*Artweb: A Nonlinear Model for Urban Development**

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INTRODUCTION

THIS PAPER DESCRIBES A COLLABORATIVE ACTION RESEARCH PROJECT that uses landscape-based operations and techniques to realise arts and science interventions in the urban realm. The project is funded by the Arts Regional Trust (ART), a body established to promote the development of arts infrastructure in the Auckland region of New Zealand, and by the author's institution, Unitec New Zealand. Action research is a flexible, iterative process that allows both change and understanding to be achieved at the same time. The understanding permits more informed change, and at the same time is informed by that change. The research does not have to be designed in detail before it commences. Instead, the design of the research is refined as more is learned about the situation being researched (Dick, 2002). This project is testing the agency and viability of a complex adaptive systems model for urban development.[1] To do this the researchers had both to develop the model and find an application for it. This was accomplished in the first phase of the enquiry and the project is currently being implemented in Auckland and Manukau cities in the Auckland region. The research strategy utilises the *modus operandi* of nonlinearity – time-sensitivity, bottom-up patterns of organisation, and a disorderly rhythm of growth – in the development of a physical urban network that is operationalised by the arts and the environmental design disciplines.

The research, a public art project, is based on the premise that the city is not something given, but is formed through participation in and with the objects, images, values, codes and processes that constitute it. It also recognises and emphasises that designers and artists who work in the public realm participate in the production of meanings, uses and forms in cities. A recent report for the Auckland City Council on arts infrastructure notes that a creative city values its arts and cultural sectors for just this reason, stating that "Our arts, artists and arts industries are key contributors to the new economy and society" (McCormack and Carr, 2002). Another local authority document, *Arts in Tomorrow's Manukau*, demonstrates that city administrators recognise that supporting arts projects makes economic and social sense, and encourages collaboration between the arts and business sectors for "mutual benefit" (Manukau City Council, 2003). There are, however, a number of difficulties associated with the kind of public arts policy that derives from the relationship between art and the public realm that these well-intentioned documents promote.

To be sure, public art can help secure consent to redevelopment and to the advancement of normative techniques of urbanisation, but it can also question

and resist these operations. Public art is often part of an agenda that is larger than simply making art accessible – it often accompanies the promises made by the principal actors in the real estate market – developers, financial institutions, landlords, corporations and politicians.

The Auckland City CD Public Artworks Plan (Pringle and Reid, 2004) notes that "public art is intrinsically tied to the provisions, controls, uses, qualities and values of public space". And art theorist Deutsche asks: "Given the proliferation of pseudo- and private public spaces, how can public art counter the functions of its 'public' sites in constructing the city?" (1998: 59). She cites as a principal issue confronting all urban practices the current appropriation of public space and of the city itself for use by "the forces of redevelopment". Since the rise of critical discourse on public art in the 1990s, it has become clear that it is impossible to dissociate art from the social environments with which it "interacts". All urban sites are socially constructed spaces. Public art in high-value locations mostly confirms a pre-existing social construction.[2]

The research reported in this paper is situated in a territory located somewhere between art, landscape architecture and urbanism.[3] One of its objectives is to find out if locations with 'negative' or 'neutral' social values undergo revaluations when artworks alter them in some way. This is to shift public art from its place within the parameters of aesthetic discourse and re-situate it within critical urban discourse. Most public art projects put objects into pre-formed milieux, and very few make it possible for artists or designers to enter into prolonged engagement with the specific circumstances of the sites for which they have been commissioned. Accordingly, two of the questions informing this investigation are as follows: Is it possible to design a public art project that enables artists and designers to select the physical situations with which they will work? Further, is there a way to enable artists and designers to engage critically as well as creatively with the complex qualities of the urban landscape through which their work will emerge?[4] The research goal is the development of a platform or framework – a cultural sector infrastructure – which will make possible the actualisation of artworks and landscapes that avoid some of the difficulties associated with both art and design in the public arena.

DESCRIPTION OF THE PROJECT

The project known as artweb has as its main aim the realisation of a network of sites in Auckland and Manukau cities, connected by pathways that can be travelled on foot or by bicycle, throughout which art and landscape architectural projects are distributed. Many of these projects are themselves collaborative and interdisciplinary. Many of them will be arts/science/landscape collaborations that investigate specific terrain, although the artweb project concentrates on artworks in the first phase of enquiry, and will introduce scientific and science/art projects in the second, 18-month phase. What is unique about this public art initiative, at least in New Zealand, is that it is driven by landscape architectural concerns and techniques that deploy mappings, organisational strategies, diagrams, algorithms and operators to make formal, material interventions in the urban matrix.

The project works primarily with marginalised sites – terrain that is off the beaten track, outside the purview of real estate agents, developers and council-inspired open space plans (although this, of course, is an idealism; nowhere is beyond the purview of the market). For instance it utilises railway corridors, urban streamways, public reserves, coastal walkways, existing bike paths and culverts to link industrial sites, toxic dumps, golf courses, suburban reserves, quarries, urban paddocks and other 'wasted' landscapes in the city. One of the reasons *terrain vague* is being explored is to avoid the problems discussed above that are associated with high value, high profile sites, and which, additionally, often lead to resource consent and financial problems that eventually swamp the projects.[5]

The artweb project uses ArcMap, a Global Information Ssystem tool that identifies sites for intervention by searching the urban field against selected criteria. Social and physical data about the Auckland region are selected by means of GIS operations, and those sites that most exemplify the criteria regulating any particular search are identified as possible locations for intervention. These sites are called 'intensities', since they are intensifications of the urban field. Normative classification systems, such as vegetative, hydrological, industrial and so on have been made available to the project by Auckland and Manukau cities. Further data sets have been acquired from TerraLink, TranzMetro and Statistics New Zealand.

The compilation of data sets is ongoing, and includes social and cultural data such as crime sites, taniwha locations,[6] local anecdotes and histories, and subculture populations. The collection, transformation and distribution of arts and cultural data in relation to physical and social space occur alongside the collection of botanical, ecological and geological data. This forms a field. Intervention takes the form of an artist's or designer's proposal for the actualisation of specific locational qualities through an artwork or landscape architectural work. Such a work may contest, re-arrange, destabilise, celebrate, or simply mark the site by means of installation, performance or permanent transformation. The projects are implemented at their various locations, and these sites are connected by 'vectors', or pathways, by means of which it is possible to navigate the whole network.

An important component of artweb has been the development of a website that makes the entire project available online. The website has two major roles:

1 To make it possible for people to select places within the physical project network to visit.
2 To enable artists, scientists and other interested professionals to contribute to the project by registering new projects, preparing research proposals and moderating the proposals of others.

The website also makes available information about the project, patrons and sponsors, artist and designer biographies, and downloadable images created specifically for their projects by the artists and designers involved in the creation of physical sites.

BACKGROUND TO THE PROJECT

Artweb arises out of a broader research investigation that explores ideas to do with nature within the discourse of landscape architecture. One aspect of this larger project includes an investigation into the feasibility of using nonlinear models of organisation to guide and inform landscape architectural design. Much has been written in recent years on the conjunction of nonlinearity and urbanism (De Landa, 1999; Salingaros, 1998; Batty, 2000 and Daffertshofer A, 2001), but there has been little on-the-ground testing of the theoretical propositions.[7] We decided that the best way to test nonlinear theory in landscape architecture was to design and implement an urban landscape architecture project that operationally exemplified the qualities of nonlinear dynamical systems. The artweb project is therefore part of a more general re-visiting of the systems theory that was played out in so many disciplines in the middle decades of last century.[8] It is also linked to field theory, since it begins with a conception of the city as a network of interactive fields (Allen, 1997; Arida, 2002, Lefebvre, 2003).[9] Finally, the project draws on network theory to understand the behaviour of web-like systems (Barabasi, 2002; Buchanan, 2002). Taken together, these theoretical connections imply an underlying conception of urban systems as having similar organisational characteristics to ecosystems (Vrijlandt and Kerkstra, 1994; Davidson *et al*, 1997; Bogunovich, 1999; Riddell, 2003).

A ten-year roll out has been planned for artweb. During its implementation the project will be monitored against a set of performance criteria, and evaluated for its ability to deliver on its aims and objectives. It is nearing the end of its first 18-month cycle (determined by funding cycles), when critical and systematic reflection will take place. This will be characterised by a vigorous search for disconfirming evidence. As the project nears the end of this first term, some questions have arisen and a number of issues will need to be addressed. These will be discussed at the end of this paper.

The artweb research project arose out of an interest in the interplay between concepts of nature and of the city, and how these affect urban landscape architecture. Ideas of nature in the cultures of western societies are notoriously ambiguous, and scholarly discourse consists of a wide and expanding range of critical discussion (Kwinter, 2001; Macnaghten and Urry, 1998; Simmons, 1993; Smith, 1996; Soper, 1993). Some of the important 'naturalised' theories about natures and cities prevalent in many western societies are under increasing pressure from science, philosophy and the social sciences.

The separation of nature into the One and the many,[10] the division of space and time into separate absolutes, and the positing of humans as a part of and yet separate from the natural world, underpinned most thinking about nature through the Greek, Roman, Mediaeval, Renaissance and Enlightenment periods, and influenced the production of urban landscapes such as that of the Greek polis and European baroque city.[11] This is a fairly rough and ready characterisation of

the history of nature, but it is, in general terms, agreed on by most philosophers and scientists (Torrance, 1992; Simmons, 1993; and see Albert Einstein's 1953 "Foreword" to Galileo's *Dialogue Concerning the Two Chief World Systems* for a particularly clear exposition). Alongside the rationalist tradition of nature, however, a counter-tradition developed, based on the so-called Hermetic corpus.

This 'magical' understanding of nature drew its sustenance on the one hand from the Greek sense that the world was alive, "ensouled" as Aristotle put it, and on the other from the writings of Plato, whose conception of the universe as a *harmonus mundi* based on aesthetic principles of order and perfection influenced the Christian mystic-philosophers. The Mediaeval and Renaissance magic traditions were largely Neo-platonic, and their philosophies of nature (as evidenced in the work of, for instance, Marsilio Ficino and Giordano Bruno) were quite different from the more Aristotelian conceptions of the scholastics.[12] This counter-tradition led to the twentieth-century "philosophies of flux" of Henri Bergson and Alfred North Whitehead.

Despite the interplay between traditions, the concept of a nature that is separate from, and ontologically superior to, human artifice, and therefore to cities, is still prevalent in many of the disciplines that deal with cities. Under the auspices of planning and urban design, natural events and processes continue to be registered in urban precincts in extremely formulaic ways based on typological visual constructs derived from simplistic aesthetic categories, of which 'natural' and 'formal' are still the most conspicuous.

NONLINEAR THEORY

Nonlinear dynamical theory is currently one of the main sources of pressure on conventional views of urban/nature interaction, having spread from the physical sciences to the arts and social sciences (Capra, 1996; Gleick, 1998; Hayles, 1990).[13] Nonlinear dynamical theory, also called chaos theory, is the study of systems that are open-ended, unpredictable and dynamic. The equations that describe such systems do not generally have explicit solutions (Hayles, 1990). They have complex forms, which often develop as a result of feedback from within the system.

Nonlinear dynamical theory has been applied to many kinds of systems, from ecosystems to economic systems, from chemical maps to urban networks. Nonlinear mathematics provides ways of mapping clouds and nervous systems. It is most effective in describing patterns (Capra, 1996). Patterns cannot be measured and weighed: to understand a pattern, a configuration of relationships must be mapped. The structures that emerge from such mapping have certain crucial characteristics. They are revealed as 'interactive webs' or 'differential networks' characterised by large numbers of highly mobile components that are linked to one another by various modes of communication. In short, they are like ecosystems (Davidson *et al*, 1997). But dynamical systems theory is not a theory of physical phenomena. It is a mathematical theory that is applied to a wide range of physical and non-physical phenomena, a mathematics of

relationships and patterns, of equations, of algebra and topology. The contrast with the mathematics of Newtonian physics could not be greater. The transition from classical science to quantum mechanics and then dynamical theory was not just a change of emphasis. Both the relations between structures and the structures themselves were conceived differently. These latter were, for all intents and purposes, no longer discrete or absolute, but relational. The notion of a separation between being and becoming was put into question as the importance of time and temporality came to be recognised. Instead of space and time, there was space-time (Kwinter, 2001).[14]

The science of nonlinear dynamics was a response to the possibility of understanding how nonlinear events, such as eddies in rivers, clouds, weather patterns and population dynamics, occur in the physical world. It soon incorporated social phenomena, with economists, sociologists and anthropologists applying nonlinear theory to their investigative programmes. Once the theory got going it seemed as if nonlinear systems were everywhere. By the 1990s it was being applied to cities. Urban systems, too, were open-ended and unpredictable. It turned out that chaos theory had developed into a tool for devising new strategies in urban development. Why?

In the 1960s Ilya Prigogine developed an influential theory about self-organisation while studying systems under conditions of non-equilibrium. He realised that systems that are far-from-equilibrium must be described by nonlinear equations. He discovered that as a system moves further away from equilibrium it reaches a point of critical instability, at which a new pattern emerges.[15] This he called self-organisation. It is a characteristic of what he termed "dissipative structures" (Prigogine and Stengers, 1984). Classic thermodynamics had led to the concept of equilibrium structures such as crystals. Prigogine introduced the concept of dissipative structures to emphasise the paradoxical close relationship between structure and order on the one hand and dissipation on the other.[16] In classical nineteenth-century thermodynamics the dissipation of energy was regarded as waste. Prigogine changed this view by showing that in open systems dissipation becomes a source of order.

According to Prigogine, dissipative structures not only maintain themselves in a stable state far-from-equilibrium, but may even evolve. When the flow of matter-energy through them increases, they may go through new instabilities and transform themselves into new structures of increased complexity. Prigogine showed that, while dissipative structures receive their energy from outside, the instabilities and jumps to new forms of organisation that characterise them are the result of fluctuations amplified by positive feedback loops.[17] The so-called runaway feedback, which had always been regarded as destructive in cybernetics, appeared as a new source of order and complexity in the theory of dissipative structures. Feedback is a characteristic of any system in which the output, or result, affects the input of the system, thus altering its operation. Put another way, information generated can influence the generation of further information.

Positive feedback, or autocatalysis, is a property of nonlinear systems. An autocatalytic process is one that catalyses or accelerates itself. Classical physics did not have the tools for finding this out. Newton could predict the moon's orbit from the laws of gravity, but did not have the equations to describe the nonlinear feedback produced if another moon is introduced into the system, when orbits become chaotic and linear prediction impossible. For the first time in history, the study of feedback loops enabled researchers to distinguish between the pattern of organisation of a system and its physical structure. A system may be chaotic, but not random.

Such systems, or dissipative structures, have three main features. First, they are open and part of their environment, and yet they can attain a structure and maintain it in far-from-equilibrium conditions. This undermines the traditional view that systems must be examined as if they were isolated from their environment. These systems also run contrary to the second law of thermodynamics, which states that such systems move towards molecular disorder rather than order. Second, the flow of energy in these systems allows them spontaneously to self-organise (creating and maintaining a structure in far-from-equilibrium conditions) by developing novel structures and new modes of behaviour. Self-organising systems are therefore said to be 'creative'. Third, dissipative structures are complex. Their parts are so numerous that there is no way a causal relationship between them can be established. Instead, their components are connected by networks of feedback loops operating at different levels, different scales and different rhythms.

Nonlinearity entered urban theory in the 1990s. Writers such as Salingaros (1998), De Landa (1999) and Kwinter (2001) began to explain urban processes in terms of dissipative systems. De Landa, a student of Gilles Deleuze, has been particularly influential in this regard, with his book *A Thousand Years of Nonlinear History*, the title of which echoes Deleuze and Guattari's *A Thousand Plateaus*, and has staked out the urbanistic territory of the rhizomatic process.[18] High-profile practitioners like Allen (1997), Corner (1999) and Koolhaas (2000) drew explicitly on the work of scientists and science popularisers[19] to develop urban landscape design strategies that took account of the unpredictable and open-ended character of urban systems, and used it to generate design proposals that were time based and adaptive. They also invoked the so-called process philosophers, such as Henri Bergson and Alfred North Whitehead. There were precedents within landscape architecture, however. Before these writers and practitioners of the 1990s, pattern and classification-based approaches to urban planning and design had been invented and experimented with throughout the latter half of the twentieth century, particularly by Ian McHarg, Carl Steinitz and Christopher Alexander.

Artweb builds on McHarg, who wrote (Bergson-like) that "form and process are indivisible aspects of a single phenomenon", and that his "ecological method" recognises form as "an explicit point in evolutionary progress" (McHarg, 1992). McHarg used his method to determine which potential land uses were inherently suited to landscape capability. While the artweb project adapts McHarg's mapping

technique and shares some of the basic philosophy, for instance the emphasis on taxonomies as heuristic devices, it does not share McHarg's insistence on scientific method as validation, or his evolutionary determinism - complexity is not adaptation. A major difference is artweb's emphasis on the process of selection of data sets. Scientists involved in the project will want to know that the data they are using is 'correct', while artists may wish to work with highly idiosyncratic taxonomies of their own devising. One important echo of McHarg's method is the way that the artweb project explores the possibilities of bottom-up participation by communities, at two important levels: intensity selection and physical implementation, made possible by the interactive nature of the project website. McHarg regarded the possibility of the community employing its own value system in ecological planning "a most important improvement in planning method" (McHarg, 1992). But it is his understanding of nature as "an interacting process, a seamless web" that underwrote his work, and which could be called, to adopt Christopher Alexander, a pattern language. For Alexander, this is "a fundamental view of the world ... no pattern is an isolated entity. Each pattern can exist in the world, only to the extent it is supported by other patterns: the larger patterns in which it is embedded, the patterns of the same size that surround it, and the smaller patterns which are embedded in it" (Alexander, 1977).

Despite their emphasis on structures of organisation, the work of both McHarg and Alexander lacks a sense of the propulsive character of change and the recognition of the ability of systems to self-organise without recourse to external agency. As Batty notes, early systems theories of the city "were structured around parts adding up to wholes in terms of an equilibrium which could not cope with any form of change" (Batty, 2000). A city, as Holland (2000) says "is a pattern in time". The transition from static to dynamic models has been reflected in the science of ecology. Early ecologists saw ecosystems as homeostatic. They are now seen as homeorrhetic.[20] Odum, for instance, wrote in 1971 that "homeostasis ... is the term generally applied to the tendency for biological systems to resist change and to remain in a state of equilibrium". In 1997, by contrast, he wrote: "Organization and function at the ecosystem level are (not) tightly regulated (and display) more pulsing and chaotic behaviour ... in other words they exhibit homeorrhesis as opposed to homeostasis". Reflecting this change, the work of many contemporary landscape architects emphasises the generative nature of systems modelling, and artweb accordingly places an emphasis on agency and transformation.

LOCAL AND GLOBAL

The artweb project commenced with a series of GIS mappings of the Auckland region depicting social, cultural, ecological and biological patterns and systems. The mappings reveal the city as composed of multiple levels of organisation acting in different ways, each level advancing through time individually (in fact, each of the levels is likely to contain its own time frame). Representations of these levels are superimposed and, through the process of layering, 'intensities',

are identified.[21] Individual intensities are considered not as autonomous points but rather as microcosms constituted by specific tropes and organising figures characteristic of the 'culture-system' inhabited by the region.[22] Intensities are not substantive. Nor do they constitute cultures; cultures constitute intensities. Moreover, the concept of the regional culture-system implies that different situations within a given spatio-temporal field are self-similar. That is to say, their elements (be they physical, symbolic, legislative or economic) are all products of the same classification systems, the same social codes. Of course, what counts as an artweb intensity is a matter of how phenomena meet various criteria that are established, along with the taxonomic system that is being used to identify them. The choice of taxonomy is critical, since it selects specific attributes for survey, measurement and depiction. An artweb taxonomy may be normative and based, for instance, on local territorial authority classifiers such as ethnicity, economy and ecology, or it may be irregular, derived from phylogenetic criteria from completely different epistemological orders, such as, for instance, taxonomies based on ideas of infection, sequencing, turbulence, heterogeny, entropy, paradox and contradiction.

Intensities occur where relational events captured in each data set coincide geographically. Movement between the data sets occurs where the events align (they are called events to acknowledge their inherent – not episodic – transitoriness, even though they may be rock formations or centuries-old Maori legends). These areas are ripe for change, because at this point the macroscopic properties of the systems they actualise are extremely sensitive to microscopic perturbation, or intervention. An intensity might develop in a situation where the patupaiarehe, the fairy folk of Maori legend, are said to have lived, a situation which might also incorporate, for instance, an ecologically degraded bush remnant, a culvert in an urban stream, a TransMetro railway station and a hundred-year-old oak tree. A large number of intensities have now been identified by the project. Their physical locations have been visited and reviewed by artweb researchers and the possibility of linking them up verified. The result is a virtual map series of a physical network of potential situations.[23] Perturbation will occur through intervention in these situations – artistic, scientific and landscape architectural.

One of the effects of this nonlinear urban strategy is that it problematises the notion of local/global relations in new ways. Global theory is not applicable to dissipative systems organised around particular local sites, and yet the taxonomic schemes used to establish the GIS classifications that identify the sites may themselves be the product of global theory. Different levels tend to act in different ways, however, so that the locality (which is not reducible to the site) intrudes itself as a necessary descriptive feature, defeating, or at least destabilising, totalisation. The map series comprise various levels both of description and behaviour. Events on one level connect with or give way to events on the next, and so on. The connections between levels mean that tiny initial changes can quickly be magnified and brought up to macroscopic expression. For example, a

tiny shift in biotic relationships in a patch of urban vegetation may have an enormous effect on Maori classifications of tapu (sacred) and noa (profane). Movement from level to level is therefore significant. The local and the global reproduce each other so that sometimes universals appear to run through the system, and sometimes not. Each taxonomic system deployed relates different sites together by self-similarity, and in-built procedures permit taxonomies to evolve over time, reflecting local change. The local designates the site within the global at which the self-similarities, characteristic of the system, are reproduced. The way a particular site is understood cannot be separated from the specific organisation of structures, events and relations that characterises it. All places, of course, are potential intensities, which is the same as saying all places are potentially interesting in one way or another.

The necessary infinitude of intensities does not seem to be a problem. After all, intensities are not made, they are found. Every intensity is the product of a diagram that guides the processes that have produced its specific attributes (Somol, 1998; De Landa, 1998; Van Berkel and Bos, 1998). The forces that come to bear in a certain locale (that is to say, for instance, the hydrological structures, local legends, wildlife populations and residential zoning laws) yield structures and forms that are conditioned by the particular topologies of the situation. These resultant structures are continually moving. They are therefore characterised by rhythms, or oscillations, which share qualities with all the other intensities that have formed as a result of the intersection of specific local and global forces. Altering, or disturbing, those forces produces variations in the quality of intensification. While the material and energetic systems that intersect within a locale are capable of generating form on their own, it is possible through intervention to enable specific events to occur that demonstrate the specificity of the interactions of the systems and their ability to become ever-different. Instabilities are introduced into the network by means of interventions that can be operationalised in different ways. For instance, operators may be derived from the qualities of an intensity itself, and used to cause interference in the systems present at a specific locale. Operators can be cartographic, and engage with the representational technologies that are put to work in the graphic realisation of an intensity. They can be ecological, and interfere with the evolutionary development of an intensity's organisational modes (disturbance theory in ecology may have a part to play here). Operators may be political: small, speculative changes to town-planning regulations can cause enormous perturbations in the physical systems that embody these regulations. Currently, artweb researchers are investigating the use of a wide range of these catalysts.

It may turn out to be possible to use the characteristics of the network itself as operational devices. Network qualities have received considerable attention recently from researchers in the physical and social sciences. The emphasis on patterns of organisation rather than on structures has led to recent cross-disciplinary developments in what has come to be called network theory. Scientists

from a range of disciplines (physics, economics, telematics, cell biology, computer technology) have been investigating the hypothesis that network structures have a deep underlying order and operate according to simple but powerful rules. Networks, or 'connected systems' across a variety of situations, (internet search engines, terrorist organisations, living cells) seem to exhibit similar behaviour patterns and structural organisation (Barabasi, 2002).

One of the first properties of networks to be discovered was the relatively small number of links between most nodes of a network. A simple logarithmic pattern is shared by most networks so that nodes come in clusters with short vectors between them. These clusters are themselves served by relatively weak links over relatively long distances that net the clusters into a matrix. "Small worlds", as these clustering networks with many close links and a few distant links are called, are characterised by "hubs", or "connectors", nodes with an extraordinarily large number of links (Buchanan, 2002: 73). Such qualities rarely exist in random networks. They are governed by what are called "power laws", which distribute nodes into large hubs with relatively few links. Power laws often signal a transition from disorder to order and, now that scientists are looking for them, have been spotted in the field of nonlinear dynamics as occurring in phase transitions (the transition point where a system is poised between two phases, such as water on the verge of becoming ice). The significant point here is that nonlinear systems (liquids, magnets, superconductors) display identical power laws in the critical moments as they emerge from disorder. The conclusion drawn from this was that self-organising systems may be mapped mathematically to demonstrate regularities.

Networks grow by adding new nodes, which prefer to attach to the more connected nodes, causing the emergence of a few highly-connected hubs. The rich get richer. Networks are always in a state of emergence. They are dynamical systems that change over time, as a result of organising principles acting at each stage of the network formation process. The scale-free hub topology of the network both accommodates, and is caused by, the evolutionary processes of self-organising dynamic systems. The process of intensity identification in the artweb project seems to have followed the clustering characteristic of networks. More often than not, intensities tend to cluster into groups, a quality which is convenient for two very practical reasons: the forging of pathways between them, and the ability of a cluster to act as a destination for visitors.

Artweb's investigation of self-organisation proceeds from the recognition by a number of urbanists that complexity theory deals with systems whose structure is emergent. This property is a feature of both cities and ecologies, where new elements are continually developing within their morphology. The autocatalytic nature of urban processes is regarded as the driver of urban morphological change. As Daffertshofer, Haken and Portugali (2001) put it: "Self-organisation by no means suggests the absence of any planning in the city ... but rather implies several parallel planning processes: each of the many agents operating in the city – individuals, households, firms, or government agencies – can be viewed as

'urban planner' at a certain scale". Often the problem is a question of focusing and regulating the decision-making processes that are taking place at various levels. In order for the artweb project to investigate the application of nonlinear dynamics to urban processes it must encourage feedback into the system of the project, and it must enhance the energetic resources which supply that feedback. "Without an energy flow of a certain intensity, no system, whether natural or cultural, can gain access to the self-organisation resources constituted by endogenously generated states (attractors) and transitions between those states (bifurcations)" (De Landa, 1999). To achieve this, artweb must reach the largest number of likely constituencies, encourage their involvement and regulate their interaction with the project without discouraging novelty and diversity.

The question is how to build a homeorrhetic system that pushes the project to differing levels of complexity without any particular individuals being in control. The solution was to do this by way of the website, utilising a technique based on the gate-keeping systems used in internet chat rooms, where participants share the role of regulator in turn. Each moderator acts, sequentially, as a catalyst. In the chemistry laboratory, catalysts are chemical substances that 'recognise' more or less specific material and alter its molecular state so that it can react with substances with which it would not normally react. We needed to design a self-regulatory system, perhaps based on a simple set of rules, like the Slashdot.com website rules (Johnson, 2002). All users of artweb can then apply the rules to review and/or filter contributions and proposals. These rules might be something like:

- Exhibit charateristics of non-linearity.
- Promote quality, discourage rubbish.
- Do not allow specific users/contributors to dominate.[24]

In other words, the quality-control job is handed over to the community itself. This would permit a mix of negative and positive feedback, structured randomness, neighbour interactions and decentralised control, by means of the artweb website. The devolution of control is of fundamental importance to the project, and a key element in the claim that it is an inherently nonlinear system with properties of bottom-up self-organisation, autocatalysis, open-endedness and unpredictability. If one of the research questions has been about how to build a self-regulating system that gradually pushes artweb towards an ideal state without any particular individuals being in control, then the moderation of the website is an integral feature of the answer to that question.

Every development on an artweb location – every new artwork, bird species or performance – will also appear on the website. The intention in the next phase of artweb (2005–2006) is to establish remote sensing devices at certain locations, and perhaps even a webcam that can relay real-time data to the artweb website – ecological data such as bird counts to check how many tuis are coming back into the area after revegetation, pollution counts of urban streams, the number of cyclists using the network, as well as images and data from the artworks

associated with the sites. At the website, therefore, a person can call up a map of the Auckland region and select a particular location. A homepage comes up for that location, which identifies its travel coordinates, gives information about the site (such as regularly updated ecological data and the artists involved) and briefly discusses the artwork (or equivalent intervention). It also links to other sites in the artweb project, and to related websites around the world. Visitors to Auckland can readily plan a day trip to several linked sites.

INTERVENTIONS

To date, two artists have been invited to participate in the project by creating interventions in the artweb field. Brief descriptions of the artists' proposals follow.

John Reynolds

John Reynolds's[25] artweb proposal is for cabbage trees to be planted in arrow formation at each intensity selected by the GIS mapping process. Fourteen cabbage trees (*Cordyline spp*) are planted 800mm apart to form a palisade of trunks, and the arrowhead is similarly formed. Each *cordyline* arrow points to a central location in Auckland, the Scented Gardens of the Blind in the Auckland Domain. The cabbage trees are located in a variety of sites selected by the GIS process across the Auckland region. Some arrows are on hillsides, some in industrial zones. Some straddle cadastral lines; some appear to point at walls or houses. The proposal allows various corporations, charitable organisations, schools and individuals to sponsor one arrow each. Each patron owns the arrow (but not the land it is located on) in some far-flung place, and each receives from the artist an image documenting the creation of the arrow. Visitors to the artweb website can call up a map of the arrows as they spread across the Auckland isthmus, and visit each one as it appears in the landscape.

David Hatcher

David Hatcher's[26] proposal, "Key Words", involves the use of a document associated with the founding of Auckland in 1851, the *Charter of Incorporation of Borough of Auckland.* Intensities have been found based on key terms from these documents, which reflect the values and aspirations of the day. These are understood as the current locations of the highest concentrations of the selected concepts in the Auckland region. At these locations, markers are installed as inscriptions reminding Aucklanders of the values on which the city is founded. Terms such as "prosperity", "community" and "efficiency", words close to the heart of business-minded, nineteenth-century settler companies, are employed. If the word "efficiency" is selected, for instance, we set about trying to interpret the legacy of this term in the Auckland of today. We locate the highest concentration of efficiency in the city. Perhaps it is an electrical substation, perhaps it is a small business, perhaps it has ecological implications and involves efficient organisms such as a population of a particular variety of flora in the region. The markers are site-specific, since there are no two locations with the same attributes. In one case it may be a small bronze plaque set into a rock, at another a billboard.

CRITICAL REFLECTIONS

There are many problems associated with the adoption of nonlinearity into design and planning, and some of these have been raised in journals such as *AD* and *ANY*.[27] Several of the issues that have surfaced in the artweb project are not specific to it, and through them the project is connected to a wider set of problematics around the use of mapping techniques as design generators, the role of the designer in community projects, the use of diagrams to disclose design operations and the "drawing out" of "new and latent relationships", as Corner puts it, which can be discerned between different elements of the graphic field that the designer has established (Corner, 1999). These are all important concerns, and it is hoped that this research will assist in finding ways through them.

From the point of view of specific critical reflection on artweb, however, there are more pressing issues to work through as we enter the next phase of the project. These include issues to do with methods of intensity selection, how artists and scientists become involved in the project,[28] the regulating and guiding of arts/science projects, and inevitably, the difficulties associated with explaining the project to lay people, territorial authorities, arts administrators, and even to landscape architects. Some of these questions are critical: is artweb merely a locational device? Does the intensity-based taxonomic technique really leave the synoptic realm of the map behind and drill down to 'life on the ground'? Is it possible or wise to leave the crucial connection to the nonlinear systems that comprise an intensity to artists and designers who may have little interest or background in this?

On this last point, it is clear that involving 'others' in artweb introduces a contingency that destabilises the ideological determinacy inherent in such a project. It also demonstrates the heterogeneity of connections to the movement of self-organisation in the world. For instance, David Hatcher's project may seem at first glance to be restricted to ideas to do with representation and signification, but a close scrutiny of his work shows that the billboards do not merely represent or picture a situation, but permit it to become present within a habitus that obscures or defers from the situation, even as it is constructed by it. Given the political nature of the very idea of a public realm, and the highly politicised activities of commissioning, funding and implementing public art projects, the gradual capture of artweb by local authority administration and/or corporate muscle is also a critical possibility. Readers of this paper will no doubt have many more concerns not acknowledged here, and their feedback is welcome.

CONCLUSION

The artweb team is testing the agency and viability of a complex adaptive systems model for urban development. It has developed a proposal for action research to do this. This consists of the conception of the Auckland region as a space of emergence and propagation, a set of interactive fields of structures and processes that when, as it were, 'disturbed' at certain places, permits the emergence of novel effects. Artweb's organisational energy comes from the discipline of landscape

architecture to provide a function through which it is possible to express the principles, *inter alia*, of immanence, dynamism, continuity and discontinuity. The result is a network of artworks, science projects and other design interventions that attempts to work outside dominant concepts of the city and to engage people in local narratives, local geographies, local negotiations between the specific and the generic, and between the public and the private. It also opens a critique of the monolithic perfectibility of the city as a work of art.

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NOTES

1 Also referred to variously in the quite voluminous literature as a self-organising, nonlinear, emergent or dissipative systems model.

2 There is not enough space in a short essay such as this to provide a full treatment of the issues around 'public art'. Suffice to say that critical discussion begins with the terms themselves. Both 'art' and 'public' have come in for immense scrutiny, especially since *Tilted Arc* and Maya Lin's Vietnam Veterans' Memorial. Landscape architecture has much both to contribute to and to learn from this debate, especially the kind of landscape architectural design purporting to share its conditions, its functions and its responsibilities with works that are more paradigmatically regarded as works of art. See Mitchell, WJT (1992) *Art and the Public Sphere*; Miles, M (1997) *Art Space and the City: Public Art and Urban Futures*; and Deutsche, R (1998) *Evictions: Art and Spatial Politics*, especially the latter, for useful discussions of the negotiations between ideas to do with art and ideas to do with the public realm. A key text for all three is Habermas, J (1989) *The Structural Transformation of the Public Sphere: An Enquiry into a Category of Bourgoise Society*.

3 It also questions the cosy relationship developing between landscape and urbanism by requiring a critical revaluation of landscape architecture's habits of practice, particularly the understanding of normative practice as that which accepts and instantiates normative civic values.

4 Because of the diverse practices of those invited to participate in artweb, the notion of critical and creative engagement necessarily and importantly covers an enormous range of techniques and modes of operation.

5 The term "*terrain vague*" was invented by architect Ignasi Sola-Morales Rubio (2002), and refers to urban space that is "empty, abandoned, available", unengaged and void and yet implying "promise, the space of the possible, of expectation".

6 Taniwha are creatures of Maori legend that live in streams, rivers, lakes and seas.

7 Site designs that have an analogical relationship to self-organisation have been completed, the most famous being Koolhaas and Mau's *Tree City*, for Downsview Park, Toronto, and Corner's competition entry for the same site, but the author has found no actual design strategies that are themselves self-organising (although, see Barnett (2001) for a report on a design studio where the process of design itself is nonlinear.

8 Artweb differs from General Systems Theory (GST) in some major respects. GST was to a certain extent, for instance, teleological. "Systems were guided not only by mechanical forces, but also moved towards certain goals of self-realisation" Skyttner, L (1996) *General Systems Theory: An Introduction*. Neither did it deal with emergent properties well: "The Systems Approach ... looks at a system from the top down rather than from the bottom up" (Skyttner, 1996: 25).

9 Artweb uses the notion of 'field' in the Einsteinian sense, as a four-dimensional manifold, not, as it sometimes seems to be understood, as a rather flat three-dimensional system evolving according to a separate and external one-dimensional time. Each artweb intensity ('inertial system' in Einsteinese) expresses its own particular time, determined as a mutual relation of events to the frame in which it is registered. Space-time is a field which cannot be reduced to component dimensions or conditions.

10 This ancient formulation goes as follows: The One, Nature with a capital "N", is being. It is eternal and unmoving. The many, the 'phenomena', those things which change state, which

'become', which 'emerge' and fade away, are transitory and mutable. Only the One is real, all else is illusion. Of this formulation Deleuze and Guattari (1987:5), in *A Thousand Plateaus*, famously state: "One becomes two: whenever we encounter this formula ... what we have before us is the most classical and well-reflected, oldest and weariest kind of thought". Also see Alain Badiou, (2000) *Deleuze: The Clamour of Being*, for a critique of Deleuze's own monism.

11 There were myriad variations on these themes. See the author's paper "The Nature of Urban Space" for a more detailed discussion.

12 Of course it was more complex than this generalisation. Many scholastics were influenced as much by Plato as Aristotle, and the magician-philosophers of the Renaissance cleaved to much that was Aristotelian in origin. For instance, the four elements underpinned the theory of correspondences.

13 This interdisciplinary movement has been accelerated by the philosophical work of Gilles Deleuze and Michel Serres, both popular sources of 'theory' among artists and designers and their critics.

14 The major break here for landscape architecture is Einstein's emancipation of the field concept from any association with a substratum (the One) as a bearer of forces and events (the many). Forces and events are imminent in the field.

15 For example, uniform temperature throughout a liquid that changes from conduction to convection.

16 Interestingly, this relationship has been investigated in gardens for thousands of years. "Dissipative Gardens" is the subject of a chapter of the author's PhD thesis.

17 It is the sudden move across levels of organisation that inspired the title of Charles Jencks's book, *The Architecture of the Jumping Universe.*

18 De Landa calls rhizomatic structures "meshworks".

19 For example, Capra (1996) and Gleick (1998).

20 "Homeorrhesis" refers to the self-organising attributes of an ecosystem, including its ability to move through far-from-equilibrium conditions to higher orders of complexity.

21 Deleuze uses Duns Scotus' term "haecceity" ("this-ness") to describe the mode of individuation that the word "intensity" here seeks to connote: "A season, a writer, a summer, an hour, a date have a perfect individuality lacking nothing, even though their individuality is different from that of a thing or a subject." See Deleuze and Guattari (1987: 261).

22 "Culture-system" is an anthropological term, used by Clifford Geertz. It is not ideal, but I can think of no other that captures the range of epistemological, behavioural, affective and linguistic practices that characterise what Serres refers to as "regional epistemologies" and Foucault as "epistemes". Latour uses the useful portmanteau "natures-cultures" to describe the socio-cultural field to which I am alluding, a phrase which incorporates the constructed and plural dimension of nature-culture relations; but "natures-cultures systems" is rather a mouthful.

23 The use of the word "situation" implies a vastly wider aggregation of structures and forces than the word "site". Alain Badiou (2000: 64) describes the situation as "an ordinary multiple, a multiple that is obviously infinite because all situations in reality are infinite. It can be a historical, political, artistic, or mathematic situation; it can even be a subjective situation. I take situation in an exceptionally open sense, and to capture that openness I say it's a multiplicity".

24 Visit Craig Reynolds' "Boids" website to see three simple rules producing complex self-organising behaviour, <http://www.red3d.com/cwr/boids/> (last accessed 2 December 2004).

25 John Reynolds is a major New Zealand artist. He has won many awards for his painting, and has exhibited in all major galleries in New Zealand and many overseas.

26 David Hatcher is a New Zealand artist, resident in Los Angeles and Berlin. He exhibits regularly internationally and is currently developing a series of works based on the diagrams of philosophers.

27 See the following journal articles for discussions of nonlinearity in design (the list is by no means exhaustive): Davidson, P and Bates, DL with Kipnis, J (1997) Future Generations University, in *AD Architecture After Geometry*, Vol 67, No 5/6, p 32. Bettum, J and Heusel, M (2000) Channelling Systems, in Rahim, A (ed) *AD Contemporary Processes in Architecture*, Vol 70, No 3, p 40. Corner, J (1999) Field Operations, in *AD Architecture of the Borderlines*, Vol 69, pp 7–8. Rahim, A (2000) Systemic Delay: Breaking the Mold, in Rahim, A (ed) *Contemporary Processes in Architecture*, p 6. Allen, S (1997) Field Conditions, in *AD Architecture After Geometry*, Vol 76, No 5/6, p 24. Editorial, (2000) in *Environment and Planning B: Planning and Design*, 27(2) March. Ho, Mae-Wan (1997) The New Age of the Organism, in Jencks, C (ed) *New Science = New Architecture, AD*, Vol 67, No 9/10, Sept–Oct. Saunders, PT (1997) Nonlinearity: What It Is and Why It Matters, in Jencks, C (ed) *New Science = New Architecture, AD*, Vol 67, No 9/10, Sept–Oct. Jencks, C (1997) Editorial, in Jencks, C (ed) *New Science = New Architecture, AD*, Vol 67, No 9/10, Sept–Oct.

28 From the outset of the research, the writer has favoured establishing a relational database of arts practices and using a selection method based not on name or reputation but on matching certain types of arts practice with certain taxonomies. Arts advisors to the project, however, have argued that this could lead to 'bad' art being selected. Initial commissions, therefore, have been on the basis of working with artists of the highest calibre, at least in the early stages of the project.