RE-DEFINING CUTTING EDGE SUSTAINABLE DESIGN: FROM ECO-EFFICIENCY TO REGENERATIVE DEVELOPMENT

MAIBRITT PEDERSEN ZARI (1) AND SARAH JENKIN (2)

(1) School of Architecture, Victoria University, Wellington, New Zealand
maibritt.pedersen@vuw.ac.nz

(2) URS New Zealand, Wellington, New Zealand
sarah_jenkin@urscorp.com

ABSTRACT

This paper explores the concept of a living systems approach to the built environment through the adoption of strategies such as regenerative development and eco-effectiveness. The research examines the differences and connections between these new concepts of sustainable architecture and design, compares these to current typical design approaches, and evaluates their effectiveness as a means to contribute to future development over the short, medium and long terms. Benefits and difficulties with each approach are elaborated upon, and a series of recommendations are made for future design, development, planning and policy directions, using New Zealand as an example case. The paper concludes that focusing on a goal of ecological and community regeneration, where success is measured by improvements in health and wellbeing for humans, other living beings and ecosystems, could contribute to a more resilient built environment which is better able to adapt to the pressures of peak oil, climate change and economic change.

KEYWORDS:

Regeneration; eco-effectiveness; cradle to cradle; eco-efficiency.

INTRODUCTION

The definition of a truly sustainable built environment is changing rapidly. Aiming for 'neutral' or 'zero' environmental outcomes in terms of energy use, carbon emissions, waste generation, or water use are worthwhile targets. However, designers and occupiers of the built environment have the opportunity to limit future negative environmental outcomes and produce net positive environmental benefits. In order to do this, the built environment would need to produce more than it consumes as well as remediate past pollution and environmental damage. This is a departure from the idea that the best the built environment can be is 'neutral' in relation to the living world. Strategies such as regenerative development, eco-effectiveness, and eco-efficiency may contribute to achievement of this goal.

It is important to recognise that the built environment does not solely comprise buildings, infrastructure and public spaces; it also includes human community and cultural experiences. The relationship between these components influences how the built environment develops over time and contributes to creating a 'sense of place'. The 'sense of place' is the character or essence of a location, comprising all features whether they are natural or constructed.

In 2008 the New Zealand Ministry for the Environment commissioned a discussion document entitled 'Rethinking our Built Environment' to explore regenerative and related cutting edge development concepts for the New Zealand context. That document explores the ideas touched upon in this paper further, providing case studies and additional references (Jenkin and Pedersen Zari, 2009).

A SUSTAINABLE BUILT ENVIRONMENT - THE NEW ZEALAND CONTEXT

The majority of the world's population now live in urban environments. Urban development is rapid, and its environmental effects are long-lasting (Grimm, et al., 2008). In New Zealand the built environment is responsible for half of the country's waste; up to forty percent of all materials used; a quarter of all water and energy consumed; and a fifth of greenhouse gas emissions, not including embodied energy in materials (Sinclair Knight Merz, 2008). New Zealanders have developed a growing awareness, particularly over the last five years, of the importance of a sustainable built environment that can address these negative impacts, while at the same time increase the quality of the built environment. This is reflected in a number of ways, including the development of the New Zealand Urban Design Protocol; establishment of the New Zealand Green Building Council and the Green Star rating scheme and tools; review of the Building Code; and establishment of built environment sustainability research consortia such as Beacon Pathway.

The increase in demand for sustainable buildings may be due to a number of factors including lower operating costs; increased occupant satisfaction and health; increased adaptability of the building; an increased understanding of the necessity of addressing environmental issues; and a general global trend towards sustainable building increasing market demand (Fullbrook & Jackson, 2006). 'Business as usual' in the New Zealand built environment is therefore changing rapidly to include green or high performance building design, termed here 'eco-efficiency'.

Eco-efficiency is the concept of creating the same or better outcomes while using fewer resources and producing less waste and pollution, achieved through the delivery of '*competitively priced goods and services that satisfy human needs and bring quality of life while progressively reducing environmental impacts of goods and resource intensity throughout the entire life-cycle to a level at least in line with the Earth's estimated carrying capacity*' (DeSimone & Popoff, 2000).

Eco-efficient design, whilst an improvement on conventional design, ultimately still results in negative environmental impact. The ecosystems required to support healthy human communities and economies continue to degrade over time, but presumably at a slower rate (Reed, 2007b). Despite a rapid increase in the uptake of eco-efficiency in New Zealand's built environment (which is to be encouraged) the majority of new and existing buildings in New Zealand still take few such aspects into account. It is necessary to consider whether current actions are sufficient to bridge the gap between the existing built environment and that which would constitute a truly sustainable built environment. Given the predicted impact of environmental issues such as climate change, and the timescale some experts suggest is available to make changes to avoid substantial damage (IPCC, 2007), current actions may not be an adequate response to the problem beyond the short term.

LIVING SYSTEMS IN ARCHITECTURE AND DESIGN

The goal of a truly sustainable built environment is restoration or regeneration, where success is measured by improvements in health and wellbeing for humans, other living beings, and ecosystems as a whole (Kellert, 2004; McDonough & Braungart, 2002; Reed, 2007b). A regenerative built environment becomes a conduit for producing resources and energy; remediating past pollution; and transforming and filtering waste into health giving resources. This requires a living or whole-systems approach to development that takes into account both the human and non-human ecology of the built environment.

In taking a living-systems approach, a more expansive notion of the built environment is required; one where dynamic relationships exist between a greater number of built and un-built elements and where a balanced, enduring relationship between these elements is explored (Moffatt & Kohler, 2008). Buildings should not be considered as individual objects, but rather designed to become parts of larger systems.

A systems approach to development is not new (Reed, 2007a). Patrick Geddes (1854-1932) for example, emphasised connections between city and the countryside. Geddes developed a theory of 'biopolis', a two-pronged approach to viewing the city as an organic entity (Heinonen, et al., 2006). Moffatt et al (2008) refer to 1930's German landscape architect Leberecht Migge, who formulated

and implemented principles of urban metabolism in developing social housing for workers; a balanced socio-ecological metabolism for organics. Authors such as Leopold (1949), McHarg (1992) and Van der Ryn (2005) also explore the relationship between nature and humans in terms of development.

EMERGING CONCEPTS IN LIVING SYSTEMS – CONVERGENCES AND DIVERGENCES

There are several concepts worthy of exploration for moving beyond an eco-efficiency paradigm.

Regenerative Development

Regenerative development acknowledges humans, as well as their developments, social structures, and cultural concerns, as an inherent and indivisible part of ecosystems. Regenerative development investigates how humans can participate in ecosystems through development, to create optimum health for both human communities (physically, psychologically, socially, culturally, and economically) and other living organisms and systems.

Understanding the unique and diverse human and non-human elements of each place is a crucial part of regenerative development (Cole, et al., 2006). This results in a deep understanding of the 'sense of place', and a localised response to environmental challenges and opportunities. This approach implies that built environments could be designed to produce more energy and resources than they consume, and to transform and filter waste into health giving resources (Pedersen Zari & Storey, 2007). Reed (2007b) describes this approach to design as *'building capacity not things'*. Regenerative development aims to restore or create the capacity of eco-systems and biogeochemical cycles (carbon, hydrological, nitrogen etc) to function optimally without constant human intervention.

Regenerative design is also about relationships between humans and the natural environment, between buildings and their occupants, and between natural and constructed environments. Regeneration therefore is a process of engagement rather than a set of outcomes. This process of engagement has significant environmental, economic, social and cultural benefits related to community building and participation.

A systems-based approach is crucial to regenerative design and development, to support a constantly dynamic and responsive built environment which evolves over time. This is a key difference between regenerative design and eco-efficiency. Regenerative development is a positive contributor to the living systems (biotic and human) in which it occurs; is an instrument for achieving true sustainability through creating living systems with the capacity to continuously evolve; and is a source of deeper meaning and significance for all who engage in it (Reed, 2007b).

Pedersen Zari (2009) and Reed (2007b) discuss several characteristics of regenerative development. They point out that an understanding of the whole system or master pattern of place beyond site boundaries is required, designs are based on local reality (both ecological and cultural) rather than theory alone and the human aspirations of a project are understood and aligned. The diversity and uniqueness of each place (socially, culturally and environmentally) is crucial to the design and is used to define the project and to create a sense of place so that relationships and systems are understood and leveraged. Multidisciplinary design teams, and integrated, participatory design and construction processes are used. It is critical that the development of system complexity, and ongoing feedback and dialogue processes are allowed for, so that the development evolves over long time periods. Finally the design seeks to create or restore the capacity of ecosystems and bio-geological cycles to function without human management.

Eco-effectiveness

Eco-effectiveness can be described as an interim stage between eco-efficiency and regenerative development. Eco-effectiveness as defined by McDonough and Braungart (2002) questions and redesigns the goals and methods of design to provide products, buildings or systems with beneficial environmental or social outcomes. This approach moves beyond reducing environmental impacts ('less bad') to looking at a systems approach to designing buildings or industrial systems that perform well without *any*, rather than *fewer*, negative environment or social consequences.

An eco-effective approach to design aims to restore the health of water, soil and atmosphere. It eliminates the idea of waste by proposing that waste can equal food (or resources). Products and building components should be 100% biodegradable or 100% recyclable to avoid cross contamination of waste/resource streams so that it is possible to move from a paradigm of 'cradle to grave' (linear use of resource resulting in waste) to 'cradle to cradle' (cyclic use of resource eliminated waste). The eco-effective future of industry is seen to be a 'world of abundance' rather than one of limits.

Eco-effectiveness seeks to improve ecosystem health through active human management, while regenerative design seeks to repair the capacity of ecosystems to function at optimum levels without ongoing human intervention. Both of the concepts touch on the importance of understanding ecology and mimicking it where appropriate to design a built environment with positive environmental impacts.

The fundamental difference exhibited by eco-effectiveness and regenerative design, compared to eco-efficiency is that eco-efficiency works within the existing paradigms of designing and producing products and buildings. A fundamental rethinking of architectural and urban design as well as town planning is required to shift from human-only oriented design approaches which have a focus on improving efficiencies, to a more inclusive systems approach to designing the built environment, which focuses on maximising mutually beneficial interactions between human and non-human elements.

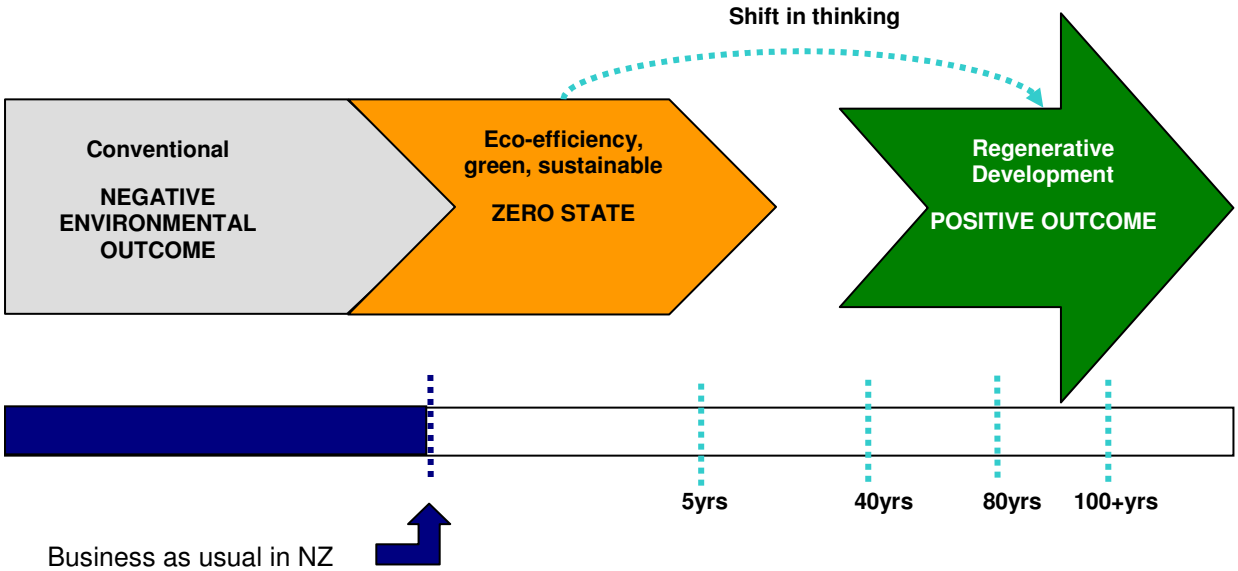

Figure 1: A shift in thinking to move from 'business as usual' to positive environmental outcomes.

BENEFITS ASSOCIATED WITH LIVING SYSTEMS APPROACHES

The built environment delivers economic, social and cultural benefits and generally provides a suitable environment for humans to reside and work in. The built environment also, as discussed, has wide ranging negative environmental impacts, including impacts associated with air quality, water and energy consumption, transport accessibility, materials use and management of waste. As the negative environmental impacts of some human activities become better understood, reducing and reversing these impacts is becoming more urgent (Rojstaczer et al., 2001). This is especially true with regard to climate change. The built environment as principle habitat of humans and as a key contributor to the causes of climate change must respond to this. The built environment must also respond in a positive manner to matters such as air quality, water consumption and human health.

Table 1 illustrates the major benefits of regenerative development and eco-effectiveness compared with conventional and eco-efficient design. Each of the identified benefits depend largely on the

project in question. It is anticipated that the identified benefits will intensify as the design approach moves from eco-efficiency to regenerative development (Reed, 2007b).

Conventional	Eco-efficiency	Eco-effectiveness	Regeneration	Benefits of eco-efficient, eco-effective and regenerative design
				1. Works within current mode of thinking
				2. Reduced environmental impact
				3. Increased human physical health
				4. Increased psychological wellbeing
				5. Reduced economic costs (over life cycle)
				6. Increased economic value of project
				7. Increased innovation in projects
				8. Positive environmental outcomes
				9. Building / development becomes a potential source of income
				10. Manageable and strategic approach to global issues such as climate change through a place based approach
				11. More integrated and therefore accurate knowledge of place
				12. Mutually beneficial relationships are created between people and place
				13. Increased robustness, flexibility and adaptability in the built environment
				14. Creates stronger, more equitable communities

Table 1: Comparing benefits of eco-efficient, eco-effective and regenerative design.

A significant benefit of a regenerative development, less present in eco-effective approaches, is positive outcomes for human society and culture. A regenerative approach positively affects aspects such as cultural identity, satisfaction, and psychological health. Because a regenerative approach includes people rather than just a small design team in the design and decision-making processes, this may contribute to the recognition of the indivisibility of environmental, economic, social and cultural health.

Aspects of eco-effective and regenerative architecture are beginning to emerge in the built environment but translation into comprehensive and widespread examples of architecture or urban design has not been rapid. Despite this, the limited, but growing numbers of realised projects provide opportunities for case studies that assist in demonstrating the potential benefits of such approaches. Several case studies are available in the New Zealand Ministry for the Environment discussion document entitled ‘Rethinking our Built Environment’ (Jenkin & Pedersen Zari 2009).

LIVING SYSTEM APPROACHES OVER TIME

Table 2 examines a timeline for implementation of new sustainability paradigms in the built environment. Short term is defined as 5 years; medium term is defined as 40 years and long term as 80 years. An 80 year time period relates to the average life of a building in New Zealand, and is a reasonable expectation of a human life span in New Zealand (O'Connell & Hargreaves, 2004; Rojstaczer, et al., 2001). In addition, in discussing living systems approaches, there is a need to look beyond a human generation for an 'extra long term' time frame of several hundreds of years (Wheeler, 2004).

Short Term – 5 years (2015)

The concept of improving efficiencies and reducing pollution is well understood and already appears in legislation such as the Building Act and the Resource Management Act. Eco-efficiency then is valuable in the short term to reduce the negative environmental impact of the built environment while other more long term strategies are developed and tested.

A regenerative approach is synergistic with current eco-efficient building practices and can potentially amplify their effectiveness by integrating individual green technologies and methodologies into interactive whole systems. In the short term, incorporating the simpler aspects of regenerative design into projects may occur, particularly in landscape developments.

Actively increasing the number of realised projects demonstrating regenerative development would provide opportunities for more in depth case studies. This would assist in demonstrating the benefits of the approach, and help to refine regenerative design concepts, methodologies and processes. Test cases could take several forms. Firstly, these approaches may be applied to individual projects with the intention that these will eventually transform the built environment in a building by building, or development by development way. Alternatively, concepts could be applied to whole neighbourhoods, larger developments, sections of cities, or potentially new towns to more effectively demonstrate the benefits of comprehensive regenerative development.

Medium Term – 40 years (2050)

In the medium term, eco-efficiency may become less viable. It is likely that the impacts of climate change and diminished availability of resources such as oil, water and metals will impact negatively on the built environment and the wider economic context. For example, a potentially rapid change in human settlement patterns could occur because of climate change, continuing urbanisation, population increase, and changes in food and fuel availability (Altomonte, 2008). This may demand a different approach to the built environment that sets goals beyond efficiencies and instead moves towards positive environmental outcomes. Changing social expectations could further require that energy sources and materials used in construction, renovation and maintenance of the built environment are without negative environment impacts. This may also contribute to a shift from an eco-efficient paradigm, to eco-effective or regenerative practice.

Regenerative built environments may provide more suitable built environments for humans in this changing context, realising value through positive environmental outcomes, benefits to human physical and psychological health, and a more robust built environment with significant economic advantages. It may be during this medium term period that regenerative methodologies and processes become more clearly defined in practice and will be exemplified in a growing number of realised built projects.

	Short term (5 years)	Medium term (40 years)	Long term (80 years)	Extra long term
Eco-efficiency	Continues to contribute to the rapid transformation of 'business as usual' resulting in decreased environmental degradation.	May phase out as legal requirements change, environmental issues become more urgent and expectation of building performance change.		
Eco-effectiveness	Contributes to change in thinking and increased realised projects	May be included into a regenerative approach		
Regenerative development	Contributes to changes in thinking about the ecological goals of development. 'Cherry picking' of the easier parts of regenerative design continue to appear in projects. Realised demonstration projects continue to grow and are analysed. Regenerative theory solidified.	Increasing number of realised new projects and retrofit initiatives. Regenerative practice solidified.	Built environment is successfully integrated with ecosystems. Built environment contributes to increased community wellbeing.	A dynamic truly sustainable built environment may emerge with greater ecological, economic, social and cultural health. Healthier ecosystems and bio-diversity indicators. More robust built environment as climate continues to change.

Table 2: Timeline for implementation

Long Term and extra long term – 80 years + (2090 +)

In the long and extra long term a regenerative approach to the built environment, which integrates with ecosystems, will more likely ensure a continuous suitable environment for humans (and other species). Such an approach to development may strengthen eco-systems and reverse or repair some environmental damage caused by current and past human patterns of living and consumption. It would also ensure that the built environment integrates more successfully with ecosystems and contributes to increased community wellbeing.

Biological systems are evolving and dynamic, rather than steady state or finished (Sahtouris, 2008). A truly sustainable built environment will need to incorporate and address this dynamism. A dynamic environment is potentially more resilient, as it is more adaptive to change. This is crucial in the long term as the climate continues to change (Pedersen Zari 2008).

RECOMMENDATIONS, OPPORTUNITIES AND CHALLENGES

Buildings and infrastructure are long-term assets, with a typical design life in New Zealand of 100 years for infrastructure and buildings of 80 years (Storey et al., 2004). Consequently the existing built environment will largely still be in place in 50 years time given New Zealand's current rate of development. The continued development of a truly sustainable built environment will, therefore, largely involve a retrofit of the existing built environment. If the progression towards a truly sustainable built environment solely follows an eco-efficient approach, opportunities to influence the built environment for many decades to come will be missed.

There are a number of challenges associated with implementing regenerative development in New Zealand, primarily associated with the current lack of an integrated approach to development and a scarcity of realised examples, both nationally and internationally, that provide quantifiable evidence of the various benefits. The technology and expertise necessary to implement such ideas exists; developing the concepts and testing them in built form presents an opportunity therefore for New Zealand. Short term adoption of regenerative design approaches is required to produce New Zealand examples and demonstration projects and to allow long-term benefits to accrue. New Zealand is in a position to become synonymous with research and experimentation in regenerative development, similar to the way in which the Netherlands are associated with a cradle to cradle approach to design after adopting the strategy for their built environment. They have become an international test bed for the concept and an example of proactive change.

Because regenerative development values local participation and knowledge the opportunity to foster increased understanding between tangata whenua and tauiwi communities in New Zealand may occur. These same aspects of regenerative development also mean potentially greater acceptance of change and new development by the public, thereby avoiding the 'NIMBY' (not in my back yard) phenomenon. This could translate in turn into faster positive transformation of the built environment. Regenerative development will also contribute towards offsetting the inevitable ongoing negative environmental impact/burden of existing building stock as well as the many current new buildings which will be energy dependant over a long time frame.

CONCLUSION

Shifting from a built environment that is degenerating ecosystems to one which regenerates capacity for ecosystems and communities to thrive will require a rethinking of architectural, town planning and urban design. An expanded notion of the built environment and its goals for ecological performance is required. This reflects a shift from human-only oriented design approaches which have a focus on improving efficiencies, to a systems approach to designing the built environment. Although the value in adopting regenerative development may be difficult to test currently, development which aims to repair and integrate with ecosystems is more conducive to positive healthy outcomes than remaining in a paradigm of development which only slows the rate of degradation.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the Ministry for the Environment for funding this research and Chris Wood specifically. The following people also provided valuable comments and review: Bill Reed, AIA, LEED, Regenesis Group, New Mexico, President of the Integrative Design Collaborative; Nils Larsson, FRAIC, Executive Director of the International Initiative for a Sustainable Built Environment (iiSBE); Craig Pocock, Director of Pocock Design: Environment; and Alex Couchman, Principal, Warren and Mahony Architects.

REFERENCES

Altomonte, S. (2008). Climate Change and Architecture: Mitigation and Adaptation Strategies for a Sustainable Development. Journal of Sustainable Development, 1(1), 97-112.

Cole, R. J., Charest, S., & Schroeder, S. (2006). Beyond Green: Drawing on Nature (For the Royal Architectural Institute of Canada' s "Beyond Green: Adaptive, Restorative and Regenerative Design" course - SDCB 305). The University of British Columbia.

DeSimone, L., & Popoff, F. (2000). Eco-efficiency - the business link to sustainable development. Cambridge, M.A.: MIT Press.

Fullbrook, D., & Jackson, Q. (2006). Value Case for Sustainable Building in New Zealand. Wellington: Ministry for the Environment.

Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., et al. (2008). Global Change and the Ecology of Cities. Science, 319(5864), 756-760.

Heinonen, S., Halonen, M., & Daldoss, L. (2006). Slow housing - competitive edge for innovative living elements. Fennia, 1(184), 91-104.

IPCC (Intergovernmental Panel on Climate Change) (2007). Climate Change 2007: Mitigation Contribution of Working Group III to the Fourth Assessment Report of the IPCC. Cambridge: Cambridge University Press.

Jenkin, S., & Pedersen Zari, M. (2009). Rethinking our built environments: Towards a sustainable future. Wellington: Ministry for the Environment, New Zealand Government. http://www.mfe.govt.nz/publications/sus-dev/rethinking-our-built-environment/

Kellert, S. R. (2004). Beyond LEED: From low environmental impact to restorative environmental design, key note address. Paper presented at the Greening Rooftops for Sustainable Communities, Portland, OR.

Leopold, A. (1949). Sand Country Almanac: Oxford University Press.

McDonough, W., & Braungart, M. (2002). Cradle to Cradle - Remaking the Way We Make Things. New York: North Point Press.

McHarg, I. (1992). Design with Nature (25th Anniversary ed.). Garden City, New York: John Wiley and Sons Inc.

Moffatt, S., & Kohler, N. (2008). Conceptualizing the built environment as a social-ecological system. Building Research and Information, 3(36), 248-268.

O'Connell, M., & Hargreaves, R. (2004). Climate Change Adaptation Study Report No. 130: BRANZ.

Pedersen Zari, M. (2008). Bioinspired architectural design to adapt to climate change Paper presented at the World Sustainable Building Conference, Melbourne, Australia.

Pedersen Zari, M. (2009). An architectural love of the living: Bio-inspired design in the pursuit of ecological regeneration and psychological wellbeing. In C. A. Brebbia (Ed.), Sustainable Development and Planning IV (Vol. 1, pp. 293-302). Southampton: Wessex Institute of Technology.

Pedersen Zari, M., & Storey, J. B. (2007). An ecosystem based biomimetic theory for a regenerative built environment Paper presented at the Lisbon Sustainable Building Conference 07, Lisbon, Portugal.

Reed, B. (2007a, May). A Living Systems Approach to Design. Paper presented at the AIA National Convention, Theme Keynote Address.

Reed, B. (2007b). Shifting from 'Sustainability' to Regeneration. Building Research and Information, 35(6), 674-680.

Rojstaczer, S., Sterling, S. m., & Moore, N. J. (2001). Human Appropriation of Photosynthesis Products. Science, 294, 2549 - 2552.

Sahtouris, E. (2008). LifeWeb: Living Systems, the Internet and the Human Future. Retrieved 16 June 2008.

Sinclair Knight Merz (2008). Sustainable Building Data: Environmental Impacts of Buildings. Results of Research, Report prepared for the Ministry of the Environment, New Zealand. Unpublished.

Storey, J. B., Page, I., Wyk, L. v., Collins, M., & Kriel, T. (2004). Confidential Report for Beacon Pathway: Housing Interventions, Stock, and Markets

Van der Ryn, S. (2005). Design for Life: The Architecture of Sim Van der Ryn. Salt Lake City: Gibbs Smith.

Wheeler, S. (2004). Planning for Sustainability - Creating Liveable, Equitable and Ecological Communities. New York: Routledge.