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Sustainable systems promote wholeness-extending transformations: The contributions of systems thinking

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ABSTRACT

This paper reviews and compares systems thinking ideas originating from three individuals in diverse disciplines: American ecologist Bernard Patten, German sociologist Niklas Luhmann, and Austrian-born architect Christopher Alexander. From all three, stem ideas promoting the importance of differentiation (boundaries), connectedness, relations, and feedback. The congruence of these ideas formed independently, in different disciplines, on different continents, at roughly the same time speaks to the deep resonance systems concepts have on understanding our world. Consistent as well, is the insight that individual objects emerge from the structural couplings of their physical and social environmental context. These systems concepts are applied here to classify diversity in a holistic and integrated fashion and then extended to inform the question of sustainability. Sustainable systems are ones that are able to maintain coherent self-organization and simultaneously, recursively extend interactions to neighboring coherent wholes.

"Systems theory is, strictly speaking, not a theory of systems, but of system–environment distinctions" Moeller (2006), p. 40.

1. Introduction: a systems perspective

The first step in a systems analysis is establishing a boundary (Parsons and Shils, 1951; Patten, 1978). Creating a system-level boundary demarcates both the system and the environment. The most basic representation of the distinction between an object and its environment has the object separate from an environment (Fig. 1). This reveals the standard object–environment dichotomy of Aristotelian Philosophy which permeates all areas of Western (Cartesian) thought. In this view, environment is that which is outside and other than the object, thus forming a disconnection between the object and its surroundings. Consider now, replacing the word 'object' in Fig. 1 with 'system' such that instead of an object separated from its environment that the distinction is made for a whole system. In this way, the focal scale of interest is the system (which in turn is comprised of multiple interacting objects). The boundary separation is still present but at a higher level of organization.

As Gallopin (1981) has stated, the idea of environment is a paradox because one can always increase the system's boundary thereby eliminating environment. Therefore, this expansion from object to system appears to not be very fruitful in terms of understanding and analyzing the order and continuity of nature. However, the object to system scale was key in the system-oriented development by Patten (1978) because by focusing on a system rather than an object, he was able to enlarge the scale of study and create two environmental levels. The peripheral environment, exterior to the system boundary, is the conventional one with which we are familiar in which resides unknowable and undeterminable objects, systems, and interactions. The environment interior to the system boundary is the inner-world of the system, embedding objects and separated from the environment. This new space within the system boundary yet outside a focal object's boundary was termed 'environ' to distinguish it from environment (Patten, 1981, 1982). From this systems-oriented beginning, bolstered by the mathematical formalisms of networks and graph theory, emerged the field of Network Environ Analysis (see e.g., Higashi and Burns, 1991; Fath and Patten, 1999).

Within network environ analysis, the presence of the boundary is the first postulate of Patten's Systems Theory of the Environment (1978). Patten (1978) claimed, "The prerogative of realization of internal system structure is that of environment" (p. 211). This demarcation is not unique to ecological systems, but to all systems and mirrors Niklas Luhmann's observation when working within the social sciences that, "[b]y constructing itself as a system, a system also constructs its understanding of the environment" (Moeller, 2006, p. 16). The boundary gives meaning to both the system and its environment, but it is the permeability of the boundary

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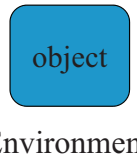

Fig. 1. Traditional object–environment dichotomy. Environment is that which is other than the object.

to exchange energy, matter, and information that keeps the system sustained and ultimately alive. The boundary flows provide the system with the needed fluxes that are further used internally to create and maintain order and organization.

The objects within the system interact and exchange energy, matter, and information. They are linked both physically and conceptually by these interactions such that each object both receives input and generates output. Building on this principle of differentiation, one recalls that these input–output exchanges are both receptive and effective. "The difference system/environment occurs twice: as the difference produced by the system, and as the difference observed within the system" (Moeller, 2006, p. 68). Or, similarly, in Patten's words "Every object defines two environments: an input environment and on output environment" (Patten, 1978). Each object has a pair of environs, the detecting input-environ and the effecting output-environ. A system is composed of a set of partitions of each object's input and output environs (Patten, 1978; Bata et al., 2007). Recognition, and the logical extension of this, flips the whole dichotomy away from object–environment into input-environment–output-environment (Fig. 2). The object is now not separate from its 'environ'ment, but rather a nexus straddling two halves of two separate environs (see Patten's Janus Hypothesis, this volume).

This gives a new, non-objectified (non-Cartesian), perspective of nature that puts the emphasis on the interactions, transactions (i.e., flows of energy, matter, or information), and relations rather than the objects themselves. In this perspective, a network is one formal way to represent a system, which identifies the parts and the connections, can occur at multiple scales, and represents categories generically from various disciplines. Furthermore, using network analysis, one is able to quantify precisely the direct and indirect environs as the exchange between objects in the system (see e.g., Fath and Patten, 1999; Gattie et al., 2006; Whipple et al., 2007). The relevance of indirectness is core to systems and systems thinking (Jørgensen et al., 2007), which provides holistic context for the potential unanticipated and unintended consequences of local, bi-lateral interactions. Of course, as open systems, all ecological and environmental systems rely on the ability to receive and discard energy and matter across this system–environment boundary,

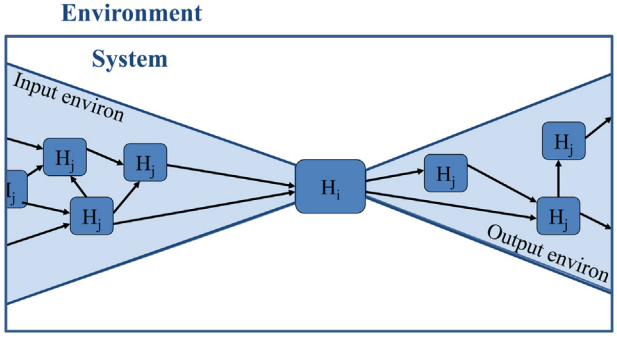

Fig. 2. Interaction-oriented perspective shows an object as the nexus of two interconnected environs, a definable input environ of object impinging on object H_i's receptors and the other a definable output environ of generated by object, H_i.

and therefore, connect to the outside environment through these boundary flows.

There are many extensions and applications of this systems-oriented, network-based flow model that have relevance, but in this paper the focus is on the new perspective it gives to classifying biological diversity and on the question of system sustainability. This is done by exploring and comparing the contributions of three seminal systems thinkers of the 20th century: ecologist Bernard Patten, sociologist Niklas Luhmann, and architect Christopher Alexander. Before getting to that, let us further set the stage.

Pirsig (1974) is best known for his 1974 classic book *Zen and the Art of Motorcycle: An inquiry in values*. However, his 1991 sequel, *Lila: an inquiry in morals*, touches upon issues relevant to our discussion about systems theory and object–system distinctions. *Lila* is largely an exploration for the origins of this object–environment dichotomy and the implications it has had on philosophy, individual and group behavior, and eventually on human–environment interactions. The main character searches for cultures that do not carry this worldview, and concludes that a holistic, system-oriented view does exist within certain cultures such as Native American and Eastern philosophies. A passage at the end of *Lila*, takes place on a Montana Indian reservation, summarizes this nicely:

> [The main character] was with Dusenberry and John Wooden Leg, the tribe's chief, and a woman named LaVerne Madigan from the Association of American Indians . . . They were all walking down the road, four abreast, when one of those raggedy non-descript dogs that call Indian reservations home came onto the road and walked pleasantly in front of them.
> They followed the dog silently for a while. Then LaVerne asked John, "What kind of dog is that?" John Wooden Leg thought about it and said, "That's a good dog." LaVerne had been asking the question within an Aristotelian framework. She wanted to know what genetic, substantive pigeonhole of canine classification this object walking before them could be placed in. But John Wooden Leg never understood the question. The whole idea of a dog as a member of a hierarchical structure of intellectual categories known generically as 'objects' was outside his traditional cultural viewpoint. What was significant, he realized, was that John had distinguished the dog according to its Quality, rather than according to its substance (Pirsig, 1991, pp. 408–409).

The profound nature of the question of "what kind of dog is this" – an object or part of a system defined by others in the system – was broached by ecologist Tim Allen when he introduced the concept of 'dogginess' (Allen and Wuennenberg, 2003). By this, he means that the feature which defines a dog is how others interact with it: some animals run from it, some animals look tasty to it, some animals associate or mate with it, etc. In other words, the dog-object is defined by its interactions (or its quality in Pirsig's perspective) within the environmental network and how well it expresses its dogginess. The idea of an object independent and divorced from its environment has no meaning. The same could be said for any species. We may desire to look strictly inward at the genetic code of the organism to classify it as a particular kind of object, but that coding is a response to the environmental conditions in which it evolved.

Luhmann, systems sociologist, went further and he applied such a systems definition of object on humans. For example, statements such as: "While the individual is supposed to constitute him- or herself 'uniquely', the criteria for his or her uniqueness are still supplied by society" (Moeller, 2006, p. 88). And, "The characteristics that distinguish me from others always have to be socially available" (Moeller, 2006, p. 89). From this, we see that the definition of the object is given by the interactions that make up the characteristic qualities. From our Western individualistic and reductionistic perspective, this sounds almost demeaning and Luhmann was accused