Ecological Thought in Contemporary Architecture:
The Impact of an Ecological Conception of Nature

Nicole Chojecka
Master of Architecture, 2013

Certificate of Authorship / Originality

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

27.05.13

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Abstract

The use of the word *ecology* in architecture has up until recently failed to effect a profound impact on the practice of architecture. The development of the concept and word ecology in the sciences was the result of a radical change in the conception of nature. Within the sciences the word ecology is strongly associated with a conception of nature that is enmeshed and dynamically changing. The science of ecology constitutes a radical overhaul of conceptual frameworks and methods for understanding this idea of nature.

Architecture, like science, is a discipline that historically has been profoundly influenced by its engagement with concepts of nature. This is why it is interesting to note that the link between the word ecology and a conception of nature is often unacknowledged in architectural literature. As a consequence the effect of ecological ideas within architecture has often been peripheral to the principal concerns of architectural theory, design and construction. In the 1960's when the word ecological was first used in architectural discourse, the use of the word is associated with a sense that architectural concerns of form and aesthetics should be put aside in order to deal with environmental concerns; that architectural concerns should be sacrificed for the sake of the environment. What is striking about this early discourse is that discussion of design methods and aesthetic concerns were often eschewed in favour of environmental concerns. Historically when we see the word ecological in front of architecture it signifies an overlay of additional concerns and design parameters, but not usually an overhaul of architectural thinking or design and construction methods.

An ecological understanding of nature is important because architecture has so often situated and understood itself through its relationship with nature. Ecology, rather than being equal to nature, is a specific conception of nature. It constitutes a dramatically different conceptualization of nature from that which existed before ecology emerged as a scientific discipline. This radical change in the conceptualization of nature demands a serious level of engagement from the discipline of architecture.

Few architects interrogate the assumptions about nature in architecture. It is possible to identify a trend towards an ecological concept of nature within those disparate practices which use ecological ideas in a way that infiltrates territory that is distinctly architectural. The aim of this thesis is to examine ecological thought and concepts of nature in recent architectural discourse and the work that results from that discourse. The purpose is to identify an ecological understanding of nature in recent architectural discourse and to identify the characteristics of architectural practice associated with this understanding. Because no significant discourse exists which identifies an ecological conception of nature in recent architecture three case studies are selected, which this thesis suggests

display such a conception. The written work of Greg Lynn is examined as an exemplary case in which the assumed character of nature within architecture is challenged. The R&Sie(n) and the Emergence and Design Group case studies involve examining written work, current/recent design and also built forms. The aim of these two case studies is firstly to identify an ecological conception of nature, and secondly to draw some conclusions about the impact of this understanding on their authors' architectural work

Introduction

An Ecological Understanding of Nature

This thesis explores the question: *What effect is an ecological understanding of nature having on contemporary architecture?* In order to do so it is necessary to examine the use of terms "ecology" and "ecological" in architecture, and to identify the understanding of nature associated with the use of these terms. Although the two terms are often equated, *ecology* is not *nature*. It is a science, which developed as a result of shifts in the way nature was understood. Ecology is based on a *conception of nature* that comprises living and non-living elements, which are interconnected with each other, yet differentiated. Nature is conceived of in ecology as dynamically changing as a result of interactions between organisms and environments. Prior to the development of ecology nature was primarily characterized as a mirror of divine perfection, eternal and unchanging. The principal mode of studying nature was to look at each individual type, element or species in isolation rather than as part of a whole. By contrast the dominant modes of analyzing nature in ecology are focused on the individual as part of a larger whole and the interactions that occur.

This thesis uses the term *enmeshed* to describe the character of nature as represented by the science of ecology. The term is adopted from Professor of English Timothy Morten, who often uses it to characterize an ecological conception of nature in his book *Ecology without Nature*. The word enmeshed strongly conveys the sense of nature implicit in the science of ecology as individual elements firmly bound in a web of interrelations. It is for this reason that this word is often used in this thesis rather than interrelated or linked.

Architecture has historically positioned itself in relation to nature, or an understanding of nature. The way in which this has been done has changed over time. In the fifteenth century polymath Leon Battista Alberti put forward the neo-Platonist argument that the *concinnitas*[1] found in nature was the source of beauty in architecture (Forty 2000, p.220). In contrast, by the twentieth century interest in nature as a model for architecture had declined in favor of mechanical models.[2] the typographical standard is footnote ref number after punctuation Architect Louis Kahn expressed the perceived separation between architecture and nature during this period when he comments that "What man makes, nature cannot make. Nature does not build a house, nature does not make a locomotive, nature does not make a playground. They grow out of the desire to express" (Louis

[1] *Concinnitas* is defined by Leon Battista Alberti as the principle of harmony that underlies the graceful arrangement of parts in relation to each other and to the whole.
[2] One of the best known examples of a mechanical metaphor or model for architecture is expressed by Swiss architect Le Corbusier when he redefines the house as a machine for living in (Vers Une Architecture, 1923).

Kahn, 1969 at (Wurman 1986, p. 75). Regardless of whether architects embraced or rejected it, nature has remained an important concept against which architecture has defined itself. Architecture has also adopted methodologies and systems of classification developed as a way of understanding natural forms (such as Linnean taxonomy) in order to classify man-made, architectural forms.

Since the 1960's when the word "ecology" first came to be used in architecture it has not always been used in a way that acknowledges an ecological conception of nature. The definition of ecology is "the study of the relationships, distribution, and abundance of organisms, or groups of organisms, in an environment" (Bramwell 1989, p.4). An ecological conception of nature recognizes nature as a system of interconnected yet differentiated elements, which are dynamically evolving and changing over time as a result of their relationship. Often the word "ecology" has been loosely defined in architectural discourse and used interchangeably with the words green or sustainable.

This thesis provides an overview of the emergence of the term "ecological" architecture, and identifies whether an ecological conception of nature accompanies the use of the term. It also identifies evidence of an ecological conception of nature in three case studies and identifies the effect on architectural theory and design within those practices.

Methodology

Firstly, this thesis focuses on the history of ecology in order to provide a clear understanding of the origin and meaning/s of the word, and to highlight that the basis of the science of ecology is a specific understanding of nature (that is, an ecological understanding of nature). Secondly, this thesis examines and reviews post-1960's architectural texts to identify examples of the use of the word "ecology" and any corresponding use of an ecological understanding of nature. The final section of the thesis examines an ecological conception of nature in detail in three case studies and identifies its influence on architectural theory and design. The design work and writing of the three case study practitioners is examined for evidence of "ecological thinking". Ecological thinking is defined in this thesis as: the demonstration of an ecological conception of nature and the application of this ecological conception to the practice of architecture

The first chapter of this thesis examines the literature from the history of the sciences in order to establish the origins, development and aims of ecology. This is in order to establish a more objective understanding of the science of ecology and the origin of the word than is developed in the discourse on ecology in architecture. This history of ecology focuses on the shift in how nature was perceived after the word "ecology" was coined and ecology became established as a discipline. It also identifies the meaning associated with the word "ecology" as a basis for understanding the use of the term in architectural discourse.

The second chapter of the thesis interrogates architectural discourse between the 1960's and early 2000's in order to identify two distinct ways that the word "ecology" is used in that discourse: the *normative* use and the *scientific* use. These texts are analysed to establish whether an ecological conception of nature accompanies the use of the word "ecology" and to identify its influence in architectural thought and design.

The third chapter of the thesis is a case study of Greg Lynn. This chapter examines the writing of Lynn to identify his response to ideas of nature in architecture. This focuses on a body of work written by Greg Lynn from 1991 to 1998 which examines the relationship between thinking about organisms or bodies and architectural form. These texts are interrogated in order to identify which assumptions about nature he criticizes in architecture. The characteristics of nature he seeks to introduce into architecture as a basis for thinking about form and geometry are also identified. Secondly the texts are interrogated to identify an ecological conception of nature underlying the alternative methodologies that he proposes. This chapter also analyses Lynn's design work to identify the effect of ecological thinking in that work.

Chapters four and five are case studies of two architectural firms, R&Sie(n) and the Emergence and Design Group (referred to as the EDG from this point forward) respectively. In these chapters the writing and design work of the practices are examined to establish the kinds of architectural outcomes that result from the presence of an ecological conception of nature. The R&Sie(n) and EDG case studies focus on how their ecological conception of nature translates to ways of thinking about the relationship of architecture to environment or notions of nature. The way in which an ecological conception of nature plays a role in developing modes of design is also examined

The case studies are analysed in order to verify a hypothesis that it is possible to find an ecological conception of nature influencing the architectural approach of each practice. The case studies are approached in a critical manner, by asking firstly how they express an ecological conception of nature. This ecological conception of nature is identified in the way the case studies describe nature, and the types of examples they choose to represent that natural environment. The second question asked of the case studies is how they conceptualise architecture and its relationship to nature. The third question is: what kind of design strategies are used by the case studies? The fourth question asked focuses on how the building design of the case studies relates to the environment. All three of the case study architects contribute to architectural discourse through journal articles and books. They also produce design work, some of which is built and some of which is never intended to be built (paper architecture). The sources used also include architectural literature including books by architects, theorists and historians as well as peer reviewed architectural journal articles.

Both R&Sie(n) and the EDG are characterised by a fluid membership. Particularly in the case of the EDG this presented some challenges in selecting written material on which to base the case study chapter. The EDG operate in a similar manner to the international research network OCEAN Design Research Network.[3] Both OCEAN and the EDG are international associations of small, semi-autonomous practices with diverse backgrounds. Due to the shared membership between OCEAN and the EDG it is sometimes ambiguous whether a particular piece is published under the authorship of OCEAN, the EDG or independently by one of the members. This thesis aims to track the development of ecological ideas in architectural discourse rather than focusing exclusively on one group or individual, so the overlap and ambiguity in authorship have been disregarded due to the proximity of research interests in the two groups. The material used in this chapter is authored by at least one of the members of the EDG but not always under the name EDG. R&Sie(n), like the EDG, comprised a group of members who have changed over time, each change reflected in a revision of the group's name. However, throughout its evolution, Francois Roche has been involved, if not the principal author in almost all of the projects and writing that R&Sie(n) have produced.

[3] The current permutation of a network dating back to 1994

Overview

Until now there has not been an examination of the particularities of the conception of nature in ecology and how it may be identified and expressed in architecture. This thesis examines how the word "ecology" and ecological concepts of nature have been used in architecture and their consequential impact on architectural practice in three case studies. It examines how we have arrived at a point where an ecological conception of nature is now being used in architecture and what kind of work is resulting from this ecological thinking in architecture and the implications of that thinking.

Chapter one outlines the origins and development of the science of ecology in the context of a revolution in the perceived character of nature. This chapter aims to unpack what was novel and radical about the conception of nature as seen through the lens of ecology. This chapter identifies the characteristics of an ecological conception of nature as *composed of interconnected yet differentiated elements, which are dynamically evolving over time as a result of their relationship.* This chapter also describes the scope and aims of ecology today. The chapter focuses on points in time when the perceived character of nature changed. These changes resulted in changes in disciplinary approaches within natural history and eventually to the establishment of ecology as a science. The period covered in this chapter spans from the 1700's when the discipline of natural history was the dominant mode of understanding the natural world. The historical survey ends in the 1960's by which time ecology was established as a scientific discipline and natural history was relegated to a largely amateur pursuit. I am not an ecologist or a historian of science, but an architect, although I have tried to step out of an architectural role in this chapter as its aim is to objectively examine the way architecture uses ecology to make certain claims. Therefore the chapter aims to examine what ecology is and how it came to be, as opposed to what architects say ecology is. This chapter is based on published histories of natural history, biology and ecology.

Chapter two gives a background to the relationships between ecology and architecture. It also discusses the role of the concept of nature in this relationship. This chapter outlines the historical uptake of ecological ideas in architecture since the 1960's and the way the definition of the word "ecology" has shifted over this time. The main argument of this chapter is that although the word "ecology" has been used extensively within architecture the definition that has been used is limited and as a result architecture has not always engaged meaningfully with an ecological conception of nature. In fact, ecology has often been understood as simply meaning nature. Furthermore, the understanding of nature that operates within architecture is often a pre-ecological conception of nature as static and unchanging.

Chapter three forms the basis for identifying an ecological conception of nature in the following two case studies. Greg Lynn challenges the established idea of nature in architecture as ideal, static

and unchanging. He seeks to replace these assumptions about nature with evidence of nature as non-ideal, and dynamically changing. This chapter identifies in Lynn's writing a critique of pre-ecological concepts of nature in architecture. Furthermore it identifies a common thread linking the alternative ideas about nature that Lynn seeks to introduce into architectural discourse. This common thread is an ecological conception of nature that runs through the alternative examples of nature that Lynn analyses. The chapter concludes that Lynn seeks to displace a pre-ecological understanding of nature within architecture with an ecological understanding of nature. His work represents a comprehensive challenge to assumptions about nature that have historically influenced architectural theory, design strategies and ideas of beauty. This chapter identifies effects of ecological thinking on the work of architect and theorist Greg Lynn This chapter identifies Lynn's Architectural Curvilinearity as an architectural representation of ecological thinking.

Chapter four identifies in the work of R&Sie(n) an ecological understanding of nature that upsets the traditional dichotomy between nature and culture that is central to architectural thought. This chapter identifies in the work of R&Sie(n) a deliberate blurring of things traditionally considered to be either artificial or natural. R&Sie(n) redefine the terms used to describe architectural design and engagement with the environment in order to disrupt established thinking of the environment as natural and architecture as artificial.

Chapter five identifies the use of an ecological conception of nature by the Emergence and Design Group as a way to reorder thinking about architecture's location relative to culture and nature. Ecological thinking in the EDG manifests as an argument for conceptual continuity between nature and culture. The Group clearly places architecture within this continuity.

Chapter six summarises the argument of the thesis, and presents the conclusions and its contributions, and also directions for further research. Suggestions for further research are focused on the idea of nature in architecture, and whether a perceived separation between architecture and nature may stifle ecological thinking in architecture.

Chapter 1: What is Ecology?

The aim of this chapter is to examine the origins and development of the science of ecology in order to gain an objective idea of what ecology is and does, independent of the various meanings attributed to the word "ecology" in architectural discourse. The intention is to develop a clear understanding of the scientific meaning of the word "ecology" and the characteristics of an ecological conception of nature. This is done in order to develop a context within which to analyse the use of the words ecology and ecological in architectural discourse.

In the space of less than 100 years – between 1895 and the 1970's – the scope attributed to the word "ecology" expanded greatly. Ecology is a discipline that emerged quite rapidly as a coalescence of concepts, methods and techniques from a range of other sciences and disciplines. The word "ecology" was coined by biologist Ernst Haeckel in 1866 to describe Natural Historian Charles Darwin's study of evolution as a result of interactions between organisms and environment. The fledgling science of ecology adopted methods and techniques from the biological and physical sciences and the word came to be attached to a range of diverse investigative practices. By 1895, less that 30 years after the obscure appearance of the term in Haeckel's treatise, Danish botanist Eugenius Warming had established the first university course and ecology had become established as a science and taken the place of natural history as the dominant mode for understanding the natural world. By the late 1800's ecology was accepted as a name for a distinct and respectable science. In the words of historian of ecology Robert McIntosh, in "the last decade of the 19th century several facets of natural history and physiology combined and emerged quite suddenly as a recognizable discipline of ecology" (McIntosh 1985 , p. 27). Ecology came to include a wide range of phenomena that had been pursued since antiquity under different rubrics and philosophies of nature (McIntosh 1985 , p.2). During the first half of the 1900's ecology grew and became specialized. In the 1960's when the word became known in the public domain a second expansion of the word occurred when, within the space of a few years, it came to be attached to a range of political and social movements. During the spread of the word "ecology" in this period its meaning was variously interpreted and was attributed qualities and abilities to solve problems that are beyond its actual scope and aims. During the 60's and 70's in the context of energy crises and pollution problems, ecology came to be looked upon as the saviour of damaged nature.

Pre-Ecological Concepts of Nature

In the 1700's nature was conceived of as an eternal, unchanging collection of species and phenomena. Prior to the development of ecology in the late 1800's, knowledge of nature was categorized by Europeans into two branches: natural history and natural philosophy. Natural history was characterized by a descriptive approach and natural philosophy an analytical one.

Modern ecology and biology developed from natural history, while modern physics and chemistry developed from natural philosophy.

Natural history dates back to classical antiquity and by the 1700's it was concerned with the observation and description, and cataloguing, of naturally occurring phenomena. During the 1700's and early 1800's many exploratory expeditions were undertaken by the maritime powers, Britain, Spain and Portugal, to establish commerce with other countries. The identification of new and potentially useful natural resources was an important aim of these expeditions. Scientists and natural historians accompanied them charged with the task of identifying and cataloguing new species with the result that about 40,000 species were known by the beginning of the 19th century. The primary concern of natural history was the systematic categorization of facts and the generation of empirical laws. This is reflected in the methodology of natural history, particularly the use of biological classification or Linnaean Taxonomy, named after Carl Linnaeus, an 18th century Swedish botanist. Originating in the concept of ranked classification dating back to Aristotle, Linnean Taxonomy is the method of formally naming species known as Binomial Nomenclature. Linnean taxonomy is the empirical science of identifying elements of nature (based on evidence) and communicating the findings through a classificatory system under the following taxonomic ranks: Kingdom, Phylum, Class, Order, Family, Genus, Species. The table below is an example of a taxonomic table which divides species of animals into different categories.

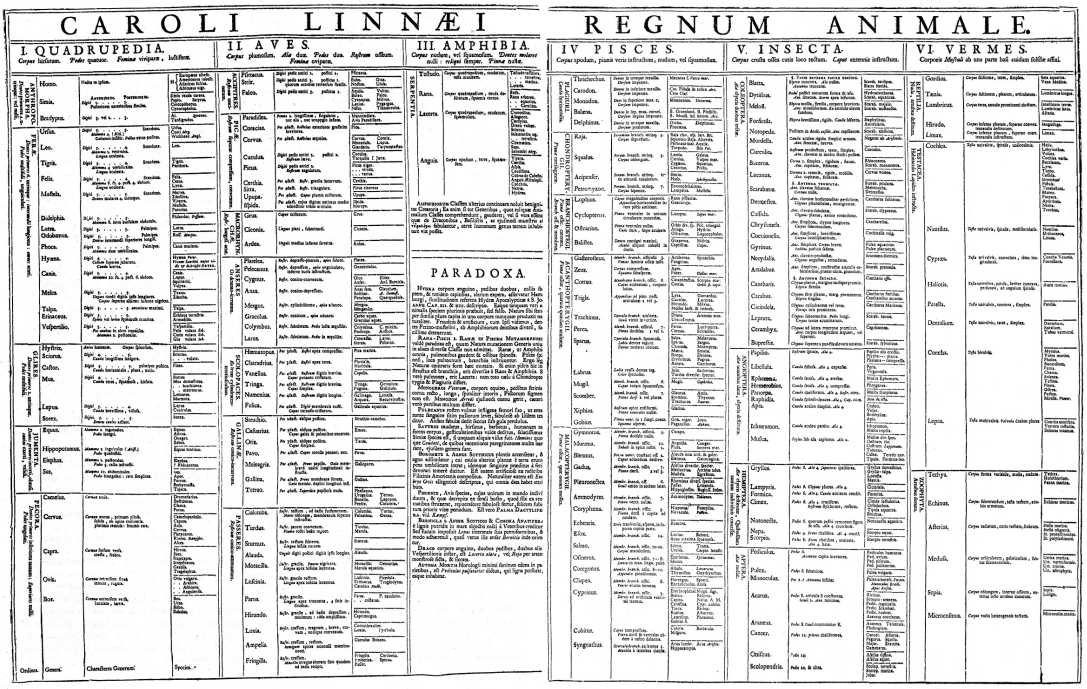


Figure 1: A taxonomic table of animal species (<http://en.wikipedia.org/wiki/File:Linnaeus_-_Regnum_Animale_(1735).png>)

The focus on categorization in natural history was the result of essentialist thinking which dominated western biological thinking until the 18th century. The philosophy of essentialism was informed by Plato's Theory of Forms, Forms being the ideal, true essence of a real world object. This theory holds that objects observed in the real world are only *reflections* of a limited number of essences (*eide*). Variation merely results from an imperfect reflection of these constant essences. Essentialism in the biological sciences manifested as the belief that every species has essential characteristics that are unalterable. Nature was regarded as a static entity or divine creation and small variations in individual species were not looked upon as significant, but merely traces of the imperfect copying of an ideal "essence" that linked those individuals as a type. The task of the natural historian was to observe and record this world in great detail. If nature is static the project of natural history could be expected to eventually come to an end. Natural history would be able to classify all of the species and form a complete picture of the natural world and its resources.

The system of taxonomic classification was developed to make sense of the essentialist view of the natural world and is a direct product of a conception of the natural world as static and unchanging. A static essentialist view of nature dominated until it was undermined during the enlightenment in the 1800's when evolutionary cosmology and mechanical philosophy spread from the physical sciences to natural history. Naturalists began to focus on the variability of species. The emergence of paleontology with the concept of extinction further undermined an essentialist view of nature. At this point in history a pattern began to emerge that showed variation over time in species. This appeared to be more significant than an imperfect copying of Plato's essences. Gradually naturalists started to propose that the production of variation or change was a fundamental quality of nature

Change as a Characteristic of The Natural World

From the mid 1700's and into the 1800's this tranquil, eternal conception of nature was challenged by evidence that change was occurring and that the changes were a result of relationships between elements within nature, such as the relationships between species and environment. The acceptance of change as a characteristic of nature was important as it demanded a new set of tools to study, record and analyse it. The descriptive methods used by natural history such as taxonomy would be of only limited use in making sense of this new idea of nature.

The essentialist conception of nature was challenged by 18th century French naturalist Georges-Louis Leclerc, Comte de Buffon, a figure who would influence the naturalists Jean-Baptiste Lamarck and Charles Darwin. Through the observation of variation within species related to geographic location, Buffon drew the radical conclusion that species must have both "improved" and "degenerated" (evolved) after dispersing away from a centre Australian spelling of creation. The principle that different regions support different species was elaborated by Buffon in "Histoire naturelle, Générale et Particulière" [if this is a publication, use italics not quote marks (1749–1778).

Buffon asserted that despite similar environments, different regions have distinct plants and animals, a concept later known as Buffon's Law, widely considered the first principle of Biogeography (Coleman 1971). Buffon also asserted that climate change must have facilitated the worldwide spread of species from their centre of origin. He allowed for the possibility not only of organisms changing over time in response to external factors but, in his assertion regarding climate change, also addressed the possibility of the external factors changing. Buffon's thesis introduced a dynamic conception of nature that did not previously exist in natural history.

Buffon believed that the basis of natural history needed to change in order to take his hypothesis into account. These developments were a great challenge to the original methods of natural history, which were based on the idea that everything about nature could eventually be discovered and recorded. McIntosh credited Buffon amongst others (Hutton and Lamarck, for example) for changing natural history from a "mere" description of facts into a set of scientific disciplines with their own methodology, ontology, and epistemology, distinct from the physical sciences. Lyon and Sloane asserted that the transformation from the description of nature to a genuine historical understanding of nature as a temporal process, interpreting nature as a dynamic process rather than a static non-temporal mechanism, was initiated by a radical change in natural history in the late 1800's, notably in the work of Buffon (Lyon & Sloan 1981). The notion of nature being in a state of change was later developed by Lamarck and Darwin who built on the work of Buffon by developing theories of evolution. Both Darwin and Lamark's theses contributed to the development of evolutionary theory, which has extensively influenced science as we know it today.

The development of geology during the 18th century provided further evidence of nature's capacity for change through evidence of environmental changes on a large scale and over a long period of time. During this period insight into the earth's structure developed rapidly and geology soon focused on change. In the words of science historian William Coleman, "Historical explanation … evidence produced by cosmology, geology, and biology revealed that progressive change was the most salient characteristic of natural phenomena" (Coleman 1971). Geologists also started to decipher the fossil record, which reinforced and expanded the theory of organisms changing over time.

Developments in geology had produced evidence of organisms and environments changing over time. Ecologists and natural historians were starting to see the natural world not as a static number of resources to be recorded, but rather a community of species, interacting with each other and with their environment, changing in response to these interactions over time. Furthermore there was an understanding that the environment was also changing. This new idea of nature gradually outgrew the traditional methodology of natural history, for how could a complete classification of species be carried out when both species and environment were in a state of flux? The idea that

nature was changing emerged and developed in the century before the word "ecology" was first used, and is a fundamental characteristic of nature as defined by ecologists today. The idea of variation of species as a product of geographical location or climate gave a meaning to the variation observed beyond the essentialist explanation of the imperfect copy.

Relationship as an Agent of Change in Nature

Once the idea that nature could change was accepted, attention turned to the causes of the variations observed. From around 1800 the idea that organisms were related to each other and to the environment slowly grew. By the mid 1800's this dynamic interrelationship was proposed as the mechanism for change over time in nature, most notably in Darwin's *On the Origin of Species*.

The study of relationships between organisms and environments was first introduced into natural history by the German explorer and botanist, Alexander Von Humbolt, in the early 1800's. Humbolt travelled in many exploratory expeditions. He expanded the project of natural history and the cataloguing of species by adding information about their geographic location. He developed the study of Geobotany, which recorded the relationship between plant species and climate, and described vegetation zones using latitude and altitude. One of Humboldt's famous works was *Idea for a Plant Geography* published in 1805. In it Humbolt introduced the idea that variation in plant species could be explained by their geographic location or the climate in which they lived. Using a similar concept French naturalist Adolphe Dureau de la Malle began to study the distribution of plant species relative to each other using the term "*société*" to describe an assemblage of plant individuals of different species. Humbolt's concept was applied to animal species by Alfred Russell Wallace, contemporary and competitor to Darwin. Wallace was the first to propose a "geography" of animal species.

By the mid 1800's ample evidence for change and relationship as integral characteristics of nature had been uncovered in a range of disciplines. Both Buffon and Lamarck had worked to establish credibility for the concept of nature as changing and evolving. Buffon had even gone so far as to suggest a link between primates and humans. However it was Charles Darwin who made a comprehensive argument for the interrelationship of species and environment as the agent of change in nature. Darwin's theory of evolution was elucidated in his 1859 treatise, *On the Origin of Species*. In his book Darwin reviewed the diverse meanings of the struggle for existence, a metaphor standing for all the factors that affected an organism's survival and reproduction (Kingsland 1991). Darwin was the first natural historian to describe competition between members of the same species (eg: for the same resources or territory), rather than competition between different species, such as predator and pre (Kingsland 1991). Naturalists had already accepted the idea of predation as a form of selection and it was believed that this process would reinforce the characteristics of a species. However Darwin describes a mode of competition that could create real changes in a

population thereby turning natural selection into a creative force, not a mechanism for the preservation of a species type (Kingsland 1991). The nature that Darwin describes is constantly producing new characteristics in individuals, which are more or less suited to their environment. The individuals best suited to their environment gain an advantage over their contemporaries in the competition for limited resources. These individuals survive to pass on these characteristics and over time cause gradual changes in the physical characteristics of a population. The crucial thing to note in the context of this thesis is that these changes are produced through the interplay of the species and its environment.

Darwin's most shocking assertion at the time was that this dynamic change in nature was powerful enough to have resulted in humans evolving from primates. Such a theory placed man squarely within the "natural" world, disrupting the perceived division between man and his culture and wild nature. Darwin allows for humans as another organism, as a part of ecology rather than its observer. Human culture and forms can also be considered to be an extension of nature. Darwin's work carried the potential to bring nature and culture into closer correlation.

By the mid 1800's concepts of nature as changing as a result of dynamic interaction between species and environment had become more accepted within various disciplines. However no single discipline possessed modes of analysis that were designed to deal with such a conception of nature. It was as though the idea of nature had grown beyond the confines and methodologies of disciplines such as natural history or biology. It was at this point that the word "ecology" was coined and began to develop as a separate discipline.

The Origin of Ecology as the Economy of Nature

Considering the frequency with which we come across the word "ecology" in everyday life today it is notable that the word, concept and science of ecology are relatively young (Dodson 1998). There is some lack of consensus about the origins and first use of the word "ecology". However most historical accounts agree on the term *ökologie* being coined by the German biologist Ernst Haeckel in 1866 in his *General Morphology*, a book on Biology and Philosophy. Haeckel defined *ökologie* as "the comprehensive science of the relationship of the organism to the environment". The etymology of *ökologie* is from the Greek roots *oikos* (household) and *logia* (knowledge). The German word *ökologie* was adapted as "ecology" in the English language and this thesis uses the English spelling of the word from this point, unless as part of a quote. Haeckel elaborated on his brief definition in 1870 as follows:

> "By ecology we mean the body of knowledge concerning the economy of nature-the investigation of the total relations of the animal to its inorganic and to its organic environment; including above all, it's friendly and inimical relations with those animals and plants with which it comes directly or indirectly into contact- in a word, ecology is the

> study of all those complex interrelations referred to by Darwin as the conditions of the struggle for existence" *(*Haeckel quoted by Ecologist W.C. Allee (Allee et al. 1949)

In defining ecology Haeckel refers to the concept of "economy of nature" in Charles Darwin's 1859 book *Origin of Species*. By this Darwin meant the seemingly well-ordered interactions between plants, animals and their environment that exists in nature. Darwin proposed that the appearance of order in nature was the result of a process of evolution and struggle for existence by each organism rather than the result of an order imposed on nature. Haeckel was a supporter of Darwin's theory of Evolution and was prompted to coin the word "ecology" to describe the multifaceted "struggle for existence" that Darwin described (McIntosh 1985).

What Haeckel did was to give a name to a field of study, the primary focus of which was to be the relationships and interactions between species and environment that produced the evolution of forms in nature. Haeckel put the focus on studying dynamic relationships in nature over time, rather than as a "snapshot" of the present moment as Natural History had done. He created parameters for examining nature in a new way, acknowledging the importance of relationship and change as characteristics of nature. This clear framing of nature in a new way formed the basis for the generation of new techniques and adoption of existing techniques appropriate to exploring nature as dynamic and changing. Methods of describing nature had already begun to accommodate change as a characteristic of nature. An example is the genealogical table shown in figure 2 from Haeckel's *General Morphology*.

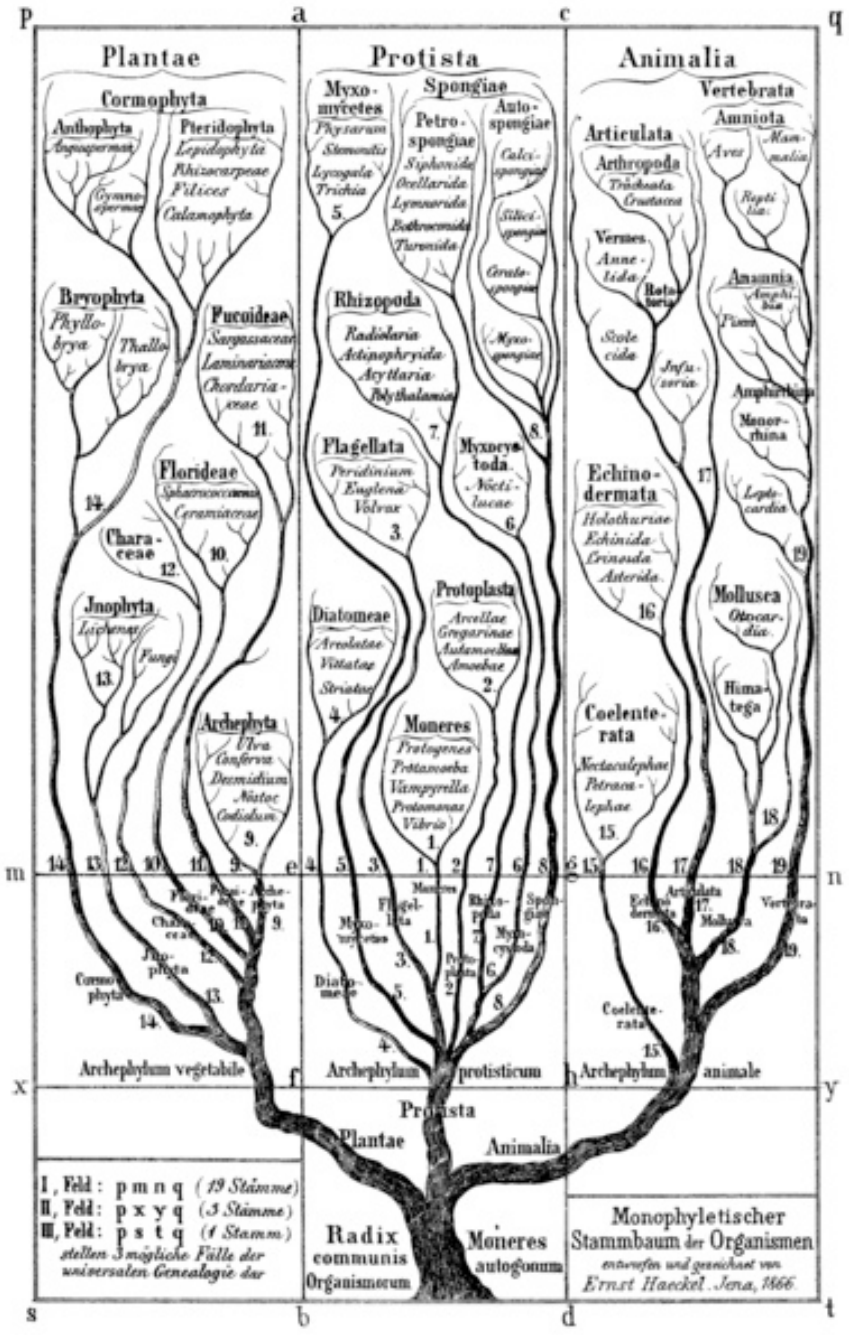


Figure 2: A genealogical tree of species showing common ancestors. (Ernst Haeckel, *Generelle Morphologie der Organismen*, Genealogischen Tafel 1, 1866, Fr. Frommann, Jena)

The table represents the common "roots" or genealogy of species. It is a clear shift from the taxonomic classification which separates species into categories. The notion of nature changing over time allows the species to be linked together over time. The tree represents the development of species in nature over time. Time advances as we move from the roots, up the trunk and to the tips of the tree braches. The taxonomic table shown in figure 1 carries no indication of time; it is like a snapshot of nature at one moment. Furthermore the genealogical tree links species together,

acknowledging their interactions and common roots rather than categorizing them in separate boxes.
Once it had a name, methods of description and analysis were gradually accumulated as Ecology gained adherents and grew as a science. The word "ecology" came to describe an anti-mechanistic, holistic approach to biology (Bramwell 1989, p.4)

Ecology Emerges as a Discipline: Communities in Equilibrium

The development of ecology is described by historian of science Thomas Söderqvist by reference to the spread of the term ecology through the scientific community. Over time scientists working as natural historians or biologists labelled their work "ecology". As the fledgling science developed, the word came to take on new meanings and to claim new territory in relation to existing disciplines and other new disciplines developing at the same time.

While Darwin focused mostly on competition between living things as a selective force, he gave less weight to environmental factors. Danish Botanist Eugenius Warming in the late 1800's developed a new discipline that took abiotic factors, such as earth, drought, fire, cold as seriously as biotic factors (organisms such as plants, animals) in the development of communities. Warming went on to play a fundamental role in establishing ecology as a discipline. It was Warming who developed the first university course on ecology and wrote the first ecology textbook

By the late 1800's a picture of nature had emerged that consisted of communities of biotic and abiotic elements interacting. Furthermore, the biotic and abiotic elements of nature were considered to be changing in response to each other over time. This was a picture of nature that required a more nuanced set of tools than a taxonomic system of classification upon which the discipline of natural history relied. As a result ecology adopted various experiment-based techniques from chemistry and began to use mathematical models to understand systems. Perhaps because of the multiple influences on ecology and the diverse origins of the tools it uses it has been criticized from various quarters during its short life. The criticisms come from all sorts of scientists, ecologists as well as others from outside the discipline. The former mainly focus on the fragmented nature of the discipline, its lack of commonly agreed principles. The latter tend to contest ecology's status as a science. Ecology as it developed in the 1800's and 1900's was criticized for adhering to observation, description, and an inductive approach to science – a legacy of its origins in natural history (McIntosh 1985). Ecologist Chandler Cowles described ecology in 1903 as "chaos" saying that "ecologists are not agreed on fundamental principles" (McIntosh 1980).

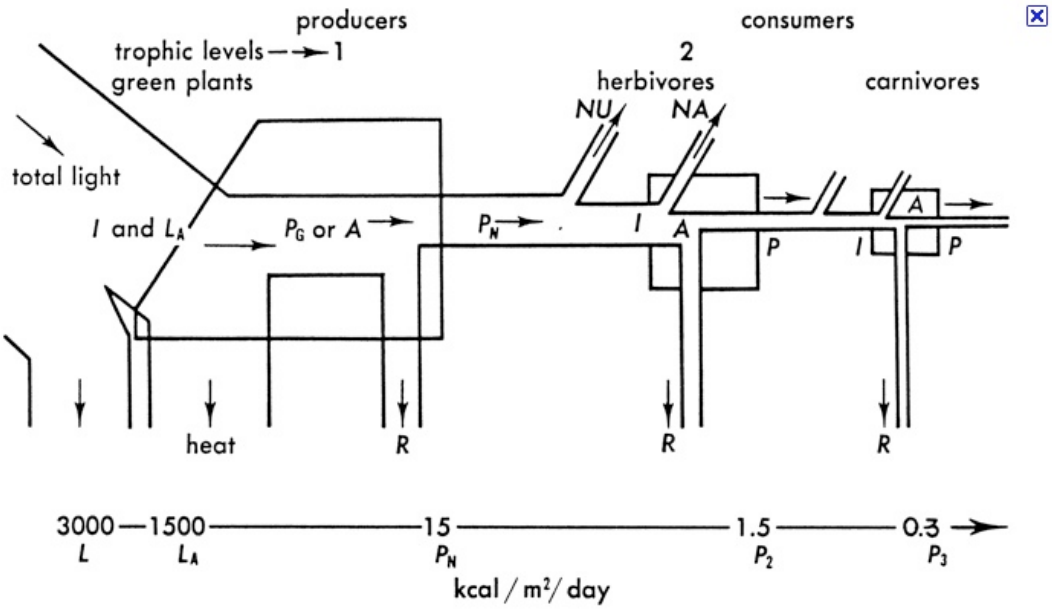
By the late 1800's ecologists agreed that environments and species were slowly changing over time. However the variety of influences from various disciplines meant that ecologists used many different techniques to examine nature at many different scales levels. Ecology began to diversify

and specialise. Many ecologists turned their attention to the nuances of change in nature, such as the type and pace of change. How stable ecological communities formed and the evolution of these communities over time became a focus (Egerton 1977). Some ecologists like Stephen Forbes also speculated on the process of evolution over time and whether evolution would ever reach a stable point and stop (Kingsland 1991, p.4). Others such as Chandler-Cowles concentrated on the interaction between plant communities and underlying geological formations. His study of the plant communities on the dunes of Lake Michigan sought to prove that as geological conditions changed so too would plant communities. He believed this process of succession would not stop, but would reach a climax and keep on going as a dynamic process (Kingsland 1991, p.4). During this period Frederic Clements began to refer to communities of species as akin to living things themselves or "complex organisms" undergoing a life cycle and evolutionary history analogous to the individual organism (Kingsland 1991, p.5). From around 1900 ecology began to split into various branches identified by the organism (such as plant or animal ecology), the environment studied (such as ocean or lake ecology), the methods used, or the scale applied. This process of specialization within ecology is still growing, and ecological ideas and concepts are also increasingly being applied to other disciplines and interdisciplinary studies.

In the 1930's English botanist Sir Arthur George Tansley began to develop the concept of the ecosystem which would have a great influence of the science of ecology. The word "ecosystem" was coined in 1935 and is defined as a biological environment consisting of all the organisms living in a particular area, as well as all the nonliving (abiotic), physical components of the environment with which the organisms interact, such as air, soil, water and sunlight (Campbell 2009). Ecosystems are functional units consisting of living things in a given area, non-living chemical and physical factors in their environment, linked together through nutrient cycle and energy flow (Odum 1971). The concept of ecosystem is important in the context of this thesis as it signifies how far ecology had shifted away from the approach of natural history, which conceived of nature as a collection of separate individuals. The idea of ecosystem allowed disparate living and non-living elements of nature to be conceived as a "whole" functional unit with each element co-dependent on the others.

In the 1950's the ecologist brothers Howard and Eugene Odum fused the concept of the ecosystem with cybernetics. They focused on the flow of energy through ecological systems, developing Energy Systems Language to represent the flows and balance of energy. This led to an increased focus on balance within ecological systems, with the result that ecology turned its focus away from change in nature and returned to focus on the idea of stable, static nature. In the 1960's this focus on equilibrium in ecology continued with a focus that would later be deemed by many ecologists to be something of a fixation. It was at this point that the word "ecology" came into public consciousness and the focus on equilibrium in nature was attached to the word "ecology" as

it began to be used in general speech and to become associated with environmental and political movements.



Source: Odum, E.P. (1971)

Figure 3: A diagram of Howard Odum's Energy Systems language representing the energy flow through an ecosystem. (Odum, H.T., *Environment, Power, and Society*, 1971 Wiley-Interscience New York, N.Y.)

The Word "ecology" Enters Public Consciousness

A number of respected histories of ecology including those by Bramwell, McIntosh and Egerton agree that the first use of the word in general speech in the 1960's. Within scientific discourse Haeckel's 1866 definition of ecology in *General Morphology* as "the comprehensive science of the relationship of the organism to the environment" is still accepted today, although various historians, ecologists or other scientists may use slightly different wording or an expanded definition. However, a critical semantic change coincided with the wider use of the word resulting in the evolution of an alternative meaning of the word. Semantic change (also known as semantic shift or semantic progression) is an evolution of word usage – usually to the point that the modern meaning is radically different from the original usage. In his *History of American Ecology* written in 1977 Frank Egerton comments on the slight distortion of the term ecology as it came to be known by the public. He asserts that public awareness of ecology occurred in the context of natural resources shortages and pollution problems in the 1960's. This was shortly followed by the energy crisis of the 1970's and the fist images of the planet from space. The natural world was for the first time represented as small, finite and fragile, and natural systems were presented as in a delicate balance and susceptible to change through human activities. In the context of the realisation of environmental problems interest in ecology increased greatly. As a consequence the new public

term "ecology" was altered from its application as a name for the science of ecology and was closely linked to conservation and pollution control activities that ecologists consider applied ecology (Egerton 1977)

Bramwell describes the semantic change as a division of its usage into two categories: *normative* and *biological*. The biological meaning stems from biologist Haeckel's original definition of the science of ecology as "the study of the relationships, distribution, and abundance of organisms, or group of organisms, in an environment or the study of energy flows within a closed system". In this chapter I argue that this definition is very similar to Haeckel's definition with the difference that Bramwell puts emphasis on energy flows linking living things and their environments. From this point on this thesis refers to what Bramwell calls the *biological* definition of ecology as the *scientific* definition (as opposed to the newer normative definition). Bramwell argues that:

> "the normative sense of the word has come to mean the belief that severe or drastic change within that system, or indeed any change that can damage any species within it, or that disturbs the system, is seen as wrong. Ecology has come to be associated with the preservation of natural patterns or energy flows. In normative use ecology is often used as a synonym for the natural environment. Thus, ecological ideas have come to be associated with the conservation of specific patterns of energy flows" (Bramwell 1989, p.4).

The important aspect of this semantic shift in the context of this thesis is that the development of the normative sense of the word involves a significant shift from the original definition of ecology "as the study of relationships between living things and environment" to "preserving those relationships as they are". Later, in 1985, McIntosh agreed with Egerton's claims about distortion of the term ecology from its original meaning. He claims that in the wake of the environmental crisis of the 1960's ecology was thrust into the spotlight, largely in "distorted forms" and hailed as a guide for how humans should relate to the environment, stating that "The word "ecology" was often confused with any concern for or ideology about, the environment" (McIntosh 1985, p.1-2). The meaning of ecology as a way of understanding nature was distorted into a solution for preserving nature in a state of equilibrium. This distortion of the word "ecology" weakened the power of the word to convey a sense of nature as dynamically changing.

The 1960's also marked the beginning of a large-scale environmental movement. Ecological knowledge has given a scientific basis to the expression of aims of environmentalism and evaluating its goals/policies. Ecologism as a political and social phenomenon broadened the meanings attached to the word "ecology", especially for the general public. Bramwell's description of the use of the word "ecology" in a normative sense is an example of the word being removed from its original meaning and being attached to all sorts of popular and political causes. Other historians of science such as Swedish Thomas Soderqvist refer to ecology as the catchword of the day in 1970's Sweden: "it sneaked into the everyday vocabulary not only of scientists and their culture, but of government bodies, political parties and social movements as well" (McIntosh 1985;

Soderqvist 1986, p.v). This account portrays the spread of the word "ecology" as rapid and far reaching. Combined with the semantic shift in the meaning of the word there is a good argument for understanding the word "ecology" in the 1960's and 70's as a word that carried many different meanings and associations for many groups of people. Although Soderqvist's study is confined to Sweden it is useful not only because Sweden was a main source of ecological progress, but because of the breadth of his study. This plurality attributed to the word was addressed by historian Donald Worster when he published one of the first histories of ecology in 1977. H proposed that at that time it had become impossible to talk about man's relation to nature without referring to *ecology*. What he called "this peculiar field of study" had been called on to play a central intellectual role. He asserts that leading scientists of the time has become "new Delphic voices, writing bestsellers, shaping government policies, even serving as moral touchstones". Worster even says that the 1970's could be called the *Age of Ecology* highlighting the sudden importance and influence of a relatively new science (Worster 1977 ,p.vii).

The many historical accounts of the rise of ecological ideas in the 1960's and 70's portray ecology almost as larger than life. It appears to grow beyond being a science which frames nature in a specific manner and is attributed false meanings and powers beyond its aims. In the 1960's the word "ecology" became known in the general community, and this event was accompanied by new claims about it. The word was distorted and new meanings attached to it. Since the 1960's the words "ecology" and "ecological" have been removed from their scientific root, disseminated, distorted and used in a political/strategic manner. This is useful to remember when we encounter the word used in an architectural context. This background is intended as a framework against which to consider the ways that practices, objects, and discourse are called "ecological" in architecture.

The science of ecology emerged from a new appreciation of nature as interconnected and capable of dynamic change. However, by the time the word "ecology" emerged into public consciousness and was taken up into government policy, politics and the discourses of other disciplines including architecture, a focus on equilibrium and stability has gripped ecology. This focus led to ecological ideas being used in a warped manner in many realms. The next chapter discusses how in architecture it lead to a focus on creating architecture so as to avoid disturbing the perceived equilibrium of nature.

Since the 1960's the words ecology and ecological have been used frequently within architecture as evidenced by the large number of publications and journal editions devoted to the subject. Ecological has often appeared as an adjective describing a type of architectural practice. However the meanings associated with the word "ecology" when it is used in architecture are often removed from its original meaning. It is only in the last decade that a small number of architects have

explicitly used the original scientific definition of the science of ecology, which is: "the study of the relationships, distribution, and abundance of organisms, or groups of organisms, in an environment" (Bramwell 1989, p.4). The explicit use of this original definition of ecology within architectural discourse is the exception rather than the rule. In many instances the word "ecology" is used as a synonym for *nature* or *the natural environment* (Bramwell 1989, p.4). Following from this, *ecological architecture* has come to mean architecture that protects nature. As a result the term "ecological" architecture is often used interchangeably with the terms *green architecture* or *sustainable architecture*. The word "ecology" in its original meaning is not equivalent to *nature* or *natural*, however it does describe a conception of nature as enmeshed and dynamically changing over time. This conception of nature was novel at the time ecology emerged as a discipline.

Chapter 2: Architecture, Nature and Ecology

As discussed in chapter one, ecology was born of a new understanding of nature as interconnected and in a state of dynamic change. However by the 1960's ecology's focus had to a great degree narrowed on understanding webs of relationships in terms of energy flows. In addition, the idea that natural ecological systems were in a balanced equilibrium was dominant. Although it was accepted that change had occurred in the past to create the present natural ecological systems, the idea that change was still occurring was sidelined in favour of focusing on concepts of equilibrium. In this respect ecology was framed within a pre-ecological idea of nature as static. In the context of the environmental and energy crises of the age, the idea of ecology became inextricably linked to preserving the equilibrium of nature and preventing change in the public mind. It was in this context that ecological ideas about nature began to permeate not only architecture, but also politics, government policy and other disciplines. Ideas about nature that were barely formed and were still being thrashed out within the discipline of ecology were taken up and used within disciplines such as architecture to inform their own activities and concerns.

Historically architecture has engaged deeply with various concepts of nature. From the 1960's when the word "ecology" entered public consciousness it began to be used within architectural discourse. This engagement of architecture with ecology represents a continuation of architecture's historical relationship with nature. This chapter aims to track some critical moments in the use of the word "ecology" in architectural discourse. This is done in order to review the extent to which an ecological understanding of nature and ecological thinking accompanies the use of the word "ecology" by architects. Ecological thinking in architecture has been defined in this thesis in two related ways. The first is the demonstration of an ecological conception of nature as composed of interconnected yet differentiated elements, which are dynamically evolving and changing over time as a result of their relationship. The second part of the definition is the application of this ecological conception of nature to the practice of architecture. This chapter covers the period from the 1960's when the word entered public consciousness until the early 2000's. In it I argue that an understanding of ecology as a new conception of nature does not always accompany the use of the word "ecology" in architectural discourse. Furthermore it is only when this understanding of nature or an appreciation of the scientific meaning of ecology accompanies the use of the word in architecture that ecological architecture can be distinguished from sustainable or green architecture. This chapter concludes that ecological architecture that recognises the specific qualities of nature as seen by ecology has a tendency to aim towards a higher level of integration between architecture and nature.

The distinction between the scientific and normative definitions of ecology discussed in chapter one is important to the way in which the word "ecology" has been used within architectural discourse. Both the scientific and normative definitions are used in that discourse, although this chapter observes a tendency for the normative definition to be used more often. Chapter one argued that the normative definition expresses less strongly the character of nature as a web of relationships in a state of dynamic change. The normative definition carries a sense that ecology is concerned with preserving balance and harmony in the natural world. Therefore the word "ecology" used in the normative sense does not effectively challenge an established idea of nature as static and unchanging; in fact it may reinforce such ideas of nature. The word "ecology" is often being used interchangeably with the word "nature" or the *natural environment* within architectural discourse. Following from this, ecological architecture has come to mean architecture that minimizes harm to the natural environment. For the purposes of this chapter a scientific use of the word "ecology" in the architectural literature is identified when a definition is given which accords to either Haeckel or Bramwell's defintion of ecology. A great deal of literature in architectural discourse uses the word "ecology" without definition, and in most of these cases the normative definition is used, particularly in literature where the words natural, sustainable or green are used interchangeably with the word "ecological". There are also a few cases where both definitions are given, but no distinction is made between the two (Steele 2005). The use of the normative meaning of ecology in architecture has resulted in the aims of ecological architecture aligning closely to the sustainable design and green building movements. Historically the three terms – sustainable, ecological and green – have been used in similar ways in architectural discourse.

Sustainable, Ecological and Green

The terms sustainable, ecological and green have a shared history with all being used to describe a similar approach to architecture after the 1960's. The context in which these approaches to architecture were being developed was one marked by the energy crisis of the 1970's, the first pictures of the earth from space and a growing awareness of the science of ecology, which described nature as mutable. During this time the natural world began to be understood as a web of relations in delicate equilibrium and that man's actions were capable of disturbing this balance. The terms sustainable and green are very closely aligned within architectural discourse, frequently displaying the same aims and methods.

Sustainable architectural design sits within the larger context of sustainable development which is defined in the World Commission on Environment and Development's *Our Common Future* report as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN 1987, p.43). Sustainable architecture aims to minimize negative the environmental impact of buildings by enhancing efficiency and moderation in the use of materials, energy, and floor area of buildings. Green Architecture is another term used in

architectural discourse to describe architecture that aims to minimize disruption or harm to the natural environment. The interchangeable use of these words is evident in many well-regarded works, even appearing as synonyms in book titles such as *Green Architecture: A Guide to Sustainable Design* by architect and researcher, Michael J. Crosbie. In the title of this book the words sustainable and green are closely aligned.

The word "ecological" is frequently used in architecture in similar ways to sustainable and green, although it is not always defined in the same way as sustainable or green. At the height of the environmental activism of the late 1960's Ian McHarg defined what ecology was thought of then and offered architecture as "the science of the relations of organisms and the environment, integrative of the sciences, humanities and the arts – a context for studies of man and the environment" (McHarg 1969). In *Design with Nature*, published less than a decade after the word "ecology" came to be known to the general public, McHarg seeks to lay out a set of design principles derived from the science of ecology. He suggests that an ecological view has the capacity to effect profound changes in the perceived relationship between man and nature, with integration as the aim. Although this early definition of ecology in architectural discourse clearly uses a scientific definition and sets the aims for ecological design principles apart from sustainable or green, historically ecological design has often been perceived to be the same as sustainable design by the architectural community. In fact McHarg is often championed as a leader in *sustainable* design.

An indicator of how closely aligned these terms have become is the way they are presented in *Ecological Architecture* by American architectural historian and theoretician James Steele. This publication constitutes an overview of the development of ecological architecture and charts possible directions for the future. What is interesting in the context of this thesis is the way in which Steele defines the various terms ecological, sustainable and green. In the preface of the book the first paragraph addresses this issue with Steele stating that the three terms are "used interchangeably to describe environmentally responsive architecture" (Steele 2005, p.6), a convention which he follows in the book. Steele does however acknowledge the varied origins of the three terms, identifying in detail the UN guided institutional roots of the word sustainable. The word green is identified as a radicalized variant of the "ecological sensibility of the 1960's" (Steele 2005 , p.8). It is important to note that this publication tracks the word "ecology" back to its roots in science, defining it as "the science of the relationship between all living organisms and their surroundings" (Steele 2005 , p.8). Steele comments that ecology is easy to understand, but becomes *murky* when the term is applied to a building. He passes briefly over the scientific origins of the word "ecology" to discuss in detail the social and political ecological movement of the 1960's. This corresponds to when ecology first entered public consciousness and underwent a semantic shift as described previously. For this reason Steele focuses much more on tracing the word "ecology" after

this semantic shift occurred rather than defining it in its original sense. The strong link between the original definition of ecology and its application to design has been lost. This illustrates that even in 2005 when Steele's book was published that its implications for the way nature is conceptualized were not engaged with by the architecture profession, even those specializing in ecological architecture. Steele identifies the varied origins of the three words but does not problematize the slippery, interchangeable use of the words in architectural discourse. What the terms ecological, sustainable and green have come to share in the majority of architectural writings is a common definition of an aim to develop design and construction practices that minimize harm and disruption to the natural environment.

This chapter argues that the interchangeable use of the word "ecology" with the words sustainable and green stems from a lack of understanding of what the science of ecology is and how it understands nature. In adopting a normative definition of ecology, the architecture profession began to generate an understanding that building activities could harm nature and responded to this by developing modes of doing architecture that avoided harm to nature. However this chapter argues that this development of ecological, green and sustainable architecture occurred without recognition of the dramatic shift in conceptualizing nature that is a fundamental part of the science of ecology. The word "ecology" was adopted within architectural discourse in the 1960's and 70's, although a clear understanding of the science of ecology accompanied the use of the word only in some instances. It is as though there are two versions of ecological architecture that have developed since the 1960's, one that understands ecology as a *conception of nature* and one which understands ecology as a way of *protecting nature as it is*. Within the sciences the development of ecology signalled a dramatic shift in conceptualizing nature. Nature was transformed from an eternal, ideal collection of specimens into a dynamically changing, creative, enmeshed whole. Furthermore ecology also represented a way of conceptualizing continuity between nature and culture. This chapter argues that there is little evidence of an ecological conception of nature in early ecological architecture. This lack of an ecological conception of nature in architecture is evidenced through the persistence of pre-ecological concepts of nature in architecture. This results in a perceived divide between nature and culture, the persistence of an idea of nature as static or eternal, and the idea that human activities can be external to nature.

Two Streams of Ecological Architecture

One of the first architects to write extensively on the topic of ecology and its potential for architecture was Ian McHarg in *Design with Nature* in which he referred to the scientific definition of ecology as discussed previously. McHarg displays an ecological conception of nature when he proposes that by understanding nature as interconnected ecosystems that are creative through organizing matter and energy into increasingly ordered patterns. McHarg proposes a model that

would allow an inventory of all ecosystems to determine their relative creativity in the biosphere. He also proposes that the same model can be applied to evaluate human processes.

What he does is to advocate the recognition of value in aspects of the natural world that were not recognized in pre-ecological thinking. As an example, he proposes that negentropy (an increase in the levels of order) is a measure of creative potential in an ecosystem. Negentropy is a characteristic of an ecosystem in which ordered relationships and forms evolve from a chaotic, undifferentiated mass of matter and energy. It is a quality that has been attributed to nature only since nature was recognized to be changing over time and is associated with the development of the science of ecology. To suggest attributing value to this quality in nature demonstrates that McHarg has an ecological understanding of nature. Furthermore McHarg suggests that such a value system could also incorporate the human creativity stating that "[t]his model contains the possibility of an inventory of all ecosystems to determine their relative creativity in the biosphere. This same conception can be applied to human processes" (McHarg, Design with Nature 1969). To suggest that human processes of creativity can be evaluated or assigned value on the same basis as creativity in nature suggests ecological thinking as McHarg applies an ecological conception of nature to architecture.

The publication of a long feature in *Architectural Design* [A.D] titled "Designing for Survival" [if this is the article title, it takes quote marks] in 1972 marks the fact that by this time environmental issues were considered to be important to architecture. A.D is a peer reviewed and respected magazine within the architectural community and this issue presents a varied range of research. What is interesting for this thesis is the way in which the word "ecological" is used. There is no definition of ecology or ecological and the two words are used in different ways by the various contributors. This edition is heavily focused on the failure of technology and development to provide necessities for human life. It is also focused on the harm and potential harm of human activities on the environment. The issue explores ways of reducing this harm by preserving existing ecological relationships through reduction in use of resources, local production of food, and reclaiming value from waste products. Several articles describe urban development as damaging to the natural environment and design proposals centre around ways of removing new buildings from existing urban infrastructure. The focus is on reducing impacts at a small scale, at the local level. The descriptions of nature are focused not on its creative potential but on its delicate balance or equilibrium. Ken Yeang, a Malaysian architect who went on to become a respected ecological architect, states that the "areas where natural vegetation is removed for construction of buildings are anti-ecological in nature, i.e. they are non-ecosystems" (Moorecraft et al. 1972 , p.434). American Architect Malcom B. Wells states that "machines should be tucked away underground where they'll do the least amount of harm to the living land" (Moorecraft et al. 1972 , p.433). Wells went on to advocate this type of building for the rest of his long career. This kind of statement is

important in the context of this thesis as it evidences the use of the word "ecology" in a normative sense. The words "Ecosystem" or "living land" are used as a synonym for "nature" and the idea that is conveyed is that man-made things such as machines or buildings threaten the delicate balance of nature. The two quotes carry the idea that man-made forms are intrinsically opposite to nature.

This use of the word is associated in these articles with the persistence of an idea of nature that can be separated from culture, that there is a space away from nature where architecture can occur and cause no harm. This is at odds with the conception of nature implicit in the science of ecology. The new concept of nature in ecology is nature that is completely enmeshed, with both living and non-living things. This chapter argues that the concept of nature separate to culture is a clear indicator of pre-ecological thinking. The sense of nature being "out there", removed from culture and needing to be protected from culture, is pervasive in this issue of A.D. Statements like these express a reaction to the idea of ecology that is centered on the idea that architecture and nature are at odds. The solutions proposed in that edition focus on ways to remove architecture from nature either by putting in underground or by reusing any waste products created by the building by its inhabitants, thereby aiming to have zero impact on the surrounding natural environment. The dominant theme of the issue is how to deal with energy requirements (light, energy) and energy outputs (human waste, garbage) within the dwelling so as to have no effect on the surrounding environment. This theme is at odds with the idea of nature as completely enmeshed and with humans as being part of that enmeshed whole. The issues discussed are also primarily to do with the servicing of dwellings rather than the planning and design of architecture itself. There is little discussion about the form of the buildings and how architectural form or design methods could be influenced by ecology. When building form is discussed it is notable that the proposed forms often make attempts to separate the building from those parts of the environment that are seen as natural or sensitive to change. Two examples are the ecological house (Michael Caine) which is a kind of self-sufficient bubble, and the earth covered houses of Wells previously described. The focus of the issue is how architecture can modify the built environment in order to reduce quantifiable effects on the environment. These effects are related to energy consumption or output. The manner in which ecological concerns are discussed and the centering of this discussion around energy flows and minimization of harm show the influence of the normative definition of ecology through the ecological movement as a social or political phenomenon rather than the influence of ecology as a science.

Since the 1990's many publications on ecological, sustainable or green architecture have been published. Very few of them show a clear understanding of the origin of ecology in the biological sciences and an understanding of ecology as a way of conceptualizing nature. There is a trend in most of the larger, multi-contributor publications to use a normative definition of ecology.

However a smaller number of publications using the scientific definition appear regularly. Mostly these have one or two contributors. In order to examine the difference between the two definitions in architectural discourse it is useful to look at two publications which came out in the late 1990's. The first is *Ecological Design* by Sim Van Der Ryn and Stuart Cowan and the second is an issue of *Architectural Design* entitled "The Architecture of Ecology".

This issue of A.D responds primarily to threats to the ecology as a function of institutional ecological directives such as the Rio Earth Summit mentioned in the editorial. The focus is on the scope for designers to influence the energy consumption of projects and the environmental impact of materials. The editor, Maggie Toy, suggests that ecological architecture can be split into two streams. The first has an organic appearance, or a natural form, or uses vernacular methods and techniques. The second stream is that which uses technology and new materials to improve environmental performance and minimize energy requirements. This edition includes content from a wide range of architects and so can be considered to be a benchmark for where ecological architecture was at that point in time. What is notable is that the urgent sense of impending environmental catastrophe that is present in the 1972 *Designing for Survival* is largely gone. It is replaced in a number of contributions by arguments that the terms used to describe environmentally responsive architecture such as green are nebulous and ill defined (John Farmer, p. 18). Contributors like Farmer also argue that the critical issue in ecological architecture is around how architecture positions itself in relation to nature.

There is a sense that this issue of A.D is more reflective and critical of the way the word "ecology" is used in architecture than *Designing for Survival* was. This edition is based around ecological architecture either mimicking nature or using technology to avoid impacting on nature. There is no definition of what ecology is and it would appear that little consensus prevailed about a definition in the architectural profession at that point in time. Furthermore there are no proposals about how these ecological concerns may affect design techniques or the form of buildings, although this is acknowledged as a problem by Toy who states that "the aesthetics of ecological architecture have to be addressed and asking Why are revelations in hydrology or geology not used as sources for architectural inspiration when the contours of a fuselage or the structural crane are considered visually appropriate?" (Toy 1997 , p.7). What is interesting in this quote in the context of this thesis is that even if designers are not yet using ideas of ecology to influence design processes or aesthetics, the question is being asked of why those who practice what they call ecological design or architecture are not questioning some core ideas about architecture, such as how to design or create forms and what the forms should look like. Perhaps it is because very few architects closely examine what ecology is in order to distill something from it that might influence the way architects work and design beyond conserving resources and energy. This could have been the result of the dominance of the normative idea of ecology and because its close correlation to sustainability

provided a framework that was so heavily focused on conservation of resources. In other words, architects focused on architectural solutions that fulfilled the requirements that were clearly defined in reports on sustainability such as "Our Common Future" rather than researching or probing deeply to find out what the ecological in ecological architecture meant and what its origins were. Some articles in this issue hint at ecological "issues" being so overwhelmingly important that design no longer matters, or that a designed building is a reminder of wrongs against nature by man. For example, Susan Roaf writes of The Solar House in Oxford, England, that "The Solar House is very ordinary looking and except for the internal planning, is certainly not very 'architectural'. This is because the architects wanted to reach out to the person on the street and provide them with an ecological house they could relate to" (Toy 1997 , p.x). It is interesting here that the author asserts that the appearance of the house is meant to serve as a reminder to tread lightly within the environment, perhaps inferring that buildings that look "architectural" are a reminder that architecture is generally harmful to the environment. This edition of A.D brings together many different voices that speak of ways that architecture has addressed ecology and reflects upon the range of responses. It also raises a number of important questions around the lack of clarity in the terms used. In addition it raises a lack of attention to the potential in ecology to influence aesthetic considerations and design techniques.

Ecological Design by contrast uses the scientific definition of ecology. Van der Ryn and Cowan caution against thinking of nature as "out there" (Ryn & Cowan 1996 , p.163) and emphasize that nature and culture are interconnected. Prominent ecological architect Sim Van der Ryn defines ecological design as "any form of design that minimizes environmentally destructive impacts by integrating itself with living processes" (Ryn & Cowan 1996, p.18). This definition is similar to the definitions of sustainable and green architecture but there is a greater emphasis on the integration of architecture or design into environment. In the 1970's Van der Ryn founded the Farallones Institute, which helped to create national awareness of "ecologically integrated living design".

By the 1990's Van der Ryn and Cowan suggest that "design should be defined as the intentional shaping of matter, energy, and process to meet a perceived need or desire. Design is a hinge that inevitably connects culture and nature through exchanges of materials, flows of energy, and choices of land use"(Ryn & Cowan 1996 , p.8). This chapter argues that this definition marks a progression in thinking in ecological design from the approaches of the 1960's and 1970's. The overwhelming focus of early ecological architecture was on creating ways to minimize these flows and exchanges. By contrast Van der Ryn and Cowan focus on the potential of these flows and exchanges. Instead of ecological concerns being an add-on they advocate using ecological principles as a new way of thinking about design (Ryn & Cowan 1996 , p.x). They argue that in order to create a sustainable world we must transform present forms of agriculture, architecture, engineering and technology. "In order to successfully integrate ecology and design, we must mirror nature's deep

interconnections in our own epistemology of design" (Ryn & Cowan 1996 , p.x). This represents an ecological understanding of nature that is directed towards questioning a fundamental part of architecture – the way architects design and the study of how and why they design in the way they do.

Van der Ryn & Cowan make a distinction between technological sustainability and ecological sustainability. They argue that sustainability as a principle set out in "Our Common Future" does not push for an overhaul or rethinking of how humans develop plant (including architecture). The report suggests that development continues in a modified form. What Van Der Ryn and Cowan suggest is that we need to reexamine every aspect of why and how we carry out development in response to an ecological understanding of nature – "Nature is more than a bank of resources to draw on: it is the best model we have for all the design problems we face" (Ryn & Cowan 1996 , p.7). What Van Der Ryn and Cowan are suggesting is that an ecological understanding of nature can be used as models for building interactions with nature and for processes of design. This thinking is not evident in a lot of ecological architecture, which uses the normative definition (as pointed out by Maggie Toy in "The Architecture of Ecology"). Toy points out that architecture often models buildings on nature in a superficial way, mimicking nature's forms rather than its processes and relationships.

Urban and environmental researcher Mattias Gross also argues for a reversion to Van Der Ryn and Cowan's definition of design and attitude towards nature. Gross argues that ecological design provides a way of thinking about human interventions into the natural world that goes beyond mainstream environmentalism, which often merely calls for a minimization of human impacts on the natural world. Gross argues that if we follow Van Der Ryn and Cowan's definition of design as a connection between nature and culture then ecological design can be defined as form of human intervention with the natural environment that attempts to improve natural conditions or reverse environmentally destructive impacts (Gross 2010, p.10).

What is clear from the research in this chapter is that the word "ecology" or ecological has been applied to a great variety of approaches in architecture. In addition, ecology or ecological have been defined in various ways (or often not defined at all). What this chapter has identified is that since the 1960's there have been two primary ways in which the word "ecology" has been used in architectural discourse. The first is the dominant tradition of using a normative definition where ecology is equated to nature. This definition stems from engagement with ecology as a social and/or political movement. There are also a smaller number of architects using the scientific definition, and acknowledging and engaging with ecology as a science. A review of literature about ecological architecture shows that since the 1960's there have always been some voices in architectural discourse that display ecological thinking, although they have been a minority. Both

streams of literature originate in a new idea of nature that emerged in the 1960's. Both the normative and scientific uses of the word "ecology" carry a new understanding of nature as capable of change. The two streams of literature react to this new characteristic of nature in different ways.

The literature that sees a normative definition of ecology shows a tendency to be very "anti-architecture" especially in the 1960's and 1970's. A lot of writing strongly blames human development for corrupting nature's perfect balance. A normative definition of ecology in architecture is associated with anti-development and anti-design sentiments, and a preoccupation with energy cycle aspects of development. Some of the designs seem to want to reduce architecture to a bubble enclosing functions, a hidden underground house, or not "architectural". Although it acknowledging nature's newfound potential for change, I see this as the reaction to it – that change is a negative thing and that it should be avoided as much as possible. There is much research about how to develop, while having little or no impact on the environment. This stream of literature, however, does not inquire into what this new conception of nature is, how it changes and what it could mean for architecture. There is a larger volume of literature that uses the normative definition of ecology and equates ecology with sustainable or green. Sustainability is a concept that has clearly defined goals and a framework. This explains why this stream of literature and work is more preoccupied with tangible, material or measurable results in terms of reduction of waste or energy use. A desire is expressed to make buildings more responsive, e.g. by developing smart materials, although there is no suggestion to look to how this occurs in nature as a solution. This is perhaps because this stream of thinking considers nature and culture as separate and could be resistant to transferring techniques and solutions from nature to cultural applications. The use of the term ecology in the normative sense does not lead as readily to a radical questioning of the aims, methods and place of architecture in relation to nature. The normative definition of ecology is associated with questioning how architecture can modify its practices in order to reduce harm to the environment or fulfill sustainability requirements. Those architects who have explored the scientific definition of ecology have sought to integrate architecture with nature rather than to "protect" nature from human development.

In contrast, the literature that uses a scientific definition of architecture is associated with a renewed interest in what nature is, what the place of humans and culture is, and what this can mean for architecture. In summary, a scientific conception of ecology in architectural discourse is associated with a greater questioning of the big questions of architecture. This chapter has tracked a tradition of ecological thinking in architecture from Ian McHarg who in the 1960's displayed ecological thinking through the use a scientific definition of ecology in his work, and began to develop an ecological understanding of nature and applied it to architectural design principles. This tradition continued with Sim Van Der Ryn's work in the 1990's. This chapter has highlighted a relationship between the use of the scientific definition of ecology in architecture and the recognition that

ecology is a specific way of understanding nature through relationships between elements in nature. This often leads to questioning the relationship of architecture to nature and the tradition within architecture of viewing man and culture as "outside" nature. This progression of ideas has been discussed in the work of Sim Van Der Ryn.

The word "ecology" as it is used in architectural discourse has not carried across the concept of dynamic change in nature that is implicit in the science of ecology. Awareness of ecology in the public sphere did transform the concept of nature to an extent. The major shift in awareness of nature was that nature could change. However, this chapter argues that this concept was often understood in architecture in a negative, harmful way. Much attention was focused on how nature's perfect balance might be undone by man's activities. Change or dynamic change was not regarded as a continuous quality in nature. In this sense the architecture profession often preserved an idea of nature as eternal rather than an ecological conception of nature as dynamically changing. When ecology is defined as being equal to "a conception of nature" rather than "nature", a more complex relationship begins to form between ecology, nature and architecture.

The following case study chapters show how certain architects follow from the tradition of understanding ecology in its scientific definition as "a conception of nature" to question how nature is understood in architecture and to employ an ecological conception of nature in their work. The next chapter examines how Greg Lynn's critique of methods of classifying and understanding architectural form that are rooted in pre-ecological concepts of nature. This chapter also demonstrates that Lynn seeks alternative ways of analyzing, describing and generating forms that are linked to an ecological conception of nature.

Chapter 3: Greg Lynn - Challenging the Ideal Perceptions of Nature in Architecture

Chapter two dated the infiltration of ecological ideas into architecture to the 1960's. It argued that there are two distinct ways in which the word has been used, the normative and the original definition. The chapter argued that the normative definition equates ecology with avoiding harm to nature, and that it is this definition which has dominated in architectural discourse. The word "ecology" has become disassociated with an ecological understanding of nature. The use of the word "ecology" in the normative sense, far from conveying an understanding of nature as dynamic and changing, has served to reinforce a sense of nature as static, in a delicate balance. It has influenced architects to mobilize many of the tools at their disposal to aid in efforts to protect this balance, even at the expense of architectural considerations of design theory, method and aesthetics.

In this context Greg Lynn is an interesting case study of an architect and theorist who examines and challenges assumptions about the characteristics of nature within architecture. The aim of this chapter is to identify which assumptions about nature Lynn challenges and also to analyse alternative concepts of nature that he proposes. This chapter argues that Lynn criticizes the prevalent use of a static concept of nature in architecture and he champions the use of an ecological understanding of nature. Furthermore this chapter argues that Lynn applies an ecological conception of nature to thinking about architectural form in three ways: firstly, to challenge the way that architectural forms are analysed; secondly, to develop new and alternative ways of describing architectural forms; and, thirdly, to develop an approach to the design of forms that is informed by an ecological understanding of the relationship between parts and wholes.

This chapter focuses on selected projects in addition to a series of papers that Lynn wrote early in his career which were later published as an edited book entitled *Folds, Bodies and Blobs*. This collection of essays analyses the ways in which forms are conceptualized, analysed and described in architecture. It also links these modes back to ways of thinking about organisms and bodies. Lynn suggests alternative ways to think of the organization of a body or "whole" informed by science and philosophy. In doing so he makes an argument for his design method, Architectural Curvilinearity.

Lynn asserts that architecture has always modelled itself on nature to achieve beauty. Architecture has historically based aspects of design and aesthetics on ideas about what nature is and does. As an example, classical architecture based architectural proportions on the "ideal" proportions of the human form and extensively used biological forms and motifs as decorative elements of buildings. Lynn describes the discipline of architecture as mirroring an understanding of nature through

theories and methods of design and building. Architects through the ages have had a certain conception of nature informed by science, or philosophy and this has formed an important part of the context in which the profession of architecture operates.] As new understandings of nature arise they have had an influence on architecture.

Lynn argues that the effect within architecture is dependent on the perceived characteristics of nature and the tools available to analyse nature and represent them in architectural form. Lynn works within a context where architecture has historically adopted concepts attributed to nature such as symmetry, ideal forms and wholeness as a basis for analyzing and generating architectural form. What Lynn critiques is the acceptance of such concepts as intrinsic to nature. These understandings or assumptions about context/the world/nature are often accepted as fact, a conceptual landscape within which architects carry out their own work. Lynn acknowledges the profound influence that ideas of nature have had on architectural design and theory, particularly on the use of taxonomy to categorize architectural forms. This chapter argues that he also takes a second important step in recognizing that it is not *nature* itself that has influenced architecture but rather an *idea of nature*. It is the perception of nature within architecture that he sets out to critique and eventually to overturn.

Lynn uses the words "body" or "bodies" frequently to refer to forms in nature, philosophy, the sciences and architecture. In the context of this thesis it is assumed that Lynn means "body" to be something that is considered to be *whole* or *cohesive* at some point in time. He states that: "Conventionally, architecture describes itself as an inanimate, modular, divisible, universal and static body. An alternative model of the body in architecture involves processes of continuous, indivisible differentiation" (Lynn 1993a, p. 140). This chapter argues that it is through this alternative model of the body in architecture that Lynn develops involves ecological thinking.

He looks to a variety of sources to find alternative ways of conceptualizing nature in order to challenge the accepted "nature of nature" within architecture. In doing so this chapter argues that he displaces a pre-ecological (ideal and static or eternal) idea of nature in architecture with one that is ecological (enmeshed and changing).

Chapter one defined an ecological conception of nature as dynamic and changing, nature as the interaction of living things with each other and with the environment. The effect within the scientific community of the science of ecology has been to move on from an idea of nature as discrete organisms or eternal and unchanging forms. This eternal idea of nature has been replaced by one of nature as a mesh of complex interactions between living and non-living entities, the forms of which have been shaped over time through these interactions.

Lynn and *The Fold*

During his early career at the beginning of the 1990's Lynn was involved in the deployment of the philosophical ideas of Gilles Deleuze in architecture. The way that Deleuze proposes the physical world be understood shares certain similarities with an ecological conception of nature. Lynn developed the potential for Deleuze's philosophy in architecture while working in Peter Eisenman's office between 1987 and 1991. At this time Eisenman was shifting from his role as the main proponent of Deconstructivist philosophy as a formal strategy in architecture. He was taking up a new interest in the concept of "the fold" as described by the philosopher Deleuze. Deleuze's book *The Fold* describes a way of conceiving of physical matter in which a force runs through matter, connecting it and differentiating it at the same time. Deleuze describes the physical matter of the world as being a continuous indivisible mass. It is not divisible into smaller parts (such as particles or atoms). Matter in Deleuze's *The Fold* is: "where fluctuation of the norm replaces the permanence of a law; where the object assumes a place in a continuum by variation…The new status of the object no longer refers to its condition to a spatial mold – in other words, to a relation of form – matter – but to a temporal modulation that implies as much the beginnings of a continuous variation of matter as a continuous development of form" (Deleuze 1993, p.19).

The Fold as a mode of understanding the physical world shares traits with an ecological conception of nature. In both, the physical world is understood as an enmeshed whole (rather than separate parts) and in a process of dynamic change.

Various architects took up the concept of "the fold" as a way of understanding the physical world during the 1990's. Greg Lynn played an instrumental part in disseminating the philosophy of Deleuze within architectural discourse, particularly via an edition of A.D. entitled "Folding in Architecture" which explored the potential for Deleuzean philosophy in architecture. While for Eisenman the impact of the philosophical concept of the fold, like deconstruction, could be considered to be merely an extension of his radical formalism (an example is Eisenman's Rebstockpark in Frankfurt Germany), in the writing of Lynn I propose that his encounter with the fold in the 1990's is a catalyst to Lynn's questioning of the assumptions in architecture about physical matter and nature. He begins to examine the implications of applying the conception of the material world found in *The Fold* to the materiality of architecture to the relationship between matter and form, and to the relationship between architecture and its context.

When Lynn says that "Deconstructivism theorized the world as a site of differences in order that architecture could represent these contradictions in form" (Lynn 1993a, p. 114), I suggest that Lynn draws a contrast between the aims of Deconstruction and his own aim: to theorize the world as a site of "differentiation", gathering examples of how to see the material world without disjunction and discontinuity so that architecture might represent this world view in form. Lynn collects many

real examples of material interactions and transformation from the sciences amongst other disciplines to begin this exploration. This understanding of nature shares many characteristics with the understanding of nature found in ecology, that is, of material form continually reorganizing and in the process of creation, rather than static separable elements making up nature.

Lynn has seriously engaged with *The Fold* and its potential to influence architecture. Philosophical sources, particularly the writing of Deleuze and Guattarri, continues to inform his thinking about architectural form. *The Fold* describes a conception of the physical world in which nothing is separable from any other thing. The material world is one continuous whole, within which the "differentiating force" or "the fold" runs and creates individual forms.

Directly after Lynn's involvement with Eisenman and *The Fold*, he wrote a series of essays focusing on ideas of wholeness and the "body" in architecture. The impact of Deleuze's *The Fold* is evident in these writings. Lynn identifies mathematic and geometric methods of analyzing and describing forms in architecture as based on a view of the material world that is very different from the material world described in *The Fold*. He argues against the dominance among architects of ideal over nature. An additional concern of his is to move on debates about architectural design based on these assumptions about nature. By looking at this endeavour with the understanding of the science of ecology developed in Chapters one and two, we can understand that Lynn is displacing modes of thinking about nature with new ones. The mode he is trying to interrupt views nature as eternal, static and perfect.

The mode that he argues for views nature as ecological in the sense that it changes dynamically over time due to interactions between living and non-living elements. Rather than being in a state of perfection, an ecological understanding of nature views nature constantly in a state of creating itself. This chapter argues that Lynn's architecture is "ecological" in that it is based on a very similar conception of nature to that which the science of ecology is based on. This work represents a significant influence of an ecological conception of nature on architecture. What Lynn initiates in architecture is a deep questioning of the perception of nature in architecture and he turns this analysis toward questioning the resulting impact on architectural representation, form and design. At stake are the assumptions of how the natural world works and the effect of these assumptions in architecture; how architecture positions itself in relations to a conceptual construction of the physical and "natural" world. By considering Lynn's exploration of natural systems relative to the major characteristics of nature according to the science of ecology, we can see the similarity between ecology's conception of nature and Lynn's.

A question that runs through Lynn's question of human concepts of nature and their application to architecture is *how do we understand the material world to be organized and to what extent does this inform the*

way we create architectural forms? Much of Lynn's early writing lies around the question of how assumptions about wholeness, differentiation and separability of bodies in nature get translated in architecture as universal types in a typological (taxonomic) system. Lynn explores alternatives to taxonomy that would allow a more ecological understanding of the material world, that is, differentiation and connectedness without recourse to ideal types. Lynn's ecological understanding of nature has three main effects in terms of architecture. Firstly, it results in questioning how to analyse architectural form. Secondly, it raises questions of how to describe architectural form. Thirdly, it questions how to design architectural forms not as separate elements that are put together but as a related set of forms that are similar yet differentiated.

Analysis of Architectural Form: Questioning Taxonomy in Architecture

One of the important things that Lynn does is to challenge the dominance of taxonomic classification as a way of analyzing architectural form. In doing so he identifies the origins of taxonomy in architecture in the taxonomy of species, which relies on an essentialist concept of nature. He looks to other ways of analyzing form in nature that do not rely on as essentialist ideas of ideal types as potential ways of analyzing architectural forms. These alternative ways of relating forms to each other share an ecological understanding of nature.

One of the important things that Lynn does in several pieces of writing is address the reliance of architecture on taxonomic classification to make sense of the diversity of architectural form and program. As discussed in chapter one, Taxonomic classification is a system for ordering and understanding difference that drew on an essentialist view of nature. Taxonomy relies on relating individuals through an abstract "ideal" version of the individuals. The individuals are related to each other by something outside them; something abstract that does not exist in the world. Furthermore the individuals are related by each one's relationship to the ideal, not to each other. This method of categorization is based on an essentialist view of nature in which each species is considered a variation of an eternal, unchanging essence.

Taxonomic classification was adopted in architecture after various architects saw how successfully it had been used in natural history and biology as a way of categorizing forms in nature (species of plants and animals). Typological classification in urban planning and architecture is defined as the taxonomic classification of (usually physical) characteristics of buildings or urban space, according to their association with different categories, such as intensity of development (from natural or rural to highly urban), degrees of formality, and school of thought (for example, modernist or traditional). Individual characteristics form patterns. Patterns relate elements hierarchically across physical scales (from small details to large systems). Architectural historian Adrian Forty states that although a basic classification (by use) of buildings was inherent to the classical system of architecture since antiquity it was only in the 1800's that classificatory systems originating in the

biological sciences were expanded and refined by several architects including Jacques-François Blondel, Jean-Nicolas-Louis Durand and Gottfried Semper. Forty makes particular reference to the direct link between classification of species and of buildings by Semper, stating that:

> "It was by direct analogy from his knowledge of animal and plant morphology that Semper formulated his theory of architectural types. His terminology for the 'prototypical forms' were taken from Goethe's theory of plant and animal morphology" (Forty 2000, p.306)

Architecture has historically often sought to imitate nature or a conception of nature as ideal, perfect, or symmetrical. The employment of taxonomic classification in architecture is a strong expression of how architecture has been wedded to an essentialist understanding of nature. What Lynn does in the 1990's is to challenge an essentialist, ideal conception of nature. This leads to a search for alternative modes of analysis and description of architectural forms than a system of Taxonomic classification.

As discussed in chapter one, taxonomic classification in the sciences is based on the selection of a number of classification categories associated with "types" of forms. Species are then categorized according to which type they best fit. This means that each individual species is related to the "type" it is categorized in. However, the way that each individual relates to each other individual is relatively unimportant. Lynn recognizes the application of this technique of classification in architecture and links it to a conception of nature, which treats organisms/species/bodies as wholes that are separate from each other. Science has moved on from understanding organisms as separate and unchanging, although Lynn criticizes the reliance in architecture of forms of classification rooted in an outdated understanding of nature.

Lynn criticizes taxonomy in architecture, arguing that it is reductive. It treats differences or variation as anomalies which are ignored while the creation groups of forms, which can be said to be of the same "type", are privileged. An important analytic method that Lynn critiques is classification of architectural form through geometric types as used by Art Historian Rudolph Wittkower and Architectural Historian Colin Rowe. In his 1949 *Architectural Principles in the Age of Humanism*, Wittkower uses the geometric device of the nine-square grid as a type to create a link between ten villas designed by Andrea Palladio (Lynn 1992 (December), p.33). The nine-square grid is a geometric reduction of all ten houses that allows the villas to be linked together. Wittkower develops the type and then deems that each villa has enough similarity to it that any differences can be cancelled out. In this sense it is taxonomic classification of a group of architectural designs based on an abstract or ideal geometric type.

What Lynn embarks on is an exploration of how the differences and particularities of a group of similar forms (such as Palladio's villas) can be accounted for in ways that do not rely on the

invention of ideal and reductive types such as the nine-square grid. Lynn sees the problem in this taxonomic method of analysis and the geometric description associated with it is that they do not explain the relationships between the individual Palladian villas. This method does not allow for an examination of how one ideal form diverges into many variations. In order to find methods of representing the relationships between form, Lynn turns to studies of natural forms that explore the relationship between various forms without referring all of the forms to one "type".

Lynn enacts a change in architectural thinking and seeks examples from the sciences in order to find alternative approaches to taxonomic classification to express relationships between individuals. Lynn focuses on examples which prioritize identifying, and represent relationships between individuals that in a taxonomic system would be classified as different "types". In this way Lynn's approach is ecological as he look for models in nature that employ an ecological way of thinking about nature and seeks to explore these models as an alternative to thinking of a body or organism as a separate whole with top-down organization.

Lynn sees a problem with the reduction of variation in architecture to static types and the use of geometric description techniques based on whole numbers. Instead he is interested in methods of geometric description that are capable of describing transformation and deformation. He gives an example of such geometry in the Cartesian grids used to describe deformation by morphologist D'Arcy Wentworth Thompson.

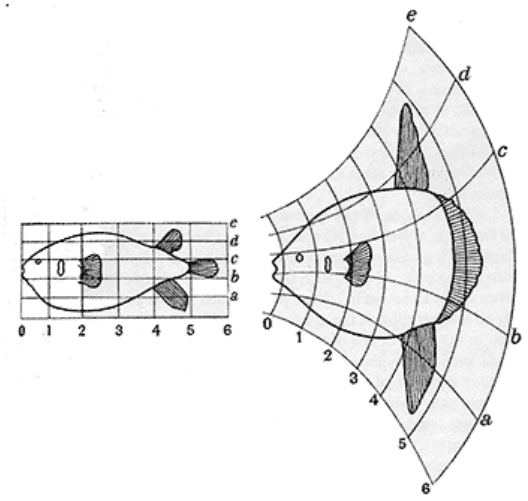


Figure 1: Diagrams representing transformations of related forms by D'Arcy Thomson. (D'Arcy Wentworth Thompson, ed. John Tyler Bonner, *On Growth and Form*, Cambridge University Press, Cambridge, 1961 figures 154, 155. Orthagoriscus, p. 301)

The geometric grid used by Thomson is a geometric map that is deformable. It can be used to describe similar but different forms easily. Lynn describes the use of geometry in this example rather than being a static measure of invariant characteristics, as becoming what philosophers Deleuze and Guatarri call the "plane of consistency" where transformation occurs. By this Lynn means that the grid describes geometric fluctuations in the organisms that occur as a function of its environment. For example, the size and position of the eye of the fish shift according to the depth at which it lives or the light level. Whereas an ideal prototype always remains the same, the grid is able to deform continuously as such variables change (Lynn 1993a, p. p.45). Lynn's educational background has focused on the relationship between Philosophy and Architecture. He has focused a great deal on the work of Deleuze and its application to architecture. Deleuze describes an understanding of the physical world that is not separable into individual elements, but is enmeshed in a continuous field of matter, which is constantly changing.

Lynn first suggests the use of geometric methods of description from the natural sciences in order to describe continuous differentiation rather than fixed types (Lynn 1993a, p. p.35). He proposes that Thompson's system of Cartesian Deformation as an alternative to the nine-square grid. Thompson developed a numbered and lettered grid in order to describe the variations of morphology in fish in response to environmental forces. What is important about Thomson's diagrams is that they represent the development of form as a function in response to an environment. The deformable grid is a way of geometrically and mathematically representing change in a form in response to an outside influence that does not reduce all variations. Thompson's grid is a flexible "type" that deforms to fit each variation. By contrast in the example of Wittkower, Palladio's villas are related only to each other through the device of an ideal type that consists of a reductive simplification of each real villa's form. In order for architectural variations to fit into the nine-square grid, information must be discounted. In contrast. Thompson's grid is a perfect or "ideal" for every variation. It also reflects an ecological conception of nature in that the premise of the method is that individual species are interrelated with their environment and change their morphology over time in response to it. This thinking is ecological as the method of relating the individuals emphasizes their relationship to each other rather than each individual's relationship to an abstract ideal form.

In taking up this example of biological form analysis as a potential method of analysis in architecture Lynn also imports the ecological thinking inherent in it. Lynn is thinking ecologically within architecture in the sense that he is focused on relationship – specifically finding a way of relating all forms to each other. The ideal type/taxonomic system relates each individual to an ideal type, but in this process they are only related to each other through the ideal type. The grid used by Thomson on the other hand is not ideal; on the contrary, it is flexible and accommodates each

individual equally well. Lynn's purpose is to find another way of respecting particularities and differences without using "universal types" (Lynn 1993a, p. p.34)

The Description of Architectural Forms

Lynn attributes the preoccupation in architecture with taxonomy with the way architectural forms have historically been described. Lynn argues that practices like adopting the proportions of a human body as the basis for the proportions of an architectural form such as a temple rely on understanding both human body and architectural form as a closed system incorporating top-down organization. Lynn argues that this ignores the development of the form of a body as a product of the interactions of its parts, as well as the interaction between a body and its context.

As an alternative to the whole body that architecture is often modelled on, Lynn seeks a reformulated concept of the body based on "anexact, yet rigorous topological descriptions that are neither ideal nor reducible". An anexact[4] form is one that cannot be reduced to a mathematical statement, nor measured with precision (Lynn 1993a). He seeks to establish ways of describing architecture as "indeterminate, nonideal, heterogeneous, and undecidable" (Lynn 1993a p.82). Lynn proposes an alternative model of architectural origination that could be "based on the behaviour of local particularities (base matter) as they contribute to the composition of provisional unities (bodies) from the bottom up, describing various degrees of cohesiveness and unity within bodies" (Lynn 1993a, p.136). Lynn also compares problems and limitations with describing form mathematically and geometrically in architecture and compares them to similar problems in the biological sciences. He then explores the solutions at use in the sciences and proposes versions of these solutions as useful in architecture. This is done with little discussion of the different aims and issues in architecture as opposed to the sciences. In this sense his argument centres very much on formal and material possibilities. He invites the reader to adopt solutions for problems in the sciences into architecture.

Lynn looks back to analyses of nature to find alternatives to the clear separation of bodies. He looks to examples of parasitism, symbiosis, codependence and mutualism in nature to find examples of disparate bodies in integral unities (Lynn 1993a, p. 139) . One example that he goes into in detail is the pseudocopulation of a type of orchid and digger wasps. Lynn comes to this example in a convoluted manner through the writing of philosophers Gilles Deleuze and Felix Guattari. The interaction as described by Zoologist Friedrich Barthes occurs when the wasp is lured to attempt copulation with the orchid which looks and smells like a female wasp. During contact with the wasp the orchid deposits pollen onto the wasp's body, which it subsequently spreads to other orchids. In this interaction the wasps can be regarded as mobile sex organs of the orchids

[4] Lynn's definition of anexact yet rigorous geometry is based on Edmund Husserl who developed the concept in the "Origin of Geometry" published in 1936

(Deleuze & Guattari 1987, p.10).

Figure 2: Photograph of Pseudocopulation between Gorytes mystaceus wasp and Ophrys insectifera orchid. (<Image source : http://aramel.free.fr/INSECTES14ter-23.shtml>)

What Lynn regards as important in this is that the relationship between individuals allows a whole to form. The wasps and the orchids retain separate characteristics, although through their interaction they form one system, or one body. This is an example of a conception of nature where species, which are of different "types", can be understood as one "body" or a "whole entity". This ability to understand individual elements of nature as interdependent and forming "wholes" is associated with the development of the science of ecology. It is ecological to think of nature in this way in that it allows for a unity to be created across the boundary of the form of the orchid and the wasp. Lynn describes this as "the formulation of bodies whose interiors are both produced by and are openly continuous with their external surroundings" (Lynn 1993a, p.137). The fact that they are physically separate is no boundary to the wasp being considered as part of the orchid's body or form. Lynn looks to various examples from the biological and physical sciences in order to examine how species can be described or conceived of as enmeshed and interactive ensembles. The character of nature described in these examples is ecological. Lynn brings this ecological conception of nature into architecture by using his examples as arguments from alternative ways of classifying and describing form to typology.

This chapter suggests that what Lynn is saying through these examples is that nature does not have to be divided into whole self-contained bodies – nature can be dynamic and enmeshed, and we can translate this thinking into architecture. The species form a whole system through their participation in an interaction; their relationship with their surroundings makes them a whole. The focus is on the dynamic interaction between individual forms (or species) and how to think of them as being integrated into a whole while maintaining their individual characteristics. This is a different way of looking at the natural world that by the definition given in chapter one is an ecological way

of thinking. Lynn displaces the idea that since Vitruvius, indeed since the beginning of recorded architectural history, the whole concept of architecture has been dependent on a unified (or ideal) body (1993 *Body Matters*). However he seeks to overthrow this way of thinking and replace it with a looser idea of a whole where "continuity and differentiation are the two conditions by which any collection of animate matter can be described as a body" (Lynn 1993a, p.140).

Methods of Designing Architectural Form

Lynn questions how ideas about bodies, wholes and forms in nature get translated into architecture. He looks for alternative models in nature and tests these models in architectural form. It is through this process that he developed the idea of Curvilinearity in Architecture, which can be identified in a number of his projects. Lynn's Stranded Sears Tower (1993) is a speculative project in response to a design competition for the city of Chicago, which has a rich history of architectural monumentality. This project aims to reformulate the image of the American monument by reconfiguring the dominant icon of the Chicago skyline and the tallest freestanding building in the world, the Sears Tower. Lynn asserts that monumentality derives from its dissociation with the surrounding context and establishing itself as a discrete and unified object (Lynn 1993b). He has stated that this project was a testing of ideas generated in his article "Body Matters" (Lynn 1993a) which is discussed in the first section of this chapter. It was his first project after he left Eisenman's office and established his own practice (Lynn 2008, p.308).

Figure 3: Physical model of Stranded Sears Tower (Design Competition), Chicago Ill.., Greg Lynn, 1992. (<http://www.tommoody.us/archives/2008/09/14/greg-lynn-reimagined-sears-tower/>)

Figure 4: Physical model of Stranded Sears Tower (Design Competition), Chicago Ill., Greg Lynn, 1992. (<http://www.tommoody.us/archives/2008/09/14/greg-lynn-reimagined-sears-tower/>)

This project takes a tower based on a nine-square grid and multiplies it into a series of tubes, which are then bundled, tangled and arranged horizontally along the site. The different tubes connect and mesh with the surrounding urban and infrastructure context. This project is important as it represents the beginning of an interest for Lynn in the form of buildings being heavily influenced by context. The form of the building is based on the idea of a body that is not whole and complete unto itself, but a body that is implicated and dependant on its environment. It is based on an ecological understanding of the relationship between living forms and their environment.

Lynn's concept of architectural curvilinearity evolved from his focus on defining forms not as separate and whole, but as connected and shaped by context. Architectural Curvilinearity employs ecological thinking as it unites difference into one entity. Lynn's concept of curvilinearity is not about the way a project looks (although many of his projects do use curved and sinuous forms). In fact many of his projects find ways to be connected, or form a series without having the same form. Lynn defines Curvilinearity as "a gesture of unification" like a wave passing through a crowd in a sports stadium. "The wave is a curvilinear gesture that circulates through the individual particles, within the monolithic structure (of the stadium – my comment), uniting disparate elements into a dynamic, temporal body" (Lynn 1993a, p.151). A typological approach describes architectural forms as a set of discrete individuals grouped into ideal types. Lynn's curvilinear way of thinking focuses on the connections between forms. It sees architectural forms as enmeshed and part of a larger whole. The modes of thinking that allowed the science of ecology to emerge could also be described as "uniting disparate elements into a dynamic, temporal body". Where some disciplines study elements of nature in isolation, ecology studies nature as a whole at a range of different scales. Historically it has acted as a force of ? for ? unification that allows living and non-living parts of nature to be conceptualized as one "body" or system (Lynn 1993a).

Two other examples of projects in which Lynn implements the concept of Architectural Curvilinearity are the "Korean Presbyterian Church" (1995-1999) and "Embryologic Housing" (1998-1999). In the design of the Korean Church elements of the design are repeated but not copied exactly. For example, in figure 5 the faceted façade of the church is made up of several folded pieces that are similar in form, but each is slightly different.

Figure 5: Photograph of the exterior of the Korean Presbyterian Church, Sunnyside NY, Greg Lynn FORM, Garofalo Architects, Michael McInturf Architects, 1999. (<http://www.suckerpunchdaily.com/tag/greg-lynn/>)

Figure 6: Photograph of the interior of the Korean Presbyterian Church, Sunnyside NY, Greg Lynn FORM, Garofalo Architects, Michael McInturf Architects, 1999. (<http://archinect.com/blog/article/21452029/255th-dream-song-of-john-berryman>)

This repetition with difference creates a unity between the components of the façade but allows each part to be differentiated from the others.

Another example is Lynn's "Embryologic Housing". In this project the concept of Architectural Curvilinearity unifies not only elements within one building, but creates a unity between many separate buildings. The Embryological Houses are designed using calculus based form description. They are related to each other through an algorithm that Lynn has used to generate each form. This algorithm runs through each form "like a wave" (Lynn's description of architectural curvilinearity). Each form can be differentiated or customized by changing the variables of the equation.

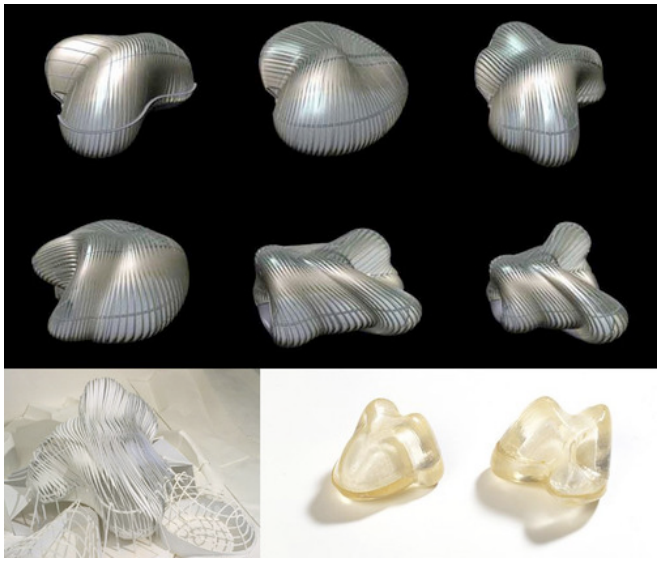


Figure 7: Rendering and models of the Embryological Houses. (<http://pichaus.com/greg-lynn-blobular-design-@c390bd1215add448bf8b5817c29716a0/>)

More recently Lynn has described a project that merges not only the disparate parts of a building or a suite of buildings, but building and nature. In his writing he is able to do what is impossible in a physical building or a building model – to import DNA and material from nature into buildings and products. He uses science fiction type writing in "A new Style of Life" where he explores the possibility of interactions between buildings and living things, between manufacture and evolution at a cellular level. In the context of this chapter this article is considered to be a design for a building that is described with words instead of drawings, models and renderings. The article is in a narrative style and describes a dwelling, an environment that blurs the line between artificial and natural, and that interacts with its inhabitants on a molecular level. It describes a human who lives within the "guts" of an "organic being" (dwelling) and wears "bioprosthetics". The "time-consuming process of removing, cleaning, feeding, and putting to bed animate contact lenses, clothing, hearing aids, wigs, shoes, and other bioprosthetics" is described in lavish detail (Lynn 2008, p.298).

It is not necessarily the case that Lynn meant for anything to be read into the use of the word "style" in the title of this piece of writing. However, the word style is used in architecture in order to categorize buildings based on form, techniques, and materials, time period or region, and their visual appearance or form. Copying forms in nature has also been a way of defining styles, especially in classical architecture. In this science fiction type piece elements of the natural world are no longer copied in a superficial, visual way. Rather the man-made elements of the setting rely on processes and products of nature to function. Natural and mechanical processes are fused. The article speaks of "miracle fabric" that is a "growthing" or an object created through man-made

materials fused with genetically engineered cells. One "growthing" is the protagonist's slacks and jacket which, having been "put away wet…was now mated to the alligator shoes they landed upon" (Lynn 2008) (Greg Lynn FORM, p. 298). These are products, man-made, yet they are unpredictable and interact with other objects…in this case "pattern disruption on his pants caused by their exposure to three hours of television test pattern" (Greg Lynn FORM, p. 298) which in this fantastic story would necessitate a trip to the pet store for "genetic cleaning". Lynn also speaks of submitting to the "Ecological paradigm".

The article refers to the special qualities of organic processes that cannot be replicated mechanically and the adoption of these biological and organic processes into man-made products: "Why invent a silicon chip to regulate carburetion in your car engine when a smear of rat brain is far more sophisticated?...The cosmetic surgery industry was the first to submit to the 'ecological paradigm'. [single quote marks for a quote within a quote] Instead of inventing better machines, organic processes were being harnessed and the natural processes of auto cannibalization were being catalyzed by a new parasitic sensibility coupled with readily available genetic technologies" ("A New Style of life" [I am assuming this is an article not a book] p.47). "He (*speaking of the protagonist – my comment*) [you didn't use italics above for your own interpolation] and his generation were the first to abandon dominion over nature in favor of mutation and recombination." "Before the marriage of industrialization and genetic bestiality, the master narrative of his generation had been ecology. Instead of seeing nature as a structure organized from a God modelled on humanity, the New Age religions of ecology redefined nature as a web of intricate exchanges. God was not a rational architect of nature but a procreative virus" (p. 47).

The character in the story is portrayed as being controlled by his environment as much as controlling it, of having intelligence like a parasite – "Unlike the rhythmic, repetitive patterns of an agricultural intelligence, his sensibilities were more akin to those of a parasite." ("A New Style of life", p. 47).[5] This type of writing is a continuation of his ecological thinking to the final frontier, where nature and culture are also enmeshed as an ecological whole.

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[5] The story is reminiscent of a Ballard science fiction short story-especially one of those he has written about Psychotropic homes that evolve in accordance to interactions with their inhabitants.

Lynn has also included in "Greg Lynn "Form" a story by science fiction writer Bruce Sterling (R&Sie(n) have also had Sterling write stories about his work) the story describes architecture and man-made surroundings that act as though the are biological living-responding and interacting with the inhabitants. He architecture is 'grown' rather than constructed and can be genetically manipulated and copyrighted.
It also includes a story by J. G Ballard called "The Thousand Dreams of Stellavista" about a psychotropic house that retains the personality and events of inhabitants. This story was published in "Vermillion Sands" 1971 by J. G. Ballard and was first published in "Amazing fact and Science Fiction" 1962.
"Greg Lynn Form" also reprints "A New Style of Life" by Lynn.

Lynn acknowledges that architecture has adapted techniques such as taxonomy that were originally developed to analyse forms in nature. He does not challenge this relationship between nature and architecture, although he does challenge the perceived qualities of nature that such methodologies are based upon. This chapter has argued that what Lynn does is to identify an essentialist understanding of nature as the basis of his taxonomy. He identifies this concept of nature as based on ideal forms. This manifests in architecture as understanding architectural forms as separable wholes. Lynn seeks alternative ways of understanding relationships between wholes and parts and, in doing so, he draws on a range of examples from biology, nature and the sciences. These examples have in common an ecological understanding of nature.

Lynn compares problems and limitations with describing form mathematically and geometrically in architecture and compares them to similar problems in the biological sciences. He then explores the solutions in use in the sciences and proposes versions of these solutions as useful in architecture as alternatives to taxonomy. This is done with little discussion of the different aims and issues in architecture as opposed to the sciences. In this sense his argument centres very much on formal and material possibilities. A commonality of both typology in architecture and Lynn's Curvilinearity is the appropriation of scientific methods of understanding nature, specifically ways of understanding form and materiality in nature. The difference is that Typology and Curvilinearity relate to fundamentally different understandings of nature. Typology came from an understanding of nature that was static and ideal. Curvilinearity comes out of an understanding of nature and materiality that is ecological, dynamic, evolving and non-ideal. The implication of what Lynn is enacting in his ecological thinking of nature in architecture is that established ways of analyzing and generating architectural form are challenged.

The implication of displacing methodologies based on essentialist ideas of nature with alternative ideas about nature is that Lynn is able to generate alternative ways of thinking about architectural form. He mimics an ecological rather than an essentialist idea of nature and natural processes with a completely different formal outcome.
These questions that Lynn is asking are important because architecture has so often taken inspiration from nature. Architects have often modelled their creations on nature with a conviction that nature is a solid thing that exists somewhere with defined enduring qualities, rather than as a construction or a concept in the mind of the architect. Lynn is bringing a level of detached critique to the manner in which nature is perceived within architecture. Lynn's work is important as it questions the construction of a concept of nature in architecture for the first time since ecology came to be widely known in the 1960's. Even though some architects since then have called themselves "ecological", often pre-ecological ideas of nature as ideal and unchanging have persisted in these practices. Lynn's writing displaces pre-ecological ideas of nature with ecological ones.

The next chapter examines how an ecological conception of nature in the work of R&Sie(n) is used to redefine terms that define the boundaries between architecture and environment. In doing so R&Sie(n) blur the boundaries between architecture as artificial and environment as natural.

Chapter 4: R&Sie(n) – Artificial Ecologies

The previous chapter examined ecological thinking in the work of Greg Lynn. Lynn links the historical preoccupation in architecture with idealized forms with an essentialist concept of nature. The focus of that chapter was on how Lynn sought to displace this platonic, ideal concept of forms in architecture with ways of analyzing and describing form that includes characteristics such as dynamic change, enmeshed relationships and unpredictable creativity. It argued that these characteristics are based on an ecological conception of nature.

The present chapter is a case study that aims to identify ecological thinking in the work of R&Sie(n). In chapter one ecological thinking was defined in two parts, both of which this chapter will identify in R&Sie(n)'s architectural practice. Firstly, R&Sie(n) show evidence that they conceive of nature in an ecological way. Secondly, they use this understanding to inform and develop their methods of architectural design.

An ecological definition of nature as outlined in chapter one is composed of interconnected yet differentiated elements, which are dynamically evolving and changing over time as a result of their relationship. An ecological conception of nature can be identified in R&Sie(n) in the way that they describe nature, environment, site and ecology as actively engaged in dynamic exchanges rather than passive, ideal and unchanging. They do not critique or theorize the idea of nature in architecture comprehensively as Lynn does. Instead, an ecological idea of nature in their practice can be identified through the aspects of nature they focus on, and how they describe it.

The application of an ecological conception of nature is evident in two main aspects of their practice Firstly, it is evident at a conceptual level, in the way in which they conceive of architecture. Secondly, it is evident in their design processes, strategies and formal outcomes. An ecological conception of nature leads R&Sie(n) to question the place of human culture relative to nature. At a conceptual level they use language to describe environment and architecture in a way that disrupts both the separability of environment and architecture and the tradition of assigning natural or artificial labels to these entities. This redefinition of terms stems from the way they understand the discipline of architecture as dependent on interaction with specific situations in order to exist as a discipline. Architecture is defined by R&Sie(n) as a product of its dynamic and enmeshed relationship with the environment. The design processes and strategies employed by R&Sie(n) develop and extend this focus on architecture as enmeshed with context.

This chapter identifies a theme in the way R&Sie(n) conceptualize the creation of architecture as a discipline and the creation of an individual work of architecture. The approach they take in each

case is referred to as an *artificial ecology* in this thesis. This term is used to characterize the way R&Sie(n) conceptualize architecture arising from a network of interactions. This use of an ecological conception of nature by R&Sie(n) disrupts the categorization of environment and architecture into natural and artificial categories and also disrupts the idea of architectural theory as an autonomous schema separate from site. The chapter concludes that ecological thinking in R&Sie(n) manifests as an enmeshing of elements such as environment and architecture that are traditionally through of as either natural or artificial and therefore though to be separate.

R&Sie(n) was founded in 1989 by French architect François Roche and his wife Stephanie Lavaux, an artist as well as an architect. Architect Toshikatsi Kiuchi has been part of R&Sie(n) since 2007. They engage in regular collaborations with others including Jean Navarro, artist Pierre Huyghe and artist/film-maker Phillipe Parreno. The name of the office has changed numerous times mirroring modifications to the office itself (disciplinary, organizational and human), which is described by Anna Foppiano as "an ectoplasmic entity" (Foppiano 2002, p.118). Ectoplasm is a substance or spiritual energy associated with paranormal activity. It is said to be produced by physical mediums when in a trance state. This material is excreted as a gauze-like substance from orifices on the medium's body and spiritual entities are said to drape this substance over their nonphysical body, enabling them to interact in our physical universe. This description of R&Sie(n) as ectoplasmic is apt, as whilst they do not shy away from the publication of their projects and writings, they do everything they can to avoid being described or defined. While journalists have described them as an "architectural practice", R&Sie(n) does not describe itself as anything. In fact they appear to avoid generating a practice profile. On their website the usual profiles of the office and its staff outlining experience and capabilities and accompanied by photographs are notably absent. The constant change of the group's name accompanied with an intentional avoidance of having their photographic likeness associated or captured is a deliberate strategy to escape the constraints of an architectural "brand" (Designboom 2008). Roche prefers not to be photographed as a reaction to "starchitects" of the late 1980's who promoted themselves more by their identity than by their work. Roche has spoken of his wish to avoid the stifling need to repeat oneself once an architectural brand is established (Inaba & Clouette 2006 ,p. 27). As a protest against these issues the practice is often represented by a morphed image combining the faces of Roche and Lavaux as shown in figures 1 and 2.

Figure 1 (left): Morphed image that combines portraits of Roche and Lavaux.

This image is frequently used to represent R&Sie(n) in place of images of its individual members.

(<http://www.new-territories.com/blog/?p=466 >)

Figure 2 (right): Morphed image of Roche and Lavaux's portraits.

The image is aged to represent how they would look in 2050. This image was created to illustrate a publication authored by R&Sie(n) +D entitled "2050/Bitterness" which is a monologue set in the year 2050 of Roche lamenting the lack of uptake of his urban project "I've heard about".
(<http://www.new-territories.com/2050%20b.htm>)

François Roche is the principal participant in R&Sie(n); having authored the majority of publications, he has also been involved in all of R&Sie(n)'s projects. Roche was born in Paris in 1961 and is a graduate of the School of Architecture of Versailles (1987). He originally trained as a mathematician and worked in that capacity for 10 years. The current name – R&Sie(n) – is a combination of Roche and Lavaux's names and when pronounced in French is the same as the French word for *heresy*, perhaps alluding to a wish to carry out architecture in a way that would be considered heretical, or which goes against the established profession. R&Sie(n) have produced comparatively few built works and what has been built is small to medium scale. A large part of the practice is publication, exhibitions, "paper architecture" and teaching.

This chapter argues that R&Sie(n) react to what they perceive as the autonomy of architecture. They react to the idea that architecture can exist as a theory, methodology or manifesto separate to its engagement with local environmental conditions. This chapter argues that an R&Sie(n)'s ecological thinking stems from their reaction to this tradition of separation of nature and culture within architecture. They search for alternative roles for environment and architecture in the design process and a more enmeshed relationship between the two. This begins with redefining terms that are traditionally associated with either nature or culture.

Before returning to the relationship between nature and culture in R&Sie(n)'s work, this chapter aims to identify an ecological understanding of nature in it. The first chapter of this thesis outlined how a recognition of nature as dynamically changing influenced the development of ecology from natural history. This changed view of nature also influenced the aim of ecology as a continual interrogation of nature rather than the quest for complete knowledge of nature found in Natural

History. R&Sie(n) employ a conception of nature as interconnected, and dynamically changing and interacting – similar to the definition of nature operating in the science of ecology.

François Roche explains in an interview the evolution of the firm's approach. This gives an insight into the ecological conception of nature that has developed in their practice. Roche states that:

> **"**In the beginning, we were thinking to integrate nature as a substance and now we integrate nature as a protocol, as an algorithm. Protocols and scripting protocols. So we re-discovered mathematics…I re-discovered that we could define some scripting for the evolution of plants, to understand the growing system behind the geometry of the plants. So it's interesting now, because at the beginning we used nature to mimic its substances and now we are trying to understand what kind of geometry, what kind of unpredictable geometry, we could develop from it. So it's an evolution, for sure." (Designboom 2008)

This statement highlights that R&Sie(n) are focusing on the capacity for nature to grow, to change unpredictably over time and to generate a form. It is these aspects which they focus on and draw knowledge from, rather than the geometry or form of nature at one moment in time. This quote indicates a focus on the dynamically changing and creative characteristics of nature associated with an ecological understanding of nature.

An ecological understanding of nature or worldview influences the approach, methods and techniques of R&Sie(n). This chapter argues that at the broadest conceptual level it affects the way R&Sie(n) conceive of architecture's place within culture and in relation to nature. At a more detailed level it can also be identified in the design processes used, the way that projects relate to site characteristics and in the way R&Sie(n) discuss the relationship between site and project. In doing so they disrupt a tradition in architecture of conceiving of nature as ideal and unchanging – what is traditionally considered to be a passive eternal backdrop to cultural activities becomes active and part of an enmeshed network of relationships.

The application of a conceptual understanding of nature by R&Sie(n) is identified in this thesis through the concept of an *artificial ecology*. At both a conceptual and physical level R&Sie(n) understand architecture not as an abstract idea imposing order on its environment, but as a product of a dynamic and enmeshed relationship between natural and artificial elements.

At the conceptual level, the way that R&Sie(n) conceptualize the discipline of architecture shares certain characteristics with the way that ecology conceptualizes nature. As discussed in chapter one, ecology conceives of nature as a web of dynamic interactions between living things and their environment in a process of constant change. Ecology understands the forms of nature to have been created through the dynamic interactions of organisms and environment over time. In

contrast to a pre-ecological view of nature as created in one moment and enduring forever unchanged, an ecological view of nature is never complete but continually in the process of creation. R&Sie(n) conceptualize architecture in an ecological way, as enmeshed with context and in a continual state of creation as a result of interaction with outside forces. This chapter argues that as a result of this they treat their architectural practice as a process of continual interrogation rather than having a research component and an application component.

R&Sie(n) refuse static or idealized architectural principles that can be abstracted and understood in isolation. It is historically quite common for architects to develop a style or signature design method, which is conceived of and refined in ideal terms, separate to any specific site. This ideal style is then adapted or compromised in order to build on a particular site. Roche is caustically critical of such an approach to architectural design and has made clear in his writing that he is against architecture that constitutes an overarching "creed" because it treats the site as a "found object". Roche states that he is "not a research architect. I've no real desire to research without a commission, without this confrontation with a particular situation" (Inaba & Clouette 2006 , p.30). In this statement Roche defines the architecture of R&Sie(n) through its engagement with what is outside it, what it cannot control. R&Sie(n) place little value in architecture as an abstract system; architecture is a system of dynamic connections rather than something that can exist and be conceptualized separately. This definition is ecological because it depends on an ongoing dynamic interaction with other disciplines, site and environment. An analogy for how they conceptualize the discipline of architecture is the physical act of building. A building cannot be constructed without a site, without a physical space to place the building. R&Sie(n) extend this way of thinking to a conceptual level; we can't conceive of architecture without the specificity of the interaction between an individual building and its site. The discipline of architecture emerges as a result of the web of interactions in the *artificial ecology* it sits within.

This idea of architecture as a product of an interaction with a wider ecological web of connections is evident not only in the way R&Sie(n) discuss architecture as a discipline but also in the way that they define the interactions and relationship between projects and site. R&Sie(n) refuse the separability of architecture as a discipline from the influencing forces surrounding it and they also refuse the separability of project and site. Ecological thinking in R&Sie(n) manifests in the way that they consider elements (such as project and environment) which are traditionally treated as qualitatively different in architectural practice as continuously differentiated rather than separable. R&Sie(n) use specific terminology to refer to site and project, disrupting the association of site with nature and project with artifice (a man-made design intervention). Firstly, the word *scenario* (Yoon 2006 , p.75) (R&Sie) is used by R&Sie(n) instead of *program* or *brief*. Typically a program or brief outlines the requirements of a project separate from the constraints of the context. This is interesting for this thesis as the word *scenario* clearly conveys a sense of the provisional that is not so

strong in the word program or brief. It has a connection to performance or theatre in which a scenario is a sketch of a performance that could be very different depending on the dynamic interaction between the scenario/script and the actors, set, and audience. A scenario is a provisional plan, which requires significant input from unknown elements to complete it. This way of defining an architectural project is ecological as it focuses on the scenario as an indication of a future action, an incomplete element of a whole, which relies on interaction with a context to create a complete work.

The context of a scenario is the subject of the second important use of language, the use of the word *territory* instead of *site* or *environment*. The word territory is less neutral than either site or environment. The word site implicitly defines the piece of ground as a function of architecture. The site is a *construction site*, a *building site*. The use of site defines a piece of earth in relation to architectural activities and does not allow for its independent identity. The word *territory* however implies that the site has its own identity. The word *territory* translates to *terroir* in French and describes an area that is not defined by geographical, state or municipal boarders but by its distinctive characteristics. An example is the various distinctive regions in France that are defined by the specialty foods they produce. Rather than being defined by judicial borders these regions are defined by a character of food that has arisen out of a complex combination of meteorological conditions, geographical features, geology, culture, and agricultural practices. Following the example of food production, it is the particular qualities of a *terroir* and the interaction of those qualities with other conditions that play an integral role in the final characteristics of produce from that *terroir* or *territory*. There is a strong case to argue that R&Sie(n) use the word territory instead of site with a similar conception of the relationship between environment and architecture in mind. This thinking is ecological because it positions environment as an active force in the creation of form, rather than a passive landscape or background against which architectural activities are played out. Roche has said of his conception of territoriality that unlike others he was not born with a "creed", an overarching view of what architecture should be. Instead he states:

> "What I'm interested in is the manifold, complex ways by which architecture can throw off its self sufficiency and draw sustenance from the territory it was supposed to dominate...Architects have always represented man's domination over nature, the city over the ecosystem, the full over the empty. Territory has rarely been anything other than a found object, at the worst an alibi that can be used any old how." (Roche et al. 1994 , p.58)

This illustrates clearly how the word territory as used by R&Sie(n) works to challenge the pre-conceptions that are operating in architecture about the environment and nature. Roche describes here dissatisfaction with assumption of site or territory as a passive natural object in contrast with the creative, dynamic cultural practice of architecture. The description of the site as a "found object" or an "alibi" indicates passivity, something that is incidental to the practice of architecture. This correlates with a pre-ecological concept of nature as eternal and unchanging, a backdrop to

cultural activities and the evolution of human pursuits. The relationship between architecture and nature that R&Sie(n) propose is one where architecture is not "self-sufficient" but part of a dynamic and symbiotic relationship with a nature that has specific qualities (territory). This relationship between architecture and context is ecological in the sense that it is a relationship of dynamic, symbiotic change over time. Rather than architecture as a cultural practice evolving in front of a backdrop of eternal nature, Roche proposes that architecture is formed through its relationship with context. This relationship R&Sie(n) advocate between architecture and context describes architecture as dependent on context to enter into a relationship through which architecture develops its characteristics. The result of this ecological thinking is an ecological relationship between architecture and environment that avoids categorizing either as natural or artificial.

As described in chapter one an ecological understanding of nature involves thinking of everything as connected and of humans as a part of nature instead of outside it. If we conceive of humans as a part of nature there is the potential for the distinctions between natural things and artificial things to also break down. This chapter argues that while Lynn critiqued the idea of nature upon which architectural form is based he did not critique the fact that architecture historically has defined itself as being separate from nature. R&Sie(n)'s work does break down perceived divisions between culture and nature and as a consequence blurs the lines between what is natural and artificial. They explore these divisions through their design work and also through the descriptions of their projects.

It is important to note that the design processes discussed by them are from projects that have never been built and possibly were never intended to be built. A large part of R&Sie(n)'s practice might be described as storytelling. Roche discusses the importance of story telling in their practice stating that he is interested in the potential of a story to "talk about the truth through a narration that does not directly reproduce reality. When you tell stories you use the context of your society. If you want the stories to penetrate, to infiltrate, and to be the vector of a transformation, you have to use the background of the society you are in" (Inaba & Clouette 2006 , p.28). This chapter argues that in R&Sie(n)'s work the design process and the forms of the buildings they design are just as much part of the storytelling as the words that accompany their projects. Ambiguity about whether architecture is culture or nature is expressed in the more "science fiction" style of writing by R&Sie(n). An example is Roche's recounting of a story set in "theBuildingThatNeverDies" (2009-2011) in which cultural and natural images are blurred together. "The BuildingThatNeverDies" is a project for a scientific research centre. This strange combination of a fiction about the building that references another fiction by Edgar Allen Poe describes a protagonist who, having arranged a rendezvous with a scientist at the research centre describes his experience of arrival. As he walks toward the building the mist blurs it and the protagonist recalls lines from Edgar Alan Poe's novel,

The *Narrative of A. Gordon Pym of Nantucket*. In the novel a pale apparition of a human figure appears from the darkness at the moment a man dies. In this manner the appearance of the building is made to appear ghostly by recounting this fictional ghost story of Poe. After describing this dreamlike image the story analogizes the building to the derma of a plant. The building is also likened to a David Lynch film as follows:

> "In Les Andelys [the location of the building], this silhouette could be perceived as an afterglow sensation, as a phosphorescence of the death of daylight. In front of me I perceived a multitude of bright curves, reminiscent of long-exposure photography that transforms the stars in the night sky into staggered white threads. As I approached, these linear fireflies became a multitude of sophisticated hybrid glass components, populating the surfaces of the building like the photosynthetic derma of a plant. Wrapped by the glowing lines of the entrance, the scientist was waiting for me with a worrying, endless black corridor – a "Lost Highway" of David Lynch – at his back. He invited me to penetrate into the layered darkness, but with a mischievous air suggested that I should go first into the darkness, into the unknown" (R&Sie(n) 2009).

These examples suggest that R&Sie(n) avoid directly describing their work, preferring the use of natural or synthetic (cultural) metaphors and analogies. This chapter suggests that the constant shifting between natural and synthetic analogies is part of their strategy to confuse the natural and artificial and to question this dichotomy. R&Sie(n) create a conceptual continuity between architecture and environment through their use of language to break down the traditional categorization of building and site. The language they use also breaks down the division between nature/culture, natural/artificial and the correlation of these terms to site/building or environment/architecture.

The concept of artificial ecology can also be identified in the way R&Sie(n) design projects. The approach to design is to create an artificial ecology out of which a form emerges. This artificial ecology is defined as a network of elements, both natural and man-made, which interact to create a form.

There are two main types of projects identifiable in the work of R&Sie(n), which are relevant to this thesis. The first creates an artificial ecology using a robotic system to create a form. The second type "intensifies" an aspect of the relationship between humans, building and environment. Both types of projects share a common thread in that they focus on creating a form out of the contradictory needs that arise from relationships between human habitation, building and context.

First to discuss the robotic projects. The artificial ecology in these projects is an interaction between an information-carrying "artificial life form" and its environment, which produces a form from this interaction. Two examples are examined here. The first, "I've Heard About" is a concept

for a way of producing an urban environment using a machine called the Viab which uses a contour crafting process to print a structure. The Viab contains information and programmed processes, which interact with local conditions to produce a form that is unpredicted. This form is the product of the interaction of the data and possibilities of the Viab and the local context. The second, "Olzweg", is a museum made of structural glass built by robots within an existing courtyard. Both are speculative projects. These artificial ecologies apply processes of form-making that are central to the science of ecology as well as to the creation of architectural form.

This chapter suggests that R&Sie(n) use form generation strategies that replicate processes of form generation as explained in the biological sciences. R&Sie(n) design using ecological thinking by setting up scenarios or *artificial ecologies* that mimic the way form is produced in an ecological conception of a natural environment. An important example of this type of design process is the Olzweg project – a design for a museum of experimental architecture in collaboration with a group of artists including Pierre Huyghe. It is constructed by robots, which place glass structural elements within the courtyard of an existing building to form a new space within.

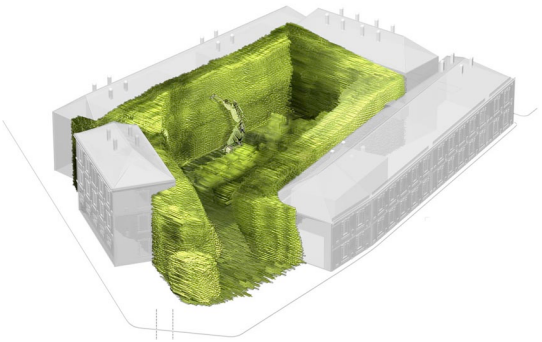

Figure 3: A rendering depicting the Olzweg project, a new glass structure inside an existing courtyard building. (<http://www.new-territories.com/welostit.htm>)

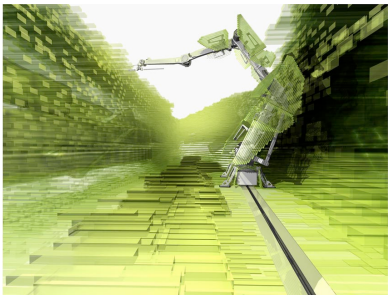

Figure 4: A rendering of the Olzweg project depicting a robot placing glass structural elements. (<http://www.new-territories.com/welostit.htm>)

Roche states that R&Sie(n) use the project to explore:

> "How uncertainty could be introduced through a robotic and mechanical process with a moment of indeterminism in the software driving the machine that is constructing the building. This type of work is a continuation of the 'I've heard about' project which was a 'self-organized, aggregated urban structure where a social protocol became the random vector of the growing and entropic process' " (Archis, Volume 10: Agitation, p. 28).

The robots can be programmed to interact with the environment and with each other and through this interaction produce a form that cannot be determined in advance. In this respect the project is ecological through the way that the project sets up an *artificial ecology* where data, materials and environment interact dynamically to produce a form. The robots act like artificial life forms, embedded with information about how to react to their environment but not programmed to produce a particular formal outcome. The project results in machines creating form in architecture in a way that closely correlates with the way an ecological system in nature creates new forms. This is the creation of an architectural ecology: a web of interrelations that produces an architectural form

Figure 5: A physical model of the Olzweg project representing a robot placing glass structural elements within an existing courtyard building. (Inaba & Clouette 2006 ,p. 29)

Instead of designing a form R&Sie(n) design an environment and a *robot* or a *program* that carries out a series of actions within that environment. The interaction of the "robot" and the environment produces the form. In this type of project the form that R&Sie(n) design is never finished. The design process constitutes setting up a relationship in a process that it set in motion. The way in which R&Sie(n) design a process in order to produce a form has been discussed. A part of this design process allows for uncertainty in the final form that it produces, as the form is a product of unforeseeable interactions between elements of the process. The design outcome is the process rather than the final form. R&Sie(n) do not impose measurable standards or goals on the final formal outcome. The final form is an unpredictable product of an encounter with date and with context. In this respect it mimics the evolution of form in an ecological conception of nature.

This chapter identifies a variation of this design process, which operates by creating an artificial ecology which *intensifies* a critical relationship within the ecological system. Two examples are

examined to illustrate how this design approach reflects an ecological understanding of nature, "Mosquito Bottleneck" (2003), a private house for an art collector in Trinidad and "Dusty Relief" (2002), a museum in Bangkok. The primary characteristic of these projects is that the form, structure and material of each building acts to *intensify* an aspect of the interaction between "scenario" and "territory" and, often, this aspect is an ambiguous or conflicted one. The quality or element that is intensified is highly specific to the context of the project, although they have one thing in common which is that the element always represents a conflict that results from the relationship of human habitation, building and context.

The example of "Mosquito Bottleneck" is a house in the form of a vessel with double layer walls. The dwelling accommodates both a couple of art collectors and swarms of mosquitoes. The interior is for human habitation and mosquitoes that carry the West Nile virus inhabit space between the double walls.

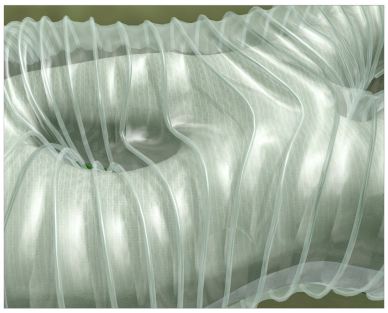

Figure 6 (left): Rendered image of the Mosquito Bottleneck house in forest setting. (<http://www.new-territories.com/mosquitos.htm>)

Figure 7 (right): Rendered image of the Mosquito Bottleneck showing the double exterior walls of the house. (<http://www.new-territories.com/mosquitos.htm>)

The outer skin of the house allows the mosquitoes to enter, trapping them there. The internal skin provides a seal between the mosquito's domain and the human's, but is transparent allowing the humans to observe the swarms of mosquitoes living and dying inside.

The presence of the mosquitoes is the very thing that threatens human habitation in this location. The design of the house creates a space in which the presence and threat of the mosquitoes and the disease they carry are more acute to the human inhabitants of the house. Trapping the insects, the design may also make the site safer by reducing the physical threat the mosquitoes pose. Perversely,

the mechanism for achieving this safety increases the visibility of that danger and increases the psychological effect of the danger (Roche et al. 2004 , p.68).

Figure 8: Rendered image of the interior of the Mosquito Bottleneck house.
(<http://www.new-territories.com/mosquitos.htm>)

What is interesting in the context of this thesis is that R&Sie(n) take inspiration from nature for the form of the building. However they do not take their inspiration from a certain form in nature as is more common in architectural history. They do not mimic the proportions or structure of the mosquito. Neither do they attempt to use architecture as a solution to allow the mosquitoes and the humans to live harmoniously together whilst minimizing the impact on the natural environment, an approach that has dominated much of ecological architecture since the 1960's. In "Mosquito Bottleneck" the aspects of nature that they intensify are interconnections, encounters, and relationships. The project intensifies the conflicted relationships between the client, the mosquitoes and the context that supports both of them. The approach of ecological architecture would be to balance the need to preserve the natural environment and create human dwellings in a harmonious state, minimizing conflict between these interests. The approach of R&Sie(n) in this project would be better likened to the brutal understanding of nature in Darwinian evolution where species compete for resources. This project highlights the competing interests of mosquito and humans, rather than portraying humans as readily able to dominate the mosquito through technology or cunning. However this chapter suggests that what R&Sie(n) do in a project like "Mosquito Bottleneck" is to intensify the aspects of the environment that are at odds with development and to derive the design of the project from this conflict. The design is generated from a set of relationships in the environment that creates an uneasy or conflicted relationship between humans and that environment. In the case of "Mosquito Bottleneck" it is the relationship between the virus-carrying insect, and the humans, at risk from the virus.

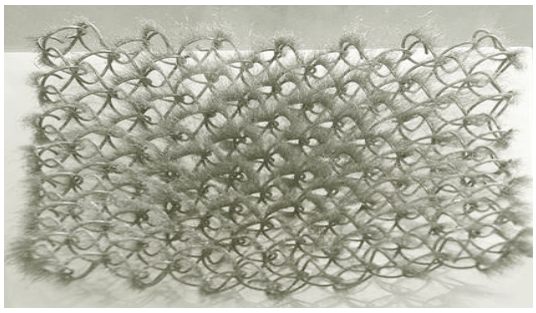

Figure 9 (left): Dusty Relief Museum, cross section. (<http://www.new-territories.com/roche2002bis.htm>)
Figure 10 (right): Dusty Relief Museum, detail of façade. (<http://www.new-territories.com/roche2002bis.htm>)

In the case of "Dusty Relief" the pollution and dust in the air is a reminder of humans' conflicting desires to preserve nature and to create and use machines to modify our lifestyles. "Dusty Relief" takes another aspect of an *artificial ecology* formed by the interaction of "scenario" and "territory", which causes a conflict between the requirements of human habitation and the pollution caused by human activity.

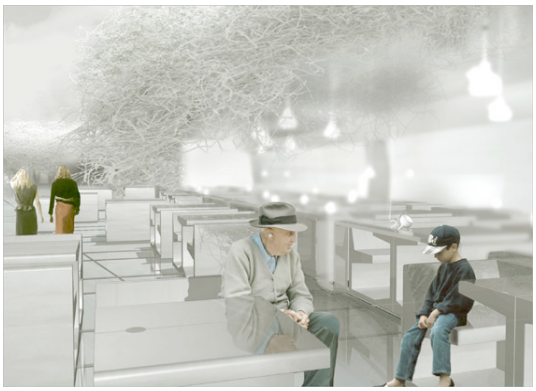

Figure 11(left): Rendering of Dusty Relief exterior. (<http://www.new-territories.com/roche2002bis.htm>)
Figure 12 (right): Rendering of Dusty Relief interior. (<http://www.new-territories.com/roche2002bis.htm>)

This chapter proposes that the project could be seen to represent the conflict between two desires. The first is the desire to preserve the environment as free of pollution, for the good of the environment and also for the health of humans. Second is the desire to make human activities faster and easier, to drive a car and to live in a way that is removed from nature. In this case the threat is dust pollution in the air collecting on the building's surface; it is designed to attract the dust. By concentrating the pollution and making it highly visible Roche states that the architecture provokes a sense of disgust while also forcing visitors to overcome the feeling (Roche et al. 2004 ,

p.69). Like the "Mosquito Bottleneck" it takes a conflicted aspect of the relationship between a project and an environment, and generates a design for the building based on this aspect. This focuses on a critical aspect of the relationship between humans and the environment, a critical and conflicted intersection of culture and nature and derives a form of a project from it. The form of the project is generated by the relationship between culture and nature. The form is not generated through adhering to an abstract philosophy or style of architecture but through interaction of culture with nature. This is ecological as it focuses on the relationship between culture and nature rather than on nature and culture separately.

This design process is influenced by an ecological conception of nature as it represents relationships between elements of nature (including humans) in the project. The design process does not represent idealized proportions found in nature or isolated elements, but focuses on representing the relationships between elements. They are also representative of an ecological idea of nature as R&Sie(n)'s approach places humans within nature as part of a system of competing desires rather than outside it, dominating it.

Roche has said of these types of projects that what an architect does is to make parts of the biotope visible and produce an understanding of relationships in the context through aesthetic means – *a relationship by aesthetics*. He also places humans squarely within the biotope, "inside the system of our own destruction and reconstruction". For Roche humans are not a higher intelligence, but "a parameter of this biotope, [as] one of its elements" (Inaba & Clouette 2006 , p. 29). Biotope roughly means habitat, the area within which a living thing lives, eats, mates or socializes. In this article he also equates the word biotope to territory, the critical size of land where a living thing can survive. This chapter suggests that both "Dusty Relief" and "Mosquito Bottleneck" confront humans with their place within a system, a part of nature rather than standing outside it. However the moralistic overtones that are sometimes associated with ecological architecture (especially in the early years) are gone. R&Sie(n) are not pointing out the dusty polluted air of Bangkok as a call for change, to stop the pollution. On the contrary, the qualities of the context are accepted and exploited in such a way that intensifies the conflict between the human desire for purity and the need to live in an environment of our own making

R&Sie(n)'s approach to nature and the interactions of humans with it is illuminating when considering these types of *intensifying* projects. Roche argues that architecture consists of revealing two contradictory impulses in constant tension: the desire to preserve nature and a fascination with technology. He argues that these contradictory impulses protect us from "ecologist alibis, 'primitivist' dreams of purity and of the *Heimat,* as well as from becoming enslaved to the mechanisms of the *tabula rasa*" (p. 58, spoiled climate). In the context of this thesis this statement is interesting in that he is stating that the contradictory desires of humans make impossible simple

divisions between dreams of nature's purity and culture as a separate entity. Nature and culture are inextricably enmeshed like the rainforest and the bulldozer, invented by humans as a reaction to the existence of the rainforest.

At a disciplinary level, R&Sie(n) define architecture as an ongoing, unfolding encounter with context. At the scale of a building, the architectural form is generated through the relationship between building, inhabitant and context. Architecture at every level is reframed as the product of an *artificial ecology*, an enmeshed relationship between "scenario" and "territory".

This redefinition of architectural terms results in a blurring of nature vs. culture or natural vs. artificial dichotomies that are often associated with thinking about the relationship between environment and architecture. These redefined relationships are ecological because they are enmeshed dynamic relationships rather than hierarchical relationships between two things that are fundamentally separate.

The next chapter will examine the work of the Emergence and Design Group. Similarly to R&Sie(n) the definition of terms around environment and architecture are redefined within EDG due to the influence of a scientific definition of ecology. The EDG are much more explicit in their ecological thinking and the importance of redefining ecology in architecture. Chapter five argues that the EDG go beyond the blurring of architecture and nature seen in R&Sie(n) and place architecture within nature by correlating the definition of ecology with architecture.

Chapter 5: *The Emergent Continuum* The Emergence and Design Group

Chapter four argued that an ecological conception of nature in the work of R&Sie(n) can be identified in the way that they describe and characterize architecture and the relationship between program and site. It also argues that the employment of an ecological conception of nature by the R&Sie(n) firm results in blurring of boundaries between elements often considered to be either natural or artificial through the creation of *artificial ecologies*.

This chapter identifies ecological thinking in the Emergence and Design group (the EDG) through the concept of an *emergent continuum* they establish between nature and culture. Ecological thinking is defined in chapter one as the application of an ecological conception of nature to architecture, which in the case of the EDG is identified though the application of the concept of emergence in architecture.

The EDG are the most contemporary practice examined in this thesis. This chapter focuses mainly on their most recent work although the background and the development of their ideas are also touched upon. This chapter argues that the EDG show ecological thinking in two ways. Firstly, they conceive of nature in an ecological way. They do this by explicitly using a scientific definition of ecology. They also focus on the concept of emergence as a process of form generation in the natural world, a concept that requires an ecological understanding of nature constituted by enmeshed relationships and dynamically changing as a result of those relationships. Secondly, they use this understanding of nature to inform their architectural practice: to create an *emergent continuum* at three levels. At the first level, this emergent continuum creates a link between nature and culture at a conceptual level. The EDG propose that culture has emerged from nature and that forms produced by culture are an extension of forms produced by evolution in nature. At the second level, the EDG redefine key terms in order to create a continuum between natural forms and man-made forms. At the third level, the continuum is a link between built form and environment. The EDG use emergent processes to create more close and intricate links between buildings and their environments: to achieve a greater level of modulation between the built and the natural environment.

This chapter concludes that ecological thinking in the EDG results in their considering nature and architecture as continuous rather than fundamentally different. This places the EDG in a line of thinking about ecological architecture starting with Sim Van der Ryn that aims to integrate architecture and nature. Van der Ryn argued that "design should be defined as the intentional shaping of matter, energy, and process to meet a perceived need or desire. Design is a hinge that inevitably connects culture and nature through exchanges of materials, flows of energy, and choices of land use" (Ryn & Cowan 1996 , p.8). In this quote design is described as a mechanical link that

can connect two things that are, by their nature, separate. In their use of emergence as a design method the EDG place designed forms into a continuum with natural forms. They use ecology and emergence as a way to think of design as a continuation of the development of forms in nature through evolution.

The Emergence and Design Group (EDG) is a multi-disciplinary design and research practice, which began with the aim of exploring the concept of emergence in architecture. The group consists of geographically dispersed individuals with regular shifts in its membership and collaborations with others for particular projects. Michael Hensel, Michael Weinstock and Achim Menges are the directors of the group formed in 2002 in London. The group undertakes design and research that combines architecture, industrial design, Biomimetic engineering, digital morphogenesis, as well as advanced CAD/CAE/CAM and explores design approaches based on evolutionary design, self-organisation and emergence. Like Lynn, early in their research the EDG responded to the dominance of typological methods in architecture. The EDG focused their early research by problematizing taxonomic systems of classification in architecture and in a search for alternative ways of describing differentiation without relying on categories. This chapter argues that the beginning of ecological thought in the work of the EDG was in their search for alternative ways of describing differentiation of architectural form that did not rely on typology. The main focus of their early teaching work was on rethinking discrete building typologies and merging them into a continuous urban fabric. This project was expanded where they sought to combine landscape and urban forms – disregarding established typologies and exploring temporal organization for architecture.

Their search for ways of representing and generating forms as a continuous urban fabric rather than disparate "types" led the EDG to reject mechanistic models as the basis for form generation in favor of organic or biological models. Mechanism is the philosophical belief that natural wholes (principally living things) are like machines or artifacts, composed of parts lacking any intrinsic relationship to each other, and with their order imposed from without. Mechanistic models try to understand complex forms or systems by examining each part in isolation and adding the knowledge together to get an understanding of the whole. By contrast, Organicism is a philosophical idea that reality is best understood as an organic whole. Organic models try to understand parts as part of an enmeshed relationship with a whole. The EDG focus on the potential for organic and biological models of form creation in which parts of a whole are not separable. As the name of the group suggests they are particularly interested in models of emergent form generation. Emergent form generation is based on an idea of nature in which more complex patterns or forms arise out of relatively simple interactions. This focus has led the EDG to explore emergent processes of form generation in nature and appropriate these processes and the names for them into their architectural design processes. By tracking the names they use for their design

processes it is possible to see a progression from "morpho-genetic design" to "morpho-ecologies". Morpho-genetic design models architectural design on natural processes of morpho-genesis, or the process by which a living form in nature develops its form through an emergent process. The later use of the term "morpho-ecological" design by the EDG reveals an increasing focus on the role of interaction between a living thing and its environment as a generator of form and the application of this process in architectural design.

An Ecological Understanding of Nature

This chapter argues that the EDG display an ecological understanding of nature in two principal ways. The first is by defining ecology using the original definition. The second is in their focus on the concept of emergence, which requires an ecological conception of nature as enmeshed and dynamically changing.

The EDG are distinguished from the other two case studies in that they use the word "ecological" a lot and are very clear that they are using its original definition rather than a normative one. This thesis proposes that one of the clearest indications that the EDG use ecological thinking in their practice is the clear statement that they wish to redefine ecology within architecture, stating that "Ecology is the study of the relationship between organisms and their environment" (Hensel & Menges 2006 , p.16). This clear use of the scientific definition of ecology is important for this thesis because it results in the EDG focusing on ways of understanding the natural world that are ecological in character and have potential for architecture. This use of the original definition of ecology is evidence of the EDG's understanding of nature as dynamically enmeshed. The EDG focus their interest in nature on ways of understanding how forms grow and develop in response to their environment. For example, they are interested in ways of analyzing how a plant grows and develops a form in response to its environment and how knowledge of this process can be applied to architecture.

Weinstock has stated the belief that the current fascination with nature in architecture is the continuation of the central role of the relations of mankind and nature to the "conceptual apparatus of architecture". He also comments that today new modes of imaging and simulating biological forms and processes allow a continual exploration of nature. He also makes the observation that in the biological sciences there has been a shift from a focus on *Morphology* (the study of forms) and categorization, which were the principal methods of analysis prior to the theory of evolution. After the theory of evolution came to be accepted there was a shift to focus on *Morphogenesis*, which

emphasizes the forces that generate living forms and how forms and environments come into being rather than the study of the forms themselves (Hensel & Menges 2006, p.12). This chapter suggests that statements such as this indicate that the EDG believe that the relationship between nature and architecture is valuable and should be continually updated as science develops new ways to understand nature. However they are quite specific about how ideas of nature should be used. For example, Hensel and Menges caution against the use of biology as a source of metaphor or superficial formal repertoire in architectural design. They argue that a focus on Morphogenesis and Ecology involves a deeper engagement with biological sources of knowledge (Hensel & Menges 2006, p.16). They are not only interested in the architectural potential of studying the external appearance, symmetry or form of individual species in isolation. They also focus on the potential of processes of form generation as a product of a complex and interconnected ecological system.

Some of the research into natural systems challenges assumptions in architecture about engineering. For example, Weinstock does research into self-organisation and structural dynamics of plants and discovers that robustness in plants is caused by redundancy and differentiation rather than optimisation and standardisation (*A.D Techniques and technologies in Morphogenetic Design*, 2006, "Self-organisation and the Structural Dynamics of Plants", Michael Weinstock, p. 26). This knowledge about plant structural systems is only attainable by looking at those structures in the context of the environmental forces acting on them (ie: in an ecology). If we look at the structure in isolation it is impossible to know whether the structure is optimised for the environmental load or whether redundancy is built in. This article looks at the Emtech masters' work which analyses plant behaviour in response to environmental stresses. The article addresses the challenge of developing software to analyse the structural response of biological systems as there is not just one component system that can be examined in isolation, rather the article comments that biological forms are systems within systems, hierarchical arrangements of semi-autonomous organisations each having it's own function but also having sufficient excess capacity to contribute to the responsiveness of the global organisation (*A.D Techniques and technologies in Morphogenetic Design*, 2006, "Self-organisation and the Structural Dynamics of Plants", Michael Weinstock, p. 28). This comment shows that the EDG have an interest in examining structural capacity as a dispersed phenomenon. The aim is to gain knowledge to apply to architectural applications by looking at natural structures as complex interacting sub-assemblies working together to deal with external forces of the environment. They look at the development of the form under stress, not just the capacity for the complete form to perform under the stress. This is an ecological way to approach the study of nature. Like Lynn changes architects' ideas about nature, the EDG enact a change in the way architects think about ecology.

The second piece of evidence for an ecological understanding of nature in the EDG is their focus on the concept of Emergence. Emergence requires an understanding of nature as interconnected

and changing dynamically over time. Emergence is a term used in philosophy, systems theory, science, and art to describe the way complex systems and patterns arise out of a multiplicity of relatively simple interactions. The EDG focus on examples of biological emergent processes. Within the biological sciences emergence is strongly tied to the increasing complexity of life forms that develop through the process of evolution ('Encyclopædia Britannica Online' 2011). Emergence as a concept allows the complexity of life forms found in nature to be explained as products of a series of interactions occurring between less complex forms over time. In this sense emergence relies on an ecological understanding of nature as dynamically changing as a result of interaction. The EDG equate emergence with evolutionary optimisation and aim to match what they call "the restless perfection of the natural world" (Hensel, Menges & Weinstock 2004). In regard to this thesis the crucial thing about the desire of the EDG to mimic the natural world is that they conceive of the natural world not as a static perfection but as a constantly changing web of relationships out of which patterns constantly emerge. The restless perfection they wish to mimic in architecture is not an essential notion of perfection but a dynamic, evolving one. This chapter argues that this way of thinking about the urban environment is ecological as it focuses on the enmeshed nature of individuals as part of a continuous whole rather than viewing them as a collection of discrete objects in an environment.

The Emergent Continuum of the EDG

At a conceptual level the EDG apply an ecological conception of nature to architecture in two ways, which together create a conceptual continuum between nature and culture. They do this firstly by redefining the words ecology and architecture, and secondly by proposing an expanded definition for the word "ecology".

As previously mentioned, the EDG use the original definition of the word "ecology" in their practice: "Ecology is the study of the relationship between organisms and their environment" (Hensel & Menges 2006 , p.16). They also extend this definition of ecology to define architecture, proposing that:
"This definition also suits architecture surprisingly well: in our view one of the central tasks of architecture is to provide opportunities for habitation through specific material and energetic interventions in the physical environment. Correlating morphogenesis and ecology, we have developed a new framework for architectural design that is firmly rooted within a biological paradigm, and thus concerned with issues of higher-level functionality and performance capacity. We have named this approach Morpho-Ecology" (; Hensel & Menges 2006). In addition to this expanded definition of ecology, the EDG redefine architecture as "the organization and internal infrastructure of a natural or culturally produced object" (Weinstock 2010, p.8). This redefinition of

terms has two major implications. Firstly it breaks down the link that exists in architectural discourse between the word "ecology" and ideas of nature or the natural environment. At the same time it broadens the meaning of architecture from a cultural activity to something that can also be found in nature.

The redefinition of these two terms challenges the idea of architecture and nature as separate. By extending the definition of ecology to architecture this chapter argues that the EDG create a conceptual continuum between architecture (culture) and nature. This is ecological thinking as it breaks down traditional divisions between ecology (which is often viewed as nature in architecture as discussed in chapter two) and architecture as part of culture. As discussed in chapter two of this thesis ecological architecture often positions itself as architecture that respects nature or reduces harm to it. The EDG define architecture as *a conception of nature*, essentially that architecture is a part of nature or operates in a similar way. This breaks down a tradition of thinking about architecture as removed from nature, as changing and evolving against a static and passive nature.

This suggestion of ecology and architecture sharing a definition can be interpreted in multiple ways. Firstlt, in using the definition of ecology as a definition for architecture, the obvious "organism" is the human who inhabits the architecture. Taking the definition of architecture as ecology, architecture could be redefined as the relationship between organisms (humans) and their environment (built form). Another interpretation stems from the fact that the EDG also express conviction that, should their biological paradigm for architectural design be expanded, the consequence may be an understanding of the design product as "synthetically alive and embedded within generative ecological relations. Including the molecular scale in the scope of architectural design would deliver advanced performativity and sustainability of a completely new magnitude" (Hensel & Menges 2006, p.24). In the second interpretation, architecture or buildings could potentially be designed as a form of synthetic life and able to respond dynamically to an environment, creating its form through this interaction. Both interpretations of these statements by the EDG show ecological thinking on the part of the EDG as they both focus on the relationships between living things and their environments as a method of form generation. Furthermore they translate this ecological thinking to ways of conceiving of form generation in architecture.

This chapter argues that this two-fold redefinition of terms erodes distinctions, perceived or real, between man-made and natural forms. Through the redefinition the EDG create a conceptual continuity between forms created by nature and forms created by humans. This continuity is a conceptual framework that would then allow all forms to be evaluated on the same criteria. It also allows for the justification of the analysis of form creation phenomena found in nature and the adoption of techniques derived from such analyses within the architectural discipline. The word "Morphogenesis" in the second quote refers to the biological process that causes an organism to

develop its shape, although it can also mean *generation of form* in general and could be extended to the generation of form in architecture. Therefore this chapter argues that by proposing that morphogenesis and ecology are correlated, the EDG give value to the relationships between organisms and their environment as a potential source of morphogenesis or form generation in architecture. This quote is very interesting in the context of this chapter as it makes a very direct claim for the value of ecological thinking in architecture. Unlike Greg Lynn who rarely uses the word "ecology", the EDG are very clear about their intention to blur the boundaries between morphogenesis in nature and morphogenesis in architecture. The emergent continuum that the EDG create between natural and architectural forms in nature culminates in their most recent major publication, *The Architecture of Emergence: The Evolution of Form in Nature and Civilisation* (2010). Weinstock argues in this book for human culture to be considered as enmeshed with nature. He argues that human culture has evolved as a continuum with all other forms in the world and is influenced by the same flows of energy, information and material. The EDG understands the creation of architectural forms to be an extension of the emergent process of evolution which has created forms in nature.

The EDG also extend this concept of emergence to design methods in architecture. In adapting emergent processes of form creation found in nature the EDG create an emergent continuum between form creation in nature and in architecture. In order to decipher the development of their design techniques we need to look closely at the terms they use. Since the early 2000's they have based their design techniques on emergent processes of morphogenesis. The EDG have often variations of the word morphogenesis to name their own design processes.

Morphogenesis is an emergent process of form generation involving self-organisation of matter and described by the EDG as "a process in which the internal organisation of a system adapts to the environment to promote a specific function without being guided or managed from outside" (Hensel 2006, p.12). The word morphogenesis has its origins in the biological sciences and refers to the biological process leading to the development of an organism's shape. Morphogenesis is the study of the formation and differentiation of tissues and organs in a living organism or form. The process of morphogenesis controls the organized spatial distribution of cells during embryonic development of an organism. The process is driven by genetic information carried by cells, hormones and environmental factors (such as chemicals, radiation, temperature or mechanical stress). The word's etymology comes from the Greek *morphê* (shape) and *genesis* (creation) – "beginning of the shape". The important thing about morphogenesis is that it is an explanation for the generation of biological forms that is driven by the internal processes of the organism, not by forces from outside, although the form may respond to factors such as chemicals in its environment. An example of morphogenesis is the way plants grow from a seed and develop their form in response to multiple external forces such as sunlight and wind. The plant has DNA which

contains information and tells the cells to grow and organise themselves in a certain way. This information also allows the plant to respond to various forces. It is the interplay between the information carrying DNA and the environmental forces that generated the final form. [not clear]

Morphogenetic design is what the EDG have named a design technique based on the concept of morphogenesis – an interplay between information internal to a form and the form's environment. As a basis for this design method the EDG look to self-organising morphogenetic processes in nature and explore ways to adapt these form generation processes to the generation of architectural form. The EDG express the belief that such processes of form generation in nature result in higher level integration and functionality which evolves from a dynamic feedback relation with the host environment (Michael Hensel, Computing Self-Organisation: Environmentally Sensitive Growth Modelling, p. 12) One of the principle aims of the EDG in developing this design method is to achieve a higher level of sustainability. The EDG explain the aim of morphogenetic design as utilising the response of self-organisational processes to external stimulus as a way of creating performance-oriented designs. Performance-oriented design means the EDG are aiming to create buildings that respond to their environment in a detailed and sophisticated manner and are more sustainable as a result. Simply put, it means a focus on the performance of the building in its environment over and above its aesthetic or formal characteristics. For example, if a building was able to respond to changing light conditions by moving shade structures, then sustainability could be increased by reducing the need for air conditioning and its associated power use. In order to achieve this aim they are exploring the potential to incorporate the desired response criteria into a design process that utilises emergent, self-organisational processes.

After using the term *morpho-genetic design* the EDG started to call their design method *morpho-*ecologies (Hensel & Menges 2006). This corresponded with them suggesting the word "ecology" as a shared definition for the science and also for architecture. They assert that biology tackles some questions of how a form is developed in relation with its environment (Hensel & Menges 2006, p.20). Hensel and Menges suggest that by correlating morphogenesis and ecology they create a framework for architectural design that is rooted in a biological paradigm that goes beyond a superficial formal link to biology (Hensel & Menges 2006, p.16). The EDG explain the Morpho-Ecological approach as based on an understanding of morphogenesis in nature. They explain morphogenesis in nature as the generation of polymorphic systems: "hierarchical arrangements of material that display both scale-dependant articulation and high-level articulation across scales". This is achieved through exposure of a growing living organism to extrinsic influences and stimuli from its environment. In the case of a living organism the cell numbers are growing in size, increasing in number and becoming differentiated at the same time. As Hensel and Menges explain, in nature morphogenesis formation and materialization processes are always inseparably related (Hensel & Menges 2006, p.20). It is this quality of natural morphogenesis that the EDG are looking

to capture in their Morpho-Ecological design technique. They wish the material and its qualities to be a driver in the design process, not for the material to be organised by extrinsic forces. The design process they are aiming towards is one where a polymorphic system of interrelated form, materials and structure generates a form in response to its environment. They wish to translate the process of natural biological form generation within an environment to an architectural design process were the architectural form is likened to an organism that grows and develops as a result of information within it responding to external influences. They even suggest that advances in molecular biology may make it possible for design products to be synthetically alive. An important aspect of this design strategy is the desire to use redundancy as a latent performance capacity, in the way that the EDG have researched redundancy to work in natural systems. Hensel and Menges assert that their approach will result in a synergistic and integral understating of material elements and systems, something which they say sustainable architecture claims to have but which it implements in a simplistic manner focused on energy consumption, material life-cycles and waste production. They aim to do this by analyzing whole systems, not parts (Hensel & Menges 2006, p.22).

This summary of the EDG's design techniques and their links to emergent processes in nature shows a progression from interest in the development of form (in morphogenesis) to interest in the development of form as a product of interaction between a species and an environment (in Morpho-Ecologies). This is a response to architecture's tendency to design a form and then impose that form onto a material without inherent material properties playing a part in the design process except in the mind of the architect. "The ME approach to architectural design aims instead to achieve morphological complexity and performative capacity in material constituents without separating formation from materialisation processes. The core of such an approach is an understanding of material systems as generative drivers in the design process – rather than derivatives of standard building systems and elements facilitating the construction of predetermined design schemes…This promotes an understanding of form, materials and structure not as separate elements, but as complex interrelations in polymorphic systems resulting from the response to varies input and feedback relations" (Morpho-ecologies, p. 21).

This chapter argues that the EDG display ecological thinking in recognizing the creative potential of the enmeshed nature of the species or environment. As discussed in chapter one, a major shift in understanding nature that occurred during the development of ecology was the concept of nature not as created (in one moment, in accordance with an overall plan), but constantly creating itself. The creativity of nature is a central characteristic of ecological nature. This chapter argues that the creative aspect of nature associated with an ecological conception of nature is a focus of the EDG and is the major characteristic of nature which they seek to exploit in architectural design in order to achieve greater environmental integration and an associated level of sustainability. They look for

examples of how nature creates new forms through ecological relationships such as emergence and morphogenesis and explore the potential for such modes of form creation within architecture. "We can say that all forms emerge from the dynamic processes by which natural systems, both living and non-living, produce organized arrangements of material in time and space" (Weinstock 2010, p.16).

One way that the EDG explore the potential of emergent processes of morphogenesis in nature as a basis for architectural design techniques is displayed by their interest in L-Systems. An L-System is what is called a formal grammar in computer science. It is a way of describing the dynamics of plant growth in response to environmental factors. The work is the evolution of digital plants that "grow" according to environmental input. Change in the input results in a different growth result, or a different articulation of the modelled species. This process is called *modelling environmentally sensitive growth* and uses a descriptive computer system called the Lindenmayer-System (L-System) developed in 1968 by the biologist Aristid Lindenmayer. The L-system was developed to analyse and model the growth of plants and plant communities for biological research. L-Systems are also popular in generating artificial life. This chapter suggests that the L-System derives from an ecological understanding of nature and form creation in nature as it studies the role of the relationship between environment and organism in the development of form in plants. It does not study plant forms in isolation. It is based on the premise that plant forms arise through the interplay between a plant's genetic information and the environment in which it is growing. L-systems are computer programs that model the interaction and subsequent form.

Hensel looks at work undertaken by Professor Przemyslaw Prusinkiewicz at the Department of Computer Science at the University of Calgary in Alberta, Canada, on the potential for L-Systems in architectural design, Prusinkiewicz proposes that L-Systems could be used in architecture to facilitate a better understanding of synergies between systems and environments, or subsystem interaction. (Hensel 2006, p.14) L-Systems are capable of describing complex arrangements such a spiral phylotaxis, which optimises packing of seeds of scale, or the orientation and exposure of leaves to environmental factors such as sunlight. Hensel comments that the ability to describe a complicated arrangement of elements in response to environmental factors could be useful in architecture in designing arrangements of façade elements in order to achieve any desired exposure to environmental effects. The value that the EDG perceive in this method of description is that, rather than describing the growth of plants in response to environmental effects, it could also be possible to describe the development and growth of building systems and envelopes informed by multivariable input and optimised to satisfy multi-performance objectives (Hensel 2006, p.14). L-systems model growth systems where system-intrinsic organisational information and system-extrinsic influences interact to produce a form. If such a descriptive system were applied to the modelling of a building form it would be possible to program system-intrinsic parameters such as program requirement, room sizes and configuration, and material properties and allow these to

interact with system-extrinsic parameters such as gravity, wind and sunlight. Over time an architectural form could be grown that would respond to multiple environmental parameters.

L-Systems can also be used to model the distribution and interaction of a community of plants in an environment. Hensel proposes that L-Systems could be used to model the distribution and interaction of buildings with each other in a similar way – the tool could also be useful at an urban scale. This type of design process is very different to the development of a building type or ideal in isolation from a particular circumstance and its subsequent modification to suit the environmental requirements of its site. In L-Systems the starting point is not a prototype form but two sets of information, one pertaining to the intrinsic qualities of the system, the other pertaining to the external environmental influences. The interaction of the two information sets over time governs the growth of a form. Such a process means that the final form is often unpredictable and is a product tailored to its specific environment. The interest in using a system like L-System in architectural design stems from the potential for such a system to produce architectural design that is highly responsive to and integrated with the environment. This fits into the EDG's aim of achieving an advanced level of sustainability through designing buildings which are responsive to their environments.

This chapter argues that the L-System is a mode of learning about forms and structure in nature that displays an ecological understanding of nature. This is apparent because it is strongly focused on understanding the development of form over time and through interaction with environment rather than by analyzing a form in isolation. L-Systems represent an understanding of nature as dynamically changing over time as a result of enmeshed relationships and interactions. The consideration of such a system as useful in architectural design by the EDG shows the applications of an ecological understanding of nature to architecture. Prusinkiewicz and the EDG propose using such a system to develop a similarly enmeshed relationship between an architectural form and its environment.

L-Systems are capable of simulating the intricate relationships between organisms and their environments,. The fact that the EDG see value in transferring such a system of form generation as a way to produce architectural form shows that they are thinking of architectural form as a product of an unfolding interaction between architecture's internal concerns (program, spatial relationships, client needs) and the external pressures of the environment (sunlight, wind, and interaction with existing urban context).

The EDG clearly use an ecological understanding of nature through their focus on emergence. Emergence is used by them as a concept that allows them to create a link, an *emergent continuum* between architecture and nature. The EDG create this emergent continuum on three levels. Firstly,

at a conceptual level, the link between architecture and nature is strengthened. Secondly, a link between physical forms in nature and architectural (man made) forms is created. Thirdly, the physical link between built form and environment is prioritized by the EDG.

This chapter has argued that an ecological conception of nature has influenced the work of the EDG in two ways. Firstly, at a conceptual level an ecological conception of nature has been instrumental in the EDG's thinking of nature and culture as existing in a continuum. Secondly, they use an ecological conception of nature to explore form creation in nature and to apply the findings to architectural design and the relationship of architectural forms to environment.

The EDG began their work by experimentation with the potential of emergence in nature for architectural form creation. This experimentation evolves to the point where they understand architecture and the development of architectural form as an emergent process in a continuum with emergent processes in nature. The EDG go on to look to biological models of form creation that embody an ecological idea of nature. They translate these models (such as morphogenesis) into architecture as a basis for form creation in architecture. Their more recent work (since 2006) discusses architecture as existing in a continuum with nature. Through the concept of emergence they argue for human culture to be considered as enmeshed with nature, proposing that forms produced by human culture have evolved as a continuum with forms produced by the natural process of evolution. This chapter argues that the major result of this ecological thinking by the EDG is the conceptualization of nature and culture (architecture) as existing as part of a continuum.

This is in contrast to early ecological/sustainable architecture where architecture and ecology were often correlated with culture and nature and seen as fundamentally separate. As such the focus was how to better integrate these different entities more effectively and to minimize disruption to nature. Often the solutions for achieving sustainability do not affect the form of the architecture very much. The solutions are often "add-ons" or modifications to architecture. A building is regarded as an "architectural" form which, in order to achieve sustainability, adapts in order to avoid disturbing the natural environment or to integrate with ecology. EDG in equating architecture to ecology define the architectural object as something that not only adapts, but is part of a continuum with the natural environment. This is very different from the discourse on ecological architecture that occurred in the 1960's. In early ecological architecture ecology was "nature" and needed to be protected from , yet integrated with architecture which was man-made or "artificial". The definitions that the EDG use involve ecological thinking in that they focus on connection and relationship between humans, architecture, and environment as part of an ecological whole as a means to achieving sustainable architecture. This is in contrast to treating humans, architecture and environment as different entities with different needs, which need to be

adapted to fit each other. These definitions serve to break down the division between *natural* form and *architectural*, *man-made* or *artificial* form. The definitions treat humans, architecture, and environment as simply *forms*, which arise due to interactions. These interactions are seen as the source of new forms. This is ecological as the continuum between materiality and relationships is unbroken by lines representing discipline.

The EDG seek to find a connection between culture and nature through linking their fundamental properties and redefining ecology and architecture. Rather than considering their fundamental properties as different and seeking ways to integrate architecture and ecology the EDG link them conceptually. This seems to me to be a radical departure from the ecological architecture of the 1960's and 1970's.

EDG redefine the words ecology and architecture in order to break down the traditional division between nature and culture. In this way they shift the focus away from the difference or separateness of nature and culture. This chapter argues that EDG focus on the relationship between architecture and nature. They position the development and evolution of culture as an extension of the development and evolution of nature. This in an architectural context is unusual because it places culture in a continuum with nature. It happens more often in the history of architecture that architecture positions itself within culture and separate from nature. Placing culture and architecture as part of that culture in a continuum with nature is ecological thinking because it thinks about the world as a web of relationships without sharp distinctions between concepts such as nature and culture. The science of ecology focuses on physical and formal interconnections in the world. Ecological thinking in the EDG shifts this emphasis on interconnections to concepts as well as physical connections.

The next chapter provides an overview of the effects of an ecological understanding of nature in the three practices: Greg Lynn, R&Sie(n) and the EDG. It also summarises the main conclusions and contributions of the thesis and proposes some directions for further research.

Chapter 6: Conclusion

The question this thesis has explored is: *What effect is an ecological understanding of nature having on contemporary architecture?* This thesis has examined the question in three ways corresponding to three sections of the thesis. The first section (chapter one) gives an overview of the characterisation of nature associated with the development of ecology as a science. It tracks the development of the science of ecology as a response to changing ideas of nature. The second section (chapter 2) examines the way ecological ideas have been used in architecture since the 1960's and the ideas of nature associated with the word "ecology". The third section examines three contemporary practitioners in detail to identify some effects of an ecological conception of nature in recent architecture.

This thesis is based on the premise that the dominant tradition in architectural discourse is to conceive of nature and culture as a dichotomy where nature is the opposite of culture, the two differing fundamentally in character. Although nature has often been considered to be an inspiration, a model, or even the origin of architecture, it is still considered to be "out there" and separate from the cultural activity of architecture. This thesis has argued that this dichotomy relies on a pre-ecological idea of nature operating in architecture.

A pre-ecological conception of nature refers to the dominant way of thinking about nature prior to the establishment of the science of ecology. At this time an essentialist view of nature dominated science. Elements making up the natural world were considered to be unchanging, separable, and to have no connection to each other. Chapter one of this thesis outlines the conceptual events during the eighteenth and nineteenth centuries, which led to this concept of nature being discredited. A new enmeshed and connected idea of nature filled the void and the science of ecology developed as a method of understanding this concept of nature. Chapter one finds a radically changed conception of nature as enmeshed and dynamically changing associated with the scientific definition of ecology. This chapter defined the specific characteristics of an ecological understanding of nature as *enmeshed and dynamically changing over time as a result of relationships between elements of nature.* This chapter emphasises that ecology is relatively young science. Only a century passed between the time that the word was coined in 1866 and when it became known to the general public in the 1960's. Ecology in the 1960's was a science that had grown rapidly and had developed within it diverse groups which only partially agreed on how to carry out their scientific investigations. In addition, in the mid 1900's ecological ideas had become mixed with mechanistic ideas of nature resulting in a focus on the stability and equilibrium of the relationships in natural systems. Ecology at this time was still breaking free from older essentialist ideas of nature that saw it as stable or static. This influenced the way the word "ecology" was interpreted in various spheres

such as society, economics, politics as well as architecture. This chapter identified two distinct uses of the word "ecology". The first corresponds with the original definition of ecology dating to 1866. The second originates in the wider use of the word "ecology" in the 1960's and its association with maintaining nature in equilibrium.

The second chapter of this thesis tracked the introduction of an ecological conception of nature into architecture since the 1960's. This chapter argues that ecological concepts and the word "ecology" were introduced to architecture at a time when ecology was very young as a discipline and was still establishing a unified conception of the character of nature and methods for understanding nature. This chapter argues that the new concept of nature from which the science of ecology emerged has been only partially explored within architecture. Since the 1960's the word "ecology" has been used in architecture, although the word has taken on various meanings removed from the original meaning of ecology and an ecological conception of nature has not always been associated with its use in architecture. This chapter concluded that two definitions of ecology have been used in architecture since the 1960's. The first is the normative definition, which is an example of semantic shift from the original meaning of ecology and lacks an ecological conception of nature. The second is the original scientific definition, which is associated with an ecological conception of nature.

The third section of the thesis, the case study chapters three, four and five, explore the effect of the recent use of an ecological conception of nature in architecture. These chapters draw out the different effects of applying an ecological conception of nature to architecture in each case study.

Chapter three argues that Greg Lynn enacts a shift in conceptualising nature, and that this shift has some similarities with the shift that occurred in the sciences around the time that ecology was developing. This chapter argued that the work of Lynn focuses on overturning essentialist ideas about nature in architecture and replacing them with an ecological concept of nature. His also looks to apply these ecological ways of understanding nature to architecture and in this way carries on a tradition of architecture that is informed by ideas of nature. In this sense he maintains a tradition in architecture of culture and nature being understood as separate. He acknowledges the importance of nature as a concept within architecture and illustrates many ways in which architecture has imitated nature. What is radical about what he does is that he argues that it is not nature itself that architecture imitates, but concepts of nature which have changed over time. He also argues that the representation of concepts of nature in architecture has been influenced by the tools we have had to analyse and represent nature and forms. He questions what nature is and does, and what concept of nature is represented in architecture. The most important argument he makes is that architecture has based methods of designing and describing form on imitating an essentialist concept of nature. He also explores alternative ways of designing and describing form that are derived from ways of

understanding nature. Lynn seeks ways of describing form that allows for a relationship to be described between parts that are differentiated, yet part of a whole. The science of ecology is a way of describing forms in nature as differentiated parts of a whole, and many of the examples that Lynn relies on to support his arguments reflect an ecological understanding of nature.

The case study on Lynn is useful in illustrating the impact that concepts of nature have had on how architects historically have gone about form making as a reflection of a perception of nature. It is also useful as an atypical example of an architect who has questioned the way architects conceive of nature. The case study on R&Sie(n) focus more on the influence of ecological concepts of nature on methods of design and the relationship between built form and environment.

In the R&Sie(n) case study I identify in their work the idea of an *artificial ecology* where ecological ideas of relationships, change, and development of form include both natural and man-made elements. They conceive of architecture existing in an *artificial ecology*, merged with the environment and formed by it. The evidence for the use of ecological concepts of nature by R&Sie(n) is around the acknowledgement of nature as active and responsive, rather than as a passive background. The R&Sie(n)case study argued that an ecological concept of nature is used by them to redefine the relationship between building and site and architecture and environment as ecological. This redefined relationship is ecological in that it is an enmeshed dynamic relationship rather than a hierarchical relationship between two things that are fundamentally separate. This chapter argued that R&Sie(n) describe an ecological relationship between architecture and environment when they assert that architecture does not exist without the particularities of an encounter with environment. Ecological Thinking in R&Sie(n) results in a blurring of the boundaries between entities like environment and architecture that have been traditionally polarized as either natural and artificial. This chapter suggests that for R&Sie(n) the division between nature and culture is complicated. Nature is corrupted with and is not always pure or easily separable from culture. R&Sie(n) also describe nature as having qualities that are more often associated with culture or artificial forms such as the capacity to enact change, synthesise, evolve. At the same time they describe cultural objects or artificial things as acting like natural things. R&Sie(n) play on the possibility to create blurriness or confusion between these categories. In this way nature and culture become closer in an ambiguous way. In R&Sie(n) the physical form of projects has the affect of "magnifying" the surrounding environment, making the inhabitant more aware of its unpredictable or ambiguous qualities. This effect magnifies nature as dynamic and interconnected, or ecological. Two projects that serve as examples of this are "Dusty Relief" and "Mosquito Bottleneck". The form of the project is generated by what this thesis calls an *artificial ecology* – a dynamic relationship between culture and nature, which produces a form. The form is not generated through adhering to an abstract philosophy or style of architecture but through interaction of culture with nature. This is

ecological as it focuses on the relationship between culture and nature rather than treating them as separate.

The key way in which an ecological understanding of nature manifests in the work of the EDG is through the use of the concept of Emergence, which carries an implicit understanding of nature as interconnected and changing. The EDG use the concept of Emergence to create what I call an *emergent continuum* between nature and culture. The use of emergence as a concept for form making is rooted in an idea of nature that is not in a balanced equilibrium, but which is constantly reorganising itself to form new patterns and forms. The EDG case study argued this ecological understanding of nature has two primary effects. The first is that culture is understood as existing in a continuum with nature rather than separate from it. Culture has evolved from nature. They argue that forms that humans create are products of the same process of evolution that creates forms in nature. The second effect evident in EDG is the appropriation of form creation processes in nature in order to create architectural forms. This thesis has put forward the argument that the result of using an ecological conception of nature in the Emergence and Design group has been that the EDG position on culture (including architecture) is an extension of nature. Rather than architectural forms "mimicking" natural forms the words *architecture* and *form* are such that a distinction between the two types of forms is no longer relevant – there are only forms. Results in the breakdown of the nature/culture dichotomy that has often dictated the way that architecture is considered to be related to nature.

A progression through the three case studies is evident in terms of how their ecological thinking allows nature and architecture or culture to be positioned relative to each other. In Lynn's work nature and culture keep their relationship of culture imitating nature for using it as a basis for design, although he challenges the characteristics that nature is assumed to have in architecture. In the work of R&Sie(n) the use of *artificial ecologies* creates a blurring between culture and nature. Finally in the work of the EDG the concept of an *emergent continuum* between nature and culture diminishes the perceived divide between them.

This section outlines the main conclusions of the thesis and links them to the question of the thesis. The first conclusion is that the word "ecology" is charged with multiple meanings and interpretations. This tendency is not confined to the use of the word "ecology" within architecture, but has contributed to the inconsistent use of the word within architecture.

The second conclusion is that there are two primary modes of using the word "ecology" that developed since the 1960's when the word entered general language. These two distinct modes correspond to the *normative* and *scientific* definitions as identified by science historian Anna Bramwell. The first, normative use of ecology emerged around 1960 and is associated with the

word "ecological" used as a synonym for nature or for reducing harm to nature. This mode of use is not generally associated with an ecological concept of nature. The second mode is the use of the original definition of ecology dating back to 1866 which is *the science that studied relationships between living things and their environments*. The second mode of using the word "ecology" in architecture is often associated with an ecological conception of nature as enmeshed and dynamically changing.

The third conclusion is that both the normative and the original definition of ecology have been used within architectural discourse since the 1960's, although the normative definition has come to be more dominant. This use results in ecological architecture frequently being equated with green or sustainable architecture. This use of the word "ecology" is focused on avoiding harmful effects of architectural development on nature and on changing architectural practices in order to maintain the equilibrium of nature. Associated with the original definition of ecology, it is possible to see a tendency to aim for integration of architecture with the natural environment rather than its separation from it. The ecological understanding of nature is associated with an enmeshed approach to architecture and nature rather than the aim to separate.

This thesis also draws conclusions about the impact of this ecological conception of nature on architecture. The first effect is that the ecological conception of nature challenges established ideas about forms, form making strategies, and engineering efficiency that are based on assumptions about nature. Nature has often been understood to contain ideal solutions to proportion or aesthetic appeal and these have been applied to architecture. Many of these links to nature were set down as rules in architecture at a time when an essentialist view of nature dominated (and nature was conceived of as static and enduring). An ecological understanding of nature is itself in a state of change and any rules we may take from it are taken from a particular understanding of nature. With the new lens of ecology through which to view nature, it is possible to take different rules or ideas from nature to apply to architecture.

The second is that an ecological conception of nature affects architecture by challenging the separation of things into natural and artificial categories. The first chapter outlined that a major change from a pre-ecological to an ecological conception of nature was that the possibility was opened for humans to be placed within nature rather than outside of it. Moreover, nature was attributed characteristics that were previously associated only with man-made or artificial things. The infiltration of an ecological conception of nature in architecture has resulted in the conceptual boundaries between nature and culture or nature and architecture to be progressively eroded. Particularly in the work of R&Sie(n) and EDG the effect of this ecological conception of nature is apparent in the way that R&Sie(n) describe elements of their projects, and in EDG's approach to architectural design. This breakdown of established dichotomies between nature/culture and natural/artificial results results in OR puts greater focus on the interactions between elements as a

whole in architecture. This is evident in the focus on the interaction between natural and built environment on several levels. As an example in R&Sie(n) the qualities of the site play an active role in generating a concept for the building form. Rather than being a passive background for a built form the relationship between site and program is used as a conceptual generator for the built form. In the work of EDG the relationship between program and context is used as a data driven and physical generator for the built form.

This thesis argues that the third effect of an ecological concept of nature on architecture is that it results in architecture being seen as an extension of nature. This aspect is clearly expressed in the work of the EDG and is the subject of their most recent publication, which makes the arguments that cultural evolution is an extension of natural evolution. This argument places forms created by humans in a continuum with forms created by nature. This is a clear break from traditional architectural thinking, which understands natural form as separate from the forms produced by human culture.

The fourth effect comes as a result of culture being understood as an extension of nature and concerns approaches to form generation in architectural design. An ecological conception of nature has affected the way that recent architects design. An ecological understanding of nature explains how forms are created over time in nature as a result of their interaction with the environment. The processes that result in forms have been studied by the EDG and are being transferred into architecture in order to create architectural forms that have similarly enmeshed relationships with their environments. An ecological conception of nature has influenced the way the case studies seek to create forms. Ecology allows for forms to be continuously transforming through process of interaction. Ecological thinking in architecture takes up this idea of continuous transformation of form and applies it to architecture – seeing architectural forms as interacting with each other and with the environment rather than being static separate objects. This is particularly apparent in the work of Lynn and the EDG.

This section summarises the contributions of the thesis. Firstly, this thesis has described the origins and development of the science of ecology in order to present its characteristics, influences, methods and aims. This background to ecology aims to define ecology independent from the varied interpretations of ecology and its aims within architectural discourse. Secondly, this thesis has highlighted the importance of defining ecology as an *understanding of nature* rather than *nature* or *sympathetic to nature*. Thirdly. it has highlighted the impact of an ecological conception of nature on the dichotomy between nature and culture in the context of architecture. Fourthly, it has highlighted ecology as a way of looking at nature rather than another word for nature. The fifth contribution is that it has identified the case study architects within a tradition of ecological

thinking in architecture that has existed as a minor tradition since the 1960's and which promotes greater integration between architecture and nature.

Following from this thesis, three directions are proposed for further research. The first is to examine in more detail ideas of nature and artificiality in architecture and how they are impacted by an ecological understanding of nature. The second is to examine further how nature is conceptualised in architecture. The third is to question whether the idea of nature is helpful in architecture today, or whether it hinders the potential of ecological ideas in architecture. Professor of English Timothy Morton argues that nature is a concept rather than a concrete "thing". In his book titled *Ecology without Nature* he asserts that to have a properly ecological view the idea of nature must be relinquished. Morton explores the value of art and literature in conceptualising future environmental projects and suggests that our thinking about these projects would be freed by giving up the conceptual construct of nature. Morton suggests that:

> "All forms of life are connected in a vast, entangling mesh. This interconnectedness penetrates all dimensions of life. No being, construct, or object can exist independently from the ecological entanglement, nor does "nature" exist as an entity separate from the uglier or more synthetic elements of life. Realizing this interconnectedness is the ecological thought" (Morton 2010).

This quote illustrates Morton's definition of "the ecological thought" – the act of understanding that everything in the world is interconnected: all living and non-living things, concepts and objects are connected in a vast "mesh". "Nature" does not exist as a concept separate from the impure or synthetic elements of the world. Following this argument it could be questioned whether the uptake of ecological ideas and thinking in architecture has been limited by pervasive and powerful traditions of thinking about nature.

Another direction for research could be to take this information about how the science of ecology has influenced architecture and to put it in the context of how science has influenced the discipline of architecture over a longer period. The way that ecology was taken up within architecture in the 1960's was in a context of fear of human power to change nature. Ecology was seen as a science that could provide the answers to problems of human creation. This sensibility is reflected in the early discourse around ecological architecture. There was a strong sense that architectural concerns needed to be put aside in order to address more pressing problems of environmental crisis. There is a sense of panic in the early discourse, of the planet in a fragile state, menaced by imminent danger. There is also a sense that certain architects "dropped everything" in order to redefine architectural practice in response to this perceived crisis. In more recent architectural discourse around ecology, particularly in the work of the EDG, this sense of panic is gone. Rather than architecture having to "sacrifice" its own concerns in order to address pressing environmental concerns seen in the ecological architecture of the 1960's, in the work of the EDG it is possible to see ecological

thought infiltrating core architectural concerns. The EDG use ecological concepts of nature to carry out processes that are fundamental in architecture. Rather than sacrificing design concerns for the sake of the environment, they use ecological thought to generate ways of designing and relating to the environment.

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