READING THE YUANYE IN THE WEST: THE RELATIONSHIP BETWEEN LANDSCAPE ECOLOGY THEORY AND TRADITIONAL CHINESE GARDEN DESIGN

by

YANG SHEN

(Under the Direction of Judith Wasserman)

ABSTRACT

Some scholars consider traditional Chinese gardens to be purely aesthetic, without a consideration of ecological and social outcomes. Study of the *Yuanye*, an ancient Chinese monograph on garden design in Suzhou, proves that modern ecology can be applied to traditional Chinese gardens, transferring classical Chinese philosophical principles into contemporary practice. Because the research scale and major principles of landscape ecology theory are similar to those of Chinese garden design and construction, and the *Yuanye* is based on the study of Suzhou's gardens, this thesis aims to find the relationship between modern landscape ecology theory and traditional Chinese gardens, specifically those of Suzhou. Sources in both English and Chinese are used to draw the conclusion that landscape ecology and traditional Chinese gardens are consistent with one another, and that differences between the two become the potential to integrate landscape ecology and Chinese philosophy for contemporary landscape design.

INDEX WORDS: landscape ecology, traditional Chinese gardens, *Yuanye*, Chinese philosophy, landscape design, Suzhou

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CHAPTER 1

INTRODUCTION

This thesis investigates the relationships, both positive and negative, between traditional Chinese gardens—particularly those in the city of Suzhou—and Western ecological theories, in terms of their backgrounds, principles, and applications. It also explores the applicability of historic design concepts to the ecological concerns of contemporary Chinese landscape architecture design. The author makes the assumption that the Chinese philosophy exemplified by traditional gardens, and concepts of landscape ecology can be applied to rethinking, planning and designing contemporary landscapes.

1.1 Context

Landscape ecology emerged as a formal field in the twentieth century, based on a combination of biology and geography. Carl Troll, a German ecologist and geographer, coined the term of "landscape ecology" in 1939. Many related theories like island biogeography and metapopulation, introduced from the 1960s onward, served to supplement the discipline. Landscape ecology utilizes technologies of remote sensing, GPS, and GIS to survey and collect data in efforts to solve environmental problems (Ndubisi 2002, 168–71). Currently, landscape ecology is applied in many professional

realms such as landscape management and natural resources conservation (Farina 2006, 275–98).

On the contrary, the development of ancient Chinese gardens and their ecological principles has a much longer history. The precursor to Chinese gardens was the “You”, a hunting land for emperor’s use more than three thousand years ago. (Yin 2011, 110–3).

There are three main characteristics of traditional Chinese gardens. Firstly, they derive their truths from nature (Xing 2003, 29–31), and embody environmental characteristics in human works (Li 2012, 93–95). Moreover, strongly influenced by the traditional philosophies of Taoism, Confucianism, and Buddhism, Chinese gardens have sought to create and develop harmony between humans and nature for thousands of years (Fu 2010, 482–5). Lastly, Chinese gardens try to represent the ideal artistic conceptions expressed in ancient landscape poems and paintings (Yin 2011, 110–3).

Chinese gardens can be organized into three main categories based on function: royal garden, private garden, and temple garden (Zhou 2008, 19). The focus of this thesis is on the private gardens of Suzhou. Ji Cheng, a famous garden designer in the Ming Dynasty (1368–1644 C.E.), composed the book *Yuanye* (园冶) specifically to interpret the methodologies and details of the traditional Suzhou garden design and construction (Zhang and Ji 1993, 2–18).

This thesis attempts to verify the assumption that Chinese wisdom, stylistics, and tactics can be integrated with the Western theory of landscape ecology. Ultimately, it analyzes the applicability of this combination to contemporary landscape architecture design.

1.2 Problem and Question

Theories, methodologies and applications of landscape architecture have become interdisciplinary and transdisciplinary (Chen and Wu 2009, 1015–26) due to the dynamic interaction between nature, culture, and society (Antrop 2005, 105–17). Traditional Chinese garden is known as "the mother of gardens in the world" (Zhang 2009, 27–30). However, the theory connecting contemporary design with ancient Chinese philosophy is still immature.

The globe is experiencing more environmental crises than in any century previous (Han 2008, 246–8; Wang and Wang 2013, 27–9). When facing these contemporary problems, the power of traditional gardens seems limited. The ideals of nature embedded in traditional gardens are descriptive, and lack precise ecological principles. Therefore, some researchers claim that traditional Chinese gardens are purely aesthetic and lack any ecological merits (Yu 2006, 39–43). More contemporary Chinese landscape designers are blindly mimicking design styles in Europe and the United States without careful consideration of China's particular context and conditions.

Traditional Chinese gardens were built in the era when ancient China was still exploring agriculture (Zhang 2009, 27–30). Problems of industrial development did not yet exist. Due to the admiration, respect, and conservation of nature, the principles, concepts, and techniques of traditional Chinese gardens are potentially applicable to contemporary society. Now is the time to connect traditional gardens with solutions to increasing global environmental problems.

Correspondingly, the overarching question of this thesis is: What is the relationship

between traditional Chinese gardens and landscape ecology theory as developed and practiced in the Western world? To answer this question, development backgrounds; principles and concepts; and the applicability and methodologies of traditional Chinese gardens are compared with those of landscape ecology. The relationships may be either consistent with each other or—on the other hand—some aspects of traditional Chinese gardens may have a negative correlation with landscape ecology. This thesis explores whether the two systems will interact mutually to meet today's needs of aesthetics and ecology.

1.3 Purpose and Significance

This thesis aims to investigate the relationship between traditional Chinese gardens and contemporary landscape ecology theory. To this end, the author talks about the modern ecological principles and methodologies that are examined in traditional Chinese gardens. Furthermore, it is determined where ecological theory is not applicable to traditional Chinese garden design. In all, traditional Chinese gardens and Western ecological knowledge are possible to integrate as a whole, with two mutual parts combining to interact and supplement each other.

Contemporary thinking in Chinese landscape architecture practice has brought new investigations into the value of national traditions, historic heritages, folk customs, and landscape patterns (Fu 2010, 482–5). Finding answers to the overarching research question has the potential to unlock solutions to contemporary ecological problems using the principles and methods embedded in traditional Chinese gardens.

More importantly, Chinese landscape architects can aesthetically and ecologically exemplify their ancestors' principles and methods to create a contemporary landscape architecture that is specific to Chinese culture. The author believes that in the following decades, contemporary landscapes with classic Chinese characteristics and spirits will blossom.

1.4 Limitation and Delimitation

Direct site observation of traditional Chinese landscapes is unfeasible; therefore, secondary sources must compensate. A further limitation is that both the ecological and traditional Chinese garden information applied in this thesis is qualitative, incorporating no quantitative analysis. Principles in traditional Chinese gardens are typically presented within a narrative, lacking a network or theory to quantitatively evaluate traditional Chinese gardens' functions. For example, the concept of "harmony between nature and humans" (天人合一) is the core of manipulating garden design. This harmonious relationship, however, refers to no systematic theory. Ji Cheng's monograph, the *Yuanye*, specifically states "there exists no exact rule to create a garden" (构园无格) (Wang and Wang 2013, 27–9). The belief is that human intervention naturally forms a condition that is similar but artistically superior to surrounding environment (Han 2008, 246–8). Thus, this thesis intends to apply the theory of landscape ecology to measuring the success of traditional Chinese garden design in a contemporary condition.

As for the relationship between landscape ecology and traditional Chinese gardens, this thesis mainly focuses on examples from the city of Suzhou, as well as the ideas

presented in the *Yuanye*, which involves ecological concepts embodied in Suzhou gardens. Different territories in China have different styles of gardens. Beijing, Jiangnan, and Lingnan, for example, derive their regional styles from different geographic and cultural backgrounds. Suzhou, as a part of Jiangnan, has a majority of the resources used in private gardens (Zhang 1980, 52–65). Moreover, each category of royal, private, and temple garden has further characteristics within the regional style. Though there exist some similarities, the concepts generated in private garden landscapes and some techniques employed in Jiangnan are different from those of royal gardens in Beijing. In this thesis, the author will only analyze the relationship between Western landscape ecology and Suzhou private gardens, using the *Yuanye* as a fundamental tool of understanding ecological concepts in ancient Suzhou gardens.

1.5 Thesis Structure

Chapter Two first addresses the developments and disciplines that contributed to landscape ecology's evolution. Certain categories about landscape ecology, based on different classification standards, and several basic terms help form a more integral impression of this discipline. Landscape ecology's principles are illustrated by the author in four aspects of spatial effects; process and patterns; population; and resilience (Farina 2006, 1–228). This chapter finally reviews how landscape ecology is applied to landscape design and management; natural restoration and conservation; as well as cultural landscapes.

Chapter Three initially discusses historic, cultural, and religious backgrounds of

traditional Chinese gardens, specifically drawing on Suzhou gardens and the *Yuanye*. Following that introduction, Chinese garden philosophy covers topics of the wisdom of ancestors, guidelines of design, and the notion of the charm of artificial nature. This chapter later explains siting, landscape elements, and other factors that affect actual implementation of Chinese garden construction.

Subsequently, Chapter Four is fully devoted to the comparison of landscape ecology theory with traditional Chinese gardens in terms of all the aspects listed above. It analyzes the outcome of their positive complements and the reality of negative correlations by applying the comparison results to the evaluation of Zhuozheng Garden.

Based on the integration of traditional Chinese garden philosophy and landscape ecological knowledge, the last Chapter concludes with comprehensive concepts that frame and guide contemporary Chinese landscape design. All the Chinese characters and sentences of the original quotes or ancient expressions are shown behind the English translations in the text. In some cases, the English translations are literal to preserve the flavor of ancient Chinese connotations. In others, the English translations are word-for-word from Chinese pronunciations. Either type of English translation and original Chinese expression will help western as well as Chinese scholars to better understand the development and concept of traditional Chinese gardens.

1.6 Literature Review

Landscape theories, developing from ancient dynasties through modern periods, have become interdisciplinary and transdisciplinary (Chen and Wu 2009, 1015–26).

Because of the dynamic interaction among relevant factors of nature, culture, and society, the methodologies and applications of landscape architecture have continuously changed (Antrop 2005, 105–17). Pushed by such a background, Chinese landscape architects are concerned about the means to exemplify Chinese ancestral principles and philosophy—both aesthetically and ecologically—to create a contemporary landscape architecture specific to Chinese culture.

1.6.1 Ecological Landscape and Landscape Ecology

The triangle model of the human–landscape interaction process (Figure 1) (Zube, Sell, and Taylor 1982, 1–33) illustrates that "interaction between humans and landscapes leads to outcomes that feed back to the interacting elements" (Taylor, Zube, and Sell 1987, 362). Disputes between ecosystem management and landscape visual impact assessment have been occasioned by the view that ecological aesthetics is an intrinsic value when beautifying landscapes (Hosey 2012, 1–12). Instead of possessing static visual impact, ecological landscapes are dynamic and polysensual (Jorgensen 2011, 353–55). Based on the six "E"s of landscape sustainability – environment, economy, equity, aesthetics, ethics, and experience (Musacchio 2009, 993–1013), sustainable landscapes serve to promote economic development, enrich human life, and maintain ecology (Chen and Wu 2009, 1015–26).

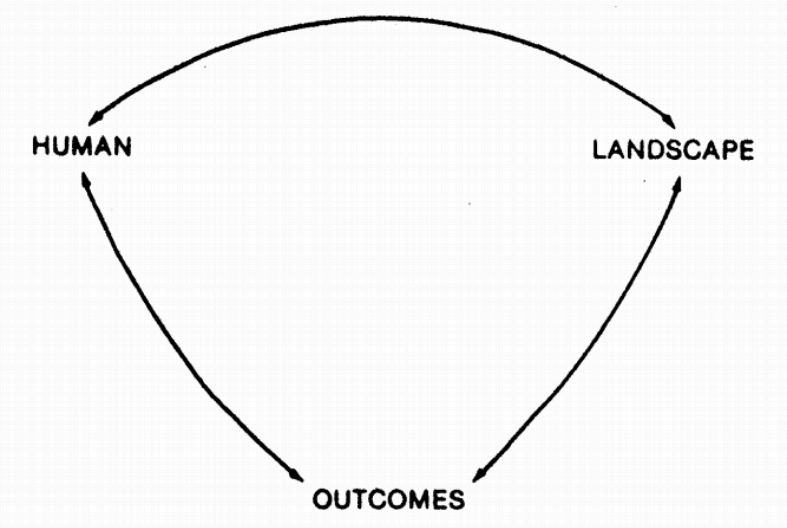

Fig. 1 Human–landscape Interaction Process (Zube, Sell, and Taylor 1982, 1–33)

Though landscape ecology has a comparatively short history, scholars and designers sense solutions to ecological problems of planning and design within its knowledge base (Ndubisi 2002, 168–71). Less than eighty years have passed since Carl Troll first proposed the term "landscape ecology" in 1939. This discipline has managed to incorporate diverse principles related to ecology, geography, and even sociology, economics, culture, and psychology in order to address human impact when modifying the environment. It is believed in the twenty-first century that landscape architecture will mainly focus on underlying landscape benefits such as diversified landscape functions, ecosystem services, and environmental resilience (Jorgensen 2011, 353–55).

1.6.2 Chinese Gardens

The early Chinese "garden" (園) originated around two thousand years ago in the form of "a fenced space for animals" (囿) or "an enclosed area for vegetables" (圃) (Chen

and Wu 2009, 1015–26). Contemporary study classifies historic Chinese gardens into three categories: royal, private, and temple gardens (Zhou 2008, 21). They are influenced by the unique artistic pursuits of calligraphy, paintings, and poems. For example, calligraphic landscapes depicted on plaques, couplets, and steles (Figure 2) in Chinese gardens are used for decoration and, more importantly, emotional expression (Han 2008, 246–8). This conventional mark of Chinese culture encounters the problem that people fail to recognize the artists' inner spirits expressed underneath the calligraphy (Qi, Yang, and Zhang 2013, 128–38; Zhou, Zhang, and Edelheim 2013, 99–112).

Fig. 2 Plaque and Couplet in Zhuozheng Garden, Suzhou

Source: http://www.guoxue.com/?p=19140&page=3

Influenced by the *I Ching* and traditional Chinese religions, including Taoism, Buddhism, and Confucianism, the ancient Chinese concept of "unity of man with nature" describes the harmonious status between humans and nature, which simultaneously

interact and influence one another. Although traditional Chinese gardens are successfully "evolved from nature, and superior to nature" under the guidance of harmony (Chen and Wu 2009, 1015–26), these words are commonly misused by Chinese landscape designers (Wang 2012). The style of traditional Chinese gardens has been regarded as backward ever since the new China government started to wield power in 1949 (Sun 2013, 42–3). Nowadays, with rapid urbanism, expanded cities in China are planned with no sense of place and history. A footprint of history, culture and philosophy is missing; traditional landscape beauty is overlooked; and the design tradition of respecting nature that has existed in China for thousands of years was unexpectedly disregarded.

Today, historic and cultural elements are blindly collected, regrouped, and assembled to represent a superficial Chinese philosophy, because this "productive" method is easy to follow. The condition of landscape design is cheerless: each landscape has no unique characteristics; historic and cultural elements are arbitrarily assembled; large trees are transplanted, but ironically, these trees fail to provide any shade for visitors. While traditional Chinese gardens are small in area, they have always functionally attracted people, emotionally cultivated a sense of beauty, and technically maintained urban density.

Another theory summarized by ancient Chinese thinkers is "the truth comes from nature" (道法自然), contributing to one of the aesthetic standards of appropriateness in Chinese landscapes (Sun 2013, 39). This theory recommends that design should obey the laws of nature as regards the rationality of space and scale arrangements. Landscape

design adapted to local circumstance shows a natural aesthetics. The idea can be interpreted as the Chinese quote that “even though it is artificial, the landscape is comparable to a natural wonder” (虽由人作,宛自天开) (Zhang and Ji 1993, 2–18).

Based on the concept of harmony between nature and humans, and the traditional principle of learning from nature, Chinese gardens have four main landscape elements, including hills, waters, plants, and buildings (Zhou 2008, 5). They all contribute to aesthetic and conditionally ecological functions of the garden and its urban context.

1.6.3 Applicability

Major cities in eastern China have been threatened by severe smog pollution for more than ten years (Chai 2015). In the past era of agricultural civilization, China had a long history of awareness for building a harmonious relationship with nature, and followed basic guidelines to realize ecological concepts. In recent years of industrialization and urbanization, landscape ecology plays a fundamental role in Europe and the United States to fight against environmental crisis by means of restoration, conservation, planning, and design (Ndubisi 2002, 168–71). China, with its unique background of vernacular culture and ancestral perspectives on nature, should therefore be able to explore comprehensive methods to deal with contemporary problems (Fu 2010, 482–5).

It is surprising that some researchers insist that traditional Chinese landscapes are aesthetic-centric and lack adequate socio-economic considerations (Yu 2006, 39–43). In contrast, Taiwan has applied cultural values to form a set of enlightened principles of

design. Performed within a traditional Chinese community in Zuoying District, these principles combine sustainability and ecology in terms of "visual thinking" (Lin and Lee 2010, 38–43), which means to "pervade all human activity from the abstract and theoretical to the down-to-earth and everyday" (McKim 1970, 8). In this design, cultural meanings are conveyed by means of both expressing aesthetics through harmonious images of the social order, and by transferring human activities from an abstract theory to everyday life on earth (McKim 1970, 8). This case, to some degree, showcases the feasibility of applying traditional Chinese philosophy to contemporary landscape planning and design with ecological concerns.

CHAPTER 2

LANDSCAPE ECOLOGY

This chapter forms an integral impression of landscape ecology's disciplines and its development that promoted landscape ecology's evolution, with the illustration of several landscape ecology terms and categories. According to Farina (2006), the author classifies landscape ecology's principles into four aspects: spatial effects; process and patterns; population; and resilience. Each section will be introduced respectively. The applications of landscape ecology to landscape design and management; natural restoration and conservation; as well as cultural landscapes come at last.

2.1 Development of Landscape Ecology

2.1.1 Development Process of Landscape Ecology

Landscape ecology theory did not emerge until the end of World War II, beginning its development throughout eastern and central Europe (Schreiber 1990, 21–33), and later spreading to America and Asia (Forman 1990, 35–41), becoming more international than ever.

The term "ecosystem" was proposed by the English botanist Arthur Tansley (1935) in his publication "The use and abuse of vegetational terms and concepts". As economy and society rapidly developed, many questions about environment could no longer be

answered solely by existing ecosystem theory (Ndubisi 2002, 168–71). Current landscape patterns derived from environmental and social revolutions in history, such as those occasioned by major technological advancements. As the environment where people live changes its condition, society is destabilized and must adjust to the new surroundings. Thus, human activities gradually become a leading cause of worldwide landscape transformation. Some reactions of landscape changes may fail to overcome the emergencies while other modifications can weather the destructions from human beings. To solve the ecological problems in a more considerate way, researchers needed to consider human beings as a component of the ecosystem that varies with the shift of space and time (Burel and Baudry 2003, 6–39).

As awareness of the significance of multidisciplinary thought spread across the globe, the German biogeographer Carl Troll, in 1939, first coined the concept of landscape ecology, which primarily regards landscape as a figurative language of abstract ecology. Landscape ecology incorporates geography with ecology by connecting dimensional networks to green development procedures, consolidating spatial aspects of geography and temporal aspects of ecology. Because of the dense European population and human intrusion at that time, landscape ecology flourished on the Continent (Ndubisi 2002, 168–71).

Landscape ecology is the discipline that investigates the relationship between living entities and their surrounding ecosystem on a landscape scale of patterns and structures (Dramstad, Olson, and Forman 1996, 12–13). After landscape ecology gained credence as a discipline, two major criteria arose affecting how ecosystems were categorized

—heterogeneity of the natural environment, and activities of human society. People strongly affect the environment in multiple directions, including customizing the surroundings to meet human needs (Burel and Baudry 2003, 6–39).

Ecologists, together with biogeographers like Troll, started to compare, analyze, and integrate each subjects' theories, techniques, and practices. Following the founding of the International Association for Landscape Ecology (IALE) in 1982, the ecologists, geographers, landscape planners, and architects came to a new stage of cooperation (Burel and Baudry 2003, 6–39). With the synthesis of sociology, economics, culture, and psychology, landscape ecology is widely used today in the realms of industry, forestry, and agriculture by means of land use planning, resources and energy management, and ecosystem conservation (Silva Ecosystem Consultants 1992, 3).

Learning from the evolution of history, contemporary thinkers have gained a better understanding of the causes behind many ecological problems and how to solve them by management of variables like urbanization, even though certain methods, not yet properly developed, can cause new problems such as rural culture crises, smog pollution, and extensive economic development (Burel and Baudry 2003, 6–39). Thanks to the technological development of Remote Sensing (RS), Geographic Information Systems (GIS), and Global Positioning Systems (GPS), researchers have upgraded the theories, investigation methods, and applications of landscape ecology to a new level (Wiens and Moss 2005, 23–6).

2.1.2 Disciplines Related to Landscape Ecology Emergence

Though rooted in ecology, landscape ecology is quite different from it. Landscape is one element of the rising frontiers of ecology, commonly viewed through soil science, geoecology, and geomorphology. As a systematic network, landscape ecology combines geography, geoecology, geobotany, ecology, behavioral ecology, biosemiotics, environmental psychology, cognitive sciences, anthropology, landscape architecture and planning, and aesthetics (Farina 2006, 53–86).

Island biogeography and ecological geography cooperated to form the root of today's ecology. Geography, geobotany, and landscape management were the most basic contributors to the fresh subject of landscape ecology (Ndubisi 2002, 168–71). Carl Troll intended to build a bridge between geographers and ecologists in order to research functional spaces in the ecosystem. After its creation and prior to the 1970s, landscape ecology was chiefly driven by geographic analysis to explore possible ecological outcomes and to administrate natural resources (Ndubisi 2002, 168–71).

The term geosystem covers the concepts in a homogeneous geographic system, including morphology, movements, and transformations (Bertrand 1978, 239–58). The discipline of geosystem uses cartographic analysis as a tool. Cartography, as a crucial method to study landscape, diagnoses homogeneous elements and heterogeneous mosaics on a piece of land. These elements are related to the ecotope, a basic spatial unit of ecology (Burel and Baudry 2003, 6–39).

Landscape Ecology is a continuum of existing ecology theories, disciplines, and mechanisms (Burel and Baudry 2003, 6–39). In the interest of discovering natural

intricacies, other theories such as fractal geometry were also introduced. Heterogeneity and disturbance regime further developed with the help of percolation theory, metapopulation, connectivity, and ecotones. These concepts, along with information theory, biosemiotics, and autopoiesis, promoted a complicated but self-controlling landscape mechanism (Farina 2006, 53–86). Another contributor to landscape ecology, phytoecology, recognized vegetation as a part of environment (Long 1975).

Current landscape ecology is interdisciplinary, encompassing environmental and human sciences such as cognitive ecology and landscape architecture. It assists to maintain a balance within the triangulation of economics, society, and ecology.

2.1.3 Terms and Categories

For a better measurement of planning and management, categorizing landscapes is generally based on a human perspective of land mosaics and their interaction with surrounding environments. Some elementary materials for categorizing landscapes are images such as photographs, satellite figures, and maps documenting hydrology, biology, geology, soil, and land use (Farina 2006, 10–14).

Landscape elements categories have a system of terminology, implication, and function. The term "Mosaic" denotes a dominant element consisting of patch, corridor, and matrix (Dramstad, Olson, and Forman 1996, 19–46). (Figure 3) Mosaic is a set of land cover and habitation patches, and network is a set of corridors or linear elements. The spatial arrangement of mosaics and networks forms a landscape pattern. The edge of a patch has strong interactions with adjacent patches, while interactions in the interior are

looser. The edge-interior ratio indicates the degree of fractal conditions of landscape elements (Forman and Godron 1981, 733). Each landscape or element has its own characteristics of area, environmental function, heterogeneity, fragility, and applicability to society and economy (Coppolillo et al. 2004, 419–30).

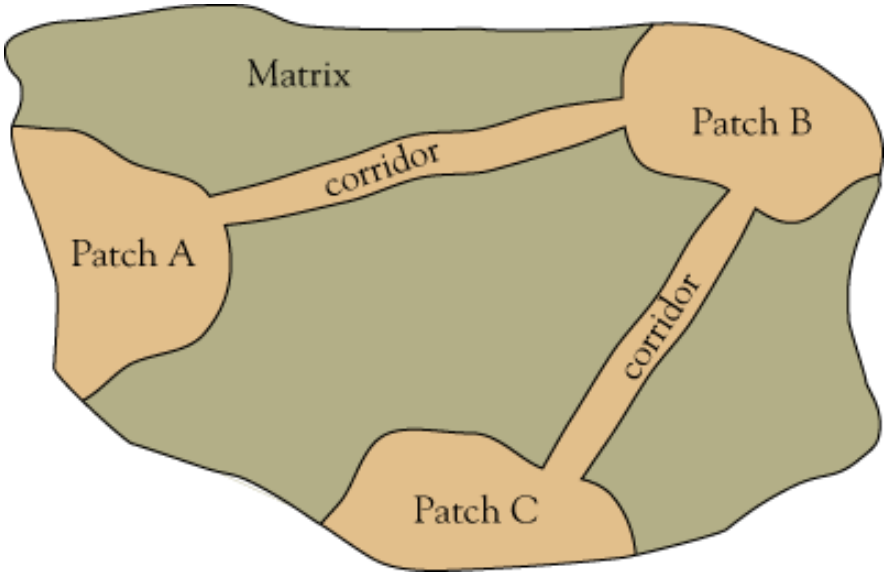

Fig. 3 Patch, Corridor, and Matrix Contribute to Mosaic

Source: http://www2.ca.uky.edu/agc/pubs/for/for76/for76.htm

Ecological landscapes contain both biotic and abiotic environments inhabited by organisms. Landscape and its fundamental patches are categorized according to whether the research target is human or natural. A structural patch comprises soil type and plant community, whereas a functional patch refers to an area dominated by one legend such as altitude, temperature, or moisture. A resource patch is a sector or range for living organisms to survive and act, and contains several unique functions such as feeding. Habitat patches include different plant communities that cover several animal habitats

and are shared by various species populations. Finally, a corridor patch usually means a slice of land beneficial for the dispersal and resettlement of species (Farina 2006, 10–2).

Hierarchical landscape categories range from physiotope, ecotope, and land unit to land system. They are useful in landscape analysis for comparisons between different locations. A physiotope is a spatial entity specializing in abiotic elements measured by geology, slope aspects, and rates. The physiotope is fundamental for further scrutiny of landscapes (Vos and Stortelder 1992). Ecotopes display a primary landscape system made up of physiotopes, soil condition, vegetation, and land use. It represents topological dimension of landscapes through a combination of characters that form the property at the upper hierarchy of land unit. Land units in turn can be identified through characteristic, correlative, or exclusive ecotopes. Land systems are chronologically reflected in patches such as climate zones and ecological regions (Zonneveld 1995).

Anthropocentric landscape classification focuses on biotic and abiotic arrangements and distributions that impact the triangulation of environment, economy, and society. This classification is particular feasible in intact countryside with easily accessible information and ecological feedbacks. According to the increasing gradient in size, the spatial distribution of landscape units is divided into five hierarchical levels from ecotope or site; microchore or landscape facet in site scale; mesochore or landscape system in landscape scale; macrochore or main landscape in regional scale; and megachore (Dramstad, Olson, and Forman 1996, 49–55; Farina 2006, 12–13).

Actions of animals, humans, and vegetation, inform researchers of the system integration, via two levels of hierarchy. For one thing, within the boundary of an ecotope,

centripetal landscape elements jointly serve their shared ecosystem. For another, between each ecotope, various systems mutually interact and unify (Phipps and Berdoulay 1985, 3–19).

2.2 Principles of Landscape Ecology

2.2.1 Spatial Effects

2.2.1.1 Hierarchy

Hierarchy theory assumes that changes happen at a slower pace in larger backgrounds than in smaller ones (Lewis et al. 1996, 440–5). Those progresses that happen at a similar pace or scope can be categorized into one hierarchy. This theory targets a series of changes happening at different levels of places and periods. According to the different levels of progresses that vary in spatial and temporal attributes, a system can be classified into several hierarchies to allow researchers an orderly approach to study (Burel and Baudry 2003, 6–39). Changes happen smoothly and widely at a higher level, while at a lower level they vary promptly in a comparatively small area (Koestler 1967). Different levels of the ecological hierarchy act relatedly as a whole system when evolving. Higher levels determine the operation mechanism of a system. Elements of a higher hierarchical stage have a weak relation with each other. Between distinctive hierarchies of progresses there is almost no interference and continuity but obvious divergences exist (Krummel et al. 1987, 321–4). Procedures like growth or vanishment in ecosystems are separated into diversified spatial and temporal scopes between which exist interrelationships. Hierarchical length or frequency of a period will diversify the

landscape into a hierarchy of scales, resulting in many ecological phenomena (Wiens and Moss 2005, 23–6). (Figure 4)

Landscape ecology employs these concepts of hierarchy to discuss spatial and temporal levels of configurations and procedures. Taking complexity into account, hierarchy differentiates one level in the system from another, and one system from the larger one covering it. In the shift between levels or systems, conditions are by no means the same. The complexity accumulates as the number of components increases (Farina 2006, 64–8). When analyzing landscape systems, the higher level of landscape structure and the lower level of landscape elements are considered. The former level investigates how the landscape is organized, while at the latter level probes the way in which different landscape elements interact with one anothr (Burel and Baudry 2003, 6–39).

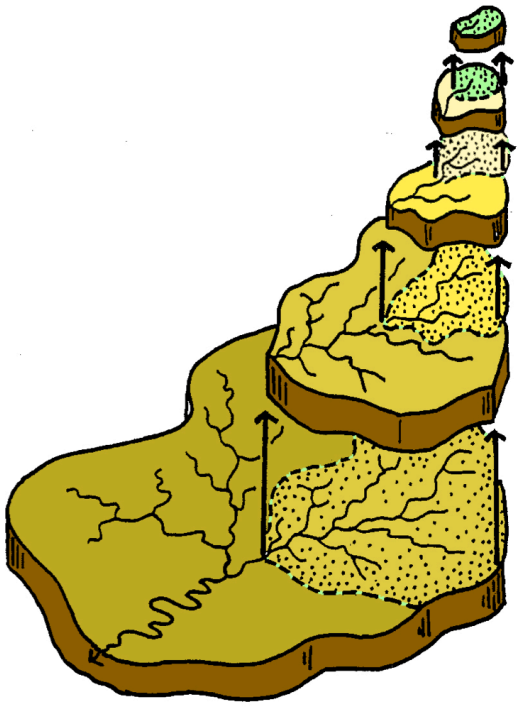

Fig. 4 Hierarchy of Nested Watersheds (Marsh 2005, 172)

Studies classify landscape into levels of ecotopes, microchores, mesochores, macrochores, and megachores, based on the rate at which development occurs (Farina 2006, 12–13). Lower levels of the hierarchy have a higher rate of movement frequency than higher levels. Both biotic and abiotic elements of an ecosystem can jump over scales of time and space as they develop, leaving a trail of dashed transformation trajectories (Holling 1992, 447). Researchers need to analyze the proper scale in order to specifically answer their questions about landscape structures and processes. Limitations of applying hierarchy theory to space analysis includes the possibility that its feasibility in one scape may not function in another (Turner et al. 1991, 17–49).

2.2.1.2 Fractal Geometry

Fractal geometry is a model applicable to measuring the outline, volume, and division of complicated casual shapes in any scope (Mandelbrot 1984). It illustrates the gesture of a complex system, as such an unpredictable system possesses a casual but hierarchical structure (Hastings and Sugihara 1993). Professionals use fractal geometry to measure natural substances regarding their degree of irregularity and fragmentation. In the realm of landscape, fractal geometry is practiced to evaluate the intricacy of landscape elements (Burel and Baudry 2003, 6–39). In most cases, landscape evolution is similar to a fractal shape filled into or cut out of natural patterns (Green 2000, 11–50).

2.2.1.3 Percolation

Percolation theory explains how irregular landscapes connect to each other (Gardner et al. 1989, 217–27). Similar to the fact that water can filter from one media to another,

information, movements, and disturbances can also diffuse far once they reach a threshold of quantities. When the number of percolating elements stays small, their action scopes are limited. The more area they occupy, the greater the possibility they will connect to each other and spread (Burel and Baudry 2003, 6–39).

Research on fluid movement through a medium finds that all the fluid is connected once it covers more than the critical probability (0.5928) of a target area (Ziff 1986, 545–48). (Figure 5) Similarly, percolation theory explains how irregular landscapes connect to each other. In the case of simply having suitable and unsuitable conditions, when the habitat area within a sample landscape boundary covers more than the threshold of percolation (pc, 59.28%) of all the sample area, the habitat then becomes one cohesive whole (Wiens and Moss 2005, 23–6).

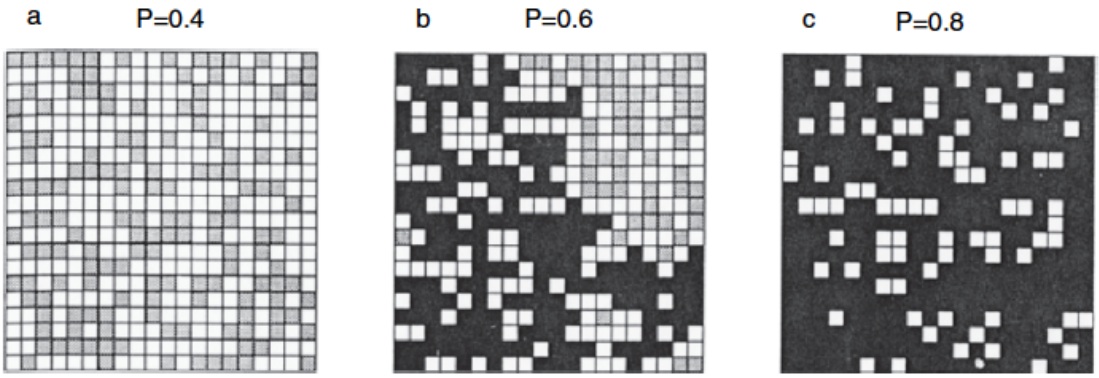

Fig. 5 Different Values of Dark Percolation Cluster (Gardner et al. 1992, 259–69)

Landscape ecology applies percolation theory to phenomena such as forest fire spread, infectious disease distribution, pest expansion, and human or natural disturbances (Turner 1987). When a substance can move beyond the 0.5928 threshold

of an area, it is able to reach every corner of the landscape to obtain target resources (O'Neill et al. 1988b, 63–9).

Though percolation theory has established applications, it still needs more empirical testing in the field. Landscape ecology attempts to decipher the impacts that geographical arrangement has on ecosystem operation (Urban, O'Neill, and Shugart 1987, 119–27). However, percolation theory targets irregular and fragmented landscape patterns, producing challenges for statisticians (Wiens and Moss 2005, 23–6).

2.2.1.4 Island Biogeography and Economic Geography

The theory of dynamic equilibrium posits that geographical structure has an impact on ecological mechanisms (Burel and Baudry 2003, 6–39). Environmental diversity is linked to condition changes and population mobility caused by the switching distance from an island or the transformation of a patch (Wiens and Moss 2005, 23–6). Island biogeography originally explains that an island's size and the distance between it and the mainland determine the island's species richness of birds by maintaining migration and elimination rates. Immigration potential is promoted by the accessibility to the mainstay neighborhood, and extinction may result on islands with lower capacity (MacArthur and Wilson 1963). Later the theory is applied to evaluating the ecological structure of a patch on a contrary background, like an island in the ocean. (Figure 6)

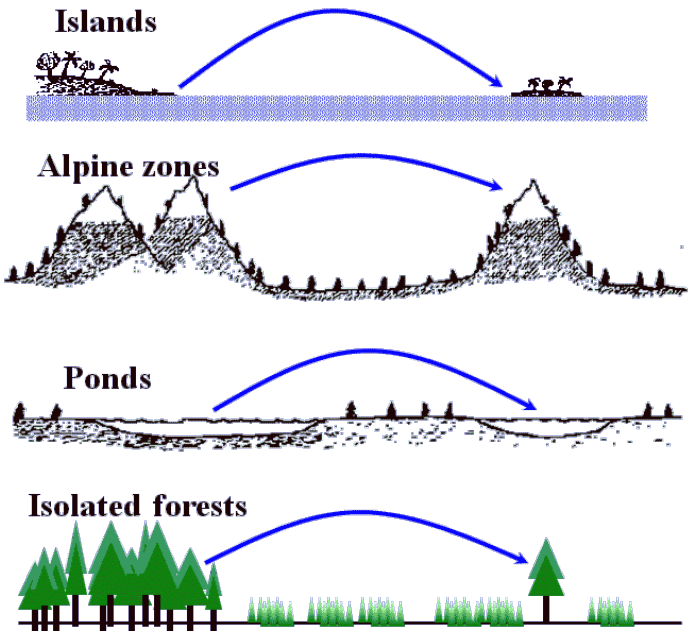

Fig. 6 "Real Islands" and "Habitat Islands" Evaluated by Island Biogeography

Source: http://hosho.ees.hokudai.ac.jp/~tsuyu/top/dct/island.html

Similarly, economic geography explains how much profit is earned depending on the transportation distance between production locations and markets. Economic geography determines aspects of landscape structure and dynamics. Details of economic geography are explained by central place theory, location theory, and market area evaluation. Economic geography contributes to landscape ecology's understanding of why land use is changes, and how consumers obtain more resources while incurring less costs (Wiens and Moss 2005, 23–6).

2.2.1.5 Heterogeneity and Ecotone

Fragmentation and disturbance make possible two main landscape patterns —heterogeneity and ecotone. Heterogeneity exists at many scales and plays a key role in the formation of ecotones (Farina 2006, 179–216).

"Heterogeneity" is an unequal status of landscape arrangement and pervasion of seemingly chaotic but reasonable appearances (Forman 1995). Similar to diversity, which elaborates the variety of patch properties, heterogeneity explains physically complicated patterns and contributes to inconstant systems with contrasts at patch rims. Though heterogeneity occasionally obstructs ecological mechanisms, such as small patches being restricted in capacity (Farina 2006, 179–216), it is beneficial to species movement and materials exchange in many cases (Pickett and Cadenasso 1995, 331–4). As a result, biodiversity is encouraged.

Heterogeneity is classified into the three categories: spatial heterogeneity, temporal heterogeneity, and functional heterogeneity. Spatial heterogeneity comes from the special characteristics of local conditions and its historical development background. Spatial heterogeneity is further divided into horizontal heterogeneity and vertical heterogeneity (Kolasa and Rollo 1991, 1–23). The former indicates irregular patch layouts, while the latter focuses on upright vegetation layers. Temporal heterogeneity evaluates one place over different periods of time. The twist of spatial characters and temporal successions make the heterogeneous situation much more complex. Functional heterogeneity demonstrates the complexity of ecosystem elements caused by their growths and changes (Farina 2006, 179–216).

An ecotone is a mixing boundary or field with the ecosystem complexity, resulting from the overlap of different community patches and ecological functions (Clements 1905). (Figure 7) A species cannot meet its needs beyond the ecotone adjacent to its

favorable patch, because ecological conditions change so dramatically (Farina 2006, 179–216).

An ecotonal community is a community at the overlapping section of two or more patches. Due to the edge effect between different patches, species are more diverse at this location (Harris 1988, 330–2). Ecotones assist in transferring material, energy, and information from one patch to another, so as to integrate the whole ecosystem (Farina 2006, 179–216).

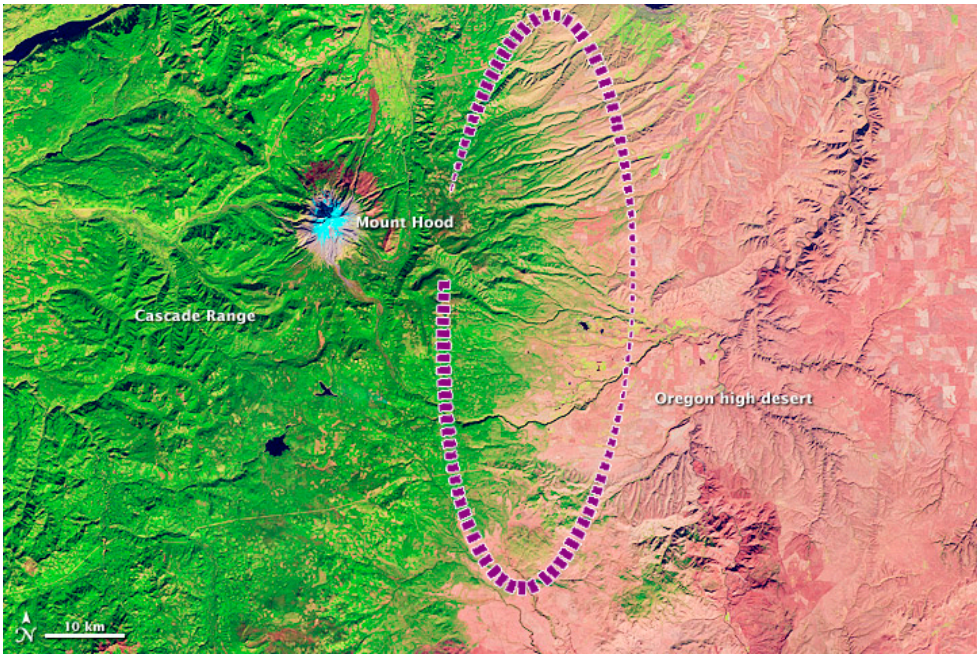

Fig. 7 Ecotone Appears as a Mixture of Two Patches

Source: the NASA Earth Observatory

https://www.esa.org/esablog/about/ecotone-explained/

2.2.2 Landscape Process

2.2.2.1 Disturbance and Chaos

As indicated by chaos theory, some incidents are hardly predictable because they identify rules and patterns in seemingly chaotic systems (Burel and Baudry 2003, 6–39), or. Disturbance, as seen in nature, is the most effective factor for ensuring ecosystem operation and modifying all landscape expression. It also serves as the base for other phenomena such as patch fragmentation and population variation. Caused by human or natural variables, disturbance sequences in a system can be either continuous or disconnected (Farina 2006, 110–27).

Incorporation occurs when an outer disturbance is absorbed by the existing structure (Farina 2006, 110–27). Disturbed and undisturbed districts interchange information and distribute communities. Species diversity is sometimes balanced through dynamic movements (Burel and Baudry 2003, 6–39). However, if the disturbances are very severe, the structure cannot resolve all of them and the components of the system will shrink, simplifying the complexity of the structure, creating the possibility that the system will crash and or assume a new form. In fact, ecological development in every scope of space and time has changed landscape layout and structure. Perturbation has the force to break the balance of landscape patterns and even entire complex and self-sustaining systems (Farina 2006, 110–27).

Gaps in tree canopies are usually formed by regular events, either biotic, as in the case of pathogen disturbance, or abiotic, in the event of snow cover or prescribed burns (Farina 2006, 118–20). The density of gaps is generally even throughout the forests but

different portions may gently vary. Gaps are more visible in fully-grown forests. The contrast between the original forest and a gap caused by modest disturbances, such as wind blow, is less apparent (Farina 2006, 118–20). However, a small disturbance can have a considerable impact on the forest structure if large disturbances seldom happen at this location (Lertzman et al. 1996, 1254–70). A large disturbance—for example, a fire and hurricane—will destroy the heterogeneity between edges and underwoods. Gaps are important to organism growth. Biodiversity is richer in forest gaps than under the trees, as they make landscape heterogeneity and resources accessibility possible (Farina 2006, 118–20).

Fire is the most significant disturbance to nutrient recycling (Moore 1996, 312–3). Influenced by wind direction, the large size of a fractal fire is more unpredictable than a small one. The more mature a patch of forest is, the greater the possibility of significant fire disturbances, due to the higher amount of resident organisms. Other factors contribute to fire severity, including terrain, weather conditions, and plant community structure. Fires result in higher heterogeneity of physical patterns but lower diversity of patch capacity. The product of fire events, charcoal, can hold water and sequester carbon. Today, prescribed fires are one element of managing landscape processes (Farina 2006, 121–4).

Animal disturbances like digging and grazing will change plant community conditions and restrain biodiversity. Disturbances sometimes have overlaps (Farina 2006, 126–7). For example, animal excretion stimulates the growth of grass, which in turn

encourages more animals to feed on grass, resulting in a complex interaction between organisms and environment (Steinauer and Collins 1995, 1195–205).

Contemporary human beings impose more severe interruptions on nature than ever before (Han 2008, 246–8). The causes of human disturbances are unlike natural ones. Compared to natural causes, disturbances generated by human technologies and activities—such as industrial and agricultural development—are more widespread, intense, and constant. (Farina 2006, 114–7). The capability of nature to absorb human disturbances has reduced to a level that threatens landscape composition, ecosystem diversity, and demographic dynamics (Palmer et al. 2004). Human activities threaten the safety of animals in need of more energy to survive (Frid and Dill 2002), and enhance the spread of invasive species (Farina 2006, 114–7).

2.2.2.2 Fragmentation

Fragmentation and disturbance are typically connected in their diversification of the gestures and functions of landscape and its components. Fragmentation means the isolation and shrinkage of habitation areas. The structure of patches, corridors, and matrices is applied to analyzing the continuous evolution of fragmentation (Dramstad, Olson, and Forman 1996, 19–46). “Geographical fragmentation” discusses a patch that is visually separated into pieces. However, “structured fragmentation” or “fine-grained fragmentation” creates a “pseudocontinuum” that appears connected but is functionally divided (Lord and Norton 1990, 197–202). Fragmentation conditions are complicated because they vary as seasons change (Farina 2006, 128–50), and have diversified impacts on different edge and interior species (Alberti 2008, 105).

Fragmentation results from patch decline and separation. If a fragmented patch continues shrinking in size, its surviving species richness is endangered. For instance, trees at forest edges exposed to sunlight lose more water, reducing production and habitation capacity (Farina 2006). Similar to island biogeography theory, once a species reduces in number, whether it will recover depends on how far its patch is located from a main habitat with abundant resources (Wiens and Moss 2005, 23–6). But the reality is more complex than a theory, worthy of careful considerations of ecological principles like corridors and metapopulation. Usually, people cannot realize the true severity of fragmentation because of the false security of organism persistence and rehabilitation (Farina 2006, 128–50).

Fragments endanger species, especially those "area-sensitive" ones that are less capable of immigration (Farina 2006, 128–50). Some animals are born to adjust to new fragmented environments, while others are less adaptable. Habitat fragmentation changes the route and frequency of animals' movement and feeding patterns. To avoid fragmentation's negative impacts, there needs to be a focus on the development of animal populations along with landscape structure transition, instead of dealing with species richness alone (Farina 2006, 128–50). Building corridors and maintaining the mosaic quality can lessen fragmentation aftermath (Dramstad, Olson, and Forman 1996, 35–46).

Fragmentation, especially that caused by human factors such as infrastructure construction, noise, and land use change, plays an essential role in ecological problems by affecting landscape elements and flux, contributing to worse water quality, soil

erosion, invasive species spread, and biodiversity decline (Farina 2006, 128–50). The effects of fragmentation are measured through variables of size, structure, connectivity, and land use context (Hinsley, Bellamy, and Newton 1995, 41–50). Other factors like traffic and the size of animals also matter (Schmidt and Jensen 2003).

Fragmentation increases the vulnerability of patches to disturbance. A large intact patch possesses contents of small fragmented ecological islands. The characteristics of an island community rely on the surrounding landscape context. Each isolated patch is farther from another when its density is lower. Compared with patch density, island size and shape, and the distance of an island from the mainland, the quality of a settlement is more competitive in affecting species richness and variance. Species distribution can compensate for the effects of isolation, but simultaneously supports the spread of viruses (Farina 2006, 128–50).

2.2.2.3 Connection

Heterogeneity comes from the variety of patch patterns that change the distribution and livability of related species. Patch segregation is discussed in terms of connectedness, connectivity, and corridors. Connectedness denotes the distance between patches (Baudry 1984, 55–65), whereas connectivity indicates the size, amount, and accessibility of favorable habitats (Merriam 1984, 5–15). Functional corridors can increase the connectivity of patches even though their connectedness is weak.

Corridors are linear territories assisting target species to migrate. A corridor's width determines its capacity, and land cover regulates its practicability. Corridors intensify the connectivity of patches, ensure species richness, and construct environment

heterogeneity by weakening the impact of fragmentation (Dramstad, Olson, and Forman 1996, 35–40). Specific types of corridors are determined by landscape elements such as topography, hydrology, and vegetation (Farina 2006, 150–6); of these, a dynamic river is the most vital to improving system diversity (Ward, Malard, and Tockner 2002, 35–45).

2.2.2.4 Flux

An environment's quality and organism activity, especially as affected by vegetation, are fundamental to explaining an ecosystem. The variety of vegetation type, size, and sprawl greatly contribute to landscape effects of energy exchange, resource transportation, local or global climate character, and animal movements (Farina 2006, 157–78).

Nutrients originate from fallen leaves in deciduous plant communities, and flow with topographic patterns such as slopes and aspects. Thus, different plant species, complex terrains, and the unevenness of leaf-produced fertility contribute to landscape heterogeneity (Farina 2006, 157–78). In addition, topography and rubble movement on the ground influence each other. A tiny transformation of topography, such as elevation, contour, and slope direction, can change the characteristics of soil (Wang et al. 2002, 671–84). Soil is the constitutional factor that determines plant arrangement and distribution. Soil moisture influences many processes in soil landscape, such as plant productivity, nitrogen and carbon mineralization, and organism abundance and distribution (Farina 2006, 157–78). Precipitation is also related to slope character and soil composition (Ripl 1995, 61–76).

Landscape unpredictability and complexity control the circulation of information,

energy, and material. Land use and soil condition dominate the nutrient cycle, which supports the system in generating biomass (Boerner and Kooser 1989, 81–92). Land form influences the framework of waterways and the ability of soil to retain nutrients. Furthermore, landscape mosaic alters nutrient effects, even between patches of identical land uses. For example, riparian landscape systems are dynamic enough to disturb soil characteristics. An active river can change the components of a connected wetland (Farina 2006, 157–78).

2.2.3 Population

2.2.3.1 Metapopulation

Mathematical ecologists apply metapopulation theory to demonstrate that a patch can allow a changeable population to survive (Wiens and Moss 2005, 23–6). Breeding and migration are considered as the agents of flux affecting sub-populations (Levins 1970, 77–107) of the dynamic and complex metapopulation system.

Similar to island biogeography, fragmentation is an important cause of metapopulation disturbance (MacArthur and Wilson 1967). Dispersion between patches will change site demographics to a level below or over metapopulation capacity (Farina 2006, 72–4). With the help of metapopulation models, planners can ecologically conserve species struggling in fragmented patches.

2.2.3.2 Dispersion

There exist three major contributors of dispersion: “economic threshold”, “conflict over resources”, and “inbreeding avoidance” (Hansson 1991, 89–103). The causes can be

further modified by the triangulation of economy, society, and environment. Though economy and society are respectively similar to the economic threshold and conflict over resources, they address a wider scope that includes human beings. Moreover, environmental effects such as earthquake caused by nature and air pollution induced by people can be added to the causes of species dispersion.

2.2.3.3 Source-sink System

Metapopulations are heterogeneous. In the source-sink paradigm, source indicates a population increase resulting from breeding and migration. The patch that accommodates source populations is as accordingly called a “source patch”. On the contrary, a sink patch is a patch where population decreases. Resource unavailability is not the only factor that causes dispersion and changing population. Fragmentation and other elements as yet unclear to modern study have a negative impact on the number of source patches (Farina 2006, 75–86).

2.2.4 Resilience

2.2.4.1 Complexity

The concept of complexity can be traced through many disciplines. Huge amounts of differentiated components at interplay constitute a complex, unstable, but very resilient organization (Wu and Marceau 2002, 1–6).

Three hypotheses led to the emergence of complexity. The Uncertainty Hypothesis indicates the uncertainty of a phenomenon. The Inter-domain Hypothesis discusses complexity in a structure in which one domain interacts with another. The Connection

Hypothesis claims that connections are important for system maintenance unless they go beyond thresholds that connected structures cannot tolerant (Farina 2006, 53–6).

Because of the character of complexity in landscape ecology, a system could be understood as an entity composed of adjustable and creative elements. Though matter, energy, and information seem to be simply transported throughout the ecosystem, fresh communications appear all the time. When two or more systems are related and mixed, a different complexity will emerge (Farina 2006, 53–6).

2.2.4.2 Eco-field Hypothesis

"Eco-field" describes a spatial composition where the biotic elements choose to reside or act based on their natural instincts. Different eco-fields are specialized to accommodate corresponding functions and activities. Once the behaviors and habits shift, due to factors such as a species' growing age, the eco-field pattern tends to change accordingly. Both animal and vegetation eco-fields are able to affect the surrounding environment in accordance with their growth process (Farina 2006, 32–7).

Eco-field hypothesis assists in connecting biodiversity composition with landscape features (Jeanneret et al. 2003, 253–63). It also proposes that a species taking advantage of a wide, diversified area will in turn influence ecosystem compositions and services (Redford et al. 2000). A current application of eco-field hypothesis is to track, analyze and predict herbivore movements (Farina 2006, 32–7).

2.2.4.3 Cognition and Autopoiesis

Cognition is the ability to perceive outside information, energy and activities, the feedback of which is the basis for biotics adjusting their own configuration. Regardless of

configuration irregularity, the internal system of a living thing and its relationship with external surroundings remain resilient (Farina 2006, 61). Autopoiesis (Greek for "self-producing") theory studies how an organism reacts to irregular changes through a self-sustaining mechanism to remain stable (Maturana and Varela 1980). However, it is hard for professionals to revise or generate a configuration or relationship that can cognize and self-sustain on its own (Farina 2006, 61).

2.2.4.4 Semiotics

Semiotics translates existing signals into signs in the case that the signals cannot be conveyed in a new context of space, time, or vocabulary (Kull 1998b, 299–310). Biosemiotics, by extension (including vertical semiotics and horizontal semiotics), explains how landscape phenomena and ecology processes are shaped by cognitive adjustment (Kull 1999a, 385–414). Landscape ecology is always discussed from different levels of individual and mutual relationships (Phipps and Berdoulay 1985, 3–19). Similarly, vertical semiotics is closely linked to autopoiesis theory, describing how restructured components strengthen the internal connection of animals and vegetation. Horizontal semiotics, on the other hand, delivers information between organisms (Farina 2006, 62–63).

As biosemiotics deal with message exchange within or between biota, ecosemiotics builds a bridge between biotic and abiotic elements. It also takes into consideration the relationship between environment and civilization. By inheriting sensory abilities from ancestors, the opportunity for survival is increased with "semiotic fitness" (Farina 2006, 62–63).

2.3 Application of Landscape Ecology

2.3.1 Landscape Design and Management

Landscape ecology studies the arrangement of landscapes and its impact on ecological development. Animals and plants, energy and nutrient flows, natural resources and perturbations are moving in a patch pattern due to the landscape's heterogeneous arrangement. These elements' distribution in turn grants the landscape complexity (Burel and Baudry 2003, 6–39).

Patches are connected to each other in landscape ecology theory, and, though seeming alike from a distance, are actually distinct when scrutinized at a landscape scale, allowing the identification of the major structures and procedures of an ecosystem. These entities are categorized into ecotope, micro, meso, macro and megachore levels (Naveh and Lieberman 1984). Each level affects and is affected by human involvement, ideally when economy, society, and environment merge into one triangulation of mutuality and equilibrium. Accessible food and a large patch size will attract animals. Because of this, a model representing a wide patch with resources available in its surroundings is useful for improving spatial quality and inviting a greater number of species (Dramstad, Olson, and Forman 1996, 19–26).

Corridor efficiency is based on the appropriate community quality afforded by species, enabling a smooth migration process. Also important are species behaviors, habits, and characteristics, as well as the environmental conditions around the corridor.

Therefore, a variety of patterns, structures, and functions should be investigated at multiple spatio-temporal scopes to evaluate corridor elements (Farina 2006, 150–56).

A mosaic is characterized by its maturity, configuration, outline, and size. Landscape structures are correspondingly dynamic if a productive mosaic is available (Dramstad, Olson, and Forman 1996, 41–46). In highly heterogeneous landscape mosaics, the contrast between ecotones is obvious. As a result, theories of landscape ecology such as island biogeography and metapopulation gains more popularity for professionals to ease the contrast (Farina 2006, 150–56).

Landscape design puts landscape ecology into practice (Russo, Jones, and Migliozzi 2002, 71–81). Design and ecological restoration aim to contribute valid blueprints for solving ecosystem problems as well as treating human health and recreation (Makhzoumi 2000, 167–77). Contemporary landscape design pays more attention to visual impact. However, the guideline of all ranges of design incorporates potential human needs and existing ecological situations (Hosey 2012, 1–12). The trend of design is still committed to environmental restoration and the protection of organisms. Complexity of both visual and organic values should be stressed in novel nature. Adaptive management is necessary whenever design has been put into practice (CMP 2013).

Landscape ecology principles help increase species capacity by, for example, reducing fragmentation. General approaches to conserve forest habitat require preserving original trees and maintaining surviving dispersed trees. Current theory suggests using native and non-invasive vegetation species to aid in original structure

recovery. An organic pattern is more beneficial than an artificial layout for the enhancement of configuration complexity; therefore, water, earth, and light should be considered when basing plant design on organism communities, while using new methods like prescribed grazing and fire burns (Farina 2006, 281).

2.3.2 Natural Conservation and Restoration

Unfortunately, our planet has been gradually transformed and fragmented by human modification and disturbances, resulting in ruined structures and functions of the nature. Island patterns in ecosystems formed by separation threaten species survival (Han 2008, 246–8), since animals require various community archetypes to complete their lifecycle. Landscapes assembled by people, typically, do not provide enough ecological services, with sharply contrasting functions at patch edges. For the sake of natural conservation, designers need to take initiatives in landscape fragment reconstruction (Farina 2006, 279–302).

Current conservation strategies deal more with landscape's physical issues than its functional issues. Landscape ecology, on the other hand, solves problems from structures to resource flows, and is applicable to natural conservation. Natural conservation is accomplished at individual, mutual, and system levels. The first level of individual deals with endangered animals and vegetation preservation. The mutual level maintains habitat and activities at an ecotope scale. Lastly, the system level diversifies ecological systems, creating a more vibrant state (Farina 2006, 279–302).

Frameworks of both ecological pattern and mechanism gain significance when

applied to ecological maintenance. Disturbance is one strategy able to modify ecological frameworks on all levels (Baker 1992, 181–94), ranging from individual, mutual to systematic. Indirect strategies of disturbance like prescribed grazing and fire are no less necessary than direct conservation of habitat quality (Moreira et al. 2001, 175–87). From the aspect of natural resources utilization, the Full World Hypothesis (Farina et al. 2003, 11–8) claims to maintain the ecology by uniting schemes of agricultural harvest, natural preservation, and cultural landscapes (Beismann 1997, 173–84).

A primary goal of conservation is to enrich biological diversity (Norton and Ulanowicz 1992, 244–9). The configuration, outline, and size of patches and corridors are crucial to their ecological capacity and quality. Forested patches contain more species. An uninterrupted patch has higher capacity than several separated ones do. If fragmented, the nearer patches are to each other, the higher species richness they can accommodate due to their greater connectivity. Thus, corridors are preferred when attempting to connect detached patches. Moreover, a larger interior is superior for establishing and managing natural reserves (Robinson et al. 1995, 1987–90).

Instead of keeping existing conditions stable, diversified landscapes ask for robust progress (Norton and Ulanowicz 1992, 244–9). According to the hierarchy theory of landscape ecology, an ecosystem consists of several layers of subsystems, with higher dynamics at smaller subsystems and lower dynamics at larger ones (Lewis et al. 1996, 440–5). Different preservation theories and methods are applicable for targeting layers of subsystems. Each subsystem must have autopoietic capacity to weather uncertain

revolutions (Farina 2006, 301–2). Thus, landscape architects and ecologists need to manage natural mechanisms to customize ecosystem operation.

2.3.3 Cultural Landscape

As a fundamental integration of nature and culture, landscape architecture pursues establishing a state of sustainability with ecology. More importantly, it reveals local characteristics and fulfills the requirements of humanity, welfare, and personality. Derived from people's continuous interaction with nature, cultural landscape is used to describe landscapes that have been modified by human beings over a continuous period of time, often associated with significant historic resources. The structure, character, and role of a patch in a cultural landscape are complicatedly products of interaction between human disturbances and natural conditions (Plachter and Rossler 1995, 15–8).

On the one hand, it seems that human activities are always decreasing the quality of landscapes and should be avoided. Linked to its historic land use progression and natural resource availability, the pattern of a cultural landscape is more linear and fragmented than a natural one due to its ecotone lack and homogeneity (Farina 2006, 269–75).

Usually, human modifies landscape into a fine-grained structure with comparatively high contrast against adjacent patches (Lord and Norton 1990, 197–202). For example, land use typically changes the ground slope to prevent soil erosion, retain water, or conserve nutrients (Antrop 1997, 105–17). While ecological functions seem to be attained, these methods may have actually destroyed the balance between patches. The

achievement of a vigorous and sustainable future for both humans and nature is still an unrealized future (Farina 2006, 269–75).

Generally attempts to change nature by shifting land use cannot return the landscape to its status before transformation. However, cultural landscapes tend to see a return of natural processes as human disturbances decline. Human practice on nature does not last forever except for the marks carved through abstract ideas (Farina 2006, 269–75) such as memories and names, which are passed down from generation to generation (Sloane 1955).

On the other hand, human intervention is necessary to maintain the biodiversity in a novel ecosystem. It is possible to apply environmental values to culture. With people's support in cultural landscapes, species richness in certain places is even higher than natural landscapes, though larger quantity does not always indicate high quality (Farina 1995). Current intentions to integrate agricultural activities with natural conservation (Meurk and Swaffield 2000, 129–44) employ livestock to keep patches open once agriculture has ceased. In urban and suburban landscapes, greenways provide people with sites for healthy entertainment and simultaneously benefit biodiversity by offering ecological services.

Cultural landscapes try to meet human needs without destruction of natural environment and resources (Antrop 1997, 105–17). Meanwhile, the fragility of a cultural landscape requires maintenance to keep it sustainable. For instance, fire can occur when land is abandoned, causing a sequence of results such as secondary succession and soil erosion during rainy reasons (Farina 2006, 269–75).

CHAPTER 3

TRADITIONAL CHINESE GARDEN

This chapter first interprets the background of traditional Chinese gardens in terms of history, culture, and religion. Moreover, Chinese garden philosophy is represented in three aspects: the wisdom of ancestors, guidelines of design, and the notion of the charm of artificial nature. Finally, the author emphasizes on the siting, landscape elements, and other related factors that play an important role in the traditional Chinese garden design and construction.

3.1 Background of Traditional Chinese Gardens

3.1.1 History

Development of humanity and society from the primitive period through to the agricultural era and industrial times has depended on environment as its constitutional physical condition (Zhang 2009, 27–30). Traditional gardens regarded aesthetics as the criteria of design and practice. It was thought all proposed plans should be at least beautiful (Cui 2014, 104–5). Ancient Chinese designers modified nature to accommodate dwellings based on personal wishes. However, natural disasters, such as flood and natural fire, threatened livability in response to extensive development. Chinese gardens gradually regarded the ecological conditions, instead of personal wishes, as the most

crucial base for social developments. People came to pay more attention to the objective laws of nature, chasing the beauty of sustainability, introducing this concept into everyday life. Design gradually focused more on saving negative situations and sustaining the cycle of nature (Cui 2014, 104–5).

China has been called "the mother of world gardens" (Zhang 2009, 27–30). From the "You", or hunting land, to the mature garden art of the Ming and Qing Dynasties (1368–1911 C.E.), each step of Chinese landscape development has followed the order of ecological beauty. Ecological beauty is linked to both environment and humanity. The Chinese garden is a miniature world with diverse sceneries depicting natural features, from mountains to lakes (Han 2008, 246–8). Garden styles reveal a view of nature through design on its historical, cultural, and social bases. The appearances of these gardens are abstract nature fashioned by human work. Typologies include imperial royal gardens of magnificence, and private gardens of a more natural taste (Zhang 2009, 27–30). Designers explain their artistic conception of the environment through natural landscape elements, which is a method used by ancient Chinese to understand the natural world. As environmental problems arise, people pursue a harmonious relation with nature using environmental preservation strategies (Cui 2014, 104–5), like restrictions on the consumption of old trees.

Within its long history of more than three thousand years, Chinese landscapes and garden design concerned itself with the human relationship to the natural. Palaces with gardens appeared in the Shang Dynasty (around 1600–1046 B.C.E.) (Zhou 2008, 51–8). Advocating nature has a crucial power in human thoughts and lifestyle. Artificial works

mimic natural objects for human worship. For example, mountains indicate supreme power in politicians' view. At the end of the Yin and beginning of the Zhou Dynasty (1046–771 B.C.E.), garden builders simply copied the superficial form of nature. Gardens' functions largely transitioned from advocating nature to entertainment (Han 2008, 246–8). Early in the Zhou Dynasty designers utilized the natural landscape and plant materials to build their gardens (Yin 2011, 110–3), expanding natural water bodies to serve as the main feature of their concepts (Han 2008, 246–8). In one notable example, the emperor ordered the digging of Lingzhao Pond (灵沼) and the construction of a high terrace for his ministers and generals to enjoy a hunting land (Zhou 2008, 54–5).

Natural landscapes have a history spanning more than two thousand years in China, starting as early as the Chunqiu and Zhanguo Periods (722–221 B.C.E.). Due to the undeveloped science, technology, and transportation of the period, people, in their limited lifetimes, were not able to frequently commute from urban settlements to distant natural wonders. The primary purpose of the garden was to reproduce an idea of nature for personal enjoyment. Users' emotional expressions are merged into the artistic manipulation of natural landscape archetypes. Accordingly, traditional Chinese gardens stress the admiration for nature and an eagerness to explore its secrets of operating principles (Xue and Zhang 2014, 106–9).

Subsequently, the Qin Dynasty (221–206 B.C.E.) built palaces beside the gardens called "Yuan" (苑). Located along the Wei River, Epang Palace (阿房宫) had several artificial islands in a pond created by water diverted from the river. This was the origin of what become known as the landscape format of "three hill islands in a lake" (Figure 8).

Private gardens thrived after the Wei, Jin, Nan, and Bei Dynasties (220–589 C.E.) when the empire of China split and the bureaucracy weakened. During these periods, increasing numbers of private gardens uncovered the beauty of the nature. Hunting and field entertainment were no longer the only functions of these spaces. Consistent with the economic prosperity and nation's reunification during the Sui and Tang Dynasties (581–907 C.E.), the system of Chinese garden also formed its style and characteristics. Literature and art had an opportunity to grow, facilitating cultural exchange between multiple ethnicities. In such a peaceful and secure background, garden design achieved many advances. Natural landscapes matured in the Tang and Song Dynasties (Yin 2011, 110–3). As Chinese landscape paintings developed during this period of prosperity, gardens also started to incorporate not only these artistic conceptions, but those of poems as well (Han 2008, 246–8).

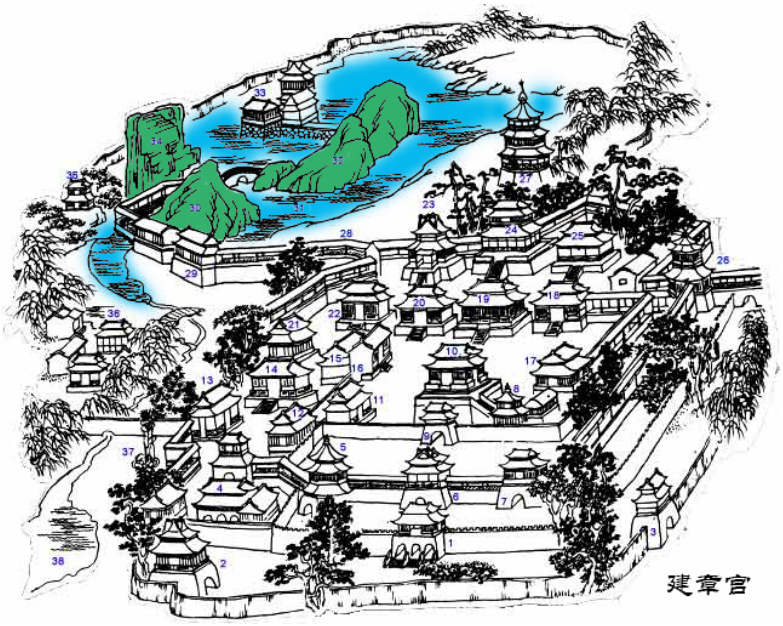

Fig. 8 Three Hill Islands in the Lake of Jianzhang Palace (104 B.C.E.)

Source: http://www.kepu.net.cn/gb/civilization/gardens/course/cou103.html

After the peasant economy solidified and business is bloomed in the Song Dynasty (960–1279 C.E.), Chinese gardens accordingly matured in these fertile conditions. The literati of the Song Dynasty (960–1279 C.E.) admired the beauty of natural sceneries and expressed personal desires via metaphors of landscape elements. This unique appreciation of nature had a strong impact on traditional Chinese garden development. The Ming and Qing Dynasties (1368–1911 C.E.) inherited and propelled these cultural characteristics of spiritual metaphor (Yin 2011, 110–3). The imperialist aggressions of the Qing Dynasty (1616–1911 C.E.) led to the decay of traditional Chinese gardens and loss of innovation (Zhou 2008, 24–5). Meanwhile, the beauty of nature was expressed in garden details (Han 2008, 246–8). For example, window frames in Suzhou gardens usually mimic the shape of plants to ease the viewers' emotion. (Figure 9)

Fig. 9 Window Frame in Traditional Chinese Garden

Source: http://lwyficec.blog.163.com/blog/static/620183232008228943485 94/

Based on different siting conditions and modification degrees, Chinese gardens are categorized into the natural landscape garden and the artificial landscape garden. Occupying large areas with wild landscapes, natural landscape gardens are generally in suburban or rural sites. They are commonly organized in correspondence with topography. Artificial landscape gardens are built by manipulating stone hills and water channels, showcasing people's perception of ecology and their relationship with it (Fu 2010, 482–5).

The natural landscape garden is so named because it refers to Chinese poems and landscape paintings, which use natural landscapes as their inspiration (Zheng and Sun 2009, 20–3). These paintings illustrate the cultural fascination with environment and animals; Chinese gardens are these idealized paintings in three dimensions (Zhang 2009, 27–30). Except for ecological functions, traditional Chinese gardens borrow their techniques of artistic expression from poems and paintings to revive a natural pleasure (Zhang 2006, 255–68), by using landscape elements to illustrate the image excerpts of paintings and to generate the atmosphere rendered in poems.

3.1.2 Religions

Appreciation of the environment and its beauty is anchored in ancient Chinese culture (Li 2012, 93–95). Ecological cogitation in traditional Chinese gardens is derived from its specific cultural background (Fu 2010, 482–5). Chinese culture has been deeply influenced by Confucianism and Taoism for thousands of years, with these systems' focus on the harmony between humans and nature, as derived from the *I Ching*. This

value connects the perception of nature with social ethics (Cui 2014, 104–5). Because of the impact of religion and philosophy, Chinese culture formed a viewpoint that respected and obeyed the law of nature. As the understanding of environment gradually accumulated, traditional Chinese gardens transferred from simple imitation to the creation of a novel nature. The ideas and techniques to build gardens also shifted as time passed, and practical knowledge of nature increased (Fu 2010, 482–5).

The *I Ching* holds the opinion that people and the universe are an integrated whole. All development and production of nature always obey established rules and fulfills an evolutionary trajectory. Human beings, as a part of nature, should recognize, understand, and follow the laws of the environment to keep it sustainable. Traditional Chinese gardens embrace these principles through design and construction (Fu 2010, 482–5).

Taoism establishes that "truth comes from nature" (Li 2012, 93–95), with the unity of opposites as a fundamental, ultimate truth. Harmony is highly appreciated (Cui 2014, 104–5). Humans are a part of a simple, reserved, intact nature (Li 2012, 93–95). Taoism believes in the coexistence of man and natural elements of land, water, forests, and animals highlighting the preservation of natural elements, in addition to the mutual infiltration and adaptation of artificial works and surrounding environment (Fu 2010, 482–5). The garden is the epitome of nature through artistic treatment. The Taoist saying of "Big world in a little teapot" (壶中天地) and the Buddhist expression "Veggies and corns contain a mountain" (芥子纳须弥) demonstrate that a small garden can represent the vastest aspects of nature (Han 2008, 246–8). Under the sayings' influence, Suzhou gardens reflected and reproduced the real environment, and displayed "a nature

that is more meaningful than natural existence" (本于自然,高于自然). Along with their ecological functions, traditional Chinese gardens manage to deliver natural characteristics with the charm of poems and paintings (Li 2012, 93–95).

Influenced by Confucianism, traditional Chinese designers applied gardens to a spiritual dwelling, known as "Li" (礼) or ritual. Humanity and morality, in the Confucian model, are linked to the law of nature. The order of environment and the atmosphere of living are both expressed in gardens, because nature and humanity are equally important. Confucians urged people to treat natural landscapes with social ethic views that expressed personal spirits. Individuals should experience freedom and serenity via communication with others, society, nature, and the universe (Cui 2014, 104–5). Confucians believe that the harmony of the world comes from the integrity of humanity and nature. Under the umbrella of harmony, the beauty of gardens, as interpreted by ancient scholars, is thus the beauty of nature (Li 2012, 93–95).

Buddhism believes all plants possess moral standing. It advocates afforestation and forbids killing. Humans cannot be separated from other organisms (Fu 2010, 482–5). Buddhism highlights people's capability of perception, which is based on a subjective way of thinking. The impact is that Chinese art works including traditional gardens always have obscure implications of profound philosophy for people to sense, think, and understand. Gardens reflect and merge the natural patterns, environmental functions as well as human nature (Zhou 2008, 13–4).

3.1.3 Suzhou Gardens

There is an old Chinese idiom that "Jiangnan Gardens are the best in the world" (Yin 2011, 110–3), among which Suzhou's private gardens are the most famous masterpieces. Construction of private gardens in Jiangnan area initiated in the Song Dynasty (960–1279 C.E.), developed in the Ming (1368–1644 C.E.), and prospered in the Qing (1616–1911 C.E.) (Xue and Zhang 2014, 106–9). Having an elegant and delicate tone, Suzhou gardens are the most outstanding representatives of traditional Jiangnan garden design. Suzhou gardens specifically developed in a large extent from the Wudai Period (907–960 C.E.) until after the middle of the Qing Dynasty (1616–1911 C.E.) (Li and Fu 2007, 350–2) Suzhou has the great privilege of access to abundant water resources, lake stones, and native plant material (Zhang 1980, 52–65).

Harmony between nature and humanity deeply affected the traditional design of Chinese architecture and landscapes. Similar to poems and paintings, Chinese artificial landscapes try to express an intrinsic quality of nature, instead of simply describing its exact shape. The artistic conceptions in poems and paintings are the core characteristics of traditional Chinese gardens. For example, buildings in traditional Chinese gardens are good places for users to enjoy the natural beauty in the same way as the ancient poem sentence saying that "my window frames the scene of a snow-crowned mountain in the west". Many ancient Chinese writers and painters took charge of or participated in garden design and construction. With plentiful travel experiences, it was no difficulty for them to transform specific landscapes into abstract conceptions. They were highly

capable of appreciating aesthetics and performing environmental forms and functions when composing scenic art works (Zhang 1980, 52–65).

Because the recreational function of landscapes is an addition to other daily activities happening in private residential buildings, the arrangement of traditional Jiangnan gardens is differentiated into a residential section and a natural landscape portion. Landscape elements are categorized into four groups: hill, water, building, and vegetation. Most gardens have an inaccessible lake in the center with other landscape elements surrounding it (Xue and Zhang 2014, 106–9).

Zhuozheng Garden, or the Humble Administrator's Garden (Figure 10), was primarily founded in 1509 C.E. Covering an area of roughly 54,000 m^2 (13.34 ac^2), it is the largest and the most representative of traditional gardens in China. The garden contains 31 scenes and large numbers of plants of diverse species, logically arranged along with other landscape elements, including the Ruoshu Hall, the Little Rainbow Bridge (Figure 11), and the Bamboo Gully. (Li and Fu 2007, 350–2).

The site of Zhuozheng Garden was originally a private property owned by a poet of the Tang Dynasty (618–907 C.E.), transformed into Dahong Temple during the Yuan Dynasty (1206–1368 C.E.). Wang Xianchen, an administrator returned to Suzhou after his resignation from the Ming court, purchased the temple, and converted it into his Zhuozheng Garden (Li and Fu 2007, 350–2). Because his father was an official in Beijing, Wang was actually not born in Suzhou. Thus, he chose this garden as an important bridge to connect his own identity with the local culture, in order to gain a psychological sense of belonging (Liang 2013, 61–5). The name of Humble Administrator originated in

the diary of Pan Yue, a writer in the Jin Dynasty (265–420 C.E.), who wrote “I enjoy a happy life by building houses and planting trees, free and unfettered. I do gardening and sell vegetables to guarantee my food everyday, which is a business of the fool” (Zhang 1980, 52–65).

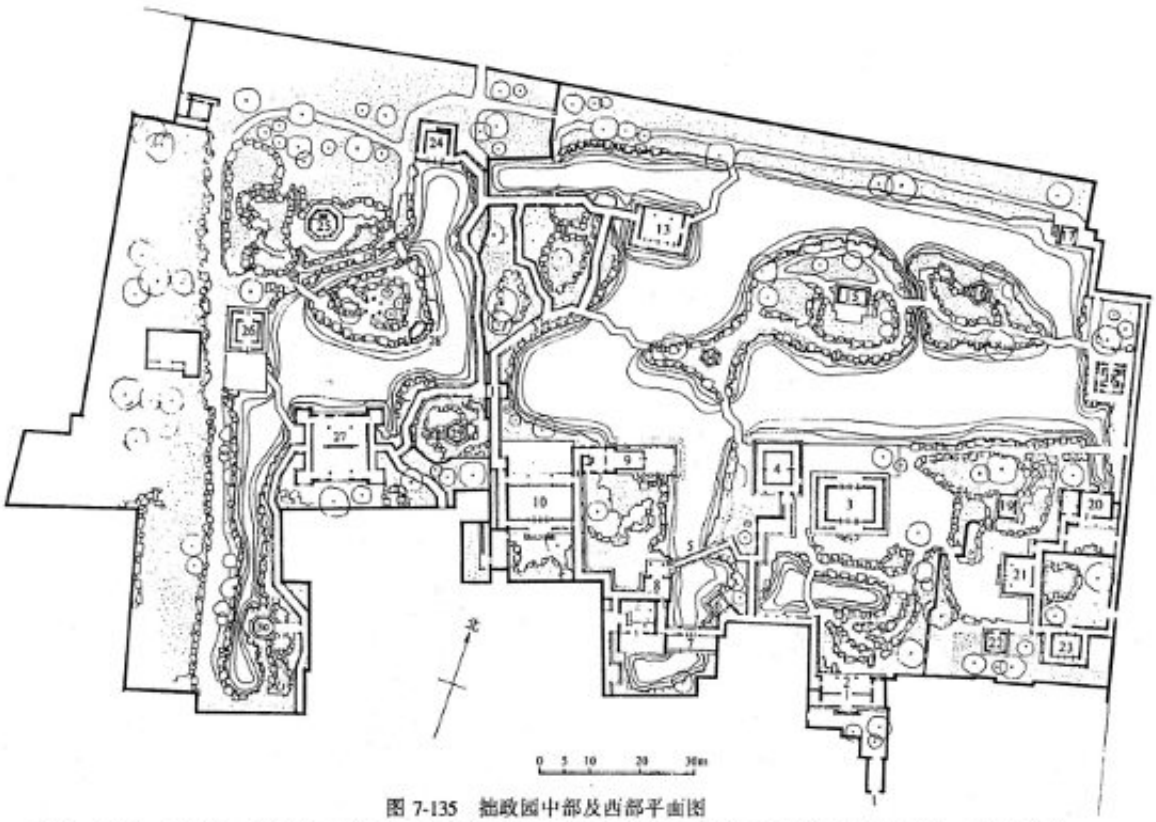

Fig. 10 The Plan of Zhuozheng Garden, Suzhou (Liu and Wang 1993)

Fig. 11 Little Rainbow Bridge in Zhuozheng Garden, Suzhou

Source: http://www.zjnmxx.com/News/201411/20/247327.html

3.1.4 The Monograph Yuanye

Divination used tortoise shells, copper coins, bamboo sticks or astrological signs to infer the future's blessing and disaster, so as for people to find, analyze, and solve problems. This method existed in all aspects of everyday life in ancient China. It was considered as a national ritualistic regime in official events ranging from politics, military, and diplomacy to economy and culture (Zhang 2006, 255–68). Moreover, divination played a fundamental role in common people's daily activities such as marriage, illness, farming, fishing, and hunting (Zhang 2006, 255–68).

A secure dwelling is a requisite for survival. Ancient Chinese had to discover natural

conditions for a potential living environment to dig caves or build nests (Figure 12). As civilization developed, Fengshui (风水) was created as Chinese people modified existing surroundings and planning with a mind toward future events. Fengshui elements—topography, soil, water, and energy—directed the theoretical principles and practical guidance for siting and construction in accordance with natural situations as well as psychological comfort, so as to pursue good fortune and expel bad luck (Zhang 2006, 255–68).

Fig. 12 Cave as a Pristine Form of Building in China during the Neolithic Period

Source: http://sns.91ddcc.com/t/31654

Ji Cheng acquired abundant experience during his life of constructing gardens, compiling his knowledge into the *Yuanye* in 1634 C.E. (Zhang 2006, 255–68), pushing the theory of Chinese natural gardens to its highest level (Zhang 2009, 27–30). The book

includes advanced thoughts of garden design at that time, synthesizing ancestral experiences and Ji Cheng's own opinions (Li 2012, 93–95). In the *Yuanye*, Ji codified the major theories and practices of traditional Chinese landscape construction (Zhang 2009, 27–30). The *Yuanye* also systematically introduces residential criteria, structural elements, building principles, and development tendencies, promoting the wide acceptance that natural landscapes featuring mountains and waters are the most ideal places for human enjoyment (Zhang 2006, 255–68).

The first assertion of the *Yuanye* is about principles of appreciation and construction techniques, with the concept of gardens possessing natural charm. To build a garden is to modify nature in accordance with people's minds and needs. The result, however, is not unilateral. Artificial landscapes can function like natural conditions in harmony with human activities (Li 2012, 93–95). Under the guidance of harmony between man and nature, ancient Chinese gardeners generated a natural world with aesthetic appeals and ecological functions through design. The siting of traditional Chinese gardens is suitable to topographic conditions. Though the environment within walls is created by human planning, design, and construction, it can be mentioned in the same breath as natural essence. The *Yuanye* indicates that artificial work should obey the rule of nature, and establish a harmonious habitat using landscape elements (Zhang 2006, 255–68).

The *Yuanye* was composed more than 380 years ago in a background of farming civilization. People's life at that time was based around agricultural production (Zhang 2006, 255–68). Considering the social development from ancient time until the end of the Ming, the *Yuanye* comprehensively compresses knowledge of Chinese gardens to a

level of conventional culture (Zhang 2009, 27–30). Japanese researchers honor the *Yuanye* as the oldest gardening literature in the world (Zhang 2006, 255–68).

3.2 Philosophy of Traditional Chinese Gardens

Chinese philosophy, civilization, and fine art all address perspectives of nature. Ideology, thinking methodology, and value contribute to traditional Chinese garden design in terms of connecting landscape to environment, geography, civilization, urban fabric, and architecture (Gao 2014, 68–9). The philosophy discussed in this section is concerned with the most fundamental and ideal concepts that have pushed the development of traditional Chinese gardens throughout their history. Ji Cheng inherited these ideas and composed the monograph *Yuanye*, which discusses specific rules and methods for designing and constructing gardens. These principles and methodologies will be more fully illustrated in the next section.

3.2.1 Wisdom of Ancestors

3.2.1.1 Harmony between Nature and Humans

"He" (和), understood in English as "harmony", possesses a significant status in traditional Chinese thought. Both Confucianism and Taoism have specific explanations for harmony. In *the Confucian Analects*, it is an essential element in the application of rites. Mencius also addresses the peaceful coordination between people and nature, including climate and topography. Laozi regards He as a universal value for sages in his classic the *Daodejing*, but it is conditional, temporary, and transitional, requiring the

regulation of objective laws. All advancing and returning things on the earth continuously reproduce in endless successions. Artistic conception comes from harmony (Ye and Zong 2014).

During more than two thousand years from the Qin to Qing Dynasties, the harmony between man and nature always influenced the Chinese view of environment (Cui 2014, 104–5). Human habitat construction should obey the fundamental principle of integrating people with nature. Besides exquisite appearance, Chinese garden culture is in favor of a harmonious interaction between environment and human. The *Yuanye* is the first monograph about gardens in China. It standardized traditional Chinese garden art and demonstrates a rich knowledge of ecology (Li 2012, 93–95). The *Yuanye* shows the direction humans should follow in order to coexist with the environment. The theories in the *Yuanye* were influenced by traditional Chinese culture, including the Confucian concept of "Ren" (仁), or kindness. In the realm of nature, kindness emphasizes the harmonious relationship people build to comfort organisms and the environment (Zhang 2006, 255–68).

Nature is always the most basic source for garden design. Ancient garden builders "learned from external environment and comprehended from internal sentiment" (外师造化,中得心源). The garden is the integrated outcome of natural landscapes and people's perception. "To learn from nature" (师法自然) is the process by which designers summarize typical landscape characters using their experiences of natural beauty, and apply them to garden construction (Yin 2011, 110–3). Harmony between humanity and

nature, like the beauty of ecology, is stored in people's pleasant experiences of environment (Han 2008, 246–8).

The core value of the *Yuanye* is about ecology. The significance of ecological concepts in *Yuanye* is obvious today in the modification process of China's urbanization and industrialization (Zhang 2009, 27–30). The idea that "truth comes from nature" serves as a concept of ecological ethics to maintain the equality of all organisms on earth. This concept has not lost its applicability in the current world of problems ranging from air pollution to ecological imbalance (Xing 2003, 29–31). Ecological awareness in the *Yuanye* manifests the concept of artificial works with the purpose to seize the spirits of the natural world. Equality between humanity and nature is cherished in the *Yuanye*. Instead of the conflict between artificial process and natural properties, the laws of nature are followed to realize an intact charm. People's willpower should not impose on nature, requiring sacrifice on its part. By considering harmony between nature and humans, the *Yuanye* provides the possibility of beautiful habitats and ecological livability in a sustainable environment (Wang and Wang 2013, 27–9).

The *Yuanye* is a global milestone of garden design literature, combining artistic theory with practical techniques. The traditional Chinese garden is a natural landscape garden that joins artificial works with natural elements and functions. The keynote of the garden is to construct a nature that is more meaningful than the natural (Han 2008, 246–8). The *Yuanye* constructs a frame for landscape design, including garden styles, design concepts, basic principles, and use of the environment and resources, as well as criteria for financial support and talent selection (Zhang 2009, 27–30). Available

resources partially determine landscape characteristics. Rational use of natural resources is highly promoted. Then, human habitat can apply natural design to landscapes, resulting in poetic and picturesque charm. The *Yanye* (or Ji Cheng) also advocates the use of cultural connotation in landscapes to arouse users' emotions (Wang and Wang 2013, 27–9). Chinese gardens commonly use plaques, couplets, and steles for decoration and, more importantly, emotional expression (Han 2008, 246–8).

3.2.1.2 Artificial Gardens with Natural Charm

Exposed to a background of Confucianism and Taoist beliefs, traditional Chinese gardens proposed to cultivate natural charm by human design. People admire and mimic nature; meanwhile, they prefer a designed environment that can keep the ecosystem in balance (Li 2012, 93–95).

When pursuing a more comfortable living condition, the highest level of environmental manipulation for humans is to stay in harmony with nature. The interdependence between humans and nature requires coordinated development for the long term. Chinese ancestors treated nature as the prerequisite and guarantee of humanity's survival, life, and development. Humans depend on nature and modify it (Zhang 2009, 27–30). A favorable surrounding will in turn meet people's needs for a high quality of life. Through the interaction of human beings and nature, a harmonious relationship of symbiotic coordination and sustainable development is reconstructed in gardens (Zhang 2006, 255–68). The process of modifying nature ought to be the union between the biotic and abiotic structure and functions of an ecosystem. This concept

inherits the traditional and fundamental value of harmony between man and environment, and applies it to practice (Zhang 2009, 27–30).

"Artificial landscapes delivering natural charm" is more than techniques and criteria of garden design. Mimicking the forms of natural landscapes is external. The core, however, is deep in recovering ecosystem and supporting natural properties (Zhang 2009, 27–30). In the *Yuanye*, Ji Cheng suggests building a whole ecological system, which refers to a novel nature influenced by artificial adjustment. The *Yuanye* sites gardens and buildings considering geomorphology like various terrain near forests, by lakes, and in developed areas. Within the delicate works of garden designers, landscape elements are organically arranged (Zhang 2006, 255–68). "Being artificial, the gardens are comparable to a natural wonder" (Zhang and Ji 1993, 2–18).

Traditional Chinese gardens vividly interpret the ancient philosophy of humanities, history, and geography. The *Yuanye* points out that forested mountains are the best choice for creating landscapes and gardens, because forested mountains form a natural taste without too much construction work. By learning from nature, garden terrains wisely recapitulate the essence of natural landscapes. Artificial landscape gardens cherish mountains by employing ranges and water with sources as they are in nature. All the gestures of water are referred to and innovated from existing rivers, lakes, springs, and waterfalls in the nature. Thus, garden designers manage to realize a complete environment within a limited space (Gao 2014, 68–9).

3.2.2 Guidelines of Design

In order to solve local problems, garden design is started only after the investigation of topography, waterways, and vegetation. Meanwhile, circumstances shift as time, place, and users change. Design should meet needs and make full use of resources. That is why extensional modification is unadvisable, and construction should fit local conditions (Wang and Wang 2013, 27–9).

3.2.2.1 Selection of Fengshui Theory

The term "Fengshui" was coined by Guo Pu from the formulation of "Chi" (气), or universal energy that "disperses with wind (Feng) and gathers at waters (Shui)". Ji Cheng expresses a dialectical attitude toward Fengshui theory (Zhang 2006, 255–68), with the view that garden design does not always need to follow Fengshui rules. There is no restriction on a garden's form. Design is acceptable if it corresponds to the justifiable needs of ecology or reasons of existing situations (Wang and Wang 2013, 27–9). To establish ecological surroundings that are also livable, the *Yuanye* selects the essential and reasonable portions of Fengshui theory and discards the unscientific points of blind faith. Thus, the *Yuanye* possesses the justified values of both theory and practice, espousing a comprehensive discipline mixing geology, meteorology, ecology, landscape architecture, planning, and architecture. In Ji Cheng's work, there is no content about superstition or fortune telling. Thus, the *Yuanye* achieves a height of applicability and objectiveness (Zhang 2006, 255–68).

3.2.2.2 Suitability to Local Circumstances

Traditional Chinese gardens are works combining aesthetics with ecology. In terms

of garden patterns, “compliance makes dexterity, and appropriateness brings delicacy” (巧于因借,精在体宜) (Zhang and Ji 1993, 2–18). As for garden structures, one of the most essential principles of design techniques in traditional Chinese gardens is to “take actions that suit local circumstances” (因地制宜) (Zheng and Sun 2009, 20–3). Suitability depends on the criteria of comfort for people and fitness for nature. Instead of nature offering one-sided services to mankind, the *Yuanye* indicates that organisms and environment interdependently coexist (Zhang 2006, 255–68). Therefore, as a part of the world, humans should show respect to nature by obeying its rules.

While Fengshui theory consists of strict rules, there is no specific archetype of a practical model to fulfill the idea of locality. The most constant concept throughout the text of the *Yuanye* is suitability. When people design and construct buildings and landscapes, they need to carefully investigate the geology and geomorphology of surroundings to ensure that living conditions are convenient and comfortable; and a house is usually situated facing south in China for the sake of sunlight and ventilation, which is helpful to human health (Zhang 2006, 255–68).

3.2.3 Charm of Artificial Nature

The artistic conceptions in traditional Chinese gardens follow the development of Chinese calligraphy, painting, poetry, philosophy, and even local custom. Every element or every atmosphere in the garden appears in accordance with human’s perception of the nature (Gao 2014, 68–9).

3.2.3.1 Artistic Conception in Poems And Paintings

Harmony with nature is strongly embedded in Chinese culture, from religions, to Chinese calligraphy, painting, and landscape. (Figure 13) An ideal status for Chinese habitats is to show a natural atmosphere like those portrayed in a romantic poem or landscape painting (Gao 2014, 68–9). This is because the art of traditional Chinese gardens, like calligraphy, peom, and painting, was created by scholars (Jiang and Liu 2014, 107–10). Zhang Zao, a Chinese painter in the Tang Dynasty (618–907 C.E.), advised artists to "learn from external environment and comprehend from internal sentiment".

Usually people can feel the charm of natural landscapes in the Chinese garden with a limited area. For example, though Wangshi Garden has a small water surface, the pond stretches out at one corner and winds behind a stone bridge, seeming to be endless and connected to the outside waterways (Yin 2011, 110–3). With artistic conception of poems and paintings implied in traditional Chinese gardens, the garden planner's emotions merge with the atmosphere rendered by landscape elements in the enclosed garden.

Fig. 13 Chinese Landscape Painting by Mengfu Zhao (1254-1322 C.E.)

Source: http://www.chinaonlinemuseum.com/painting-zhao-mengfu-autumn-colors.php

3.3 Methodologies of Traditional Garden Design in Suzhou

Traditional Chinese gardens reproduce natural landscapes using artificial techniques based on the principle of harmony between nature and humans. Influenced by a religious background of Confucianism, Taoism, and Buddhism, these gardens absorbed their perception of ecology by protecting and moderately transforming natural conditions to meet people's needs (Fu 2010, 482–5). These gardens created with environmental features and materials are artificial nature. Natural materials used in gardens include water bodies, stone hills, plants, and animals, which are selected from and refer to the surrounding environment (Yin 2011, 110–3). The garden can be analogized as a human body, as the ancient painter Guo Xi did when he wrote, "mountain is face; water is blood; buildings are eyes; and plants are hair" (Zhang 1980, 52–65).

The designers of traditional gardens wanted to protect the forests and animals while still making full use of natural resources (Li 2012, 93–95). Many famous gardens in Suzhou are arranged according to contour lines and ecological functions (Zhang 1980, 52–65). To be specific, Ji Cheng suggests in the *Yuanye* that pavilions and decks to be built on highlands (Figure 14), and that lowlands are suitable for pond construction, with recognition of the sources and ends of water linked to ponds (Wang and Wang 2013, 27–9).

Fig. 14 A Pavilion in Zhuozheng Garden Built on Highland

Source: http://zqx500811.blog.163.com/blog/static/898224562009521018648 7/

Adaptation to nature saves expenses by using natural materials and complying with existing conditions. Following the principle of relying upon nature, the plan of Zhuozheng Garden is irregular and organic, built on a large base of natural puddles. Buildings are situated by the artificial lake transformed from its original terrain. Plants and piles of stones structure a picturesque landscape, mimicking the features of a riverside town in the Jiangnan region (Zhang 1980, 52–65). Plants germinate and bloom at different times of the year, showcasing the seasonal changes of the natural world to viewers. The artificial garden is comparable to a natural wonder (Li 2012, 93–95). Unfortunately, the peaceful surrounding is hard for a contemporary visitor to appreciate, because the function of traditional gardens has transferred from private use to public park (Liang 2013, 61–5).

Under the umbrella of harmony between nature and humans, traditional Chinese gardens intended to express natural characteristics using metaphors ranging from site arrangement, landscape configuration, and vegetation communities to building details (Fu 2010, 482–5). The gardens and their landscape elements also intimate scholars' emotions, performing the concept of combining nature with human to some degree (Yin 2011, 110–3).

3.3.1 Siting and Topography

3.3.1.1 Siting

Generally, the theory and methods in the *Yuanye* aim to generate a complete ecosystem whose stability is maintained by the recycling of resources and energy flow. The system of a Chinese garden is made up of natural elements and artificial works, as the application of randomness with appropriateness to garden design accomplishes the result of a novel nature. Though artificial, this nature is an effective method of encouraging people to understand, appreciate, and experience environment. Therefore, this combination benefits both natural sustainability and residential livability (Zhang 2006, 255–68).

This eagerness to approach nature is still the expectation of people today. Whether in urban districts or rural areas, intact places remain the most suitable location for proposed gardens. Forested mountains are especially the best choice for creating landscapes (Zhang 2006, 255–68). Usually, natural landscape gardens only occupy a

limited area of the large scale of intact site, comparatively causing little conflict with surrounding ecological conditions.

Most gardens in Jiangnan established during the Ming and Qing Dynasties (1368–1911 C.E.) belong to the category of artificial landscape garden. Due to the limitation of site area and urban location, these gardens are restricted from completely taking advantage of natural landscape resources. Furthermore, large numbers of garden spaces are occupied by building masses so that designers need to exploit artificial landscapes with natural materials to generate an atmosphere of wilderness (Fu 2010, 482–5).

3.3.1.2 Topography

According to the conclusion of the *Yuanye*, artificial landscape elements and buildings merge with existing natural conditions; even when every design approach seems to be random, it contains a logical suitability to its surroundings. The proposed natural atmosphere arouses people's awareness of understanding and accessing nature (Wang and Wang 2013, 27–9).

Following the gesture of the terrain, hills are piled up on higher lands. Pavilions and decks are also suitable for this topography. Lower places are more efficient for cutting into. Ponds can be constructed at lower elevations. Earthworks cut at lower spaces are filled at highlands in order to form a gesture of natural mountains and waters. Gardens usually mimic lakes, rivers, streams, and even waterfalls in real environments using artistic and abstract skills to arrange water flows and construct revetments (Zheng and Sun 2009, 20–3).

3.3.2 Hill and Water

Ji Cheng regards a hill in the center of a pond as the focus of the garden. Construction of artificial hills and the design of waters condense various types of natural landscapes into one garden (Zheng and Sun 2009, 20–3). Stone hills and waters are located based on the existing surrounding conditions (Gao 2014, 68–9).

3.3.2.1 Hill

The two hill islands in the central lake of Zhuozheng Garden use rocks as a base and cover it with earth, quite similar to the natural ground layers. Hills built with earth on stones in this way have a natural appearance, especially as trees can take root in the soil and survive. Their roots will in turn reinforce the foundation. Rocks are also applied to revetments for this same reason (Zhang 1980, 52–65). (Figure 15)

3.3.2.2 Water

Water resource management is a fundamental process in the construction of traditional Chinese gardens. Designers need to figure out where the water comes and goes, what the water's gesture is, and how water quality is purified. Rich resources of water can optimize the ecosystem condition (Zhang 2006, 255–68).

The importance of the water cycle is strengthened for its benefits to both visual impact and ecological quality (Fu 2010, 482–5). Water management in traditional Chinese gardens pays careful attention to locating the water sources and ends. Traditional designers preferred to link water landscapes in gardens to the natural waters flowing out of an unnatural wall. An ideal method of connection was to lead running water in natural surroundings into a garden, a convenient method for landscapes in

forests, country villages, and watersheds (Zheng and Sun 2009, 20–3). In some natural landscape gardens, the inner lake is linked to a constructed stream. The stream is used for rain harvesting and the lake for water purifying. From an ecological viewpoint, this water system connecting with the natural environment acts as a simulated climate generator to guarantee the organisms' survival. Though within an enclosed space, water is usually connected to running waters outside to maintain energy. Artificial hills and treated waters that constitute a mini-ecosystem in artificial landscape gardens help develop effective locations for biotic survival. In turn, plants and animals living in the water play a considerable role in improving water function (Fu 2010, 482–5).

Fig. 15 Stone Hill and Revetment in Liu Garden, Suzhou

Source: http://www.dianliwenmi.com/postimg_2478222.html

The *Yuanye* was the first monograph that to illustrate the art of garden design comprehensively and systematically. Even though the *Yuanye* touches upon water management in different chapters, this book has no section dedicated to specifically explaining it (Zheng and Sun 2009, 20–3). This is because Ji Cheng thought that "water has no form; its form is determined by the container" (水本无形,因器成之) (Zhang and Ji 1993, 2–18). Water planning in traditional Chinese gardens is closely linked to site topography and artificial hills. Therefore, Ji mentions water together with other landscape elements (Zheng and Sun 2009, 20–3).

Where there is a building, there must be a water arrangement. Water accessibility is the most favorable condition for siting a building (Zhang 2006, 255–68). (Figure 16) Because there used to be a pond on the site of today's Zhuozheng Garden, one third of the whole area accordingly serves as a water body (Li and Fu 2007, 350–2). However, the urban surrounding causes lack of running water in the Suzhou gardens including Zhuozheng Garden (Zhang 1980, 52–65). Tranquil lakes are encompassed by high walls. Moving waters like fountains, streamlets, and waterfalls are rarely seen in Suzhou gardens. Only during the summer can stormwater contribute to a waterfall on very few occasions (Zhang 1980, 52–65). In spite of ecological cycles, the purification of water quality mainly depends on the manual clean (Suzhou Zhuozheng Garden 2015).

Fig. 16 Buildings in Zhuozheng Garden with Good Water Accessibility

Source: http://2010sailing.blog.163.com/blog/static/186313712011613493449 8/

3.3.3 Vegetation and Natural Resources Preservation

3.3.3.1 Vegetation

The *Yuanye* applies various principles and techniques to create gardens that are complete ecosystems. Vegetation is the major element that maintains the ecosystem balance (Wang and Wang 2013, 27–9). Though covering a comparatively small percentage of the whole area, plants are still the fundamental landscape elements that constitute traditional Chinese gardens, especially in Suzhou's private gardens. On the one hand, a large proportion of garden land is occupied by buildings and stone hills (Wu

1999, 33–5). On the other, awareness of showing respect for natural laws has been deeply embedded in people's minds (Fu 2010, 482–5), such as the awareness of preserving the biodiversity of plants.

The principle of harmony between nature and humanity is applied to the utilization of plants in traditional Suzhou gardens. The plant community's arrangement generally has "no formulation to follow", but learns from nature and builds an artificial garden with ecological status (Li and Fu 2007, 350–2). Even seated in an urban area, the inner environment and outer surroundings of Suzhou gardens manage a novel nature akin to a "real" one (Liang 2013, 61–5).

Application of plant communities depends on types of species and their survival requirements, natural living conditions, and aesthetic function (Zhang 2006, 255–68). Criteria of biodiversity and native status cover more than 30 species that are suitable for use in Jiangnan (Wang and Wang 2013, 27–9). Most plants in traditional Chinese gardens are native, such as cedar (*Cedrus deodara*), elm (*Ulmus pumila*), maple (*Acer palmatum*), and privet (*Ligustrum lucidum*). Some non-native but non-invasive species are gradually accepted, like magnolia (*Magnolia grandiflora*) (Zhang 1980, 52–65).

Traditional Chinese gardens have for a long time evinced different growth characteristics of vegetation and their requirements for living conditions. Designers should observe and know each plant and enhance the interaction between landscape elements and the surrounding environment. In Suzhou gardens, for example, plant communities are organized in a gradient of their favored features, from sunlight to shade. Ginkgo (*ginkgo biloba*), ash tree (*Fraxinus chinensis*), and peony (*Paeonia suffruticosa*)

are plants on the sunny side of Suzhou gardens. Osmanthus (*Osmanthus fragrans*) and camellia (*Camellia japonica*) are applied to medium sunlight areas, while Chinese privet (*Ligustrum lucidum*), podocarpus (*Podocarpus macrophyllus*) and bamboo (*Bambuseae*) are situated in the shade. Willow (*Salix babylonica*), Chinese wingnut (*Pterocarya stenoptera*), and winter jasmine (*Jasminum nudiflorum*), being moisture tolerant, are planted by the waterside (Fu 2010, 482–5).

The applicability of appropriate plants to other landscape elements such as soil is also considered. Soil fertility is poor on artificial hills where there is only a slight sheet of earth cover. Plants with developed roots and drought tolerance, including gingko (*ginkgo biloba*), pine (*Pinaceae*), and wintersweet (*Chimonanthus praecox*), are more applicable to poor soil conditions. Vines like wisteria (*Wisteria sinensis*), winter jasmine (*Jasminum nudiflorum*), and costus (*Aucklandia lappa*) can grow between rocks and under stone stairs (Fu 2010, 482–5).

Though the selection of plants for Suzhou's gardens has the drawback of most materials being evergreen, deciduous vegetation with colors are still used for decorative functions (Li and Fu 2007, 350–2). Plant diversity not only forms a beautiful landscape, but also constructs a micro-climate that is beneficial for ecological health (Zhang 2006, 255–68). The mutual effects between different plant species suggest a multi-layer structure of arbor, bush, and grass. By employing this structure, some negative reactions on certain plant growth could be reduced. Frequently seen combinations are willow (*Salix babylonica*) with flowering quince (*Chaenomeles speciosa*), winter jasmine

(*Jasminum nudiflorum*) with plum flower (*Prunus mume*), and pomegranate (*punica granatum*) with crape myrtle (*Lagerstroemia indica*) (Fu 2010, 482–5).

In order to mimic a natural gesture, plant types are selected to be mature, pristine, and graceful. Suzhou gardens have many precious plants such as peony (*Paeonia suffruticosa*), osmanthus (*Osmanthus fragrans*), and magnolia (*Magnolia grandiflora*). Trees of a prim or symmetric shape are rarely used. Flowerbeds are constructed with lake stones. The use of plant materials is economical and the overall artistic effect is achieved not because of how many trees are planted, but through the delicacy of the trees' ultimate performance. Less and simple makes sensational (Zhang 1980, 52–65).

Due to traditional custom, designers also select plants with auspicious meanings (Li and Fu 2007, 350–2). Plant communities in Suzhou gardens greatly emphasize on spiritual meanings (Wu 1999, 33–5). A plant is usually personified or endued with symbolism based on its habit, phenology, appearance, and name. Some elite who was not able to showcase their talents in their professional careers used plants as a symbol of dreams and ambitions. For example, lotuses (*Nymphaea tetragona*) floating on the water's surface in Zhuozheng Garden imply the innocent spirit of its owner, Wang Xianchen (Li and Fu 2007, 350–2).

3.3.3.2 Natural Resources

The *Yuanye* emphasizes the preciousness of natural resources like forests, ancient trees, and soil (Wang and Wang 2013, 27–9). It points out the importance of forest land use. Any human disturbances to forests, such as land occupation and vegetation destruction should be limited unless sufficiently justified. It suggests avoiding

catastrophic destruction by conserving precious natural resources such as ancient plants (Zhang 2006, 255–68). “When the building construction has a conflict with the preservation of old trees, we can either move the building base away from the trees to ensure their survival; or we can cut some tree branches so as not to affect the construction progress. It is always easier to build houses than to preserve trees” (Zhang and Ji 1993, 2–18). Hundreds of old trees in Zhuozheng Garden are preserved, confirming the harmonious relation of people and nature (Zhang 1980, 52–65).

The preservation, utilization, and modification of the natural environment pursue the goal of sustainable development (Zhang 2006, 255–68). Concepts achieved early in the era of agricultural civilization remind us in industrial times of an ideal direction of resources conservation and environmental recovery (Wang and Wang 2013, 27–9). Since resources are limited, people need to improve techniques of use, develop moderately in order to maintain water and air quality, and reduce noise and light pollution (Zhang 2006, 255–68).

3.3.4 Others

3.3.4.1 Animal

Animals are an indispensible natural element in garden environments as they interact with people. Instead of natural selection, artificial choices accelerate the species evolution and the cycle of the whole ecosystem (Zhang 2006, 255–68). The voices of cranes accompany sound sleep. Gulls gather to play on the riverbank. Deer are cultivated for recreation. Fishing by the pond provides a relaxing pastime. The *Yuanye*

demonstrates the desire to live with a diversity of animals in a well-established ecosystem (Wang and Wang 2013, 27–9). Birds, insects, mammals, and fish highlight the atmosphere of a natural environment like real forest mountains (Zhang 1980, 52–65).

3.3.4.2 Building

The arrangement of buildings with hills, waters, and plants is one technique for illustrating the relationship of humans with nature. Vernacular features and local materials are environmentally friendly elements that reflect Chinese culture and environment (Fu 2010, 482–5). Designers determine the building colors by natural conditions. For example, due to the humid climate of south China, traditional Suzhou gardens apply cool colors to all structural components as a complement to the elegant plants and grey rocks. The atmosphere of serenity purifies users' minds and calms their emotions (Zhang 1980, 52–65).

CHAPTER 4

COMPARISON AND APPLICATION

This chapter compares landscape ecology theory with traditional Chinese gardens in terms of all the aspects listed in previous chapters. It only discusses the horizontal comparisons between landscape ecology and traditional Chinese gardens in scenarios of background, principles, and application, but also draws a conclusion of vertical and comprehensive comparison between the two realms. By applying the comparison results to the demostration of Zhuozheng Garden, this chapter analyzes the outcome of positive complements combining landscape ecology and traditional Chinese gardens, and the reality of their negative correlations.

4.1 The Comparison between Background and Development

As for history, ecology—and especially landscape ecology—is a recently developed discipline in Europe. On the contrary, traditional Chinese gardens have a long history of more than three thousand years. The Western theory of landscape ecology was still in its infancy even after the declination of traditional Chinese garden development. Later, from the middle of twentieth century, landscape ecology started its role as a distinguished field of study, growing maturing over three decades before spreading to the United States (Forman 1990, 35–41).

Table 1 Comparison between Landscape Ecology Background and Chinese Garden Development

	Landscape Ecology	Traditional Chinese Garden
Emergence	Emerging in late 1930s in Europe	Emerging more than 2,000 years ago in China
Primary Function	Utilized to solve environmental problems of industrialization and urbanization	Providing recreation and improving human health
Affecting Factors	Multidisciplinary and interdisciplinary	Influenced by multiple cultural factors
Range	Nature and humans	Nature, human, and culture

As landscape ecology theory increasingly improved, scholars applied it to solving contemporary environmental problems. Humans became an important element taken into consideration in landscape ecological development. Human activities also caused large numbers of changes to the earth (Burel and Baudry 2003, 6–39). Professions from different backgrounds turned to landscape ecology to compensate for the damage done by people to natural systems and organisms. Ecosystem restoration, sustainable planning and design, natural resources preservation, and management are all related to landscape ecology, widely utilized by designers and scientists (Ndubisi 2002, 168–71).

In contrast, the traditional Chinese garden was generated against the background of an agricultural civilization, without much consideration for problems so prevalent in contemporary society (Zhang 2006, 255–68). Though Chinese gardens have always developed along with the concept of harmony between nature and humans, their main

goal is generally oriented from human use criteria (Xue and Zhang 2014, 106–9). Whether it is a royal garden, private garden, or temple garden, its origin and functions during the development process are always to provide recreation and improve human health.

Being a principle both multidisciplinary and interdisciplinary, landscape ecology concerns both spatial and temporal aspects of an ecosystem (Burel and Baudry 2003, 6–39). It primarily absorbs the knowledge of geography and biology, and then collects further information from various disciplines related to soil and vegetation. Concepts of landscape ecology like island biogeography, metapopulation, hierarchy, heterogeneity, and many other new terms show the complexity of this principle (Farina 2006). With the help of new technologies and facilities, the theories of landscape ecology are widely utilized to solve complicated problems by various professions, from forestry, to landscape, to natural resource management (Ndubisi 2002, 168–71).

Traditional Chinese gardens are affected by multiple Chinese cultural factors, such as religions, folk customs, and the fine arts. The impact of philosophy is fundamental, lasts long, and keeps improving. Some overarching philosophy in traditional Chinese garden design is generated by Confucian, Taoist, and Buddhist systems (Zhou 2008, 12–4). For example, harmony between nature and humans cultivates the understanding of how human beings should treat the environment via garden construction. The concept of harmony also contributes to the theory of Fengshui that guides siting and topographic modification. The scholars composed poems and paintings with admiration for appealing environments, and arranged gardens according to natural surroundings

(Zhang 1980, 52–65). All these religious and cultural backgrounds obeyed the laws of nature (Zhou 2008, 12–4).

Landscape ecology and traditional Chinese gardens are similar in their basic thoughts of maintaining the balance between nature and humans. Theories contributing to landscape ecology show a scientific interest in the environment. Though debatable, the beauty of ecology is gradually acquiring more popularity (Hosey 2012, 1–12). In the realm of landscape ecology, interactions between nature and humans are supposed to balance the triangulation of environment, economy, and society, advancing the discipline in a helix trajectory.

Traditional Chinese gardens are also affected by philosophy, culture, and folk customs linked to nature. The development of Chinese gardens follows the process of originating from nature, mimicking nature, utilizing nature, and finally, naturalizing artificial gardens (Han 2008, 246–8). Ancestors first pursued the aesthetics of gardens and soon found the necessity of weathering natural disasters. Thus, the most primary and important thought that affected the formation and evolution of traditional Chinese gardens is the harmonious relationship between nature and humanity, which is quite similar to people's concerns in modern society (Wang and Wang 2013, 27–9).

However, traditional Chinese gardens are not only about ecology. The harmonious relationship between nature and humans in China is more complex than the relationship within ecology. Ancestors used to experience nature, transferred what they saw into an ideal world in their hearts, and then expressed it by the practice of their gardens. Thus, garden design is not only an academic scholarship, but also an art containing humanity.

In it, we find artistic conception mixed with natural characteristics. Concepts of garden design are always acquiring new cultural elements. Finally garden design becomes a culture in itself.

4.2 The Comparison between Principles and Philosophy

Table 2 Comparison between Landscape Ecology Principles and Chinese Garden Philosophy

	Landscape Ecology	Traditional Chinese Gardens
Core Idea	Nature is the core	Harmony between nature and humans
Scale	Multiple scales of layers	Multiple scales of layers applicable
Feature	Quantitative, containing concrete theories and experiments	Descriptive, to be fulfilled by landscape ecology in contemporary background
Breadth	Science	Aesthetics, psychology, and humanity

Nature has been at the core of landscape ecology from its emergence up to contemporary practice. In landscape ecology, the natural condition guides resources preservation, environmental problem-solving, and sustainable development. Principles related to landscape ecology are generated from geographic and biological situations, develop from professional concerns with nature, and solve contemporary environmental problems (Ndubisi 2002, 168–71).

Similarly, traditional Chinese gardens connect humans with nature in harmony. Nature is integrated into design, which in turn refines nature to meet human needs. Ancestors learned from the external environment and comprehend from internal sentiment, believing truth comes from nature (Han 2008, 246–8). From these most fundamental concepts, it is possible to understand how sincerely Chinese ancestors admired, respected, and loved nature.

Landscape ecology is complex in its spatio-temporal structure. According to hierarchy theory, landscapes can be separated into multiple layers from small to large scales (Burel and Baudry 2003, 6–39). Scholars focus on a certain layer to solve corresponding questions regarding ecological phenomena (Turner et al. 1991, 17–49). Within a smaller range, landscape organization is discussed in the context of landscape ecology. At a larger scope, research interest is on the interaction between different landscape elements (Burel and Baudry 2003, 6–39). Landscape ecology, therefore, is applicable to most traditional gardens, no matter if they are the artificial small-scale landscape gardens of Suzhou or large natural landscape gardens in Beijing.

Despite the fact that the *Yuanye* suggests forests is the best place to construct gardens (Zhang and Ji 1993, 2–18), Suzhou gardens were built in ancient urban areas. As the city evolves and expands, these gardens are now in much more urbanized districts than before. Thus, these gardens are no longer single units by themselves but require a broader view. The primary goal of private Chinese gardens was to serve its users. In contemporary society, however, traditional Chinese gardens have transformed their identity from royal or private gardens to parks open to the public. The gardens are

connected to green systems beyond the garden walls in the city. As population expanded, human disturbance broke the balance between nature and people by changing landscape patterns, producing polluted air, and generating an abundance of noise. Against a contemporary background of human-induced environmental problems, consideration of a comprehensive knowledge network of landscape ecology is needed to investigate, evaluate, and improve traditional Chinese gardens and their relevance to the urban context. This is a necessary, advantageous, and long-term work.

In other words, landscape ecology theory can further the study of traditional Chinese gardens. According to the hierarchy theory of landscape ecology, natural conservation deals with a hierarchy of the individual unit, mutual relation, and system (Farina 2006, 279–302). Traditional Chinese gardens also have three corresponding levels in the contemporary background: landscape elements in single gardens, the garden as an enclosed system, and the relationship between the garden and its urban surroundings. To be specific, landscape elements such as old trees, animals, and water can be recognized as individuals. Their interactions in the garden compose a network of mutual contacts. The garden with the city greenways surrounding it comprises a whole system of ecology. (Figure 17)

The principles in landscape ecology are usually quantitative and specific, due to their basis in mature theory and sophisticated experimentation. Technologies of satellite imaging, remote sensing, GPS, and GIS are used to collect concrete data (Ndubisi 2002, 168–71). Statistics are commonly seen in landscape ecology concepts like the percolation

theory, with its critical probability of 0.5928, obtained from data simulation analysis (Wiens and Moss 2005, 23–6).

Fig. 17 Satellite Map of Zhuozheng Garden in Suzhou and Its Urban Surroundings

Base map source: http://map.baidu.com/

On the contrary, when traditional Chinese gardens developed, a systematic network of garden design and construction standards was not yet formulated. Thoughts embedded in traditional Chinese garden planning and design lacked statistical support because of unique cultural background and technological restrictions at that time. Some expressions in traditional Chinese philosophy illustrated basic concepts later found in landscape ecology theory, but did not form a systematic knowledge network. For example, the Confucian adage “birds select suitable trees to perch” is similar to today’s island biogeography theory. It suggests actions taking place according to local

circumstances. From Fengshui theory to artificialization of natural charm, there is "no specific standard to follow" (Zhang and Ji 1993, 2–18).

Some characteristics of traditional Chinese gardens are beyond the research range of landscape ecology. The *Yuanye* illustrates that Chinese gardens are "from nature but smarter than nature" (Li 2012, 93–95). While "from nature" means that Chinese gardens contain the concerns of ecology, "smarter than nature" indicates that Chinese gardens are not only influenced by science of ecology, but also by aesthetics, culture, psychology, and humanity, an example being the use of plants as spiritual symbols and metaphors.

However, this does not mean quantitative theories in landscape ecology cannot apply to Chinese garden analysis. Landscape ecology also covers several aspects that traditional Chinese gardens do not. More experiments are needed to evaluate the applicability of a specific branch of landscape ecology theory to the quality assessment of traditional Chinese gardens. In this way, landscape ecology can perfect the theories of traditional Chinese garden development by unveiling its implicit ecological functions.

For example, statistics on animal and plant species in Chinese gardens can be collected to investigate whether the vegetation forms a fine-grained fragmentation or whether its green ratio meets the critical probability of percolation (Figure 18). People will gradually understand that what matters is not how many trees to plant, but what kind of tree network should be arranged. An economic geographic analysis in Chinese gardens can assist in modifying natural resources distribution in order to more efficiently meet the needs of organisms. More than that, an appropriate arrangement of gaps, like paths between tree patches (Figure 19), can increase landscape heterogeneity

and biodiversity. The results of applying landscape ecology principles to traditional Chinese gardens are beneficial to biodiversity conservation, pest control, and rare tree species preservation.

Fig. 18 The Green Ratio of Target Area Covering Zhuozheng Garden is 0.4681, below the Critical Probability of Percolation 0.5928

Base map source: http://map.baidu.com/

Fig. 19 Tree Gap Generated by Paths in Zhuozheng Garden, Suzhou

Source: http://blog.sina.com.cn/s/blog_496b7cf1010007uu.html

4.3 The Comparison between Applications and Methodologies

Landscape ecology emerges as theory and develops in practice. On the other hand, traditional Chinese gardens thrive because of their functionality for human recreation. Experience of garden design and construction comes after established practices. Traditional Chinese gardens are cultural landscapes. While balancing a harmonious relationship between nature and humans, traditional Chinese gardens primarily serve humans by modifying nature (Fu 2010, 482–5). The original need for gardens and landscapes in ancient China was the emperor's hunting land. Temple gardens came into being when Buddhism and Taoism became popular in China. Private gardens arose due

to the weakness of the bureaucracy (Zhou 2008, 24). Every progress made in garden design resulted from changes in political structure, cultural atmosphere, and people's needs.

Table 3 Comparison between Landscape Ecology Application and Chinese Garden Methodology

	Landscape Ecology	Traditional Chinese Garden
Process	Theory to practice	Practice to theory
Present Situation	Providing a fresh view to understand Chinese gardens	Aesthetics with ecology
Mutual Improvement	Applicability to evaluation, preservation, and modification of traditional Chinese gardens	Suggesting considering historic and cultural conditions when applying landscape ecology

In spite of this, the applicability of landscape ecology to the *Yuanye* and Chinese gardens is based on the similarities they share. The application of landscape ecology to design and management provides a fresh view through which landscape architects understand traditional Chinese gardens. For example, overall principles regarding natural resources and plants include moderate modifications using local materials, application of native and non-invasive species, and existing tree preservation.

At first, Chinese ancestors mainly pursued the value of aesthetics. After natural disasters like flood threatened, people become more environmentally conscious (Cui 2014, 104–5). The point between visual impact and organic effect shifted due to people's decision. Traditional Chinese gardens were implicit in the garden plans and artistic

conceptions and applied organic forms instead of rigid patterns. Although different from most European landscapes of regular shapes, it is consistent with landscape ecology's request for a configured complexity. Elements of patch, corridor, and matrix can also be found in Chinese gardens (Figure 20), even though their creators did not design a garden following this recent, Western rule.

Fig. 20 Green Patch and Corridor of Zhuozheng Garden, Suzhou

Source: http://www.360doc.com/content/13/1231/20/5701732_341577901.shtml

Landscape ecology aims at natural preservation and sustainable development; and the *Yuanye* also emphasizes the importance of conserving natural resources (Zhang 2006, 255–68; Wang and Wang 2013, 27–9). The theories in the *Yuanye* remain relevant and can become more scientific and feasible as it absorbs modern concepts. For instance, landscape ecology assumes landscapes generated by people offer inadequate ecological functions, because artificial landscapes have high contrast between adjacent patches due

to lack of ecotones (Farina 2006, 270). Subsequently, traditional Chinese gardens may need recovery of fine-grained landscape fragments caused by their artificialization process. More than that, even though some practical techniques like prescribed livestock grazing and agricultural harvest are currently not used in traditional Chinese garden management and maintenance, there is still potential for adoption of these practices.

There is still inconsistency between the realms of landscape ecology and traditional Chinese gardens. For example, the urban context causes some problems to the gardens, such as lack of running water (Zhang 1980, 52–65) and a lower ratio of planting areas (Wu 1999, 33–5). Building occupancy in Chinese gardens also conflicts with landscape ecology's suggestion of reducing ecological patch fragmentation (Figure 21). Even though ecology claims that healthy landscapes are adapted to a natural disturbance regime, the application of landscape ecology to traditional Chinese garden management should also take historic and cultural values into consideration.

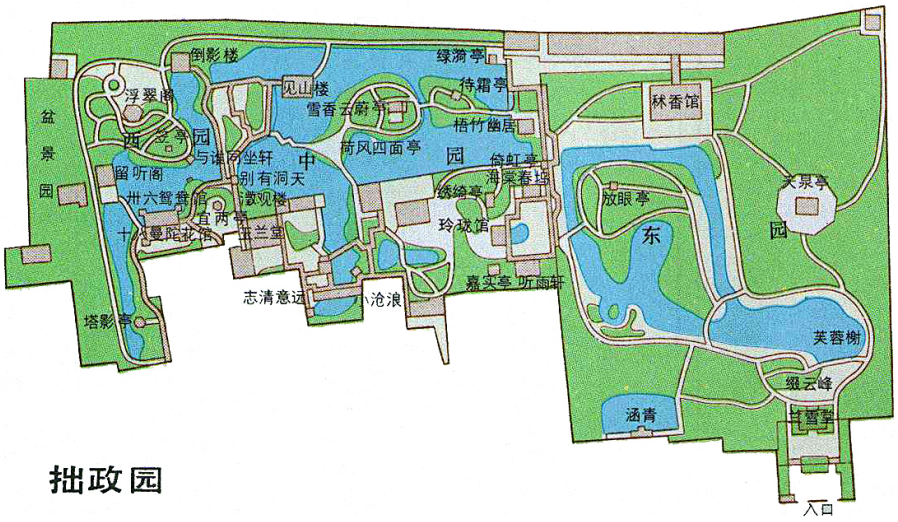

Fig. 21 Zhuozheng Garden Has a Large Area of Building Occupancy

Source: http://www.0512jd.com/news/?150.html

CHAPTER 5

CONCLUSION

This chapter is now able to answer the overarching research question raised in the first chapter: what is the relationship between traditional Chinese gardens and the Western world's interpretation of landscape ecology theory? Previous chapters have demonstrated the consistency between landscape ecology and traditional Chinese gardens regarding philosophy and principles, application and methodologies, and their developmental backgrounds. Beyond these overlaps each also has aspects that are currently not found in the realm of the other, proving the integration of both bodies of knowledge has potential benefits. However, there does exist a small proportion of knowledge in landscape ecology that does not apply well to Chinese garden designs.

After the explanation and comparison of landscape ecology and traditional Chinese gardens, this final chapter evaluates the applicability of traditional Chinese gardens' design principles to solving contemporary environmental problems, with the consideration of landscape ecology knowledge, and its significance in the future development of landscape architecture.

5.1 Application of Traditional Chinese Gardens to Contemporary Issues

On the one hand, human disturbances in geography and biology urge landscape ecology to promote sustainable development, expand biodiversity, and conserve natural

resources. On the other hand, human reliance on and respect for nature during agricultural periods had a great impact on generating the philosophy of traditional Chinese gardens (Zhang 2009, 27–30). The result is that ancestral attitude toward the environment can inform people who are concerned with ecological problems today (Wang and Wang 2013, 27–9). Some ancient expressions in Chinese philosophy and the *Yuanye* even espouse the same modern principles found in landscape ecology. Landscape ecology solves contemporary environmental problems, and with its help, the philosophical approach of traditional Chinese gardens can also meet contemporary human needs.

Chinese landscape design develops along the trajectory of "nature, imitate nature, modify nature, and nature again" (Han 2008, 246–8). The first two steps were under the control of nature, while modification gradually exceeded the capacity of environment, and eventually called for sustainable development. At the time when the *Yuanye* codified garden design principles, problems of industrialization such as water pollution, air pollution, and vegetative damage had not yet threatened the ecosystem. People desired to live comfortably in nature not because of their sense of crisis when facing environmental problems, or because of a responsibility towards the ecosystem, but because they wanted security and completeness; their ideal living condition was based on good environmental quality (Zhang 2006, 255–68).

Naturalized artificial gardens show ancient but advanced Chinese values of harmony with nature, environmental preservation, and natural resource sustainability. Because destruction of the natural environment happens after excessive change, gardens as

artificial works must moderate the transformation and modification of nature. Reproduction of natural charm concerns not only the imitation of natural patterns and functions, but also the extent to which human exploit natural resources. Appropriate development will conserve environment and resources, and maintain the ecosystem sustainability (Zhang 2009, 27–30).

While modern development makes large amounts of profits for human beings, it simultaneously causes dramatically negative impacts, such as resource exhaustion, environmental pollution, and population explosion. Thus, many scholars in the Western world advanced the idea of a harmonious relationship between humanity and nature (Zhang 2006, 255–68). Habitat is disrupted when people damage the balance of ecosystem to pursue benefits. Natural resources are consumed at a faster rate than normal (Wang and Wang 2013, 27–9). Abuse of resources and ignorance of the environment gradually contribute to severe catastrophes, as in the increase in resource exhaustion, deforestation, species extinction, and global warming (Han 2008, 246–8). An immediate example is the boom in China's urbanization, which has resulted in landscape damage and a waste of land resources (Yin 2011, 110–3).

Facing the problems of natural resource exhaustion, more severe environment pollution, and deterioration of biodiversity, people realize the importance of preserving and sustaining nature by following its laws. Current economic development demands harmonious mutuality, positive feedback, and sustainability (Wang and Wang 2013, 27–9). Designers also realize the necessity of keeping ecosystems in balance. A simple example is that landscape architects pay attention to species diversity and local climate

(Yin 2011, 110–3). They suggest increasing livability by integrating human residence with natural materials and atmosphere (Zhang 2006, 255–68).

Table 4 Contemporary Environmental Issues and Ideal Performance State

Contemporary Human Needs	Solution
Benefits of economic development Industrialization Urbanization	Application of landscape ecology Philosophy of traditional Chinese gardens
Contemporary Ecological Problems	**Ideal Performance State**
Human disturbances in geography Abuse and exhaustion of resources Waste of land resources Air and water pollution Vegetative damage and deforestation Habitat disruption Species extinction Global warming	Imitation of natural patterns and functions Natural resources conservation Sustainable development Environment preservation Recovery of organisms' life cycle Sustainability of ecosystem balance Biodiversity Vernacular features of landscape

In retrospect, though the values expressed in the *Yuanye* were generated in a period of agricultural civilization, it is applicable to contemporary industrial civilization. The design of contemporary gardens and parks can inherit traditional Chinese gardens' excellent design principles and practices, and adapt to today's conditions and needs (Zhang 1980, 52–65). According to the essential ideas of traditional design, practice ought to be based on surrounding environment and vernacular features. Preservation of

nature can recover the life cycle of organisms. People only modify nature after fully understanding its systematic properties, with beauty coming from the nature of nature (Cui 2014, 104–5). The ancient principles and techniques can solve contemporary problems and weather challenges between humans and nature (Zhang 2009, 27–30).

5.2 Practical Significance

As economic and political powers declined at the end of the Qing Dynasty (1616–1911 C.E.), garden design and construction also lost its vitality (Zhou 2008, 24–5). In modern times, traditional Chinese gardens have changed their role from private or royal gardens to public parks. These gardens' goal is no longer for personal use, but for public health and welfare. Landscape ecology theory provides a golden opportunity for traditional Chinese gardens to revive according to contemporary development requirements and human needs.

The *Yuanye* represents a comparatively complete system of traditional Chinese garden design and construction (Li 2012, 93–95). However, landscape architects should never stop marching forward on the path of theory and cultural evolution. People need to establish theoretical networks that are suitable to today's demands without ignorance of inheriting historic and traditional knowledge. Concepts and experimental methods of landscape ecology are good tools to apply traditional Chinese garden philosophy to contemporary designs.

Traditional Chinese gardens are not merely restricted to aesthetic values. They also

focus on ecology. They no longer need to be restricted to historic curiosities and tourist destinations; instead, they are awaiting a new life of serving nature in a new era.

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