A Disturbance Ecology Model for Pacific Urbanism

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ABSTRACT

Cyclones devastate Pacific urban centres regularly. Rebuilding is always difficult, for several reasons. Issues to do with the physical characteristics of islands, their social histories, land tenure systems, and the politics of overseas aid, let alone the pressure it puts on internal economics, make the sustainable planning and reconstruction of settlements a complex matter.

The natural landscapes of these islands, however, always recover quickly. The re-emergence and recovery of flora and fauna and the ecosystems they are part of occurs within three to six months of a major disturbance event, such as a cyclone or tsunami. The regenerative power of the landscape is very apparent, but the architectural and infrastructural components of island settlements come back only very slowly.

This paper suggests that a self-organising model for Pacific settlement planning and design may be the answer to the problem of recovery in Pacific urbanism. The model is based on the process of adventive biotic colonization. Ecosystems are complex adaptive systems which are in constant flux due to (natural and human) disturbance. Using as a case study post-cyclone Alofi, the capital of Niue, we draw on the natural history of that island to propose a time-based and ecosystem-led urban design strategy derived from disturbance ecology.

The paper develops first a strategy for Pacific urban planning and design, based on the Alofi example, and then speculates on possibilities for the testing of that strategy by means of a complex adaptive systems model. It proposes a model for an urban recovery scenario that operates in the manner of a nonlinear colonization-succession-disturbance sequence. The model will provide the basis for both generic and specific urban recovery projects that involve the planning, design and construction of devastated settlements in the Pacific.

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Approximately 11% of the total hurricanes worldwide occur in the South Pacific: they are a natural and expected regular event (Nunn, 1994, p. 165). While many cyclones cause only slight damage, occasionally they strike with devastating force. From an ecological point of view cyclones are a necessary part of the natural cycle that enables diverse island landscapes to regulate their condition. Self-organising systems such as ecosystems are homeorrhetic, which is to say they evolve by being pushed to far-from-equilibrium conditions, experiencing cataclysm and then shifting to a new order of complexity (Odum, 1997, p. 72). Using Alofi, the cyclone-devastated capital of Niue, as a case study, this paper describes possibilities presented by a self-organising model for urban redevelopment informed by the island's natural history. Such a model must work within the conditions imposed by both environmental and historical parameters.

The application of organic metaphors for the development of urban centres has a long history, but a resurgence of architectural interest in this figure over the last decade has taken a new direction. It is now the ecosystem, conceived as an interactive web of dynamic relations, that interests many architects and urbanists (see for example Batty, 2000, p.167-8; Salingaros, 2000). Of the more recent projects that utilise time-based ecosystem processes, some employ them as metaphor, others as models. A Future Generations University competition entry (Davidson and Bates, 1997), for example, makes of the components of the campus a metaphorical analogue for the components of an ecosystem. On the other hand Koolhaas and Mau's *Tree* City (Waldheim, 2001), uses the ecosystem as a model to generate an urban development strategy. The difference is critical. A model demonstrates how an organization functions, or provides evidence for a proposition. It does something. A model has inputs and outputs. A metaphor does not operate in this way. Borrowing language and imagery from one realm to describe or establish research or practice in another, metaphors evoke, qualify, resonate, by creating new relationships between things. Metaphors relate elements in totally different ways from models. Metaphors do not have outputs (see Arida, 2002; and Holland, 2000 for further discussion of this distinction). Architectural interest in ecosystems most often works at the level of metaphor. This paper outlines the proposal for a model.

The architectural object has flirted with complex adaptive systems theory, but the real power of process-based design has been felt in architectural urbanism, a fact which may partially account for the number of architectural practices moving into urban design. Like an ecosystem, the urban field may be understood as an interactive dynamic system whose conditions and operations undergo continual change (see Allen, 1997; and DeLanda, 1999). For instance, in *Tree City* Koolhaas uses nonlinear systems as a design model, exploring the open-endedness and self-organisational qualities of

ecosystems as they are now understood. Landscape architects have worked with ecosystem dynamics for decades (see for instance, McHarg, 1992; and Thompson and Steiner, 1997), but in landscape architecture the application of the ecosystem model to urban projects has mostly been confined to ameliorative natural systems restoration rather than to the forging of new strategies for the development of complex urban systems such as greenfields subdivisions and inner city redevelopments.[i] The emerging discipline of ruderal ecology, the study of urban margins and abandoned urban terrain, offers a practical link between landscape architecture and urbanism. A cyclone-devastated terrain is not dissimilar to other damaged urban landscapes such as bombsites and abandoned industrial areas which, over time, can be sites of natural reclamation and ecological succession; sites which develop richly diverse flora and fauna. The key feature of ruderal ecology is that its subject is specifically urban. The flora and fauna that comprise urban ecologies are usually unique, and bear little resemblance to the biotic composition of the surrounding countryside.

Ruderal ecology has developed as a consequence of changes in the discipline of ecology in general. Ecologists no longer hold the Clemensian view of ecosystems as closed, self-regulating, stable systems, which establish relatively enduring communities and a defined climax community (Clements, 1991). Ecosystems are now seen as open systems in constant flux due both to natural and to human-induced disturbance.[ii] Disturbance theory is playing an increasingly important role in the interpretation and understanding of ecosystem functioning. Disorder is regarded as necessary to 'healthy' landscapes. Disturbance, however, is just part of a larger cycle which includes colonisation and succession (Bell, 1999).

A recent example of the destructive power of cyclones can be seen on Niue, one the world's smallest independent nations, located between Tonga and the Cook Islands in the South Pacific. When tropical cyclone Heta struck the capital, Alofi, on January 5th 2004, the southern district of the town was completely destroyed. Infrastructure losses included government buildings such as the hospital and nurses' home, commercial buildings and the museum. The rest of Alofi and the west coast of the island suffered severe damage. It is unknown exactly how strong the winds were, but the last recorded wind-speed measured at the airport was 300km per hour, just before the device disintegrated. While the wind was extremely powerful, it was, in this instance, the sea that caused most of the damage. Alofi is perched on a narrow terrace 28m above sea-level, but this cyclone was sufficiently strong to push large quantities of water before it as it travelled over the surface of the ocean, causing dramatic, localised, sea-level rise. Massive waves, surfing on the elevated sea level, then swept over the town, obliterating everything before them.

Like many other Pacific centres similarly affected, Niue struggled after this cyclone with the problems associated with rebuilding. Various powerful constraints impeded the rebuilding process. In the case of

Alofi many of these constraints are historical in origin and operate at different scales. At the national scale there are economic or budgetary constraints; at the local scale land tenure issues limit the availability of suitable land on which to build; at the level of the individual site the quality of the existing building stock is extremely poor, and the type unsuited to these forces.

Niue is heavily reliant on aid and remittances which form the core of the economy. Sources of external revenue - such as agriculture and tourism are extremely limited. Immediately following the cyclone there were suggestions (in New Zealand, at least) that the damage may be more than Niue's fragile economy could withstand, and that the island should return to New Zealand rule (for example see Fisher, 2004; Editorial, 2004). These suggestions have now been shelved, but the problem of funding the recovery process remains. Any form of development requires substantial funds, but the amount required to re-establish Niue's infrastructure is enormous. Rebuilding urban areas after such events is therefore problematic, especially for those nations with very small economies. While international aid plays an important role in the re-building process there are several drawbacks to securing this kind of assistance, however, not the least being that these organisations are driven by their own agendas, and funds are generally tightly tied to these. There is also an enormous amount of paperwork associated with the securing of such funds, and then by the reporting requirements which are burdensome and costly for a small public service. History shows that money for urban redevelopment is unlikely to be easily obtained.

In the Niue example, problems of rebuilding were exacerbated by issues associated with land tenure. The part of town that was most damaged by the waves happened to be where many key government services and facilities, such as the hospital, nurses home, dental clinic, the government-owned hotel and the museum, were located. This area has been declared unsuitable for redevelopment, forcing their relocation elsewhere within Alofi. But this is problematic as the crown only holds very small areas of land in the 'safe-building zones' of Alofi, the rest being held under traditional land tenure arrangement by family groups who are unwilling to sell to the Government. One option available to the government is to legislate and force landowners to sell or lease their land to the state, but Niue has a long history of land disputes, and this option is not desirable. It appears that the favoured alternative is for the government to relocate essential services where it can obtain land; these locations, however, are not amenable to cohesive urban development.

Pre-cyclone Alofi, while tiny in population[iii], was sprawled, ribbon-like, along five and a half kilometres of road. A major planning exercise undertaken in 1992 by Riddell, a planner who has worked extensively in the Pacific, addressed many of the dispersal problems, but his proposal was only partially implemented (Riddell, 1992). He identified Alofi as having a weak inflection to place and an overall lack of cohesion, and addressed this by grouping together some key facilities - including tourist shops, the

post office, bank and grocery stores - around an existing green space. This was the beginning of a centre for Alofi, but his plan was only partially implemented. The devastation wreaked by cyclone Heta has provided the opportunity to develop Riddell's initiative further by taking a different approach.

While the temptation is to plan and design an urban infrastructure that will resist or at least minimize future cyclonic devastation, and to implement this through incremental injections of targeted aid packages which focus on architectural reconstruction, it is apparent that redevelopment in Alofi will not occur rapidly. Nor does it appear likely that an 'ideal' scenario in the form of a massive reconstruction package can be made available.

The redevelopment model suggested in this paper rethinks the notion of 'devastation.' Just as forest fires have been reconceived by landscape ecologists as necessary to, rather than destructive of, natural forest landscapes, and forest management practices have been adjusted accordingly, the episodic cyclonic disturbance of small island states such as Niue may prompt a revaluation of tropical urbanism. The influence of cyclones on Pacific island urban infrastructure provides an opportunity to consider how urban development may be conceived in terms of ecosystem forces and cycles. Pacific islands require an urban infrastructure that can operate under dynamic, fluctuating conditions. If they are conceived not as an ordered, rigid distribution of architectural objects, but as a socio-spatial pattern that can change and evolve, cyclone devastated urban areas might self-organise into resilient urban ecologies.

A strategy is required which can accommodate multiple constraints, yet offer realistic and achievable outcomes in the short term. A strong emphasis on landscape operations may result in a physical community infrastructure that, like biotic communities, responds positively and appropriately according to the long processes of evolutionary change. Used as an urbanization model rather than as a metaphor, the colonization-succession-disturbance process offers an alternative to formal intervention-based cultural aesthetic models which are currently the norm.[iv] Three months after the cyclone in Niue, clean-up operations were still underway and the rebuilding process no where near begun, but the regenerative power of the landscape had become very apparent. Plants had already begun to colonise the extensive areas of bare rubble left in the wake of the cyclone, and in other, less damaged areas, the re-emergence and recovery of the flora was clear. The town of Alofi, situated on its narrow terrace, occupies a dramatic edge. In ecology, edge conditions are the most rich and complex, for they undergo continual disturbance. It is in this dynamic threshold between one kind of landscape and another, vulnerable and exposed, consisting of elements from both landscapes, that colonisation and succession processes are most active. In this notion we find a significant proposition for Alofi. Biota that subsist in edge conditions must change in order to survive. Perhaps the town of Alofi must likewise accept continual revaluation and transformation.

How does colonization occur in biotic communities? Environmental factors such as soil conditions, winds, water, insects, animals and birds are key elements. Most important is the availability of a source of seeds of different species of plants. The interaction of these environmental processes contributes to the development of plant communities within a nested hierarchy of relational ecosystems. These communities are not only adapted to the local environmental conditions, but the environmental conditions are constitutive of the ecosystems that comprise them. Colonisation proceeds from within. Succession occurs over time as plant communities develop through interaction with other processes and provide the conditions for further colonisation and growth. There is no end to succession. The notion of climax communities is now redundant, a product of a lingering teleological conception of succession. Instead there is only change. Inevitably cataclysm occurs in the form of fire, eruption, earthquake or indeed human activity. Without such perturbations there would be no complexity. Nobel Prize-winning physicist Ilya Prigogine describes the mathematics of these complex adaptive systems in his classic text *Order Out of Chaos* (Prigogine and Stengers, 1984).

Succession forms the basis of the proposed model. In the natural environment of Niue an extensive biotic diversity cycles through various stages of succession at the same time. Historically, the principal vegetation of Niue consisted of tropical rain forest which occupied the main central portion of the island (Trotter, 1979, p. 5). This forest type is very tall and dense in nature, but only a small portion remains. Forest nearer the coast was less tall due to its exposure to wind, and this pattern is evident on the more hostile eastern coast, where small, wind-sheared trees still predominate. Currently, indigenous vascular plant species account for roughly only a quarter of the species on Niue, the rest being introduced (including coconut, taro, yam and banana) (Skyes, 1970). While the original vegetative cover has been greatly modified by human intervention, there is still a very strong arboreal matrix of native and exotic species. This matrix is driven through successive phases by a huge range of propagules adapted to a range of conditions. The regenerative capacity of the flora is therefore robust - there are multiple starting points for new colonies in environmentally specific conditions. Different micro-environments are composed of different mixes derived from the surrounding matrix. The clue here for the urban development of Alofi is to provide a heterogeneous mix of forms that respond to a particular set of initial conditions. These ‘colonisers’ will change their local environment, which as it changes permits a greater range of urban elements to establish.

How then could succession be used as a model in Pacific island settlements, given that each island nation’s biogeography and culture are specific? At this stage there seem to be two directions we could follow. We could devise a general model that is able to be adapted to different island conditions by plugging specific conditions into it. Such variables as cyclonic frequency and trajectory, species resilience to disturbance, geological formation, settlement pattern, land tenure, kinship system, water supply and political organisation (to name a few) would have to be able to be factored in. Or we could

begin with a specific model devised for a specific place, test the model through design, and then adapt it to three or four other islands before generalising from it. (We are well aware that the relationship between model and design strategy is critical and, at this stage, un-theorised).

Rather than present the possibilities for both strategies, in what follows we tentatively describe how the latter strategy might proceed, using Alofi as an example. We do not proffer a model. Rather, we paint a word picture of the kind of development scenario we have in mind. In this scenario urban regeneration would begin with three types of colonisation - by plants, buildings and infrastructure. In the first instance, adventive biotic colonisation is already occurring, with the best-suited plants gaining a foothold in the most devastated areas. This could be supplemented by directed large shade-tree planting in groups, avenues and groves wherever possible, to form a vegetative urban structure based on the tropical requirement for shade as an urban amenity. Only one species of tree should be used for this operation, such as the introduced rain tree (*Albizia saman*) or the poinciana (*Poinciana regia*) for example, so as to provide some initial organization and form. These trees grow extremely fast in tropical environments. Secondly, architectural components (inexpensive, relocatable and high quality) can then be introduced to sites selected according to three criteria;
1) they are immediately available (the buildings can be moved, or reconstructed, as other sites become available)
2) they are linked by pedestrian desire lines, both existing and in the process of formation.
3) they are close to the new tree plantings.
A further operation would be the laying of services across the surface of the landscape. Electricity and water could be distributed through surficial conduits that can be readily repaired and/or relocated. Along with pedestrian routes these vectors could form the energetic pathways that link the nodes of the urban ecosystem. At particular places anointed by popular usage, seats and drinking fountains may be placed under the shade of the urban trees. The location of these elements, too, can change, as the urban formation evolves.

Thus the fostering of human movement through Alofi can be achieved through tree planting, providing plentiful shade: a key requirement of any pedestrian activity in the tropics. The cohesion provided by the vegetation and the strong pedestrian links would minimise the effect of the indeterminate location of the buildings and services. Instead of a car-dominated urban layout, which has engendered the current ribbon development of Alofi, a clustering strategy drawn from plant seed-dispersal patterns could be adopted, permitting greater ease of pedestrian access and more efficient use of available redevelopment sites. With respect to buildings a construction methodology that allows refabrication could be considered. Cyclone damage could be repaired from existing materials without massive operational costs for the clearance of demolished buildings, and the construction of new ones.

A sucession model for Alofi would depict the town as always emergent and without final form. It would require that its planners, administrators and inhabitants accept its constant state of flux, as long as local and specific services are being delivered to the places and in the ways the community expects and desires. Recolonised by plants and buildings according to patterns of customary usage, Alofi would begin to develop a spatial organisation that can change and evolve because there is no massive financial investment in infrastructure. The urban succession that thus takes place occurs according to local environmental and community conditions.

In order for such a new kind of model for Alofi to be developed, a first step would be the modelling of the traditional morphology of a Niue village. This would describe housing typologies, linkages between activities and spatial patterns, the point centres of village life (market, church, hospital, chief's dwelling, community house etc) and the relationships between these and the village and natural ecologies that constitute the larger morphological patterns and networks of Niue settlement. A model of traditional village structure would also show the patterns of social, economic and cultural flows in which the codes of Pacific life are embedded, revealing the 'infrastructural regimes' depicted in the model as diagrams of village organisation. These social and cultural codes would have to address the issues raised earlier, to do with the limits imposed on development by traditional land tenure systems. Niuean community patterns would also have to be factored in.

By means of an open-ended and 'bottom-up' strategy, sites may slowly become available for the development of buildings, public open space, paths or roadways. These sites would necessarily have an indeterminate future, either left to continue successional processes or be reclaimed as required. Logically, it would not matter if redevelopment occurs over extended periods of time, as the 'long durée' itself is an important factor within an urban succession strategy. Logistically, however, the community would require shelter and infrastructural re-establishment to occur expeditiously. Performatively, an ecological model of Pacific urbanism would have to enable a more rapid return to pre-cyclone conditions than formal models, and would ideally mimic the short time frames in which tropical re-vegetative processes occur.

A generalised model would require similar performative measures. In this case, traditional island settlement patterns would be need to be mapped in countries such as Tonga, Samoa, Solomon Islands, Fiji and Niue. These mappings, cross-referenced with ecosystem mappings from the same regions, would provide the basis for a succession model of Pacific urbanism.

In order to decide which of the above approaches to work with, we need to learn more about the modelling of self-organising systems. The next phase of this research therefore involves exploring existing paradigms for modelling what are essentially complex adaptive systems, whether they be

ecosystems or human settlements. A number of other urban theorists are working with the notion of human settlements as self-organising systems.[v] For instance, Salingaros (2000) identified 'almost perfect urban coherence' within the *favelas* and squatter settlements of the third world: settlements which he found to follow the mathematical laws of a developing complex system very closely. Given that Pacific island communities bear many similarities to these third world squatter settlements, in that they arise under conditions without strong planning controls, and that in many instances growth tends to be owner-controlled, it is reasonable to assume that urban development may respond positively to a model based on succession over time. We do not suggest that our proposed model be set in action and left to its own devices. The model must inform a design strategy. While *favelas* and squatter settlements may have excellent urban coherence, the actual living conditions are very poor in terms of water, sanitation and utilities. The proposed model would generate a design strategy which, while flexible and even unpredictable, could operate within an overall framework that includes, on the one hand, landscape, architecture and infrastructure and, on the other social and cultural traditions, familial relationships and individual aspirations.

This model, effectively a dynamic human living-space diagram, would draw on a tradition of landscape ecology that defines the landscape broadly as a total spatial and visual mosaic, integrating the environment, living systems and human-made structures in a kind of hybrid urbanism. We foresee dense clusters of activity within a common ecology that delivers a settlement morphology quite different from the automobile-driven string of amenities currently in place. While a linear organisation of village elements is common in European settlement patterns, island biogeography (and climate change) would seem to hint at the re-emergence of traditional linkages between activities and spatial patterns, forming islands of local order within a matrix of overlapping biotic and geological systems.

Conclusion

Until the modern period, processes of urbanisation have occurred according to local and specific conditions. The architecture and layout of traditional Pacific island settlements, with their customary building materials and community-generated patterns of organization, are a case in point.[vi] The importation of architectural and urbanization practices from countries that are not subject to the cataclysmic instabilities of cyclonic ecologies may be inappropriate for settlements such as Alofi. Ecological resilience is not a matter of withstanding sudden devastating force, but of deep organisational patterns that absorb it and use it catalytically as energetic material for continual reorganisation.

With a generic model, the challenge for the researchers would be to devise a relatively simple model for Pacific urban complex adaptive systems which, while acknowledging the multiple variables that govern

and inform succession, could readily be adapted to the specific conditions of place. If, on the other hand, we were to begin with a single township, a specific set of human-environment relations would be used to generate and inform a design strategy that tested the model. If it showed promise it could be adapted to other circumstances.

Pacific island communities which are particularly vulnerable to cyclonic events generally have limited resources to aid the recovery process. The speculative models outlined in this paper look towards supporting this process by developing a realistic, achievable, sustainable approach to urbanism that develops over time and adapts to changing conditions.

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[i] There are some exceptions. See Barnett, R. (2005) Artweb: a nonlinear model for urban development. *Landscape Review,* 9**,** pp. 26-44.for the application of self-organisation to an urban project in landscape architecture.

[ii] Froman and Godron describe disturbance as 'a major natural process of landscape development.' (see Froman, R. T. T. and Godron, M. (1986) *Landscape Ecology,* Wiley, New York. Pickett and White state that disturbance is an event that disrupts the function of ecosystems over widely ranging temporal and spatial scales (see Pickett, S. T. and White, P. S. (eds.) (1985) *Ecology of Natural Disturbance and Patch Dynamics,* Academic Press, Florida.). The type, intensity and frequency of disturbance affects patch dynamics and resulting landscape mosaic.

[iii] The current population stands at around 1,500 people.

[iv] We would argue that many of the problems identified by Connel and Lea (Connel, J. and Lea, J. (2002) *Urbanism in the Island Pacific,* Routledge, London.) are caused by the fact that western cultural aesthetic models have become standard in Pacific urbanism.

[v] Recent papers on what has come to be called Landscape Urbanism point in this direction. See Mostafavi, M. and Najle, C. (2000) Urbanism as Landscape? *A. A. Files 42,* Architectural Association, London; *Landscape Urbanism* (1997) <www.uic.edu:80/dept/arch/up/ucn.html#01>; Schumacher, P. (2002) Autopoesis of a Residential Community, *Negotiate my Boundary!: Mass-customization and responsive environments*, (eds. +RAMTV and Steel, B), Architectural Association, London; and *Landscape Urbanism: A Manual for the Mechinic Landscape*, Architectural Association, London.

[vi] See Connel and Lea, *Urbanism in the Island Pacific*, p. 212: 'Pacific urbanism emphasises the role of historical specificity, plurality and difference; ultimately there are few universals in a region where culture (and emotion) are of pervasive importance.'