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## Disturbance and fragmentation in landscape ecology

<sup>1</sup>Marzieh Imani and <sup>2</sup>Iman Sayah

<sup>1</sup>Master of Architecture, International University of Imam Khomeini, Qazvin, Iran.

<sup>2</sup>Master of Architecture, Tarbiat Modares University, Tehran, Iran.

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### ABSTRACT

The paper tries to explain the landscape ecology. As there are various disciplines in this vast field, the research has focused on the disturbance and fragmentation which are most popular concept in landscape ecology. At first terminology is exemplified and initial characterization of landscape is considered precisely. Then the history of landscape ecology and its very basic roots are considered as a baseline for the research. Then it comes to the Landscape ecology theoretical framework and the scientific methods are continuously challenged to provide a comprehensive basis for this discipline. Explaining the definition of commonly used terms in landscape ecology is the next step that has been declared within the text. Since Landscape ecology application seems to make a substantial part of the paper, it has been included too while the final part has been dedicated to describing fragmentation and disturbance in landscape ecology, which has been the aim of the paper to investigate.

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## INTRODUCTION

Landscape ecology, as the name implies, is the study of landscapes; specifically, both the composition, structure and function of landscapes. The question is what landscape is? Although there are myriad ways to define 'landscape' depending on the phenomenon under consideration, it is better to state that a landscape is not necessarily defined by its size; rather, it is defined by an interacting mosaic of elements (e.g., ecosystems) relevant to some phenomenon under consideration (at any scale). Thus, a landscape is simply an area of land (at any scale) containing an interesting pattern that affects and is affected by an ecological process of interest. Landscape ecology, then, involves the study of these landscape patterns, the interactions among the elements of this pattern, and how these patterns and interactions change over time. In addition, landscape ecology involves the application of these principles in the formulation and solving of real-world problems.

Scientists have observed and described heterogeneity "complexity or variability in a system property of interest in space and time". (Li & Reynolds, 1995, 280–84) in ecological systems for a very long time. However, an explicit focus on understanding spatial heterogeneity—revealing its myriad abiotic and biotic causes and its ecological consequences—emerged in the 1980s as landscape ecology developed and spatial data and analysis methods became more widely available. Since then, progress in landscape ecology has been substantial and rapid, and its concepts and methods are now widely used in many branches of ecology. Landscape ecological approaches are not limited to land, but are also applied in aquatic and marine ecosystems (Ward et al. 2002, 33–45). As mentioned based on the situation we consider, the landscape would be defined and it is all about the interaction of elements. The landscape has mutual role, affecting other things and being affected by ecological processes.

On the other hand Literature on landscape change and habitat fragmentation is so large and complex. This research provides an over view of this realm by the different parts encompasses by it. The term "habitat fragmentation" is losing its meaning because it is frequently used as an umbrella term for a wide range of interacting process, including habitat loss, the subdivision of remaining habitat, an increase in edge effects, and altered species interactions or ecological process. In essence, there are multiple processes group under the term "fragmentation," and there are multiple consequences of those processes; thus it is difficult to determine which consequences relate to which process. All of these have made the study of "fragmentation" a "panchreston". (B. Lindenmayer & Fischer, 2013,p.2 ).

To describe the disturbance, we should add that Natural disturbance occurs in a wide variety of biomes, affecting both animals and plants, thus disturbance deals with biotic and vitality.

**Corresponding Author:** Marzieh Imani, Master of Architecture, International University of Imam Khomeini, Qazvin, Iran.

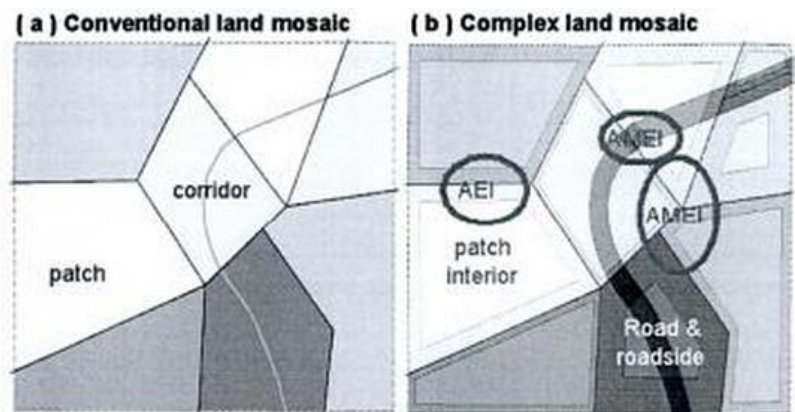
The subject of disturbance is an element generated by landscape. How a particular event may alter a system or affect the distribution of resources and the distribution and coexistence of species in an area will be greatly influenced by the nature of the landscape. Landscape may be divided into elements generated by topography, substrate conditions, organisms (including people) or disturbance; and the topographic heterogeneity of a landscape may have major significance in defining disturbance regimes. (A. Pickett & White, 1986, p.382).

### 1. Terminology:

Landscape ecology, examines the causes and consequences of the spatial heterogeneity (or patchiness) of all elements of the landscape, across a range of spatial scales. It consists of examination of composition, structure, function, and the dynamics of the landscape; it considers the interaction between spatial patterns and ecological processes. This usage emphasizes the process or functional aspects of landscapes. Landscape ecology differs from traditional scientific approaches in that it tends to focus study at greater spatial extents than traditionally examined, and the goal of understanding linkages among processes and spatial patterns is explicit. The importance for ecological understanding of defining ecological levels of organization, and physical temporal and spatial scales of study appropriate to those levels, is overt and challenging in ecological work. As with definition of term landscape, definitions of landscape ecology and its characteristics have varied through its evolution as an ecological discipline. Ultimately, the goal of landscape ecology is to increase scientific understanding within three basic problem areas: the heterogeneity of systems, the role of scale, and the effects of heterogeneity and scale among organisms and ecosystems.

The approach to delimiting of the structure and function of the landscape, initial characterization of landscape considered patches, corridors and the matrix. Definition of all of these elements will vary within the same spatial extent, dependent on study objectives and thus, classification scheme. For example, the matrix could be that element that is most extensive based on internal structural features, or the element expected to dominate function due to its role in a process such as energy or material flow across the land scape. Further, delineation will vary with grain or (resolution) of analysis. Increasingly areas can have a dominant influence (AEI) on flows among other landscape components (Figure 1). The difficulties of delineating and assessing the functional edges are never realms of study for landscape ecologists. (Chen, 2006, p.7).

Understanding the terminology leads us to a more important factor which always plays an important part and is of very importance in the scientific research, the "history". History of the landscape ecology determines where for the first time this word combination has been started to be recognized as a scientific debate in realms focused on landscape.



**Fig. 1:**

### 2. History:

As with many of natural sciences, the study of landscapes had its origins in the nineteenth-century scientific explorations of Africa and sound America by Europeans and in the mapping and resource surveys of the American west. Although the primary aim was to describe and categorize different environments and vegetation types, some attention also given to the environmental determinants and consequences of human occupancy of these places. Some of these early natural scientists also began to seek underlying principles to explain the broad scale spatial variations in environments and the distributions of plants and animals. As recognizable scientific disciplines began to emerge from these beginnings, landscapes came to be viewed from several largely independent perspectives. Moreover, because these disciplinary approaches to landscape adopted different objectives in different parts of the world, the roots of modern landscape ecology, therefore, varied. Nonetheless, four major cornerstone themes of this diver's foundation can be identified. (Wiens, 2007, p.5)

The first approach was biophysical on which was based on soil science and geography, the second one included the topics about the development of rapid landscape interventions which deal with physical geography,

the third category belongs to cultural/historical geography subjects. The fourth one is a biological based approach that emerged from biology.

In the mid-1980s, when interest in landscape ecology began to flourish, the curious could begin their journey with Naveh and Liberman (1984), Forman and Gordon (1986), Zonneveld and Forman (1990), Forman (1995), Farina (2000 a and b), and Turner et al. (2001). In the interim since these titles were issued, the knowledge base in landscape ecology has greatly expanded. Today, the substance of the literature includes scientific discovery in landscape ecology; methodologies for landscape description, analysis, and synthesis; and the application of the science for landscape-use management, planning, and design. Coulson, Robert Norris & D. (Tchakerian, 2010, p.7).

### 3. Landscape ecology theoretical framework:

Landscape ecologists have been continuously challenged to provide a comprehensive basis for this discipline. Some broadly theoretical organizations derive methods that have capacity to be tested and concepts that could be explored. This kind of formulation would fill a gap between theoretical and empirical knowledge and would offer how and where landscape ecology could be linked to the other disciplines to name conservation ecology.

Central questions to achieve this type of formulation were outlined about twenty years ago by Risser et al. (1984) These authors noted that the advancement of the landscape ecological field was dependent on the generation of fundamental concepts regarding cross-scale relationships, comparisons of systems that were relatively more and less altered by humans, and linkages between processes at different levels of ecological organization. Many of these principles refer to interaction between a specific pattern (e.g., arrangement of landscape elements) and a process (e.g., energy flow, species movement). There was recognition of the role of pattern in understanding the temporal dynamics of a landscape and the concept of metastability. There was also an emphasis on the role of humans in modifying patterns of landscape elements and altering the processes that modify landscape. However, no general, encompassing concept of relationship between pattern and process was included. (Chen, 2006, p.195)

There are different theories in landscape ecology. To describe all of them, the research requires a vast individually focus regarding the subject. To name the most important theories briefly, we can address the hierarchy theory, the percolation theory, the metapopulation and the sink-sources models for the primary ones.

Considering the increasing interest of scientists and practitioners in the landscape there are other paradigms and theories in order to complete the scenario of a landscape ecology that is moving toward a "science of landscape". Complexity, information, cognition, autopoiesis and semiotics are the additional paradigms that have to be considered for a better understanding of the landscape as a gestalt entity. (Farina, 2006, p.53)

### 4. Definition of commonly used terms in landscape ecology:

**Configuration:** specific arrangements of spatial elements; often used synonymously with spatial structure or path structure.

**Connectivity:** spatial continuity of a habitat or cover type across a landscape.

**Corridor:** relatively narrow strip of particular type that differs from the areas adjacent on both sides.

**Cover type:** category within a classification scheme defined by the user that distinguishes among the different habitats, ecosystems, or vegetation types on a landscape.

**Edge:** breaking up a habitat or cover type into smaller, disconnected parcels.

**Heterogeneity:** quality or state of consisting of dissimilar elements, as with mixed habitats or cover types occurring on a landscape; opposite of homogeneity, in which elements are the same.

**Landscape:** area that is spatially heterogeneous in at least one factor of interest.

**Matrix:** background cover type in a landscape, characterized by extensive cover and high connectivity; not all landscape have a definable matrix.

**Patch:** surface area that differs from its surroundings in nature or appearance.

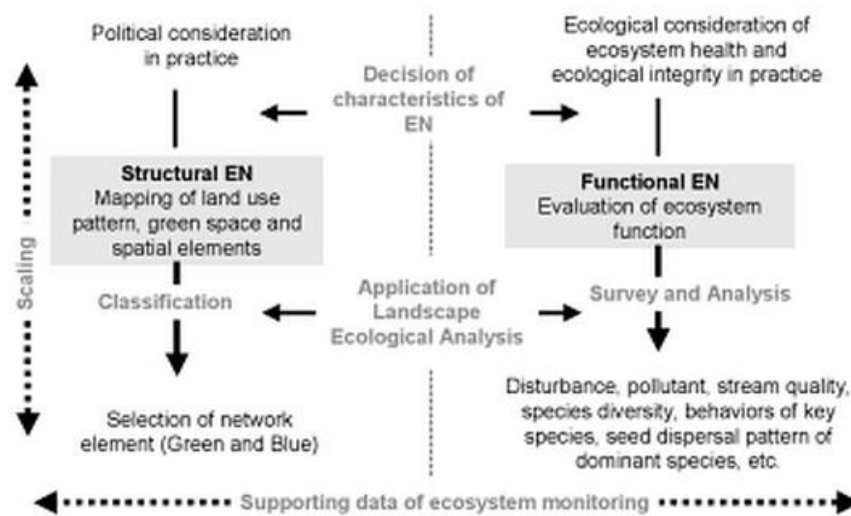
**Scale:** spatial or temporal dimension of an object or process, characterized by both grain and extent.

(G. Turner, 2001, p.3)

### 5. Landscape ecology application:

The application of landscape ecology and also itself are playing an important role in the world of ecologists and can be considered as their disciplinary baseline. Within the last century of ecology, ecologists tried their best to make a linkage between two important or in other word the term is composed of two categories: sustainable development and nature conservation in land use practice. There is here a case of importance which any kind of effort to understand the interactions between landscape change and ecological process, is recognized as the primary goal of ecology. Any kind of reason or the relatively consequence of landscape change in crowded and populated areas are undoubtedly related to human impacts in accordance with the fast pace of urbanization and land transformation. Accordingly applying landscape ecology to ecological solution in the

areas where are influenced by the existence of humankind has become an emerging issue for ecologists.



(Hong & Hong, 2007, p.511)

**Fig. 2:**

There are five categories which define the application of landscape ecology:

The first one is Landscape ethics and the notion of sustainability and to explain more, we can add that the language game of landscape ecology entails several action – guiding verbs like “ promote”, “ enhance”, “ restore”, “ preserve”, “safeguard”, “ ensure”, “ upgrade” to name just a few. They are closely related to conceptions of what should be done. Due to this evaluative and protective character of landscape ecology and due to its connectivity with evaluations, planning and decision making it seems urgent to add philosophical and ethical considerations to overall Trans disciplinary research program of landscape ecology. Due to multi-facetted concept of landscape these considerations should be performed in a more reflective way. It is quite trivial to say that humans are responsible for the regions they inhabit since they are designing and planning of how to modify landscapes according to their objectives and values. The notion of responsibility is intrinsically related to values, obligations, and principals which are debated in ethics. The other four scopes come in this order: landscape planning, assessment of Environmental impact, landscape and agricultural issues, mutual interaction of landscape and tourism. (Bastian, & Steinhardt2002, p.307)

#### 6. Disturbance and fragmentation:

The island biogeography theory of MacArthur and Wilson, which describes habitat isolation and consequent species responses, brought a substantial degree of rigor to landscape ecology with respect to inter-patch organism dynamics. This theory spawned the most popular topic of landscape ecology, habitat fragmentation; that is, the degree to which landscapes are composed of small patches isolated from others of their type. Concepts associated with fragmentation include “ecotones”, or patch boundaries; “metapopulations”, or populations of populations; and “corridors”, or paths by which flow can occur among patches. These topics remain the most studied aspects of landscape ecology.

Many topics other than landscape fragmentation have gain popularity since the mid-1980s. These include landscape disturbances, post-disturbance changes, and ecological flows. The latter refers to the physical movement of biological and non-biological materials within landscapes. ( H.Perere & L.Euler, 2011, pp.4-12)

#### 6.1. Fragmentation:

The term habitat fragmentation has now been used so broadly in conservation biology that the meaning intended by its original usage has become somewhat ambiguous. Habitat fragmentation denotes a particular special process of land conversion. In the strict sense of the word, fragmentation refers to breaking a whole into smaller pieces while controlling for the changes in the amount of habitat. (K. Collinge, 2009, p.1921-2)

The breaking up of a habitat, patch or land type into smaller parcels and/or the dissection of them with roads or similar is usually called fragmentation. Normally fragmentation is considered as a negative process in landscape ecology, because: (1) it generates the loss of species (specially animals) more dependent on the size of patches, (2) it greatly disturbs species with a high standard habitat (low density species), (3) it produces an increase of alien species, especially in human landscapes, (4) it deals more isolated populations toward an inbreeding depression.

According to Forman et al. (1976) the demonstration of species loss due to fragmentation was done by observing the species number in large forested patch, which is higher than in the same area composed of a set of smaller patches. (Ingegnoli, 2002, p.93)

In other word land scape has thresholds at which ecological process will show dramatic qualitative changes, this changes have important implication for nature conservation and territorial planning. This could be the case of habitat fragmentation, which may progress with little effect on a population until the critical pathways connectivity is disturbed. (Ingegnoli, 2002, p.10)

Habitat loss and fragmentation easily can interact with other environmental factors to cause harmful effects on different species and ecosystems. Another factor to name could be overexploitation that strongly influences changes in landscape, the reason is that hunters have more easily access to these fragmented habitats or there is a chance of existing habitats that have been bisected by roads. Fragmentation also limits the migration of various species in response to climate changes. These kinds of challenges interact with and are ultimately affected by patterns of how the land uses changes.

The term habitat fragmentation has now been used so broadly in conservation biology that the meaning intended by its original usage has become somewhat ambiguous.

### 6.2. Disturbance as an indicator:

Ecosystem functioning may be reduced in efficiency due to human disturbance, especially in highly dynamic systems like rivers, coastlines, and high mountain slopes. Disturbance may be a good indicator and a landscape can be classified as undisturbed, highly disturbed, moderately disturbed, or heavily disturbed.

These categories must be considered as “fuzzy set” and relative to the regional context in which the landscape is embedded. The level of disturbance from human activity can be measured by human population density, length of roads and other linear barriers, fossil energy involved in the productive system, quantity of chemical products in agriculture, quantity of fertilizers spread on fields, level of environmental noise from traffic or other activities, amount of logged biomass, amount of computerized services, etc.

Invasion seems a relevant process both in disturbed and undisturbed ecosystem. Invaders (plants, animals, bacteria and virus) have deep effects on the functioning of a system thus they are ideal and indicators.

Invaders can interact with the physical forces of disturbance like fire, erosion, or biotic disturbance.

Grass invasion can facilitate fire regimes due to newly available un-decomposed biomass acting as a fuel load. We have several examples from abandoned field on most of the European uplands. In other cases, the presence of invaders can reduce fire frequency due to the thickness of canopies and reduction of the fire prone grass layer.

When an invader occupies a highly dynamic system, for instance steep slopes, and has a weak root system, the slope may be exposed to rapid erosion processes which are more severe than natural conditions. In other cases, for instance in Mediterranean Europe, the utilization of black locust to consolidate, reduces the natural dynamics of the system with no clear stabilizing effects.

Large and medium size mammals can produce severe changes in disturbance regimes by a combination of trampling, biomass removal and manure deposition. Many studies have focused on the effects on rare or endangered plants but scant information is available on the changes in disturbance. For instance, the removal of the grass understory by grazing alters the nutrient retention causing an increase in decomposition of soil organic matter. New evidence is required because the alternation of disturbance regimes by invaders has not been described enough and many effects are far from being fully understood. (Farina, 2000, p.128)

As it is obvious human beings can affect the ecosystem around them and it has several reasons. We are responsible for the natural ecosystem surrounding us. Different level of disturbance addresses the various affects we have caused; Even though this level has a relation with the regional context. On the other hand as mentioned population density is the determinant which can use as a verification method for the level of disturbance.

Landscape ecology recognizes the dynamic nature of landscape, sometimes described as a shifting mosaic, change in the spatial pattern of landscape occurs by disturbance (destruction of vegetation) and the gradual change in the structure and composition of ecological communities by succession. However, succession may be prevented in intensely managed or developed areas. Disturbance can be natural or anthropogenic, and it usually results in some change to the vegetation in the disturbed area. The ecological structure seen today was produced by past ecological process, including disturbance. Obviously, the structure, function and disturbance of the present are forming future ecological systems. Changes in the pattern of vegetative communities have consequences on ecological phenomena such as dispersal, energy and nutrient flows, and faunal community composition. Community dynamics are essential to the functioning of healthy ecosystems because all species require late-successional habitat, many other species depend on recently disturbed habitat. Managing community dynamics to provide a continuous supply of this variety of habitat conditions is a complex challenge.

Disturbance has two primary effects on vegetative community: it may change the relative abundance of community types and successional stages and the spatial configuration ( just a position and the scale of patchiness) of those communities across a landscape.

*Conclusion:*

Landscape ecology includes four different approaches: biophysical, landscape interventions, cultural/historical geography and biological based approach. Ecologists consider two main field consisting natural conservation and sustainable development in landscape ecology. Since the habitat fragmentation deals with the conservation biology scope, this part of landscape ecology analyzes the process of land conversion, thus analytically, habitat fragmentation follows simultaneously biological based and landscape interventions approach. On the other hand disturbance occurs when human activity, invasion or mammals influences affect the landscape. Disturbance individually is composed of two main branches: natural and anthropogenic subcategories. The latter one is related to the cultural/historical geography approach as well as Habitat fragmentation which contain this approach.

**Table 1:** habitat fragmentation and disturbance approaches in landscape ecology

Habitat fragmentation and disturbance approaches in landscape ecology						
Habitat fragmentation				disturbance		
Landscape interventions	Biological	Cultural/historical geography	-	-	-	Cultural/historical geography

**REFERENCES**

- Lindenmayer, B., David and Fischer, Joern, 2013. Habitat Fragmentation and Landscape Change: An Ecological and Conservation Synthesis, Island Press.
- Bastian, O and Steinhardt, Uta (Ed.), 2002. Development and Perspectives of Landscape Ecology, Springer Science & Business Media.
- Chen, Jiquan, 2006. Ecology of Hierarchical Landscapes: From Theory to Application, Nova Publishers.
- Coulson, Robert Norris & D. Tchakerian, Maria (2010). Basic Landscape Ecology, KEL Partners Incorporated.
- Farina, Alberto, 2000. Landscape Ecology in Action, Springer Science & Business Media.
- Farina, Almo, 2006. Principles and Methods in Landscape Ecology: Towards a Science of the Landscape, Vol. 3. of Landscape Series Springer Science & Business Media.
- Turner, G., Monica, 2001. Landscape Ecology in Theory and Practice: Pattern and Process, Gardner, Robert H. & V. O'Neill, Robert (Ed.), Springer Science & Business Media.
- H. Perere, Ajith and L. Euler, David, 2011. landscape ecology in forest management: an introduction, in Ecology of a Managed Terrestrial Landscape: Patterns and Processes of Forest Landscapes in Ontario, H.Perere, Ajith & L.Euler, David & D. Thompson, Ian (Ed.), UBC Press.
- Hong, Sun-Kee and Hong, Sön-gi (Ed.), 2007. Landscape Ecological Applications in Man-Influenced Areas: Linking Man and Nature Systems, Springer Science & Business Media.
- Ingegnoli, Vittorio, 2002. Landscape Ecology: A Widening Foundation, Springer Science & Business Media.
- Gustafson, J. Eric and Diaz, nancy, 2002. landscape pattern, timber extraction and biological conservation, in Applying Landscape Ecology in Biological Conservation, Gutzwiller, Kevin (Ed.), Springer Science & Business Media.
- Collinge, Sharon K., 2009. Ecology of Fragmented Landscapes, contributor: Richard T. T. Forman, JHU Press.
- Li, H and J.F. Reynolds, 1995. On definition and quantification of heterogeneity, Oikos, 73.
- Pickett, T.A., Steward and P.S. White, (Ed.), 1986. The Ecology of Natural Disturbance and Patch Dynamics, Academic Press.
- Ward, J.V. and F. Malard and K. Tockner, 2002. Landscape ecology: a framework for integrating pattern and process in river corridors, Landsc. Ecol., 17(Suppl.): 35-45.
- Wiens, John A., 2007. The Early Antecedents of landscape ecology, in Foundation Papers in Landscape Ecology, Columbia University Press.