Restoration's Holy Grail — synthesising theory and practice in the development of a holistic framework for urban restoration

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ABSTRACT

Urban ecological restoration involves reinstating and maintaining the ecosystem health of a site within an urban environment and is often undertaken by volunteers and enthusiasts from the local community. With scarce resources, many of these restoration efforts depend upon the support and goodwill of the people involved and participating non-government organisations. Urban restoration serves to educate and provide communities with a point of interaction with the natural world, thereby enabling individuals to develop their own sense of value for nature.

However, restoration practice has not always delivered successful results. This may be due to the fact that restoration ecology lacks an ecologically sound theoretical foundation from which to develop management practice. This lack of fundamental guidance may have led to the current use of non-standardised restoration techniques, variable results, and an inability to progress in the field. In the development of a theoretical basis for restoration ecology, some have suggested that restoration practice could be used as an 'acid test' of ecological theory. To date, little research has been done in this area.

Part of the problem appears to lie in the fact that ecology itself lacks unifying theories, clarity in definition of terminologies, and is further complicated by non-standardised techniques in data collection and analysis.

If the development of a theoretically sound approach to restoration ecology is possible, a secondary problem would be making practical sense of this information — developing practical restoration guidelines or principles that can be communicated to and undertaken by restoration practitioners.

This paper discusses these issues in the context of developing a framework for ecological restoration that finds synthesis between theory and practice. This is illustrated through the case example of GreenFleet — a sustainable transport program that involves tree planting to offset carbon emissions.

New Zealand's commitment towards ratification of the Kyoto Protocol will promote further restoration initiatives driven by carbon-crediting objectives. Therefore, in order to meet the growing demand for progressive and successful restoration, a standardised framework is required that recognises the importance of knowledge, the necessity of people's active participation, and synergistic exchange between the two.

In this paper, I am attempting to wear two hats — one as a researcher, a PhD student at the University of Auckland, and one as a practitioner — a project manager from an organisation called the Sustainable Business Network.

Therefore, I discuss ecological restoration from both sides of the fence. I will be drawing from my research to explore how ecological theory may improve our understanding for restoration practice. I also use the case project GreenFleet to raise some questions concerning the pragmatics of actually using theory in the light of real-life, on-the-ground restoration in an urban stetting — because, as noted in other papers of these conference proceedings, there can often be a separation between the 'natural' that people desire, and that which Mother Nature may have intended. So many of the concepts discussed here are not exclusive to restoration in urban environments, rather, they are more challenging in this context.

To date, applied ecological restoration has had varying degrees of success in New Zealand and throughout the world.

The usual factors identified as obstacles for restoration arise time and time again to explain the variable success of projects. Some of these obstacles include poor project design, lack of satisfactory monitoring of projects, and lack of reporting on the progress and outcomes (Lake 2001). These may be particularly noticeable in the case of urban restoration, where scarce resources and dependency on volunteers may preclude the development of comprehensive management plans. Of the practical accounts of restoration challenges and successes that have been documented, many are characterised by minimal conceptual content (Lunt 2001).

On the theoretical side, restoration ecology has thrived with some excellent compilations of philosophical and conceptual works such as those of Jordan III (1987), Bradshaw (1996), Cairns Jr. (2000), and Hobbs & Norton (1996). Much of this literature has focused on understanding the ecological aspects of restoration, yet many of the conceptual approaches identified appear to offer little value to practitioners and do not reflect management activity on the ground. This separation between concept and reality has lead to a highly fragmented and disjointed field of research and a difficulty to learn from practical experiences.

So to summarise this in other words, restoration practice is lacking theory, and restoration theory is lacking practice.

We need to do something about this very soon. With New Zealand's ratification of the Kyoto Protocol in December 2002, we will soon need to take some action to reduce the extent of our carbon dioxide emissions, or literally pay the price with the coming 2007 carbon abatement tax. One aspect of this involves looking at methods to measure and control the source of these emissions — and Landcare Research has been amongst those at the forefront of this initiative with their EBEX21 program[1].

The other aspect of controlling carbon dioxide is to examine methods to offset the carbon dioxide already emitted. One of the most hotly debated, yet perhaps one of the most tangible actions for offsetting carbon emissions is the planting of native vegetation and again, Landcare Research have done a great deal of research through EBEX21 investigating the amount of carbon our native forest soaks up (which is around 15 tonnes per ha per year).

I am involved in a project called GreenFleet, a sustainable transport program for businesses that is designed to enable members to manage both the source of their transport related carbon dioxide (by facilitating more efficient use of available transportation, developing employee travel plans, and encouraging alternative fuels and vehicles) as well as offsett the carbon dioxide that their vehicles produce (through urban restoration planting programs). It is emphasised that the latter is not a means to an end, but is a contribution towards doing something to offset the negative impacts of using a vehicle. And it is important to be able to provide people with something tangible like this — so that they may feel empowered to be able to actually do something as an individual or a business — that our situation is not a helpless one. And by supporting pre-established urban restoration projects, business members are provided with that golden opportunity for corporate-community engagement and that creative team-building activity, and community groups receive often-needed resources and an opportunity to interact with local businesses.

These issues all highlight the growing importance for restoration projects — I envisage urban restoration in the future that is truly urban — not simply undertaken by local community, but by local business as well. I also see an important future for restoration at a larger scale, for the purposes of meeting carbon reductions under Kyoto obligations. We need to ensure that restoration for any purpose, on any scale, will have more certainty of achieving successful results.

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[1] Editor's note: Emissions / Biodiversity Exchange in the 21st Century; see http://www.ebex21.co.nz/ for more information.

This leads back to the issue identified earlier — that restoration theory is lacking practice and restoration practice lacking theory — and in deciding where to start, the problem is less of a ‘chicken and egg’ scenario than it sounds.

If we examine this from a planning perspective, it would make sense to begin by understanding how the theory can be developed into some sort of guiding principles for practice.

I mentioned before that restoration literature has largely focused on ecological theory as a basis for understanding the process of restoration. This is because most definitions for ecological restoration include the idea that it involves inducing or assisting abiotic and biotic components of the environment to recover to an unimpaired or original state that they existed in during the past. However, such ecological aspirations are not always the focus of restoration projects, but this is something I discuss soon. For now, I will examine the ecological component of restoration.

In restoration, we are essentially trying to model the ecological process of succession. We are taking the reigns from Mother Nature and attempting to do the job more efficiently — i.e., faster. So one would think that by analysing all the ecological literature that describes how nature runs the process of succession, we might be able to extract some guidance as to how we could go about managing the process ourselves.

However, despite the abundance of literature and studies, there remains no dominant theory of succession or explanation of mechanisms that affect it.

Unfortunately there is no generally accepted definition of succession either. Some see it as an orderly, predictable, directional process, others as a progressive alteration of the structure and species composition of a community. Some big name classical theorists stand out in this field — Clements (1916), Gleason (1917, 1926), Whittaker (1953), Egler (1954), Tansley (1935), Connell & Slatyer (1977), Grime (1979) and Tilman (1985) — yet all have shed a different perspective on ecological succession. One of the reasons for this is that many predictions by these classical theorists have been based on untested assumptions, uncertain logic, and inadequate data. Recent studies have even suggested classical theories are seriously flawed and that many long-believed successional concepts need to be re-examined (e.g., see http://www.rr2.ualberta.ca/courses/renr575/succession.htm; Succession: a review of 100 years of theory).

So developing some sort of sound understanding about succession from the literature seems somewhat impossible. Yet one classical theorist, the late E. P. Odum, developed a model that is flexible enough to embody the perspectives of most others. Odum’s (1969) model of ‘Trends to be Expected in Developing Ecosystems’ describes how 24 key ecosystem attributes change as a system progresses from developing to mature (Table 1). The article has been cited more than 850 times during the last 20 years as a reputable reference for describing the process of ecological succession. Evidence to suggest the trends described by Odum genuinely exist in nature can be found in the numerous studies that have validated their presence. Recently, Mageau et al. (1998) designed a model that successfully depicts many of the trends characteristic of ecological succession as outlined by Odum. Similarly, Christensen (1994, 1995) utilised Odum’s attributes of ecosystem maturity in 41 steady-state models of aquatic ecosystems. And there are a number of other studies that have indicated correlation with some of the specific trends described by Odum.

So, given that we have now established a relatively stable descriptive model that summarises the process of ecological succession, how is this useful for ecological restoration? Using Odum’s model as a monitoring tool might enable us to begin to collect some standardised data on restoration progress. We could then develop a theory base for restoration ecology that is actually based on practice. This would facilitate comparative studies between restoration projects and the development of sound management techniques and adaptive management. And everyone would live happily ever after.

Table 1 A tabular model of ecological succession: trends to be expected in the development of ecosystems. (From Odum 1969).

	Ecosystem Attribute	Developmental Stages	Mature Stages
Community Energetics			
1	Gross production / community respiration (P/R ratio)	Greater or less than 1	Approaches 1
2	Gross production / standing crop biomass (P/B ratio)	High	Low
3	Biomass supported / unit energy flow (B/E ratio)	Low	High
4	Net community production (yield)	High	Low
5	Food chains	Linear, predominantly grazing	Weblike, predominantly detritus
Community Structure			
6	Total organic matter	Small	Large
7	Inorganic nutrients	Extrabiotic	Intrabiotic
8	Species diversity – variety component	Low	High
9	Species diversity – equitability component	Low	High
10	Biochemical diversity	Low	High
11	Stratification and spatial heterogeneity (pattern diversity)	Poorly organized	Well-organized
Life History			
12	Niche specialization	Broad	Narrow
13	Size of organism	Small	Large
14	Life cycles	Short, simple	Long, complex
Nutrient Cycling			
15	Mineral cycles	Open	Closed
16	Nutrient exchange rate, between organisms and environment	Rapid	Slow
17	Role of detritus in nutrient regeneration	Unimportant	Important
Selection Pressure			
18	Growth form	For rapid growth (‘r-selection’)	For feedback control (‘K-selection’)
19	Production	Quantity	Quality
Overall Homeostasis			
20	Internal symbiosis	Undeveloped	Developed
21	Nutrient conservation	Poor	Good
22	Stability (resistance to external perturbation)	Poor	Good
23	Entropy	High	Low
24	Information	Low	High

However, reality is less of a fairytale. If you take a look at this model, you will notice that whilst it is highly descriptive of how various ecosystem attributes change over time, there has been little quantification that enables us to measure to what extent these attributes are changing. For example, when does one decide that the role of detritus in nutrient generation is important or unimportant? Where does one draw the line between low species diversity and high species diversity? If this model is going to be used as a monitoring tool for restoration, we need to have a sense of some quantifiable standards against which we can measure our progress.

However, this proves to be harder than it may seem. For a start, despite the fact that Odum’s model has been widely cited, actual quantification of the various attributes has been rarely attempted. In many instances, only parts of the model have been quantified in order to serve the needs of a specific ecological study.

And in going through the model trying to quantify it myself, I can understand why few attempts have been made.

As mentioned previously, there is an inherent problem in ecological methodology itself — often times, field and analysis techniques used have not been consistent, leading to a collection of variable data and subsequent interpretation. For example, if you attempt to quantify the gross production / community respiration ratio you need to first of all go out into the field and take measurements for gross production and community respiration. But gross production cannot be measured directly, and estimating total plant respiration at the community level remains difficult and involves significant uncertainties.

Quantifying Odum's model is difficult but not impossible. However, in going through the various attributes, I realise that for someone to actually undertake these kinds of procedures in order to monitor the progress of their restoration, they would need to be highly-trained with field, lab, and analytical skills across a broad range of disciplines including ecology, soil chemistry, geology, botany, statistics etc. and this kind of analysis would take a huge amount of time.

Again considering restoration practice in New Zealand, I began to wonder which projects would have the resources, expertise, skills and time to undertake this sort of rigorous monitoring? Furthermore, for restoration projects in urban environments, where revegetation may be for other purposes (e.g., recreational, aesthetic, cultural), how relevant is such an ecological model anyway? If volunteers and people are the drivers of restoration strategies, then any ecological guidelines developed must be simple, pragmatic, and achievable for all levels of expertise.

Odum's model requires simplification before it is anywhere near ready for use in restoration projects. Potentially, the process for monitoring these attributes could be simplified by using indicators that represent change across more than one attribute or that are principle components for the functioning of a particular ecosystem. For example, in the Northern Te Urewera restoration program, northern rata (*Metrosideros robusta*) is an important indicator species. Palatable to possums, this species is used as an indicator to measure the effect and outcome of possum control techniques. Furthermore, the species is an important habitat for epiphytes, invertebrates, and lizards, and a source of food for nectivorous birds (Beaven et al. 1999).

Further research is required to identify whether or not this type of simplification of Odum's model is suitable and possible.

The process is a difficult one, considering that restoration is not always carried out simply for ecological purposes. This questions the viability of using ecological models at all. To go back to the example of GreenFleet, here is a program that is actually about sustainable transportation, where planting native trees is a practical component designed to provide benefits to environment, community and businesses. To some extent, however, these benefits are contingent upon getting the process of ecological restoration right — having successful plantings.

In this paper, I have emphasised that getting the ecological process of restoration right may be just as important in restoration projects that focus on other goals as well. Yet although it is important, this does not mean restoration managers will have any more time or resources for lengthy ecological assessment and analyses.

The primary challenge will be to develop useful ecological guidance for restoration that balances theoretical direction with practical simplicity. The second challenge will be to develop a communication interface between restoration theory and practice so that we may facilitate the collaborative approach that is required between community, government agencies and experts in order to meet restoration objectives.

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