Introduction to One Health

An Interdisciplinary Approach to Planetary Health

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Why One Health?

The Mississippi River today is the source of economic strength and cultural movement throughout the USA. The Mississippi reaches more than 2300 miles from Lake Itaska in northwestern Minnesota to the Gulf of Mexico (Figure 1.1). The fourth largest watershed on the planet, it covers 32 states and 40% of the landmass of the USA and reaches from Appalachia to the Rocky Mountains. Pre-dating the European expansion into the Americas, Native American cultures thrived along the Mississippi River Basin. The Ojibwe, the Kickapoo, the Potawatomi, the Chickasaw, the Cahokia, the Choctaw, the Tunica, the Natchez, and many more peoples lived and flourished along the Mississippi River. Culturally diverse and rich in tradition, the peoples of the Mississippi River basin used and respected animals and the environment throughout their traditions. Focused on fishing and hunting, small-scale farming, and foraging, the traditions of the peoples of the Mississippi River are as varied as the people themselves, but importantly, these traditions shared a focus on maintaining a balance between humans, animals, and the environment. The culturally diverse native peoples of the Mississippi River region could truly be considered the first One Health practitioners of the region.

In 1539, Hernando de Soto of Spain became the first European to witness the majesty and power of the Mississippi River. In his explorations and quest for gold, de Soto and his men frequently interacted with native peoples. The Spaniards, from their first landfall, exploited native peoples. Language and culture differences, not surprisingly, emerged frequently. de Soto traveled with one translator, who spoke the language of only one tribe. As a result, skirmishes between the Spaniards and the native peoples often broke out while traveling. When the army with which de Soto traveled, numbering approximately 620, encountered a local community, they demanded use of the food stores, preferring this to hunting. As a result, the Spaniards consumed nearly a year's worth of food in only a few days in each community they encountered, with devastating impacts on the survival of these local communities. de Soto and his men also routinely enslaved men, women, and children, demanding individuals carry their equipment and gear, care for their horses, provide cooked food, lodging, and sexual services. Native peoples who resisted were frequently raped, tortured, had their homes and crops burned, and/or were killed. The violence of the initial European arrivals to the Mississippi region resulted in the murder of an uncountable number of native peoples.

The devastation of the communities of Native Americans is not the only devastation de Soto and his men wrought on the Mississippi Basin. The Spaniards were exploring to claim the land for Spain and loot the region of its gold, silver, and other precious metals. In addition to men, de Soto brought with him 220 horses and 100 pigs.
The movement of this army of people and animals from present-day Florida west through Louisiana, north through Arkansas and into Missouri, and then south to Texas left in its trail a swath of deforestation, biodiversity loss, and pollution—all One Health threats. For example, while the Spaniards exploited Native American paths for travel as much as possible, they also carved many new paths through the forests and prairies that they crossed. The livestock brought along also created significant problems for the landscape. Feeding these animals created an additional burden for the land, taxing the ecosystems as the traveling herd of between 300 and 1000 domesticated animals trampled vast swaths of pristine forest and prairie vegetation. Rats and other stowaways from their ships would, in time, become invasive and drive their own ecological catastrophes. de Soto's herd of pigs, which grew from 100 to over 900 by 1542, brought its own unique environmental and ecological threats.

The normal behaviors of pigs—rooting for tubers, wallowing in mud, and trampling vegetation—wreaked havoc on native plant life and, importantly, their feces introduced an entire suite of novel pathogens to an area, contaminating local water supplies as they defecated across the south. An often overlooked consequence of early western explorations was the introduction of lead shot into the Americas; with this, de Soto and his army slaughtered countless native animal species and introduced the potential for lead pollution into the Mississippi River basin.

In what could be considered one of the earliest intercultural One Health threats, the greatest devastation brought by de Soto and his men was not the rape and pillaging of the land and local communities but the introduction of novel infectious diseases into naïve populations. In the wake of de Soto's army, smallpox and measles spread rapidly through the diverse tribes of native peoples of the Mississippi Basin, who were exposed to these pathogens as de Soto and his men traveled through their communities. Smallpox alone killed an estimated 95% of the people with whom the Spaniards came into contact, effectively eliminating entire communities in their wake. This drastically altered the make-up of the Native American landscape well before the French and English returned some 100 years later. de Soto did not survive his expedition, dying on the banks of the Mississippi River of a fever without finding a single piece of gold or silver. More than half of his men perished along the way as well.

Fast forward 150 years to 1862, when, after exploring its reaches and seizing upon the economic and strategic benefit of the Mississippi River system, René-Robert Cavelier, sieur de la Salle claimed the river for France. The southern stretches of the Mississippi Basin briefly fell under the control of the Spanish in 1769; in 1803, the USA, not even 30 years old, purchased the entirety of the Mississippi River watershed as a part of the Louisiana Purchase. When in May of 1804, William Clark, Meriwether Lewis, and 31 others set forth from St. Louis, MO, to find a Northwest Passage, a water route to the Pacific, they were tasked with acting as cartographers, naturalists, and cultural emissaries for the young country. Thomas Jefferson, who commissioned the expedition in 1803, believed that the most critical role for the commissioned explorers was to act as diplomats for the nation among the several Native American tribes the group would encounter. The Corps of Discovery, as the expedition came to be called, ultimately made contact with 55 independent groups of Native Americans and First Peoples, frequently trading for food and medical supplies as well as befriending many tribes people.

Lewis and Clark traversed nearly 8000 miles. Their expedition is touted by many as a model of inclusion—a black man, York, and a Shoshone woman, Sacagawea, were essential members after all. However, their inclusion hints at the exploitative nature of the Corps itself. York was a master hunter, bringing in a large portion of the game that fed the Corps throughout their journey, and acted frequently as the expedition's most stalwart caregiver, providing care to ill expedition members. Still, York was Clark's slave. He was not a paid member of the Corps of Discovery, despite his critical role in its success. Sacagawea was kidnapped as a teen by the Hidatsa and then sold to her "husband" Charbonneau. As property, neither York nor Sacagawea could refuse participation in the 8000 mile journey. Still, Sacagawea, like York, played a vital role in the expedition, acting as translator and helping with the group's welcome by many Native American peoples.

In all, the Lewis and Clark expedition, while fondly remembered today, was considered at the time as something of a failure. They discovered no Northwest Passage; the northern route chosen by the group was arduous and challenging in a way that the southern route across the Rockies is not and so was not used by later settlers. They mapped lands, documented plants and animals, and improved diplomatic relations with Native peoples, but they also opened the country to western occupation that drastically altered the landscape, replaced the diversity of plants and animals with corn and cows, each with long-term ecological consequences, and ravaged Native American communities through broken treaties, forced migrations, and massacres.

Lewis and Clark's expedition had two additional repercussions in the US West: the spread of sexually transmitted diseases (STDs) and widespread mercury contamination to the environment. STDs were not introduced to Native Americans by the Corps of Discovery; French and Canadian fur-trappers accomplished this. However, STDs spread through the Corps rapidly. As the men traveled west and as they encountered local tribes, it was common for members to trade goods for sex, and frequently, wives of chiefs of several High Plains tribes were shared with expedition members in order to benefit from the men's spiritual power. The result of this was the spread of STDs across the northwest, as the Corps of Discovery shared infections between peoples who would never have otherwise come into contact with each other. At the time, there were few treatments for STDs available, with modern medicine of the day advocating a...
strong course of mercury pills and bloodletting. As a result of the rampant STDs, members of the Corps of Discovery were also all exposed to toxic levels of mercury. Additionally, heavy use of laxatives, brought on by the lack of plant materials and over-consumption of meats in their diets causing chronic constipation, further increased mercury levels among the expedition's members, as these, too, were mercury-based. As a result, it is possible to retrace the steps of the Corps of Discovery by following the path of environmental contamination of mercury from latrine pits. While not frequently considered through this lens, the Lewis and Clark expedition and its outcomes are a One Health journey, both from the perspective of collaborative and data acquisition, including the detailed accounting of flora, fauna, and people, and from the complex health concerns introduced during their journey.

As the westward expansion of the USA proceeded through the early 1800s, due in part to the doors opened by the Corps of Discovery, one significant question for new territories was whether or not to allow slavery. Resolved by the Compromise of 1850, which settled the issue via a process referred to as popular sovereignty, newly established territories were allowed to decide the issue of slavery independently by vote. Voting at this time was, however, limited to white men. Not long after Lewis and Clark departed from Missouri, Dred Scott, a slave born in Virginia, moved with his owners to St. Louis, Missouri. Located south of the Mason-Dixon Line, but north of the lines drawn by the Missouri Compromise, Missouri in the 1830s was a slave state. Once there, Scott was sold to John Emerson, a US Army doctor. As a part of his work, John Emerson traveled extensively, taking his slaves with him. As a result of this, Dred Scott and his family found themselves living in Illinois - a free state - and the Wisconsin territory - a territory that, under the Compromise of 1850, had voted to not allow slavery. In 1842, the Emersons returned to Missouri, taking up residence in St. Louis. In 1846, Dr. Emerson died, leaving his slaves to his widow, Eliza (Irene) Sanford Emerson. Upon John Emerson's death, Dred Scott attempted to buy his and his family's freedom from the widow, but she refused. And so, with the help and encouragement of local abolitionists, Dred Scott sued for his freedom in 1846. In total, the Scotts had lived for more than nine years in free territories, and according to the doctrine held by Missouri's courts at the time, "Once free, always free," there was a precedent to support his claim. After 11 years, the case landed before the US Supreme Court, where in a 7-2 decision, the Court ruled against Scott, citing property rights as the justification, and nullifying the 1820 Missouri Compromise in the process. The outage of this ruling, what has come to be known as the Dred Scott Decision, fanned the flames of civil unrest over "the slavery question" in the USA and came less than four years before the country erupted in war over the issue of slavery in 1861. Dred Scott died a slave less than one year after the Court's ruling, in 1858.

William Clark died in 1838 and was buried in Bellefontaine Cemetery, a beautiful cemetery and arboretum in St. Louis, MO; just 20 years later, Dred Scott was buried in Calvary Cemetery, an equally beautiful Catholic cemetery in St. Louis, MO. A single street separates the two cemeteries. While seemingly disparate, the stories of William Clark, Dred Scott, and the Mississippi River have shaped the region into what it is today. The actions of the past set the path for the realities of today. As such, it is possible to examine how the actions of early Americans shaped the current cultural and environmental health of the region.

St. Louis, MO, now sits as the Gateway to the West. As the second largest city on the Mississippi, it has grown up with the river as a unique part of its cultural identity. The river is the economic and cultural anchor of St. Louis, binding the city to its history in numerous unseen ways. For St. Louis, the cultural reliance on natural resources and the economic and cultural exchange brought by the Mississippi harkens back to Lewis and Clark's roles as cultural emissaries and naturalists of the Corps of Discovery. Resource extraction, epitomized by long-term iron mining in the area, and the vast loss of habitat through urban sprawl are reminiscent of de Soto's approach to exploration. Missourians' love of green spaces, embodied by Forest Park, the largest urban park in the USA, and their ardent support of conservation-minded state agencies, such as the Department of Natural Resources and the Department of Conservation, stem from the values placed on the balance between humans, animals, and the environment. And finally, St. Louis' continued status as one of the most segregated cities in America, brought into sharp focus with the recent events in Ferguson, MO, a suburban area of St. Louis, is a direct result of the country's still-open wound of slavery, as exemplified by the Dred Scott Decision.

The legacy of St. Louis' rich and complicated history is playing out in a myriad of ways today. More than 175 million tons of freight move along the Mississippi River, creating jobs for thousands of people. The river is also the source of rich biological diversity, providing habitat or resources for more than 260 species of fish, 60% of American birds, at least 60 species of mammal, and numerous reptiles, amphibians, and freshwater mussel. The Mississippi is the source of drinking water for more than 18 million people. St. Louis benefits from all of this economic and ecological wealth. The landscape of St. Louis has been shaped physically both by the river and by the social and economic divide between the city residents, established in the years following the Civil War. In the early twentieth century, systemic redlining - racist housing policies at federal, state, and local levels - prevented the integration of black and white communities. North St. Louis is now almost exclusively black while south St. Louis is predominantly white. The Delmar Divide - a street that separates north from south, black from white, and frequently, poverty from wealth - spans the city. This Divide has significant consequences for health.

For the people of St. Louis, the zip code into which one was born is the most significant factor for predicting overall health, including rates of heart disease, diabetes, and cancer. City residents living north of the Delmar Divide have an average life expectancy of 12-15 years less than their counterparts living south of the Divide. In some places, this gap stretches to as many as 35 years. The racial and socioeconomic divides, embodied by the Delmar Divide, extend beyond traditional health metrics. Residents in south St. Louis have higher rates of homeownership and a greater access to education, with a rate of college completion at more than twice the rate of residents in north St. Louis. Historic decisions determining where people of color could live, anchored in the state's slave-owning past, have also exposed the residents of north St. Louis to a significant amount of toxic pollutants over time, including heavy metals, from pollution-generating industries, such as lead smelters, refineries, and limestone and iron mines. This long-term exposure to toxic pollutants, which manifests into significant human health costs today, is, but one disparity in human and environmental health separating north and south St. Louis.

Surprisingly, this Divide is also significant for the health of urban wildlife. For example, the Camillo laboratory at Saint Louis University has examined bee and other insect pollinator populations across St. Louis and found the diversity of bees is significantly greater in St. Louis than in the rest of Missouri, suggesting that urban ecosystems may promote pollinator diversity. Dr. Gerardo Camillo suggests this is likely due to the loss of habitat in rural areas, where agricultural monocultures dominate the landscape. Wild bees are, more frequently than not, ground-nesting species, and the patchiness of urban green spaces - neighborhood parks and gardens - can promote native wildflower growth, creating small, viable habitats for the insects. Similarly, the Lane-deGraaf laboratory at Fontbonne University's Center for One
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We are all connected; human discord is indivisible. They are connected not only with each other but with each other through space and time. Decisions made by parents directly affect their children; actions of preservation or pollution made by people today display the One Health Triad, with the imagery that shows the interconnections between human and non-human animals and the environment (Figure 1.3). Another way to view One Health is from a thematic viewpoint present within One Health. With translational medicine we see a cross-taxa approach to the health challenges facing humans, which incorporates the shared knowledge of health between animals and humans. Alternatively, the ecological side of One Health focuses more on understanding the relationships of living organisms within their physical environments. This focus...
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In Part II, "six degrees of One Health," we explore One Health as it exists within the humanities. All the evidence-based science in the world will not be effective unless it can be packaged through the humanities in a way that people find fits into their cultural, religious, political, and/or economic beliefs.

Finally, in Part VI, we explore Where We Go From Here. Thinking about the challenges and opportunities that connect our global environment (Chapter 14), we may also see how this planetary approach opens up new possibilities as we move into a culture of One Health. In Chapter 15, we look at the past, present, and future of One Health and consider how the movement started, where it sits today, and examine the ethics of possible scenarios of the future of One Health. There are many possible directions of health between humans, animals, and environments as we consider how the movement started, where it sits today, and examine the ethics of possible scenarios of the future of One Health.

As Abraham Lincoln reminds us, "The best way to predict the future is to create it." We hope the readers of this book help to create the future of One Health.

### 1.2 Conclusions and Welcome to One Health

Whether you are new to the One Health movement or looking for a refresher in your current One Health work, this book will be of value to your practice. As the above introductory story exemplifies, we realize that viewing the health challenges of the twenty-first century through a One Health lens, requires an appreciation of the past, awareness of the present, and concern for the future. Only then will we be able to gain a better understanding of, and solve, today's planetary health challenges. Throughout the text it will also be evident that the One Health approach is not only about understanding the twenty-first century health challenges that link humans, animals, and environments, but it is also about finding solutions to these challenges. We live on a finite planet – the only planet in the Universe known to support life – with limited resources and a rapidly growing human population. We must heed the warnings of what the current planetary level health concerns mean for the continued support of life on Earth.

### End of Chapter Questions & Activities

#### A. Thought Questions:

i) This book starts with a historical perspective of the St. Louis, MO region of the USA. The authors present this as a story of One Health. Do you agree with this assessment, why or why not?

ii) There are many terms today that are similar to the term One Health, and each appreciating the connections of health between humans, animals, and environments. Why do you think there are so many terms? Do you see this as positive or negative for moving the One Health paradigm forward?

iii) When you hear news of environmental, conservation, and/or health challenges, do you think you approach these stories with a One Health lens? If not, do you think it would be beneficial to do so moving forward?

#### B. In-Class/Guided Activities:

i) Consider the history of the area you live in currently or grew up in. Can you retell this story through the lens of One Health? Who are the major players?

#### E. Recommended Reading:

Interview

An Interview with Cheryl Stroud, DVM, PhD; Executive Director of the One Health Commission and One Health Practitioner

How did you first hear about One Health? Like a lot of people, I first heard about One Health in the Journal of the American Veterinary Medical Association, which started in 2007 or so, putting articles in about One Health. I followed the formation of the One Health Initiative and how it evolved into a commission. I moved back to North Carolina (NC) between Duke, University of North Carolina (UNC), and NC State; it’s a One Health course. And one thing led to another until I was first representing the American Veterinary Medical Association (AVMA) on the One Health Commission Board, and then, in 2013, I was asked to be Executive Director of the One Health Commission.

Do you see Yourself as a One Health practitioner? Yes. Totally and completely, and as a veterinarian ... even when I was in practice very early on, I was very intrigued to educate clients about zoonotic diseases. That was in the mid-2000s before we were calling it One Health. So yes, I am absolutely a One Health practitioner; as are many other people who are doing One Health and may not realize it or call it One Health.

How do your actions reflect One Health, personally or professionally? I work with the One Health Commission, where we work really hard to create opportunities to form the needed relationships across professions. I tell people in my talks all the time that these collaborations across sectors are not just magically going to happen. Especially in our systems today, where we are so siloed, we cannot even read each other’s journals because of our publication system. My mantra these days is, “connect, create, educate.” We are trying to connect One Health stakeholders and create opportunities for us to work on One Health issues together, and to educate about One Health and One Health issues.

What can an individual do to make a difference for planetary health? Get involved. If there is some issue in the One Health arena, in the space, any issue that falls within the interface of all our professions that you care deeply about, get involved. You can be an active advocate, you can speak to your politicians, and you can educate and nurture the next generation of One Health leaders.

How can we encourage people to care about planetary health? I ask people, “Do you care about breakfast, lunch, and dinner?” Then you care about One Health. It includes our food safety and security, and how we care for our soils. Whether food is from plants coming out of the ground or meat coming from our food animal production industries, we have to care about our planet and how we are going to feed the whole world.

Where is One Health headed? Toward a tipping point. I really think One Health is being embraced around the world now, in some places a lot more strongly at the government and policy level than in the United States. And it is present more and more loudly. In fact, there’s a YouTube recording right now of Matthew Stone, Deputy General Director of the World Organization for Animal Health (OIE), talking about One Health in the OIE. These days the Food and Agriculture Organization of the UN (FAO), the World Health Organization (WHO), and OIE are often referred to as the One Health Tripartite.

Parting Thoughts? Oh my gosh, this is urgent! We are losing species at a rate now that is unprecedented.

Works Cited


Our Interconnected World

"All things are connected. Whatever befalls the earth befalls the children of the earth."

Chief Seattle (Figure 2.1)

Have you ever thought of how your health and that of a forest elephant in Africa or a child on the other side of the world are connected? Or maybe you have wondered about the connections that link a potential human influenza pandemic, habitat degradation, and feeding the world's 7.6 billion human inhabitants. These questions ask us to think of how all life on Earth is connected. Forest elephants in Africa are ecosystem engineers, or forest gardeners, that help maintain the Central African rainforest and the lungs (e.g. trees) of planet Earth. Just like you, all children, no matter where they may live, need fresh water, fresh air, and enough calories to be healthy and survive. The link of habitat loss, food security, and influenza at first may seem harder to grasp. However, humans continue to modify landscapes and destroy wetlands that for millennia have been stopover sites along migrating wild bird flyways. These wetlands are now largely replaced with poultry factories, thus encouraging the mixing of influenza strains so that spillover of pathogens, into a growing human population, occurs. In this context, the link becomes evident. All life and the health of all life are connected.

We may call these connections the "six degrees of One Health." Taken from the six degrees of separation, first set out in 1929 by Frigyes Karinthy but better known from Kevin Bacon, we see that all living things in the world are six or fewer steps away from each other. Today in 2017, we realize that the six degrees of separation applies to the health of all life—the six degrees of One Health. We are just beginning to understand the challenges that increasingly threaten human livelihoods and health, the health of domestic and wild animals, and ecosystem health and resilience. These extend across the globe and intersect in countless ways. One suitcase of non-human primate bushmeat on a plane traveling from Cameroon to Kansas may cause negative health ripples throughout the world, if it harbors zoonotic pathogens (e.g. monkeypox virus, simian foamy virus).

Fortunately, the solutions to these health challenges may also reach across the globe. For example, preventive measures that minimize threats to health, such as laws that lower pollutants in the environment, may have significant and positive health impacts over large geographical reaches and across taxa (see Chapter 13). In this chapter, we will explore how the health status of all life, from organisms found in the most remote corners of the Earth to the most crowded cities, is connected.

As covered in Chapter 1, One Health is a collaborative effort of multiple disciplines—working locally, nationally, and globally—to attain optimal health for people, animals, and the environment. Fundamental
to this definition is that One Health offers a transdisciplinary approach that strives to ensure the health of human and non-human animals and the environments on which all life is dependent. The emphasis of the One Health initiative is that these three domains of humans, animals, and environments – the One Health Triad – which at first glance may appear disparate entities, are in reality closely interconnected. Therefore, One Health practitioners must fully grasp the why, where, what, when, who, and how of these interconnections. More importantly, we must understand these interconnections if we are to find solutions to the challenges. As the One Health initiative gains momentum across disciplines (see Chapter 7), these collaborative efforts will ensure we are able to better understand, confront, and manage the growing interconnected health challenges.

We are living in the Anthropocene epoch in which the 7.6 billion humans alive exert powerful forces that are driving planetary changes and that are increasing connections. These rapid changes provide challenges and opportunities for the One Health practitioner. To consider these interconnected challenges we may look at how to feed just one species, humans (Homo sapiens). As the number of humans rapidly approaches eight billion with approximately 150,000 additional humans added each day, how do we provide food to ensure all people lead healthy lives without destroying the other species that share the planet, or indeed the planet itself?

It is not just the food demanded of the growing human population. Annually, humans as a species use 1.6 “Earths,” based on the resources we extract. In fact, “Earth Overshoot Day,” which has been observed since 1987, shows that humans use more from nature than can be replaced in the entire year. Simply put we overshoot the resources earlier with each passing year. In 1987, the first recorded Earth Overshoot Day was on December 19. Humans used all the resources available without over drawing the Earth's bounty when there were still 121 days remaining in the year. We borrowed 151 days from the next year. Projections of Earth Overshoot Day, if we continue with “business as usual” is on June 28 by the year 2030 (Figure 2.2). Even with humans consuming planetary resources faster each year, we still have not managed to feed all 7.6 billion of us well, since many people do not get enough calories, and have disease issues of nutritional deficiencies (e.g. starvation, weak immune systems, and vitamin/mineral deficiencies). At the same time many other people get too many calories and have disease issues of excess (e.g. obesity, diabetes, heart disease). Both present significant public health challenges.

As we dive deeper into our complex connected world and explore what may lie at the core of these concerns across the One Health Triad, we will consider how the 7.6 billion – and counting – human inhabitants are the drivers of these connected health challenges. We will do this by considering the five challenges that connect the health of all life and which impact species’ survival, including the survival of H. sapiens. These challenges, covered in more detail in Chapter 3, include: (i) emerging infectious diseases (EID) and invasive species; (ii) loss of biodiversity and natural resources; (iii) climate change; (iv) environmental degradation and environmental contaminants; and (v) loss of habitat and increased interactions between domestic animals, wildlife, and humans. We are living at a time when the health of all is connected, a time of One Health.

2.1 One Health Challenges on a Connected Planet

Let us begin by thinking about bats. When most people think of bats, they may think of vampires. These thoughts, although associated with bats, would miss one of the best One Health examples. With closer consideration of bats, we also may realize the many ecosystem services they provide for planetary health. In North America during the past decade, approximately 6 million insectivorous and cave-dwelling bats have died due to an
introduced fungus that arrived in the USA in 2006, by – you guessed it – humans. The *Pseudogymnoascus destructans* fungus entered the USA in New York, probably on a spelunker’s shoe, and since has moved across the continent (Figure 2.3). The fungus, native to Europe, causes white nose syndrome (WNS) in naive US bats, which as the name implies causes white noses, and wing webs, from fungal spores that grow on hibernating bats. The fungus irritates and wakes the bats during winter hibernation. Once awake they often starve to death since their diet of choice, mosquitoes and other insects, are not available. In the next warm season, when mosquitoes are back out in force, the bats, which normally eat about 350 mosquitoes per bat per night are no longer present to eat mosquitoes. Other bat ecosystem services, such as pollinating plants, are also lost. Goodbye pest control and pollination!

This loss of bat ecosystem services may result in people using more pesticides to control mosquitoes, or if pesticides are not applied, there may be more mosquitoes present and a higher prevalence of mosquito-transmitted zoonotic pathogens such as West Nile virus (WNV) and Zika virus: two other mosquito vectors with populations of susceptible amplifying bird species, offered the “perfect storm” for this zoonotic EID to take hold and move across the continent.

EIDs do not just target humans. There are a number of EIDs in non-human animals and plants. White nose syndrome is just one of the many EIDs in wild animal populations that have implications for the health of species beyond the affected hosts. There are countless examples of animal EIDs that are causing population extirpations and in some cases even species’ extinctions. These EIDs may be pathogens that infect only animals (e.g., WNS of bats, fungus that cause chytridiomycosis of amphibians) or may be zoonotic with direct infections of non-human and human animals (e.g., Ebola and influenza).

EIDs of food crops, often associated with monoculture agriculture, are another growing health threat. These EIDs may decimate production and lead to the increased development of genetically modified plants to withstand the application of increasingly powerful pesticides and herbicides. Many of these pesticides and herbicides come with health costs for human and non-human animals alike, and the environments where they are applied. There has also been the loss of thousands of acres of forests due to invasive species, from microbes to invertebrates, moved by humans from one location to another. In the USA, these include chestnut disease, Dutch elm disease, sudden oak death, and the emerald ash borer beetle.

### 2.2 Global Challenges for One Health Practitioners

#### 2.2.1 Emerging Infectious Diseases and Invasive Species

One of the great challenges today for human, animal, and plant health is the emergence of infectious diseases. Ironically, it was in the 1960s when the US Surgeon General, Dr. William H. Stewart, stated “It is time to close the book on infectious diseases and declare the war against pestilence won.” He was echoing the belief that modern medicine had all but conquered infectious diseases. It was soon evident that globalization and the increase in the human population were to bring a very different future. Emerging infectious diseases (EIDs), diseases that have increased in number, have spread to new regions, and/or are found in new species, are a concern for the conservation of all species, including humans. The increase in human EIDs is of global public health significance and largely related to human–animal interactions. In our interconnected world, and possibly most interest from a One Health perspective, is that 75% of EIDs in humans are zoonotic, shared between animals and humans, and 70% of these are associated with wild animal reservoirs. Many of these approximately 1600 EIDs are now common household names, including avian influenza, WNV, Sudden Acute Respiratory Syndrome (SARS), Ebola, and monkeypox viruses.

We often hear of avian influenza (H5N1) and its impact on human health and livelihoods in Asia, or Ebola outbreaks in animals and humans in Africa. However, EIDs are far from an “over there” disease issue. The USA has experienced multiple zoonotic EIDs with increasing frequency since the last decades of the twentieth century. The arrival in 1999 of WNV, and the subsequent rapid spread across the continent, clearly demonstrates the impact an EID may have on humans and other animals. Ecosystem level impacts associated with the near regional extirpation (local extinctions) of some bird species due to WNV infection, the human health costs from WNV morbidity and mortality, as well as increased use of pesticides to control mosquito vectors, may be harder to quantify. The introduction of this novel pathogen into the USA, and the presence of suitable mosquito vectors with populations of susceptible amplifying bird species, offered the “perfect storm” for this zoonotic EID to take hold and move across the continent.

#### 2.2.2 Loss of Biodiversity and Natural Resources

Humans are clearing tracts of land at an unsustainable rate as we make room for the production of food and other products on...
which humans are reliant. A great example of this is the increased production of palm oil trees in Asia, and more recently in Africa and South America. Palm oil, touted as a heart-healthy oil for people, may be found in products ranging from cookies to detergents. Palm-oil tree plantations cover thousands of acres of monoculture. These monoculture plantations cover land that was once home to many species, including and most famously the endangered orangutan (Pongo spp.). One can quickly see the One Health connections in that this food source, said to be of a human health benefit, may lead to the loss of other species, both animals and plants, and jeopardize the health of the environment, and ultimately humans themselves.

Today we are living during a time when we are witness to the "sixth mass extinction." We are currently losing species at a rate up to a thousand times higher than the background rate, or "baseline norm," and not seen since the age of the dinosaurs. However, unlike the previous mass extinctions, this is the first time in history that one species, H. sapiens is the driver of these losses. If one considers the changing composition of the terrestrial vertebrate biomass, the total mass of organisms that have backbones, we can understand how biodiversity loss in the context of food, conservation, and public health are connected.

Let's take a trip into the past. Ten thousand years ago, humans were just starting to be successful in domesticating animals, convincing that wolf to sit down next to the village campfire. There were not many humans and fewer domestic animals. Ten thousand years ago, 2% of vertebrate biomass included humans (<10 million) and the few, just domesticated, animals. The other 98% of vertebrate biomass were the non-domestic species — the lions and tigers and bears. Now if we look at the composition of vertebrate biomass today, the percentages flip flop with 2% all the "other animals" that are categorized as neither human nor domestic animal. Humans and our domestic animals now make up 98% of this biomass. This includes the 7.6 billion humans, and the dogs, cats, and other companion animals we invite into our homes. It also includes the approximately 19 billion chickens, 2 billion pigs, 1 billion sheep, 990 million cattle, 450 million goats, and 15 million camels alive on Earth each day, waiting to become human food.

There are many reasons that the loss of biodiversity and resources lead to health costs. One is a recently understood phenomenon called the dilution effect, wherein it has been shown that for some systems, infectious diseases may be more likely to emerge in regions that have lost the "normal" suite of species — the biodiversity. For example, Lyme disease, a tick-borne disease of high human health importance and first recognized in the USA in 1976, has during the past 40 years increased in prevalence. Infections are more commonly found in areas that have lost non-human host reservoirs, that may be infested with the tick vector, but which cannot carry the Lyme-causing Borrelia burgdorferi bacteria. The loss of other vertebrate hosts has resulted in an increase in Lyme disease in humans as well as domestic animals (e.g. dogs, horses) in these areas.

Second, the health cost from the loss of biodiversity also affects us at the dinner table. The recent loss in bees and other pollinators has created issues for agriculture. For example, bees help to pollinate human food; one of every three bites of food we take is from crops pollinated by bees. The loss of these pollinators, with their ecosystem services, may result in costs to human health, and to environments as the pollination of native plants also rely on bee pollination. This is in addition to the loss of bat pollination, and their pest control abilities, mentioned in the introduction.

With 38% of the arable land on Earth used to produce food for humans, we see there is little space left for the other animals that share our world. This is not that different when looking at the oceans. An estimated 70% of the world's fisheries are fully to over exploited, or significantly depleted. Further, we also know that the illegal and legal trade in wildlife, taken from lands not dedicated for food production, has become a worldwide enterprise. The numbers are hard to quantify, and harder to comprehend. For example, annually humans take an estimated five million tons of bushmeat just from the forests of the African Congo Basin. This number is a conservation and public health crisis. These five million tons represent both declining wildlife populations and disease transmission. The loss of these animals killed and transported may act as "pathogen packages" as they, and their microbes, move across the globe.

2.2.3 Climate Change

It is clear that the climate is changing and that it has impacts on domestic and non-domestic animal, human, and plant health. These impacts may be exacerbated by the inability of animals to emigrate from areas of climatic change or from a mismatch timing of hibernation, flowering, and pollination. Climate change may be the single most significant driver of health concerns that connect all life across the One Health Triad. As the climate changes, there is an increase in vector-borne diseases (VBD), a spread of infectious diseases to new areas, and heat-related non-infectious deaths. Additionally, extreme weather patterns such as more intense El Niños and storm systems create both infectious (cholera, VBD) and non-infectious (flooding, damage to shelter) health issues.

These climate changes mean that we must develop climate adaptive strategies such as the production of different livestock species, which may add costs to human health while threatening endangered wildlife species. One example of an animal health concern from climate change is occurring in the changing landscape of East Africa in which the semi-arid lands are becoming increasingly arid. The inability of traditional livestock species such as cattle to survive in these regions has led to an increasingly camel reliant human population (see Chapter Case Study).

Similar to the impacts of climate change on human and animal health, these changes create ecosystem damage on unprecedented scales. Floods and droughts associated with extreme weather events lead to significant damage and death of plants. The loss of top soil and vegetation, due to washed away, may also lead to less functional and less resilient ecosystems.

2.2.4 Environmental Degradation and Environmental Contaminants

It was in the 1960s with the publication of Rachel Carson's book, Silent Spring, that the world was awoken to the dangers of dichlorodiphenyltrichloroethane (DDT) and other environmental contaminants. The near extinction of the American symbol of freedom, the Bald Eagle (Haliaeetus leucocephalus), due to egg shell thinning from environmental exposure to DDT, was the first step in the USA for environmental measures to improve the environment. The US Environmental Protection Agency (EPA), created in December 1970, was developed to allow one agency to oversee research and to monitor and set standards for environmental health. Closely following the establishment of the EPA, DDT was banned in the USA. Yet, in the intervening 40+ years, we have seen increasing levels of contaminants that have short- and long-term health impacts for humans and animals. Whether it is the March 2010 BP Deepwater Horizon Oil Spill in which a total of 210 million gallons of oil was released into the Gulf of Mexico (see Chapter 12) or the continuous low-level release of petroleum products added daily to terrestrial and aquatic environments, we are causing severe impacts to human and non-human animal health.

More recently the book Our Stolen Future: Are We Threatening Our Fertility, Intelligence, and Survival? A Scientific Detective Story was the next wake-up call on issues of environmental contaminants with emphasis on the endocrine disrupting chemicals (EDCs). Since its publication in 1998, the amount of
EDCs in the environment has continued upward due to the pervasive use of plastics. Studies now confirm that exposure to EDCs, including bisphenol-A (BPA), a common chemical in many plastic products, may cause changes in gonadal tissue in wildlife species, intersex characteristics, and behavioral changes. EDCs may well be the DDT of this generation.

In addition to the toxins discussed earlier, the fragmentation and degradation of large areas across the globe are leading to major health issues. These modifications may create environments that are no longer able to provide ecosystem services for such things as fresh water and oxygen. More specifically, degraded landscapes have been associated with EIDs from disease spillover as humans and their domestic animals move further into previously pristine areas. These landscape changes also include an increase in light and noise pollution, with health impacts that effect species from sea turtles to humans. One need only look at the Great Pacific Garbage Patch (see Chapter 13) to appreciate that these modifications are not just on land. Humans are changing environments, whether on land or sea, and creating many of the threats across the One Health Triad.

2.2.5 Loss of Habitat and Increased Interactions of Domestic Animals–Wildlife–Humans

Although human populations are increasingly urbanized, with more than 50% of people now living in cities, the impacts on habitats as mentioned earlier continues unabated. Even if we live in urban environments, we still require shelter, clothes, and food. This takes land and water resources, leading to the environmental degradation touched on earlier. Degraded and fragmented landscapes often trap species on “islands of isolation” surrounded by human change, genetic bottlenecks, and resource limitations. As we know from island biogeography, small, isolated populations are more threatened by stochastic events and it is more likely these events will result in population declines and even extinctions.

The growth in livestock production, to feed the 7.6 billion humans, throughout the world also has resulted in an increase at the domestic animal–wildlife–human interface. In today’s connected world, this interface allows for disease transmission to occur more often and involving more species. All these changes place stressors, some subtle while others lead to peracute death, to human and non-human animals alike. These multiple stressors (e.g. land degradation, loss of resources, change in predator–prey relationships, invasive species, increased species interface) often lead to declining health and mortality.

2.3 Drivers of Our Connected Health Challenges

In the age of the Anthropocene, we humans have a footprint that extends across the globe creating connections near and far. In a few decades, human travel has changed from requiring months to circumnavigate the globe to the present day when we may travel from one continent to another in a matter of hours. Today we travel across the globe rapidly and often. This travel is not just humans physically, but also all the things that travel with us from the organisms traveling within us, and the stuff with us. For example, any one of us could, with little time and money, travel to any country on any continent (maybe not Antarctica but maybe!) by the end of next week. This should scare us, since on the trip, it will not be just us that travels, but also the billions of other life forms (microbes) that call each of our body’s home. They too will be traveling across the globe, as will the things we take along in our suitcases.

The global trade in stuff, responsible for many improvements for many humans, also has health implications across the One Health Triad. The simple act of extracting resources at an unsustainable rate (e.g. Earth Overshoot Day) is part of this cost to health. Possibly of more significance is that this trade provides the potential to transport pathogens and the ability for epidemics to surface anywhere on the planet from a disease event that started somewhere else (see Chapter 14). It may also allow for multiple entrees of an infectious agent. For example, based on genomic epidemiology data, Zika virus most likely arrived into the USA in 2016 from multiple points of entry.

The One Health connection may be most evident when we combine abiotic and biotic factors in a planetary health approach. In the 1960s, Lovelock, Margulis, and others noted the planet was self-regulating, “alive” in a sense. Their theory, accepted by many and shunned by others, is widely known as the Gaia theory, named after Gaia, the Greek Goddess of the Earth. They suggested that life on Earth was the creator and regulator of the atmosphere and charged that damage to the Earth, once done, was very difficult to undo. In fact, when we compare Earth with any other planet we have studied, the life force that is Earth is evident (Figure 2.4). Thinking of the Earth’s health, we may quickly appreciate the impacts and health threats that humans have placed on it. According to recent scientific reports, humans have transformed between one-third and one-half of the land surface, and now appropriate over 40% of the net primary terrestrial productivity, consume 35% of the productivity of the oceanic shelf, and use 60% of the freshwater run-off each year, primarily to feed our species.

Zoonotic EIDs are also increasing due to human changes to the Earth. EIDs in humans are happening concurrent with anthropogenic change that include the over 40% of the land surface exploited by humans, more than half of all accessible fresh water used by humankind, and greenhouse gas and methane emissions escalating annually. Humans may now be the single most dominant driver of planetary health. Today pristine wildernesses may be more of a concept than a reality. We are reaching ever deeper into the most untouched regions of the world with our road networks all but covering the globe. In the USA, it is estimated that roads have impacts on greater than 22% of the land area in the lower 48 states. This network allows the movement of humans, animals, plants, and microbes, making it all too easy to see how infectious and susceptible hosts encounter one another, which may lead to EID events.

The increased demand for protein has resulted not only in major landscape modifications, but also in the use of non-domestic products (see Chapter 13) available...
animal products (e.g. bushmeat) which are often moved, along with their associated microbes, between continents. Additionally, as our livestock populations grow across most continents, there is closer and more frequent contact between livestock and wildlife thus allowing for pathogen sharing that may lead to negative results for human health and wildlife conservation. An example of this link, with real world potential global impact, is the Nipah virus epidemic that surfaced among pig farmers in Malaysia in 1999, at a time that pork production was expanding in the country. As pig farms moved farther into forested lands, and the home to fruit bat colonies, the ability to have a bat-associated virus (Nipah) spillover into pigs, and then into humans as a food-borne pathogen demonstrates this One Health link. This bat–pig–virus example is one of many as we see other EIDs in human populations, including Rift Valley Fever, Q Fever, SARS, and Middle Eastern Respiratory Syndrome (MERS) associated with the ever increasing domestic–wild animal links.

2.4 Solutions Using a One Health Approach

It is easy to be despondent after examining the challenges that connect the health of life on Earth. However, there is hope. In our complicated and connected world, the One Health initiative may be the approach necessary for solutions to these challenges. Just as in the twentieth century when medical professionals more fully realized the multifactorial nature of disease, in the twenty-first century we are more fully realizing the need for a holistic, multifactorial, and transdisciplinary approach to solve these complex issues. The medical doctors that treat their pediatric patients for lead poisoning, without a preventive plan for the environmental factors that created the illness (e.g. lead paint on bedroom walls), know too well that medicines alone will not "cure" the patients. The same is true of the veterinarians treating herds of cattle for an outbreak of leptospirosis. If they do not look at the whole picture (i.e. reservoir animal sources, water supplies), they will miss the opportunity to solve the problem. No amount of doxycycline will cure the herd without preventive holistic environmental steps incorporated into the treatment plan.

We now have many examples that demonstrate the value of a holistic One Health approach providing benefits and increasingly solutions to the twenty-first century health problems. Disciplines across One Health (see Chapter 7) have teamed together to provide the solutions for many of today's health challenges. For example, once an estimated cost of anywhere between US $4-53 billion was the price tag from the loss of bats to WNS and wind energy development, people began to care about bats. A One Health team includes those that work to protect caves where bats hibernate from human visitors and potential WNS pathogen *P. destructans*. Scientists that explore the epidemiology and ecology of the disease and increasingl y how to prevent/treat *P. destructans*, while many others that explore methods for more bat- and bird-friendly wind energy.

In the translational medicine arm of One Health, we increasingly see teams of oncologists, from both sides of the human medical/non-human veterinary health professions, working together to find diagnostic and treatment advancements for our efforts against cancer. Both infectious and non-infectious cancers afflict humans and animals, with many of these cancers similar across taxa. Understanding both the environmental causes and mechanisms of cancers in human and non-human patients will lead to advancements for all.

Another important example of the One Health team approach being used to solve the challenges of today is that addressing zoonotic diseases. These shared infectious agents that cross species boundaries, and cause great suffering to human and non-human animals, may be effectively managed if we look at the reservoirs, hosts, and environments together as we work to develop preventive measures. The H1N1 avian influenza epidemics, coronavirus epidemics of SARS, and MERS are prime examples of how a species-spanning approach has helped to avert pandemics.

2.5 Connectivity Across the Human–Animal–Environment Interface

It is clear that *all* of life modifies other life at some level and that we are *all* connected. There is a reason we call it the "web of life." Humans are no exception, and indeed, we have been modifying the environment since the first bipedal footsteps of *H. sapiens*. However, our negative global modifications have increased in recent history; with key periods of escalation around 10,000 years ago at the time of domestication and again around the time of the industrial revolution in the 1700–1800s. We are now living in the age of the Anthropocene. With our advanced technologies and communication systems, the rate of change we effect on the planet is ever more evident with environmental harm and resource over-extraction leading to new health hazards for all life. We also have never been so knowledgeable of the connections that link health.

As stated earlier, the closest One Health links may be at the dinner Table. A common East African greeting is "Osso saada keriko?" which means "How are you and your livestock?" Many cultures understand the link that their family's health has with the health of the animals on which they are dependent. The problem of safely feeding the world while preserving the environment and avoiding issues such as antimicrobial resistance in animals and humans requires cooperative scientific problem solving—a One Health approach. One area worth exploring may be the ethics of One Health in a connected world. Measures taken to "ensure" human health are often at the cost of animal and environmental health. We must face our desire to provide health care for the 7.6 billion humans while not creating ever greater disease issues and health challenges to *all* other life that share the planet with us.

In today's interconnected world, the human footprint changes climate, fragments and modifies landscapes, moves invasive species, and creates health challenges for *all* life. Understanding these connections and the diseases and health challenges that threaten human, animal, and plant life on Earth is a first step to coming up with solutions. The good news is that One Health teams allow us to do this. After a period in which disciplinary silos were erected, resulting in academic fields becoming insular and disconnected, we now realize that we must bring these disciplines together—a new model that now utilizes One Health teams that work to tackle the challenges of today. We also realize that reacting to health issues, such as an infectious disease pandemic, whether in bats or people, instead of preventing them, is simply bad medicine.

In the chapters ahead, we will more fully explore the challenges and solutions for Planetary Health in the twenty-first century. We will provide tips on how to be a One Health practitioner during the Anthropocene Epoch. These ideas and actions, and the One Health initiative itself, have arrived at the right time since the health and survival of all of us might just depend on this collaborative and transdisciplinary approach. The holistic One Health approach for the health of *all* living beings, on the only planet we know supports life, may be the key to solving the conservation and health crises of today.
End of Chapter Questions & Activities

A. Thought Questions:
   i) In this chapter, we explore the connections linking all life. Can you think of ways that these connections can be used to the advantage of the One Health practitioner when looking for solutions to the current conservation and public health challenges?
   ii) If you had the ability to make one change on a global scale, what would you choose, why would you choose it, and how would you see it contribute to solutions for conservation and public health?
   iii) In this chapter, we present the world as very connected and assert that humans, animals, and environments influence one another across a continuum. Can you give an example of any situation where this is not true?

B. In-Class/Guided Activities:
   i) Have each student provide one example of how they feel the health of another person, an animal, or their local environment has had direct impacts on their health in the last 24 hours, 7 days, and month.
   ii) Have each student share how they see their health is connected to the health of another student on the other side of the world from where they are sitting. (You can look at a map!)

C. At Home Activities:
   i) Pick a 24-hr period over the past week and consider all the ways that other people, animals, and the environment affected your health. Make a list of these connections and indicate for the living organisms (other humans, animals, plants) if they had a negative/neutral/positive impact on your health and conversely if you had a negative/neutral/positive impact on their lives.
   ii) Too often overlooked, a major One Health challenge is created by the products we purchase, and how we consume. Every day in big and small ways, our actions connect us to all other life on the planet—the six degrees of One Health. At your next meal, find out where your food originated and what it took to get it on your plate. Think about the clothes, books, furniture, and other items that fill your home. Make a list of all the things you see in front of you right now.
   iii) Visit the website http://www.worldometers.info/world-population/to visualize how many more humans are on the planet by the second.

D. Long-term Action Steps:
   i) The equation $I = P \times A \times T$ (Impact = population x affluence x technology) is increasingly becoming more understood. Each of us has a global footprint. Going forward, please consider your impact on your health, other humans, animals and the planet. Take measures to minimize your global negative impacts and to increase your positive impacts.

E. Recommended Reading:
   Igo People Pathogens Planet: The Economics of One Health 2010

Interview

An interview with Agustin Fuentes, PhD, who is The Edmund B. Joyce C.S.C. Professor of Anthropology at the University of Notre Dame.

How do your actions reflect One Health, personally or professionally?

If you look at my publication record over the last 20 years, a lot of that work has focused on the notion that human-other animal interfaces, in my case particularly human-other primate interfaces, are critical ecologies for understanding what's going on today. In a health context, I think it's even more important because of the commonalities in evolutionary histories and physiologicals between human and other primates, and we have got a number of pathogen sharing events that have broad scale implications for humans and other primate health. My actions have been through research and publication, and I'd like to think that I am contributing broadly to the One Health enterprise. We have been pushing an approach called ethnoprimatology, which integrates a kind of primatologist, anthropological, and biological (One Health) approach to trying to understand this interface and pathogen sharing co-ecologies.

What can an individual do to make a difference for planetary health?

One of the most important things one can do is to be informed. One of the biggest challenges we have is getting quality information. It behooves individuals to get a good understanding of what their social and pathogen landscapes look like and how an individual is impacted. Education and information acquisition is critical.

How can we encourage people to care about planetary Health?

People can think seriously about family planning, community planning, and the infrastructure in which they live. How do we live, how do we consume, how much do we consume, and why do we consume? I am not saying, 'Don't consume,' people just should be more aware of how their consumption patterns, particularly in the global north, affect global patterns.
Where is One Health headed?

One Health should be going to true integration across the biological and social sciences, and maybe even the humanities and others to develop teams of researchers that have a full complement, or at least a very diverse complement of approaches. This will ensure we look at the complex scenarios across the ecological, biological, historical, political, and economic playing fields.

What do you see as the top two challenges for global health in this interconnected world?

I will limit this to two. The first would be movement of people and the pace at which we are modifying ecologies. The second big problem is education and information. I think we have to get the data we have in academia and in health research agencies effectively out to the public.

How do you see a One Health approach may help to minimize the potential danger of movements and trade?

In the most straightforward sense education; we must understand what the primate trade does, not just in the conservation sense, but in the potential to disseminate, and create, pathogens. One Health teams could deploy a fear factor to get people to pay attention to these problems. It can also help with interdisciplinary research in this topic, such as in global trade in animal parts. Humanists can help on how we deal with these moral and ethical dilemmas. We need to take advantage and not be afraid to push into complex, culturally dense, politically touchy topics.

Parting Thoughts?

Everyone should be bi-lingual or tri-lingual. It’s really important that we beef up on the cultural linguistic diversity. Another area is to know who to talk to, since there is just too much data for one person to know. The smart scientist today is a terrific collaborator, not just a terrific person to know. The smart scientist today is a terrific collaborator, not just a terrific person to know.

Case Study: What Does Camel Health Have to Do with Climate Change, Human Health, and Wildlife Conservation?

Co-authored by Diamond Carroll

The ability to feed the 7.6 billion people that currently inhabit the planet has become increasingly challenging due to climate change and other environmental stressors occurring on a global scale and at an ever-accelerating rate. An example of a One Health program dedicated to looking at these challenges is the Dromedary Camel (Camelus dromedarius) Health Assessment Program (Figure 2.5). This program links environmental, human, and animal health. The program is led by the Saint Louis Zoo Institute for Conservation Medicine but located in Laikipia County, Kenya; a region that has experienced significant climatic and demographic shifts in recent decades. During this time, the camel population increased by approximately 75%, while the cattle population greatly decreased. This shift in livestock species is largely due to the semi-arid land becoming increasingly arid (e.g. climate change), and therefore less hospitable for cattle survival. As climate changed in the region, a change in livestock practices also occurred. The shift in livestock has been to a more climate adaptive species—the Dromedary camel.

Camels are an important food source for the 40 million people living in Kenya, researchers estimate that at least 10% of all Kenyans, an estimated four million people, drink unpasteurized camel milk. The increase in camel milk as a source of protein may have nutritional value. However, it is also a human health hazard since infectious disease causing agents, harbored by camels, may be transmitted when people drink unpasteurized milk. Additionally, the increase in camel numbers in Kenya, to approximately three million, is also a concern for wildlife conservation. Laikipia County is one of the regions with the highest camel numbers. It is also a region with some of the best remaining wildlife populations in East Africa. Camels may share pathogens, and compete for resources with these sympatric wildlife species.

Many One Health programs focus on stopping the spread of diseases that have negative impacts on humans and animals. This Dromedary camel health program works to understand the pathogens of camels, and to develop methods that prevent the spread of these pathogens from camels to humans, other livestock species, and wildlife. To accomplish this, researchers work to improve biosecurity measures, such as better camel husbandry and veterinary care. This example of camel health in East Africa shows that livestock health has direct impacts for both human and wildlife health in the region. As we search for food security for a growing human population at a time of significant climate changes, we will have new challenges at the animal-human interface on a changing planet.

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3 Our interconnected World

3.1 The Climate Crisis

As an undergraduate, I read a book entitled *The Sixth Extinction: Biodiversity and its Survival*, by Richard Leakey and Roger Lewin, which spelled out the global extinction crisis in clear and devastating terms, likening the rate of global extinction currently ongoing to prior dinosaur-ending mass extinctions and definitively setting the blame at humanity’s collective feet. Gone are the dodo (Raphus cucullatus) and passenger pigeon (Ectopistes migratorius), of course, but so too, have we lost the Caribbean monk seal (Monachus tropicalis), thylacine (Thylacinus cynocephalus), javan tiger (Panthera tigris sondaica), West African black rhino (Diceros bicornis longipes), the Eastern elk (Cervus canadensis canadensis), and thousands of additional species of birds, reptiles, amphibians, insects, and arthropods from all over the globe. For me, it was a call to arms, much like Rachel Carson’s *Silent Spring* for scientists, activists, and environmentalists in the 1960s. The idea that we, the people of planet Earth, could so carelessly destroy not just our own environment but the environment of all living things, was horrifying. Even more concerning was the realization that we had already caused the extinction of thousands of species, and we were, effectively, just getting started on our global path of destruction. However, in the nearly 20 years since reading *The Sixth Extinction*, as scientists acknowledge our entry into the Anthropocene, the reality of our biodiversity crisis has been clarified. The crisis is not simply the loss of biodiversity (which we will return to shortly). It is a crisis of loss of expertise, of communication, and of human-ity’s seeming inability to reach out to someone who thinks, speaks, values, and/or looks different from ourselves and work to come to an understanding. While the threats discussed in the remainder of this chapter are real, ruinous, and potentially unrcoverable, the greatest threat to our planetary health continues to be our own inability to communicate clearly and compassionately with others in order to collaborate and solve problems. One Health and its collaborative, interdisciplinary approach to problem-solving is, truly, the best hope we have.

3 Greatest Threats to Planetary Health


As an undergraduate, I read a book entitled *The Sixth Extinction: Biodiversity and its Survival*, by Richard Leakey and Roger Lewin, which spelled out the global extinction crisis in clear and devastating terms, likening the rate of global extinction currently ongoing to prior dinosaur-ending mass extinctions and definitively setting the blame at humanity’s collective feet. Gone are the dodo (Raphus cucullatus) and passenger pigeon (Ectopistes migratorius), of course, but so too, have we lost the Caribbean monk seal (Monachus tropicalis), thylacine (Thylacinus cynocephalus), javan tiger (Panthera tigris sondaica), West African black rhino (Diceros bicornis longipes), the Eastern elk (Cervus canadensis canadensis), and thousands of additional species of birds, reptiles, amphibians, insects, and arthropods from all over the globe. For me, it was a call to arms, much like Rachel Carson’s *Silent Spring* for scientists, activists, and environmentalists in the 1960s. The idea that we, the people of planet Earth, could so carelessly destroy not just our own environment but the environment of all living things, was horrifying. Even more concerning was the realization that we had already caused the extinction of thousands of species, and we were, effectively, just getting started on our global path of destruction. However, in the nearly 20 years since reading *The Sixth Extinction*, as scientists acknowledge our entry into the Anthropocene, the reality of our biodiversity crisis has been clarified. The crisis is not simply the loss of biodiversity (which we will return to shortly). It is a crisis of loss of expertise, of communication, and of humanity’s seeming inability to reach out to someone who thinks, speaks, values, and/or looks different from ourselves and work to come to an understanding. While the threats discussed in the remainder of this chapter are real, ruinous, and potentially unrecoverable, the greatest threat to our planetary health continues to be our own inability to communicate clearly and compassionately with others in order to collaborate and solve problems. One Health and its collaborative, interdisciplinary approach to problem-solving is, truly, the best hope we have.

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