

Focus articles are part of a regular series intended to sharpen understanding of current and emerging topics of interest to the scientific community.

One Health—Transdisciplinary Opportunities for SETAC Leadership in Integrating and Improving the Health of People, Animals, and the Environment

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Abstract—*One Health is a collaborative, transdisciplinary effort working locally, nationally, and globally to improve health for people, animals, plants, and the environment. The term is relatively new (from ~2003), and it is increasingly common to see One Health included by name in interinstitutional research partnerships, conferences, communications, and organizational frameworks, particularly those championed by the human health and veterinary medical communities. Environmental quality is arguably the least developed component within the One Health framework, but can be guided by expertise within the Society of Environmental Toxicology and Chemistry (SETAC). Despite SETAC's long history of tripartite (academic, government, business) interdisciplinary environmental science activities, the term "One Health" is seldom used in SETAC communications (i.e., many of SETAC's activities are guided by One Health, but it is called by other names in SETAC's journals, newsletters, and presentations). Accordingly, the objective of this Focus article is to introduce the One Health concept to the SETAC membership. The article discusses the origins, evolution, and utility of the One Health approach as an organizational framework and provides key examples of ways in which SETAC expertise can benefit the One Health community. The authors assert that One Health needs SETAC and, to be most effective, SETAC needs One Health. Given that One Health to date has focused too little on the environment, on ecosystems, and on contaminants, SETAC's constructive involvement*

in One Health presents an opportunity to accelerate actions that will ultimately better protect human and ecosystem health. Environ Toxicol Chem 2016;35:2383–2391. © 2016 SETAC

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Introduction

All things are connected. Whatever befalls the earth befalls the children of the earth—
Chief Seattle

The grand challenges faced by our planet and peoples require grand action. We need to bridge barriers so as to integrate knowledge and skills from different disciplines. We need to empower individuals and institutions to take risks in order to more effectively address out-of-control infectious, noninfectious, and multifactorial diseases.

One Health offers one way forward. One Health is defined as “the collaborative effort of multiple disciplines—working locally, nationally, and globally—to attain optimal health for people, animals and our environment” [1]. It integrates human, veterinary, wildlife, and environmental health

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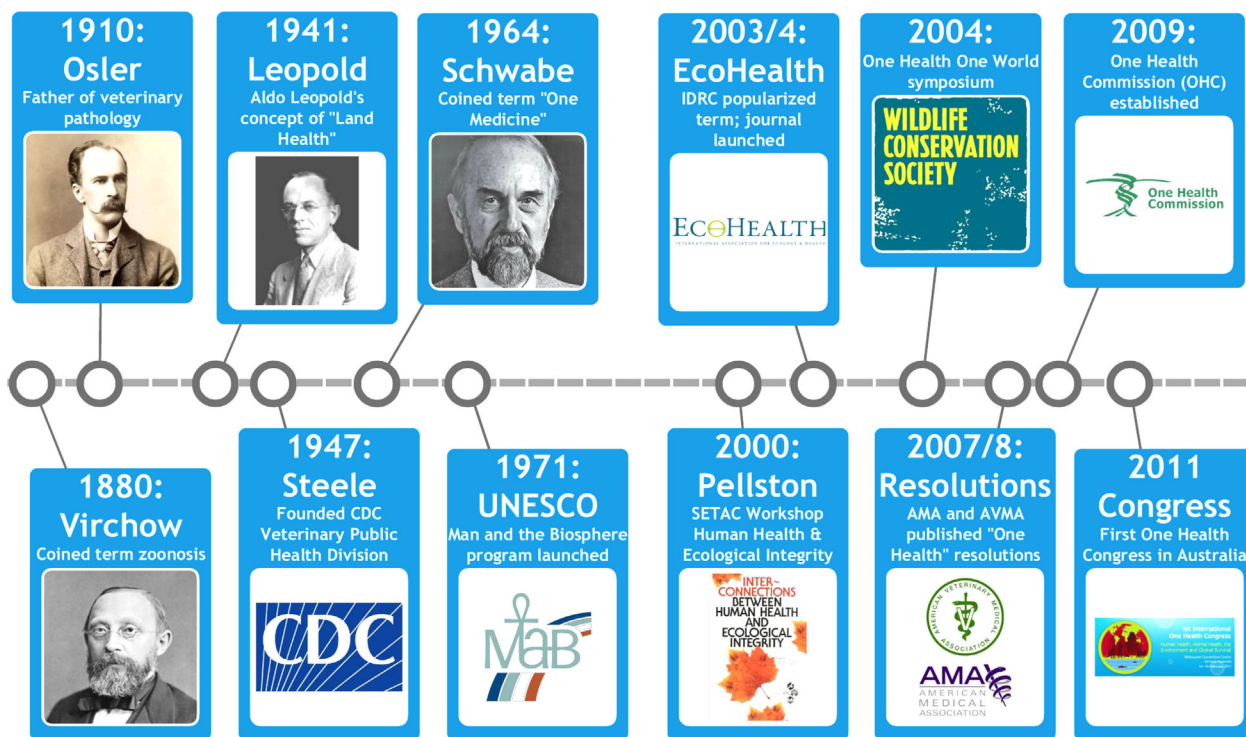


FIGURE 1: One Health timeline.

disciplines at multiple levels. It seeks to increase communication and collaboration across disciplines to promote, improve, and protect the health of all species on the planet. The principles of One Health provide a framework for individuals and institutions to integrate knowledge with the goal of formulating novel approaches that aim to achieve unprecedented benefits [2].

The objective of this Focus article is to sharpen understanding of One Health among the Society of Environmental Toxicology and Chemistry (SETAC) membership. To achieve this, we discuss: 1) the origins, evolution, and utility of the One Health approach as an organizational framework for interactions within and among professions, professional organizations, governmental agencies, nongovernmental organizations, and educational institutions; 2) the short- and long-term applications of One Health toward improving research and stewardship; and 3) the opportunities for members of SETAC to have greater involvement in One Health.

One Health Primer

Although the term “One Health” is fairly new (from ~2003), the concept arose with the dawn of medicine itself (Figure 1). From ancient Egypt, Greece, and Rome through the Renaissance and into the current modern era, similarities, differences, and taxonomic linkages among humans and other animals have formed the basis of comparative medicine. Moreover, the forefathers of medicine routinely observed, communicated, and urged avoidance of what they believed to be environmentally specific health stressors. For centuries, medical professionals cared for both humans and animals. In

Aldo Leopold as a One Health Pioneer and Trailblazer

Aldo Leopold’s *A Sand County Almanac: And Sketches Here and There* [21] spoke not only about a “land ethic” but also about land health. To Leopold, land health was encompassing, including myriad plants and animals. He defined land health as “the capacity of the land for self renewal,” and he called conservation, “our effort to understand and preserve this capacity.” Leopold also talked about abuse of the land, and he described what he regarded as preferred outcomes from interventions. In Leopold’s use and in other uses of the term health, values are necessary determinants of the prioritization of research, education, and stewardship. Ecological stewardship is a transdisciplinary approach to the development of preventive ecosystem and human health applications. It can serve as the basis for formulation of sustainable health approaches to protecting ecosystems and the environment. A recent report linked Leopold’s eco-centric wisdom to human interests in the form of an inclusive view of public health needs [22]. Land health was Leopold’s clarion call to address the ecological challenges that influence health in the broader context.

the 1700s, as medical specialties began to evolve, physicians established formal veterinary schools and led comparative physiology studies. By the mid-1800s, however, veterinarians asserted greater control in educating their own students, and a

notable schism between the professions was underway. To a substantial degree, in the 20th and 21st centuries, the divisions between animal and human health professionals have abated, and specialists in these areas routinely share knowledge and skills from discoveries, techniques, and technologies [3]. Unfortunately, there are few shared interventions for health protection (i.e., interventions that entail interdisciplinary and interinstitutional collaboration and communication), apart from those related to public health threats posed by direct interactions with domestic or wild animals (e.g., rabies, tuberculosis) or bacterial pathogens, such as *Brucella* spp. and *Salmonella* spp. in milk, meat, or eggs.

In recent years, with the unfolding of a series of zoonotic disease events, the One Health approach of bringing disciplines together not only for research but also for interventions has gained explicit recognition. Now, it is increasingly common to see One Health included by name in institutes and programs of prominent research universities, as well as in interinstitutional research partnerships, conferences, communications, and organizations—particularly those championed by the human health, public health, and veterinary medical communities (Table 1). To date, however, with few exceptions, the impacts of environmental contaminants on health and wellbeing have been largely left out of projects and programs organized under the banner of One Health [4]. Moreover, One Health as a term has rarely been used within SETAC, despite SETAC's long history of interdisciplinary environmental science. For example, our bibliometric searches of titles, keywords, and abstracts revealed no papers that contained the term *One Health* published in the 2 SETAC journals. This is despite the fact that many SETAC members abide by the same integrative philosophies and methods that underlie One Health (i.e., we do that work but just call it by other names in our journals, newsletters, and presentations).

SETAC members have contributed to the literature on the role of contaminants in noninfectious diseases of wildlife [5], and the environmental quality foundations of infectious diseases, and have provided expertise to forge transdisciplinary linkages [6]. The role of environmental quality in human and other animal health is strong within SETAC and is needed in One Health collaborations. The Wildlife Toxicology, Human Health Risk Assessment, Ecosystem Services, and Ecological Risk Assessment advisory groups of SETAC are particularly suited to advance these linkages, especially for chemically mediated health concerns shared among humans, domestic animals, and wildlife, as we have seen with endocrine disruption and are now witnessing with the development of adverse outcome pathways.

One Health—A Start, But Far More Integration Is Needed

One Health is an umbrella term for: 1) preferred outcomes; 2) focused and integrative education/training; 3) practice

Coming to Terms

Conservation medicine is the emerging discipline that focuses on the study of the ecological context of health and the remediation of ecological health problems. In response to the growing health implications of environmental degradation, conservation medicine includes examining the relationship among 1) changes in climate, habitat quality, and land use; 2) emergence and re-emergence of infectious agents, parasites, and environmental contaminants; and 3) maintenance of biodiversity and ecosystem functions as they sustain the health of plant and animal communities, including humans [12,23].

Disease is “any impairment that interferes with or modifies the performance of normal functions, including responses to environmental factors such as nutrition, toxicants, and climate; infectious agents; inherent or congenital defects, or combinations of these factors” [24].

EcoHealth, or ecosystem approaches to health, is a systems-based and participatory discipline to understand and promote health and well-being in the context of social and ecological interactions. The pillars of EcoHealth are transdisciplinarity, participation, gender and social equity, systems thinking, sustainability, and research-to-action [25].

Health, as defined by the Ottawa Charter, is an ability to achieve goals and purpose: an individual or group must be able to identify and to realize aspirations, to satisfy needs, and to change or cope with the environment [26].

One Health is the collaborative effort of multiple disciplines—working locally, nationally, and globally—to attain optimal health for people, animals, plants, and our environment [1].

Transdisciplinarity, or transdisciplinary thinking, employs perspectives and methods that transcend traditional disciplines, and engage both researchers and practitioners in addressing real-world problems. Team members are required to share roles and systematically cross discipline boundaries to develop more holistic approaches that bridge ecosystem and human health boundaries. The primary purpose of this approach is to pool and integrate the team expertise so that more efficient and comprehensive assessment and intervention services may be provided in a determined field. The communication style in transdisciplinary thinking involves continuous give-and-take among all members on a regular, planned basis. The role differentiation between disciplines is defined by the needs of the situation rather than by discipline-specific characteristics. Assessment, intervention, and evaluation are carried out jointly [27].

interventions; and 4) prioritized research. We have repeatedly uncovered toxic, infectious, and other disease agents in humans, domestic or wild animals, or plants, only to find later that such agents had injured or killed members of other taxa or

Table 1. Educational and research consortia and degree-granting programs applying One Health as an organizational framework in the United States

Institution	Program	Program website
Centers for Disease Control and Prevention	One Health Office	http://www.cdc.gov/onehealth/index.html
Colorado State University	One Health Initiative	http://source.colostate.edu/one-health-new-director-thinks-globally-acts-collaboratively-for-healthy-systems/
Duke University	One Health	http://sites.globalhealth.duke.edu/dukeonehealth/
University of Florida-Gainesville	Department of Environmental and Global Health	http://egh.php.ufl.edu/personnel/our-mission/
Harvard University	Rockefeller Foundation Planetary Health Fellows Program	https://www.rockefellerfoundation.org/planetary-health/
Ohio State University	One Health Initiative	http://vet.osu.edu/cvm/one-health-college-veterinary-medicine
Texas A&M University	One Health Initiative	http://onehealth.tamu.edu/
The US Army Public Health Center	One Health framework	https://phc.amedd.army.mil/whatsnew/Pages/PublicationDetails.aspx?type=One%20Health%20-%20APHC%20Quarterly%20Magazine
Tuskegee University	One Medicine, One Health, One World	http://www.onemedicine.tuskegee.edu
US Department of Agriculture Animal and Plant Health Inspection Service—Veterinary Services	One Health Coordination Office	https://www.aphis.usda.gov/animal_health/one_health/downloads/one_health_info_sheet.pdf
University of California-Davis	One Health Institute	http://www.vetmed.ucdavis.edu/ohi/
University of Washington	Center for One Health Research	http://deohs.washington.edu/cohr/
US Geological Survey	Environmental Health Science Strategy based on One Health	http://pubs.usgs.gov/of/2012/1069/ (http://toxics.usgs.gov/highlights/usgs_envirohealth_strategy.html)

species. To minimize and prevent such shared health problems, we need more efficient ways to generate and interlink spatially and temporally explicit data, including data sources from a range of medical, public health, and environmental experts. Notably, many within SETAC conduct research on animals as sentinels to provide real-world information on contaminant bioavailability, environmental exposures, subclinical effects, and clinical poisoning events. Furthermore, many SETAC members have contributed immensely to global efforts to study and combat endocrine disrupting chemicals.

As is often cited in writings on the need for One Health, of 1415 infectious agents known to exist in 2001, 868 (61%) cause zoonotic diseases [7]. In particular, RNA viruses are highly likely to emerge, re-emerge, and cross species barriers to cause important diseases, because they are subject to such rapid mutagenesis that they can often adapt to new hosts and vectors. Examples include retroviruses such as human immunodeficiency virus (HIV), West Nile virus, avian influenza virus, coronaviruses, arenaviruses, hantaviruses, and more recently the Zika virus. Outbreaks of diseases from these various RNA viruses have illustrated the essential value of transdisciplinary collaborations in surveillance, research, and prevention efforts [8].

One Health strategic frameworks already involve major international institutions with public- and animal-health responsibilities, including the World Health Organization of

the United Nations, the Food and Agriculture Organization of the United Nations, and the World Organisation for Animal Health. The World Health Organization, Food and Agriculture Organization, and World Organisation for Animal Health, in a tripartite alliance, established interoperative governance structures for information exchange, early warning systems, and mechanisms to enhance coordination and support for member countries as they respond to natural disasters and disease emergencies. For example, the Global Early Warning and Response System for Major Animal Diseases houses zoonoses information in its database and combines the alert and response mechanisms of the 3 organizations to avoid duplication and to coordinate verification processes. To accelerate shared communications and data analyses related to important animal diseases, including zoonoses, the World Organisation for Animal Health developed the World Animal Health Information System and Database. The official notifications of the World Animal Health Information System not only are factored into the Global Early Warning and Response System for Major Animal Diseases, but also are in the public domain. Another example is the Network of Expertise on Animal Influenza organized by the Food and Agriculture Organization and the World Organisation for Animal Health to support international monitoring and infection control. Moreover, links between the Network of Expertise on Animal Influenza and the World Health Organization's Global Influenza Programme are now strong, facilitating free exchanges of information and establishment of joint technical projects between the 2 networks. Additional

local, state, and international systems that merge, analyze, and communicate findings from diagnostic confirmatory and real-time syndromic surveillance on human and animal diseases are described in Uchtmann et al. [9]. Those authors also highlight the workings of multiple governmental, nongovernmental, and university-based groups that are heavily invested in aspects of One Health research, stewardship, and capacity building.

Despite the meaningful collaborative efforts mentioned above, One Health remains in its infancy, and far more must be done for it to meet critical challenges of today and the foreseeable future. Differences exist in the resources that are available to research concerning proximate threats to human health versus those confronting domestic animals, wildlife, and plants, as well as the ecosystems that underpin the survival of these species (in addition to human occupants); these are among the reasons why One Health is so critical at this juncture [10].

Organizations That Foster One Health Collaborations

Building bridges among human health, domestic animal health, wildlife health, and environmental health/environmental quality disciplines—and subsilos of specialization within each of these areas—will require leadership, joint educational programs, and financial support. Funding will be needed for joint research, demonstration and crisis-management projects, and outreach to share best management practices developed through such transdisciplinary efforts. These concepts were first explored by the American Veterinary Medical Association, the American Medical Association, and the Association of Public Health Physicians; followed by the formation of the One Health Commission. The One Health Commission is a not-for-profit global organization formed in 2009 with sponsorship from several universities, foundations, professional organizations, corporations, and individuals. The goals of the One Health Commission are to provide a network for One Health advocates and to encourage collaboration.

The One Health Initiative focuses on educating international multidisciplinary scientific communities, political and governmental leaders, the general public, and news media about the One Health concept and helping to promote the One Health concept implementation worldwide. The One Health Initiative website and publications provide a vital resource of up-to-date information (e.g., recent findings and funding opportunities). Although the above statements are inclusive of environmental concerns, the lack of specifics is consistent with the limited involvement in these organizations to date of full-time professionals with deep expertise in ecology, toxicology, and environmental management. Strengths of SETAC experts could readily contribute to studies of such current concerns as infectious diseases in human-altered ecosystems, the effects of climate change on infectious

agents, vector-borne diseases, toxicant exposures, and shared exposures to individual toxicants and complex chemical mixtures.

Infectious Diseases in Degraded Ecosystems

A common theme, regardless of whether the focus is human, animal, or plant health, is the ecological backdrop of infectious disease events. In certain circumstances, deforestation, travel, globalization, climate change, and chemical pollution are catalysts behind ecological simplification, increased pathogen exposures, and immunosuppression that may all contribute to disease outbreaks [11,12]. Heavy impacts can be seen in naïve populations of humans and animals that are exposed to infectious diseases. The epidemic of West Nile virus infections affected birds, horses, and other mammals (including humans), as the disease spread across the United States, from the Northeast south, westward, and into the Caribbean, Mexico, and Central and South America. West Nile virus affected humans and animals in several ways: through mild to lethal infections, through the impacts of massive pesticide spraying, and through loss of confidence in governmental health agencies when they demonstrated limited success in stopping spread of the disease. More recently, the spread of Ebola, affecting wildlife and humans in several nations of West Africa, triggered even greater concern because of the extraordinarily high case fatality rate in clinically affected people. Similarly, the Zika virus has garnered world-wide attention because of its potential impacts on pregnant women and unborn children. Important modes of cross-species contact were relevant in West Nile, Zika, and Ebola outbreaks, as well as in other infectious diseases that pose ongoing concerns. Transport related to trade and travel (e.g., via airplanes, ships, trains, buses, trucks, and automobiles) moves vectors and infected hosts more rapidly than in any previous era [13]. Also of great importance are instances of direct transmission of pathogens from animals to humans that result from human encroachment into wildlife habitats. Settlements, roads, deforestation, and agriculture fragment and eliminate wildlife habitat, bringing humans, domestic animals, and wildlife into closer contact. Bush-meat (i.e., wild game) collection, processing, and sales increase risks of direct pathogen transfers. One Health must include both infectious and toxicological diseases [14]. Members of SETAC have expertise to provide on these issues, which includes chemically mediated immunosuppression, effective disease surveillance (including determinants of healthy environments), and antimicrobial resistance (the subject of a joint SETAC–US State Department–US Geological Survey workshop in fall 2016).

Shared Health Impacts of Climate Change

Scientific evidence to date strongly indicates that climate change is an accelerating reality and that human reliance on

fossil fuels is responsible. The impacts of global environmental change on ecological processes include, for example, greatly increased precipitation in susceptible regions and more severe droughts in others; increased runoff of chemicals and erosion from severe storms and floods; coastal zones experiencing sea-level rise and more severe surges from cyclones and hurricanes; and the inability of many species to adapt to rapid changes in climatic regimes, potentially resulting in population-level impacts. A changing climate often results in disease transmission into new regions. Warmer climates promote the spread of vectors of infectious disease from more tropical ranges to temperate areas, as seen with such diseases as malaria, Chikungunya, Rift Valley fever, and dengue fever. In other instances, vectors are able to live at higher latitudes than in the past, carrying pathogens to immunologically naïve species adapted to those areas [15]. Members of SETAC have expertise to provide in One Health collaborations on issues for which a changing climate is a critical determinant [16], such as monitoring to inform ecological forecasting and amelioration of toxic algal blooms, which impact humans and wildlife and which are enhanced by cultural eutrophication [17].

Shortcomings in Toxicological Datasets

Members of SETAC have studied many toxic chemicals through extensive research and regulatory programs that were focused on particular media (e.g., air and water quality criteria), receptors (e.g., human health drinking water standards), or chemical uses (e.g., pesticide registration). The science and synthesis of SETAC have helped guide research and management frameworks pertaining to chemicals, including the European Union's Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), and the Endocrine Disruptor Screening and Testing Program. In addition, SETAC members have been active in reforms to the US Toxic Substances Control Act. The number of chemicals in need of assessment and the diversity of receptors make all of these efforts complex. Innovations in environmental and ecological toxicology should interlink different communities of toxicologists and ensure that potentially important voids in the toxicological literature are filled, that targeted monitoring for ambient concentrations of contaminants expands, and that important toxicological impacts are routinely and proactively avoided through One Health research. Data synthesis across taxa and modeling of thresholds of toxicological concern (below which no appreciable risk to human health or the environment is expected) is an opportunity to provide broadly applicable hazard information [18].

One Health Organizational Frameworks in SETAC

Although One Health by name has been uncommon in SETAC presentations, workshops, and publications, similar concepts have been used as organizing structures. A Pellston workshop

Mercury: A Classic Example of Discovering Shared Risks After Extreme Damage to an Environment, Its Wildlife, Domestic Animal, and Human Populations—A Problem Yet to be Brought Under Control

Mercury poisoning remains a One Health concern because of decades of evidence of multispecies toxicity [28]. The classic story of mercury poisoning of Minamata Bay, Japan, began with the use of mercury as a catalyst in 1932, but emissions grew more serious when a new co-catalyst added in 1951 directly produced methyl mercury. Releases into the Bay were followed soon thereafter by observations of dead fish and fishermen complaining of reduced catches. By 1953, seabirds and crows spiraled into the sea, and the same year cats that consumed seafood from the Bay demonstrated severe incoordination and seizures. Then, in 1956, neurotoxicity was observed in children eating the seafood. In 1957, feeding the seafood to cats experimentally reproduced the syndrome. In 1959, the syndrome in children was diagnosed as methyl mercury poisoning, and the point source producer was identified in 1961; but the company continued releasing methyl mercury until 1968 [28]. Despite our knowledge of mercury's harm, it continues to pollute globally. The chemical is intentionally used in several products (e.g., compact fluorescent light bulbs, certain batteries) and activities (e.g., artisanal and small-scale gold mining, mercury-cell chloralkali process), and it remains a substantial byproduct of industrial activities such as coal-fired utilities, cement manufacturing, and waste incinerators. To monitor and protect wildlife, domestic animal, and human health, an integrated and comprehensive One Health approach is needed. This is particularly required now, given the United Nations Environment Programme Minamata Convention on Mercury Pollution [29], which is the global legally binding instrument that aims to protect both human health and the environment from mercury.

entitled *Interconnections Between Human Health and Ecological Integrity* was held in 2000. Jointly sponsored by SETAC and the Society of Toxicology, the workshop was motivated by the concern of human-health, environmental, and social scientists for the interconnections between the condition of natural ecosystems and human health [19]. The goal of the workshop was to initiate substantive yet broadly considered explorations of these interconnections, including creative transdisciplinary approaches for solving environmental problems at this interface. Major themes included the biological basis of similarities and differences between human health and ecosystem quality; how the environment shapes the human sense of well-being and vice versa; linkages among land-use patterns, ecological degradation, and human health; and

implications of interconnections among human health and ecological integrity for policy makers. One outcome of the workshop was the development of a conceptual model for mapping interconnections between human health and ecological integrity, considering both the natural system (comprising the physical environment and biota) and the social system (comprising culture and institutions). Each system delivers outputs to the other system. The social system, including elements such as economics, delivers pollution and other residuals to the natural system and value-added goods and services to itself. The natural system, including elements such as natural resources, provides ecological goods and services to the social system, which together support human health and well-being. These systems and their connections served as a foundation for a conceptual model for the strategic plan of the National Health and Environmental Effects Research Laboratory, a unit of the US Environmental Protection Agency (USEPA) Office of Research and Development (Figure 2).

The National Health and Environmental Effects Research Laboratory conceptual model clearly outlines a stronger emphasis on systems-based thinking to improve environmental public health outcomes, and that itself is a step toward the One Health concept. Moreover, the framework of the National Health and Environmental Effects Research Laboratory model has been used to help drive a hiring strategy that is focused on the areas of environmental economics, decision science, predictive toxicology, watershed epidemiology, environmental public health, and children's health. The scientific strengths of the National Health and Environmental Effects Research Laboratory can be characterized as systems-based research on ecological integrity and ecosystem health with the goals of protecting the environment and improving human health and well-being. An important component of the systems-based approach is the experimental and computational research being conducted by the National Health and Environmental Effects Research Laboratory and other units of the USEPA.

One Health Goals: Collaborations, Unified Vocabularies, and Visualization Tools

With the current fragmented approach to environmental and health sciences, there is a tendency to disregard other disciplines. For example, an epidemiologist trying to predict how changes in global climate will influence the distribution of a mosquito-borne disease may assume that the ecological interactions that determine the distribution of the mosquito can be simplified by describing a range of temperature and precipitation conditions conducive to vector persistence. This specialist might be tempted to black-box all biotic interactions affecting mosquito populations as external to a set of abiotic conditions, which can be described using remote sensing data and geographic information systems, rather than embracing both individual- and population-based perspectives by scientists of different disciplines. The One Health approach can counteract the weakness of black-box approaches by bringing experts on health together with specialists in behavioral sciences, ecology, wildlife, and vector populations, climate, geographic information systems, anthropology, mathematical modeling, toxicology, veterinary medicine, and public health to help develop visualization tools that better inform the public about hazards.

As people in different disciplines work together, they will need to be able to rely on a common technical language. Members of SETAC can contribute to the development of a unified vocabulary that will enable cross-species analyses of data on health parameters, environmental contaminants, infectious agents, societal drivers, interventions, and outcomes [9]. Also, for the sake of efficiency, data entry will need to become nearly effortless across the board. Databases will need to be readily accessible in the public sphere to garner

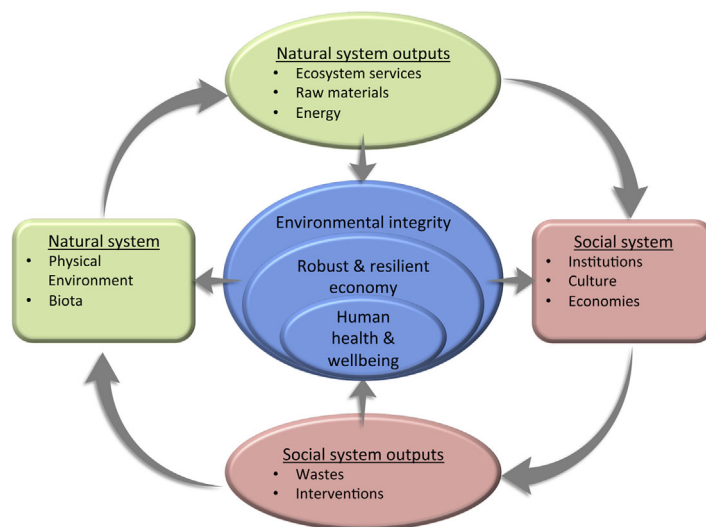


FIGURE 2: Conceptual model for the strategic plan of the National Health and Environmental Effects Research Laboratory, US Environmental Protection Agency, Office of Research and Development.

public understanding and support for astute and more timely management. One Health mapping programs should include distributions of humans; of domesticated, native, exotic, and invasive animals; and of plants, together with their respective syndromic and diagnostic health parameters, cities/towns, agricultural areas, managed forests, industries, mining and fossil fuel exploitation, buffers, wilderness, climate, and weather. The analyses should also point to existing and emerging health problems related to individual stressors and groups of stressors, data gaps, interventions, and indicators of recovery. Spatially explicit analyses should thereby reveal proximate causes, connections to underlying societal drivers, and how reliable triggers for effective mitigation and prevention can be applied. In addition, appropriate maps should draw attention to the need to extend the reach of professionals and paraprofessionals to underserved populations of plants, animals, and humans.

The usefulness of the One Health approach ultimately will depend on its applicability to solving problems. To succeed at the societal level, One Health efforts will need to rely on input from fields such as sociology, economics, and anthropology. These disciplines will inform the science and the practice of One Health by revealing the basis for human behaviors that change the environment in multiple ways. Top-down approaches to ecosystem management are being replaced by adaptive management strategies that reflect uncertainty and complexity, as well as the need for more continuous self-examination of new scientific findings. These new management techniques are necessary to further develop the field. Bioinformatics and the creation, management, and dissemination of databases relevant to humans, domestic animals, and wildlife, along with their habitats, diseases, and contaminants, will be crucial to the One Health approach.

The community also needs to work together to develop a common definition of “health.” For now, we support the definition of Stephen [20] that indicates health should comprise of the following features:

- 1) health is the result of interacting biologic, social, and environmental determinants that promote and maintain health as a capacity to cope with change over time; 2) health cannot be measured solely by what is absent (i.e., lack of disease or hazards) but rather by characteristics of the animals and their ecosystem that affect their vulnerability and resilience to a suite of interacting social and environmental harms; and 3) health is not a biologic state but rather a dynamic human social construct based on human expectations and scientific knowledge.

A Need for New Tools

There are no simple solutions to address global environmental problems. A multipronged strategy is required. At the heart of any solution-oriented agenda is the need for better problem definition. By bringing disciplines together, the One Health

approach can contribute to solving environmental problems by improving problem definition. To improve problem recognition and definition, new tools for assessing and monitoring ecological health concerns are required. One possible approach is the development of some form of integrated ecological and human-health assessment that incorporates aspects of environmental indicator studies with specific biomedical diagnostic tools. These tools might include: the development of noninvasive and real-time physiological and behavioral monitoring techniques; the adaptation of modern molecular biological and biomedical techniques that provide early warnings and predict adverse outcomes; the design of population-level monitoring strategies; the creation of ecological and sentinel species surveillance approaches; and the adaptation of health monitoring systems for appropriate developing country situations [12].

One Health Opportunities for SETAC Members

Opportunities for collaboration in One Health are increasing, and several areas of expertise within the SETAC membership already fall under the One Health umbrella. For example, investigation into the declines of managed honey bee (*Apis mellifera*) colonies and other pollinators is an extension of the One Health concept. As with other One Health endeavors, studies of honey bees start with an understanding of preferred outcomes—for example, abundant honey bee populations, relatively free of diseases, and readily able to pollinate a host of wild and agricultural plants—and an exploration of multiple threats. In the case of honey bees, potential causal factors of declines and die-offs include geographical translocations, pests, pathogens, and pesticides, sometimes acting in concert. Members of SETAC have the toxicological training, geographic information system mapping and visualization tools, and statistical expertise to produce needed models and to design and implement management paradigms to manage, understand, and offset risks.

Other potential One Health areas that could benefit from SETAC expertise include natural resource damage assessments and ecological services through which the effects of ecological integrity on human well-being are considered. Members of SETAC who serve as consultants to governments, international agencies, health industries, and chemical manufacturers could help evaluate different risk scenarios to point the way toward promising endeavours designed to better protect agricultural ecosystems, biodiversity, and human health. The skill sets of SETAC members could also be applied to tackling biological and chemical threats of bioterrorism (e.g., plague, anthrax, and nerve gas-like agents), another One Health area. One Health offers powerful avenues by which to make linkages, undertake collaborations, and build commercial opportunities that accommodate linkages among human health and well-being and ecological integrity, and the expertise of SETAC members can help strengthen each of these linkages.

Conclusions

One Health needs SETAC and, to be most effective, SETAC needs One Health. One Health to date has focused too little on the environment, on ecosystems, and on contaminants. The constructive involvement of SETAC in One Health presents an opportunity to help protect humans, animals, and plants from actions that have created an era characterized by climate change, infectious diseases, chemical pollution, and losses in biodiversity. The adverse health impacts at hand warrant an infusion of interest and effort on the part of a wide array of SETAC experts. A logical approach of One Health is to focus multiple disciplines on understanding and counteracting shared stressors in given localities. In this regard, SETAC's Global Horizon Scanning Initiative, which was designed to identify geographically specific research needs to improve environmental quality, could be a catalyst for assembling transdisciplinary One Health teams to spearhead studies of high-priority stressors that pose imminent threats to the health of plant, animal, and human populations.

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Disclaimer

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