One Health/Ecohealth Principles and Practice: Experience from Southeast Asia

Bruce A. Wilcox, M.S., Ph.D.

European – Southeast-Asian Experts, One Health (OH) in action Workshop:
From OH Theory to Reality Practical Challenges, Impact of OH Initiatives and Gaps in Research
Hanoi, 13th-15th October 2014

Global Health Asia
Integrative Education & Research Programme

One Health/Ecohealth Research Gaps

Knowledge (and data) gaps, but also:

- Methodological gaps

- Human and Institutional resource gaps

One Health &Ecohealth and “Integrative Research”: A Methodological Gap

OH/EH are integrative research* both aligned with the philosophy that the health of ***animals, humans and the natural environment are interdependent*** – unified, thus “one health”

They are informed by research and intervention approaches that combine information, theory and concepts from fields including: ***biomedicine, medical and veterinary medical practice, public health, environmental science, ecological sciences, etc.***

**Integrative* refers to projects are either interdisciplinary or transdisciplinary in that new knowledge and theory emerges from the *integration* of disciplinary knowledge.

Note: *one health* and *ecohealth* are ways of conceptually framing health challenges, neither is a particular theory that has been, or can be, tested and refined (or potentially rejected).

Example: Lancet One Health Issue

*Understanding the ecology of zoonotic diseases at the human being–animal interface is a **complex challenge**. It requires knowledge of animal and human medicine, ecology, sociology, microbial ecology, and evolution, and the underlying issues that drive increased transmission of pathogens in humans, wildlife, and livestock: an idea described as a One Health perspective.* (Karesh et al 2012)

Excellent statement—but itdoes not describe HOW addressing this challenge requires employing integrative research that attempts to combine these knowledge areas.

Keys to this challenge:

- Understanding difference between environment and ecology (and environmental sciences and ecological science).
- Use of ecological (and evolutionary biology)theory as the basis for integrative research processes that can be derived from One Health/Ecohealth tenets.

Where’s the theory in One Health and Ecohealth?

Tenets?

Concepts?

→Theory/principles

One Health Tenets

Scientifically, One Health may be best described by breaking it down into its core beliefs (tenets), and identifying the areas of relevant scientific knowledge and their associated concepts and theories.

- The health of human's, animals and environment are ***interdependent***….

- The interaction of humans and animals (domestic and wild) together with the **environment** must be studied to understand most infectious diseases – their origin, pathogen **evolution**, **transmission dynamics** and ***epidemiology***.

- Contact between and the spatial **or environmental** co-location of human and animal host species' populations (e.g., human-wildlife **population*interface***) is key…

- Human health and well-being depends on animal health and well-being and both require ***healthy ecosystems*** operationalized (made practical) in terms of life support "services" natural **ecological** processes provide…

Concept & Conceptual Framework

CONCEPT. *1 : something conceived in the mind. 2 : an abstract or generic idea generalized from particular instances.*

A conceptual framework:

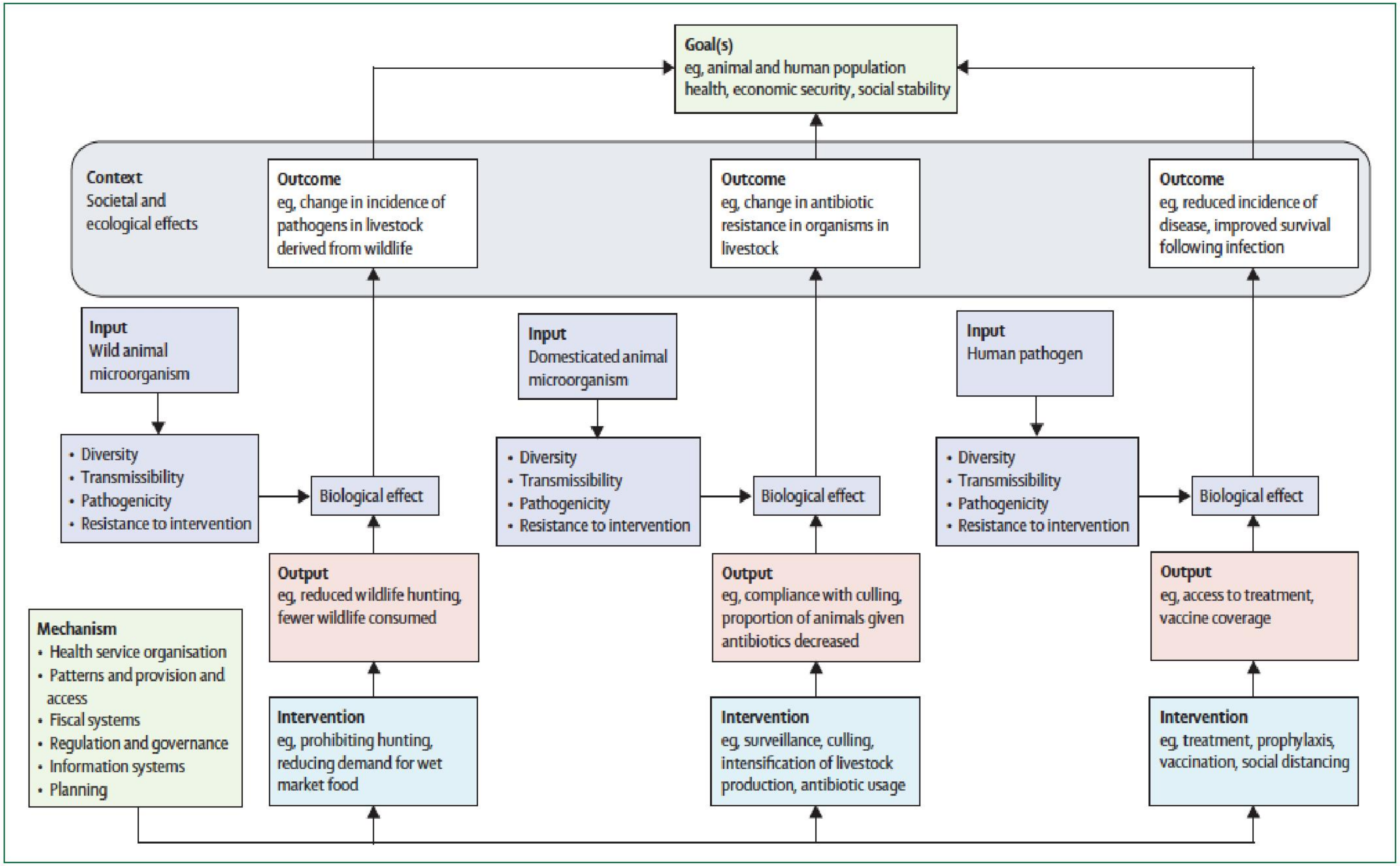
a group of concepts that are broadly defined and systematically organized to provide a focus,

a rationale, and a tool for the integration and interpretation of information.

Usually expressed abstractly through word models, a conceptual framework is the conceptual basis for many theories

medical-dictionary.thefreedictionary.com

One Health Research Policy Conceptual Framework (Coker at al. 2011)



Goal(s)
eg, animal and human population health, economic security, social stability

Context
Societal and ecological effects

Outcome
eg, change in incidence of pathogens in livestock derived from wildlife

Outcome
eg, change in antibiotic resistance in organisms in livestock

Outcome
eg, reduced incidence of disease, improved survival following infection

Input
Wild animal microorganism

Input
Domesticated animal microorganism

Input
Human pathogen

- Diversity
- Transmissibility
- Pathogenicity
- Resistance to intervention

Biological effect

- Diversity
- Transmissibility
- Pathogenicity
- Resistance to intervention

Biological effect

- Diversity
- Transmissibility
- Pathogenicity
- Resistance to intervention

Biological effect

Output
eg, reduced wildlife hunting, fewer wildlife consumed

Output
eg, compliance with culling, proportion of animals given antibiotics decreased

Output
eg, access to treatment, vaccine coverage

Mechanism
- Health service organisation
- Patterns and provision and access
- Fiscal systems
- Regulation and governance
- Information systems
- Planning

Intervention
eg, prohibiting hunting, reducing demand for wet market food

Intervention
eg, surveillance, culling, intensification of livestock production, antibiotic usage

Intervention
eg, treatment, prophylaxis, vaccination, social distancing

Figure: Schematic representation of a framework for research to inform one-health policy

Scientific Theory Defined

A scientific theory is a well-substantiated explanation of some aspect of the natural world that is acquired through scientific method and repeatedly tested and confirmed through observation and experimentation (USA National Academia of Sciences 1999)

A **scientific theory** must be *falsifiable, or refutable, or testable*. (Karl Popper 1963).

Examples in biology include: germ theory, cell theory, modern evolutionary synthesis, niche theory, etc

Theories are a specific category of models which fulfill the necessary criteria (as above). One can use language to describe a model; however, the theory is the model (or a collection of similar models), and not the description of the model.

A model *is a logical framework intended to represent reality (a 'model of reality'), similar to the way that a map is a graphical model that represents the territory of a city or country* (Ian Hacking 1983).

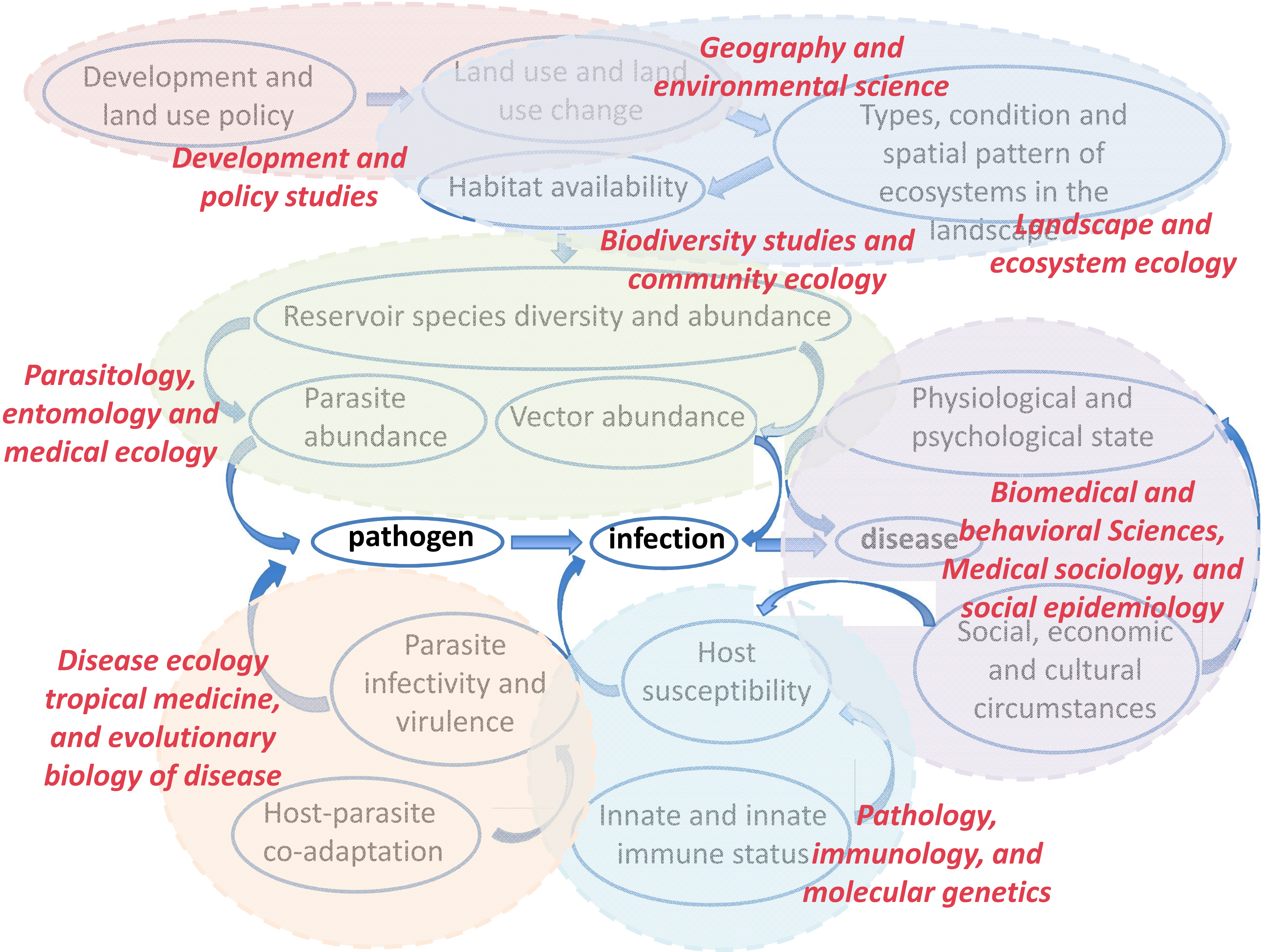
Biomedical Model, Germ Theory

A **biomedical model** is a surrogate for a human being, or a human biologic system, that can be used to understand normal and abnormal function from gene to phenotype and to provide a basis for preventive or therapeutic intervention in human diseases.
It is a conceptual model of illness that excludes psychological and social factors and includes only biologic factors in an attempt to understand a person's medical illness or disorder. http://medical-dictionary.thefreedictionary.com

pathogen → **infection** → **disease**

The **biomedical model** of medicine dates to the mid-19th century and it the predominant model used by physicians in diagnosing diseases. It has four core elements: freedom from disease, pain, or defect, thus making the normal human condition "healthy.”

http://en.wikipedia.org/wiki/Biomedical_model


Development and land use policy
Land use and land use change
Geography and environmental science
Types, condition and spatial pattern of ecosystems in the landscape
Development and policy studies
Habitat availability
Landscape and ecosystem ecology
Biodiversity studies and community ecology
Reservoir species diversity and abundance
Parasitology, entomology and medical ecology
Parasite abundance
Vector abundance
Physiological and psychological state
Biomedical and behavioral Sciences, Medical sociology, and social epidemiology
pathogen
infection
disease
Social, economic and cultural circumstances
Disease ecology tropical medicine, and evolutionary biology of disease
Parasite infectivity and virulence
Host susceptibility
Host-parasite co-adaptation
Innate and innate immune status
Pathology, immunology, and molecular genetics

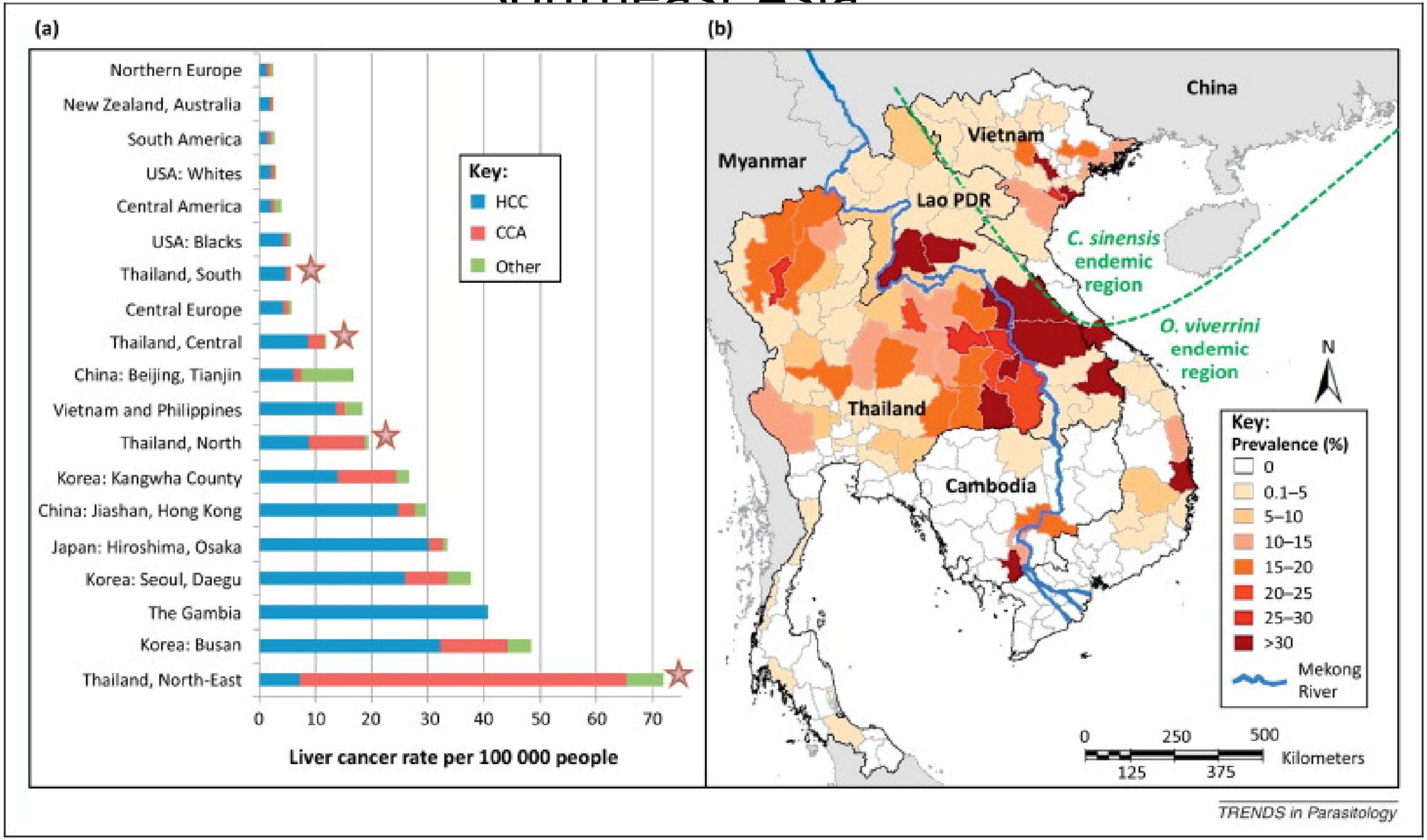
Distinguishing Environment and Ecology

Environmental science is an interdisciplinary fieldspanning thenatural, sciences, social sciences and the humanities.

Ecologyis a discipline defined as the study of interactions among organisms and their environment, such as the interactions organisms have with each other and with their abiotic environment.

http://en.wikipedia.org

Liver fluke (*Opisithorchisviverrini*and *Clonorchissinensis*) Infection and Liver Disease in Southeast Asia



TRENDS in Parasitology

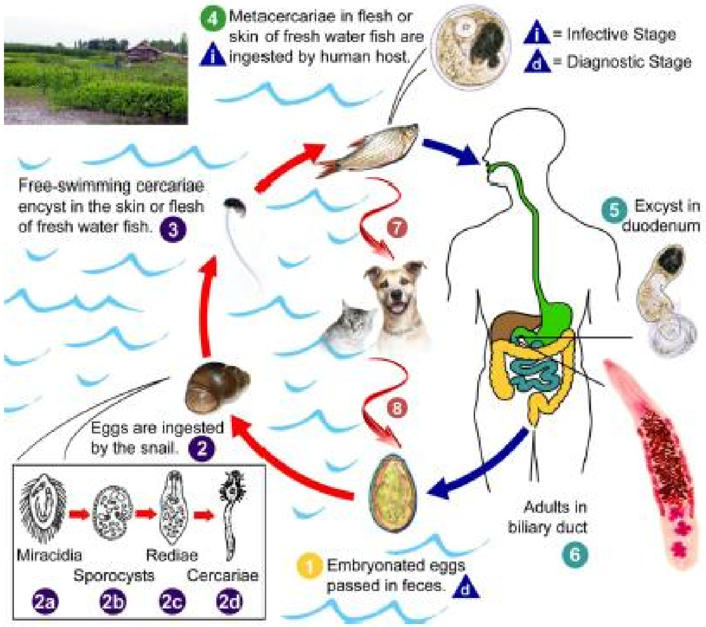
From Spripa et al 2012

Challenges to *Opisithorchisviverrini* Control

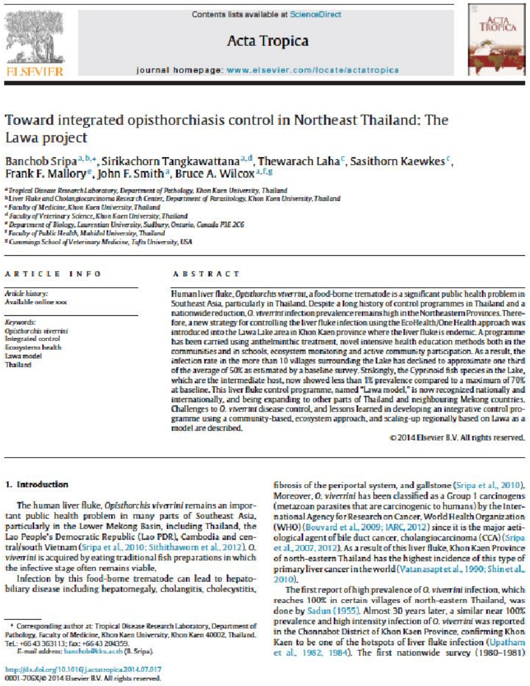
- Decades of government control efforts have failed to substantially reduce infection prevalence in the North and especially Northeast Thailand.

- Control programs has been mostly “top down” and focused on “health education” aimed at curtailing “improper” food preparation and “sanitation”.

- Control strategies have been uninformed due to a lack of depth of understanding of ecology and social ecology of transmission dynamics.



O. Viverrini life cycle is complex and transmission dynamics are largely unknown


Contents lists available at ScienceDirect

Acta Tropica

journal homepage: www.elsevier.com/locate/actatropica

Toward integrated opisthorchiasis control in Northeast Thailand: The Lawa project

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ARTICLE INFO

Article history:
Available online xxx

Keywords:
Opisthorchis viverrini
Integrated control
Ecosystems health
Lawa model
Thailand

ABSTRACT

Human liver fluke, *Opisthorchis viverrini*, a food-borne trematode is a significant public health problem in Southeast Asia, particularly in Thailand. Despite a long history of control programmes in Thailand and a nationwide reduction, *O. viverrini* infection prevalence remains high in the Northeastern Provinces. Therefore, a new strategy for controlling the liver fluke infection using the EcoHealth/One Health approach was introduced into the Lawa Lake area in Khon Kaen province where the liver fluke is endemic. A programme has been carried using anthelminthic treatment, novel intensive health education methods both in the communities and in schools, ecosystem monitoring and active community participation. As a result, the infection rate in the more than 10 villages surrounding the Lake has declined to approximate one third of the average of 50% as estimated by a baseline survey. Strikingly, the Cyprinoid fish species in the Lake, which are the intermediate host, now showed less than 1% prevalence compared to a maximum of 70% at baseline. This liver fluke control programme, named “Lawa model,” is now recognized nationally and internationally, and being expanding to other parts of Thailand and neighbouring Mekong countries. Challenges to *O. viverrini* disease control, and lessons learned in developing an integrative control programme using a community-based, ecosystem approach, and scaling-up regionally based on Lawa as a model are described.

1. Introduction

The human liver fluke, *Opisthorchis viverrini* remains an important public health problem in many parts of Southeast Asia, particularly in the Lower Mekong Basin, including Thailand, the Lao People's Democratic Republic (Lao PDR), Cambodia and central/south Vietnam (Sripa et al., 2010; Sithithaworn et al., 2012). *O. viverrini* is acquired by eating traditional fish preparations in which the infective stage often remains viable.

Infection by this food-borne trematode can lead to hepatobiliary disease including hepatomegaly, cholangitis, cholecystitis, fibrosis of the periportal system, and gallstone (Sripa et al., 2010). Moreover, *O. viverrini* has been classified as a Group 1 carcinogens (metazoan parasites that are carcinogenic to humans) by the International Agency for Research on Cancer, World Health Organization (WHO) (Bouvard et al., 2009; IARC, 2012) since it is the major aetiological agent of bile duct cancer, cholangiocarcinoma (CCA) (Sripa et al., 2007, 2012). As a result of this liver fluke, Khon Kaen Province of north-eastern Thailand has the highest incidence of this type of primary liver cancer in the world (Vatanasapt et al., 1990; Shin et al., 2010).

The first report of high prevalence of *O. viverrini* infection, which reaches 100% in certain villages of north-eastern Thailand, was done by Sadun (1955). Almost 30 years later, a similar near 100% prevalence and high intensity infection of *O. viverrini* was reported in the Chonnabot District of Khon Kaen Province, confirming Khon Kaen to be one of the hotspots of liver fluke infection (Upatham et al., 1982, 1984). The first nationwide survey (1980–1981)

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http://dx.doi.org/10.1016/j.actatropica.2014.07.017
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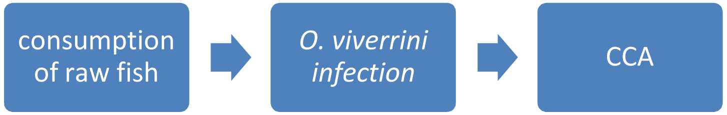
Two Views of Liver fluke infection and CCA Risk

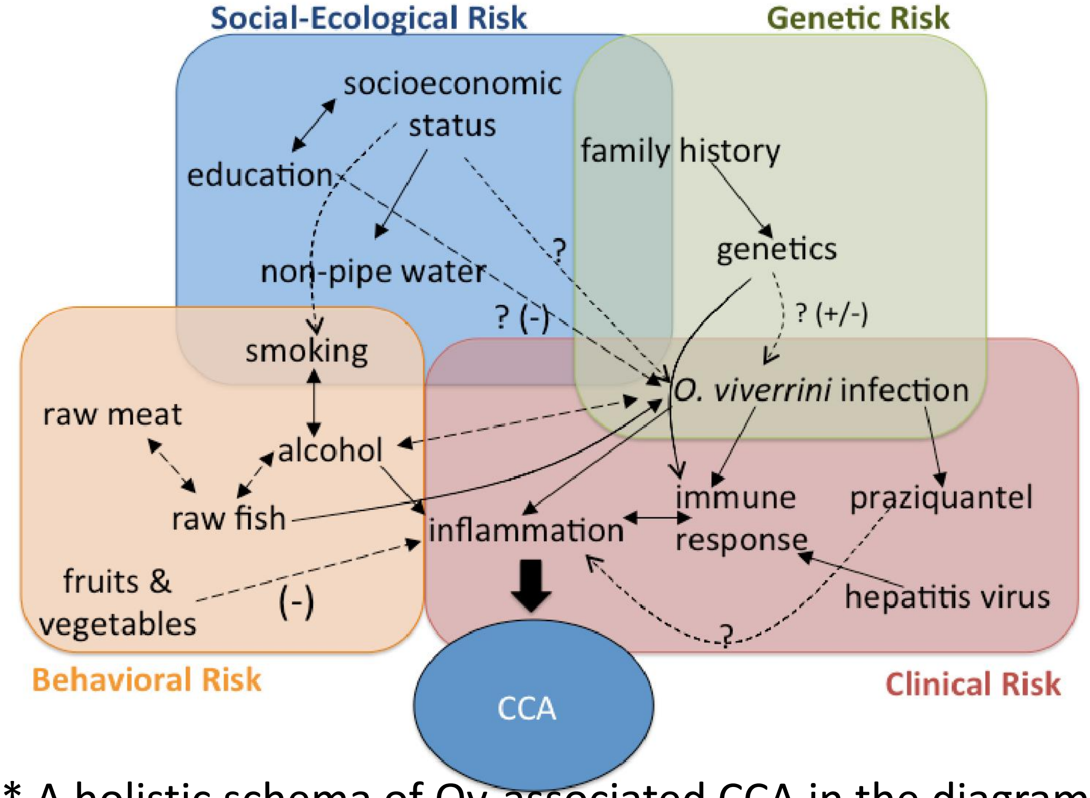
Reductionistic View of CCA Risk*



*The biomedical model-based depiction of CCA causation, informing clinical diagnostic and treatment; historically employed by government “health education” campaigns.

(Steele et al, In prep).

A Holistic View of CCA Risk*



* A holistic schema of Ov-associated CCA in the diagram to the right represents a synthesis of risk factors from an extensive literature review of published epidemiological, clinical and laboratory research.

Health Models Used Determines Research Orientation, Perceived Risk & Intervention Strategy

Biomedical model – most reductionist, clinically/pathology, diagnostic/treatment focused

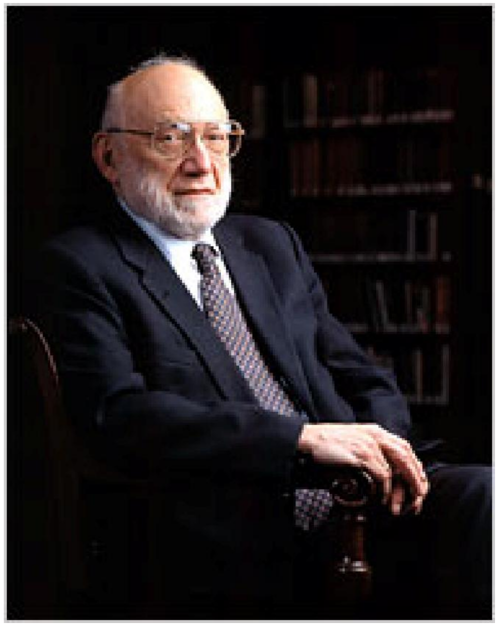
Public health models (e.g., biopyschosocial model, ecosocial model and salutogenic or continuum model) incorporate psychological, social, and culture dimensions of health—diagnostic/treatment, disease prevention/health promotion. (Tamm 1993).

Evolutionary medical model—microbial infection from an adaptive co-evolutionary perspective (Stearns and Koella 2007). As found in nature, microbial infections vary from being pathogenic to beneficial, as in the case of helminthes role in modulating a host's immune system.

Lay health models—"health model" of Isan-Lao villagers, the intended beneficiaries of most liver fluke education campaigns in Northeast Thailand, is distinctly different from the Western biomedical model. Reconciling these two views should provide the basis of more equitable and effective interventions (Samiphak 2014).

Tamm, M. E. 1993. Models of health and disease. Br J Med Psychol. 66:213-38
Stearns, S.C. and J. C. Koella. 2007. Evolution in Health and Disease (2ed). Oxford University Press.
Samiphak, S. 2014. Liver Fluke Infection and Fish Consumption in KhonKaen, Thailand: A Case Study on Negotiating the Middle Ground between Western Science and Eastern Culture. Ph.D. Thesis, University of California, Berkeley.

Joshua Lederberg on rethinking microbes and man



Prof. Joshua Lederberg (1922-2006), was a microbial geneticist who won the Nobel for Physiology or Medicine (1958) for discovering how bacteria exchange genetic material.

…. humans, animals, plants, and microbes are cohabitants of the planet…

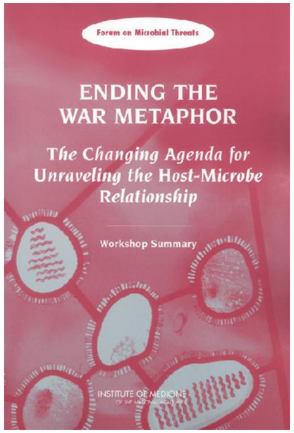
…instabilities within this context of cohabitation…arise from ***ecological and evolutionary*** [processes]...

…instabilities arise from the ways we alter the physical and biological environment…

…and our interactions (including hygienic and therapeutic interventions) with the parasites.

J. Lederberg. 2003. Infectious History. http://www.sciencemag.org/cgi/content/full/288/5464/287 (9 of 18) [9/2/2003 3:43:11 PM] Science -- Lederberg 288 (5464): 287

Ending the War Metaphor: ***…strategies and tactics for countering pathogens will be uncovered. But our most sophisticated leap would be to drop the manichaean view of microbes -- "We good; they evil." Lederberg 2003***



Duane Gubler on Ecological Understanding

The last century was one of triumphs and failures [in disease control]*. The triumphs came mostly in the first 70 years of the 20th century…*

*…from **understanding the ecology of certain diseases** **through field and laboratory research** and then using that knowledge to develop and implement prevention and control programs aimed at breaking the transmission cycles at their weakest points.*

*…The failures occurred when we became **complacent after successes** were achieved and relied too much on the **''quick fix'' or the ''magic bullet''** approach to disease control.**

---

*If there was one aspect of the [top down] Soper approach to Ae. aegypti control that failed, it was **the lack of sustainability**. It did not place the ultimate responsibility for urban mosquito control where it belongs: with the citizens of the **community**.*

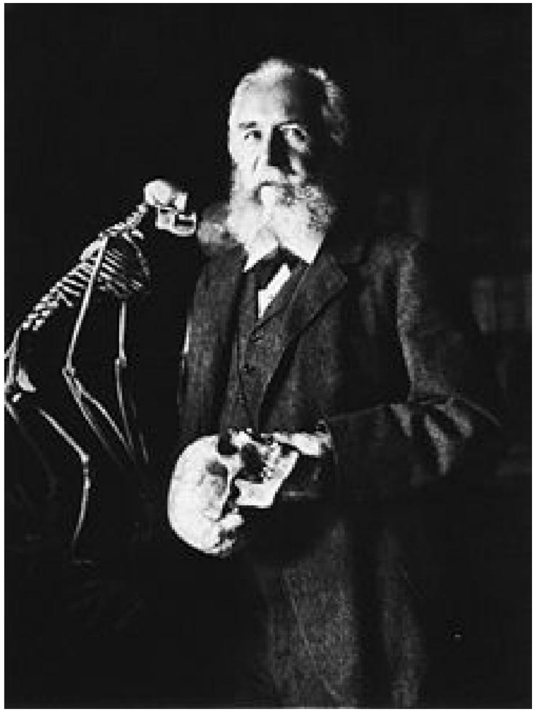
*The community-based **"bottom up"** approach to mosquito control [is] the most cost-effective over the long-term… [allows them to be responsible] for their own health destiny, [insures] mosquito control programs will have a lasting impact.***

Duane J. Gubler

*Duane J. Gubler. 1998. Prevention and Control of tropical diseases in the 21st Century: Back to the field. Presidential Address, The American Society of Tropical Medicine and Hygiene

**Duane J. Gubler. 1989. *AedesAegypti*and *AedesAegypti*-borne Disease Control in the 1990s: Top Down or Bottom Up49th Franklin Craig Lecture delivered before the American Society of Tropical Medicine & Hygiene, Washington, DC 12/7/88 Publication date: 01/01/1989

HaeckelSuggestsEcology (1866)



Ernst Haeckel (German Biologist, 1834-1919).

A new branch of study under the name Oecologie, “derWissenshaft von derOeconomie, derorganismenzueinander.”

… “the science of the relations of living organisms to the environment, their habitat, customs, energies, parasites, etc.”*

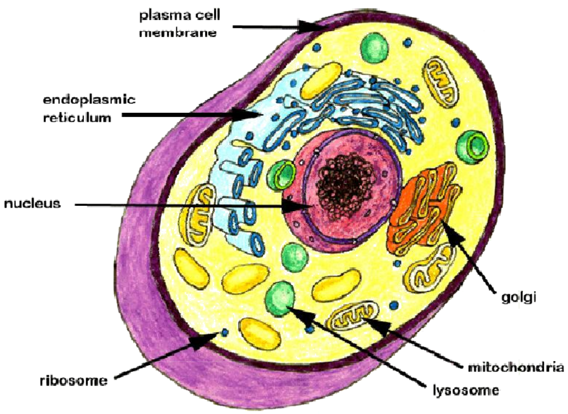
*English elaboration from Haeckel’s writings

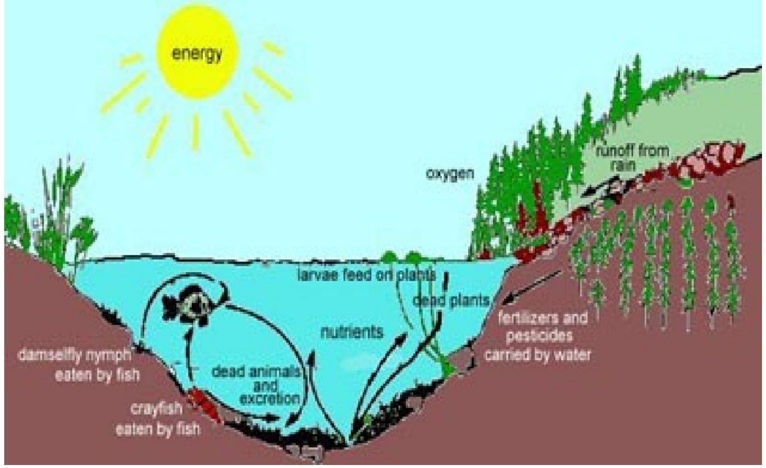
Laboratory

“Field”

Functional Units of Study in Biology: Cell and Ecosystem*

The ecosystem concept is central to ecology. It is now used frequently to describe any system.





Cell: the basic functional unit of an organism in biology

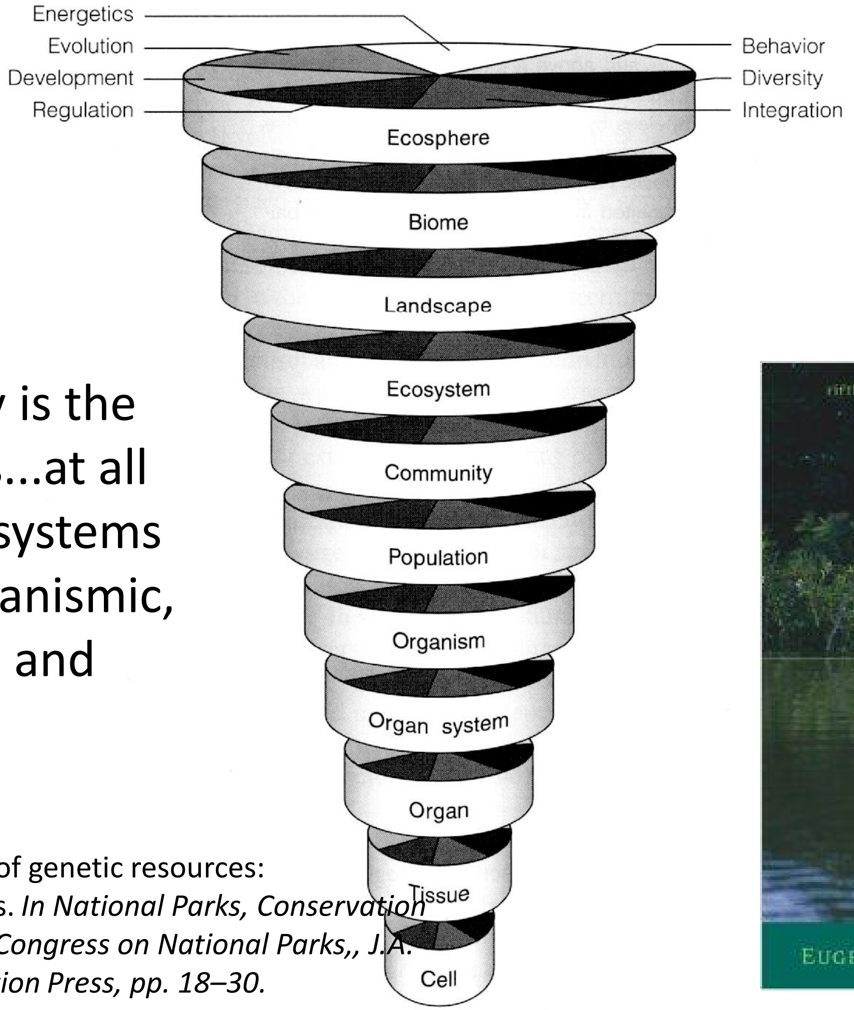
Ecosystem: the basic functional unit of a landscape or biosphere in biology

*Any unit that includes all of the organisms (I.e., the "community") in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles (ie: exchange of materials between living and nonliving parts) within the system is an ecosystem. Eugene Odum

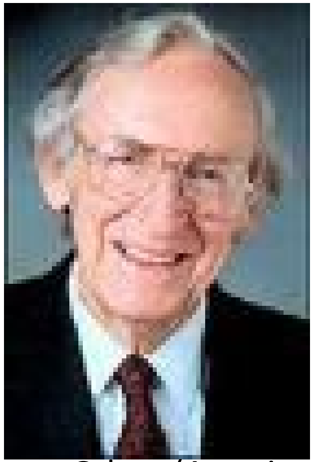
Fundamentals of Ecology: Levels of Organization in Biosystems as the Central Concept in Ecology (Hierarchy)

SECTION 2 **Levels-of-Organization Hierarchy** 5

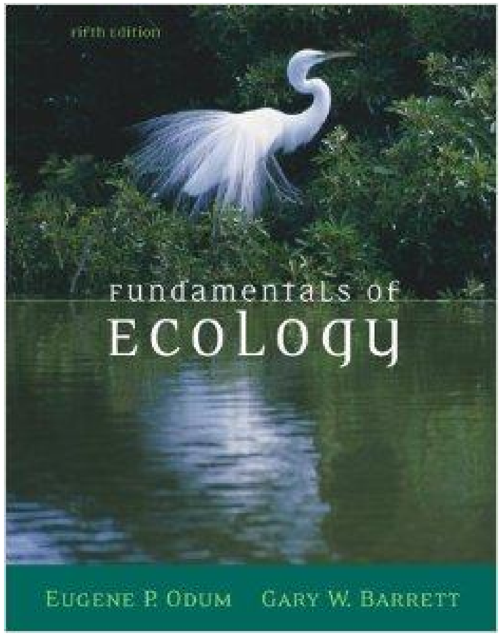
Figure 1-3. Ecological levels-of-organization hierarchy; seven transcending processes or functions are depicted as vertical components of eleven integrative levels of organization (after Barrett et al. 1997).



"Biological diversity is the variety of life forms...at all levels of biological systems (i.e., molecular, organismic, population, species and ecosystem)...".*

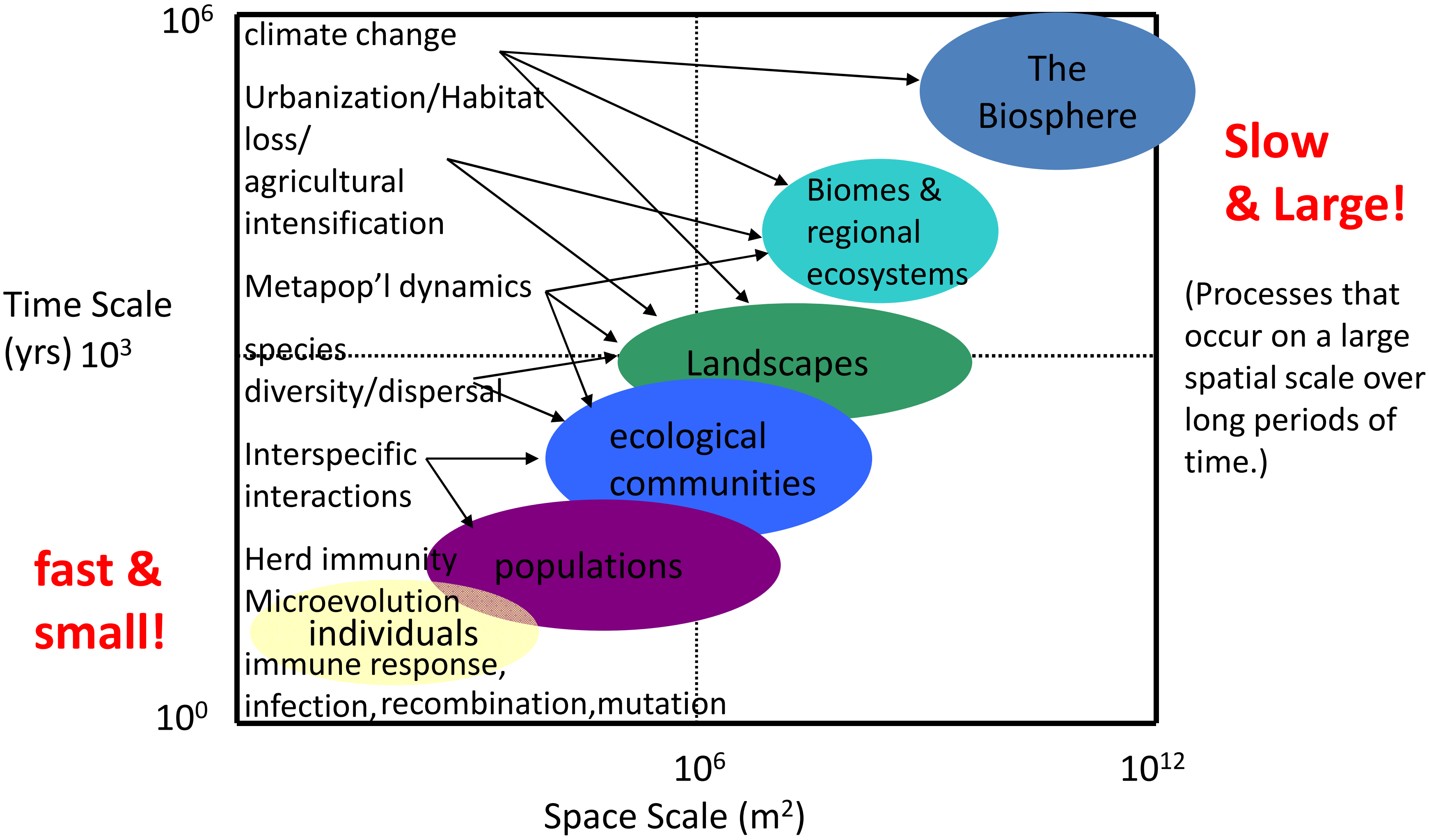


Eugene Odum (American ecologist, 1913-2002).



*Bruce A. Wilcox. 1984. In situ conservation of genetic resources: determinants of minimum area requirements. *In National Parks, Conservation and Development, Proceedings of the World Congress on National Parks,, J.A. McNeely and K.R. Miller, Smithsonian Institution Press, pp. 18–30.*

Ecological Time-Space Scales: Levels of organization relevant to disease emergence



fast & small!

Slow & Large!

(Processes that occur on a large spatial scale over long periods of time.)

Ecology as an Integrative Science

It is self-evident that science should not only be reductionist …but also synthetic and holistic in the sense of seeking to understand large components as functional wholes.

A human being, for example, is not only a hierarchal system composed of organs, cells, enzyme systems, and genes as subsystems, but is also a component of supraindividual hierarchal systems such as populations, cultural systems, and ecosystems.

Science and technology during the past half century have been so preoccupied with reductionism .. We are abysmally ignorant of the ecosystems of which we are dependent- parts.

25 March 1977, Volume 195, Number 4284 **SCIENCE**

The Emergence of Ecology as a New Integrative Discipline

Ecology must combine holism with reductionism if applications are to benefit society.

Eugene P. Odum

It is self-evident that science should not only be reductionist in the sense of seeking to understand phenomena by detailed study of smaller and smaller components, but also synthetic and holistic in the sense of seeking to understand large components as functional wholes. A human being, for example, is not only a hierarchal system composed of organs, cells, enzyme systems, and genes as subsystems, but is also a component of supraindividual hierarchal systems such as populations, cultural systems, and ecosystems. Science and technology during the past half century have been so preoccupied with reductionism that supraindividual systems have suffered benign neglect. We are abysmally ignorant of the ecosystems of which we are dependent parts. As a result, today we have only half a science of man. It is perhaps this situation, as much as any other, that contributes to the current public dissatisfaction with the scientist who has become so specialized that he is unable to respond to the larger-scale problems that now require attention. There is a rich literature on hierarchal theory and philosophy which deserves to be read by today's specialists (*1*). As expressed by Novikoff (*2*), there is both continuity and discontinuity in the evolution of the universe. Development may be viewed as continuous because it is never-ending, but also discontinuous because it passes through a series of different levels of organization.

An important consequence of hierarchal organization is that as components, or subsets, are combined to produce larger functional wholes, new properties emerge that were not present or not evident at the next level below. Fiebleman (*3*) has theorized that at least one new property emerges with each new integrative level of organization. Whatever the emergent rate, we can conclude that results at any one level aid the study of the next level in a set but never completely explain the phenomena occurring at that higher level, which itself must be studied to complete the picture. The old folk wisdom about "the forest being more than just a collection of trees" is indeed the first working principle for ecology. For example, intensive research at the cell level has established a firm basis for the future cure and prevention of cancer at the organism level, and perhaps for genetic engineering at the population level, should we ever choose to experiment in this direction. However, cell-level science will contribute very little to the well-being or survival of human civilization if our understanding of supraindividual levels of organization is so inadequate that we can find no solutions to population overgrowth, social disorder, pollution, and other forms of societal and environmental cancer. This is not to say that we abandon reductionist science, since a great deal of good for mankind has resulted from this approach, and some of our current short-range problems can perhaps be solved by this approach alone. Rather, the time has come to give equal time, and equal research and development funding, to the higher levels of biological organization in the hierarchal sequence. It is in the properties of the large-scale, integrated systems that hold solutions to most of the long-range problems of society. Again, Novikoff (*2*) expressed it well when he wrote, ". . . [E]qually essential for the purposes of scientific analysis are both the isolation of parts of a whole and their integration into the structure of the whole. . . . The consideration of one to the exclusion of the other acts to retard the development of biological and sociological sciences."

The New Ecology

The rise of what I have previously called the "new ecology" (*4*) is—in part, at least—a response to the need for greater attention to holism in science and technology. Since the word "ecology" is derived from the Greek root *oikos* meaning "house," it is an appropriate designation for the study of the biosphere in which we live. However, until quite recently, ecology as an academic subject had a much more limited scope than the name indicated. When I first came to the University of Georgia as a young instructor in 1940, my suggestion that a course in ecology be included in a core curriculum for majors received an exceedingly cold reception. My colleagues of those days confused ecology with natural history and voiced the opinion that no new ideas or principles were likely to be revealed in an ecology course that had not already been covered in courses in taxonomy, evolution, physiology, and other subjects considered to be more basic. As a partial result of this rebuff I decided to write a textbook that would emphasize unique principles that emerge at the supraindividual levels of organization. The first edition of *Fundamentals of Ecology*

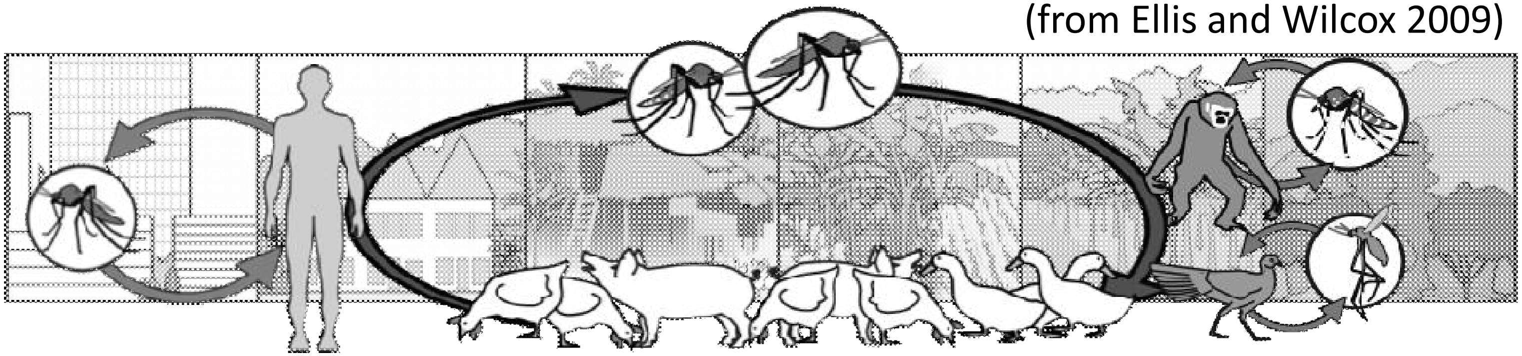
The author is Callaway Distinguished Professor of Ecology and director of the Institute of Ecology at the University of Georgia, Athens 30601. This article is based on an address given when the Prix de l'Institut de la Vie was awarded jointly to the author and his brother, Dr. Howard T. Odum, in Paris on 18 June 1975.

Eugene P. Odum. 1977. The Emergence of Ecology as a New Integrative Discipline. Science 195:1289-93

SecondCentral Concept: Integrating Ecology and Environmental Change:

- More than 75% of emerging infectious diseases are zoonotic, that is, they spread from animals to humans from natural host-pathogen cycles in nature.

- The emergence process involves a multitude of social and ecological factors, forces, and mechanisms operating at the level of microbial genetic adaptation to land use transformation and regional environmental change – not to mention globalization.



(from Ellis and Wilcox 2009)

Human Ecosystems Agroecosystems Natural Ecosystems

Host-vector ecological & evolutionary cross-landscape transition

Role of Ecology in Understanding Emergence (re-emergence) of Dengue (and other arboviruses)

Urbanization and the social ecology of emerging infectious diseases

4

Bruce A. Wilcox, Duane J. Gubler and H.F. Pizer

The twentieth century was a landmark in the history of mankind as a result of the widespread control and eradication of infectious diseases that historically had been the scourge of humans. The advent and effective use of new drugs, vaccines, insecticides, treatment and prevention strategies during and following World War II reinforced public health programs already in place, and provided the tools needed to bring many of the worst diseases under control. Smallpox was eradicated using a mass vaccination strategy. By the late 1960s, the "war on infectious diseases" was declared won by leading experts in the field and by the Surgeon General of the United States (Patlak, 1996).

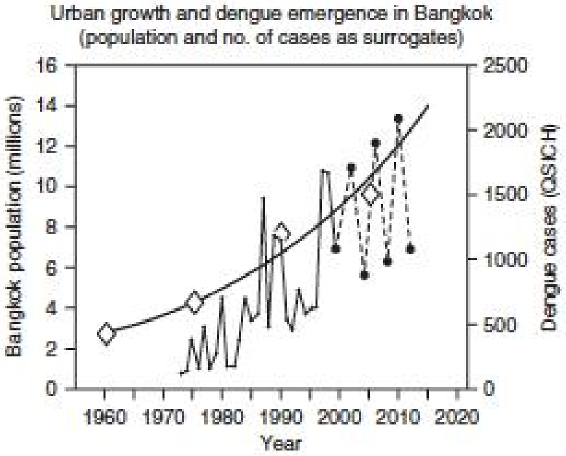
Unfortunately, the major successes in controlling infectious diseases in the 1950s and 1960s was followed by two coincident global trends that would have an impact on the dramatic re-emergence of infectious diseases in the waning years of the twentieth century. The first was the redirection of the resources that were once used to control infectious diseases to other public health priorities, such as the "War on Cancer" in the early 1970s. The perception that infectious diseases were no longer a problem led to decreased resources, widespread deterioration of public health infrastructure to deal with infectious diseases, and complacency among government and public health officials as well as the public (Smolinski *et al.*, 2003). This trend included medical education with a de-emphasis on preventive medicine and a strong focus on curative medicine in medical schools. Today, training in preventive medicine is not included in the curriculum of most medical schools in the US.

The second trend was the sharply increasing and unprecedented rate of human population growth following World War II that has continued for 60 years. Increasing human numbers have been a principal factor leading to uncontrolled

Table 4.2 Urban emerging infectious diseases of public health importance

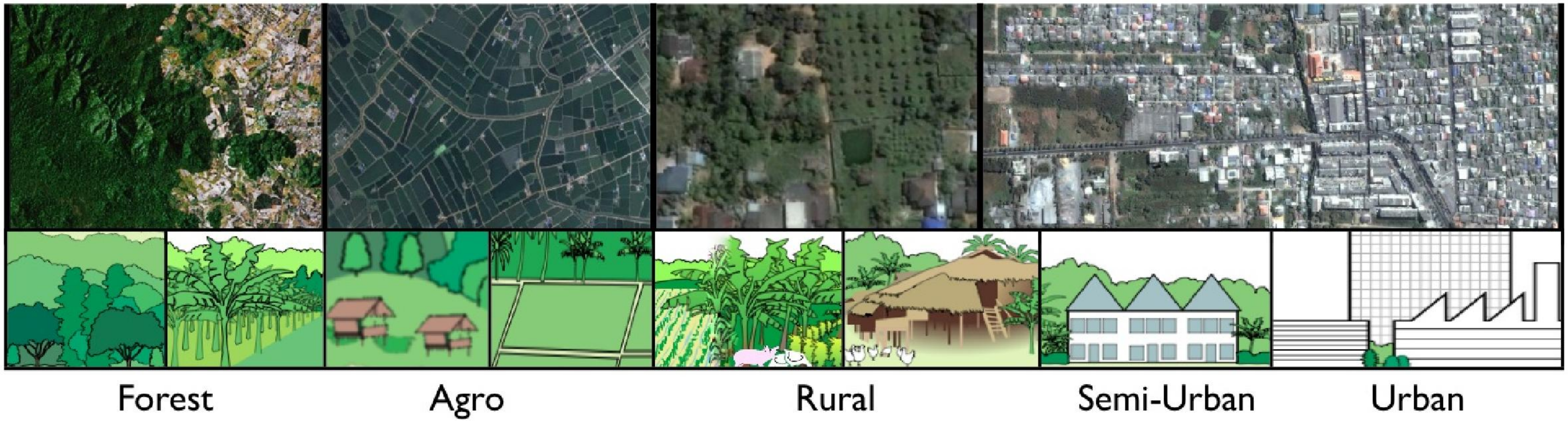
Family/virus	Vector	Vertebrate host	Ecology	Disease in humans	Geographic distribution
Togaviridae					
Chikungunya	Mosquitoes	Human, primates	U, S, R	SFI	Africa, Asia
Ross River	Mosquitoes	Human, primates	R, S, U	SFI	Australia, South Pacific
Mayaro	Mosquitoes	Birds	R, S, U	SFI	South America
Flaviviridae					
Dengue 1–4	Mosquitoes	Human, primates	U, S, R	SFI, HF	Worldwide in tropics
Yellow fever	Mosquitoes	Human, primates	R, S, U	SFI, HF	Africa, South America
Japanese encephalitis	Mosquitoes	Birds, pigs	R, S, U	SFI, ME	Asia, Pacific
St Louis encephalitis	Mosquito				
West Nile Virus	Mosquito				
Bunyaviridae					
Oropouche	Midges				

U, urban; S, suburban; R, rural
HF, hemorrhagic fever
Source: Gubler (2002).



B. A. Wilcox, D.J. Gubler, and H. Pizer. 2008. Urbanization and the social ecology of emerging infectious diseases. In K. Mayer and H. Pizer (Eds.), *The Social Ecology of Infectious Diseases*, Elsevier. Pp.115-137.

Interplay between Urban, Agricultural and Natural Ecosystems and Landscapes



Interplay exists between urban, agricultural and natural landscape largely explains disease emergence, especially:

- **Intensification** of human and biological activity (mainly driven by human activity)
- **Mixing** of living systems and biological agents
- **Transport** of biological agents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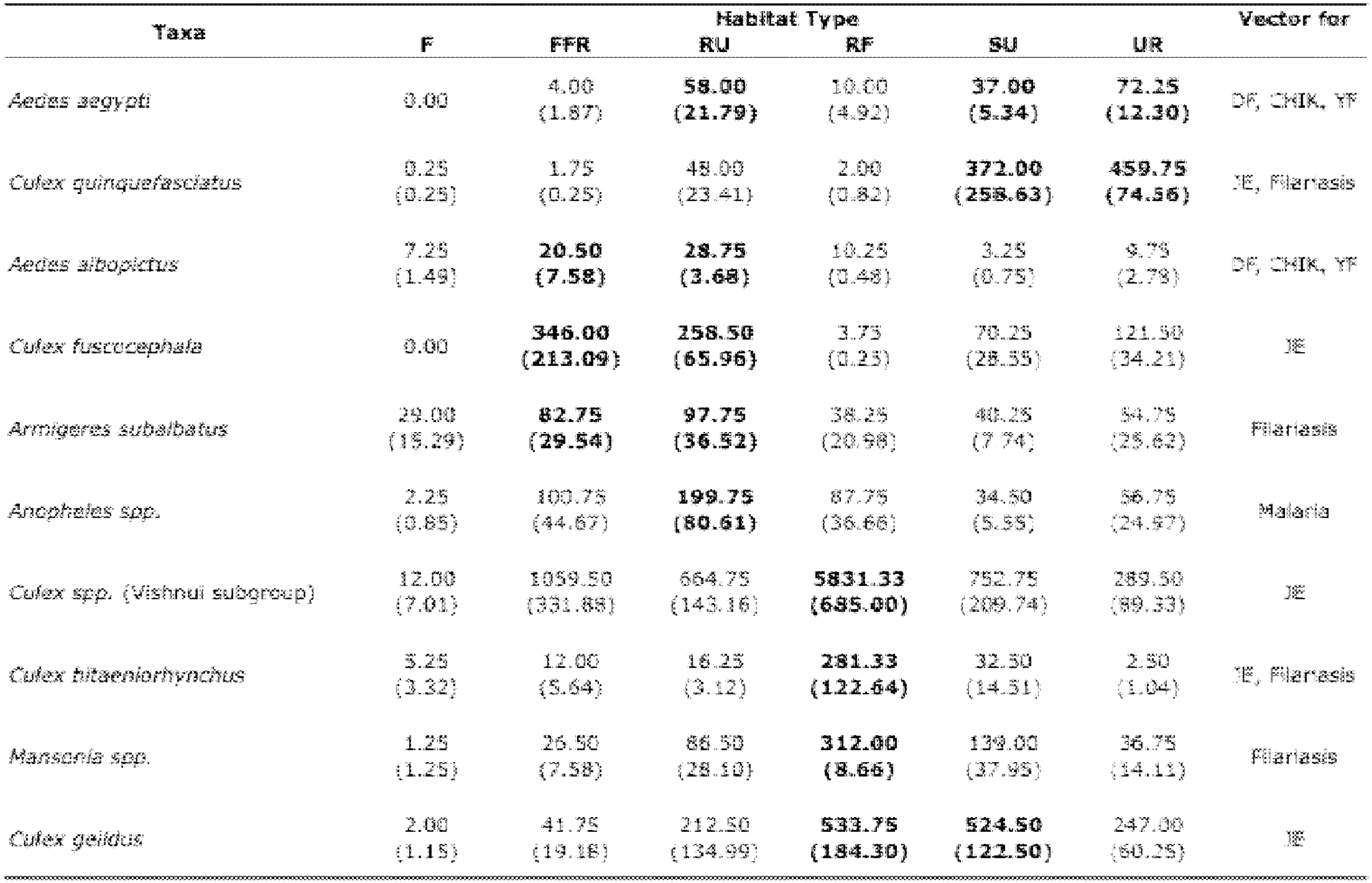
PLOS | NEGLECTED TROPICAL DISEASES

Mosquito Vector Diversity across Habitats in Central Thailand Endemic for Dengue and Other Arthropod-Borne Diseases

Panpim Thongsripong[1,2], Amy Green[3], Pattamaporn Kittayapong[4], Durrell Kapan[5,6], Bruce Wilcox[4,7], Shannon Bennett[2]*

Abstract

Vector abundance



Taxa	Habitat Type F	 FFR	 RU	 RF	 SU	 UR	Vector for
Aedes aegypti	0.00	4.00 (1.87)	**58.00** **(21.79)**	10.00 (4.92)	**37.00** **(5.34)**	**72.25** **(12.30)**	DF, CHIK, YF
Culex quinquefasciatus	0.25 (0.25)	1.75 (0.25)	48.00 (23.41)	2.00 (0.82)	**372.00** **(258.63)**	**459.75** **(74.56)**	JE, Filariasis
Aedes albopictus	7.25 (1.49)	**20.50** **(7.58)**	**28.75** **(3.68)**	10.25 (0.48)	3.25 (0.75)	9.75 (2.78)	DF, CHIK, YF
Culex fuscocephala	0.00	**346.00** **(213.09)**	**258.50** **(65.96)**	3.75 (0.25)	70.25 (28.55)	121.50 (34.21)	JE
Armigeres subalbatus	29.00 (15.29)	**82.75** **(29.54)**	**97.75** **(36.52)**	38.25 (20.98)	40.25 (7.74)	54.75 (25.62)	Filariasis
Anopheles spp.	2.25 (0.85)	100.75 (44.67)	**199.75** **(80.61)**	87.75 (36.66)	34.50 (5.55)	56.75 (24.97)	Malaria
Culex spp. (Vishnui subgroup)	12.00 (7.01)	1059.50 (331.88)	664.75 (143.16)	**5831.33** **(685.00)**	752.75 (209.74)	289.50 (89.33)	JE
Culex bitaeniorhynchus	5.25 (3.32)	12.00 (5.64)	16.25 (3.12)	**281.33** **(122.64)**	32.50 (14.51)	2.50 (1.04)	JE, Filariasis
Mansonia spp.	1.25 (1.25)	26.50 (7.58)	86.50 (28.10)	**312.00** **(8.66)**	139.00 (37.95)	36.75 (14.11)	Filariasis
Culex gelidus	2.00 (1.15)	41.75 (19.18)	212.50 (134.99)	**533.75** **(184.30)**	**524.50** **(122.50)**	247.00 (60.25)	JE

DF= Dengue Fever, CHIK = Chikungunya, YF = Yellow Fever

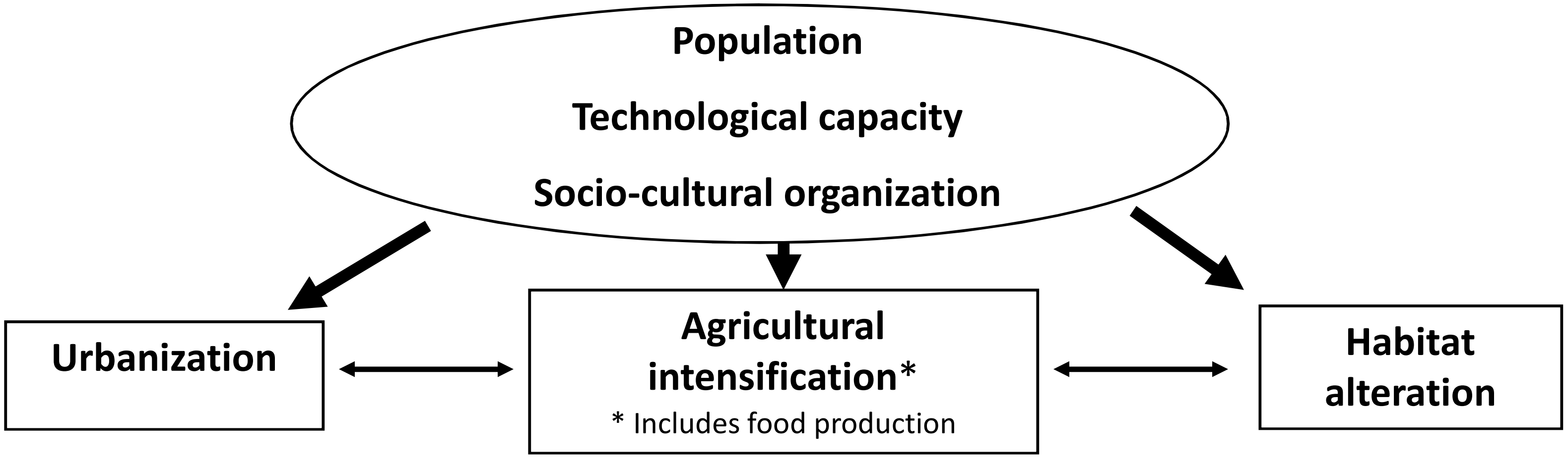
(Thongsripong& Wilcox unpublished)

Ecological Conceptual Framework for Emerging Infectious Diseases

Rita R. Colwell, Distinguished University Professor at the University of Maryland at College Park and at Johns Hopkins University Bloomberg School of Public Health. 11th Director of the United States National Science Foundation

Dr. Duane Gubler is professor and Program Director for Emerging Infectious Diseases at the Duke-NUS Graduate Medical School, Singapore

REGIONAL ENVIRONMENTAL CHANGE



Population

Technological capacity

Socio-cultural organization

Urbanization

Agricultural intensification*

* Includes food production

Habitat alteration

HUMAN ECOSYSTEM

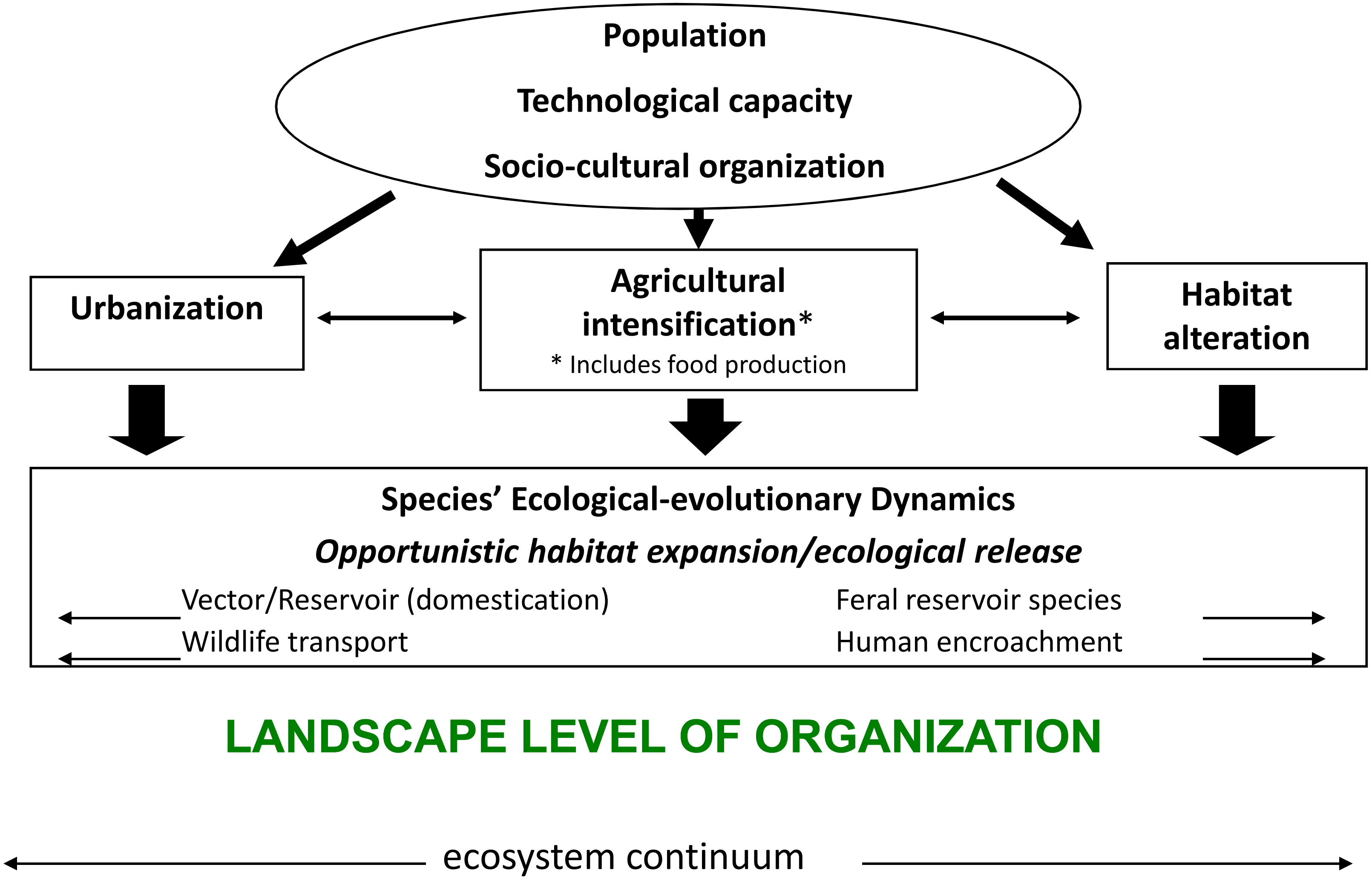
NATURAL ECOSYSTEM

ECOSYSTEM LEVEL OF ORGANIZATION

← ecosystem continuum →

(Based on Wilcox and Gubler 2005)

REGIONAL ENVIRONMENTAL CHANGE



HUMAN ECOSYSTEM

NATURAL ECOSYSTEM

Population

Technological capacity

Socio-cultural organization

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Agricultural intensification*

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Habitat alteration

Species' Ecological-evolutionary Dynamics

Opportunistic habitat expansion/ecological release

Vector/Reservoir (domestication)

Wildlife transport

Feral reservoir species

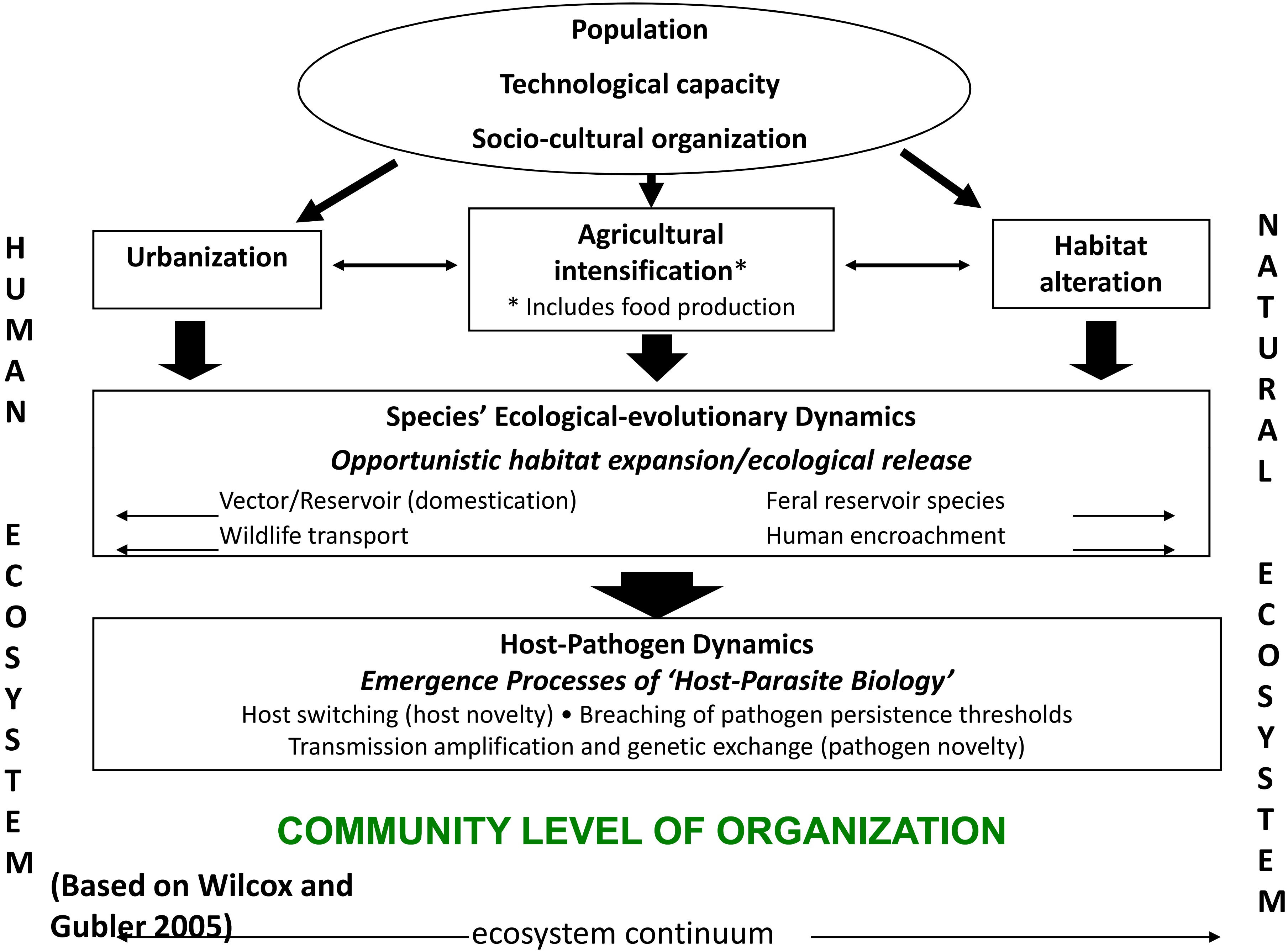
Human encroachment

LANDSCAPE LEVEL OF ORGANIZATION

ecosystem continuum

(Based on Wilcox and Gubler2005, Wilcox and Colwell 2005)

REGIONAL ENVIRONMENTAL CHANGE



Population

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Habitat alteration

HUMAN ECOSYSTEM

NATURAL ECOSYSTEM

Species' Ecological-evolutionary Dynamics

Opportunistic habitat expansion/ecological release

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Human encroachment

Host-Pathogen Dynamics

Emergence Processes of 'Host-Parasite Biology'

Host switching (host novelty) • Breaching of pathogen persistence thresholds

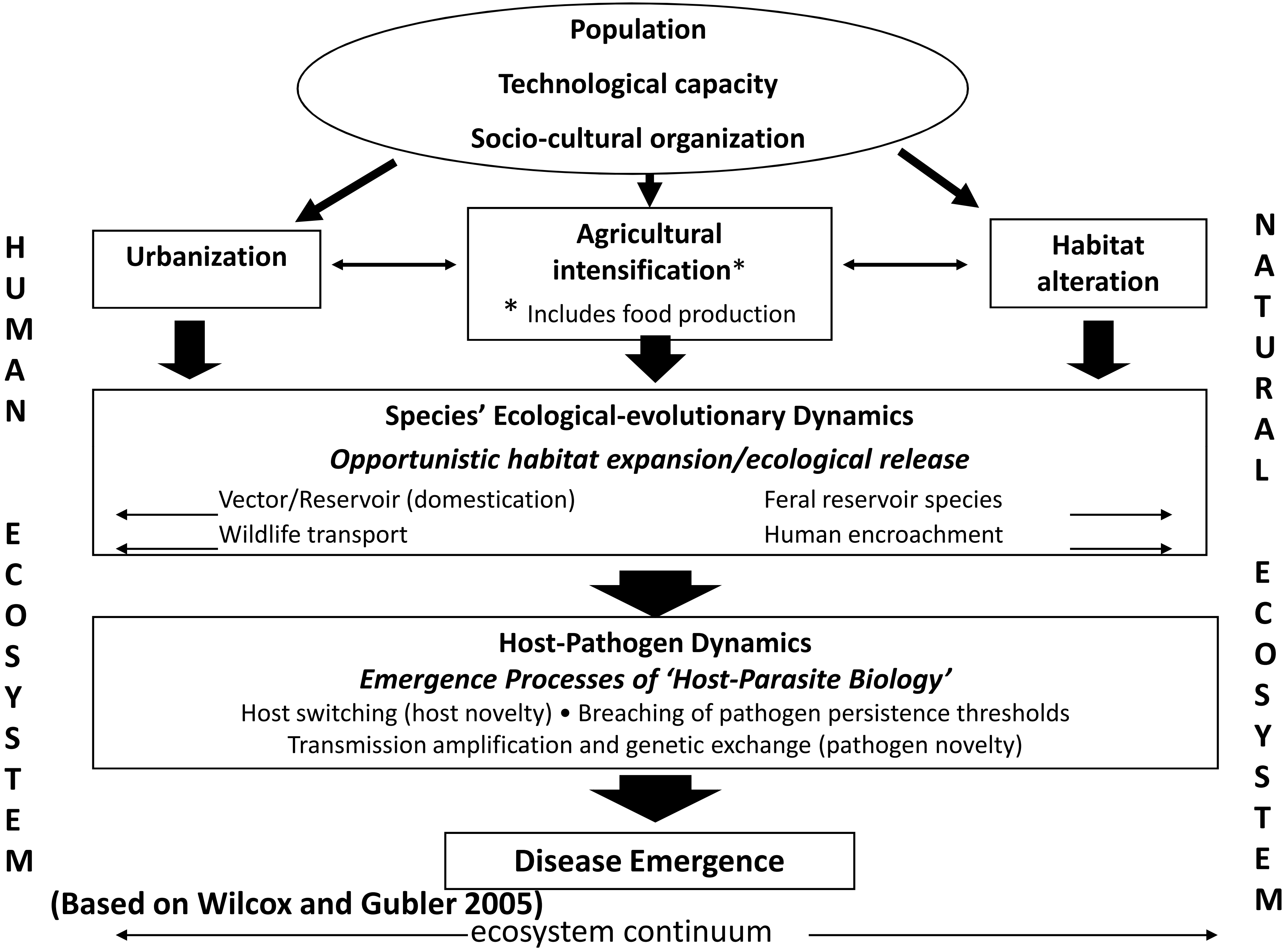
Transmission amplification and genetic exchange (pathogen novelty)

COMMUNITY LEVEL OF ORGANIZATION

(Based on Wilcox and Gubler 2005)

ecosystem continuum

REGIONAL ENVIRONMENTAL CHANGE



Population

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Habitat alteration

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Transmission amplification and genetic exchange (pathogen novelty)

Disease Emergence

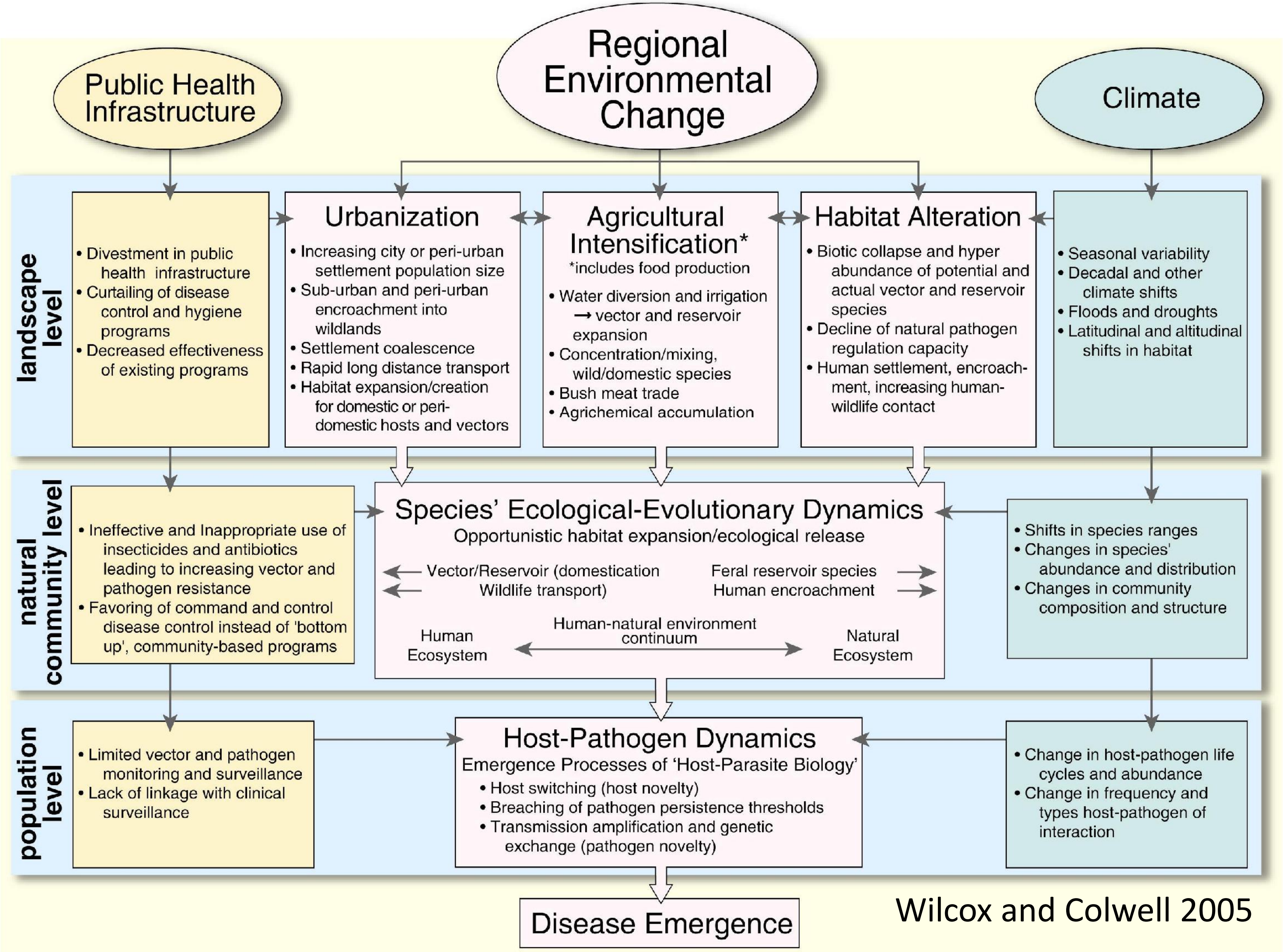
HUMAN ECOSYSTEM

NATURAL ECOSYSTEM

ecosystem continuum

(Based on Wilcox and Gubler 2005)

Emerging Infectious Disease Research "Blue Print"



Public Health Infrastructure

Regional Environmental Change

Climate

landscape level

- Divestment in public health infrastructure
- Curtailing of disease control and hygiene programs
- Decreased effectiveness of existing programs

Urbanization

- Increasing city or peri-urban settlement population size
- Sub-urban and peri-urban encroachment into wildlands
- Settlement coalescence
- Rapid long distance transport
- Habitat expansion/creation for domestic or peri-domestic hosts and vectors

Agricultural Intensification*

*includes food production

- Water diversion and irrigation → vector and reservoir expansion
- Concentration/mixing, wild/domestic species
- Bush meat trade
- Agrichemical accumulation

Habitat Alteration

- Biotic collapse and hyper abundance of potential and actual vector and reservoir species
- Decline of natural pathogen regulation capacity
- Human settlement, encroachment, increasing human-wildlife contact

- Seasonal variability
- Decadal and other climate shifts
- Floods and droughts
- Latitudinal and altitudinal shifts in habitat

natural community level

- Ineffective and Inappropriate use of insecticides and antibiotics leading to increasing vector and pathogen resistance
- Favoring of command and control disease control instead of 'bottom up', community-based programs

Species' Ecological-Evolutionary Dynamics

Opportunistic habitat expansion/ecological release

Vector/Reservoir (domestication Wildlife transport)

Feral reservoir species Human encroachment

Human Ecosystem

Human-natural environment continuum

Natural Ecosystem

- Shifts in species ranges
- Changes in species' abundance and distribution
- Changes in community composition and structure

population level

- Limited vector and pathogen monitoring and surveillance
- Lack of linkage with clinical surveillance

Host-Pathogen Dynamics

Emergence Processes of 'Host-Parasite Biology'

- Host switching (host novelty)
- Breaching of pathogen persistence thresholds
- Transmission amplification and genetic exchange (pathogen novelty)

- Change in host-pathogen life cycles and abundance
- Change in frequency and types host-pathogen of interaction

Disease Emergence

Wilcox and Colwell 2005

Coupled Natural-Human Systems and Emerging Infectious Diseases: Anthropogenic environmental change and avian influenza in Vietnam

National Science Foundation
WHERE DISCOVERIES BEGIN

"…a conceptual framework for examining the Wilcox-Gubler-Colwell hypothesis in the context of … risks, and perceptions of risk, associated with highly pathogenic avian influenza (HPAI) caused by the H5N1 virus…

…poultry deaths, can be associated with anthropogenic environmental changes produced by urbanization, agricultural change, and natural habitat alterations

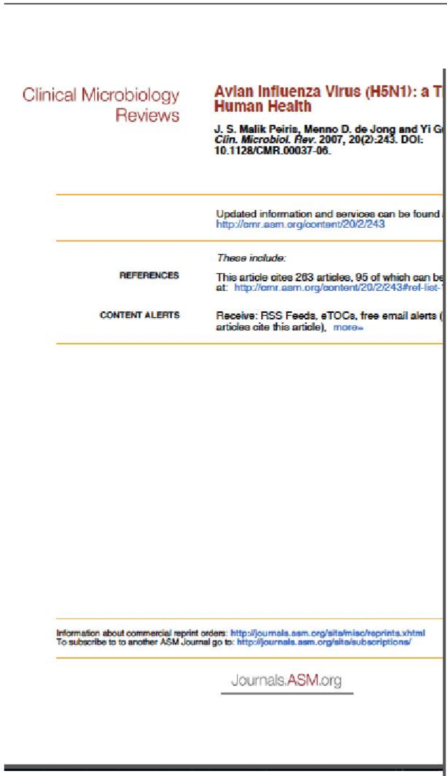
…suggesting these risks are not an accident of time and place, but rather are the prod-uct of the modernization and urbanization transitions.

M. L. Finucane, J. Fox, S. Saksena and J. H. Spencer. 2014. A Conceptual Framework for Analyzing Social-Ecological Models of Emerging Infectious Diseases.InM. J. Manfredo, J. J. Vaske, A. Rechkemmer and E. A. Duke, Understanding Society and Natural Resources: Forging New Strands of Integration Across Social Sciences. Springer

Ecological Mixing at Host Population, Community and Landscape Levels

“Surrogate measures, flock size and land use diversity of communes, significantly improve predictive power” – Saksena et al, in preparation

Highly Pathogenic Avian Influenza (H5N1) and the Missing Ecological Links



Clinical Microbiology Reviews

Avian Influenza Virus (H5N1): a T
Human Health

J. S. Malik Peiris, Menno D. de Jong and Yi G
Clin. Microbiol. Rev. 2007, 20(2):243. DOI:
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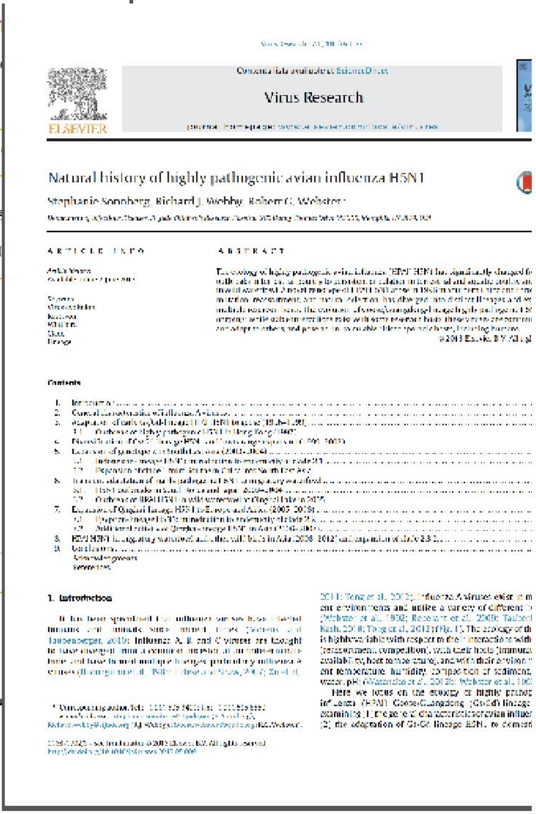

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Stephanie Sonnberg, Richard J. Webby, Robert G. Webster

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ABSTRACT

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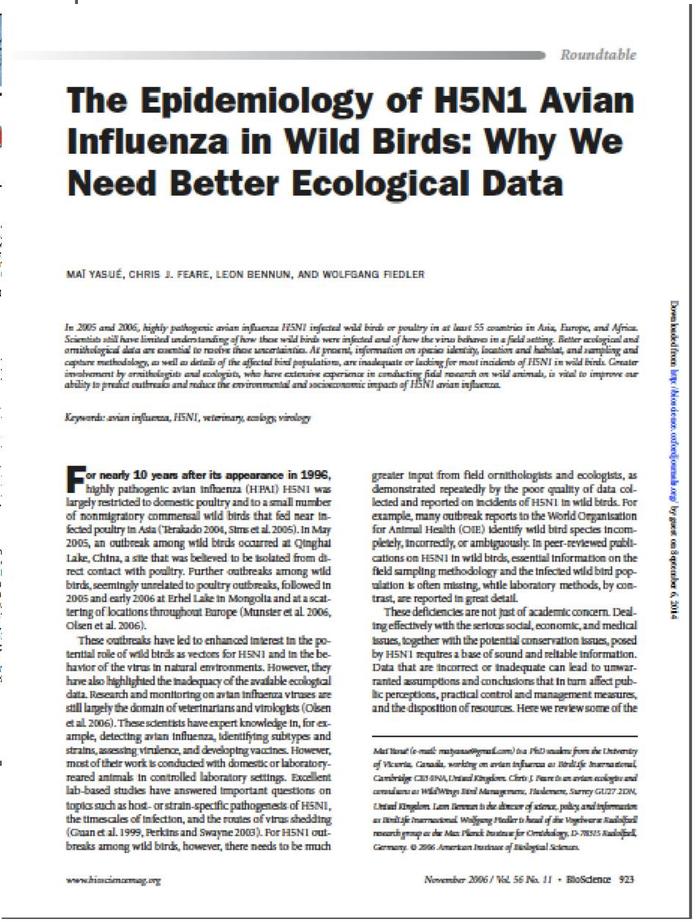
1. Introduction



Roundtable

The Epidemiology of H5N1 Avian Influenza in Wild Birds: Why We Need Better Ecological Data

MAÏ YASUÉ, CHRIS J. FEARE, LEON BENNUN, AND WOLFGANG FIEDLER

In 2005 and 2006, highly pathogenic avian influenza H5N1 infected wild birds or poultry in at least 55 countries in Asia, Europe, and Africa. Scientists still have limited understanding of how these wild birds were infected and of how the virus behaves in a field setting. Better ecological and ornithological data are essential to resolve these uncertainties. At present, information on species identity, location and habitat, and sampling and capture methodology, as well as details of the affected bird populations, are inadequate or lacking for most incidents of H5N1 in wild birds. Greater involvement by ornithologists and ecologists, who have extensive experience in conducting field research on wild animals, is vital to improve our ability to predict outbreaks and reduce the environmental and socioeconomic impacts of H5N1 avian influenza.

Keywords: avian influenza, H5N1, veterinary, ecology, virology

For nearly 10 years after its appearance in 1996, highly pathogenic avian influenza (HPAI) H5N1 was largely restricted to domestic poultry and to a small number of nonmigratory commensal wild birds that fed near infected poultry in Asia (Terakado 2004, Sims et al. 2005). In May 2005, an outbreak among wild birds occurred at Qinghai Lake, China, a site that was believed to be isolated from direct contact with poultry. Further outbreaks among wild birds, seemingly unrelated to poultry outbreaks, followed in 2005 and early 2006 at Erhel Lake in Mongolia and at a scattering of locations throughout Europe (Munster et al. 2006, Olsen et al. 2006).

These outbreaks have led to enhanced interest in the potential role of wild birds as vectors for H5N1 and in the behavior of the virus in natural environments. However, they have also highlighted the inadequacy of the available ecological data. Research and monitoring on avian influenza viruses are still largely the domain of veterinarians and virologists (Olsen et al. 2006). These scientists have expert knowledge in, for example, detecting avian influenza, identifying subtypes and strains, assessing virulence, and developing vaccines. However, most of their work is conducted with domestic or laboratory-reared animals in controlled laboratory settings. Excellent lab-based studies have answered important questions on topics such as host- or strain-specific pathogenesis of H5N1, the timescales of infection, and the routes of virus shedding (Guan et al. 1999, Perkins and Swayne 2003). For H5N1 outbreaks among wild birds, however, there needs to be much greater input from field ornithologists and ecologists, as demonstrated repeatedly by the poor quality of data collected and reported on incidents of H5N1 in wild birds. For example, many outbreak reports to the World Organisation for Animal Health (OIE) identify wild bird species incompletely, incorrectly, or ambiguously. In peer-reviewed publications on H5N1 in wild birds, essential information on the field sampling methodology and the infected wild bird population is often missing, while laboratory methods, by contrast, are reported in great detail.

These deficiencies are not just of academic concern. Dealing effectively with the serious social, economic, and medical issues, together with the potential conservation issues, posed by H5N1 requires a base of sound and reliable information. Data that are incorrect or inadequate can lead to unwarranted assumptions and conclusions that in turn affect public perceptions, practical control and management measures, and the disposition of resources. Here we review some of the

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Maï Yasué (e-mail: maiyasue@gmail.com) is a PhD student from the University of Victoria, Canada, working on avian influenza at BirdLife International, Cambridge CB3 0NA, United Kingdom. Chris J. Feare is an avian ecologist and consultant at WildWings Bird Management, Haslemere, Surrey GU27 2DN, United Kingdom. Leon Bennun is the director of science, policy, and information at BirdLife International. Wolfgang Fiedler is head of the Vogelwarte Radolfzell research group at the Max Planck Institute for Ornithology, D-78315 Radolfzell, Germany. © 2006 American Institute of Biological Sciences.

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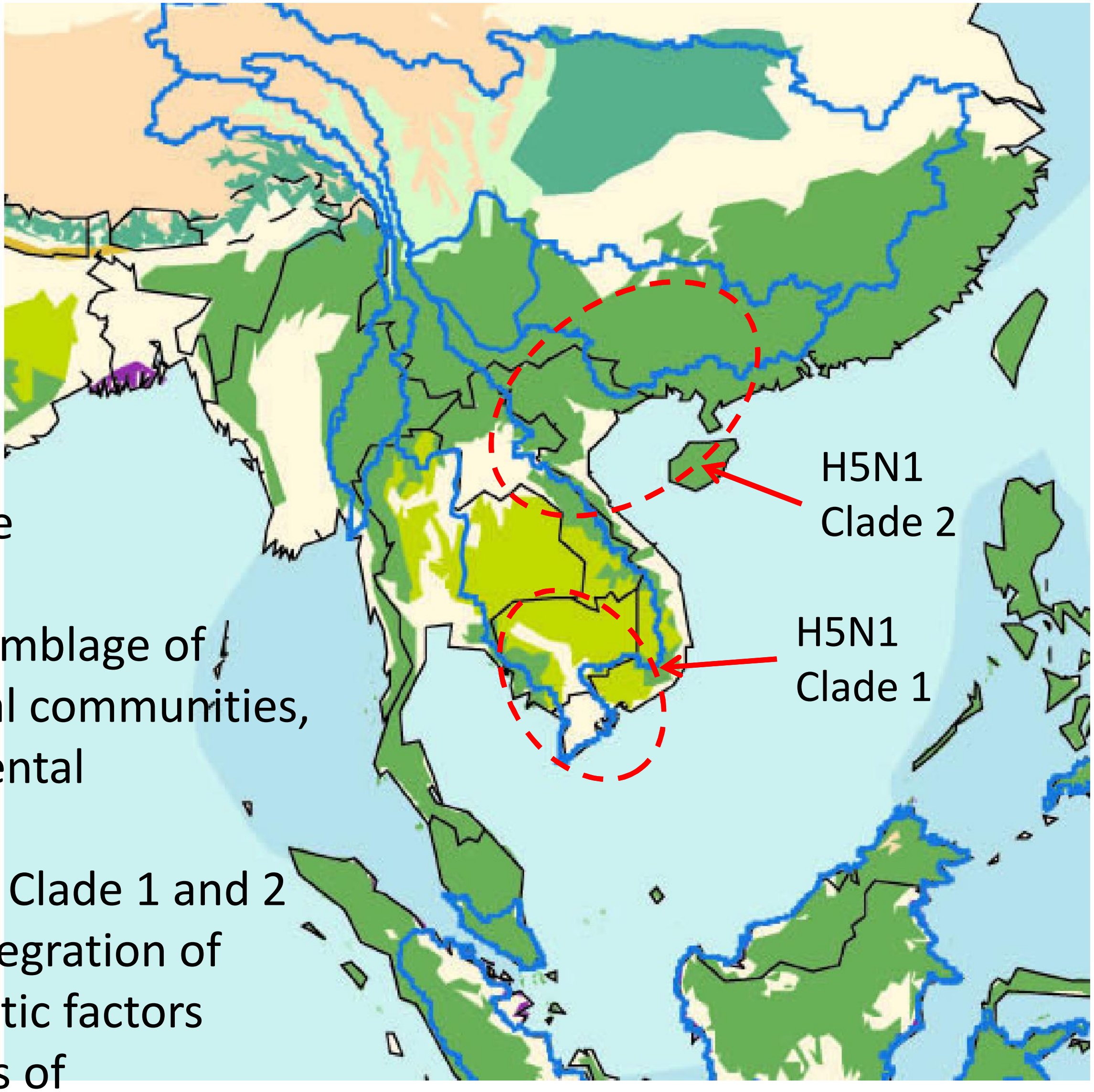
Evolution of Ecoregional-specific H5N1 variation



- Ecoregions are characterized as“distinctassemblage of species, natural communities, and environmental conditions".
- Emergence of Clade 1 and 2 reflects the integration of biotic and abiotic factors across all levels of organization

Conclusion: Ecology Matters

Understanding the ecology and evolution of pathogen/parasite transmission dynamics—including molecular and cellular processes of pathogenesis, virulence, immunogenesis—and in particular in relation to hosts (and vectors) at multiple levels of biological organization:

- ecosystem
- landscape
- community
- Population
- and interactions between these levels of the biological heirarchy

Social ecology– the organization, structure and behavior of human from the level of the individual, family, neighborhood, village/commune, etc—also is key.

Acknowledgements

Recent collaborators, among many, many more since 2001

Shannon Bennett, California Academic of Sciences
James Chandler, California Academic of Sciences
Pierre Echaubard, Laurentian University
Michael Epprecht, Swiss National Center of Competence in Research
Melissa L. Finucane, Rand Corporation
Jefferson Fox, East West Center (Honolulu, HI)
Delia Grace, International Livestock Research Institute (ILRI)
Amy Henry Green, University of Hawaii
Nguyen Viet Hung, Hanoi School of Public Health
SasithornKaewkes, KhonKaenUniversity
Durrell Kapan California Academic of Sciences
ChalisaKallayanamitra, Chiang Mai University
Nancy D. Lewis, East West Center (Honolulu, HI)
ThewarachLaha, KhonKaenUniversity
NgyuenThiLan, Vietnam National University of Agriculture
Hein Mallee, Research Institute for Humanity and Nature (RIHN), JapanFrank Mallory, Laurentian University
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