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景观生态学——生态学领域里的新概念构架

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【摘要】 景观生态学是生态学领域里的一个新概念构架。它是由生态学、地理学、森林学、野生生物管理和景观规划等学科综合产生的。景观生态学有许多特点，如它强调空间格局的研究、空间异质性的维持和发展、生态系统之间的相互作用、大领域动物种群的保护和管理、自然资源的经营和管理及人类对景观及其组分的影响，它的新颖之处主要在于，在景观水平上生态学研究的整体观以及许多本来缺乏联系的学科（尤其是地理学）在解决景观问题上的综合。景观思想是生态系统思想的进一步发展。景观生态学的形成，使人们能够从一个新的、更高的水平去观察和认识自然界。明智合理地经营和管理自然资源需要人们理解和应用景观生态学的思想。本文试图从下面几个方面较系统地介绍北美的景观生态学：（1）景观生态学的主要概念，（2）景观生态学的主要内容，（3）景观生态学的一些原理，（4）景观生态学研究方法，（5）景观生态学展望。

关键词 景观 景观生态学 生态系统 空间格局 地理信息系统 资源管理

Landscape ecology: a new conceptual framework in ecology. Li Habin (*Northeast Forestry University*), J.F.Franklin (*College of Forest Resources, University of Washington*): Advances in Ecology, 1988, 5 (1), pp.23—33.

Landscape ecology is a new conceptual framework in ecological research. It is derived from ecology, geography, forestry, wildlife management, landscape planning and many others. It has many unique characteristics, such as its emphases on spatial pattern analysis, maintenance and development of spatial heterogeneity, on interaction between ecosystems, on management of wild range animal populations, on protection and management of environment and resources, as well as on human impact on landscapes and their components. The novelty of landscape ecology lies in the holistic approach to ecological research at the landscape level and in the integration of many disciplines which are traditionally segregated from each other. The landscape ecology idea is a significant progress from the ecosystem theory. The recognition of landscape level and the formation of landscape ecology enable us to observe and understand the nature from a new, higher level. To manage wisely and rationally natural resources requires our understanding and application of landscape ecology. The objective of this paper is to try to present a relatively complete introduction of the North American landscape ecology, including the following aspects: (1) major concepts in landscape ecology, (2) the scope of landscape ecology, (3) some principles in landscape ecology, (4) methodology of landscape ecology, and (5) perspectives of landscape ecology.

Key words Landscape, Landscape ecology, Ecosystem, Spatial pattern, Geographic information system, Resource management.

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LANDSCAPE ECOLOGY: A NEW CONCEPTUAL FRAMEWORK IN ECOLOGY

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ABSTRACT

Landscape ecology is a new conceptual framework in ecological research. It is derived from ecology, geography, forestry, wildlife management, landscape planning, and many others. It has many unique characteristics, such as its emphases on spatial pattern analysis, maintenance and development of spatial heterogeneity, on interaction between ecosystems, on management of wild range animal populations, on protection and management of environment and resources, as well as on human impact on landscapes and their components. The novelty of landscape ecology lies in the holistic approach to ecological research at the landscape level and in the integration of many disciplines which are traditionally segregated from each other. The landscape ecology idea is a significant progress from the ecosystem theory. The recognition of landscape level and the formation of landscape ecology enable us to observe and understand the nature from a new, higher level. To manage wisely and rationally natural resources requires our understanding and application of landscape ecology. The objective of this paper is to try to present a relatively complete introduction of the North American landscape ecology, including the following aspects: (1) major concepts in landscape ecology, (2) the scope of landscape ecology, (3) some principles in landscape ecology, (4) methodology of landscape ecology, and and (5) perspectives of landscape ecology.

KEY WORDS: Landscape; Landscape ecology; Ecosystem; Patch; Heterogeneity; Scale; Spatial Pattern; Resource Management; Geographic Information System.

INTRODUCTION

Recently, a new concept, landscape ecology, becomes popular and occurs frequently in the literature of ecology and other related disciplines. As a result of a series of publications (Burgess and Sharpe 1981, Brandt and Agger 1984, Forman 1979, 1981, 1983, 1986, Forman and Godron 1981, 1984, 1986, Godron and Forman 1983, Merriam 1984, Naveh 1982, Naveh and Lieberman 1984, Risser et al. 1984, Turner 1987), a new interdiscipline, landscape ecology, has emerged in North America. Landscape ecology arose first in Europe. It has a strong European perspective, but has now been developed into the more natural and dynamic North American landscape ecology. Landscape ecology is derived from ecology, geography, forestry, wildlife management, and landscape planning, deals with the whole landscape and focuses on heterogeneous structure and dynamics of natural resources. Landscape is a higher level organization in the natural hierarchy above ecosystem, and may become the level at which many kinds of ecological studies at other levels can be synthesized. Landscape ecology emphasizes the development and maintenance of spatial heterogeneity (especially the horizontal patterns), the interaction among ecosystems, the distribution of widely ranging animal populations, and the human influence on a landscape and its components. These distinct features make landscape ecology become a new conceptual framework in ecology and other relevant disciplines.

Landscape ecology is still in the pre-paradigm stage in terms of Kuhn's thesis (Kuhn 1970), and is undertaking the course of rapid development in concepts, theories and research methods. Nonetheless, the introduction of landscape concepts to ecology has brought many fresh ideas to ecological studies. This new approach will provide resource managers with new tools or strategies. In view of the high potential values of landscape ecology in ecological research and natural resource management, it is important to introduce landscape ecology to Chinese ecologists and other interested readers in China. Based upon our knowledge, only a few people in China are aware of this newly-emerged subdiscipline of ecology (e.g., Chen 1985, 1986), and there is basically no research going on in this field. Therefore, it is the aim of this paper to introduce the concepts, theories, and state-of-the-art of landscape ecological research to Chinese ecologists, geo-scientists, and scholars in other related sciences, and hopefully to inspire some research interest in the field of landscape ecology in China.

MAJOR CONCEPTS IN LANDSCAPE ECOLOGY

Landscape. The term landscape may mean different things to people with different backgrounds (cf., Forman and Godron 1986), but, as an ecological term, a landscape is defined as "a heterogeneous land area composed of a cluster of interacting ecosystems that repeat in similar form throughout" (Forman and Godron 1986). By definition, a landscape is a holistic unit of ecological studies and is at the level which is higher than ecosystem in the natural hierarchy. A landscape has, just like other biosystems, its own structure, function, and dynamics. A landscape is often at the scale of 10-100 square kms (or larger), formed by geomorphic processes and disturbance regimes, including human activities, and has relatively distinct boundaries. Landscapes are heterogeneous in structure and consist of a mosaic of different ecosystems. Ecosystems (i.e., landscape elements) in the mosaic can be classified into one of the three fundamental types: patches, corridors or matrix. A landscape can be used as a holistic unit for thinking, research and management (Chen 1985).

The form, behavior and historical context of landscapes are strongly controlled by the underlying land-forms and geomorphic processes. In addition, vegetation in a landscape reflects the influences of disturbances, climate, and soil conditions. It is, therefore, suggested that a landscape should be classified by the characteristics of geomorphology and vegetation and by the intensity of human impact and named by the land-form (e.g., mountain, plain, etc.), the dominant species in the matrix (e.g., Douglas-fir, Pseudotsuga menziesii, Korean pine, Pinus koreansis, etc.), and the primary vegetation type (e.g., forest, woodlands, etc.). For example, there are montane Douglas-fir forest landscapes in western Cascades, U.S.A., montane Korean pine forest landscapes in the northeastern China, alluvial-plain rice field landscapes in the lower portion of Yangtzi river basin in South China, and suburban landscape surrounding Beijing. The intensity of human influence on landscapes can also be used as a criterion of landscape classification (perhaps at a higher level). For example, we can have natural landscapes (i.e., no significant human impact), semi-natural landscapes (i.e., to some extent influenced by man), agricultural landscapes (i.e., strongly influenced by man), and urban landscapes (i.e., created by man). Although there is not a complete landscape classification system proposed, there are many vegetation classification systems (especially the the European phytosociological classification systems) proposed and used (cf., Mueller-Dombois and Ellenberg 1974), which can certainly serve as the starting point.

Patch, corridor and **matrix**. The basic structural components of a landscape are ecosystems, which are also called patches (cf., Forman and Godron 1981, 1986). A patch is defined as a distinct ecosystem surrounded by other types of ecosystems (i.e., different patches, corridors, or the matrix). A patch is relatively homogeneous. Average patch size changes with the type of landscape and with the intensity of human impact on landscape, sometimes very small (e.g., agricultural landscape) and sometimes very large (e.g., natural forest landscape). The type, origin, size, shape, spatial pattern and dynamics of patches are important characteristics of a landscape.

There are two other structural components of a landscape: corridors and the matrix. A corridor is a linear patch (e.g., line, strip, or stream corridor). Corridors have great influence on the connectivity of the landscape and thus on the exchange of species among landscape components. A corridor may be a channel or a barrier of species migration, depending upon the nature of species. The matrix is the background land area which is usually extensive in size, is highly connected, and exerts a major influence on the successional dynamics of the landscape. The matrix can change into patches when seriously fragmented. Under this circumstance, either there is no clearly-defined matrix or the major type patches in a landscape become the new matrix. When the matrix changes, the type of a landscape changes (i.e., the idea of landscape succession). This is why it is suggested that landscapes be classified partly by the dominant species in the vegetation of the matrix.

Edge and edge effect. Edge refers to a narrow, usually sharp, strip formed by the two adjoining different patches. When the transition zone between two ecosystems is rather wide or gradual, it is uncertain whether edge effect exists or not. Edge is also the place where interactions between ecosystems occur. Around edges environmental factors tend to change to such an extent that it has a fundamental effects on composition and abundance of both plant and animal species populations. This is called the edge effect. The total edge length and the edge to interior area ratio on a landscape are indices which describe the extent of potential edge effect, and the edge width is an important attribute of a patch. Edge effect can be beneficial or detrimental, depending upon the nature of species of interest. Some species prefer edge habitats (i.e., edge species) while others can only or primarily live in the interior part of a patch (i.e., interior species). As forest fragmentation proceeds, the proportion of interior areas on a landscape will decrease dramatically, and thus the number of interior species will decrease, while the number of edge species increase rapidly. Therefore, utilizing edge effect is a key principle in wildlife population management. For example, it is a common practice in game management to create edge areas in order to increase big game populations because most game species are edge species. It is also recognized, however, that this kind of practice may have a negative effect, in terms of conservation biology, because most endangered species are primarily interior species. Designing landscapes to enhance both is concurrently a present challenge to management.

Heterogeneity. Heterogeneity refer to spatial variability in intensity within an area (e.g., ecosystem or landscape) of any resource or feature (e.g., vegetation configuration) critical to the existence of a taxon or a higher level biosystem. There are three sources of heterogeneity: (a) natural disturbances, (b) human activities, and (c) indigenous vegetation dynamics. Heterogeneity has been recognized as one of the important attributes of biosystems and is believed to play a role in diversity and dynamics of biosystems. However, it was until recently (Pickett and White 1985) that attentions began to be given to environmental and vegetational heterogeneity at the within-community scale and research to be carried out. "No landscape naturally achieves homogeneity because of the inherent differences among landscape elements and because small to moderate disturbances cause heterogeneity" (Risser 1987). The conventional assumption that the area under investigation be homogeneous has been challenged although it may still be useful under certain circumstances. As Risser et al. (1984) pointed out, "landscape ecology considers the development and maintenance of spatial heterogeneity, the spatial and temporal interactions and exchanges across heterogeneous landscapes, the influence of heterogeneity on biotic and abiotic processes, and the management of that heterogeneity". Heterogeneity is an important concept in the contemporary ecology, especially in landscape ecology. Study of heterogeneity in environment, resources, and biosystems has become one of the frontiers in current ecological research (Turner 1987).

Spatial pattern. Spatial pattern refers to the rules or repeated occurrence of spatial arrangement of elements or properties of landscapes. Spatial pattern, generated by processes at various scales, is the hallmark of a landscape and, therefore, is one of the major concerns in landscape ecology. Vegetation, as well as other environmental resources (e.g., soil), varies in a landscape, both horizontally and vertically. This spatial variation is a universal phenomenon that has two components: the structural component, which can be explained, and the random component (i.e., noise), which is unresolved (Burrough 1983). Spatial pattern is analyzed in the topological context of a landscape, that is, the size, shape, neighbors and geographic locations (coordinates) of patches will be taken into consideration. The isolation and the contrast of patches in a landscape mosaic are also important topics, and are in a sense included in the connotation of the spatial pattern concept. Many methods of spatial pattern analysis have been designed, and some of them will be presented in a later section.

Scale. Scale implies a certain level of perceived detail, and refers in the ecological context to the size or area of the system to be considered (i.e., spatial scale) or the time interval of the system dynamics to be studied (i.e., temporal scale). In other words, scale is the resolution, extent and degree at which we perceive the biosystem of interest. Usually, the terms 'finer' and 'coarser' (i.e., broader) are used to imply the high resolution (low generalization) and low resolution (high generalization) respectively. For example, a study considering canopy gaps in a forest stand is a finer scale study compared to a patch study in a landscape mosaic. Landscape study is at a broader scale than that of population. In general, patterns of spatial variations may vary with a change in the scale at which observations are made, and it is usually the case that some of the noise in spatial variation at one scale becomes structured at the other scales (Burrough 1983). This is partly because different processes or factors control the formation and development of vegetation at different scales (Burrough 1983, Delcourt et al. 1983, Meentemeyer and Box 1987, Urban et al. 1987). Understanding of scale effects in ecological studies is critical, not only because different processes operate at different scales but also because many ecological concepts, such as diversity, heterogeneity or homogeneity, and spatial or temporal patterns, are scale-dependent. A heterogeneous system at one scale can be transformed into a homogeneous system as scale becomes finer or coarser. Therefore, in ecological research, scale effect has to be taken into consideration if one wants to expand generalizations obtained at one scale to another scale (Urban et al. 1987, Risser 1987).

Diversity. Diversity is, in ecological context, a measure of variability and complexity in environmental resources in a given system. It has also been suggested, in the sense of resource management, that natural diversity be regarded as a requirement, criterion, and output of good resource management (e.g., Cooley and Cooley 1982). Diversity is a major concern of conservation biology as well as ecology. According to Pielou (1975), diversity can be viewed from different levels of biological organization, such as the ones from the level of species (i.e., species diversity) and from the level of ecosystems or patches (i.e., landscape diversity). These two types of diversities are both important in landscape ecology. Species diversity has been discussed thoroughly by many researchers, such as Whittaker (1972) and Pielou (1975). The discussion will concentrate on landscape diversity.

Landscape diversity characterizes the complexity of ecosystems or patches, instead of species, in a landscape mosaic. Landscape diversity is often ignored in conventional ecological studies. In landscape ecology, much attention will be given to landscape diversity because it describes landscape heterogeneity and because diversity itself is also an ecological component which should be preserved. Usually, diversity is measured by various indices (Pielou 1975). It is believed that a single index is not adequate to fully characterize landscape diversity. Romme (1982) postulated three components for landscape diversity in his study of diversity in the Yellowstone National Park. His idea is adapted and developed here so that four components of landscape diversity are proposed: (1) richness, which is the total number of different patch types in a landscape mosaic; (2) evenness, which measures equilability of distributions (usually area-weighted) of different patches in a landscape mosaic; (3) patchiness, which measures the contrast of patches or the tendency of patch aggregation and interspersion in a landscape mosaic; and (4) connectivity, which measures the connectedness of the matrix, or patches of the same kind, in a landscape mosaic (cf., Romme 1982, Merriam 1984). The mathematical formulas of the four indices should be determined in terms of the objective of research.

Disturbance. Disturbance was recognized at the early days of ecology, but treated only as an external force or a mechanism resetting the inexorable march towards equilibrium (i.e., succession). As Pickett and White (1985) have pointed out, "disturbance per se had no place in the theory of community and ecosystem dynamics until recently". The results of recent studies have shown that disturbance is an important component of most biosystems (e.g., Forman and Godron 1986) and often plays a significant part in the structure and dynamics of biosystems. The importance of disturbance in ecology has been recognized because (a) it occurs at all ecological levels of organization, from organisms to landscapes; (b) it is a source of environmental heterogeneity in space and in time; and (c) it can deflect a community from some otherwise predictable successional path (cf. Pickett and White 1985).

A disturbance is defined as an event which causes significant change from the normal pattern in an ecological system (Forman and Godron 1986). Disturbances, as mentioned before, affect the spatial heterogeneity of ecosystems and landscapes and the relative abundances of the species present. Typically, disturbances open space, allowing the establishment of other individuals, species, or even biosystems like ecosystems and landscapes. A disturbance may either increase or decrease environmental heterogeneity, depending upon the scale of the disturbance and upon the scale of important underlying environmental patterns. In landscape ecology, the term disturbance regime is usually used to imply the disturbances in the whole landscape over time. Disturbance regime is described by distribution, frequency (i.e., mean number of events per time period), return interval (i.e., the inverse of frequency), area or size, magnitude or intensity, severity (i.e., impact on biosystems) and synergism (i.e., effects on occurrence of other disturbances) of disturbances.

LANDSCAPE ECOLOGY

Landscape ecology is an interdiscipline synthesized from ecology, geography, forestry, wildlife management, and landscape planning. Landscape ecology can certainly be regarded as a new branch of ecology in its own right (Forman and Godron 1986, Forman 1987, personal communication). "Landscape ecology basically studies how a heterogeneous combination of ecosystems is structured, functions and changes in a landscape" (Forman and Godron 1986). Not everything in landscape ecology is new because some ideas have existed for years in ecology and other disciplines which constitute landscape ecology. The novelty of landscape ecology, however, lies in the holistic approach to ecological research at the landscape level and in the integration of many disciplines which are traditionally segregated from each other. There are several distinct characteristics of landscape ecology: (1) It studies the development and management of spatial heterogeneity of landscapes; (2) It considers the whole landscape and therefore the interactions among ecosystems; (3) It treats landscape as a higher level biosystem above ecosystem in the biological spectrum; (4) It combines the "horizontal" approach of geographers in examining spatial interplay of natural phenomena with the "vertical" approach of ecologists in studying functional interplay in a given site; (5) It addresses some research questions which can not be handled appropriately or adequately at finer scales; (6) It incorporates human and their activities in ecology and is equally effective for pristine landscapes or those with a heavy human imprint; and (7) It is management-oriented and provides the theoretical basis to natural resource management, and to regional planning and its ecological evaluation. It is natural due to those significant features that landscape ecology be a new conceptual framework in ecology.

Landscape ecology can be considered as an approach, an attitude, or a state of mind (Zonneveld 1981). Forman (1986) pointed out, when characterizing landscape ecology, that landscape ecology certainly provides ecologists a new way to address questions. In the following paragraphs, we would like to present some examples of the research questions in order to illustrate some general ideas about the nature of landscape ecological studies. These research questions are either real (i.e., collected from literature) or potential (i.e., in terms of landscape ecology theories). In addition, some examples of landscape ecological researches in the United States are also discussed to demonstrate how to approach these problems.

A landscape can be characterized by its structure, function, and dynamics. Some examples of research questions address those theoretical aspects of landscape ecology may be: What causes spatial patterns in a landscape and how? What are the effects of geomorphic processes and disturbances on patch distribution and dynamics? Or vice versa? What are the roles that environmental heterogeneity plays in the structure, function and dynamics of landscapes? What is the pattern of landscape dynamics in a region (e.g., a deforested region) and its ecological consequences? What are the characteristics and patterns of redistribution and flow of energy, nutrients, and species among patches in a landscape? How and how much (many)? What are the differences between human-modified and natural landscapes in terms of patch characteristics (i.e., patch type, size, shape, distribution and dynamics)? These are the questions for which we certainly lack definite answers.

Forman and other scholars (cf., Forman 1979) synthesized studies of the half-million-hectare Pine Barrens landscapes in New Jersey (U.S.A.), considering the characteristics of most aspects of a landscape: (a) human influence, (b) geology and soils, (c) climate, water and aquatic ecosystems, (d) vegetation pattern, (e) plants and (f) animals. This was a pioneer work of landscape ecology in the United States although not all the participants appreciated the landscape ecological perspective. This work also showed that landscape ecology not only requires cooperation of scientists from different disciplines but also has the synthetic power in integrating the information from different fields.

According to the previous results of ecological studies and our observation, it is postulated that patch patterns in space or time or under different human impacts may appear great different and that some characteristics of landscape may follow the trends given in Table 1. This is because the important environmental gradients and the disturbance regime in a landscape under different conditions may differ.

Table 1. The hypothetical trends of some characteristics of landscape under different human impacts.

LANDSCAPE FEATURE	NATURAL LANDSCAPE	MANAGED LANDSCAPE
SPATIAL PATTERN	UNCERTAIN	UNIFORM
AVERAGE PATCH AREA	LARGE	SMALL
TOTAL EDGE LENGTH	SMALL	LARGE
PATCH SHAPE	IRREGULAR	REGULAR
DYNAMIC RATE	SLOW	FAST
CONNECTIVITY	HIGH	LOW
NATIVE SPECIES DIVERSITY	HIGH	LOW

Landscape ecology has direct applications to conservation biology, and some of the research questions in conservation biology can only be addressed at the landscape level. The questions may include: What kind of patchy structure of landscape (or habitat) diversity is required for a certain species to survive? What is an appropriate size of a natural reserve to serve the purposes of the preservation of indigenous species and the maintenance of species, habitat diversity, and natural disturbance? How do plant and animal communities respond to environmental heterogeneity? How does landscape heterogeneity affect spread of disturbances? What are the edge effects on within-patch structure and animal activity? What is the scale of edge effect gradient? How would resource management strategies maintain species and habitat diversity at the landscape level?

The research for solutions to these questions is important because, as a result of economic development, natural vegetation in most countries of the world is becoming "green-patches" (i.e., habitat islands) surrounded by agricultural fields, tree plantations and urban areas at such a rapid pace that a large number of species as well as natural ecosystems are threatened. It is believed that landscape ecology can provide the principles and methods for solving, at least partially, this dilemma. An example of research of this kind is Harris' study on the montane Douglas-fir forest landscape in the Pacific Northwest, USA (Harris 1984). Harris used the Douglas-fir forest landscape as a model to study characteristics of plant and animal communities, to determine trends and patterns of forest dynamics under the influence of human activities and to assess the feasibility of application of island biogeography theory to resource management. He focused on the preservation of old-growth Douglas-fir forests in order to preserve the endangered species therein. He suggested that patches of old-growth forests be considered as islands in a sea of tree plantations or other human dominated systems and thus island biogeography theory can be used as a guide to comprehensive planning for conservation and management of old-growth forest ecosystems in the context of managed forest lands. He then proposed a management plan to meet both objectives of preserving the old-growth forest ecosystems and producing certain amount of timber. The proposed plan would first to protect old-growth patches as much as possible (e.g., to reduce management activities and human disturbance and to keep a larger area), then to establish around an old-growth patch a buffer zone in which low intensity management should be performed and which is divided into several parts in such a way that each part is in one stage of forest development, such as clearcut, young stand, middle-aged stand and mature stand. It seems clear that Harris' plan incorporates the idea of multi-purpose management. In addition, his suggestion is rather similar to the idea of "long-term utilization of forest resources" among Chinese foresters.

Ecology in general, landscape ecology in particular, is a theoretical basis of resource management. Landscapes may be the most appropriate unit of resource management. Several examples of research questions are: How does the increasing level of landscape modification by people affect each of those patch characteristics? What if the landscape is progressively modified by human activities? What are the consequences of transferring one landscape type to another? How do other attributes change as the matrix changes in type and/or in connectivity? What are the effects of forest fragmentation on wildlife populations? How to manage riparian zone vegetation in order to remain its effects, both structurally and functionally, on the other components of a landscape as much as possible? How to make comprehensive evaluations on our management activities ecologically?

Franklin and Forman's study about the influences of forest clearcut on the montane Douglas-fir forest landscape is one of the examples of applications of landscape ecology to resource management (cf. Franklin and Forman 1987). They utilized the perspectives of landscape ecology to make qualitative evaluation and predictions about the changing trends of landscape structural characteristics with forest cutting methods. Using a checkerboard model they postulated the thresholds of landscape pattern change with progressive fragmentation of forest and the concomitant change in species diversity and game populations as management practice intensify. They expressed their suspicion against the use of the staggered-setting system of clearcutting, which has commonly been used in the Pacific Northwest for some forty years. They argued that, although this method has some advantages (e.g., easiness to regeneration, to handling slash, and to develop roads, etc.), it deserves a reconsideration whether or not this method is appropriate economically and ecologically, because the objectives and technologies have changed and the intensity of forest fragmentation has increased. They suggested that logging operations be concentrated and the unit area of clearcuts increased, because it is better economically (e.g., reduction of unit management expense) and more feasible ecologically (e.g., improvement in protection of species diversity and reduction of catastrophic disturbance frequency). They also pointed out that both ecosystem and heterogeneous landscape perspectives are critical in resource management.

Another area of application of landscape ecology to resource management is the study of effects of riparian zone vegetation (e.g., Swanson et al. 1982). This is an active research area in the United States and many investigations have been carried out. The results suggest that riparian vegetation not only is the most important corridor element upon which wildlife species populations depend heavily for food and shelter but also exerts great influence on stream channel structure, sediment budget and fish habitats. It has been proposed that riparian vegetation be protected as much as possible in order to protect wildlife habitats and maintain stability of structure and function of stream ecosystems.

It should be pointed out that the concepts of landscape ecology introduced here really reflects the flavor of the North American landscape ecologists. Landscape ecology was not recognized in North America until recently. Landscape ecological concepts were first developed, originally from geography, in Europe (Naveh 1982, Naveh and Lieberman 1984, Forman and Godron 1986). C. Troll, the late leading German biogeographer, is usually regarded as the founding father of landscape ecology (Naveh and Lieberman 1984, Forman and Godron 1986). Troll began his landscape ecological studies in the late 1930's, but the formation of landscape ecology as a scientific discipline is usually believed to begin in 1960's. Since then, most landscape ecology research has been carried out in Europe (cf., Forman and Godron 1986, Naveh 1982, Naveh and Lieberman 1984). Today, landscape ecology is a well-established discipline in Europe in the light of the establishment of both landscape ecology education systems (i.e., schools and departments) and landscape ecology research institutes. A comprehensive discussion of the history of the development of landscape ecology is beyond the scope of this paper. Readers who are interested in this topic should refer to Naveh (1982), Naveh and Lieberman (1984), and Forman and Godron (1986), where thorough discussions are given.

European landscape ecology emphasizes the human role in landscapes and regards human as the major component of a landscape. Researches of landscape ecology in Europe focus primarily on landscape (region) planning, landscape architecture, management and land-use policy making. Aesthetic attributes of a landscape and the urban landscape totally controlled by people are also major concerns. That landscape ecology incorporates systematic studies of the dynamic role of human in the landscape, in the sense of the "total human ecosystem" proposed by Naveh and Lieberman (1984), might be the desirable direction of progress in the future. However, the total human ecosystems are controlled by laws in economics, sociology, psychology, and politics, apart from the natural laws, and it will require a rather extensive integration among natural and social sciences. It seems appropriate to restrict landscape ecology to the natural systems under little or great human influence---systems that therefore are amenable to scientific analysis, and to perform research to answer fundamental questions before the involvement in more complicated systems. The differences between landscape ecology in Europe and in North America are getting smaller and smaller (Forman 1987, personal communication), which is exemplified by the cooperations of Forman and Godron (e.g., Forman and Godron 1981, 1984, 1986, Godron and Forman 1983).

PRINCIPLES OF LANDSCAPE ECOLOGY

Theories of landscape ecology are still in the stage of initial formulation and development. Many of the concepts discussed in the early section of the paper are actually the embryo form of theories and they may be developed into theories as research goes deeper. Nonetheless, the formation and development of landscape ecology has a sound basis on some existing theories in ecology and other disciplines, such as ecosystem theory, biocybernetics, island biogeography theory, and general system theory. Other ideas like the first law of geography (or spatial dependency theory) also made contributions to landscape ecology. Although formation of landscape ecology theories requires further research, some principles of landscape ecology have been proposed.

Forman and Godron (1986) postulate seven principles for landscape ecology in terms of landscape structure, function and dynamics. These principles provide guidance to planning and performing studies on landscape ecology, although they still need to be verified or modified. In addition, more principles may be formulated as the results of the ongoing researches. The seven principles of landscape ecology are cited below (Forman and Godron 1986).

(1) Landscape Structure and Function Principle. Landscapes are heterogeneous and differ structurally in the distribution of species, energy, and materials among the patches, corridors, and matrix present. Consequently, landscapes differ functionally in the flows of species, energy, and materials among these structural landscape elements.

(2) Biotic Diversity Principle. Landscape heterogeneity decreases the abundance of rare interior species, increases the abundance of edge species and animals requiring two or more landscape elements, and enhances the potential total species coexistence.

(3) Species Flow Principle. The expansion and contraction of species among landscape elements has both a major effect on, and is controlled by, landscape heterogeneity.

(4) Nutrient Redistribution Principle. The rate of redistribution of mineral nutrients among landscape elements

increases with disturbance intensity in those landscape elements.
(5) Energy Flow Principle. The flows of heat energy and biomass across boundaries separating the patches, corridors, and matrix of a landscape increase with increasing landscape heterogeneity.
(6) Landscape Change Principle. When undisturbed, horizontal landscape structure tends progressively toward homogeneity; moderate disturbance rapidly increases heterogeneity, and severe disturbance may increase or decrease heterogeneity.
(7) Landscape Stability Principle. Stability of the landscape mosaic may increase in three distinct ways, toward (a) physical system stability (characterized by the absence of biomass), (b) rapid recovery from disturbance (low biomass present), or (c) high resistance to disturbance (usually high biomass present).

Risser et al. (1984) synthesized discussions from a workshop of landscape ecology held at Allerton Park, Illinois in 1983, provided a good state-of-art summary of the concepts, theories, methodology, and applications of landscape ecology, and foresaw optimistically a rapid development in the future. Some of their principles are also cited below (cf., Risser 1987).
(1) The relationship between spatial pattern and ecological processes is not restricted to a single or particular spatial or temporal scale.
(2) Understanding of landscape ecological issues at one spatial or temporal scale may profit from experiments and observations on the effects of pattern at both finer and broader scales.
(3) Ecological processes vary in their effects or importance at different spatial and temporal scales. Thus, biogeographic

processes may be relatively unimportant in determining local patterns but may have major effects on regional patterns.
(4) Different species and groups of organisms (e.g., plants, herbivores, predators, parasites) operate at different spatial scales such that investigations undertaken at a given scale may treat such components with unequal resolution. Each species views the landscape differently, and what appears as homogeneous patch to one species may comprise a very heterogeneous patchy environment to another.
(5) Scales of landscape elements are defined, using spatial perspectives of sizes determined by the specific objectives of the investigation or the pertinent management question. If a study or management issue focuses at a specified scale, processes and patterns occurring at much finer scales are not always perceived because of filtering or averaging effects, whereas those occurring at much broader scales may be overlooked simply because the focus is within a smaller landscape unit.

METHODOLOGY IN LANDSCAPE ECOLOGY

Development of new methods is essential to every science. Since landscape ecology is a newly-emerged discipline, many basic questions about the methodology are still open to research, such as: What are the methods to describe and quantify landscapes? How can spatial patterns of landscape elements be described and analyzed? How can landscape dynamics be modeled? These questions focus on the methodology of landscape ecology and thus should be answered before any thorough studies can be performed.

To answer questions like those above, the International Association for Landscape Ecology (IALE) organized a conference in 1984, entitled 'Methodology in Landscape Ecology Research and Planning' (cf., Brandt and Agger 1984). Research is currently being performed to address these methodological questions. Although the methodology of landscape ecology is still in the course of rapid development, some general trends and agreements can be observed. Methods used in a landscape ecological study vary, depending upon the nature, objectives, and research conditions of the study, as well as the personal preference of investigator(s). In the light of the characteristics of landscape ecology, however, certain methods may be emphasized in landscape ecological studies.

The most important approach to data collection in landscape ecology is the one using aerial photography and other remote sensing techniques (Brandt and Agger 1984, Forman and Godron 1986, Naveh and Lieberman 1984, Troll 1971). The usefulness of aerial photos in landscape ecological studies has been recognized since the very beginning of landscape ecology (Brandt and Agger 1984, Forman and Godron 1986, Troll 1971). Only on aerial photos and satellite imageries can one obtain an overall view of the landscape and the patch patterns on it. In addition, data of some kinds, such as patch area and edge length, are difficult to obtain on the ground. The common procedure of data collection by aerial photos is that features like patches are identified on photos (through photo interpretation), and then the graph information (i.e., attributes and topological data of patches) converted into digital forms and stored on computers by means of a geographical information system (GIS). GIS are specialized computer softwares and hardwares and have four processing functions: computer mapping, spatial data-base management, spatial statistics, and cartographic modeling (Berry 1986). The use of GIS in ecological researches will increase due to the strong interest of ecologists in determination of spatial patterns, especially those at landscape level.

Another approach is the one which collects data and other information from various existing maps (e.g., vegetation maps, management maps, soil maps, topographic maps, etc.). This is actually a modification of the aerial photo approach (i.e., without photo interpretation part). The advantage of this method is that it is simple and can efficiently use the previous results on maps. Its disadvantage is that it is greatly affected by the precision of maps used and that the precision of its results is unknown although it may not be a critical defect to landscape ecology studies. When dealing with animal populations or when detailed information is needed, field sampling for data collection is necessary, including the radiotelemetric techniques used in animal ecological studies to detect animal movement in landscapes.

Spatial pattern analysis will be of great importance in landscape ecological studies, because spatial pattern is one of the most interesting attributes of a landscape. There are many pattern analysis methods proposed in the literature (e.g., Burgess and Webster 1980, Cliff and Ord 1981, Cormack and Ord

1981, Gauch 1982, Diggle 1982, Forman and Godron 1986, Grieg-smith 1983, Pielou 1969, 1977, Webster 1985, Whittaker 1978). They are: (1) mapping, which is the conventional method of describing spatial patterns and can display the interested properties in two- or three-dimensions so that one can actually visualize the spatial variations in the system, (2) probability distribution, the idea of which is to fit one of the theoretical probability distributions, such as Poisson, Negative Binomial, or Neyman's type A, to sample count frequency data, and then to use the results of a chi-square goodness-of-fit test to indicate whether a spatial pattern is random or non-random, (3) index, which is simple, descriptive, and comparative, designed to measure either aggregation (e.g., Lloyd's index of patchiness) or departure from randomness (e.g., the variance-to-mean ratio), or landscape characteristics (e.g., fragmentation), (4) spatial correlation, which is commonly used in geographic studies and can directly measure spatial patterns on maps in detail, including point, line and area pattern analysis, autocorrelation analysis, (5) geostatistics, which uses theory of regionalized variables to study the spatial correlation and dependency of natural phenomena and takes into consideration the spatial coordinates, which may be the key factor for determination and interpretation of patterns in space and which are ignored by other methods, and (6) graph theory, which uses abstract network to analyze properties of spatial pattern. Other methods, such as simulation, ordination and gradient analysis, and multivariate analysis, can also be used in spatial pattern analysis in landscape ecology.

PERSPECTIVES OF LANDSCAPE ECOLOGY

As economy develops, human requirement for resources increases dramatically. Therefore, how to wisely exploit, utilize and manage our resources, especially those which can be regenerated (i.e., water, vegetation and animals), has become one of the severe problems to which governments and scientists face today. Traditional branches of ecology have serious limitations in dealing with analysis and management of such large-scale biosystems. One solution to the problem may be the understanding and application of landscape ecology perspectives. Landscape ecology is a new conceptual framework in ecology. It has many distinct and significant characteristics, such as the emphases on spatial heterogeneity, the consideration of interactions among ecosystems, the recognition of landscape as a higher level biosystem than ecosystem, the application to conservation biology and resource management, and the power to deal with problems which can not be handled adequately by other subdisciplines of ecology. The formation and development of landscape ecology is a significant progress in ecological research.

Landscape ecology is such a wide open field that almost no scientist or scholar can or should be excluded since it deals with issues related to bioscience, geoscience, as well as socio-economic science (Zonneveld 1981). Integration of all the relevant disciplines is fundamental to the development of landscape ecology, but great difficulties exist due to the traditional gaps among those disciplines. Therefore, cooperation is strongly required in landscape ecological research, and education of a new generation of landscape ecologists is essential. Landscape ecology should be developed into a science with sound hypotheses and with clear and efficient ways of verifying and falsifying hypotheses (i.e., experimentation). Landscape ecology should also be developed to bridge the gaps between ecology and resource management and thus enhance the development of ecology.

Landscape ecology is certainly a candidate for major explosion in the next decade and might become a mainstream of ecological research in the future. To conclude, we quote Forman (1983): "A richness of empirical studies, emergent theory, and applications [of landscape ecology] lies ahead. With principles waiting for the curious, and with an expected short lag between research and the amelioration of environmental and human societal problems, let the young in spirit, looking to the future, 'Think Landscape'".

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景观生态学——生态学领域里的新概念构架

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【摘要】 景观生态学是生态学领域里的一个新概念构架。它是由生态学、地理学、森林学、野生生物管理和景观规划等学科综合产生的。景观生态学有许多特点，如它强调空间格局的研究、空间异质性的维持和发展、生态系统之间的相互作用、大领域动物种群的保护和管理、自然资源的经营和管理及人类对景观及其组分的影响，它的新颖之处主要在于，在景观水平上生态学研究的整体观以及许多本来缺乏联系的学科（尤其是地理学）在解决景观问题上的综合。景观思想是生态系统思想的进一步发展。景观生态学的形成，使人们能够从一个新的、更高的水平去观察和认识自然界。明智合理地经营和管理自然资源需要人们理解和应用景观生态学的思想。本文试图从下面几个方面较系统地介绍北美的景观生态学：（1）景观生态学的主要概念，（2）景观生态学的主要内容，（3）景观生态学的一些原理，（4）景观生态学研究方法，（5）景观生态学展望。

关键词 景观 景观生态学 生态系统 空间格局 地理信息系统 资源管理

Landscape ecology: a new conceptual framework in ecology. Li Habin (*Northeast Forestry University*), J.F.Franklin (*College of Forest Resources, University of Washington*): Advances in Ecology, 1988, 5 (1), pp.23—33.

Landscape ecology is a new conceptual framework in ecological research. It is derived from ecology, geography, forestry, wildlife management, landscape planning and many others. It has many unique characteristics, such as its emphases on spatial pattern analysis, maintenance and development of spatial heterogeneity, on interaction between ecosystems, on management of wild range animal populations, on protection and management of environment and resources, as well as on human impact on landscapes and their components. The novelty of landscape ecology lies in the holistic approach to ecological research at the landscape level and in the integration of many disciplines which are traditionally segregated from each other. The landscape ecology idea is a significant progress from the ecosystem theory. The recognition of landscape level and the formation of landscape ecology enable us to observe and understand the nature from a new, higher level. To manage wisely and rationally natural resources requires our understanding and application of landscape ecology. The objective of this paper is to try to present a relatively complete introduction of the North American landscape ecology, including the following aspects: (1) major concepts in landscape ecology, (2) the scope of landscape ecology, (3) some principles in landscape ecology, (4) methodology of landscape ecology, and (5) perspectives of landscape ecology.

Key words: Landscape, Landscape ecology, Ecosystem, Spatial pattern, Geographic information system, Resource management.

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生态学是一门研究生物系统的结构、功能和动态，以及其与环境之间相互关系的学科。60年代的生态危机使得生态学及其基本概念家喻户晓，并得到了各国政府及公众的重视。60年代末到70年代初的国际生物学计划(IBP)，以其巨大的人力、物力支持，将生态学（尤其是生态系统生态学）的研究推到了一个高峰。随着数学和统计学的理论和方法的大规模引进和应用，生态学逐渐成熟起来。然而，新的发展仍在进行中。近年来，景观生态学 (Landscape Ecology)这一新概念，频繁出现在北美生态学及其它有关学科的文献中。随着一系列代表文献的发表（如Forman，1979，1981，1983，1986，1987；Forman和Godron，1981，1984，1986；Godron和Forman，1983；Burgess和Sharpe，1981；Brandt和Agger，1984；Naveh和Lieberman，1984；Risser et al.，1984，1987；Turner，1987），一个新的生态学分支——景观生态学——在北美蓬勃发展起来。

景观生态学以整个景观为研究对象，并且着重研究景观中自然资源的异质性（不均匀性）。景观在自然等级系统中是一个比生态系统高一级的层次。在景观这个层次上，许多其它层次上的生态学研究也许能够得到必要的综合。景观生态学强调空间异质性的维持与发展，生态系统之间的相互作用，大领域动物种群的保护与管理，环境资源的经营管理，以及人类对景观及其组分的影响。根据T.S.Khun (1970）的科学发展理论，景观生态学仍处于形成阶段，它正经历着概念、理论和研究方法的迅速发展过程。然而，景观概念的引入已经给生态学带来了许多新鲜的思想。一个新的生态学研究领域已由此而敞开，并且其研究成果将为环境保护和资源开发提供新的科学方法和策略。景观生态学有广阔的发展前景，已成为生态学研究中的一个新的概念构架。

鉴于景观生态学的发展潜力以及它在生态学理论发展和自然资源管理方面的重要价值，将其介绍给国内的生态学工作者和其他感兴趣的读者，显然是有意义和必要的。据我们所知，国内仅有少数人了解这门新兴的学科，翻译的国外代表性文章仅有几篇（如《陆地生态译报》，1983），文章也仅限于简单介绍（如陈昌笃，1985，1986）。本文目的在于较系统地把景观生态学的主要概念、理论和研究现状介绍给读者。我们期望，这篇文章能使读者了解美国和其它西方国家生态学研究的某些新发展、新趋向，以引起国内学者对景观生态学的研究兴趣。

一、景观生态学的主要概念

景观（Landscape）。景观这个词对于背景不同的人可以有不同的涵义（参见Forman和Godron，1986）。然而，作为一个生态学术语，它被定义为：由相互作用的拼块(Patch）或生态系统组成的，以相似的形式重复出现的，具高度空间异质性的区域（Forman和Godron，1986）。由定义可知，景观是整体性的生态学研究单位，并且在自然等级系统(Natural hierarchy）中居于生态系统之上。与其它生物系统一样，景观具有其特定的结构、功能和动态特征。景观由地貌过程和干扰状况（Disturbance regime）所形成，其大小通常是数平方公里至数百平方公里（在自然条件下也许更大），具有较明显的边界。显然，景观在空间结构上是异质性的，这是因为它是由不同的生态系统以块状镶嵌的形式构成的。景观可以作为一个整体单位来进行思考、研究和管理（陈昌笃，1985）。

景观的结构形态以及发展史在很大程度上是由地貌类型和地貌过程来决定的。此外，景观中的植被反映出干扰、气候和土壤等因素的影响。因此，我们建议景观应该根据其地貌学和植物学特征以及人类影响的强度来分类，并以其地貌类型（如山地、平原等）、模地上植被的主要建群种〔如花旗松（*Pseudotsuga menziesii*)、红松（*Pinus koreansis*等）〕以及主要植被类型（如森林、草原等）来命名。例如，美国西北部地区喀斯喀特山脉西侧的山地花旗松森林景观、中国东北地区小兴安岭、长

白山的山地红松森林景观、中国东部长江下游的冲积平原稻田景观等等。人类对景观的影响程度可以作为景观在更高水平上分类的一个准则。例如，景观可以首先被粗略地分为：自然景观（即没有显著人类影响）、半自然景观（即在某种程度上为人类所干扰），农业景观（即强烈的人类干扰）以及城市景观（即完全由人类控制，甚至由人类创造的）。尽管现在还没有一个完整的景观分类系统，但许多植被分类（区划）系统特别是欧洲植物社会学家的分类系统（参见Mueller-Dombois和Ellenberg，1974），显然可以作为景观分类的出发点。

拼块（Patch）、廊道（Corridor）和模地（Matrix）。拼块是一个具体的生态系统，是景观的基本组分之一（Forman 和 Godron，1986）。根据定义，拼块是一个与包围它的生态系统截然不同的生态系统。它在结构上是相对同质的。拼块的大小随景观类型而变化，有时很小（如农田景观），有时则很大（如自然森林景观）。拼块的类型、起源、形状、平均面积、空间格局和动态是景观的重要代表性状。廊道和模地是景观的另外两个结构组分。廊道是线状或带状拼块（如林带、河岸植被带等）。廊道在很大程度上影响景观的连接性，因此影响物种（尤其是动物）在景观上，特别是在分离的同类拼块之间的交流。廊道既可以是物种迁移的渠道（如河岸植被带对于多数动物），也可以是物种迁移的屏障（如道路对于某些小动物），其作用要视具体物种的特性而定。在某些情况下，廊道的存在与否以及它的类型，对于物种是否会从景观或拼块里灭绝将起决定性作用。模地是景观上的背景植被或地域，其面积在景观中占较大比重，且具有高度连接性。模地是景观的重要组分，在很大程度上决定景观的性质。模地与景观里的某种主要拼块是可以相互转换的，其转换过程就是景观的演替过程；模地变了，景观自然也就变了。这就是我们建议以模地植被的建群种作为定义和命名景观的准则之一的根据所在。

边缘（Edge）和边缘效应（Edge effect）。边缘是指由两个不同的生态系统相交而形成的窄带状区域。在自然条件下，两个生态系统之间存在比较宽的过渡带，这时边缘效应是否存在要视具体情况而定。通常，边缘是生态系统间相互作用的场所。在边缘地带，各种环境因子趋于变化，而这种变化则可以对植物和动物种群的组成、多度及生长状况产生极大影响。这就是通常所说的边缘效应。景观中边缘的总长度和边缘面积与内部面积之比是两个描述潜在的边缘效应程度的参数。边缘宽度则是拼块的一个重要性状。边缘效应可以是破坏性的，也可以是建设性的，这取决于所研究物种的性质。有些种喜欢边缘生境（边缘种，Edge species），而有些则只能或主要在拼块的内部生境中存活（内部种，Interior species）。随着景观破碎化（Fragmentation）的发展（如森林采伐），景观中内部生境的比例将急剧下降，从而使内部种的数量减少，而使边缘种的数量增多。边缘效应的合理利用是野生生物种群保护与管理的一个重要依据。例如，在狩猎动物（Game species）管理中，增加边缘面积以增加其种群数量是个普遍使用的经营措施，因为狩猎动物多属于边缘种。可是，从物种保护的观点来看，这种经营方法有副作用，因为多数濒危种属于内部种的范畴。合理设计景观以达到既保护濒危种又增加狩猎动物种群数量，是目前我们所面临的自然资源管理方面的挑战。

异质性（Heterogeneity）。异质性是指在一个区域里（景观或生态系统）对一个种或更高级生物组织的存在起决定性作用的资源（或某种性状）在空间上（或时间上）的变异程度（或强度）。异质性有 3 个来源：（1）自然干扰；（2）人类活动；（3）植被的内源演替或种群动态变化。异质性是生物系统的主要属性之一。异质性可能是限制干扰传播的主要因素（Forman，1987），并可能在生物系统的多样性和动态方面起作用（Pickett和White，1985）。可是，生物系统空间结构及其内部环境异质性，仅仅是最近才被注意到，研究工作

也刚刚开始（Pickett和White，1985；Turner，1987）。“由于景观组分之间的内在差异以及中小规模干扰通常引起异质性，没有任何景观可以自然地达到同质性”（Risser，1987）。实验地内各种因子同质性（Homogeneity）这一生态学常规假设已受到异质性理论的挑战。正如Risser等（1984）所指出的，“景观生态学研究空间异质性的发展和维持、异质性景观中不同组分在时间和空间上的相互作用以及能量与物质的交流、异质性对生物和非生物过程的影响以及对这种异质性的管理”。在北美的现代生态学，特别是景观生态学中，异质性是一个重要概念；环境、资源和生物系统结构的异质性的研究，已成为当今生态学研究的前沿课题之一（Turner，1987）。

空间格局（Spatial pattern）。空间格局是指环境、资源以及生物系统结构的异质性在空间上有规律的分布。在景观生态学中，空间格局通常是指拼块在景观镶嵌体中的分布规律。它可以由各种自然过程在不同尺度（Scale）情况下的作用而产生。它是景观的标志，因此是景观生态学的主要课题之一。植被及其它自然资源在景观中既有水平变化，又有垂直变化。这种空间变异是个普遍现象，它有两个成分：可被认识的结构性成分和难以解释的随机性成分（Burrough，1983）。对这两个成分，景观生态学都将开展研究。分析空间格局要考虑景观及其组分的拓朴学性状，即要考虑它们的形状、大小、分布和地理位置或相对位置。空间格局分析是景观生态学研究的核心之一，分析空间格局的目的是，在似乎是无序的景观上（或图上）发现潜在的有意义的秩序（即规律）。只有当我们知道景观空间格局是什么样的，我们才能进一步去探讨它为什么是那样的，进而去设想和描绘景观空间格局应该是什么样的。

尺度（Scale）。尺度暗示着对细节了解的一定水平。从生态学的意义上来说，尺度是指所研究的高级生物系统的面积大小（即空间尺度），或者指所研究生物系统动态的时间间隔（即时间尺度）。通常，小尺度和大尺度被用来分别表示高分辨度（低概括）和低分辨度（高概括）。例如，林分中林窗的研究与景观上拼块的研究相比，或种群动态研究与森林演替研究相比，都是小尺度的。空间分布格局可随观测尺度的变化而异。通常，在一种尺度下空间变异中的噪音（Noise）成分，可在另一个较小尺度下表现成结构性成分（Burrough，1983）。人们已经认识到尺度在生态学研究中的重要性（Burrough，1983；Delcourt et al.，1983；Meentemeyer和Box，1987；Urban et al.，1987），景观生态学也将着重研究尺度的作用（Risser et al.，1984；Turner，1987；Urban et al.，1987）。这不仅因为不同的过程在不同的尺度上发展和起作用，而且是因为生态学中的许多重要概念（如多样性、异质性或均质性、空间和时间格局等等）都是与观测尺度有关的。显然，在一个尺度上定义的均质性系统，可以随着观测尺度的越来越小而转变成异质性系统。因此，生态学的研究必须考虑尺度的作用，绝不可未经研究，就把在一种尺度上得到的概括性结论推广到另一种尺度上去（Urban et al.，1987；Meentemeyer和Box，1987）。

多样性（Diversity）。多样性是在一个给定系统中环境资源（如物种、生境）变异性和复杂性的量度。有人曾从资源管理的角度出发，建议把多样性作为明智而有效的资源管理的规则、标准和结果（如 Cooley 和 Cooley，1982）。多样性是生态学所重视的研究课题。根据Pielou（1975）的观点，多样性可以从不同的生物组织水平去考虑。景观生态学重视下面两种不同类型的多样性：一是物种多样性，二是景观多样性。物种多样性已被许多学者（如Pielou，1975；Whittaker，1972）较详尽地讨论过了。在此，我们仅对景观多样性作进一步讨论。景观多样性描绘在景观镶嵌体（Landscape mosaic）中生态系统（拼块）的复杂性。它在景观生态学中受到重视，是因为它既可以作为一种描述资源异质性的方法，而且

体身又是应该得到保护的对象。通常，多样性由各种各样的指数来测定（Pielou，1975）。一般认为，仅仅一个指数是不足以较完全地描绘景观多样性的。Romme（1982）在他的美国黄石国家公园(Yellowstone National Park)多样性的研究中，提出用3个因子来定义景观多样性。我们接受并发展了他的想法，建议用4个因子来定义景观多样性（参见Romme，1982；Merriam，1984）：（1）多度（Richness），即景观镶嵌体中不同类型拼块的总数，（2）均匀度（Evenness），即景观镶嵌体中不同类型拼块数量分布的均匀程度的量度，（3）镶嵌度(Patchiness)，即景观镶嵌体中拼块团聚或散布趋势的量度，（4）连接度(Connectivity)，即景观镶嵌体中模地或某一类拼块连接性的量度。这些因子的具体数学表达式，应随研究目的而定。

干扰（Disturbance)。干扰及其作用在生态学研究的早期就已被注意到了，一直被认为是一种演替的外力或机制。近来的研究结果表明，干扰是多数生物系统的重要组分之一，并且在生物系统的结构与动态变化中起重要作用。干扰可以出现在所有生物组织层次上（即从个体到景观），它可以使群落演替偏离其本来是可预测的途径，并且往往是空间上和时间上环境资源异质性的来源之一（Pickett和White，1985）。Forman和Godron（1986）定义干扰为“引起生态系统格局显著偏离其常态的事件”，干扰可以破坏生物系统的结构和功能，并在某种程度上改变资源可利用性和环境。干扰的实例有火灾、水灾、病虫害猖獗等。前面提到过，干扰影响景观及其组分的空间和时间异质性，并影响其物种的相对多度。典型的干扰可以开辟空间，使得其它新的个体或种群乃至生态系统或景观得以建立。干扰发生后，环境资源异质性是增或减，取决于干扰的程度和范围，以及潜在的环境格局。在景观生态学中，干扰状况（Disturbance regime）这个术语通常意指，在整个景观中一段时间里所有干扰的分布、频率、恢复周期、面积大小、强度、严酷性（指对生物系统的影响）和协生性（指对其它干扰的引发作用）之总和。

二、景观生态学的研究内容

景观生态学是由生态学、地学、野生生物管理学和景观规划等学科衍生出来的一门新的综合性学科。当然，景观生态学也可以被视为生态学的一个新分支(Forman，私人通信)。景观生态学基本上是“研究景观是如何构成的，如何执行功能的和如何变化的”（Forman和Godron，1986）。它的思想和观点并不都是新的，因为许多类似的东西已存在于生态学和其它有关学科中许多年了。其新颖之处在于，在景观水平上，生态学研究的整体观以及许多本来缺乏联系的学科在解决景观问题上的综合。景观生态学具有如下独特之处：（1）它着重研究景观中空间异质性的发展、维持和管理；（2）它考虑整个景观，因此强调生态系统之间的相互作用；（3）它视景观为生物学谱系中高于生态系统的生物系统；（4）它将地理学在研究自然现象空间相互作用时的水平途径与生态学在研究自然现象功能上的相互作用时的垂直途径结合起来；（5）它提出并解决许多在其它低级生物组织层次上无法解决或不能有效处理的研究课题；（6）它把人类及其活动结合在生态学的研究中，并且对处于原始状态的景观和受人类严重影响的景观都能有效地开展研究；（7）它增强了生态学与公众和决策人之间的交流，与资源管理紧密相关，并为区域规划及其生态学评价提供理论基础。由于上述特点，景观生态学自然成为生态学的一个新概念构架，并“为资源与环境的规划和管理提供了统一的概念和方法论构架”（陈昌笃，1985，1986）。

景观生态学也可以被视为是一种研究途径，或者是一种思维方法(Zonneveld,1981)。Forman在谈到景观生态学的特点时指出，其新颖之处在于它看问题的出发点不同，提出的问题也不同（Forman，私人通信）。下面，我们将列举一些景观生态学的研究课题，以使读

者对景观生态学的研究特点有一个基本了解。这些课题将涉及景观的描述，景观生态学在环境保护生物学中的应用，以及环境资源管理等三个方面。此外，我们也将介绍一些美国景观生态学的研究实例，以说明如何去解决这些课题。

景观的描述和研究可以以其结构、功能和动态3个方面进行。要求从理论上探讨与此有关的许多景观问题。例如，地貌过程和干扰状况对拼块空间格局及其动态有何作用？环境异质性在景观的结构、功能和动态方面扮演什么角色？在一个区域内（如森林已基本被破坏的地区）景观动态格局及其生态学意义是什么？景观中拼块之间能量、养分、物种的流动和再分配的特点和格局是什么？其流动和再分配是如何进行的，流通量又是多少？人类严重干扰下的景观与自然景观之间在拼块特性（即类型、大小、形状、分布和动态等）方面有何差异等等。这些问题中，有许多至今还没有确切的答案。Forman和他的同事们对美国新泽西州的海岸平原松栎林景观的研究，是这类问题的一个研究实例（参见 Forman，1979）。Forman等人试图较全面地分析和描述这一海岸平原松栎林景观，其研究涉及：（1）人类的影响；（2）地质和土壤；（3）气候、水文和水生态系统；（4）植被格局；（5）植物；（6）动物。这是美国景观生态学最早的研究之一，尽管并非所有参与者都理解并在文章中运用景观生态学的观点。他们的工作也表明，景观生态学不仅要求各有关学科专家的协作，而且本身具有综合许多不同领域知识和信息的能力。此外，根据以往的生态学研究结果及我们的观察和初步研究，我们推断，在空间和时间上，特别是在不同人类干扰状况下，景观中的拼块格局也许会表现出明显的变异，景观的一些特性也许将遵循表1中所示的趋势。这是因为在不同条件下，景观中的决定性环境梯度和干扰状况是不同的。

景观生态学与环境保护生物学密切相关。它的研究成果可以直接用于环境保护生物学，而且许多环境保护生物学课题的研究，只能或最适合在景观这个层次上进行。这类课题的例子有：一个特定种的存活要求什么样的生境多样性镶嵌结构？自然保护区面积要有多大才能达到保护濒危种、维持物种和景观多样性以及自然干扰体制的目的？植物群落如何受环境异质性影响，而动物群落又是如何受它们二者的影响？边缘效应对拼块的内部结构和动物活动有何作用？边缘效应的规模有多大？如何在景观水平上维持种和生境的多样性？这些课题的解决之所以重要，是因为目前世界上多数国家的自然植被正以相当惊人的速度变为由农田、居民区或工商业用地所包围的“绿岛”（如在国家公园和自然保护区中的植被，这种变化的结果已使大量的动植物种濒于或已经灭绝。景观生态学的研究，将为解决这些难题提供理论基础、方法和策略。Harris对美国西部地区山地花旗松森林景观的研究，就是这方面探索的实例之一（参见Harris，1984）。他用山地花旗松森林景观做样板，研究了动植物群落的特性和森林变化的趋势和格局，并以此估价了岛屿生物地理学理论在资源管理中应用的可行性。

表 1　景观特性在不同人类干扰条件下的可能表现趋向

Table 1　The hypothetical trends of some characteristics of landscape under different human impacts

景观性状 Landscape feature		自然景观 Natural landscape		人类经营景观 Managed landscape	
拼块空间格局	Spatial pattern	不确定	Uncertain	均匀	Uniform
拼块平均面积	Average patch area	大	Large	小	Small
边缘总长度	Total edge length	小	Small	大	Large
拼块形状	Patch shape	不规则	Irregular	规则	Regular
动态速率	Dynamic rate	慢	Slow	快	Fast
景观连接度	Connectivity	高	High	低	Low
本地种多样性	Native species diversity	高	High	低	Low

他把着眼点放在如何保护现存的原始花旗松林，进而保护其中赖以生存的动植物种上。他建议把景观中原始花旗松林拼块看成人工林或其它人类主宰系统的“海”上的“岛屿”，然后，用岛屿生物地理学理论来指导，对其进行保护和管理的全面规划。他还由此提出一个具体的经营方案：对现存的岛状原始花旗松尽最大可能进行保护（即尽可能排除经营活动和人类干扰，并维持其面积）；在其周围建立实施弱集约经营的缓冲林带；将缓冲林带分为若干小区（根据采伐周期长短而定），使每一小区处于不同的森林发展阶段（即采伐林地、幼龄林、中龄林、近熟林等）。由此来达到既保护原始森林，又保证有一定的木材产量的目的。显然，Harris方案体现了多种经营的思想。此外，Harris的建议与国内林学界在森林经营上的“永续利用”思想有一定相似之处。

生态学，特别是景观生态学，是环境资源管理的理论基础。景观作为经营管理单位，也许比生态系统或单个的立地小区更为合适。景观生态学中涉及环境资源管理的课题举例如下：假如景观为人类活动所不停地改变的话，其后果将如何？随着模地在类型或连接度上发生变化，景观的其它组分及其特性将如何变化？森林破碎化（Forest fragmentation）对野生生物种有什么影响？河岸植被带应如何进行经营和管理，才能尽可能维持其在结构和功能上对景观其它组分的作用？如何比较全面地对经营活动进行生态学评价？……Franklin和Forman（1987）进行的森林采伐对山地花旗松森林景观的影响的研究，是景观生态学在资源管理方面应用的一个范例。Franklin和Forman运用景观生态学的观点，对花旗松林景观的结构特性随森林采伐而变化的趋势做了定性的评价和预测。通过使用“棋盘模型”（Checkerboard model）分析，他们提出了景观格局随森林逐渐采伐而变化的阈值，并对随之而产生的景观中干扰状况、物种多样性和狩猎动物种群数量的变化情况做了预测。根据理论分析的结果，他们对美国联邦政府农业部林务局在花旗松林区的采伐方法——交错安置皆伐地法（Staggered-setting system of clearcutting）——提出疑问。他们认为，尽管这种采伐方法有一定优越性（如易更新、易处理枝桠，易发展道路等），但是，由于经营目的和技术上的变化和森林破碎程度的逐渐增大，这种采伐方法在生态学和经济学上合适与否，值得重新研究。他们建议适当集中采伐作业区并扩大单位伐区面积，因为这不仅在经济上合算（可降低单位面积经营费用），而且在生态学上更为合理（有助于保护物种多样性，减小灾难性干扰的发生频率）。他们指出，景观生态学的观点和思想在资源管理中是极为重要的。另外一个值得一提的景观生态学在资源管理方面的应用，是其对林区的河流及其两岸植被的研究（如Swanson et al.，1982）。这是目前在美国很受重视的研究项目，大量和深入的研究工作已经完成或正在进行中。根据景观生态学的观点，河岸植被不仅是野生动物取食和栖居的主要场所和景观中重要的廊道成份，而且对河床结构、河流质地（如沉积物含量）及鱼类生境都具有巨大的作用。许多学者建议，应划出河岸植被保护带，在保护带中尽量避免采伐并且尽可能减少经营活动，以保护野生动物的生境并保护河水生态系统的功能和结构的稳定性。

应该指出，上文所介绍的景观生态学基本上是北美风格的，或者可以说是景观生态学的北美学派的观点。景观生态学仅仅是在最近几年才在北美得到理解和重视，它是在欧洲的景观生态学的基础上发展起来的，但与欧洲的景观生态学有显著的不同。景观生态学的概念和思想是首先在欧洲，而且开始是在地理学领域里形成和发展起来的（Naveh，1982；Naveh和Lieberman，1984；Forman和Godron，1986）。它的创始人一般认为是已故德国杰出地植物学家C.Troll（Troll，1971；Naveh和Lieberman，1984；Forman和Godron，1986）。Troll在30年代末40年代初就开始了景观生态学的研究，但是，景观生态学作为一个学科是在60年代形成的（参见Forman，1986）。从那时起，欧洲

的景观生态学家做了大量研究工作。根据其教育系统和研究系统的建立与发展现状，景观生态学在欧洲已是一门比较成熟的学科。对景观生态学的发展史的详细讨论，超出本文的范围。感兴趣的读者可参阅Naveh（1982）、Naveh和Lieberman（1984）及Forman和Godron（1986）等人的著作。一般认为，欧洲的景观生态学强调人类在景观中的作用，并且把人类视为景观的主要组分。它的研究重点主要是在景观（或区域）规划、建筑和管理以及土地开发政策的制定上，景观的美学特点和完全由人类控制的城市景观，也是其主要研究课题。景观生态学综合人类在景观中的动态作用的研究，正是Naveh和Lieberman（1984）所倡导的“总体人类生态系统”思想；这也许是景观生态学的一个很有希望的发展方向。可是，所谓“总体人类生态系统”除了要服从生物学（主要是生态学）规律以外，还要受到经济学、社会学、心理学及政治规律的制约。这要求自然科学与社会科学进行相当广泛的交流与综合，而这显然在目前条件下尚有一定困难。不过，北美景观生态学与欧洲景观生态学的差异已逐渐缩小，Dr.Forman和Dr.Godron的合作就是一个例证（Forman，私人通信）。

三、景观生态学的原理

景观生态学还没有成熟的理论体系。但是，前面介绍的景观生态学主要概念，实际上都是理论的雏形，都可能随着研究的深入而发展成为景观生态学的理论。此外，景观生态学在其形成和发展过程中，吸收了许多生态学和其它学科的现有理论，如生态系统理论、岛屿生物地理学理论、一般系统理论、地理学第一定律等等。这些理论可以说是景观生态学的基础理论。尽管景观生态学理论体系的形成还有待于研究的进一步深入发展，Forman和Godron(1986)已经根据他们对景观的结构、功能和动态的初步研究，提出了7条景观生态学原理。这些原理尽管还未被证实，还有待于检验和修正，但它们显然能够为我们规划和进行景观生态学研究提供指导。我们把Forman和Godron的7条原理引述如下：

（1）景观结构与功能原理　景观是异质性的，在物种、能量和物质于拼块、廊道及模地之间的分布方面表现出不同的结构。因此，景观在物种、能量和物质在景观结构组分之间的流动方面表现出不同的功能。

（2）生物多样性原理　景观异质性减小稀有内部种的多度，增加边缘种及要求两个以上景观组分（生境）的动物种的多度，并提高所有潜在种的共存机会。

（3）物种流动原理　物种在景观组分之间的扩张和收缩既影响景观的异质性，也受景观异质性的控制。

（4）养分再分布原理　矿质养分在景观组分之间的再分布速率随这些组分中的干扰强度而增加。

（5）能量流动原理　热能和生物量通过景观各组分之边界的速率随景观异质性的增加而增大。

（6）景观变化原理　在无干扰条件下，景观的水平结构逐渐向着均一性发展；中度干扰将迅速增加异质性；而严重干扰则可能增加，也可能减小异质性。

（7）景观稳定性原理　景观拼块的稳定性可能以3种明显不同的方式增加：①趋向于物理系统稳定性（以没有生物量为特征），②趋向于干扰后的迅速恢复（存在低生物量），③趋向于对干扰的高度抗性（通常存在高生物量）。

Risser等（1984）根据1983年在美国依利诺斯州举行的“景观生态学研讨会”的讨论结果，对景观生态学的概念、理论、研究方法和应用状况做了全面总结，同时对景观生态学的发展远景做出乐观估价。在这篇北美景观生态学的经典文章中，他们就景观生态学的思想核心发表了许多精辟且很有启发性的论述；其中一些被认为是景观生态学的原理（参见Risser，1987）。我们将Risser等的5条景观生态学原理转述如下（Risser et al.，1984；Risser， 1987）；

（1）空间格局与生态学过程之间的关系并不局限于单一的或特殊的空间尺度和时间尺度。

（2）对景观生态学在一个空间或时间尺度上的问题的理解，也许会受益于对格局作用在较小或较大尺度上的试验与观察。

（3）在不同的空间和时间尺度上，生态学过程的作用或重要性将发生变化。因此，生物地理过程在确定局部格局方面也许相对来讲是不重要的，但对区域性格局可能会引起主要作用。

（4）不同的物种和物种类群（如植物、食草动物、食肉动物、寄生物）在不同的空间尺度上活动（生存）；因此，在一个给定尺度上的研究对不同的物种或物种类群的分辨性可能是不同的。每一种物种对景观的观察和反应是独特的。对于一个种来说是同质性的拼块也许对于另一个种来说则是相当异质性的。

（5）景观组分的尺度是由具体的研究目的或确切的经营问题的空间尺度或大小来定义的。假如一个研究或经营问题主要涉及一个特定的尺度，那么，在更小尺度上出现的过程与格局并不总是可以被察觉的，而在更大尺度上出现的过程与格局则可能被忽略。

四、景观生态学的研究方法

新的、更有效的研究方法的设计与发展，对于每一门学科来说都是必需的。由于景观生态学是一门刚刚出现的学科，许多涉及其方法论的基本问题，仍需深入研究加以解决。例如，如何去定性和定量地描述景观？如何描述和分析景观中的空间格局？……为了解决这类问题，国际景观生态学会（International Association for Landscape Ecology，简称IALE）1984年曾在荷兰组织了一个以“景观生态学研究和规划中的方法论”为题目的学术讨论会（参见Brandt和Agger，1984）。与会者就景观生态学的研究方法问题提出了许多有意义的建议，并对许多具体方法进行了讨论。此外，许多目前正在进行中的研究，也还在探索有关的方法论问题。用于景观生态学研究中的方法，随研究对象的性质、研究的目的、条件以及研究人员的喜好而不同。最主要的数据收集途径是使用航空照片或其它遥感技术（Troll，1971，Brandt和Agger，1984；Naveh和Lieberman，1984；Forman和Godron，1986）。航片非常适用于景观生态学的研究，这一情况在其发展早期就已被认识到了。因为只有在航片（或卫星照片）上，人们才能获得景观及其中空间格局的完整图象。此外，有些参数（如各拼块的面积和边缘长度）是很难在地面上通过野外抽样取得，用航片测定则轻而易举。现将利用航片收集数据的一般程序简述如下：首先，通过航片判读将拼块等地面目标识别出来，加以分类，并勾画出其轮廓；然后，通过地理信息系统（GIS）将图表信息（即拼块的属性和拓朴学信息）转换成数字信息，并贮存在计算机里。地理信息系统由专门化了的计算机软件和硬件构成。它通常有4种作业功能：计算机制图、空间数据处理、空间统计学计算及制图模造（参见Berry，1986）。景观生态学研究的一个最显著特点是，其结果大都包括各种类型的图。从这个角度上看，许多景观生态学的研究必须借助于地理信息系统。由于生态学家对空间格局（特别是景观水平上的空间格局）的确定表现出极大的兴趣，地理信息系统在生态学研究中的应用将越来越多。

景观生态学的另一个主要抽样方法是从已有的各种图（如经营管理图、土壤类型分布图、植被分布图、地型图等）上获取所需要信息。这种方法实际上是前面所提方法的变型（即没有航片判读部分）。它的优点是简易且能够有效地利用前人的研究成果；它的缺点是受原图精度的影响，且所得数据的精确度常常是未知的，不过这对景观生态学研究通常影响不大。在需要较详细信息的情况下，野外实地抽样方法将被使用，其中包括动物生态学中用来确定动物在景观上运动情况的无线电遥测法。

景观生态学中的数据分析方法是多种多样的，其中特别值得一提的是空间格局分析。空间格局分析在景观生态学研究中十分重要，因为空间格局是我们最感兴趣的景观特性之一。在以往的文献中（如Brandt 和 Agger, 1984；Cliff和Ord, 1981；Cormack和Ord, 1979；Gauch, 1982；Diggle, 1982；Greig-Smith, 1983；Matheron, 1963；Pielou, 1969, 1977；Webster, 1985；Whittaker, 1980），已有许多空间格局分析方法被提出、使用，证明是有效的。我们将这些方法总结归纳如下：（1）作图法，这是一种传统的描述空间格局的方法，可以将感兴趣的景观属性在二维或三维空间上展现出来，人们可以直接观察到系统中的空间变异情况。（2）概率分布法，这是一种在生态学研究中曾被广泛使用的方法。它的思想是用某个理论分布（如波松分布、负二项式分布、奈曼A型分布等）去拟合样本频率数据，然后用x^2拟合优度检验的结果来表明空间格局是否服从某个理论分布。（3）指数法，这种方法是描述性的，简单且具有可比较性。所用指数通常被设计用来度量团聚性或对随机性的偏离程度（如Lloyd的镶嵌性指数）。（4）空间相关法，通常用于地理学研究，可在图上直接、详细地度量空间格局（包括点格局分析法、线格局分析法、面格局分析法，各种自相关分析法等等）。（5）地统计学法，这类方法应用区域化变量理论来研究自然现象的空间相关性和依赖性。它可定量描述空间变异，并可用来计算空间插值及设计合理的抽样方法。其最显著的特点是摈弃了经典统计学的样本空间无关的假设，而考虑变量的空间相关性，这是一类在景观生态学研究中很有潜力的方法。（6）图论，这种方法是用抽象的网络图解来分析景观空间格局的性质。其它方法，如模拟法、常规统计学法、渗透理论（Percolation theory）等，也都可用于景观生态学的空间格局分析。

五、景观生态学研究展望

随着人类社会经济的发展，人类对资源的需求日益增大。因此，如何合理地开发、利用和管理现有资源，特别是如何科学地经营可更新资源（如动植物、水等），已成为各国政府和科学工作者所面临的急待解决的任务之一。然而，传统的生态学各分支对这种大范围生物系统的研究和管理，表现出明显的局限性。在这种情况下，景观生态学应运而生。

景观生态学是生态学的一个新分支。它为生态学提供了一个新的概念构架和新的研究途径。景观生态学有许多引人注目的特性，如它强调空间异质性，考虑生态系统之间的相互作用，视景观为比生态系统更高级的生物系统，在环境资源的保护与管理方面有很高的应用价值，可以解决生态学其它分支所难以解决的课题等等。景观应该作为一个整体单位来进行思考、研究和管理。显然，在理论生态学和资源管理方面，许多基本问题的解决要求人们对景观生态学思想的理解和应用。景观生态学的重要性也恰在于此。景观生态学的形成和发展，是生态学研究中的一个有意义的进展。

景观生态学是一个广阔的领域，几乎所有学者都可以参予其研究，因为其研究课题与生物科学、地学乃至社会和经济学科都有联系。所有这些有关学科的有机结合，是景观生态学得以进一步发展的关键所在；但是，由于这些学科的传统性分离，要做到这一点困难是很大的。因此，各方面专家学者之间的协作对景观生态学来讲是必需的，而培养教育出一代新的景观生态学家也势在必行。景观生态学应该发展成为具有严密的假说和有效的假说检验方法的一门学科，成为连接理论生态学和环境资源的保护与管理的桥梁，并促进生态学的进一步发展。

景观生态学将是在今后10年里蓬勃发展的学科之一，也许还会在将来成为生态学研究的主流之一。我们引用R.T.T.Forman的一段话来作为本文的结束语：“景观生态学的丰富的实验、理论研究和应用就在我们面前。原理在等待着富有求知欲的人去发现，理论研究与环境及人类社会难题的解决之间隔应该缩短，展

望未来，让那些热情的年青人去思考景观吧！”

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我愿借此机会向读者推荐李哈滨等这篇综述性的文章。生态学是一门快速发展的学科，新的概念、新的理论、新的分支不断涌现。景观生态学是近年来出现的最引起注意的分支之一。对这门新的生态学分支国内尚缺乏较全面的、系统的介绍。广大读者都希望扼要地了解它的基本概念、主要理论和研究方法，李哈滨等的这篇文章，在一定程度上满足了这个要求。

景观生态学虽然在欧洲大陆已有约50年的历史，但蓬勃发展，特别是在北美的发展是1980年以后的事。所以它是一门正在形成，内容还不很固定的学科。就目前已出版的几本以《景观生态学》命名的英文专著来看，它的研究对象是地面景观（生态系统的镶嵌）的结构、功能和动态。相当于“区域生态学”（regional ecology），和我所理解的“地生态学”（geoecology）有一定差别。景观生态学强调景观的空间格局分析，地生态学的重要内容如生态指示、生态监测与预测、生态影响评价等没有被包括在内。所以地生态学的范围比景观生态学要广。我认为地生态学可以包括景观生态学，而景观生态学不能包括地生态学。当然，如上所述，景观生态学尚未定型，尚在发展之中，将来二者也许会趋于同一。

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