



Domestic fowl housed near waterways create risk for transmitting zoonotic pathogens (Bogor, Indonesia) Photo by Jamie K. Reaser

## Land Use-Induced Spillover: Considerations for Urban Mitigation Planning

By Jamie K. Reaser and Gary Tabor

The advent of COVID-19 (SARS-CoV-2 virus) is a call for greater attention to the human activities that drive pandemics. An understanding of causes facilitates the envisioning of solutions. Here we provide a brief overview of the ecological conditions and processes that facilitate pandemics, as well as pose questions for urban planners to take into consideration for achieving pandemic risk reduction.

Along with other colleagues, we recently proposed dominos as a way of imagining the chain of events that ultimately result in pandemics: something triggers the first domino to fall and the rest then fall in sequence, until all of the dominos have been

knocked over. The trigger, we believe, is land use change—human activities that destroy or degrade natural systems. We refer to the process as land use-induced spillover (Plowright et al. 2021, Reaser et al. 2021a, 2021b). Ecological countermeasures are targeted landscape-scale interventions that can be employed to reduce pandemic risks in human-modified ecosystems (Reaser et al. 2021c)

The metaphoric dominos fall as land use change creates environmental conditions that stress wildlife. The theory, which is backed by an increasing amount of scientific research, is that when wildlife become stressed, their immune systems become impaired making them

highly susceptible to infection by pathogens, disease-causing microbes. These animals thus become hosts, larger organisms that pathogens thrive on or within. Ongoing or additional stresses cause wildlife hosts to shed (release) pathogens in the environment, usually through urine, feces, or saliva. When humans come into contact with these pathogens, directly or indirectly, they too become pathogen-infected—they contract diseases. The transmission of a pathogen from animals to humans is known as zoonotic spillover. Sometimes the pathogens are transmitted from wildlife to people, and sometimes from wildlife to domestic animals to people. Some pathogens rely on vectors,

such as mosquitos or ticks, to accomplish transmission. Once a pathogen enters the human population, it spreads from person to person. The term epidemic means that a disease is prevalent throughout a community. The term pandemic means that a disease has reached global scale.

*What role do urban environments play in triggering land use-induced spillover?*

*How can urban planning mitigate zoonotic disease risks?*

Urban environments are constantly interacting with the landscapes in which they are embedded; the collective expression of human activities reaches near and far. While an urban “footprint” may be discrete, a city’s “metabolism” is hyper-connected to other cities and landscapes at a global scale. Urban living can facilitate large-scale zoonotic disease outbreaks—through the transmission opportunity associated with high density living, as well as the geographical extent of urban lifestyles. This poses challenges for urban planners in considering zoonotic disease risk mitigation (Ahmed et al. 2019).

We breakdown the mechanistic process of land use-induced spillover through the infect-shed-spill-spread cascade as it relates to cities, with the aim of highlighting points of strategic epidemic intervention for forward-looking urban designers. Although tropical and subtropical environments are

most commonly associated with zoonotic pathogen emergence (origin), once a pathogen spreads into a widely-distributed host, such as a house mouse or a human, the world may become borderless to disease. This is particularly worrisome given the increase in inter-urban networks. As COVID-19 has aptly demonstrated, the consequences for communities that have not wisely-invested in disease prevention and mitigation strategies will be measured in lives and livelihoods lost.

### Infection & Shedding: Urban Stressors

*Risks:* Urban areas are developed and provisioned through various land use processes that impact terrestrial, freshwater, and marine ecosystems. Environmental impacts may occur within a city’s vicinity as habitats are destroyed and degraded for construction purposes, or in relatively remote wildlands on the other side of the world where minerals are

mined, timber is felled, wildlife is extracted, or food is grown for export to urban centers. These impacts may be localized and acute, or intensive and pervasive, as well as dynamic across space and time.

Of course, cityscapes are not just characterized by what they take up and take in; urban areas also have a wide-range of outputs, among them pesticides, pharmaceuticals, garbage, and excrement. Noise, dust and light pollution are often overlooked as disturbances, but the scale of these nuisances are becoming vast as cities grow together creating mega-cities. Many of these pollutants can directly stress wildlife. Others may increase the prevalence and distribution of pathogens in the environment, sometimes in unexpected ways. For example, plastic products (including microplastics) can serve as colonizing substrates for various pathogens.



Fruit stand with unwashed produce could be contaminated with zoonotic pathogens. Sanitation stations could reduce risk (Rome, Italy). Photo by Jamie K. Reaser

### Considerations:

What can be done to educate urban developers about the risks their projects pose to human health so these risks can be mitigated? How can the development process be biophilic?

How can regulatory measures be more effectively employed to prevent land use-induced environmental stresses on wildlife species that are known zoonotic pathogen hosts?

How can urban environments be designed so that the majority of resources are provisioned locally?

### Spillover: Wildlife-Human Proximity

*Risks:* The risk of zoonotic pathogen spillover (transmission) between wildlife and people is largely a matter of proximity. In urban environments people may intentionally and unintentionally come into contact with numerous types of wildlife that have the potential to carry and transmit zoonotic diseases. Some of these diseases, such as rabies, are not readily spread from person to person. However, disease such as plague, cholera, and monkeypox have strong pandemic potential. Invasive vertebrates should be of particular concern in city environs because many zoonotic pathogens are associated with wide-spread invasive species (often considered “pests”) and ports of entry make urban areas especially vulnerable to biological invasion.

Common ways in which people intentionally come into direct contact with wildlife in urban areas include keeping wildlife (non-domesticated species) as pets (this includes animals purchased in pet stores), feeding wildlife, handling injured or orphaned wildlife, and consuming wildlife for food, medicine, or display purposes (e.g., trophies or art). Common ways in which people unintentionally come into direct or indirect contact (e.g., excrement) with wildlife in urban areas include via the infestation of invasive rodents and birds in dwellings, handling of containers used to feed wildlife, touching unsanitary surfaces in outdoor areas (e.g., picnic tables), and interacting with domestic animals that have been exposed to wildlife in urban yards, parks, farms, and zoos.

### Considerations:

What can be done to educate city dwellers and tourists about the risks that contact with wildlife poses to human health while also promoting wildlife appreciation—fostering biophilia?

How can regulatory measures be more effectively employed to minimize human contact with wildlife in urban environments by, for example, establishing stringent measures to eradicate and control invasive species, effectively manage waste and sanitation, and prohibit wildlife feeding?

How can urban environments be better designed to prevent

contact between high-risk wildlife (species known to carry zoonotic diseases) and people in ways that are not only humane to wildlife but foster wildlife populations in low-risk contexts? This could involve, for example, refraining from landscaping with fruiting plants that attract and concentrate high-risk wildlife near dwellings and recreation areas.

### Spread: Human Relations

*Risks:* Urban environments are characterized by large numbers of people living and working in close proximity. Human to human contact is high, whether direct or indirect, intentional or unintentional. For this reason, cities can serve as pandemic epicenters—hubs for the spread of zoonotic diseases.

### Considerations:

What can be done to better educate city dwellers and tourists about the importance of and options for reducing disease transmission risk? This might include, for example, city-specific social marketing campaigns that promote adoption of risk mitigation behaviors.

How can regulatory measures be more effectively employed to minimize human to human contact in urban environments as a pre-emptive strategy rather than just a response measure after a zoonotic outbreak has been reported? For example, could regulations be more effective at managing food and water supplies, ventilation systems, and waste streams?

How can public transportation and structures in urban environments be designed to reduce person to person contact risks?

Human health is determined by environmental health. The more we can do to support large, intact, well-connected natural landscapes, the healthier—and much happier—we’ll be as people (Patz et al. 2004). When the “natureful city” paradigm extends the full length of the urban footprint, urban living can help reduce the risk of land use-induced spillover through public education, regulatory measures, and design innovation. Urban living is being redefined to reduce stress and promote the equitable well-being of city inhabitants. This goal should also encompass protecting the quality of life for all species, far and wide, impacted by urban structure and function. Reducing the risk of zoonotic disease outbreaks is consistent with celebrating and conserving nature, with regular immersion in nature and appreciation of native plants and animals as an aspect of urban thriving, and with expressing the ethical responsibility that cities have to conserve nature to the benefit of all life on Earth from local to global scales.

### References and Further Reading

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With a close evolutionary relationship, non-human primates pose a high risk of transmitting pathogens to humans (Macaque, Phnom Penh, Cambodia). Photo by Jamie K. Reaser

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