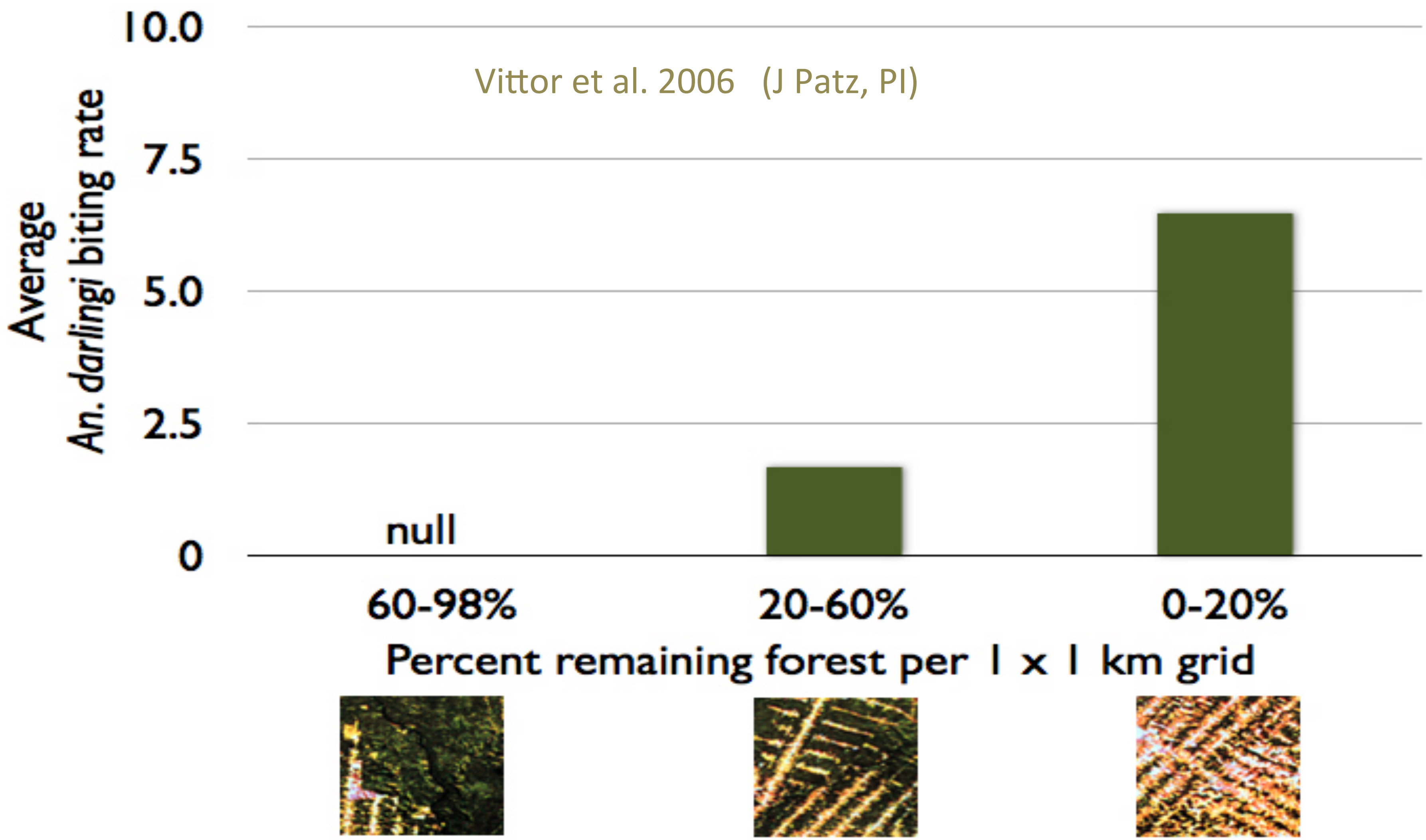
†Total number collected (887 6-hr nights); mean human-biting rate per 6-hrs per person

* (N) = s.g. *Nyssorhynchus*, (A) = s.g. *Anopheles*, (L) = s.g. *Lophopodomyia*; ** areas that have low human population density in addition to being deforested

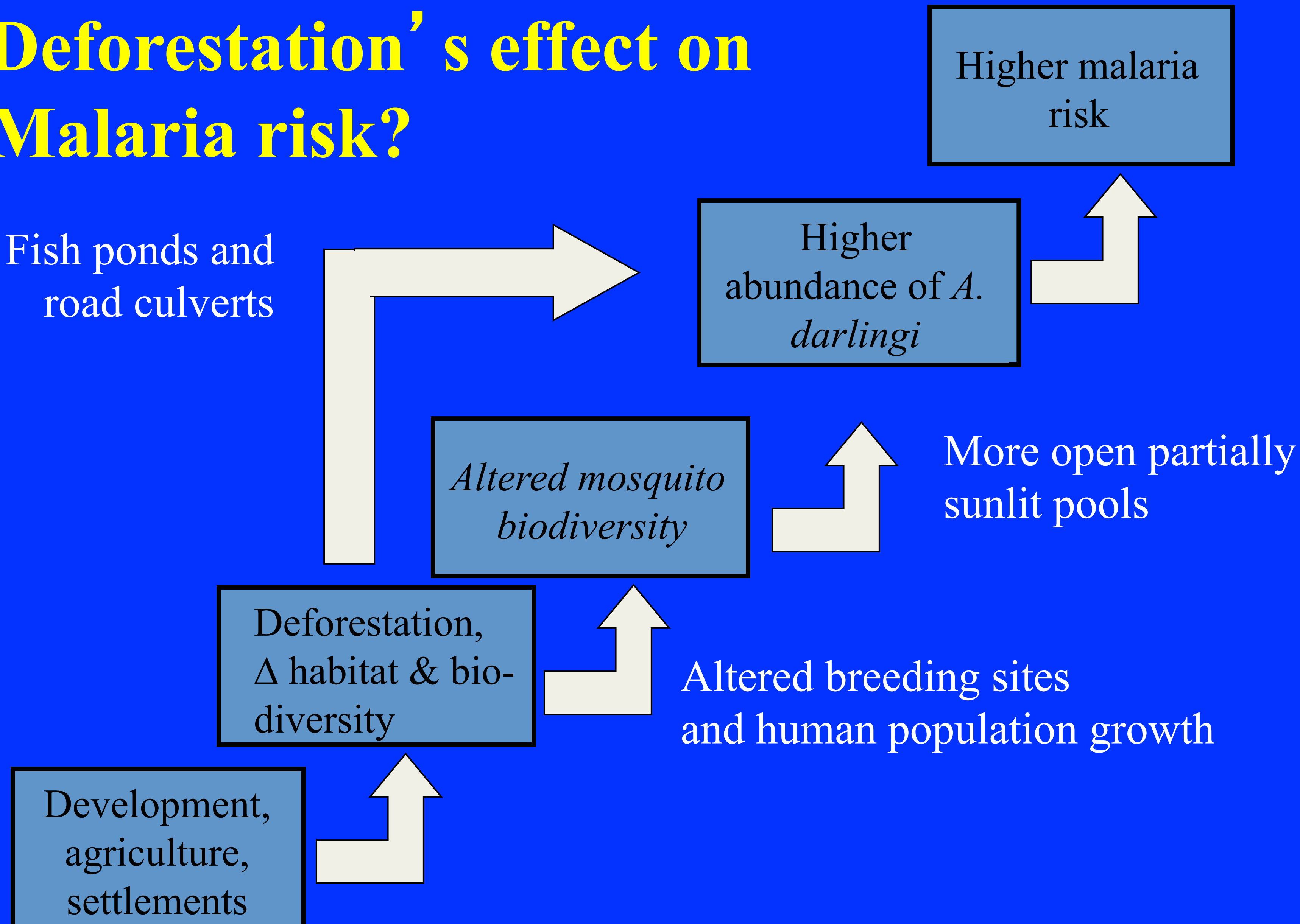
high deforestation (54%), low forest (3%) medium deforestation (25%), medium forest (20%)

low deforestation (5%), medium forest (35%) low deforestation (6%), high forest (76%)

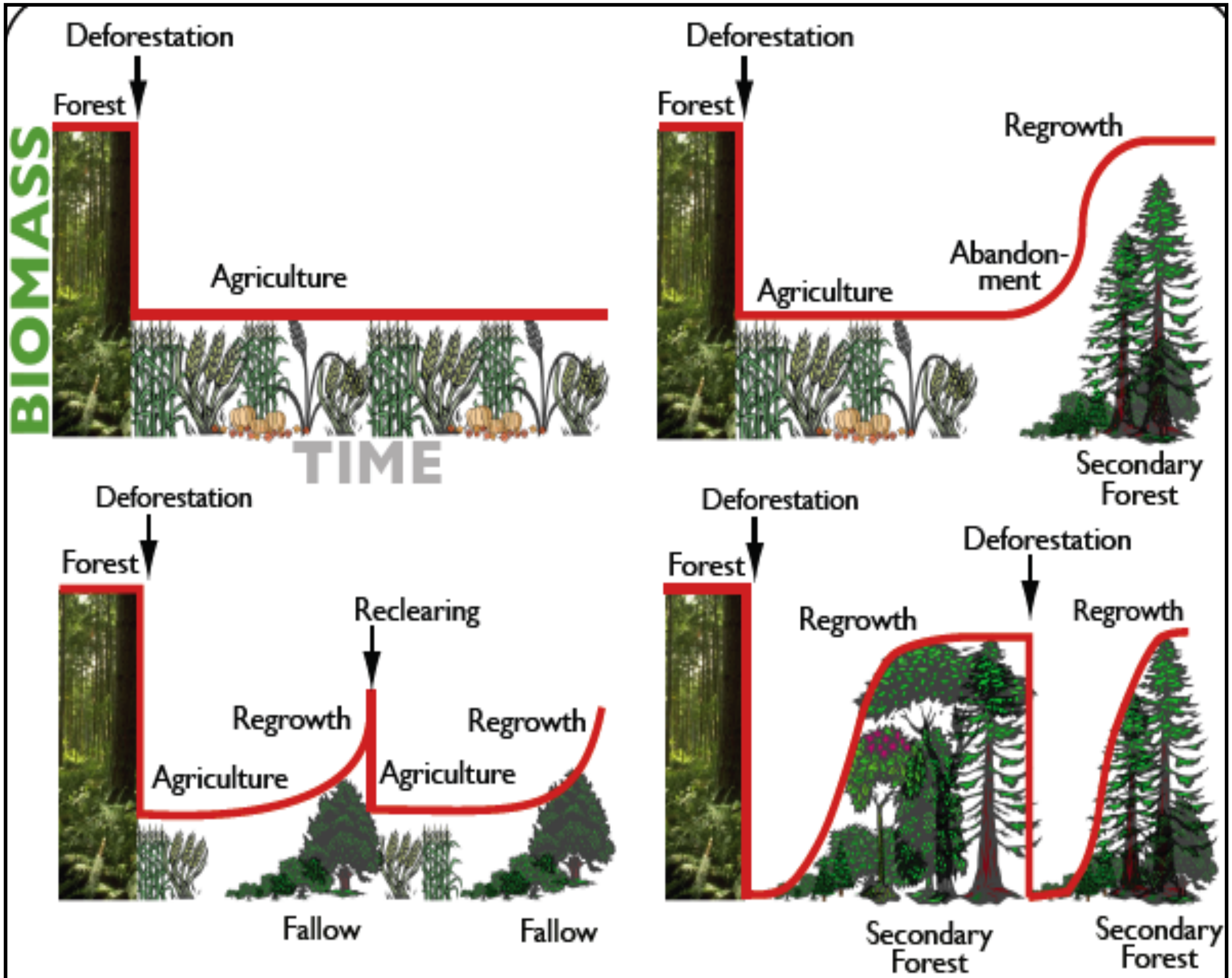
Deforestation & malaria risk, Amazon



Deforestation's effect on Malaria risk?



Spatial & temporal patterns in land use affect risks



- ✓ Land-use transition models track land as it cycles between crops, fallow, and regrowth
- ✓ "States and Rates"

Ramankutty, Gibbs, et al., (GCB, in press)

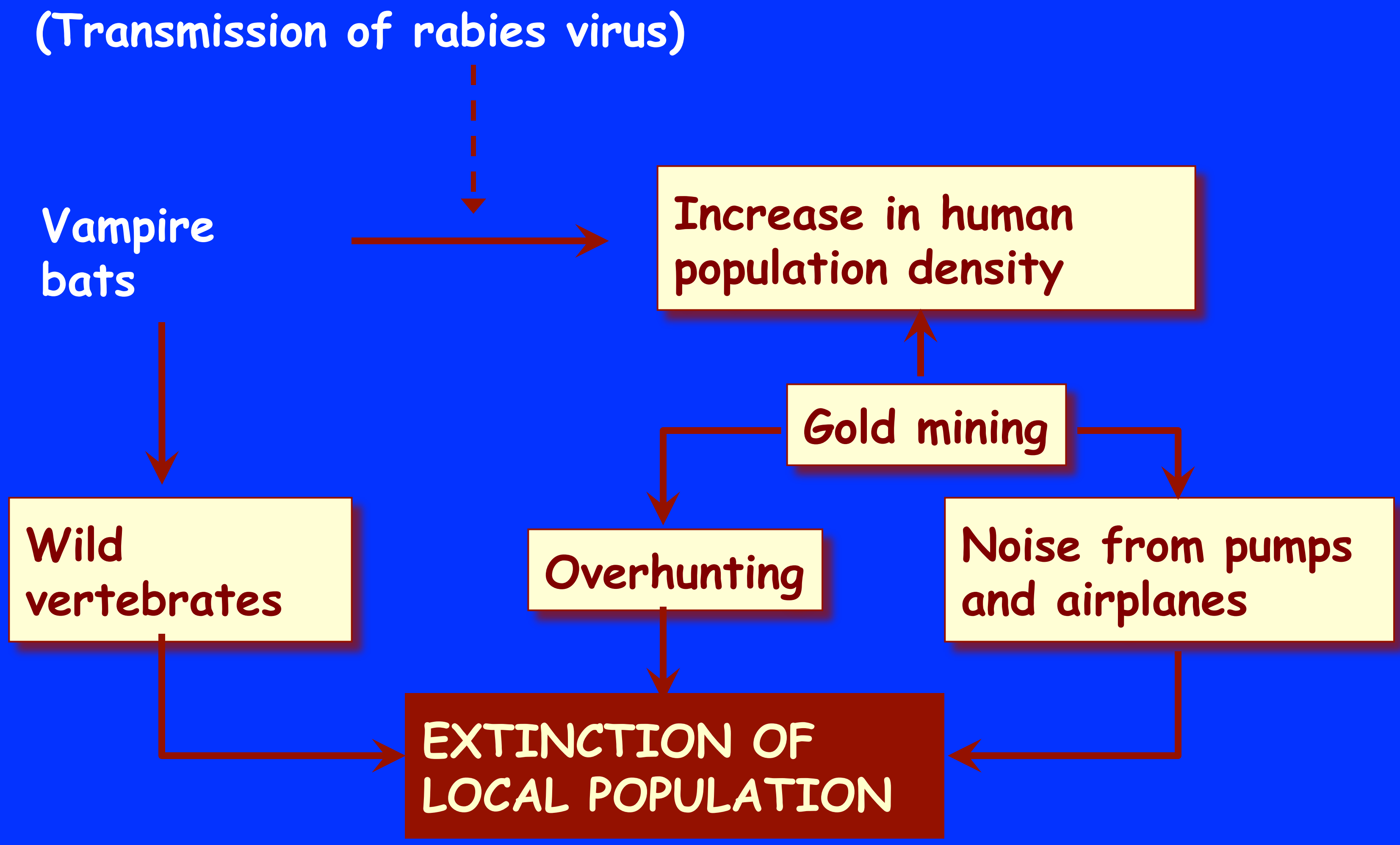
Land use Δ and other diseases

- Rabies from human incursion into rainforests?

- Yellow Fever, Latin America?
  - Sylvatic cycle: canopy mosquitoes & monkeys
  - Rapid re-emergence *Aedes* in cities poses risk for large epidemics as trees felled and migrant workers exposed
- Leptospirosis and irrigated rice fields?

RABIES, Northern Amazon

Courtesy of: U. Confalonieri



Cycle of Yellow Fever in the forest and transfer to human populations

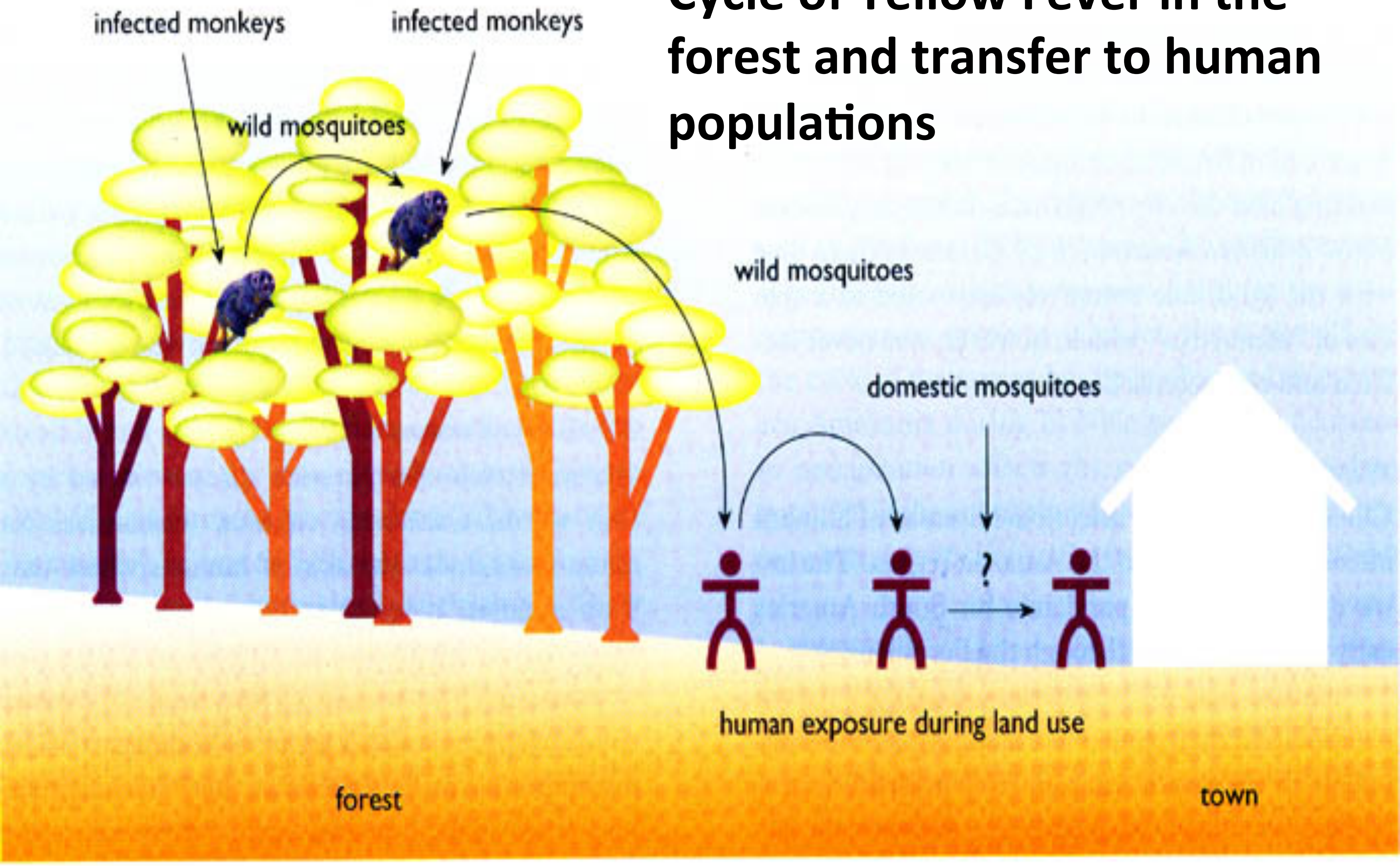
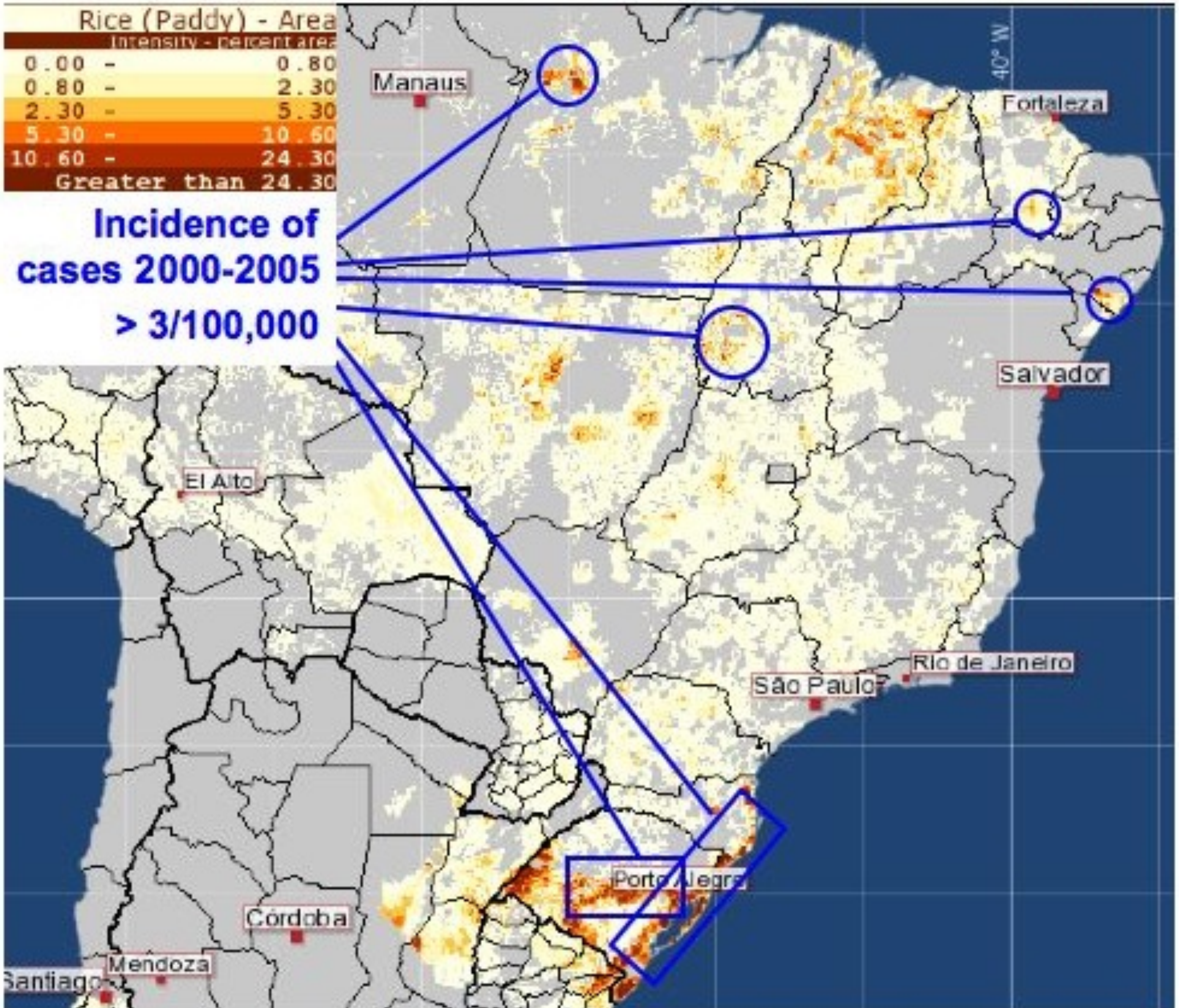


Figure 6 *Cycle of Yellow Fever in the Amazon Forest*

Source: Confalonieri, 2001

Rice Cultivation and Leptospirosis in Brazil



Data source: Ministry of Health Brazil and Monfreda et al 2008

Conclusion

1. Intact ecosystems can "regulate" infectious diseases

2. Biodiversity change can directly or indirectly affect the risk of certain infectious diseases

3. Disease prevention must extend beyond human health systems to include ecological factors and monitoring their status