

Perspective

Intertwined Strands for Ecology in Planetary Health

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Abstract: Ecology is both blessed and burdened by romanticism, with a legacy that is multi-edged for health. The prefix ‘eco-’ can carry a cultural and political (subversive) baggage, associated with motivating environmental activism. Ecology is also practiced as a technical ‘science’, with quantitative and deterministic leanings and a biophysical emphasis. A challenge for planetary health is to avoid lapsing into, or rejecting, either position. A related opportunity is to adopt ecological thought that offers a rich entrance to understanding living systems: a relationality of connectedness, interdependence, and reciprocity to understand health in a complex and uncertain world. Planetary health offers a global scale framing; we regard its potential as equivalent to the degree to which it can embrace, at its core, ecological thought, and develop its own political narrative.

Keywords: romanticism; ecosystems; rationality; relationality; living systems; interdependence

1. Introduction

Viewing health in the context of the living systems on which humans and other species depend, is not a new idea. Ecological thought offers a rich entrance to understanding these living systems, with its emphasis on connectedness and interdependence. This understanding is coherent and foundational within many human knowledge systems (consider Indigenous cultures, through to Hippocrates: *Airs, Waters, Places*) but has been overlooked and poorly addressed in our current framing of how we consider health and well-being in society, including in public health policy and health-related scholarship. Even so, the past decade has seen an expanding range of calls for, and claims of, integrative approaches to health and well-being that engage with ecological context. Accompanying this has been an expansion of terminology across scales and issues, spanning biodiversity and health, ecohealth, one health, healthy parks healthy people, ecological determinants of health and planetary health (see [1,2]). These efforts are in addition to ongoing Indigenous leadership in this space [3–6].

These calls and claims, significant and global in their scope, warrant close attention and demand critical reflection. It is, therefore, timely to reflect on the role of scholarship and framing of health in relation to the ecological, with attention to ways in which language and terminology are used. Our purpose here is to examine the evolution of ecological thought and practice as it has been applied to health and well-being, and the cultural and socio-political consequences of these adoptions. We build on recent efforts to consolidate thinking around the diverse, complex and—to many—confusing field developments at the intersection of human health and environmental change [1]. While the gaze of this paper is, specifically, on ‘ecology and health’, we acknowledge the vast range of world views, knowledges and literatures that are relevant to this terrain, but which are not the focus of our analysis here (consider for example geography and post-humanism). Similarly, for the purposes of this paper, we recognize planetary health’s diverse historical background and its foundational principle that human health is irrevocably coupled to the health of natural systems within the Earth’s biosphere [1,7].

To examine the influences of ecology, in relation to planetary health, we outline some (but not all) substantial and intertwined strands contributing to the development of ecology as a disciplinary field, as well as the applications of these strands to the ways in which the condition of the environment, the health of humans, animals and the planet itself, have been considered. We then provide a commentary on the ways in which health-related fields have been selective in their application of these strands of ecological thought and examine the implications and challenges of that selective application. We conclude by offering observations on the potential for planetary health to enhance health imperatives by meaningfully engaging with the living systems on which we depend and benefitting from ecological thought to accomplish this.

2. Historical Threads of Ecology in Health and Well-Being

For many, ecology is primarily associated with the endeavours of science. Yet we, like others, see the romantic period (late 18th century to early–mid 19th century) as having made important contributions to the development of ecological thought. Romanticism can be characterised by, among other things, the deepened appreciation of the beauties of nature, and what Hay [8] refers to as ‘heightened imaginative sensibility’. In the visual arts, the landscape was portrayed as a dynamic natural world, capable of evoking awe and grandeur, often by travelling through.

These tendencies were, in part, a reaction to the Enlightenment and its rationality [8] and to a Cartesian mind-matter dualism [9,10]. Views of a mechanistic natural world were supplemented by reconceptions of nature as dynamic and enmeshed, and by aesthetic perspectives from the literary and visual arts. We argue that these threads of influence on ecological thought continue to have implications for how we understand contemporary convergences of ecology and health, and indeed how planetary health is positioned in respect to them.

2.1. *The Mesh of Nature and the Emergence of Ecological Thought*

The biogeographer Alexander Von Humboldt in 1827 likened the natural world to an all-encompassing “interlinkage, not simply in a linear direction, but in an intricate netlike interweaving” [11]. Nature was now looking more like a decentralised ‘mesh’ and perpetually reweaving itself. Developments in astronomy, geology and biology were showing that the world/nature was not a static entity. Expressing nature as a ‘process of perpetual becoming’ [11] can be seen as protoecology, and the first half of the 19th-century texts were imbued with preoccupations about geological and later biological evolution.

For example, Jean-Baptiste Lamarck saw the environment in constant transformation, where change was moderated by the relationships between organisms and their environment [12]; and Charles Lyell described the Earth’s crust, and gradual changes in the history of the planet [13]. As the pieces of Darwinian evolution fell into place in the 1850s, protoecology had its essential principle: that the environment is constantly changing which causes those with best adaptations to survive by the mechanism of natural selection.

First coined by Ernst Haeckel in 1869, ecology was born from the Greek word *Oikos* meaning “household” and *logos* meaning “study of”, therefore the “study of nature’s household” (in the same way that economy is the measures and management of nature’s household). The first ecological journals and ecological societies appeared in the early 20th century. By the 1930s ecology developed concepts of hierarchical levels of organization beyond individuals and populations, first with the community, then with Arthur Tansley’s concept of “ecosystem”—characterized not only by the components of a living system but by the interactions among those components [14]. ‘Ecosystems’ was adopted by the texts of ecology of the 1950s and still later it was designated as (more than the sum of) the various communities plus the inert atmosphere. Eugene Odum’s first text book on ecology was published in 1953, and some saw it as the “radical science”. Interestingly, the levels of communities and ecosystems implicitly included humans in early texts. Ecology has been variously defined as Elton’s “scientific natural history”, or “the science of super-individual complexes” [15]. To us ecology (should) never

deviate from its principle of holism, which acknowledges the (eco)system, including what processes it uses, and what it does (structure, process and function) as well as how components are distributed and how the whole is organized. On that basis, ecology seeks to make sense of a complex and uncertain world [16].

2.2. Efforts to Reconnect Ecology and Health

Developments in ecology offered a lens by which industrial societies could undertake a critique of their own activities, activities which would ‘boomerang’ [17], to affect the very societies that industrialisation was supposed to benefit. Ecology was a subversive instrument, increasingly politicized, to demonstrate how we are fouling our own nests. The field of ecotoxicology, ‘the study of poisoning our home’ [18], exemplifies these processes.

Rachel Carson catalysed this politicization. She trained as a marine biologist and worked for 15 years with the US Fish and Marine Wildlife Service. She was a writer, a poet and a nature lover, influenced by romanticism. Touched by the experiences of her acquaintances, influenced by her family experiences of caring, and her own breast cancer, she shared a concern over spraying of pesticides [19]. She sought to publish about what she knew, eventually drawing on the extensive evidence and contacts compiled by two biodynamic farmers for a suite of legal actions (1957–1960) against the US Government contesting the aerial spraying of DDT. She wrote a series of articles for *The New Yorker*, and 1962 published *Silent Spring*.

The book had sold out before it was published. Carson mixed good science with good story-telling: specific, real-world examples that illustrated larger concepts, such as how food-chains and ecological systems work. And she did not mince words: “The road we have long been traveling is deceptively easy, a smooth superhighway on which we progress with great speed, but at its end lies disaster . . . ” [20] (p. 277).

A few years earlier Aldo Leopold’s [21] famous series of essays in *Sand County Almanac* was published posthumously, defining the cultural value of wildlife and wilderness and human’s ethical responsibility to keep intact the ‘land pyramid’ of agricultural landscapes as well as inherent in natural ecosystems. Leopold used ‘land’ as shorthand for the complex of features, especially biotic components, the pyramidal structure (today called ‘trophic structure’) and processes driven by solar energy, encompassed by ‘ecosystem’.

Leopold defined ‘land health’ as a condition under which ‘the land could be humanly occupied without rendering it dysfunctional’ and ‘the capacity of the land for self-renewal’ [21]. Indeed, his use of the health metaphor extended to recognition of ‘land sickness’. As humans are ‘part of’, and not ‘apart from’ the landscape, Leopold argued that the degree to which the landscape satisfies human needs necessarily links into an assessment of landscape health.

Leopold’s ‘landsickness’ is a metaphorical exploration of the concept of organismal health. In the late 1960s the first photograph of the blue planet taken from the moon tapped into a pre-existing perspective of ‘spaceship earth’, limited by its natural capacity, and self-regulated by its internal dynamics to which life is adapted. Lovelock’s Gaia hypothesis [22] then extended the metaphor to the health of the planet (see also [23]).

Later, the notion of ‘ecosystem health’, a progenitor of ecohealth as a field and movement, engendered a vigorous and important debate in the 1990s [24]. The concept captured the attention of natural resource managers because it provided a narrative hook that embodied a more difficult series of questions concerning whether an ecosystem could be healthy and if so, how it could be measured. Rapport et al.’s seminal 1985 paper challenged ecologists to consider ecosystem degradation in the same way that illness in humans can be diagnosed by some medical practitioners, that is, according to a suite of indicators that, together, were referred to as the ‘ecosystem distress syndrome’ [25]. The ‘ecosystem health’ project did not deviate much from this theme and emphasis, leaning to a description of measurable properties, whereby healthy ecosystems retain their natural

vigor (productivity), their resilience (capacity to recover from disturbance, indeed self-renewal), and their organization (diversity) [26].

The above trajectory and subsequent debate necessarily broadened to cover what we now regard as the range and richness of ecohealth as ‘ecosystem approaches to health’, seeking to understand the health of people, animals, and ecosystems in the context of social and ecological interactions [16,27,28].

3. Ecology and Public Health

3.1. *The Incomplete Embrace*

The emphasis on ecosystem and ecosystem approaches contrasts with several decades of the use of ‘ecological’ in traditional public health in general, and in epidemiology and health promotion in particular. In most cases the attention was towards the ‘environment’, the language of the ecological has been adopted in a variety of ways, but in ways in which ecosystems, and the richness of ecological thought, have not been fully embraced.

Public health has a long and solid tradition of losing the ‘eco’ in ecological work, notably overlooking the origins of ecology, as described above. The ‘ecological model’, ultimately drawn from Bronfenbrenner [29], identifies an individual’s health and population health as nested within a series of scaled influences that are together termed ‘environmental’ because they are part of the ‘surroundings’. Despite the contributions of Bronfenbrenner’s “ecological model” to understanding nested systems influencing public health: “... these propositions, and the literature surrounding this model, surface three important and common weaknesses in its application—a delineation and oversimplification of system levels, a focus on proximal influences and a very limited use or inclusion of the chronosystem” [30] (p. 37). A related critique is that the nested features are almost always interpreted as social and economic ones, meaning that ecologies become, somehow, devoid of ecosystems. This line of thinking gives primacy to societal interventions, that seek to address the social determinants of health, and tend to view nature as a static constraint, or a form of distant context. This can also lead to counter-intuitive disconnects, whereby a field as important as environmental justice [1,31], draws necessary attention to the relationship between ‘environmental exposures’ and health inequities; (e.g., increased likelihood that poorer people will be exposed to environmental hazards) but can remain blind to the ecological processes underpinning these hazards.

Some of the range, and inconsistencies, of the use of ecological in relation to health, are exemplified in McLaren and Hawe’s [32] glossary. Here, the terms ‘ecological depth’, ‘ecological fallacy’, ‘ecological perspective’ (health promotion), ‘ecological psychology’, and ‘ecological public health’ are represented in the literature but in doing so are neither defined with reference to—nor coherent with—definitions of ecology and ecosystems. McLaren and Hawe frame the application of the ecological with reference to the limitations of the use of metaphors, ironically cautioning against the potential for misrepresentation arising from careless or partial application [32]. Some of these disconnects are associated with the tendency, especially by early ‘human ecology’ to focus the application of insights from ecological sciences to conglomerates of humans within cities [32,33] as compared to the living systems they depend on. This compounds the dilemma that McMichael describes as “prisoners of the proximate” [34] where eco-epidemiology offers only a partial response, even though it is apparently overt about linking the ecological and social and where it rests “... on an understanding of a universe in which nothing exists as a thing by itself, but only has existence in relation to everything else” [32] (p. 8).

The field of environmental health is ecological in so far as it deals with the pathways responsible for human exposures to harmful aspects of the environment. These pathways can be related to lifestyles and livelihoods (occupational, residential, recreational). Practitioners attend to these proximal and direct effects by minimising exposures. They have been, however, less likely to tackle distal, indirect determinants, such as global cycles, trophic structures, biodiversity loss and hydrological change, as reciprocal relationships that link human behaviours with human health outcomes. Contemporary

environmental health [35] at least recognises the importance of these ecosystem properties, functions and processes even if they are not yet appropriately recognized in regulatory structures for occupational and environmental health.

From a different perspective, socioecological approaches in health promotion have also made valuable contributions by more fulsome attention to some systems components. They were expressed foundationally and profoundly in the Ottawa Charter for Health Promotion [36]. Interconnectedness is recognized because societies are complex and interrelated. Reciprocal maintenance is “the overall guiding principle” in the need to create supportive environments. In addition, ‘a stable eco-system’ (sic) was listed as one of the nine prerequisites for health, the others being peace, shelter, education, food, income, sustainable resources, social justice and equity. According to the Charter, improvement in health requires a secure foundation in all of these. A challenge here is the ease by which it is possible to miss the point about the fundamental connections with the natural world [16,37,38] where, for example, ecosystem changes can lie at the base of any or all of the other eight pre-requisites. Another problem is that stability is sometimes not a desirable end-point in ecosystems, which are always changing, and where a desire to stabilize ecosystems can be driven by a perceived need to maximize productivity, but this will come at the expense of diversity and resilience [39], two properties of ecosystems that are just as important as productivity.

These examples have shown ways in which developments in public health fields have tended to acknowledge ecology in a limited way, especially by framing an environmental influence on human lives in general, or the need to embrace environmental effects in a discipline. In response, a range of efforts are pushing beyond limitations.

3.2. Contemporary Corrections

More recent developments include more explicit attention to ecosystems in relation to health, such as the work of the Millennium Ecosystem Assessment [40], with its conceptual framework for the relationships between ecosystem services (supporting, provisioning, regulating, and cultural services), and health and well-being.

The use of ecosystem services addresses a commonly cited form of market failure, the externalities of the environment, both positive and negative [41]. In a broader sense, it is a way of making explicit the value judgments humans make concerning the state of ecosystems. Valuations of ecosystem services are varied but the most common is the monetary form and, while contentious [41], this allows cost and benefit comparisons, evaluation of trade-offs and consideration of consequences where decision makers propose or undertake ecosystem changes. Ecological economics highlights feedback loops and perverse outcomes particularly in initiatives concerning natural resources, not least due to the imperatives and diversity of different ecological and socio-political contexts (locally through to globally). These perspectives are essential considerations for public health. Without them, dominant market forces can, as Rayner and Lang [42] argue, promulgate a fantasy that human health could somehow be disconnected from ecosystems. “This is both poor science and poor politics and policy. It translates and corrals public health into a fantastic pursuit of private or personalised health.” [42] (p. 618)

The efforts of the Millennium Ecosystem Assessment have been foundational to the array of efforts across disciplines, sectors and policy realms that have arisen in the last several years. The period of 2015–2016 alone is especially noticeable with the release of: the Lancet Commissions on Planetary Health [43] and Climate and Health [44], the 2015 state of knowledge on Biodiversity and Health co-produced by WHO and the UN Convention on Biodiversity [45], the Canadian Public Health Associations Discussion paper on the Ecological Determinants of health [37], a far-reaching text taking stock of the emerging field of One Health [46], a state of the evidence review for Healthy Parks Healthy People [47], the culmination of work on Wetlands and Health associated with the Ramsar Convention [48], a rekindling of attention to Landscape and Health [49], the microbiome revolution for pediatric allergy and immunology [50], and a landmark reorientation for Indigenous Health (‘Beyond

the Social' [3]). Work in the mid-2010s also suggests shifts in how ecology is viewed in relation to 'urban health', including recognition of the health implications of enhancing ecological understanding of cities [51], and that a focus on health in cities demands attention to ecologies from the local to the planetary [52–54].

This range of somewhat complementary efforts can be seen as evidence of a vibrant scholarly dynamic, fuelling a variety of innovative research, policy and education efforts. Yet there is merit—and a responsibility—to step back and look for some of the big pattern dynamics that are emerging from this corpus of work, and to highlight challenges and opportunities associated with bringing ecosystem approaches and ecological perspectives to bear on human health and well-being. This is especially the case when seeking to build a next-generation of integrative research, policy, education and action that is better equipped to respond to the contemporary health and sustainability challenges, such as global environmental change (and climate change), biodiversity loss, emerging and re-emerging infectious diseases, antimicrobial resistance, nutritional deficiencies, dietary shifts and pollution, that each strand of this convergence is seeking to address.

4. Discussion

4.1. Challenges for the Ecology and Health Nexus

An enmeshed and complex, interconnected world, that benefits from units of analysis that are ecologically coherent, provides a counter view to mechanical and reductionistic interpretations of nature's component parts and functions, where a divide exists between nature and culture. The counter view allows recognition of a 'living system' of which humans are a part. As noted, this orientation resonates with Indigenous peoples' knowledge systems [7,55]. An example is the way that spiritual entities create and continue to exist in landforms and lifeforms: where relationships and interdependence are prominent in socio-cultural structures [56], and are equivalent to, and inform, the systems' principles inherent in ecological thought. A first, fundamental challenge for the health community is to genuinely engage with the ecological in this 'living system' sense [16,57].

A living system is more than the literal, mechanistic recognition that ecosystems have living components. For example, soils can be described as 'living' because they have a significant biological assemblage—from a plethora of microbes (bacteria and fungi in particular) to microinvertebrates, to the roots of plants and macroinvertebrates, where complex symbiotic relationships enhance function (e.g., [58]). This recognition is important, but not yet the fullness of the concept. A soil (system) is 'living' where there is no easy distinction between the biological components (including humans) and the mineral, physical and chemical components with which they are constantly interacting. These components all contribute to the processes and functions of what the soil is doing, or capable of doing. Soils respond to, and modify, their surroundings and conditions, in this way they are self-organised, and have emergent properties. Soils grow, they have states—and can be healthy and unhealthy accordingly. The essential properties of soil as a living system are the properties of the whole soil, which none of the component parts have, requiring us to shift our focus from objects to relationships (see [57]).

An engagement in the ecological in a living systems sense means a commitment to boundary-crossing in a number of ways: engaging with flows, processes and dynamics that extend beyond (often equally arbitrary) governance boundaries or the conglomerates of human populations. This demands explicit attention to the way systems are nested. All systems are components of smaller systems and make up larger systems. Therefore, the 'living system' scales up: from local, landscape, regional through to the planetary. A particular challenge for health researchers is the need for attention to the contextual meso-scale of living systems: the landscapes where the benefits from ecosystems manifest, where the ecological footprints of our cities and countries stamp, and where ecosystems do much of their work of creating the foundation for life (and health).

A second, related challenge is a need to move beyond dichotomies that have tended to characterise our health orientations, achieved by a simple but powerful shift from either/or thinking, to both/and thinking [59]. Separating the biotic (living) and abiotic (non-living) in a system, instead of seeing the whole 'living system' as outlined above, is an example of a dichotomy that structures the way we think about our relationships in the world. Another two familiar, but outdated, and false, dichotomies highlighted by the recent convergence of knowledge, are those between urban and non-urban, and between ecological and social determinants of health.

Exclusive attention to urban contexts, and urbanization, without attention to non-urban, will fail to offer an adequate understanding of reciprocal, interrelated upstream determinants of health. The point here is not to dispute the merits of the urban health agenda or its ongoing effort to engage with the ecological context of a growing proportion of humans on the planet [52,53,60]. Rather, a key concern is that a primary emphasis on the urban can have a domineering and 'othering' effect that tends to diminish the meaningful mutual relationships with the non-urban, creating an entrenched and misleading dichotomy that has long-term political, governance, ecological and societal consequences for our shared future [61,62]. In addition, a dichotomizing of the urban and non-urban simply fails to reflect the ecological principles of how living systems interact. For example, the mass production of food and water means that rural systems can be understood in terms of where regional demand arises, and the regional populations receiving these provisioning services must be aware of how that production occurs. While the demand may indeed be understood, the latter is at a critical low point, exacerbated by declining food (ecosocial) literacies. Despite some effort labelling foods, fewer and fewer people know where their food comes from, how it is produced and perhaps more importantly, what the ecosocial consequences are of those means of production and distribution.

Likewise, the time has come to celebrate the benefits of a focus on social determinants of health, while also making a path correction to overcome the exclusion of and blindness to the ecological [1,2,45,53]. Put simply, these dichotomies construct a reality that diminishes the ecological in the living systems sense. Similarly, the benefits of understanding the social determinants of health cannot be divorced from understanding the ecological and vice versa. Both are culturally value-laden and socially constructed. A river contributes differently to public health depending on which of multiple perspectives is considered: a clean or polluted domestic water resource, a recreational asset, an aesthetic landscape feature and a source of awe and wonder, a way of removing wastes or delivering nutrients to the floodplain, a transport route or impediment, or providing real estate. The social and ecological are both mediated and moderated by market forces that enable the trading of these values. Measuring the benefits provided by ecosystems, that underpin, compound, and enable socio-economic factors determining our well-being, is an explicit attempt to intervene in the market's exclusion of the things we value yet take for granted from nature. The next generation of systems-oriented work will enable an increased focus on interdependence and relationships among urban and non-urban, the ecological and social, in our collective future.

A third, obvious, but critical challenge, informed by the convergence described above, is to engage actively in the moving across scales and boundaries to operate in complex and uncertain worlds. For the ecological determinants of health, a sectoral paradox exists. Response and intervention themes are often common across different sectors, yet many of the possible response options for human health and ecosystem change lie outside the direct control of the sectors responsible for each [63–65]. Options exist as embedded attitudes, decisions and activities in areas, such as sanitation and water supply, education, agriculture, energy, trade, tourism, transport, development, employment and housing. Cross-sectoral activity is nothing new to those engaged with systems thinking, but the failure to do so remains a potent blind spot for many contemporary institutions, processes and prioritization, especially in health. This boundary crossing is particularly important when moving between and among scales and levels within global, through regional to local systems [64,66]. The deep governance and policy implications of this add to already recognized challenges of efforts toward Health in All Policies and Intersectoral Action for Health [67–70].

Overlapping sectoral mandates and organizational complexity mean that context-specific ecologically informed solutions are uncertain, a situation best addressed by action followed by reflection, in the adaptive management [71] of cyclical learning and policy adjustment and implementation. When we overcome the boundaries created by dichotomous thinking, it allows us to pursue a focus on relationships, reciprocity, and interdependence [72].

4.2. The Demand for a Critical Re-Interpretation

Discernible in this commentary and related challenges is a critical interpretation by those involved in these intertwined strands, whether they be poet, painter, ecologist or planetary health practitioner. First, we are dealing with living systems, the mesh continually and perpetually reweaving itself, the mesh of which we are a part. Second, the environmental crisis is caused by a cultural tradition that rationalizes the separation of culture from nature, including an elevation of the former to moral predominance, and a failure to recognise or benefit from longer standing traditions that have held, fostered and honoured human capacity that emphasise reciprocity and interrelatedness. Third, the reflexive features (poisoning our home) demand application of, and to, concepts of health, directly, indirectly and metaphorically. Fourth, there is a commitment to effecting change. By its very character, this is a political enterprise.

Accordingly, elements of the romantic period, remain: an emotional wonderment of nature, the aesthetic of the beauty of nature, and a subversion of the mechanistic and even the rational. In their article on the human dimensions of the environmental crisis, Bergthaller et al. [73] point to the need for a slow methodology that involves “shuttling back and forth between the whole and its parts, between the past, the present, and the future, and . . . between the environment and culture”. As we continue to relearn the relationships between ecology and health, Bergthaller et al. challenge that “The skills of narration and of careful reading demand that we pay attention to texts and contexts until we can reveal their deeper implications, ambiguities, and blind spots”.

These challenges and the (re)learning and convergences involved represent a fascinating juncture in our understanding of expanding health imperatives. This presents the additional challenge (not always the strong suit of emergent fields) of being engaged, reflective, inclusive and respectful of history, precedents and near-neighbours. Indigenous knowledges and perspectives serve as a particular, and often overlooked, exemplar. Moving beyond pervasive and erosive deficit-oriented approaches to Indigenous health, are rapid and ongoing developments in Indigenous leadership and governance around the ecological in relation to the cultural, social, historical and political [3], which carry notable imperatives and provide potential fuel for the efforts to re-couple the ecological with social dynamics that serve as the context for health.

The challenges noted here emerge as relatively consistent themes across the diverse, and somewhat ‘crowded’ understanding of the ecosocial and health dynamics of our planet and regions. We are challenged to harness this range of overlapping knowledge in constructive ways. As we do so, we should also anticipate the fertile tensions of living systems—continuing to learn about convergences, overlaps, cycles, redundancies and resilience across our understanding and our responses to expanding health imperatives.

5. Conclusions

We have presented strands of ecological thought that have influenced public health, picking out influences, such as romanticism (as a response to the Enlightenment), ecosystem principles, ecotoxicology, environmental philosophy, and perceptions of healthy ecosystems, to emphasize ecosystem approaches to human health. We acknowledge that these lineages are neither direct nor complete. They are influenced by other strands, reflecting history as an intertwined web of strands. We could, for instance, have adopted the historical trajectory used by Rayner and Lang [42] that led to their heuristic for ecological public health (which integrates the material, biological, social, and cultural aspects of public health): they recognize *inter alia* the influence of Darwinian evolution, complexity

science and system dynamics. We have also steered clear of some strands, like those that have led to problematic or dangerous endpoints, such as the naturalistic fallacy of social Darwinism, or the beliefs and practices of eugenics, because neither could be called an ecosystem approach.

Our focus has been to highlight two leanings of ecology in our discussions, noting that ecology is both blessed and burdened by these complementary ontologies. We have argued that ecology is laced with the arts and aesthetics of romanticism, wonderment and beauty, engendering passion, being holistic in its intent, and radical at its core. Even practicing ecologists might be oblivious to these historical threads. Ecological thought offers emotional preparedness to motivate and provides an instrument for, a change agenda that is set against the rationalities and social and environmental impacts of resource exploitation. The legacy of romanticism and later developments is a multi-edged sword for health and other representative facets of the legal administrative system, where the prefix 'eco-' carries this cultural and political (subversive) baggage. These aspects of ecology are too easily dismissed due to its invoking of the emergent, the 'intangible' (even the magical), the non-rational and the emotive.

Ecology is also adopted as a technical 'science', practiced with a biophysical emphasis, with increasingly quantitative, deterministic leanings, where evidence for the behaviour of the non-human environment is gathered. This approach tends towards an experimental science that is clinical and where variability is controlled, and focuses on a (reduced) component of a system, an important part of evidenced-based medicine. The effects of environmental exposures in urban settings are examined using this approach. These applications can also (ironically) disconnect us from the observing, and learning available in relation to nestedness and interconnections, that are core strengths of ecological thought.

A challenge for planetary health is to avoid lapsing into, or rejecting, either leaning. Ecological thought offers much more: a rich entrance to understanding living systems, a relationality of connectedness and interdependence, consistent with other multiple lines of thought, principal among them being those of Indigenous peoples. It is consistent with system approaches that seek to reconnect the environmental with, and in fact see ecosystems as, foundational to the cultural, social, economic, political and philosophical directions of societies. It also celebrates the learnings available to us from reciprocity, the giving and taking in our ecological relationships. Ecology also offers a theoretical basis for adaptive management and cycles of learning, as iterative practical, humble pathways to health in a complex and uncertain world. In this way, connecting ecology and health provides frameworks for us to learn from and understand the nuances of context-specific ecologies, that will also yield context-specific solutions.

Planetary health has offered us a global scale framing. We regard its potential as equivalent to the degree to which it can embrace, at its core, the strengths of ecological thought and develop its own political narrative. Similarly, planetary health must also transcend a dominant worldview that separates and dichotomizes (mind and body, culture and nature, subject and object, etc.), and a worldview of living systems of interdependence of everything that exists. In the words of Escobar [74] (p. 3), "Moving in the direction of ontological equity between these worldviews requires nothing less than a civilizational transition. Herein lies the greatest challenge . . .".

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