Chapter 20
Integrating Nature and Culture in Landscape Ecology

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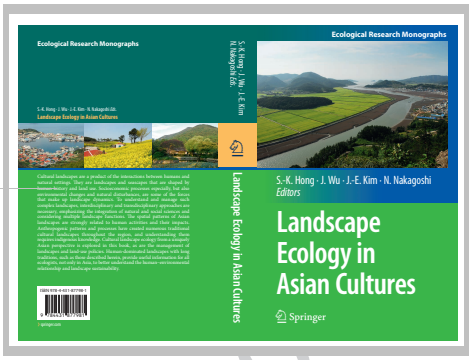

20.1 Introduction

Landscape ecology is an interdisciplinary field that aims to understand and improve the relationship between spatial pattern and ecological processes on a range of scales (Wu and Hobbs 2007b). Although the term was coined in Europe in 1939, landscape ecology was not a recognized scientific field of global research until the 1980s, when remote sensing data and computers became widely accessible to ecologists and geographers. The 1980s was also a time when ecological ideas of spatial heterogeneity and nonequilibrium dynamics flourished, and when landscape ecology was reborn in North America. During the two decades of the 1980s and 1990s, landscape ecology swept through North America like a storm, was rejuvenated in Europe, and reached out to other parts of the world, including Asia and Australia. Today, landscape ecology is a well-established field of study, with the active participation of ecological, geographical, and social scientists from around the world.

It has become a cliché to describe landscape ecology as being dominated by two schools of thought: the European perspective and the North American perspective. At the risk of over-simplification, we may consider the European landscape ecology perspective as having been characterized by a more holistic, humanistic, and society-centered view of landscapes, with a focus on user-inspired and solution-driven research. The North American landscape ecology perspective, on the other hand, has been dominated by a more analytical and biological ecology-centered view of landscapes, with a focus on basic science-oriented and question-driven studies (Wu and Hobbs 2002; Wu 2006). However, caution must be exercised to avoid over-interpretation of such dichotomous characterization. The two perspectives are neither

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inclusive nor exclusive; they are not contradictory but complementary to each other. There are, and should be, other approaches to landscape ecology. For example, one could argue from an Australian landscape ecology perspective that focuses on pragmatic and functional approaches, typically tied in with land management, restoration, and conservation issues (e.g., Ludwig et al. 1997; MacKey et al. 2007).

Is there an identifiable Asian landscape ecology perspective? What contributions have Asian scientists and practitioners made to the development of landscape ecology? What is the state of Asian landscape ecology? What are its future directions? These are likely to be interesting questions to the readers of this book, but they are not the key questions to be addressed in this chapter. I will, however, make a few brief comments here which may be helpful to those who are looking for answers to these questions. A quick literature search suggests to me that much of the landscape ecological research in Asia during the past few decades has taken place in China, Japan, and Korea. China has produced substantially more publications than any other Asian country. For example, Cao et al. (2002) reported that Chinese authors published 619 journal articles and 13 books during the 1990s, of which over 90% were in Chinese. Of course, quantity is not quality – numbers do not always translate into impact. Nonetheless, these statistics are indicative of an exceptionally high level of enthusiasm for landscape ecology in China since the late 1980s. A more recent and comprehensive review of landscape ecology in China is found in Fu and Lü (2006). Although I have not detected a similar trend [AU1] elsewhere in Asia (at least not on this magnitude), the last few decades have also seen the rapid development of landscape ecology in Japan and Korea, among other countries in this region.

Instead of summarizing all other chapters of this book on Asian cultural landscapes or reviewing the history of Asian landscape ecology in general, I thought that this chapter would be more useful if it presented a more comprehensive picture of landscape ecology in relation to cultural landscapes and sustainability. A broader and ecumenical perspective should foster a better understanding of the idiosyncratic topics covered in this book.

20.2 Evolving Concepts of Landscape and Landscape Ecology

20.2.1 What is a Landscape?

The term "landscape" is a key concept in a number of fields, from social to geographical and ecological sciences. With the rise of landscape ecology in the past few decades, the concept of landscape has achieved a prominent status in the interdisciplinary literature. However, because of the plurality of its origins and interpretations, landscape has acquired various connotations. For example, the same word may refer to a natural landscape, a cultural landscape, a political landscape, an

economic landscape, a mental landscape, an adaptive landscape, a landscape view, landscaping, or landscape painting (Mitchell 2000; Tress and Tress 2001).

Even within the field of landscape ecology, the word "landscape" has different meanings, and the differences usually hinge on the spatial scale and the contents of a landscape. For example, landscape has been defined as a kilometers-wide geographic area (Forman 1981; Forman and Godron 1986) which corresponds to a "human-scale" landscape. This is the scale at which the field of landscape ecology was originally developed in Europe, and at which most landscape studies have been conducted around the world ever since. The human-scale landscape, in general, seems to coincide well with geographic units such as watersheds and urban regions (Forman 1995), as well as spatial domains of human perception (Gobster et al. 2007). Thus, it resonates with the public, the decision makers, and researchers who are conscious of the environmental setting in which they live, work, and engage in recreation.

However, many other landscape ecologists have treated landscape as a multi-scale or hierarchical concept, meaning that a landscape is a spatially heterogeneous area that may be of various sizes depending on the subject of study and the research questions at hand (Urban et al. 1987; Pickett and Cadenasso 1995; Turner et al. 2001). In this case, landscape is an "ecological criterion" (Pickett and Cadenasso 1995), and its essence does not lie in its absolute scale, but in its internal heterogeneity. Different plant and animal species perceive, experience, and respond to spatial heterogeneity at different scales, and patterns and processes in landscapes tend to have different characteristic scales (Kotliar and Wiens 1990; Wu and Loucks 1995; Wu et al. 2006). Thus, a hierarchical concept of landscape, also encompassing the human-scale of course, is both sensible and necessary. Clearly, one does not need to consider a landscape of tens of square kilometers to study how grassland vegetation patterns affect the movement of beetles (Wiens and Milne 1989) or is affected by gophers (Wu and Levin 1994).

The contents that constitute a landscape vary greatly in landscape ecological research. For simplicity, the components of a landscape may be classified as tangible versus intangible, and biophysical versus cultural. This is not intended to represent a dichotomous view, but rather a continuum within which a variety of components coexist. Tress and Tress (2001) proposed a "trans-disciplinary landscape concept" that encompasses five dimensions: (1) landscape as a spatial entity, (2) landscape as a mental entity, (3) landscape as a temporal dimension, (4) landscape as a nexus of nature and culture, and (5) landscape as a complex system. Landscape ecological studies have often focused on some but not all of these dimensions. Evidently, the concept of landscape provides a meeting ground for a number of disciplines, including archeology, ecology, geography, geology, history, landscape architecture, and regional economics. To achieve its interdisciplinary and trans-disciplinary goals, landscape ecology needs to appreciate and integrate the multi-faceted perspectives on the culture–nature/people–place relationships that are offered by these diverse disciplines.

20.2.2 What is Landscape Ecology?

The definitions of landscape ecology are also diverse, although they are not quite as numerous as those of landscape. Images can be powerfully inspiring, and this is especially true to someone who has a special interest in landscape patterns. Partly inspired by the conspicuous spatial patterns revealed in aerial photographs, the German geographer and botanist Carl Troll (1939) coined the term "landscape ecology" and defined it later as "the study of the main complex causal relationships between the life communities and their environment in a given section of a landscape" (Troll 1968, 1971). Carl Troll's training and research in multiple disciplines endowed him with the abilities to synthesize across, and innovate at the interface between, different fields. He was trained as a botanist, did his doctoral dissertation in plant physiology, and then spent decades working on the climatic, geological, geographical, and ecological aspects of various landscapes in Europe, South America, and Africa. It is easy to understand why Troll could simultaneously appreciate the then-new idea of an "ecosystem" put forward by Arthur Tansley (1935), as well as the great potential for geospatial analysis presented by aerial photography. As a result of his attempt to integrate the "vertical" ecological approach with the "horizontal" geographical approach, a new field of study was born.

In the past few decades, landscape ecology has acquired a number of definitions, which are all in some way related to Carl Troll's original definition. For example, Zonneveld (1972) defined landscape ecology as "an aspect of geographical study which considers the landscape as a holistic entity, made up of different elements, all influencing each other." He advocated that the landscape should be studied as the "total character of a region," and not "in terms of the separate aspects of its component elements" (Zonneveld 1972, 1989). This holistic landscape perspective continues and culminates in the work of Naveh (1991), who described landscape ecology as the study of "the total spatial and functional entity of natural and cultural living space" (also see Naveh 1982; Naveh and Lieberman 1984; Naveh 2000).

Some key ideas of contemporary landscape ecology, such as patch dynamics (Levin and Paine 1974; Pickett and Thompson 1978; Burgess and Sharpe 1981) and the patch–corridor–matrix model (Forman and Godron 1981, 1986) began to emerge in North America in the late 1970s, apparently with little connection to their European root. The early ideas of landscape ecology in North America were inspired by the theory of island biogeography (MacArthur and Wilson 1967), with an explicit focus on spatial heterogeneity. The first major communication between North American and European landscape ecologists occurred in 1981, when five American ecologists (including Forman, Golley, and Sharpe) attended the 1st International Congress on Landscape Ecology in The Netherlands. Two years later, 25 ecologists (23 American, 1 Canadian, and 1 French) gathered at Allerton Park, Illinois, USA, to discuss the nature and future directions of landscape ecology. The report of this historic meeting, published in the following year (Risser et al. 1984), became an important guide to budding landscape ecologists in North America.

Why was such a discussion necessary after landscape ecological research had been practiced for more than 40 years in Europe? The answer seems clear from Forman (1983): "What theory explains the spatial heterogeneity of energy, nutrients, water, plants, and animals at the level of a landscape, the setting in which we live? Alas, none." To develop such a landscape theory, broader scales that encompass multiple ecosystems need to be considered, and horizontal interactions have to be a focus of study. Thus, Forman and Godron (1981, 1986) defined landscape ecology as the study of the structure (spatial relationships among the distinctive landscape elements), function (flows of energy, materials, and species among landscape elements), and dynamics (temporal change in landscape structure and function) of landscapes. The main theme of landscape ecology in North America, with an unmistakable focus on spatial heterogeneity, was set out in Risser et al. (1984):

> Landscape ecology focuses explicitly upon spatial pattern. Specifically, landscape ecology considers the development and dynamics of spatial heterogeneity, spatial and temporal interactions and exchanges across heterogeneous landscapes, influences of spatial heterogeneity on biotic and abiotic processes, and management of spatial heterogeneity.

Is landscape ecology a sub-discipline of ecology? Certainly the semantics of the term suggest that it is. In fact, many ecologists do consider landscape ecology to be a branch of ecology (e.g., Turner et al. 2001), and most ecology programs of major research universities world wide now offer courses in landscape ecology. However, Zonneveld (1972) indicated that landscape ecology was not part of biological sciences, but a branch of geography. In fact, Risser et al. (1984) contemplated three ways that landscape ecology might be viewed: as an intersection of many disciplines, as a separate discipline, or as a branch of ecology. They concluded that only the first option was "intellectually and practically the most persuasive." In addition, "viewing landscape ecology as an interdisciplinary field of research avoids the issue of which discipline 'owns' landscape ecology" (a problem that may have hindered the healthy development of some interdisciplinary fields, such as human ecology, for which geography, sociology, and anthropology have all claimed ownership) (Risser et al. 1984). Reflective of the collective view of the group of 25 participants, likely with some internal heterogeneity, the Allerton workshop report clearly recognized the importance of the multi-dimensionality of landscapes and the cross-disciplinarity of landscape ecology:

> A major forcing function of landscapes is the activity of mankind, especially associated cultural, economic, and political phenomena. … Landscape ecology is not a distinct discipline or simply a branch of ecology, but rather is the synthetic intersection of many related disciplines that focus on the spatial–temporal pattern of the landscape
>
> (Risser et al. 1984).

Today, a general consensus seems to have emerged that landscape ecology is not simply an academic discipline, but rather a highly interdisciplinary field of study (Wu and Hobbs 2002). Landscape ecology is an interdisciplinary and trans-disciplinary science that focuses on the relationship between spatial pattern and ecological processes across scales. The goal of landscape ecology is not only to understand this relationship, but also to influence it so as to help achieve landscape sustainability.

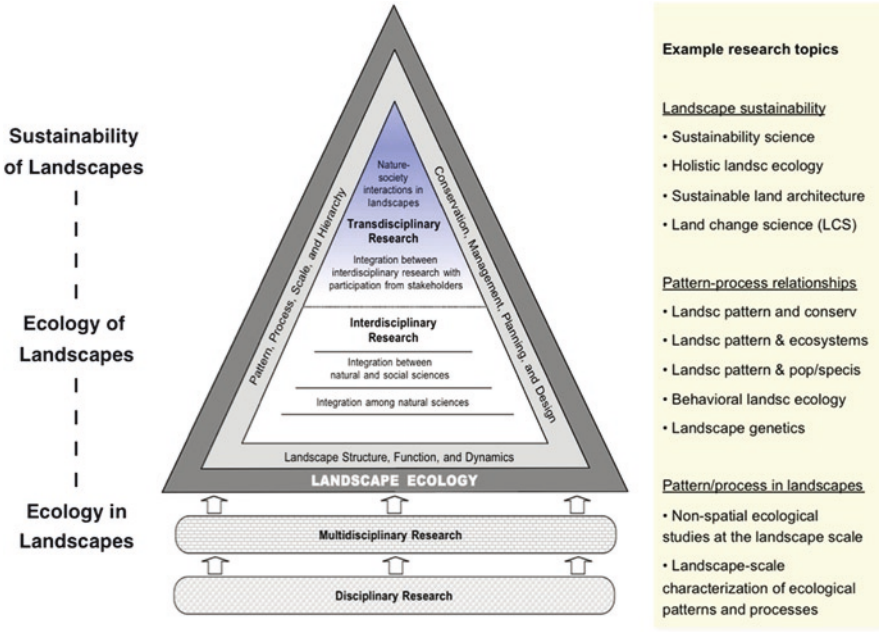

Fig. 20.1 A schematic representation of a pluralistic and hierarchical framework for landscape ecology (modified from Wu 2006; Wu and Hobbs 2007a, b) [AU3]

In an attempt to integrate the various connotations, Wu and Hobbs (2007b) defined landscape ecology as the integration of the science and art of studying and influencing the relationship between spatial pattern and ecological processes on multiple scales (also see Wu 2006). The "science" of landscape ecology focuses on the theoretical basis for understanding the formation, dynamics, and effects of spatial heterogeneity, whereas the "art" of landscape ecology reflects the humanistic and holistic perspectives necessary for integrating ecology, design and planning, socio-economics, and management practices. Wu (2006, see also Wu and Hobbs 2007b) put forward a pluralistic and hierarchical framework that facilitates synergistic interactions between biophysical/pattern–process and holistic/humanistic perspectives in landscape ecology (Fig. 20.1). The "hierarchical" view here recognizes the varying scope and degree of cross-disciplinarity in landscape ecological studies, whereas the "pluralistic" view stresses the importance of different disciplines and perspectives. This pluralistic and hierarchical framework implies that all the five dimensions of landscape, as discussed in Tress and Tress (2001), are important in landscape ecological studies.

20.3 Landscape of Culture and Culture of Landscape

20.3.1 Cultural Landscapes and People–Landscape Relationships

As discussed earlier in this chapter, the term "landscape" in landscape ecology has various meanings ranging from predominantly biophysical to emphatically holistic and humanistic. In the landscape ecology literature, however, even the "humanistic" definitions are usually much more concerned with contemporary socio-economic processes than with long-term interactions between culture and nature in particular landscapes. The cultural dimension of landscape has not been completely ignored in landscape ecology (especially in Europe), but more emphasis is needed.

"Landscape gives identity to place" and "landscape is where past and present meet" (Phillips 2007). Human geographers may think of landscape as "a work of human labor" or "an activity" of dynamic interactions between people and place (Mitchell 2000). As such, a landscape may also be considered as "a form of ideology" or "a way of carefully selecting and representing the world so as to give it a particular meaning," and thus it can be "an important ingredient in constructing consent and identity" (Mitchell 2000). If one subscribes to the aforementioned holistic and interdisciplinary definition of landscape ecology, such cultural characteristics of landscapes have to be important to the science and practice of the field. Thus, the topic of "cultural landscape," which reflects the interactive relationship between culture and nature in a geographic area, is quite relevant to landscape ecology. The meaning of a cultural landscape is much richer than simply a human-altered setting such as a farm or a city.

The term "cultural landscape," like "landscape," also has various connotations. It has been a fundamental concept in geography since its first use in Germany in the 1890s, when the German geographer Friedrich Ratzel (1895–1896) defined it as "landscape modified by human activity," as opposed to the primeval natural landscape (Jones 2003). The term was introduced to English-speaking countries in the 1920s by the American geographer Carl O. Sauer, who made it the central concept of the Berkeley school of geographic thought (Jones 2003). In his seminal publication, *The morphology of landscape*, Sauer (1925) wrote:

> The cultural landscape is fashioned from a natural landscape by a cultural group. Culture is the agent, the natural are the medium, the cultural landscape is the result.

Since the 1960s, the concept of cultural landscape has been widely used in human geography (of which cultural geography is a part), anthropology, environmental management, and other related fields (Sauer 1925; Webb 1987). A major burst of interest in cultural landscapes took place in the early 1990s, known as the period of "the rise of cultural landscapes" (Jacques 1995).

One of the major factors that contributed to the recent popularity of the term on a global scale was the adoption of cultural landscapes in the International Convention for the Protection of the World's Cultural and Natural Heritage (often

referred to as the World Heritage Convention) by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in 1992. The World Heritage Convention was established in 1972 to recognize and protect the world's natural and cultural heritage of "outstanding universal value," and in 1992 it became the first international legal instrument to recognize and protect cultural landscapes (http://www.whc.unesco.org/en/culturallandscape). The Operational Guidelines for the Implementation of the World Heritage Convention states that:

> Cultural landscapes are cultural properties and represent the 'combined works of nature and of man' ... They are illustrative of the evolution of human society and settlement over time, under the influence of the physical constraints and/or opportunities presented by their natural environment and of successive social, economic and cultural forces, both external and internal. … The term 'cultural landscape' embraces a diversity of manifestations of the interaction between humankind and its natural environment (UNESCO (United Nations Educational 1996).

Three categories of cultural landscape are included in the World Heritage Convention: (1) "clearly defined landscapes designed and created intentionally by humans," which include mainly garden and parkland landscapes, (2) "organically evolved landscapes" resulting from successive interactions between local people and their natural environment (including "relict" and "continuing" landscapes), and (3) "associative cultural landscapes" that have powerful religious, artistic, or cultural associations with the natural elements (Table 20.1). These categories cover landscapes that are profoundly transformed by human actions (designed and created landscapes) as well as those that carry significant cultural values primarily in an intangible way (associative cultural landscapes). This implies that culture and nature are not mutually exclusive, and that cultural landscapes do not have to be entirely created by humans.

As of 2010, 66 cultural landscapes have been included in the World Heritage List (Table 20.2). Although the cultural landscape definition by the World Heritage Convention does not exclude urban landscapes, the sites selected so far are predominantly rural, with only a small number of urban and industrial areas included. Also, a glance at the World Heritage List reveals that there is an evident imbalance in terms of the global geographical representation, as European countries have a disproportionately greater number of selected sites. In particular, Europe has 37 (56.1% of the total), Asia 15 (22.7% of the total), and Africa 9 (13.6% of the total). China has only one, and the United States has none. Sirisrisak and Akagawa (2007) identified "the political and economic stability in each state party" as a major contributing factor to this imbalance. Other factors related to the selection process must have played a role as well.

Cultural landscapes have also been recognized by national programs around the world. For example, in 1988, the United States National Park Service (NPS) formally identified cultural landscapes as a type of cultural resource to be protected in the NPS Management Policies (Page et al. 1998). The NPS defined a cultural landscape as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person or exhibiting other cultural or esthetic values" (Page et al. 1998). The NPS

[AU4]

Table 20.1 Categories and definitions of cultural landscapes in the World Heritage Convention (UNESCO 1996; Fowler 2003)

Category	Definition
Clearly defined landscape designed and created intentionally by humans	A landscape designed and created intentionally by humans. This embraces garden and parkland landscapes characteristically constructed for esthetic, social, and recreational reasons, which are often (but not always) associated with religious or other monumental buildings and ensembles
Organically evolved landscape 1.Relict or fossil landscape 2. Continuing landscape	A landscape that results from an initial social, economic, administrative, and/or religious imperative and has developed its present form by association with, and in response to, its natural environment. Such landscapes reflect that process of evolution in their form and component features. They fall into two sub-categories 1. *Relict (or fossil) landscape*: a landscape in which an evolutionary process came to an end at some time in the past, either abruptly or over a period However, its significant distinguishing features are still visible in material form 2. *Continuing landscape*: a landscape which retains an active social role in contemporary society which is closely associated with the traditional way of life, and in which the evolutionary process is still in progress. At the same time, it exhibits significant material evidence of its evolution over time
Associative cultural landscape	A landscape with definable powerful religious, artistic, or cultural associations with the natural element rather than material cultural evidence, which may be insignificant or even absent

Table 20.2 Cultural landscape inscriptions on the World Heritage List as of 2010 (data from UNESCO, http://whc.unesco.org/en/culturallandscape)

Region	Number of inscriptions	Percentage of the total number of inscriptions
Europe	37	56.1
North America	0	0
Asia and the Pacific	15	22.7
Africa	9	13.6
Latin America and the Caribbean	4	6.1
Arab States	1	1.5
Total	66	100

cultural landscapes fall into four general categories: historic sites, historic designed landscapes, historic vernacular landscapes, and ethnographic landscapes (Table 20.3).

Table 20.3 Categories and definitions of cultural landscapes recognized and protected by the National Park Service of the United States (Page et al. 1998)

Category	Definition
Historic site	A landscape which is significant for its association with a historic event, activity, or person. Examples include battlefields and houses of presidents
Historic designed landscape	A landscape which is significant as a design or work of art. A landscape which was consciously designed or laid out by a master gardener, landscape architect, architect, or horticulturist according to a design principle, or by an owner or other amateur according to a recognized style or tradition. A landscape which has a historical association with a significant person, trend, or movement in landscape gardening or architecture, or a significant relationship to the theory or practice of landscape architecture. Examples include parks, campuses, and estates
Historic vernacular landscape	A landscape whose use, construction, or physical layout reflects endemic traditions, customs, beliefs, or values. Expresses cultural values, social behavior, and individual actions over time. A landscape which is manifested in physical features and materials and their interrelationships, including patterns of spatial organization, land use, circulation, vegetation, structures, and objects. It is a landscape whose physical, biological, and cultural features reflect the customs and everyday lives of people. Examples include rural villages, industrial complexes, and agricultural landscapes
Ethnographic landscape	A landscape containing a variety of natural and cultural resources that associated people define as heritage resources. Examples include contemporary settlements, such as the Martin Luther King Jr. National Historic Site, New Orleans neighborhoods, and the Timbisha Shoshone community in Death Valley. Small plant communities, animals, and subsistence and ceremonial grounds are often components

All these connotations of cultural landscapes are rooted in the definitions of Ratzel (1895–1896) and Sauer (1925), with further elaborations and extensions (e.g., the associative cultural landscapes in the World Heritage Convention). However, the degree of human modification or "fashioning" beyond which a natural landscape should be regarded as a cultural landscape is subjective, and has been a point of debate and a source of confusion. On the one hand, cultural landscapes have often referred only to agricultural or rural landscapes that occur between the natural and urban landscapes (Jones 2003). For example, Plachter (1995) advocated a "functional definition" that only includes landscapes in which culture and nature have mutually shaped one another and still do, with modern metropolitan landscapes explicitly excluded. On the other hand, the term has also been used to include all landscapes that are influenced by human activities and human values (Jones 2003). As a result, some have questioned the usefulness of the term based on the argument that landscapes untouched by humans no longer exist in reality.

For instance, Phillips (1998) argued that "Since there are cultural aspects to practically every landscape on earth, it follows that practically all landscapes are cultural landscapes." One conclusion from such an argument is to abandon the term altogether. However, this does not have to be the case, as the vagueness of the meaning of cultural landscape is not "bane or boon" but "both bane and boon." As Rowntree (1996) stated, "This etymological elusiveness [of cultural landscape] is both a liability and asset; to some, the notion of a cultural landscape is an appropriate bridge between space and society, culture and environment, while to others its definitional fluidity weakens the concept and disqualifies it from serious analytical usage." Indeed, this dialectical, rather than binary, property characterizes many terms that are essential to landscape ecology, including patch, disturbance, resilience, sustainability, and the word "landscape" itself. Geography has a long history of studying human–environment relationships, and a number of perspectives have been developed, with different research cores and methodologies that reflect a varying degree of affinity to either natural sciences or the humanities (Turner 1997).

20.3.2 An Asian Perspective on the Culture–Nature Relationship

One of the most far-reaching Asian philosophies about the relationship between culture and nature is the ancient Chinese philosophy known as the "Unity of Man with Nature" ("天人合一"), which has had a widespread influence in Asia and beyond. The Unity of Man with Nature is the unifying theme of several ancient Chinese philosophies and cultural traditions, and is consistent with the most central tenet of Taoism – that people should be in harmony with the rhythms of nature (Ji 2007; Chen and Wu 2009). According to scholars of oriental cultures, the Unity of Man with Nature was the quintessential theme shared by dominant ancient Asian cultures (e.g., Chinese and Indian), and has been described as the greatest contribution of Chinese culture to humanity (Ji 2007). In today's terminology, the Unity of Man with Nature means that human activities, including their architectural creations, should be integrated within natural patterns and processes so that sustainability can be achieved.

Reflective of the Unity of Man with Nature philosophy, Feng–Shui theory (风水理论) – the theory of Feng (wind) and Shui (water) – consists of a set of empirical principles that integrate biophysical landscape features with cultural traditions and religious beliefs to guide the practice of selecting and designing dwellings and burial spaces (Hong et al. 2007; Ji 2007; Chen and Wu 2009). Feng–Shui theory was originally developed based on Taoist Yin–Yang dualism, Five-Element theory, and Eight-Trigram theory. Its main premise is that the human–environment relationship (or the fate of the occupant of a space) can be influenced either positively or negatively by manipulating the Qi (the vital force or energy) that drives all change. As the conceptual basis for both the Five-Element and Eight-Trigrams theory, Yin–Yang dualism emphasizes the balance between natural and anthropogenic forces as well as the harmony and eternity of the whole. The Five-Element

theory further articulates how the essential elements of the world are related to each other, and how they can be arranged properly to achieve sustainability. Related to the Five-Element theory, the theory of Eight Trigrams deals with more components that make up the world, and is commonly used as a tool in Feng–Shui practices (Chen and Wu 2009).

A well-known landscape model of the Unity of Man with Nature philosophy is the "Peach Blossom Spring" ("桃花源") ideal, originally described by a celebrated Chinese poet some 1 500 years ago, which vividly portrays an ecologically unspoiled landscape with mountains, water, and fertile land where people integrate themselves harmoniously with their natural environment. This ideal reflects people's desire to be closely connected with nature in order to seek peace and minimize disruptive interactions with the outside world. The philosophy of the Unity of Man with Nature is probably best illustrated in traditional cultural landscapes, such as gardens and farming systems, in China and certain other Asian countries (e.g., Korea and Japan). China is the "mother of gardens" (Wilson 1929), and early Chinese gardens began to appear about 2 000 years ago, mainly as "the gardens of literati" or "scholar's gardens" (Chen and Wu 2009). These gardens were created by combining the concepts from Chinese landscape paintings with poems of idealized bucolic settings. These gardens had neither the rudimentary fabrics of folk dwellings nor the symbolic features of a power hierarchy and social rites often explicit in feudalistic governmental architecture. In general, oriental architecture has a time-honored history of developing structures in concert with natural landscapes using wood as the primary construction material, and emphasizing the proper flows of energy and natural rhythms of the environment. This seems in contrast to the long tradition in Western landscape architecture of creating more permanent monuments with stones and mortar as the main construction materials, which demonstrate human perseverance.

Our perception and understanding of the relationship between people and nature are often influenced by our philosophical roots and cultural traditions. Both classical Western and oriental thinkers meditated on the philosophy of nature and its relationship to humanity. Emerging from this period of classical thought, however, the Western and Eastern perspectives on the natural environment began to diverge. For example, while traditional Chinese culture continued to embrace the power of nature to influence and inform humans, Western culture reacted more audaciously to it. Eastern philosophy emphasized a greater sense of harmony with nature, whereas in Europe there was a stronger emphasis on "taming" nature. In other words, the traditional Western philosophy of nature was based on a one-sided relationship between people and nature: humans are influenced by nature, react to nature, and then find ways to tame nature through technology and policy. Thus, culture and nature were perceived as being separate and conflicting. Such a philosophy represents the historical antecedent to the modern technocratic approach to economic development that has been adopted around the world in the past century. As Phillips (1998) stated: "The separation of culture and nature – of people from the environment which surrounds them – which has been a feature of Western attitudes and education over the centuries, has blinded us to many of the interactive associations which exist between

the world of nature and the world of culture." Its influence can be felt even in the way the environment has been studied: "most of our intellectual weapons in the environmental area – from prehistoric fire debates to projections of climate change – have maintained a separation of humans and nature" (Head 2008).

While the ancient Chinese philosophy of the Unity of Man with Nature seems much in tune with the sustainability theme of our time, the environmental movement in the West, which started in the 1960s, had a major role in promoting human values for integration, rather than separation, between culture and nature. Even before that, Aldo Leopold (1949), in his landmark book *A Sand County Almanac*, clearly recognized the problems with the conquering-nature tradition, and promoted "a state of harmony between man and land" with his new land ethic: "The land ethic simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land. …… In short, a land ethic changes the role of *Homo sapiens* from conqueror of the land community to plain member and citizen of it." The eminent American landscape architect Ian McHarg (1969) advocated the "design with nature" approach, which echoed the philosophy of the Unity of Man with Nature. With passion and clarity, he wrote: "Let us then abandon the simplicity of separation and give unity its due. Let us abandon the self-mutilation which has been our way and give expression to the potential harmony of man–nature." After a long period of divergent developments, Eastern and Western cultures now seem to be beginning to converge on a shared recognition and vision – the harmony between culture and nature – of sustainability.

20.4 Connecting Culture and Nature in Landscape Ecology

20.4.1 Emphasizing the Cultural Dimension in Landscape Ecology

If landscape ecology is to achieve its goal of understanding and improving the relationship between spatial pattern and ecological processes, it must explicitly connect culture with nature or people with a place in particular landscapes. In general, landscape ecologists are much more familiar with the physicality than the culture of landscapes. Nonetheless, as discussed earlier, the cultural dimension of landscapes has always been a part of landscape ecology since its inception, particularly in Europe. In recent years, the need to reconnect culture with nature has increasingly been recognized by landscape ecologists around the world.

For example, following the European tradition of landscape ecology illustrated by numerous studies, most noticeably in Germany and The Netherlands, Naveh (1982, 1998) has repeatedly stressed the necessity and importance of cultural landscapes, suggesting that cultural landscapes should encompass all landscapes created and modified by humans. Farina (2000) advocated the use of the cultural landscape as a model for integrating ecology with economics, because they are "geographic areas in which the relationships between human activity and the environment have

created ecological, socio-economic, and cultural patterns and feedback mechanisms that govern the presence, distribution, and abundance of species assemblages." In the case of Farina (2000), cultural landscapes referred only to traditional cultivated landscapes. Tress et al. (2001) stated that: "The perceived division between nature and culture has dominated the academic world. In the case of landscapes, this divide is counter-productive and must be overcome since all landscapes are multidimensional and multifunctional."

The dichotomous characterization of European versus North American perspectives may suggest that the latter focuses only on the biophysical aspects of landscapes, but this is not true. The importance of cultural aspects and the inseparability of culture and nature in human-dominated landscapes were also recognized in the nascent stage of North American landscape ecology. This was made clear in the ground-breaking book by Forman and Godron (1986): "To understand why a landscape looks as it does, we cannot limit ourselves to the natural or physical environment. We must also understand human influences and culture. … In a landscape with people, the human role and the role of nature may be alternatively emphasized but cannot be disentangled." However, this vision has not been adequately implemented in research practice in North America in the past 30 years. As Nassauer (1995) noted:

> Culture changes landscapes and culture is embodied by landscapes. Both aspects of this dynamic are encompassed by landscape ecology, but neither has been examined sufficiently to produce cultural theory within the field. … American landscape ecology has entered the cultural realm with its vocabulary and in environmental policy, but cultural effects on landscapes have been more assumed than examined. Research in landscape ecology has not focused on culture despite its centrality to the field.

Landscape ecology, like landscapes themselves, is changing. In North America and other parts of the world, landscape ecology has evidenced a rapid increase in a research emphasis on the integration between the culture and nature of landscapes in recent years. A fundamental reason for this surge of interest is the realization, increasingly shared by landscape ecologists around the world, that the world has been on an unsustainable trajectory, particularly since the Industrial Revolution, and that landscape ecology can and must contribute to sustaining our landscapes and the world (Wu 2006; Naveh 2007; Fu et al. 2008; Wu 2008; Barrett et al. 2009; Musacchio 2009b; Wu 2010). One example of recent studies on this topic is the special issue of *Landscape Ecology*, the flagship journal in the field, which was published in 2009 with the title: "The ecology and culture of landscape sustainability: emerging knowledge and innovation in landscape research and practice" (Musacchio 2009a). However, much needs to be done to reconnect culture and nature in landscape ecology. To move forward, "We must formulate ecological questions by considering cultural possibilities, and we must formulate cultural questions by considering ecological processes" (Nassauer 1997). To formulate such interdisciplinary questions, the four general principles of the culture and nature relationship articulated by Nassauer (1995) should be helpful.

1. Human landscape perception, cognition, and values directly affect the landscape and are affected by the landscape.

2. Cultural conventions powerfully influence landscape patterns in both inhabited and apparently natural landscapes.
3. Cultural concepts of nature are different from scientific concepts of ecological function.
4. The appearance of landscapes communicates cultural values.

Landscape ecology needs more integrated studies that consider cultural landscapes as co-evolved holistic systems of culture and nature. False separations of humans from nature may adversely affect the quality of our research and practice (Head 2008). In our attempt to integrate culture and nature in landscapes, we need to fully recognize the necessity and opportunities of taking pluralistic and ecumenical approaches in landscape ecological research (Wu et al. 2006; Wu and Hobbs 2007a). No single perspective or approach is sufficient to understanding human–environment relationships (Turner 1997). At the same time, collaborations between natural and social sciences, which are designed to synthesize and integrate diverse perspectives, are crucial. Diversity is not divergence. Diversity is a basis for innovation, whereas divergence is more a cause for distraction. After all, the usefulness of pluralism is predicated on the effectiveness of building bridges among research cores with different perspectives (Turner 1997).

20.4.2 Understanding the Diversity of Cultural Landscapes

Cultural landscapes are diverse; cultural landscapes are idiosyncratic; cultural landscapes carry the legacies of the past and foster possibilities for the future. Therefore, to formulate either ecological questions of culture or cultural questions of ecology, it is necessary to recognize the diversity of landscapes with different degrees of human intervention in particular cultural settings. To this end, it is useful to recall the five landscape types classified by Forman and Godron (1986), which constitute a landscape modification gradient.

1. Natural landscape – without significant human impact.
2. Managed landscape – where native species are managed and harvested.
3. Cultivated landscape – with villages and scattered patches of natural or managed ecosystems.
4. Suburban landscape – a town and country area with a heterogeneous patchy mixture of residential areas, commercial centers, cropland, managed vegetation, and natural areas.
5. Urban landscape – with remnant managed park areas scattered in a densely built up matrix.

Forman and Godron's (1986) classification can be complemented or refined by considering characteristics more directly related to the resilience and self-regenerative capacities of the system (Walker and Salt 2006). For example, Naveh (1998) proposed that cultural landscapes should include semi-natural and managed multi-functional

landscapes (e.g., protected areas, parks, recreation areas), traditional agricultural landscapes, rural and suburban landscapes, and urban landscapes. He also articulated that these different types of cultural landscapes can be distinguished based on their energy inputs and self-organizing and regenerative capacities through the photosynthetic conversion of solar energy: (1) "solar-powered" semi-natural and managed landscapes, ranging from protected areas and traditional agricultural landscapes to contemporary organic farming systems; (2) "intensive agro-industrial" landscapes, including modern agricultural systems that are heavily subsidized by fossil energy; (3) "technosphere" landscapes, including rural, suburban, and urban–industrial landscapes that are supported primarily by fossil energy, with all internal natural regenerative capacities lost (Naveh 1998). Such landscape gradients provide a broader framework based on which different cultural landscapes can be compared, idiosyncratic studies can be synthesized, and thus our understanding of landscape sustainability can be improved.

20.4.3 Learning About Sustainability from Cultural Landscapes

Based on the discussion in previous sections, I argue that the concept of a cultural landscape is useful and effective, especially when it is used in the context of a landscape modification gradient. Biophysical forces create, alter, and maintain landscapes, but humans have played a rapidly increasing role in the processes of landscape development during the past century. In today's human-dominated earth system, almost all landscapes around the world have been somewhat influenced, and even "domesticated," by anthropogenic processes (Kareiva et al. 2007). Humans now appropriate about 24% of the Earth's terrestrial net primary productivity (Haberl et al. 2007), and have directly influenced 83% of the world's land area through agriculture, urbanization, and associated activities (Kareiva et al. 2007). There are still landscapes, on increasingly smaller scales, that may be called natural or semi-natural. It is evident, however, that the major objects of landscape ecological research are cultural landscapes.

Scholars who study landscapes from either ecological or cultural perspectives seem to agree on the importance of the landscape on an operational scale in the study and practice of sustainability. For example, Forman (1990) argued that human-scale landscapes, as a spatial scale for the study and practice of sustainable development, have significant advantages over broader scales such as the continent. Forman (1995) further pointed out that to deal with "the paradox of management," i.e., that actions tend to be more effective at local scales, whereas success often needs to be achieved at broader scales, "management and planning for sustainability at an intermediate scale, the landscape or region, appears optimum." The ordinary elements of human landscapes (e.g., forests, crop fields, urban land cover, residential areas, streams, and streets) also resonate well with human perception and thus facilitate decision making (Nassauer 1997; Gobster et al. 2007). From a cultural geographer's perspective, Phillips (1998) commented that cultural landscapes are

"places which can demonstrate that talk of sustainable development can be more than rhetoric."

"Cultural landscapes often reflect specific techniques of sustainable land-use, considering the characteristics and limits of the natural environment they are established in, and a specific spiritual relation to nature" (UNESCO, United Nations Educational 1996). As well as contemporary cultural landscapes such as agricultural and urban landscapes, traditional cultural landscapes should also be emphasized in landscape ecological studies. Such landscapes are the products of long-term co-evolution between culture and nature, and there is much to be learnt from them. Good examples include the rice terrace landscapes in the northern Philippines, the Iberian agri-silvo-pastoral landscapes of the montado and dehesa, the Scandinavian grazed deciduous woodlands, the puszta of Hungary, and the sheep grazed downlands of southern Britain (Stanners and Bourdeau 1995; Phillips 1998). Many Asian countries are rich in such traditional cultural landscapes, some of which are discussed in other chapters of this book. Cultural landscapes that have survived for hundreds of years must have some sustainable land management strategies and techniques that can contribute to our abilities to develop and maintain sustainable landscapes in future. Even those that have disappeared may still provide us with valuable insights.

For example, based on a review of lessons from history, Forman (1995) observed that water problems, soil erosion, high population density, war, and a decline in exports are key attributes associated with decreased sustainability, whereas cultural cohesion, low population density, an export–import trade, the overall level and arrangement of the resource base, religious cohesion, varied links with adjacent areas, and a major irrigation or dike system are key attributes associated with increased sustainability. Selman (2007) suggested three propositions as a basis for assessing the sustainability of cultural landscapes: (1) "cultural landscapes are sustainable if they are regenerative," (2) "landscape sustainability is characterized by ecological integrity and cultural legibility," and (3) "regenerative landscapes are distinguished by feedback loops leading to an accumulation of cultural and ecological assets." Forman (1990) postulated that "for any landscape or major portion of a landscape, there exists an optimal spatial configuration of ecosystems and land uses to maximize ecological integrity, achievement of human aspirations, or sustainability of an environment." More detailed studies need to be carried out to further test these observations, propositions, and hypotheses. This represents a promising future direction not only for landscape ecology, but also for sustainability science.

[AU5]

20.5 Conclusions

Landscape ecology is now a well-established interdisciplinary field of study, which is evidenced by several characteristics. These include an evolving but identifiable system of concepts, theories, principles, methods, and applications, a hierarchy of professional organizations consisting of international associations and regional and

local chapters, a reputable flagship journal as both a platform and a barometer of the development of the field, the adoption of educational and training programs by major universities and research institutes around the world, and an increasing number of publications in main-stream scientific journals which indicate its recognized status as well as its expanding impacts on related disciplines. One may argue, however, that these characteristics do not constitute a complete set of necessary and sufficient criteria that qualify landscape ecology to be a well-established "discipline" in the strict sense of the word. This deficiency may be attributed to the lack of consensus on a set of clearly articulated research questions and goals, as well as a systematic methodology for the field. Indeed, in the past few decades, some have been concerned with the diversity and divergence of concepts and ideas in landscape ecology, and others have worried about its loss of identity as a field of study. While such concerns are common with rapidly developing fields, landscape ecology is not a "discipline," but rather an interdisciplinary and trans-disciplinary science. The state of landscape ecology today is stronger than ever; its relevance to science and society is clearer than ever; and its future looks brighter than ever.

Although landscape ecology has come of age, it is not yet a mature science that is capable of achieving its trans-disciplinary goals. The most important and challenging goal of all involves providing a theoretical basis, developing a set of systematic methodologies, and demonstrating successful applications through place-based studies, in order to understand, manage, and design sustainable landscapes. To achieve this goal, as I have discussed in this chapter, landscape ecology must reconnect culture with nature, and unite people with place in both theory and practice. Cultural landscapes will be the main objects in future ecological landscape studies. Although they are common, the divisions between culture and nature, between society and environment, and between people and place are not based on reality, but on human perception. While such divisions are useful and even necessary as we try to simplify complexity or to reveal mechanistic details, any artificial separation of constituents without a holistic unifying framework tends to obstruct, not construct, a genuine understanding of complex adaptive systems such as landscapes. This is especially important when our research questions are about landscape sustainability.

To landscape ecologists, there is much to be learnt from human geography and other social sciences, there is much to be gained by integrating analytical and holistic approaches within the field, and there is much to be studied of contemporary and traditional cultural landscapes! However, as we expand the spectrum of our research interests, embrace a greater complexity of landscapes, and reach a higher level of trans-disciplinarity, we must not forget the quintessential characteristics of landscape ecology – the emphasis on spatial heterogeneity and associated spatially explicit methodology – which underlies the original definition by Carl Troll, and which has become the cornerstone of landscape ecology today. These are not merely some unique features that distinguish this field from others; more importantly, they provide landscape ecology with a special capacity for tackling complex real-world problems.

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References

Barrett TL, Farina A, Barrett GW (2009) Aesthetic landscapes: an emergent component in sustaining societies. Landsc Ecol 24(8):1029–1035

Burgess RL, Sharpe DM (eds) (1981) Forest Island dynamics in man-dominated landscapes. Springer, New York

Cao Y, Xiao DN, Li XZ, Hu YM (2002) Literature analysis and research progress of landscape ecology in China in the 1990s. J For Res 13:98–102

Chen X, Wu J (2009) Sustainable landscape architecture: implications of the Chinese philosophy of "unity of man with nature" and beyond. Landsc Ecol 24:1015–1026

Farina A (2000) The cultural landscape as a model for the integration of ecology and economics. Bioscience 50(4):313–320

Forman RTT (1981) Interaction among landscape elements: a core of landscape ecology. In: Tjallingii SP, de Veer AA (eds) Perspectives in landscape ecology: contributions to research, planning and management of our environment. Pudoc, Wageningen, pp 35–48

Forman RTT (1983) An ecology of the landscape. Bioscience 33:535

Forman RTT (1990) Ecologically sustainable landscapes: the role of spatial configuration. In: Zonneveld IS, Forman RTT (eds) Changing landscapes: an ecological perspective. Springer, New York, pp 261–278

Forman RTT (1995) Land mosaics: the ecology of landscapes and regions. Cambridge University Press, Cambridge

Forman RTT, Godron M (1981) Patches and structural components for a landscape ecology. Bioscience 31:733–740

Forman RTT, Godron M (1986) Landscape ecology. Wiley, New York

Fu B, Lü Y (2006) The progress and perspectives of landscape ecology in China. Prog Phys Geogr 30:232–244

Fu B, Lü Y, Chen L (2008) Expanding the bridging capability of landscape ecology. Landsc Ecol 23(4):375–376

Gobster PH, Nassauer JI, Daniel TC, Fry G (2007) The shared landscape: what does aesthetics have to do with ecology? Landsc Ecol 22(7):959–972

Haberl H, Erb KH, Krausmann F, Gaube V, Bondeau A, Plutzar C, Gingrich S, Lucht W, Fischer-Kowalski M (2007) Quantifying and mapping the human appropriation of net primary production in earth's terrestrial ecosystems. Proc Natl Acad Sci USA 104:12942–12947

Head L (2008) Is the concept fo human impacts past its use-by date? The Holocene 18:373–377

Hong S-K, Song I-J, Wu J (2007) Fengshui theory in urban landscape planning. Urban Ecosyst 10:221–237

Jacques D (1995) The rise of cultural landscapes. Int J Herit Stud 1:91–101

Ji X (2007) Ji Xianlin on Chinese culture. China Books, Beijing

Jones M (2003) The concept of cultural landscape: discourse and narratives. In: Palang H, Fry G (eds) Landscape interfaces. Kluwer, Dordrecht, pp 21–51

Kareiva P, Watts S, McDonald R, Boucher T (2007) Domesticated nature: shaping landscapes and ecosystems for human welfare. Science 316(5833):1866–1869
Kotliar NB, Wiens JA (1990) Multiple scales of patchiness and patch structure: a hierarchical framework for the study of heterogeneity. Oikos 59:253–260
Leopold A (1949) A Sand County Almanac. Oxford University Press, New York
Levin SA, Paine RT (1974) Disturbance, patch formation and community structure. Proc Natl Acad Sci USA 71(7):2744–2747
Ludwig J, Tongway D, Freudenberger D, Noble J, Hodgkinson K (1997) Landscape ecology, function and management: principles from Australia's rangelands. CSIRO, Collingwood
MacArthur RH, Wilson EO (1967) The theory of island biogeography. Princeton University Press, Princeton
MacKey BG, Soulé ME, Nix HA, Recher HF, Lesslie RG, Williams JE, Woinarski JCZ, Hobbs RJ, Possingham HP (2007) Applying landscape-ecological principles to regional conservation: the Wildcountry Project in Australia. In: Wu J, Hobbs R (eds) Key topics in landscape ecology. Cambridge University Press, Cambridge, UK, pp 192–213
McHarg IL (1969) Design with nature. Natural History Press, Garden City, NY
Mitchell D (2000) Cultural geography: a critical introduction. Blackwell, Oxford
Musacchio LR (2009a) The ecology and culture of landscape sustainability: emerging knowledge and innovation in landscape research and practice. Landsc Ecol 24(8):989–992
Musacchio LR (2009b) The scientific basis for the design of landscape sustainability: a conceptual framework for translational landscape research and practice of designed landscapes and the six Es of landscape sustainability. Landsc Ecol 24(8):993–1013
Nassauer JI (1995) Culture and changing landscape structure. Landsc Ecol 10(4):229–237
Nassauer JI (ed) (1997) Placing nature: culture and landscape ecology. Island Press, Washington, DC
Naveh Z (1982) Landscape ecology as an emerging branch of human ecosystem science. Adv Ecol Res:188–237
Naveh Z (1991) Some remarks on recent developments in landscape ecology as a transdisciplinary ecological and geographical science. Landsc Ecol 5:65–73
Naveh Z (1998) Ecological and cultural landscape restoration and the cultural evolution towards a post-industrial symbiosis between human society and nature. Restor Ecol 6:135–143
Naveh Z (2000) What is holistic landscape ecology? A conceptual introduction. Landsc Urban Plan 50:7–26
Naveh Z (2007) Landscape ecology and sustainability. Landsc Ecol 22(10):1437–1440
Naveh Z, Lieberman AS (1984) Landscape ecology: theory and application. Springer, New York
Page RR, Gilbert CA, Dolan SA (1998) A guide to cultural landscape reports: contents, process, and techniques. U.S. Department of the Interior, National Park Service, Washington, DC
Phillips A (1998) The nature of cultural landscapes – a nature conservation perspective. Landsc Res 23:21–38
Phillips A (2007) International policies and landscape protection. In: Benson JF, Roe M (eds) Landscape and sustainability, 2nd edn. Routledge, New York, pp 84–103
Pickett STA, Cadenasso ML (1995) Landscape ecology: spatial heterogeneity in ecological systems. Science 269:331–334
Pickett STA, Thompson JN (1978) Patch dynamics and the design of nature reserves. Biol Conserv 13:27–37
Plachter H (1995) Functional criteria for the assessment of cultural landscapes. In: von Droste B, Plachter H, Rossler M (eds) Cultural landscapes of universal value – components of a global strategy. UNESCO, Gena, pp 380–392
Risser PG, Karr JR, Forman RTT (1984) Landscape ecology: directions and approaches. Illinois Natural History Survey Special Publ. 2, Champaign
Rowntree LB (1996) The cultural landscape concept in American human geography. In: Earle C, Mathewson K, Kenzer MS (eds) Concepts in human geography. Rowman & Littlefield, Lanham, pp 127–159
Sauer CO (1925) The morphology of landscape. Publications in Geography (Berkeley: University of California), vol 2, pp 19–53

Selman P (2007) Landscape and sustainability at the national and regional scales. In: Benson JF, Roe M (eds) Landscape and sustainability, 2nd edn. Routledge, New York, pp 104–117
Sirisrisak T, Akagawa N (2007) Cultural landscape in the world heritage list: understanding on the gap and categorization. City and Time 2:2. (online) URL: http://www.ct.ceci-br.org
Stanners D, Bourdeau P (1995) Europe's environment: the DobriS assessment. European Environment Agency, Copenhagen
Tansley AG (1935) The use and abuse of vegetational concepts and terms. Ecology 16(3):284–307
Tress B, Tress G (2001) Capitalising on multiplicity: a transdisciplinary systems approach to landscape research. Landsc Urban Plan 57:143–157
Tress B, Tress G, De'camps H, d'Hauteserre A-M (2001) Bridging human and natural sciences in landscape research. Landsc Urban Plan 57:137–141
Troll C (1939) Luftbildplan and okologische bodenforschung. Zeitschraft der Gesellschaft fur Erdkunde Zu Berlin 7–8:241–298
Troll C (1968) Landschaftsokologie. In: Tuxen R (ed) Pflanzensoziologie und Landschaftsokologie. Berichte das 1963 Internalen Symposiums der Internationalen Vereinigung fur Vegetationskunde. Junk, The Hague, pp 1–21
Troll C (1971) Landscape ecology (geoecology) and biogeocenology – a terminology study. Geoforum 8(71):43–46
Turner BL II (1997) Spirals, bridges and tunnels: engaging human–environment perspectivers in geography. Ecumene 4:196–217
Turner MG, Gardner RH, O'Neill RV (2001) Landscape ecology in theory and practice: pattern and process. Springer, New York
UNESCO (United Nations Educational S, and Cultural Organization), (1996) Operational guidelines for the implementation of the world heritage convention. UNESCO, Paris. http://whc.unesco.org/archive/opguide05-annex3-en.pdf
Urban DL, O'Neill RV, Shugart HH (1987) Landscape ecology: a hierarchical perspective can help scientists understand spatial patterns. Bioscience 37:119–127
Walker B, Salt D (2006) Resilience thinking: sustaining ecosystems and people in a changing world. Island Press, Washington, DC
Webb M (1987) Cultural landscapes in the National Park Service. The Public Historian 9:77–89
Wiens JA, Milne BT (1989) Scaling of 'landscape' in landscape ecology, or, landscape ecology from a beetle's perspective. Landsc Ecol 3:87–96
Wilson EH (1929) China: mother of gardens. Stratford, Boston
Wu J (2006) Landscape ecology, cross-disciplinarity, and sustainability science. Landsc Ecol 21(1):1–4
Wu J (2008) Making the case for landscape ecology: an effective approach to urban sustainability. Landsc J 27(1):41–50
Wu J (2010) Urban sustainability: an inevitable goal of landscape research. Landsc Ecol 25:1–4
Wu J, Hobbs R (2002) Key issues and research priorities in landscape ecology: an idiosyncratic synthesis. Landsc Ecol 17:355–365
Wu J, Hobbs RJ (eds) (2007a) Key topics in landscape ecology. Cambridge University Press, Cambridge
Wu J, Hobbs R (2007b) Landscape ecology: the-state-of-the-science. In: Wu J, Hobbs R (eds) Key topics in landscape ecology. Cambridge University Press, Cambridge, UK, pp 271–287
Wu J, Levin SA (1994) A spatial patch dynamic modeling approach to pattern and process in an annual grassland. Ecol Monogr 64(4):447–464
Wu J, Loucks OL (1995) From balance-of-nature to hierarchical patch dynamics: a paradigm shift in ecology. Q Rev Biol 70:439–466
Wu J, Jones KB, Li H, Loucks OL (eds) (2006) Scaling and uncertainty analysis in ecology: methods and applications. Springer, Dordrecht, The Netherlands
Zonneveld IS (1972) Land evaluation and land(scape) science. International Institute for Aerial Survey and Earth Sciences, Enschede, The Netherlands
Zonneveld IS (1989) The land unit – a fundamental concept in landscape ecology, and its applications. Landsc Ecol 3(2):67–86