

A holon approach to agroecology[1]

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Systems thinking contributes to envisioning agricultural sustainability. However, it faces two dilemmas, recently highlighted by complexity theory: the problems of boundary and change. We propose that interpreting Koestler's *holon* as an *intentional* entity embedded in an *ecology of contexts* provides an ontological construct which addresses both of these issues. The holon is in some ways a whole and in other ways a part, and to see it simultaneously as both we suggest an epistemological tool that we term *flickering*. In our interpretation a holon is bounded by its intentionality to persist, and the imperative to do so in multiple, incommensurable, and ever-evolving contexts motivates – indeed, makes both possible and inevitable – change. Farms are compelling examples of holons, as their humans plan and act to maintain them as a source of livelihood, necessarily in contexts as diverse and shifting as climate, life histories, trade rules, subsidies, personal spirituality and public perceptions of agricultural practices.

Keywords: systems, complexity, theory, agriculture, sociology, human-environment systems, agroecology, holon

Like all major human endeavours (our lists would surely overlap), agriculture has pervasive and deep connections with diverse issues. In the case of agriculture, the prosperity of the vast majority of species, myriad human cultures and our own spiritual sensitivities are all shaped by, and in turn shape, these connections, these *involvements*. Agriculture is a huge, and hugely important, undertaking, and its students are at long last finally coming to appreciate this involved hugeness. This is a great step forward from the many decades of understanding it more as an ensemble of discrete bits – a large ensemble of bits, to be sure, and one that is articulated here and there, but still as a kind of machine, fundamentally separable part from part, and as well from the world at large: rigid, linear, detachable and controllable. We are, along the way, learning to welcome the perspectives and contributions of a great many entry points for the study of agriculture, from soil science to social science, from agronomy to zoology.

The turn to systems thinking has been decisive. Agricultural theorists embraced systems thinking as a powerful and essential epistemological tool. Early articulations of the interconnectedness of the biophysical and social, for example Bawden and Ison (1992), Conway (1987), Pearson and Ison (1987), looked to systems thinking to structure further research on farming systems in developed settings toward efficiency, and in more resource-poor settings to make more effective interventions leading to greater productivity for vulnerable farmers and populations. Thirty years later, systems thinking serves as a fundamental tool in the task of transforming agriculture towards a 'sustainable' future

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(e.g. Gliessman, 2004). It has now become a matter of our intellectual reflexes to speak of agricultural systems, to consider the ecological context of agriculture, to invite participation from stakeholders into agricultural decision-making, and to embrace the complexity of doing all of these. We are seeking interconnections, we are finding them, and we are doing better at acting on them.

All this is good news, but there remain a number of places for intellectual growth in this more involved understanding of agriculture, particularly with regard to systems thinking. As valuable as it has been for conceptualizing agriculture's complex involvements, there are limitations in what systems thinking allows us to describe and discuss. Our principal concern is that the language of systems encourages an *over-connected understanding* of the world – an understanding that leads to two dilemmas currently besetting systems thinking: the problems of *boundary* and of *change*.

In the under-connected view of agriculture – as a collection of tools and techniques to be steadily improved – that formerly held the intellectual field, boundaries were precise and secure, if unrealistic. But if as the systems view would have us see it – that all is connected – how do we draw boundaries by which we might understand the world, as William James phrased it, as anything other than a blooming, buzzing confusion? Where are the surfaces and breakpoints of significance? Where does, for example, a farm begin and end? At the property boundary? At the edge of the watershed and the wildlife migration corridor? At the consumer's dinner plate? Indeed, if everything is connected, can there be a surface or breakpoint that bounds any thing? All is one, and the analyst is immobilized in finding an intelligent way to describe, research, and account for particular portions of the system. Yet in order to proceed the domain of the analysis must somehow be limited or bounded, explicitly or otherwise. This is an epistemological challenge that we term the *subjectivity* problem of system boundary. There is an inevitable subjectivity in defining the system to be studied, that is, another analyst might well draw the boundaries demarcating the system of interest differently.

An equally vexing challenge is deciding on which of the many stories that might be told about the system are we trying to tell – what we term the *narrative* problem. This arises because the same set of observations are part of very different stories, for example Bill Cronon's (1992) comparison of alternative tellings of the meaning of white migration into the US Great Plains reveals it to be interpretable as destruction of peoples and nature, or the triumph of a people over nature. The 'soft-systems' methodology of Checkland (e.g. Checkland & Scholes, 1999) confronts directly the narrative challenge in the boundary problem. They argued that systems thinking always in part reflects the priorities of the systems thinker, and has to be understood as caught up in human institutions and politics, with all their implications for ideology and social power. Checkland (Checkland & Scholes, 1999; 7) identified diverse narratives connected to the program to build the Concorde supersonic airliner beyond fabricating a machine: an important collaboration between the British government and the country's leading aircraft manufacturer, a project to stimulate European engineering, and an exercise in British collaboration with European partners.

Thus the narrative problem is about choosing which story is being told about a set of events, because there are always multiple possible meanings to any situation. Selecting a story forces the analyst to seek an ontology, that is, to make decisions about what entities and relationships are important and must be emphasized, in order to tell this story. While the subjectivity issue is an epistemological question, the narrative issue is ontological. Unfortunately, this means that systems thinking must represent only a partial view, in two senses of the word: limited and, in the end, political. The question at hand is limited by the (epistemologically essential) boundaries that, alas, allow us to address only part of the larger web of connections, and it is made political, that is, a matter for contention, by the ontological choice of which questions to ask and which to not ask.

An early exposition of systems thinking in agriculture provides an opportunity to reiterate the subjective and narrative boundary problems. In Spedding's (1988) *An Introduction to Agricultural Systems*, he illustrates the subjective boundary problem by considering the mass and energy exchanges of a chicken, and specifically the implications of confining said chicken in a box. Once so confined, the boundary of any systems analysis about the chicken's physiology probably must expand to include the box and perhaps the box's environment. But maybe not, depending on the particular question and assumptions about what aspects of the chicken will change as a result of being in the box. This is the subjective boundary problem: where can we validly draw the outer boundary of our system? Few situations are anywhere near as simple as this example. Spedding did not address the narrative boundary problem, however. Here we imagine the other stories in which the chicken plays a role. Does placing it in a box raise ethical issues about using animals in research? Was the farmer who raised the chicken rewarded appropriately? Did related farming activities degrade soil and water resources? Will the chicken become part of a nutritious meal, or actually harm the health of the eater?

The boundary problems of systems thinking have long been recognized (e.g. Churchman, 1979). Theorists continue to the present to advance procedures for addressing the problems in an orderly and transparent way. Midgly (2000), for example, cites four earlier examples of efforts to overcome inevitable and confounding boundaries in systems analysis, and proposes yet another. There is likely no escaping the dangers of the inevitable boundaries in systems thinking, only ways of being aware of their possible implications in applications of this epistemology – as Ulrich (1993) points out, 'The "right" boundary judgments depend on the subjective interests, values, and knowledge of those who judge... [and] will tend to be disputed.'

Change is also difficult to discuss within systems thinking and its view of a connected-up world. Indeed, most systems accounts do not discuss change, but rather present a boxes-and-arrows snapshot, with perhaps a tip of the hat to 'dynamic equilibrium'. But even dynamic equilibrium is a kind of change without change in that, under the presumption of connectedness, everything is accounted for and understood. It is predicted change, and thus in a deeper sense is not change at all. As well, there is a presumption that the connectedness of things puts them at 'equilibrium', a kind of constantly readjusting balancing act in the involved hugeness of it all. But is the world everywhere balanced out, or even seeking balance? Are there no disjunctures, conflicts and contradictions? Does it really function as some great whole? Systems thinking gives us little means of conceiving any incompleteness of involvement, any options for the emergence of new entities and connections. Yet that we should be prepared for infinite, unimaginable possibilities is surely a fundamental lesson of Darwinian evolution. Ways to talk about these infinite possibilities are essential to the possibilism and unpredictability of a deeper sense of the meaning of change.

Further a system model is inevitably obsolete. This out-of-dateness arises because it can only be constructed from observations made over some span of time. Our presumption of change means that at least theoretically the relevant entities are in flux – new types appearing, new relationships replacing obsolete ones, all the while as the observer gains and loses sensitivities. In the snapshot portrayal there is an inescapable assumption of a 'system' that it is just that: an identifiable thing, and not some other identifiable thing, static and worked out, staying in equilibrium, despite dynamism.

The under-connected view of agriculture had a comfortable theory of levers-and-knobs change that gave us a pleasant feeling of control over a simplified world. We rightly reject that linear and mechanical view today, but systems thinking does not reject the pleasant feeling of control over change. On the contrary, systems thinking typically presents itself as a better source of control, one that takes into account the real connectedness of life. But in continuing this mode of control, it has still found little desire for accommodating the plain reality of unpredictability (Bell, forthcoming). In this way, the problem of narrative also extends to the problem of change. In order to tell a story of control, systems thinking has distanced itself from highlighting the incompleteness, disjunctures and possibilism that undermine such a story.

A sense of control is supported by a feeling of stability in the boundaries we draw. A rich sense of change brings us back to the narrative challenge of boundary. The most powerful and least unpredictable changes are ontological: when the important entities and their connections seem to have somehow shifted. The result, as we will describe, is a tendency of systems thinking to present an overly tidy view of agriculture, in which the very collection of parts that are relevant, and the boundaries we draw through them, are too precise, too stable, and too worked out. Further, we may see the connections within as stronger and more rigid than they really are, causing us to fail to imagine myriad alternative behaviors. Doubts have been growing about the advisability and feasibility of system theory's pleasantness (e.g. Allen *et al.*, 2001; Checkland & Scholes, 1999; Rosen, 1991, 2000; Vayda, 1986). The term 'complexity theory' is perhaps the best overall summary of what these authors have tried to highlight for us, in their various ways.

We describe here a path that leads on and out from the insights of complexity, and especially from a reframing of Koestler's (1967) idea of the *holon*. We adopt the holon as a key ontological type, and an analytic method that we term *flickering* as an essential epistemological tool. We will describe how the holon enables discussion of boundary and change within a world of involvement *à la* systems, while flickering gives us a flexible vision of boundaries that remain open to evolution and unconnectedness.

We apply the notions of holon and flickering to *agroecology*, a word we greatly admire because its etymology asks us to consider the issues of agriculture's connections. A scholar-student may approach agriculture with little more than a sense that it is a rich and fundamentally important complex of activity, worthy of study, or with a particular problem in mind, say, protein malnutrition in Sub-Saharan Africa, or the relatively high cost of growing apples in Wisconsin. With either such a general or specific concern in mind, the agroecological commitment, in our understanding of it, is to seek to transcend any one particular entry point into the agricultural debate. But to seek such a transcendence should not be to presume entry points do not or should not exist. If all the world is connected, then there are no connections to make, nothing to transcend, nothing to learn. Thus, we offer the holon approach not as a final answer, but as a way for the agroecologically concerned to at least agree on a radio frequency on which they might communicate with one another as they pursue their journeys through complex agricultural questions.

The holon approach, as will become clear, takes as one of its points of departure that agriculture is, most fundamentally, *humans planning and acting to cultivate a livelihood through the phenomena of plant and animal increase*. Further, these planning humans seek configurations of their endeavours that will allow them to sustain their agricultural ambitions. It is, we believe, important to start out with a reverence for this planning.

Systems thinking and the problem of over-connectedness

'When we try to pick out anything by itself, we find it hitched to everything else in the Universe', wrote John Muir (1911), a much-cited line, and justly so. Its imagery aptly captures the anti-reductionist stance that has long been a part of the ecological mind, and that has always characterized systems thinking. This is often a good emphasis to have. Systems thinking provides a language and habits of the mind that repeatedly alert us to the idea that 'you can't do just one thing' (variously ascribed to Leopold, Bateson, Ehrlich, Campbell and no doubt others). There are typically numerous implications of an action, some of them distant in time and space, and the under-connected vision of reductionism encouraged us to overlook these, at least at first, often to our eventual dismay. As we have come to rue the stubbing of our toes, we have come to embrace the word *system*.

These are old intellectual troubles, however. Although it has come to seem a relatively new concept, with the continuing flurry of academic writing on it since the 1950s, the word system actually dates back to the ancient Greeks. It was they who combined the root *syn*, meaning 'connect' or 'combine', with *histanai*, meaning to 'set up' or 'establish', into *sustema*, in order to describe an 'organized whole' (Onions, 1955 (1933)). The Romans felt they needed to be reminded of these insights too and they took *sustema* almost directly into Latin, calling it *systema*.

But there are perils as well in carrying this sense of an organized whole too far. These too are perils that have long troubled us. Aristotle, for example, railed at the 'monism' he found in the thought of his teacher, Plato, who offered a united view of the world in which 'the Good' created all things and all things were a manifestation of 'the Good'. With such a perspective, Aristotle (1987) retorted in the *Physics* (185b: 15–25), all things 'will be the same, and the thesis under discussion will no longer be that all things are one, but that they are nothing at all'.

Systems thinking, in its currently common modes, courts these Platonic troubles. Let us take, for example, a recent effort to present an overview of the agricultural endeavour from a systems point of view, by the noted agroecologist, Steven Gliessman. We reproduce in Figure 1 the visual representation that Gliessman gives of his systems analysis, what he terms the 'functional and structural components of an ecosystem converted to a sustainable agroecosystem' (Gliessman, 2004: 21). Let us immediately emphasize some of the helpful features of Gliessman's figure, most notably its emphasis on agriculture as having a broad array of connections with human endeavour, including aspects generally not thought of immediately as having agricultural consequence, such as recycling. To do agriculture is to do many things, not one alone, the figure rightly tells us, as it is indeed hitched to much else. Moreover, the figure plainly speaks to the need for more than one disciplinary voice to handle this involved hugeness. This is all to the good.

But let us next note some matters that this figure, and approach, does not easily alert us to. First, there is its neat and tidy appearance, with precise lines and boxes and arrows and feedbacks, drawn with computerized exactness. Second, there is the language Gleissman's article uses to describe this view of agroecology – that it is based on 'the balance needed for long-term sustainability', that it is 'a functional system of complementary relations', that it strives for 'equilibrium', albeit a

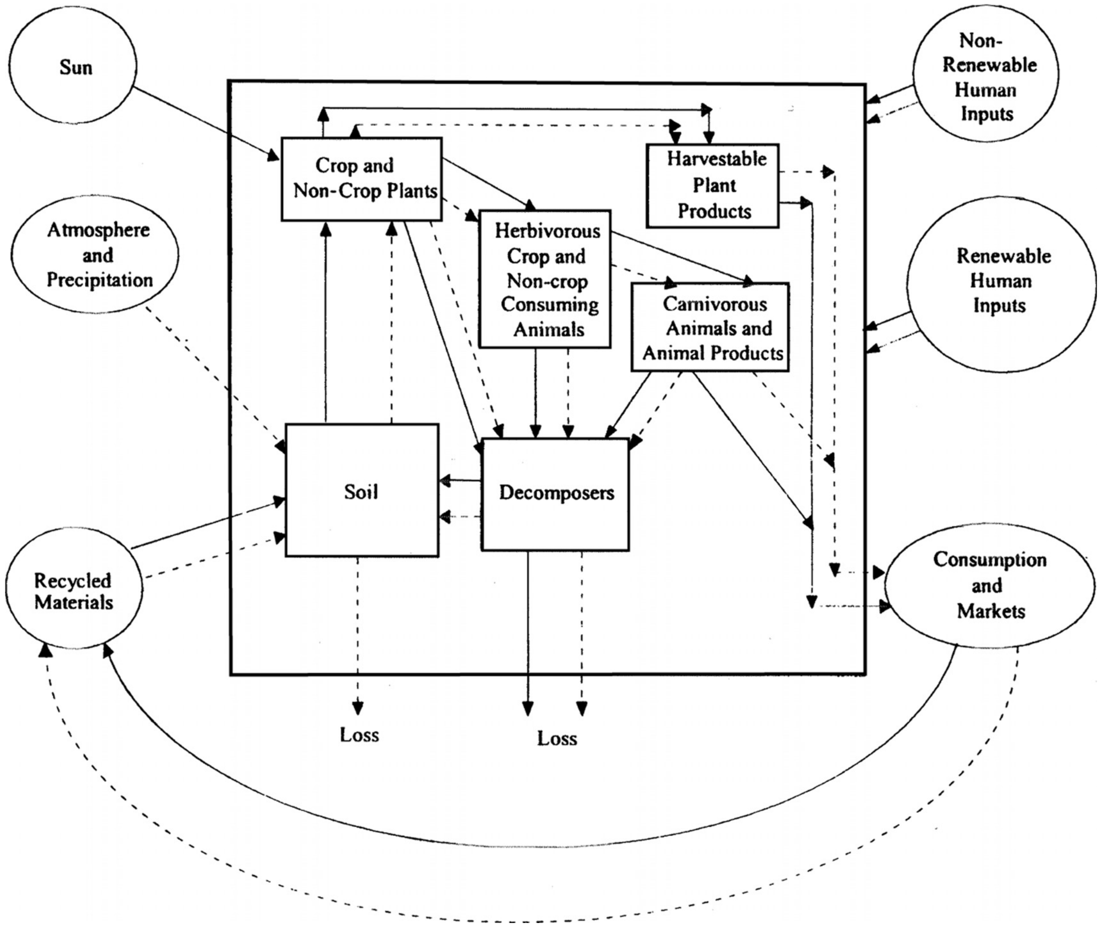

Figure 1 From Gliessman (2004): the 'functional and structural components of an ecosystem converted to a sustainable agroecosystem'

'dynamic' one (Gliessman, 2004: 19–21). Similar language shapes the depiction of an agricultural system in Spedding (1988) as 'operating together for a common purpose', or as 'integrated to accomplish a well-defined purpose' (Peart & Shoup, 2004: 2). Like Gleissman's diagram, words and phrases like complementarity, equilibrium, balance, common purpose and integration portray agroecology as orderly, articulated and unified: as clean. But is the world a neat and tidy place, at least always and everywhere? In a connected world, how can we draw such precise boundaries through reality? And where is there scope for change, beyond a dynamic return to equilibrium? Is agriculture so finished, complete, and balanced out?

Complexity theory would argue that it is not, and that systems thinking is as much an effort to create a sense of order as it is to find it. The term 'complexity' is used both colloquially and formally in several ways. As well, some theorists have made broadly equivalent arguments without invoking the word 'complexity' as their central term, such as Checkland and Scholes's 'soft systems methodology'. We use 'complexity' in part as a shorthand to differentiate this broad body of work from the tidy view of systems, in much the way that Rosen (2000) does. Rosen begins with the view that all reality is complex, in the sense that any given action has the potential to cause unexpected results in unexpected places. For Rosen (2000: 306), 'a system is called *complex* if it has a nonsimulable model'. In other words, a complex model expects *unpredictability*. In this sense, the more accurate model is a less accurate model.

One could, of course, deliberately choose to study a portion of reality by imagining it as what Rosen (2000) has suggested terming a 'simple system' – that is, as a collection of entities and interactions whose behaviors we can 'model' through equations and algorithms and thus predict with some acceptable amount of error. Such simple system models may be highly detailed, for example those used in weather forecasting – numerical models of the atmosphere are among the most sophisticated and computationally intensive simulations that exist of any physical domain. They are nonetheless simple in the sense that they presume an ordered predictability. There may be considerable utility in having such a model, for the result is more easily comprehensible and programmable, and easier to act on. Weather forecasts, for all their known and likely irresolvable inaccuracies, help billions through their day. But the tidiness of a simple systems model will in most circumstances involve a fair bit of sweeping under the rug.

In simple systems, then, we assume we have knowledge of all of the relevant parts and their interconnections and interactions, while in complexity we take it as a starting point that this is not possible. In philosophical terms, then, epistemology and ontology are equal in simple systems, that is, we know about the system (epistemology) as a result of the fact that we chose what entities and relationships to include (ontology) in our simple representation (Rosen, 2000: 281). The numerical simulation models widely used in agronomy are simple in this sense. They are viewed by their creators and users as generic descriptions of phenomena of interest, for example, how seeds, soil, water and sunlight interact to bring forth a crop. Comparisons to actual observations are imperfect presumably because of some special characteristic of the harvested test plot. This is exactly the opposite of Rosen's perspective, that is, that reality is complex and the generic situation; for Rosen, the simple model, because we have made choices about what to exclude, is special and therefore of limited applicability (Rosen, 2000: 304).

Allen *et al.* (2001) have proposed a more fully postmodern approach to the selectivity of system thinking, arguing that systems are always stories inevitably told from the perspective of a storyteller, and that, properly understood, this is not necessarily cause for intellectual alarm. They point out that narrative allows the storyteller to adroitly leap over manifold scales of space and time when describing the web of involvements an action might entail. This expansion/compression of time and space greatly reduces the care required in defining system boundaries, if not negating it altogether. Here the analyst need no longer support a conjecture with, for example, output of a meter-scale hourly timestep model purportedly simulating continents over centuries. This narrative approach (correctly) understands that this is not likely valid anyway, and rather draws on whatever arguments are at hand for looking ahead. But as we look through the recent pages of our agroecological journals, we see little explicit use of such a postmodern take on complexity and narrative. Most authors continue to use a simple systems ontology and epistemology. For them perhaps the postmodern view is intellectually alarming, or maybe it seems more a matter of philosophical truth than the practical truth they seek.

We thus detect a nervousness in the current moment: while it seems plain now that the confidences of reductionism were misplaced, and that a more connected view is necessary, a deep dilemma has opened up in agroecological thinking. Simple systems are solvable but wrong, while complexity theory is unsolvable but right. Neither seems a comfortable position to maintain, but perhaps through appeal to both schools of thought we can develop new conceptual tools to help us think about and act creatively within human-environmental relationships like agriculture.

From systems thinking to holonic thinking

We would like to suggest a theoretical framework by which agroecologists might better accommodate the subjectivity and narrative boundary problems, as well as the crucial issues of innovation and change. We propose drawing into agroecology a number of ideas from complex system thinking, specifically a reconceptualization of *holonic thinking*. We first introduce the holon and the conceptual aid of flickering.

Seeing holons requires flickering

The term *holon* was proposed by Arthur Koestler (1967) to address the problem that interesting entities in biology and society are in many senses wholes, but, on the other hand, can not be understood without recognition of contexts in which they survive. For Koestler holons are entities that have autonomy in some senses, yet are clearly a part of something larger in other senses. As Koestler (1967: 210) put it, 'Parts and wholes in an absolute sense do not exist in the domain of life. The concept of the holon is intended to reconcile atomistic and holistic approaches.' Clear candidates for the holon label include individual humans and university departments: to answer many questions that one might raise about them it is essential to envision each simultaneously as a whole and as a part of other entities. An individual carries on physiological functions as a whole, yet exchanges food and waste as part of an ecology. The academic department carries out many functions autonomously from the university in which it is embedded, often to its regret and frustration, yet has little meaning outside the context of the larger institution, which has its own autonomous movements. Switching to an agricultural frame, certainly an individual animal reared as part of an agricultural endeavour may at times be usefully thought of as a whole, that is, it most probably has intent and capability (about which we will have more to say later), and perhaps moral standing in its own right, but is also part of a farm. We may say as much (if not more) of the farmer himself or herself. Both animal and farmer are part of the farm holon, while themselves being wholes comprised of parts, just as the farm is part of larger holons, such as the agricultural economy.

A holon exists within an *ecology of contexts*. These contexts collectively form the situation in which the holon functions. Contexts important to the farmer might include, for example, family, farm business, genetic heart disease, and spiritual beliefs (see Bawden & Ison, 1992 for a rich compilation of the breadth of the issues that imaginably enter here). The holon is a nexus of many contexts, involved in infinite ways with them, yet still an identifiable entity. Indeed we only recognize anything as a separate entity if it is somehow visible against the background of its contexts – it is the contrast with these contexts that give the object of our attention any identity at all. A particular context of a holon *may* itself be a holon, but not necessarily (a point we will return to).

These contexts are incommensurable, that is, they cannot be compared directly to one another, or converted to a common unit of measurement, despite the best efforts of economists. They are as diverse as the farmer's beliefs about the sentience of livestock and the cost of corn. An important implication of incommensurability is the impossibility of calculating optimal configurations of the holon. Determining such optimal arrangements requires the ability to mathematically trade a bit more of this for a bit less of that, but incommensurability makes this impossible. At the scale of the individual farm it may be a choice between growing more corn or creating habitat attractive to grassland birds, while at the international scale it may be low-cost shrimp at the cost of mangroves.

A holon thus bounds a collection of entities that are involved with one another relatively intimately. This close involvement within a holon suggests that a change, movement, or action somewhere within the holon does not happen in isolation of the rest of the holon, for example, a major loss of health by one member of a farm family likely has fairly immediate repercussions throughout the enterprise. In contrast the holon is less intimately involved with the broader ecosystem of contexts in which it exists, and not all changes in a context will necessarily impact the holon appreciably. While the farm holon is likely impacted by the health of each member of the household, it is far less clear that the health of the top government official in a country's department of agriculture would have significant implications. But it might – any involvement leaves open the possibility that the effectiveness of this distant official might be significant to the farm, if government policies changed as a result of his or her illness.

Allen and colleagues (Ahl & Allen, 1996; Allen & Starr, 1982) further elaborated the holon concept, emphasizing, as did Koestler, a presumed hierarchical organization of living and social systems. For us hierarchical organization is helpful for building the notion of holons (as evidenced by our earlier examples), but the holon and its ecology of contexts is much too messy to be usefully envisioned solely in hierarchical terms. Rather, our development of the concept of holon takes seriously Koestler's suggestion that both parts *and wholes* do not exist in an absolute sense. Systems thinking, even when embracing complexity, has continually placed its emphasis on the notion that parts do not absolutely exist – that they are always connected to something else, and that one can never do, or be, one thing. This boundless view, while a vital insight, all too easily slides into the view that all is an appropriately connected whole, that is, functionalism. Our case is for recovering Koestler's implication that we should equally interrogate the manifestations of wholeness in what is readily seen as a part (of some greater whole). Thus parts require wholes, wholes require parts, and yet neither pure parts nor wholes actually exist.

There is, however, no necessary discomfort in this paradox. The trick is to learn to continually switch back and forth between the perspective of the part and the perspective of the whole, something we call *flickering*. The imperative of flickering arises because, for most of us, our minds seek to settle on a single representation of an entity. Think of the well-known outline drawings that appear to be of two different depictions, depending on very small changes of focus. In one of these, many observers first see a goblet, while others see two faces in silhouette. Our vision tends to settle on one or the other and must be consciously pulled to see the other. So the patterns of white and black are (at least) two distinct images, just as a holon is both a part of something greater and a whole in its own right. Flickering gives us a tool with which we can engage the paradox that holons are simultaneously wholes and parts (the subjectivity boundary problem) and players in a set of sometimes competing stories (the narrative boundary problem). Further, while holons are both part and whole, they are not completed, completely worked-out manifestations of either. The whole is always reshaping its parts, the parts that constitute the whole are ever changing, and thus so is the resultant whole, and so the very boundaries around what might be identified as a part are transient. Flickering helps us imagine the cognitive 'light touch' that allows us to remain open to a fuller range of possible interpretations of things and events. Flickering gives us a glimpse of the holon's transcendence of part and whole – an ephemeral state between these two far more concrete ideas – as the flickering light is between on and off.

The point here is not to argue against ever drawing a boundary – to do so is to put aside thought. But we need to see an agroecological boundary as a kind of two-ness, not a hard singularity. Envisioning a holon's bounds too tangibly risks atomizing the situation, while too ephemeral a boundary leads to complete dissipation of the topic and thus toward a totalizing holism. Flickering keeps this problem ever in our minds. We need this conceptual stereo view, with one eye for partness and one for wholeness, to avoid conceptual stereo*types*. We need a continual shifting back and forth in our depth of focus: every whole a part; every part a whole; every whole and part neither. It is not intellectually uncomfortable to do so. Indeed, we submit, this flickering is the most every day of acts, as we negotiate our own lives as parts, wholes, and neither.

Intentionality bounds holons

We have proposed that the holon is a useful conceptualization of a to-a-degree bounded entity within a web of involvements. Its usefulness for addressing the boundary problems, however, turns critically on our ability to decide what is and is not a holon and what is included in something so identified. We propose that *intentionality* is the primary criterion for identifying and bounding a holon. By intentionality we mean the active envisioning and seeking of a set of goals, such as the farm family working and planning so that they may continue to derive a livelihood by collecting milk from cows. Active intentionalities in the world seek to maintain themselves as wholes of mutually involved parts, and this usually requires that they also try to maintain themselves as parts involved in wholes, through their flickered imagination of themselves and their contexts. The humans in a farming enterprise try to maintain the farm as a whole amid the colliding disjunctures of each passing day, and do so in part by trying to maintain the farm as a part of markets, cultures, and ecologies that may not integrate with the farm as closely as those humans might like. They try to get along better with each other within the farm, just as they try to have the farm get along better with changing prices, values, and rainfall. The potential for a better state to get to comes from a holonic recognition that no whole or part is just that, a part or whole over and done with, and that wholeness and partness are always changing. Intentionalities strive for and act on these potentials, and in the process create them. At the same time, contexts shape the direction – the sense of motivational pull – of intentionality *toward* a vision or plan (Emirbayer & Mische, 1998; Martin, 2003). Intentionality emerges out of the contexts in which it seeks to act, possibly transforming them.

Looking toward intentionality as a guide to the boundary problem appeals to Ahl and Allen's (1996) suggestion that a 'robust' boundary is one that remains useful from multiple prespectives, or 'observation regimes'. Such multiple perspectives arise with both the subjective and narrative boundary problems. Perspectives might be variations on what physiological phenomena can (or must for the work to be valid) be included in research on measuring animal welfare – a subjective boundary issue – or on what story about the role of animals in agriculture we are trying to tell – a narrative boundary issue. By the criterion of utility from multiple perspectives farms are appropriately holons, for they are, at least, sources of livelihoods for owners and workers, centres of economic activity, producers of food, and large-scale manipulations of land, air and water resources.

A holon may have *capability* to affect change in some of its contexts, but not in others. Here we have in mind a holonic take on Amartya Sen and Martha Nussbaum's vision of a person's ability to be and to do (Nussbaum & Sen, 1993; Sen, 1992, 1999). In the language of agency, we mean that an intentionality's agency *towards* something must also be understood in the context of its agency *from*, its degree of release (Bell, forthcoming). Regardless of how hard a farmer tries to act intentionally towards the rain, he or she lacks capability over the atmosphere. Conversely, the choices a farmer makes about tillage, manure and crop rotations can affect soil, expanding or contracting the possibilities this context provides. Understanding the capability (or lack thereof) a farmer has over specific contexts is an essential task for both the farmer and the agroecosystem analyst. Farmers can ill afford to tilt at windmills, even if the agrotechnologist has scientifically determined that it is a new and better way to do agriculture. On the other hand, a rich appreciation of the possibilities for beneficial positive feedbacks from improved soil health can pay dividends.

Appealing to intentionality as a criterion for identifying holons leads us to see that some components of the farm (or any other) holon are themselves holons, while others are not. Similarly, some of the contexts in which a holon exists may themselves be holons, but not all are. What a farmer can do and be is surely shaped by the tractor, and thus the tractor acts upon the farm and the farmer, and is not merely pushed around by the farm and the farmer. The tractor has capability, it has consequence, and it acts in the world just as humans do, as the sociologist Latour has so copiously argued. But any intentionality for the tractor must come from beyond its own surface. Indeed, it is that external intentionality that makes it a tractor to begin with, and not, say, an interesting work of iron sculpture to be admired in the front lawn, or a place to build a nest for the new litter of ratlings.

Not all boundaries of consequence are holonic boundaries. In our development of the concept of a holon, a holonic boundary is a boundary that intentionally tries to maintain itself as such, as a surface of consequence, across the changing dynamics of its situation. The tractor does not maintain itself (much as a farmer might wish it would), not as a tractor nor a sculpture nor a nest site. It is the holonic intentionalities of the world that give the tractor's particular capability its specific consequence. Or not. A tractor, then, is not a holon.

By contrast, take a mule. Intentionalities external to the mule might find very different consequence in it. A farmer might see a form of animal traction, a child might see a dangerous threat, and a fly might see a source of nourishment. But apart from whatever these external intentionalities might find of consequence in the mule, the mule will act on its own with regard to its bounding surface, seeking to keep that surface as a persisting, yet fluxing, source of consequence. A mule, then, is a holon.

As we have noted, some of the contexts in which our holon exists are themselves holons, manifesting intentionalities. As holons go about the work of persisting they ignore the intentionalities of other holons at their peril, for example, the farmer should realize that the banker seeks to minimize risk and maximize profit by charging higher interest to those who can least afford it, or that transnational food companies seek the lowest-cost supplies of raw material. Similarly, external analysts, for example, agroecologists, will miss a good bit of the story if they fail to recognize and acknowledge intentionality in the holons they study. Finally, a great variety of intentionalities in the world are themselves acting from concepts of the farm as a fundamental construct, helping justify our frequent contention that the farm is a useful and compelling holon.

Summarizing our argument to this point, then, the holon is an intentional entity embedded in an ecology of contexts. The totality of the holon and its contexts is an involved hugeness, and yet unfinalized. If we wish to conduct research in order to effect change we must draw some boundaries within this hugeness, and intentionality offers a surface that is imaginable, appropriately poorly defined and porous in spots, and of great significance to the persistence of the sorts of entities we care about understanding more richly.

Representing holons

Many of us would find useful a visual rhetoric for describing holon agroecology. There is danger here, as the stability of the inscribed page implies the very completeness and settlement that we wish to keep forever in question. We elect to attempt the visual, deciding in favour of perhaps serving a broader community, at the risk of making too concrete our concept of the holon. Describing our visual representation will also give us opportunities to address and develop several implications of a holonic approach, including contexts, incommensurability, change, and flickering.

Figure 2 shows a farm holon from two perspectives. In the centre of each view we show a semi-distinct entity – the farm holon – with an irregular surface and with many internal entities, also with similarly irregular internal surfaces. These entities do not necessarily quite fit together, and we have tried to show them with overlaps and disjunctures (which are more apparent in a color version of the figure). But they are acting, perhaps sloppily and disjointedly, to create and maintain the farm holon. Some of these internal entities are themselves holons, for example, farm family members, hired labourers, and farm animals, while others do not constitute a surface of intentionality on their own, and thus are not holons.

In the upper panel the holon creates a nexus of the contexts in which, and with which, it must construct and continually reconstruct itself. We show a few – family and finance, the crop environment, markets and subsidies and spiritual beliefs – for illustrative purposes only. There is no limit to these, either empirically or conceptually. Some contexts may act holonically on their own, and from that point of view it would seem that a wise analyst, and the wise holon, would recognize that characteristic. The state, for example, is a context

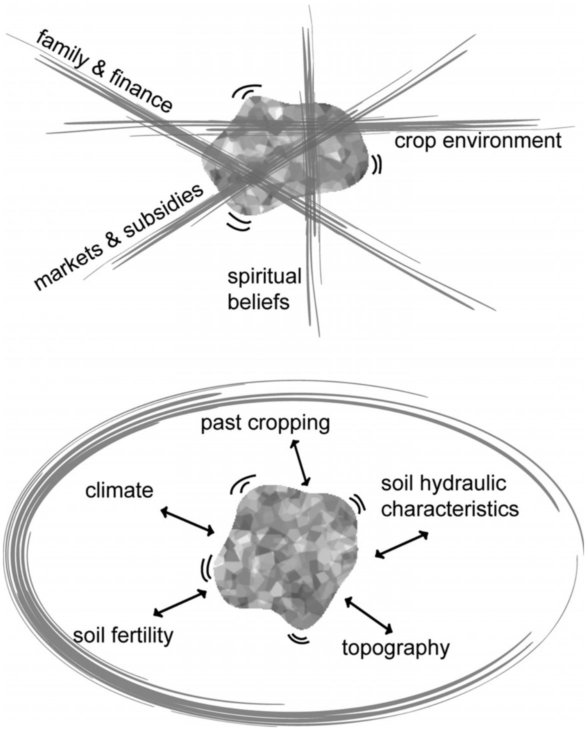

Figure 2 The farm is depicted as the three-dimensional, roughly spherical body at the centre of the upper and lower panel images. The upper panel depicts the farm holon existing simultaneously within four incommensurable sets of contexts. The lower panel depicts the farm holon embedded in but one of these, its crop environment. This set of contexts is represented as a two-dimensional space (a plane in the page), in which the farm we wish to study must operate. That is, whatever it is that the farm does it must do successfully within the facets of the crop environment context (e.g. rainfall climate, soil hydraulic characteristics) of its geographic location. These contexts are illustrative only – for particular analyses a different array would likely be appropriate.

for probably every farm holon in the modern world and one that, holonically, tries to maintain its boundary. The climate, however, may be a similarly pervasive context that, while perhaps at times helpfully imagined as an intentional entity, as in myth and story, does not try to maintain itself as a holon.

In any event, it is crucial to note in Figure 2 that the contexts extend into the holon. Markets are not separate from the farm holon. That is why markets matter for the farm holon, and why farm holons matter for the market. Many (if not all) of the entities that we represent as being internal to the farm holon also extend outside of it. The little irregular shapes we see in the holon are, in most circumstances, cross-sections of entities that extend beyond the farm, and often well beyond it. A child may labour on the farm at the weekend, and never leave its confines, but on Monday takes the bus for school, and thereby contributes to the construction of a school as holon. A farm animal may live all its life within the legal property boundaries of the farm, but its genetic history and its consequence for markets and the cleanliness of the local water supply extend far beyond into other holons and non-holonic contexts.

Each context depicted in the upper panel of Figure 2 is a bundle of interactions between the holon whole and the environments in which it exists. The lower panel unpacks what we have chosen to bundle as the 'crop environment' context of a farm: past cropping, hydraulic characteristics, and so on. But any of the parts of this bundle is a context that could be elevated such that it appeared in the upper panel. The analyst has freedom to chose the contexts relevant to the question at hand, and is ever at risk of overlooking a context that is dramatically shaping the farm holon. The arrows in the lower panel remind us that interactions between the farm holon and its contexts are multidirectional. The farm has various degrees of capability with regard to various contexts. Toward some the farm has essentially none, for example, climate, while toward others it may have considerable capability, for example, debt. Contexts might always be said (perhaps trivially) to have capability over the farm, or we would not have recognized them as relevant in the first place.

The holon and its contexts in the graphic depiction of Figure 2 are collectively the larger whole that systems thinking attempts to map. The farm is a part of this larger whole, but is itself, in multiple ways, a whole – a holon. Here the importance of flickering arises, as it helps us to see the whole/part nature of the holon. The holon is in many important ways a whole, but it is also shaped by and helps construct its contexts. Our flickered imagining of this dual nature helps us envision the many-dimensional and porous boundary of the holon. In turn, this virtual boundary gives the holon (and our conceptualization of it) the freedom to be the animated, ever-in-flux entity it must be in order to persist. Here we arrive at the problem of change, and the ways in which the holon helps us accommodate this imperative.

Holons and change

The holon exists, and seeks to persist, in its ecology of contexts. Individual contexts likely accommodate, and indeed encourage, any of several alternative configurations of the holon. However, the holon's configuration must be at least tolerated in all of its multiple, incommensurable contexts. For us to even notice a holon in the first place it must have earlier found such a configuration. But an instant later contexts and holons have changed – an illness or a price increase forces reassessment, and likely some reconfiguration, if the holon is to persist. For better or for worse, change is inevitable. This need to find a way of existing in an ecology of contexts, and that this ecology forces constant reconfiguration, motivates our contention (approaching insistence) that agroecosystem analysis should begin with a reverence for the farmer's organizational genius and planning.

The holonic interpretation we propose invites and provides conceptual room for the change that is essential to carrying on in an ever-evolving environment – 'the constant dance of cognitive systems, continually shaping, learning, and adapting to their environment . . .' as Pretty (2002: 149) described a central idea of the biologist-philosophers Varela and Maturana. The concept of the holon introduces into the greater web of involvement an entity with intentionality, and this intentionality provides the motive force for the ceaseless planning and action that is required to guide the change that is imperative to the holon's survival. For Fuenmayor (1991) intentionality causes the holon to be 'thrown' from the present *towards* a future state, but we envision a great deal more many-directional pushing and pulling, from and toward, as it moves through time, continuously reassessing its relational involvements.

That the holon finds viable configurations does not mean that it is free of internal tensions, for example, a grower of organic grains may feel uncomfortable with the repeated soil tillage needed to manage weeds, given the implications for erosion. While a particular solution may seem to conveniently and with little compromise be workable in two or three contexts, it likely will be unsatisfying in others. The incommensurability of contexts makes full resolution of conflicts unimaginable, i.e. every present solution is provisional, and subsequent re-evaluations may arrive at a different choice as the wisest. Further, the incommensurability of the holon's contexts means that it cannot be fully optimized, for example, a successful farm can never be simply the diligent application of the contents of the collected technical bulletins from the university.

Every holon is unique in both its present state and how it will react to changing contexts. The present state of the bundle of contexts in which it exists, and the path by which they evolved are unique, shaped by accidents of history. Thus a complete articulation of the present state of the holon is impossible. Further, and perhaps more significantly for the analyst, so too is predicting the holon's reaction to changing contexts. This unpredictability has multiple origins, including, at least, historical contingency, un-unified intentionalities and the sense of permission to create that a holon may gain from its contexts, for example, democracy versus authoritarianism (Bell, forthcoming). Historical contingency, that is, that what will happen here and now, is powerfully shaped by the particular history of the holon and, possibly, some of its important contexts. Legacies of past experience are embedded in the repertoire of reactions from which the holon draws as it reacts to a new environment – the schemata of Gell-Mann's complex adaptive systems (Gell-Mann, 1994, 1995).

The intentionality of the holon, in spite of its centrality, can never be unified – the holon's intentionality is not singular, but rather always at odds with itself. There are two sources of disunity, the first of which are tensions that arise from the irresolvable task of seeking satisfaction simultaneously in incommensurable contexts. Just as incommensurability makes impossible the calculation of an optimal outcome, it makes unimaginable a single, clear intentionality guiding the holon. The second source of disjunct intentionalities is political – member holons of a holon may have different interests and priorities. A farm holon that includes members who have a passion for grassland birds and others who desire to be known as the owners of the largest herd of cows in the state will likely work from an un-unified intentionality. The rich array of possibilities by which the holon might react to changing contexts as a result of historical contingency and un-unified intentionalities should humble the analyst and policy maker.

But there is reason to believe that a holon's behaviour will not be random: intentionalities have directionalities from and towards that they and their (holonic) contexts try to maintain, and in that sense have a kind of stability that is in some degree predictable. But at the same time, they carry on with those directionalities by constantly reconfiguring their stabilities amid the unfinished possibilities of the world, in ways that neither *they* nor we can ever fully prejudge. This constant seeing and reseeing of a holon's boundaries is another essential feature of the epistemology of flickering. It entails an acceptance of *directed unpredictability*, and is a large part of what we mean by holonic thinking's reverence for planning.

We thus stress the unfinished quality of holonic involvement that we label *unfinalizability*, a term we borrow from Bakhtin (1981, 1984). There is always – *always* – slippage along, and within, a holonic boundary. There is always an untidiness to reality. There is always tension between connectedness and unconnectedness. And it is a good thing too, for it is here in this potential for the continual reworking of that which was thought to be worked out that we discover the possibility for change, and indeed for life. A fully bounded and connected world is a frozen world, incapable of supporting life and its inherent capacity for change. Holonic thinking, however, with its stereo, flickering view is constantly in motion, never accepting an icy finalization of involvement. As the holon continuously rearranges itself, its external connections – its web of involvements – will also necessarily change. The holon perspective therefore accepts both an unpredictability of involvement and, fortunately, a certain predictability in that unpredictability.

Holons as narrative

To engage in holonic thinking is, of course, to construct narratives. It is a way to tell stories about the world. It is not the world itself. (Nothing but the world can make that claim.) But holonic thinking, as we have been conceptualizing it, also offers an argument for tracking through the endless swamp of postmodern discourse analysis, in which we are unable to agree on any distinctions in the gloom. While we are free to choose whatever holonic identifications we like, the analyst who exercises his or her intentionality with no regard to the holonic identifications of other intentionalities risks mistaking turnips for watches, wishes for horses, beggars for aristocrats. Holons may be constructions, but they have real consequences. Intentionalities may only imagine their holonic boundaries and their contexts, but the directions their actions follow as a result shape their lives and ours mightily. Intentional actions give persistence to flux, and flux to persistence. They create subjects and objects, texts and contexts.

The fluxing persistences and persisting fluxes wrought by intentionalities offer the analyst a great conceptual opportunity: A really helpful way to begin to understand the world is to try to understand it as others do, and then watch carefully for the consequences of those understandings, with all their conflicts and asymmetries. Understand holons as holons understand themselves, and study as they try to organize and reorganize themselves and their contexts accordingly. Make it a crucial analytic act of the agroecological endeavour to look for holonic boundaries that others are trying, with assuredly varying degrees of success, to draw, and to study the contextual relations that give such impetus.

From the perspective of practical application, holon agroecology offers suggestions, if not a rough framework, for students (be they undergraduates or national officials) of agriculture as they seek to understand or influence the behaviour of those who seek livelihoods from plant and animal increase. Because the farm holon must constantly seek a configuration that is viable in multiple, incommensurable contexts, the student should first seek to understand this constellation of contexts much as the farmer does. An openness and humility is required to avoid overlooking powerful, yet perhaps foreign (to the analyst) contexts. Closely related is the narrative boundary problem – farmer and agroecosystem analyst may start from fundamentally different premises about the meanings of an agricultural endeavour. Further, the analyst is well served by delaying normative judgments as long as possible, by approaching the farm holon with a reverence for the organization and planning that is required to create and maintain a farm holon.

Conclusion

The time is long past, or so we hope, when anyone seriously considers understanding the involved hugeness of agroecology with the metaphor of the machine. And yet the turn to systems thinking, as it is currently developed in much of agroecology, has moved on less than we often recognize. The simple systems approach, even when applied in a detailed and elaborate way, retains many of the features of the machine metaphor. Interactions are clear, complementary, balanced, and directed to common purpose in ways that yield the analyst a confident sense of interventionist power and control in a fully connected world. Such a rhetoric and mood has a definite mechanistic feel, albeit assuredly a more informed mechanism than the *simple* simple approach of the machine metaphor of earlier science.

We have argued that the concept of the holon, in which neither parts nor wholes exist in an absolute sense, can be developed to appreciate the incomplete and incommensurable quality of involvement that stems from the unfinalizability of contextual intentionality. We have suggested tracing holon boundaries by looking for the intentionalities that seek to construct themselves from the fluxing welter of context. The agroecology analyst would do well to take careful note of these constructions, their conditions and their real consequences – an appreciation we have called a reverence for planning.

While we believe that there is reason to hope agroecologists will find our arguments worth engaging, we worry that the influence of the language of systems thinking will make our argument seem oppositional, and perhaps even threatening. Much has been learned in agroecology through the application of a systems point of view, and many may wonder why we would appear to question that. We do not question that. Rather, we worry that we often reach beyond the safe height of its conceptual ladder. Complexity theory for some time has recognized that this limit is often exceeded. Our goal has been to provide more secure footings for the needed conceptual extensions – the search for 'a more comprehensive ontological and epistemological framework for studying farm enterprises', called for by Noe and Alrøe (2006).

We do not ask for the banishment of simple systems thinking, then. There are times when a shorter ladder is just what is needed. Situations in which the recognition of intentionality is less directly relevant to one's purposes – when it is only, or nearly only, the analyst's own intentionality that shapes the purpose of the encounter with the world – then a simple systems ladder is likely to be very useful.

But such a singularity is an ontological conceit, and we forget this at our peril. Sustainability entails contending with the disjunct openness of an incomplete world of intentionalities that are neither part nor whole. Sustainability means keeping life flickering amid these ongoing, if unbalanced and asymmetrical, consequences of unfinalizability. Sustainability, then, means possibility, and possibility means intentionality.

Koestler called the book in which he introduced the concept of the holon *The Ghost in the Machine*. Our argument has been that intentionality is the holonic ghost which prevents the world from ever being a machine. It is this hopeful thought that we invite agroecologists to sustain.

Note

1. Although we do not list our names alphabetically, the work (and responsibility) for this article is equally shared by the two of us.

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