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Reifications in Disease Ecology 1: Demystifying Land Use Change in Pathogen Emergence

Luis Fernando Chaves ^a, Julie Velasquez Runk ^b, Luke R. Bergmann^c and Nicole L. Gottdenker ^d

^aInstituto Conmemorativo Gorgas de Estudios de la Salud, Ciudad de Panamá Apartado Postal 0816-02593, Panamá; ^bDepartment of Anthropology, University of Georgia, Athens, GA, USA; ^cDepartment of Geography, University of British Columbia, Vancouver, Canada; ^dDepartment of Veterinary Pathology and Center for the Ecology of Infectious Diseases, University of Georgia, Athens, GA, USA

ABSTRACT

Disease ecology has the potential to help build a new society where the contradictions of our time are recognized and confronted in the pursuit of a more considered, and just, understanding of the interrelationships of organisms with the environment. Unfortunately, the discipline is facing a major dilemma as the advent of new technologies, access to remote data, and lack of engagement with the contexts where diseases emerge and are transmitted, has resulted in the creation of Blame Local Indigenous and Peasant Populations (BLIPP) narratives that align with hegemonic globalizing agents and processes. Here, in the first half of a two-part essay about reifications in disease ecology, thinking with dialectical materialism, we demystify BLIPP narratives around land use change in disease emergence.

KEYWORDS Dialectics; deforestation; machine learning; natureculture; remote data

The Dialectics of “Land” and “Use”

The COVID-19 pandemic fits within a trend of observations over recent years: land use change has been associated with the emergence of new pathogens and with the re-emergence of infectious diseases assumed to be under control, or no longer a public health concern. When we talk about land use change we often take as granted what land is. However, what is “land”? We might say it is one and many things at the same time, but certainly it is a physical ground where we and others live. But it is not that easy. Let’s take the Daoist philosopher Zhuangzi’s dialogue with Huizi about the useful and the useless. Zhuangzi says:

CONTACT Luis Fernando Chaves  lfchavs@gmail.com  Department of Environmental and Occupational Health, School of Public Health, Indiana University, Bloomington, IN, USA

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“The earth is certainly vast and wide, but a man at any time uses only as much of it as his two feet can cover. But if you were to dig away all the earth around his feet, down to the Yellow Springs, would that little patch he stands on be of any use to him?” to which Huizi responds “It would be useless.” Zhuangzi replies, “Then the usefulness of the useless should be quite obvious.” (Zhuangzi 2009)

If we try to find the usefulness of the “land use” as Huizi might have, we can be convinced by the narrative of scientific research linking “land use change” (elsewhere) with “disease emergence”, the ongoing phenomenon where pathogens that used to be hidden in nature become a problem. Studies of how land use and land cover are related to disease often discuss concepts and arguments such as “bushmeat” (Wolfe et al. 2005); uncontrolled population growth (Pimentel et al. 2007); and native and local populations cutting down forests, unsafely interacting with wildlife species and driving the emergence of new diseases (Daszak et al. 2020; Li et al. 2019). In this prominent genre of explanation, we identify a conceptual tendency we call BLIPP (Blame Local Indigenous and Peasant Populations). Although studies with BLIPP framings of disease emergence have had considerable resources to construct a base of empirical evidence in support of their framing, as we and others argue, other understandings are desirable for how land, globalization, and disease emergence relate now and how they might relate differently where capital and its neocolonialism were not driving forces.

Indeed, we can understand BLIPP explanations as drawing upon and contributing to particular discourses of globalization. Here, we draw upon the ways radical Afro-Brazilian geographer Milton Santos demonstrated we might critique the narratives of life in a globalizing world suggested by its hegemonic globalizing agents. For Santos, such narratives of globalization were globalization as a fable – but they were only one sense through which globalization could be understood and redirected (Santos 2000). Many prominent studies of disease emergence by ecologists reproduce such a fable of globalization when they conceptualize how land use change leads to new human diseases like COVID-19.

Milton Santos warned us that in our current time such fables are a fundamental component of the perversity that normalizes what is wrong (Santos 2000). We can easily choose to believe in BLIPP fables regarding the destruction of nature and point to such peoples’ existence as the major threat for its future. However, we could equally choose not to be so selectively blind about the implications of global processes and unequal relations when trying to understand how land use change might be connected to the emergence of new diseases. Our challenge is to understand nature as a unity that includes humans, and, at least at the present, very much includes capital; avoiding hegemonic fables of globalization in the process.

The central thesis of many studies espousing BLIPP fables and using “cutting edge technique”, to study disease spillover is that the main risk for disease emergence is found in wet markets (Xiao et al. 2021), the life history of reservoir hosts and pathogens as determined by a non-dynamic environment (Han et al. 2015; Olival et al. 2017), other assumed autonomous animal-related factors (Jones et al. 2008) and/or fixed notions of land use and cover (García-Peña et al. 2021) that do not try to understand or contextualize human-wildlife interactions.

Scholarship, even if not among that generally yet read by ecologists, has debunked most preconceptions around the BLIPP fable. For example, deforestation has, if anything, little to do with population growth or pressures for food production, and fertility rates have been globally decreasing, stabilizing population growth (Ceddia 2020; Cohen 2020; Curtis et al. 2018). All domestic species were at some point wildlife, and wildlife species are, and have been, a traditional and safe protein source for people (Hoffman and Cawthorn 2012; Nogueira-Filho and da Cunha Nogueira 2018). Disease emergence often couples evolutionary and ecological change, but roots for those changes, although written in the genes of pathogens (Wallace et al. 2007; Wang et al. 2017), cannot be coherently understood without reference to changes in history, particularly in the means of production (Guinat et al. 2019; Wallace 2009) and capital circulation driven by changes in political economy (Wallace 2016; Wallace et al. 2020). Ecological niches are not static entities where organisms fit, but are dynamic entities that are created by the constant interaction of organisms with the environment and vice versa (Levins and Lewontin 1985), including emerging zoonotic pathogens (Hogerwerf et al. 2010; Wallace et al. 2016).

So, why has a BLIPP fable come to dominate the scientific narrative regarding processes driving the emergence of infectious diseases? There is nothing new in blaming the victim, as warned by Marx and Engels in the *German Ideology*:

The ideas of the ruling class are in every epoch the ruling ideas, i.e. the class which is the ruling material force of society, is at the same time its ruling intellectual force. (Marx and Engels 1998)

How do we move beyond such BLIPP fables? Dialectical ecologist Richard Levins encouraged us to ask clarifying questions: Where is the rest of the world in any model? Can we see beyond what is expedient and in the now? What alternatives does history offer in its seed bank? Are alternate approaches already emerging into new futures? (Levins 2010). In turning around these questions we can investigate and learn that “land” is also what we call the surface of our planet that supports life, understanding that surface as constituted by processes and relations as much as by

isolable things potentially unconnected to other places and peoples. Being aware of that, we can then inquire about how we, humans, came to relate with land, near and far. We can realize that our human biology requires energy that we get from plants and other animals, which we call “food”, which ecology has shown us naturally generates and regenerates itself on the land.

Human civilization has then come to diverse ways to relate with land. In the golden age of ancient China, the Tang dynasty and its immediate predecessors had the *juntian* (“equal field”) system that systematically redistributed agricultural land among people according to their capabilities to use the land and not their ability to extract value from the land (Xiong 1999). Similarly, pre-hispanic Mesoamerican societies saw land not as an individual good, but as a communal good (Villa Rojas 1961) from where the commons, *calpulli* for the Mexicas (Caso 1963), got resources to maintain its population.

In ancient Europe, by contrast, the Greeks, whose societies came to be narrated as predecessors to and, in some respects, ideals for the western world, saw no issue in having their class structures built around land tenure. Differently in important ways from some of the advanced cultures of China and Mesoamerica, for the Greek land was a property with value, one that was privately owned. In this cradle of Democracy, whose economy was sustained by the exploitation of slaves which were seen as the natural counterpart to free citizens, our idealized democratic principles were forged on a class structure based on the definition of citizenship around rights for the few, including those of the formal control of land (Zurbach 2013). The Romans followed this path when conquering territories; the land was used by those who were not citizens but owned by citizens, both creating and erasing borders, bringing about new ways to relate to the land, including to the land as the source of energy that the biology of humans require (Pliny the Elder 1938).

For Pliny the Elder, the social construct of “the land” as a private good was alarming. It was not by chance that he predicted the fall of the Roman empire when saying “*latifundia perdidere italiam*” (Pliny the Elder 1938). The Roman naturalist used this Latin phrase to suggest that the alienation of land from people was not good and was an element of societal self-destruction. Centuries after Pliny the Elder reached this conclusion Marx abstracted the working dynamics of capitalism, recognizing that the appropriation of what would become use values from nature was important to capital accumulation when control over the means of production were concentrated, or belonged, to a person different from the one creating the goods and rendering them useful (Marx 1949).

Thus, in light of Marxist theory and despite its material basis, “land” has also been abstracted within the social formations that through history have

mediated various modes of production (Amin 1974, 1985). This historicity implies that “land” as a means of production, within the capitalist mode of production, is a recent construction. However, the idea of controlling “land” for the subjugation of a dominated class is older, and played a role within the class struggle of social formations within “tributary states” that predated current dominant “capitalist states”, as seen in historical societies based on slavery and serfdom in Europe, but also in Asia and elsewhere (Liu 1956; Stern 1988). Yet this is not a deterministic nor universal rule, as illustrated by China during the Sui and Tang dynasties where “land” was a commons, nor in the Mexicas’ *calpulli*, as those were also tributary societies. And the process can be very nuanced, as depicted by Trotsky and others, when referring to the “uneven and combined development” in history with some states representing social formations where different modes of production coexist (Allinson and Anievas 2009). Therefore, incorporating this kind of complexity into disease ecology becomes a necessity, especially if disease ecology is to serve people and improve population health and well-being, just as history is indispensable to understand any evolutionary trajectory in living organisms (Gould and Lewontin 1979) and ecology is, among other things, an expression of evolution (Dobzhansky 1964; Macarthur and Levins 1967).

Indeed, this approach has existed outside the anglosphere, since ecology started to transform the understanding of disease, and is illustrated by the work of Angelo Celli, who was the first to propose a general theory of disease emergence linked to changes in the used land. Celli depicted land accumulation as part of a vicious circle fomenting the transmission of disease, paying special attention to malaria history in the Agro-Pontino Romano. There, land transformation, together with a need for land ownership and the existence of pathogens resulted in the differential ownership of the land, as a mean of production, ultimately exacerbating both inequity in the access to land, as a means of production, and disease transmission (Celli 1933; Chaves 2013).

However, these results and the associated understanding of social and ecological relations was not to be widely anthologized in the ecological sciences. Today, as “disease ecologists” are called upon to understand the difficult circumstances of new infectious diseases, perverse BLIPP fables fit with hegemonic scientific common sense, inducing a state of consciousness and invisibility that ensures the automatic functioning of power (Foucault 1977), suggesting framings within which land use change and disease emergence can be examined. Funding as well as “cutting edge” technologies and methodologies have been enrolled in support of such inquiry, as we will discuss next, though such resources and ideas would be better reappropriated in support of other lines of research.

Deep Knowledge, Learning from Natureculture: Back to the Future in the Study of Natural History

The perverse BLIPP fable has been particularly oblivious to the natural history behind the “discovery” of new pathogens. Some sciences have been well engaged in understanding how Indigenous people appreciate nature and relate to it from perspectives and means different to those created within a “Western” context (Cajete 2000; Kimmerer 2000; Runk 2009). However, many sciences have become increasingly remote as laboratory-based genetics, computer modeling, earth observation technologies, the proliferation of mapping, and the ready availability of social media data allow research without engaging the socionatural complexities associated with “the field” and research “in” it. This is also evident in the abundant “meta-analyses” and “syntheses” (Han, Kramer, and Drake 2016; Han et al. 2020; Kreuder Johnson et al. 2015; Stephens et al. 2016; Stephens et al. 2021) about pathogen emergence and spillover across species, which often are structured in a way that cannot capture complex, relational, often qualitative insights from everyday life and field studies, the primary evidence and source of knowledge about the emergence of new diseases. Let us take for example some of the pioneer work, about “new diseases”, in the field of Tropical Medicine.

The Intriguing New Fever from Bolivia

The late Karl Johnson was a global health scientist who conducted fieldwork and collaborated with scientists from many nations, mentoring peoples of different cultures and beliefs. His team discovered many new pathogens, including Ebola and Hantaan viruses. However, close to his heart was the discovery of Machupo virus in the jungles of Bolivia (Glaser 2001). In 1963, his team was tasked with investigating an intriguing hemorrhagic fever killing people around San Joaquin in Bolivia (Johnson 2008). Johnson’s team embarked on a major study that combined well-designed and exhaustive field studies with sophisticated laboratory methods for that time.

The team was able to isolate the virus from the spleen of a deceased person and from there went on to establish that *Calomys callosus*, a wild rodent native to South America, was the major reservoir (Johnson 1965). This study included the sampling of numerous bat, rodent and insect species. In the study dealing with the ecology of the system (Kuns 1965), we learned from Dr. Merle Kuns that *C. callosus* was abundant, and frequently infected with Machupo virus, in villages located in “elevated areas [...] known locally as ‘alturas’” where farmhouses were “usually located at the edge of the forest overlooking the grass covered marshlands or ‘savannas’”. By contrast, more riparian villages, where the hemorrhagic fever was not observed,

included both common rats (*Rattus rattus*) and common mice (*Mus musculus*), suggesting the presence of cosmopolitan rodents protected against the invasion of Machupo virus.

As to why *C. callosus* and the lethal virus it carried became a problem in northern Bolivia, Dr. Johnson told us that “The means of introduction is (sic) not clear. Infected rodents may have been imported with the baggage of humans, may have migrated directly into the town, or may have acquired the virus through contact with some other feral animal.” (Johnson 1965) Thinking broadly, as a naturalist, Dr. Johnson even comments that DDT, the infamous pesticide with toxic neurological health effects on humans (Rogan and Chen 2005), might have had a role by impairing the ability of domestic cats to regulate rodent populations:

... cats were conspicuously scarce in San Joaquin. Residents of the town declared that these animals had been dying for several years of a peculiar neurological disease. Although we could not define its cause, oral administration of DDT reproduced the picture in cats imported for experimentation. Furthermore, subcutaneous and oral administration of Machupo virus to cats (the latter in the form of infected, sick, infant hamsters) did not result in illness. Neither were neutralizing antibodies found in response to these inoculations (Johnson 1965).

Later in his life, Dr. Johnson asserted that rodent infestations were likely triggered by the storage of plantains and cassava for human consumption where *C. callosus* feasted, and likely defecated and urinated, leaving Machupo virus in the environment (Johnson 2008). Here, as elsewhere, seeing “land use change” would only be identifying one aspect of the changes in socioecological processes and relations. Furthermore, as we will illustrate next, patterns from Machupo virus emergence were unlikely special or unique.

The Hemorrhagic Fever from Cornfields in the Venezuelan Plains

Robert “Bob” Tesh, a onetime student of the aforementioned Karl Johnson, frequently comments in his lectures that he learned a great deal about emerging infectious diseases while studying Venezuelan Hemorrhagic Fever (VHF). His team studied the epidemiology of the VHF caused by the Guanarito virus (Tesh et al. 1993), a virus they also described (Tesh et al. 1994) in the Portuguesa plains of western Venezuela. They found that *Sigmodon alstoni* and *Zygodontomys brevicauda*, both common wildlife rodents at the study site, were the most likely reservoirs for this disease. In a figure caption, the Tesh team described the socionatural history of the disease they were studying: “Property boundaries are often demarcated by tall grass or lines of trees, which serve as rodent habitats and refuges.” (Tesh et al. 1993), an observation that illustrates how land ownership is central to the

emergence of new diseases. We can ask: would these rodent habitats exist in the absence of boundaries demarcating land ownership? Beyond that, while also proposing multiple hypotheses to test, Tesh and his team ask a key question we should have always in mind when studying emergent diseases:

One obvious question resulting from our study is why was VHF not recognized until 1989? We assume that Guanarito virus has existed in the local rodent population for a long time. Also, people have lived in the VHF endemic area for more than 200 years. There are a number of possible explanations: (1) The relatively small human population and the low prevalence of infection allowed sporadic cases to occur previously, without recognition as a distinct entity [...]; (2) Increasing human migration into the region and the development of new agricultural lands have placed more people in contact with infected rodents; (3) Recent land use changes in the region (i.e. deforestation and or large scale cultivation of corn, sorghum, sun flowers, etc.) have provided more favorable habitats and food for granivorous species such as *S. alstoni* and *Z. brevicauda*, allowing populations of these rodents to increase significantly. This latter situation also would increase the risk of human contact with infected rodents. (Tesh et al. 1993)

The studies by the Johnson and Tesh teams suggest that a rich ecology that often cannot be adequately “sensed” via remote observations ultimately drives the emergence of new diseases. Indeed, if anything, a nature-culture ecological approach has shown that remotely sensed data is unable to classify forests that encompass differences in use and history, creating a rift between local and scientific knowledge that undermines the potential impact of innovative ecosystem management efforts (National Research Council 1998; Robbins 2003; Turner, L, and Robbins 2008). We can expect a similar rift between what can be observed from the skies and what is relevant for disease emergence. In our experience we have observed how remotely sensed data is unable to assess differences in land cover that can only be locally assessed looking at vegetation structure and floristics and understood through the engagement of local populations (Runk et al. 2010). Can we apprehend what is going on the land by just judging from what is seen from above? Disease ecology can proactively look for patterns that integrate both the remote and the local when it seeks to understand disease emergence. Our work in Panama engages in this strategy, as illustrated in Figure 1.

Other Disease Ecologies are Possible, and Indeed Exist

What can we learn and take forward from studies like the above? What other sciences of disease emergence are possible? As noted, the BLIPP fable predisposes us to look for causes of disease emergence and pathogen spillover in issues of (a lack of the correct type of) development in the Global South: abstractions about land use change for agriculture and urbanization driven by population growth and development among them (Gibb et al. 2020).



Figure 1. A true and deep understanding of relationships between “land use” and zoonotic diseases cannot take place by simple data “mining”, divorced from people who have an intimate understanding of the natural history and complexities of human and animal host-disease vector-environmental relationships. Though we argue more abstractly in sections below, and the second half of this two-part essay, it is critical to understand the central roles played by often-uncited experts such as José Montenegro and Roberto Rojas (A) from Instituto Conmemorativo Gorgas de Estudios de la Salud, ICGES. They have over 100 years combined experience studying vector-borne and zoonotic diseases in Panamá. In the 1960s, they started groundbreaking work with scientists from many countries, including Karl Johnson and Bob Tesh, teaching and learning with scientists about the behavior and natural history of wildlife and insect vectors of zoonotic diseases. José Montenegro and Roberto Rojas continue to teach and learn with newer generations of scientists about the complexities of zoonotic diseases, land use and the people where these diseases occur. (B) José Montenegro has a deep experiential understanding of mammals, here we can see him carefully handling a marsupial and capturing a two-toed sloth. (C) Roberto Rojas has an intimate and vast knowledge of medically important insects, including kissing bugs, vectors of Chagas disease, which we can see him examining after a field collection (D) With unparalleled generosity here we see Rojas and Montenegro training Cristina Varian, from USA, and Mayumi Abe, from Japan, to search for and collect kissing bugs from a felled palm tree. (E) On the right we see Chystrie Rigg, a junior scientist at the ICGES, extensively mentored by Rojas and Montenegro, who also uses remotely sensed data in her research, engaging with native Guna children during the development of a project about malaria elimination in Panamá. The community was involved in the research, a requirement from Panamanian research funding agencies, and as a result we can see (F) a Guna child holding a drawing about mosquitoes and malaria, showing enthusiasm about his new knowledge, expressing his desire, from a knowledgeable viewpoint, to end the transmission of an illness common in his community.

Below we sketch how diverse other scientists have framed three seemingly related issues differently with respect to disease ecology: housing, agriculture, and urbanization.

Let us first consider housing while remembering the lessons of the work by the Johnson and Tesh teams. Given the observations noted above, we

should ask how many of us store starchy vegetables in our households that get visited by rodents. If we are to have starchy vegetables and if our houses are not parts of this disease ecology, why not? What are the other relations that our housing is or is not caught up within? We can also look into the work of Angelo Celli (1900), who proposed and tested that low quality housing was important in malaria transmission. After the various changes that a century has brought, we can still find similar patterns in Costa Rica, with improved housing quality being associated with decreased malaria transmission (Chaves et al. 2021). We can also demonstrate that high quality housing materials are incompatible with the ecology of blood-sucking insects, often associated with a reduced number of sand flies, vectors of leishmaniasis, in rural Panamá (Chaves et al. 2013), where we also know that leishmaniasis transmission increases with sand fly abundance (Chaves et al. 2014; Yamada et al. 2016). Similar patterns have been observed for malaria and their mosquito vectors all over Africa (Tusting et al. 2017, 2015), and also for Chagas disease, where ecology has been used to design ecological housing and water purification systems in Mesoamerica (Castro-Arroyave, Monroy, and Irurita 2020; Lima-Cordón et al. 2018; López et al. 2019; Lucero et al. 2013; Monroy et al. 2009). The roles housing plays in disease ecologies are clearly complex – as are the origins of particular sorts of housing being in particular places and not others, which we must likewise consider. There are cases where the construction type is enough to influence the outcome by itself, whereas there are other situations where the spatial conjunction (or lack thereof) with (agroecologically diverse vs monocropped) fields matters.

Indeed, is all agriculture the same? Better yet, when is it the same between places/pixels? When does difference in context make a difference? Diverse agroecosystems, such as shade coffee, may resemble natural ecosystems (Perfecto and Vandermeer 2010; Vandermeer et al. 2019). The opposite is commonly observed for the monocultures (Vandermeer and Perfecto 2019), from maize to animal factory farms, where robust evidence keeps accumulating on the key roles the latter play in generating the next generation of deadly pathogens (Wallace 2016). When is it actually scientifically justified to generalize our terminology to the point where we speak of “agricultural land transformation” abstracted from sociological relations?

Similarly, if we are to blame (or praise) urbanization, we should ask: What kind of urbanization? Is the problem urbanization *per se*, or the massification of slums? Shall we worry about people living in suburbia and exurbia, as it happens in the Global North? Or shall we worry about people living in the slums of Latin America, Africa, and Asia? From the perspective of rodents like *C. callosys*, is a house in the Dallas metroplex or in greater Los Angeles the same as the houses quickly constructed of available materials in Paraisópolis or Petare? In light of recent “ecological synthesis” (Gibb

et al. 2020) it seems that living in Saitama or Riverside is the same as living in Tondo or Kibera.

We should only generalize about agricultural land use change, urbanization, population, and disease emergence as far as the complexities of the processes and relations allow, and for the study of the latter, diverse perspectives, data and methods are needed.

Machines or Humans: Who Is Learning?

The production and consumption of science is hardly isolated from the cultures of capitalism writ large: studies can seem more valuable when they use analytical methods whose ever evolving names appear and disappear and are reborn in their next iterations on Gartner's "hype cycle": consider the roles of artificial intelligence, big data, machine learning, and/or deep learning. Here, we advocate for computation less solely focused on finding generalizations from large, decontextualized datasets of the sort needed for control (and blame) of distant landscapes; instead, we wish for those realms of computation and associated science that can foster human understanding of complex relations and processes to be more fully developed. Generalizations are important, but not at the expense of understanding the inherent complexity of contexts (Levins and Lewontin 1985; Lewontin and Levins 2007). Generalizations must be made where they serve science, not where scientists and technocrats elsewhere prefer second best simple formulas that simplify funding of projects, as well as planning, development and administration of large areas.

Data critical to studying disease ecologies is often collected and organized in a way that separates the world into "layers". These layers often take the form of either being "vector" (e.g. individual scattered points, as in where a species may have been observed) or "raster" (whole grids of measurements over space and time, such as for temperature) in format. Either way, the representations are the ontological product of a scientific division of labor that fosters a world where expertise is specialized, distant, and focused on categorized phenomena (via reductionism) instead of their syntheses (via a more dialectical form of inquiry). What if we prioritized representing phenomena in terms of their relations and processes (Bergmann 2016; Ollman 2003, 2015), whose shadows are presently split between multiple layers, and whose non-local, even global, connections are often left out entirely? We must, as Levins (1995) argued: "challenge critically the institutional and intellectual boundary conditions that keep our efforts fragmented, reductionist and, in the long run, ineffective."

Science for and by the people is often more possible than our training leads us to believe. "Citizen science" has too often become an exercise in outsourcing data collection (Callaghan et al. 2019; Southekal 2017) for centralized analysis

and governance. Such outcomes are not necessarily the inevitable failures of those pioneering a form of science that serves the people. Consider how decades ago, academics and community members in Detroit had already revolutionized “fieldwork” by directing geographical research to serve community priorities. One such effort supported self-determination in school attendance and governance in Black communities as opposed to integration on the terms of well-meaning white liberal reformers (as detailed in the Detroit Geographical Expedition and Institute’s *Field Notes II*). Such research advanced geographical computation, cartography, children’s geographies, and urban geography, among other fields; at the same time, it experimented in new forms of higher education while forging pathways for participants into existing university systems. A disease ecology by and for the people must be a science of the whole (in the dialectical sense), which, at the same time, is a science that understands the complexities of particular places and peoples and ecosystems. And, as suggested by the parallel example above, the necessary change is tied to radical pedagogical transformations, which we will explore in the second part of this essay.

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ORCID

Luis Fernando Chaves  <http://orcid.org/0000-0002-5301-2764>
Nicole L. Gottdenker  <http://orcid.org/0000-0002-3499-2410>

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