

LWA Integration Symposium 2004 Keynote Address:

Integration—not seeing the forest for the trees?

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Integration (def.): the making up of a whole by adding together or combining the separate parts or elements (Shorter Oxford Dictionary)

'Integration' is as good a motherhood concept as we are ever likely to come across. How can anyone speak against the notion that we should manage natural resources and catchments in an 'integrated' manner—in a way that makes up a perfect 'whole' from the separate parts?

Foolishly perhaps, that is what I am going to do today.

The reason is, I can't quell the uneasiness I feel whenever I hear people talking about integration in the context of water, land catchment or natural resources management. I believe there is a risk that integration—at least as we currently practise it in Australia—is a misguided concept.

The rub lies in the definition of integration itself. To integrate, one must first dismantle a catchment or landscape into its component parts, at the same time ensuring the functional relationships between the parts are understood, so the recipe for re-cooking the integrated pie can be applied when the dissection is finished. It is assumed that we will be rewarded by the revelation of new insights that allow us to manage these natural systems so much better than we are currently doing.

The underlying premise required for integration to work is that we can reduce a complex system — a catchment, a landscape, a city, a culture — down to a finite set of components and functional relationships, and then reaggregate all this back to something that bears a good resemblance to the original system. That reduction and reaggregation, perhaps in iterative cycles, will reveal new and previously unknown meaning and insight.



It is my feeling that complex natural landscapes are not likely to reveal their *true* structure and functions under the knife of reductionism. A sole focus on integration as reduction and reaggregation is, I worry, unlikely to be a fruitful pursuit. I feel that there is a real risk of not only missing the point through reduction-reaggregation, but of actually coming up with the wrong answers to the tough questions of water and landscape management in Australia.

I am not saying that reductionism is a crazy idea, nor that we have all been wasting our time as scientists for five centuries going down that path. Quite clearly it is an important way of thinking about the world, and a really important way of *learning* about how individual parts of a system work. Indeed, much of my own research and that of my colleagues has been reductionist in nature. But in terms of understanding the way complex systems behave, we need to acknowledge that there will be features of the system, perhaps emergent ones, that cannot be fully explained through from a reductionist perspective.

In our pursuit of explanation and meaning, we run the risk of not seeing the holistic forest for the reductionist trees.

Complexity theory argues that reduction and reaggregation will not lead to true systems understanding, at least not in any simple, linear fashion. The challenge I pose for those who practise integration is to consider this argument, and to decide what can be appropriately studied at small scales through reductionist approaches, and what features must be studied at larger scales or through more holistic analysis.

Holism can be considered as a logical counterpoint to integration; one which is worthy of more concerted attention from scientists and managers than is currently the case. Although to some, holism may be a rather airy-fairy concept, it is also potentially a way of examining complex systems without first needing to totally rip them apart into small components that our small human minds can easily understand!

Holism looks for the properties of complex systems at multiple scales. Landscapes, catchments, rivers, cities and cultures are all complex natural systems. They have self-organising form and emergent properties. Emergence is a higher level outcome of the collective lower level properties and processes of a complex system. It arises from the individual parts of a system but cannot necessarily be explained by them. Emergent properties recur across multiple scales of a complex system, whether a community, an ecosystem, a landscape, or a catchment. Emergence is about macroscopic features that arise from microscopic processes.

One everyday example of emergent properties is ‘thinking’ itself. Thought can be considered as an emergent property of the brain—a complex natural system. We are unable to explain thought through neurophysiological reductionism, yet we know it exists. When it goes wrong, we can see a psychiatrist who will treat what he or she believes to be the underlying pharmonochemical problem (the reductionist approach), or we can see a psychologist who will address thought as an emergent property directly through discussion and reflection (the holistic or systems approach—after reading this paper, some will say that I need both a psychiatrist and a psychologist!).

Biodiversity has been argued by certain ecologists to be an emergent property of a complex ecosystem. But, do scientists and managers try and explain biodiversity in this way? Rarely if ever. Instead, we try to pull 'biodiversity' apart, breaking it down to complex species richness lists and habitat maps. In the end, the process leaves many of us floundering with the whole idea of biodiversity and wondering whether it has any merit at all. Maybe we would have more success considering biodiversity as an emergent property of an ecosystem, to be measured accordingly, not just as a reductionist list of individual species and habitats.

Another example is hydrologic connectivity, the four-dimensional linking of a stream in its catchment (longitudinally, laterally, vertically and temporally). In a joint project between the CRC for Freshwater Ecology and CRC for Catchment Hydrology, some exciting research is showing that in urban catchments, connectivity is a major predictor of ecological condition in streams. We do not yet know the exact functional explanation for this observation, nor if it is universally true. It may be due to pollutants washed from the catchment in stormwater, the physical effect of flashy flooding, or perhaps other yet to be considered factors. But, we are confident the effect and relationship is real, at least in those catchments we have so far studied. It may not be important whether the underlying functional mechanisms can ever be fully explained. Hydrologic connectivity, as an emergent property, can be directly controlled by managers and urban developers through a good understanding of the principles of water sensitive urban design.

I said earlier that complex systems have *self-organising* form. The concept of emergence is underpinned by the notion that meaningful order can emerge on its own in complex systems—the examples in nature are many and varied.¹ What is self-organisation about? In complexity theory, landscapes can be seen as having attributes that are self-organising, from individual organisms all the way through to large landscapes. River drainage networks and coastlines are but two of numerous well-recognised examples. Self-organisation in this form arises spontaneously. It is something that complex systems do, based on very simple processes that are repeated over and over again at multiple scales over long periods of time.

The art in all this is to learn how to look at complexity, how to think about it, and how to understand it.

I would like to talk briefly about landscape ecology at this point. Landscape ecology is not necessarily driven by complexity theory, but I think there are interesting parallels between the two. Landscape ecology is about understanding the natural mosaic and interconnection of habitat 'patches'. Habitat patches are the places where people and animals work, live, rest and eat, and the connections between them are central to how landscapes function across small to large scales. Landscape ecology does not necessarily require disaggregation of the landscape into individual habitat patches. Rather it requires an understanding of the patterns and forms that emerge as a consequence of the interactions between patches in the landscape.

1. Buchanan, M. (2002) Small world: uncovering nature's hidden networks. Weidenfeld & Nicholson, London 235 pp.

Landscape *ecology* is not the same as landscape *scale*, though the two are often (incorrectly) used interchangeably. Landscape ecology is a way of thinking about systems, independently of scale. It is a way of looking at the patterns and forms of nature, and how things relate to each other in the landscape.

I believe that in managing catchments and landscapes in Australia, we need to start doing things a little bit differently; we need to start thinking about complexity and what it means in natural resources management. We need to apply many of the ideas of landscape ecology to the way we manage rivers and catchments. Perhaps, like the Roman emperor Nero, we have been fiddling with a reductionist-integration paradigm while the Australian landscape metaphorically (and literally) burns. We could be left wanting, over the next decade, unless we start applying some of the theories and ideas of complexity science to natural resources management.

Finally, it is my vision and hope that one day Australia will have its own Complex Natural Systems Institute: a place that acts as a hothouse for innovative thinking on complexity and the emergent properties of urban and rural landscapes. A place where scientists, managers and policy makers can come for short or long periods to brainstorm ideas. I believe it is important that we start putting money aside for such big-picture, blue-sky thinking. I worry that we are all so locked into applied science these days that few, if any, of us have time to sit back and consider these more complex and difficult issues.

I have a feeling that if we don't do this, in 20 years' time we will still be asking the same questions we are asking today about Australia's natural resources management. We may feel a little more reassured about what we know, but still lack the answers to the big questions of water, catchment and landscape management in urban and rural Australia.

My talk today has been deliberately provocative, perhaps even a little exaggerated! But as someone wiser than me once said, none of us will ever be remembered for the things we didn't do or say! As the keynote speaker for this Integration Symposium, I hope I have given you just a few ideas to ponder and debate.