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Review of the Role of Landscape Approach in Biodiversity Conservation: Corridors, Patches and Matrix

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Abstract
Achieving global conservation goals requires that realizations, agreements, and directives be customized to reach all levels. In the context of the Convention on Biological Diversity, this means that approaches to conserving biological diversity must be developed at the local landscape level to support national implementation of the Convention. The main objective of this paper was to review the basic role of landscape in conserving biodiversity. To achieve the goal, different articles and books were referred. As it was reviewed, the three elements of landscape namely corridors, patches and matrix contribute pivotal roles in conservation of biodiversity as they facilitate mobility, particularly, for wild animals. In recent years, protected area management has evolved from a species-based conservation approach to a livelihoods-based landscape approach. A landscape approach to conservation offers significant benefit. It is impractical to plan and implement conservation for all species and their habitat requirements at different landscape scales. Many places around the world are considering how to simultaneously improve local livelihoods, meet national-level development needs, and achieve conservation goals on urgency as current decisions are paving the future pathway for people and biodiversity in landscapes. This is because, landscape approaches seek to provide tools and concepts for allocating and managing land to achieve social, economic, and environmental objectives in areas where agriculture, mining, and other productive land uses compete with environmental and biodiversity goals. Therefore, landscape approaches should gain prominence in the search for solutions to reconcile conservation and development tradeoffs.
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Introduction

Achieving global conservation goals requires that realizations, agreements, and directives be customized to reach all levels. In the context of the Convention on Biological Diversity, this means that approaches to conserving biological diversity must be developed at the local landscape level to support national implementation of the Convention. In recent years, protected area management has evolved from a species-based conservation approach to a livelihoods-based landscape approach (Sharma *et at.*, 2007). The shift in the conservation paradigm has been gradual, and has included acceptance of communities as an integral part of national level conservation initiatives, together with integration of many global conventions and directives. Scaling up conservation across larger landscapes, as facilitated by most global conventions, involves cooperation at various levels. Landscape ecology incorporates conservation and human dimensions to create a sustainable and harmonized living environment (Johns, 2004).

A landscape approach to conservation offers significant benefits (Lindenmayer, 2009). 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. It is impractical to plan and implement conservation for all species and their habitat requirements at different landscape scales. Many places around the world are considering how to simultaneously improve local livelihoods, meet national-level development needs, and achieve conservation goals on urgency as current decisions are paving the future pathway for people and biodiversity in landscapes (DeFries *et al*, 2016). Landscape approaches seek to provide tools and concepts for allocating and managing land to achieve social, economic, and environmental objectives in areas where agriculture, mining, and other productive land uses compete with environmental and biodiversity goals (Sayer *et al,* 2012). Landscape approaches have gained prominence in the search for solutions to reconcile conservation and development tradeoffs.

Landscape ecology shares focus on places, albeit from a different perspective. To a landscape ecologist, the places (or habitats) that so interest conservationists are elements in a larger landscape mosaic (Lindenmayer, 2009). It is the structure, spatial configuration, and context of these places, and the ways in which these influence ecological processes and undergo change, that landscape ecologists find fascinating. The two disciplines also share a common challenge. We live in a world of burgeoning human populations, rampant development, and erosive exploitation of natural resources, all driven by the legitimate desires of people for a better life. To conservationists, the goal is to find ways to maintain biodiversity, by targeting and prioritizing places for protection or conservation management and by advocating sound environmental policies (Wiens, 2008). To landscape ecologists, the goal is to use an understanding of landscape patterns and processes to design and manage land use in ways that promote the well-being of people and nature. Both aim to enhance the sustainability of landscapes, for biodiversity and people.

Walz, (2011) stated that the type of land use and the pattern of the landscape, the matrix, and also the arrangement of individual patches and their relative positions are crucial for the conservation of biological diversity. Future land use changes will have one of the biggest influences on biodiversity. The conservation of land use patterns is therefore of great importance in species protection. Biodiversity conservation through landscapes incorporate the ecosystems approach while facilitating integration and networking of regional protected areas. This approach is an evolving process for international collaboration in managing and sharing experiences and information in biodiversity conservation and sustainable use. It is also an effective tool for conserving biodiversity, for strengthening collaboration, and for collective measures to harness environmental services across landscapes (Sharma *et at.*, 2007).

Landscape diversity is also important because of its relationships with the impacts of habitat fragmentation. Thus, heterogeneity is likely to provide more living space for plants and animals except for core specialist which are rarely if ever found outside larger undisturbed habitat fragments. Managing the landscape (i.e. the matrix) to increase its suitability as habitat and increase its permeability to movement (i.e. re-establish/maintain connectivity) may significantly complement species otherwise restricted to Protected Areas and (parts of) the Permanent Forest Reserve (Lindenmayer, 2009;Malaysia Ministry of Natural Resources and Environment,2009).

A landscape is a heterogeneous area composed of a cluster of interacting ecosystems that are repeated in various sizes, shapes, and spatial relationships throughout the landscape. Landscapes have different land forms, vegetation types, and land uses (Barnes, 2000; Lindenmayer, 2009). Another way of looking at a landscape is as a mosaic of habitat patches across which organisms moves, settle, reproduce, and eventually die and return to the soil. The best way to envision a landscape is to look at the land from an aerial perspective or to examine aerial photographs to see how a particular piece of land fits into the larger picture. Landscape ecology is concerned with structure, function, and change in a heterogeneous land area composed of interacting ecosystems (Barnes, 2000). It is an interdisciplinary science dealing with the interrelationship between human society and our living space. A landscape consists of three main components: a matrix, patches, and corridors. These components and their interrelationships play critical roles in better management decisions of biological diversity at the landscape level (Lindenmayer, 2009).Biodiversity, ecosystem functions, and human activities, all take place in landscapes. Landscape fragmentation profoundly alters ecological and socioeconomic processes. Thus, the importance of applying landscape ecological principles in biodiversity conservation and sustainable development have been increasingly recognized (Wu, 2015).The main objective of this paper is, therefore, to review the role of landscapes in conservation of biodiversity.

Landscape Elements and their Contributions in Biodiversity Conservation

Landscapes are composed of elements- the spatial features that make up the landscape. A convenient and popular model for conceptualizing and representing these elements is known as the ‘patch-corridor-matrix model (Lindenmayer, 2009). Under this model, for instance, the three major landscape elements are typically recognized, and the extent and configuration of these elements defines the pattern of a given landscape (Malaysia Ministry of Natural Resources and Environment, 2009).Generally, these three elements characterize landscapes and have their key roles in conservation of biodiversity (Hilty *et al*, 2006).

Patches are relatively homogenous non-linear areas that differ from their surroundings and serve to conserve biodiversity, natural ecosystems, ecological processes, and ecosystem services (Lindenmayer, 2009). Corridors are narrow, linear features of a patch type that differ from those on either side. Matrixes are landscape areas not designated primarily for conservation of biodiversity, natural ecosystems, ecological processes, and services (regardless of their current condition as natural, modified or man-made).

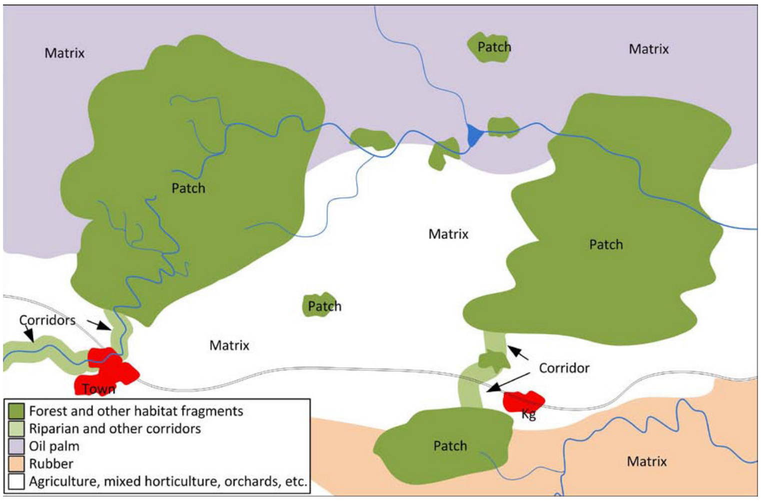

Figure1. The three elements of landscape
Source: Malaysia Ministry of Natural Resources and Environment, 2009

In the context of supporting planners, decision-makers and practitioners acting on landscapes from national to regional and local levels, the generalization adopted here is that patches and corridors typically represent habitat and dispersal pathways for a broad variety of species (plants and animals) (Sharma *et at*, 2007).Nevertheless, it is important to keep in mind that definitive patch and corridor suitability must ultimately be based on the habitat requirement, movement patterns, and other attributes of the organism of interest. Additionally, the scale of the matrix will vary according to the organism or ecological process under examination and may vary from, say, the area made up by a small patch of forest to an entire region (Lindenmayer, 2009).

Maintaining species in large Protected Areas and in the matrix is only possible by maintaining suitable habitat elsewhere and at multiple spatial scales. This is at the very core of any comprehensive planning for (forest) biodiversity since Habitat loss is the primary factor influencing species loss; Different species perceive habitat over a range of spatial scales; we cannot make Protected Areas large enough to include entire ecosystems; Biodiversity is eroding in spite of Protected Areas having doubled globally during the last quarter of a century. A suitable strategy involves management of landscape structure through the strategic placement of managed and natural elements, so the services of natural ecosystems are available across the landscape matrix (e.g. pest control by natural predators; pollination by animals; mitigation of erosion, floods and tsunamis; filtration of runoff by riparian vegetation; continuous production of freshwater).

Landscape management implies using an integrated approach in the management of extended landscapes, defined by ecosystems rather than boundaries, in which both conservation and sustainable use of the components of biological diversity are considered, and in which people and their socio cultural resources are placed at the centre of the conservation framework. This approach has been strongly recommended for linking conservation with sustainability, involving communities in decision-making processes, and exploiting biodiversity judiciously to secure effective management (Sharma *et at.*, 2007).

The Role of Landscape Matrix

Managing the matrix to buffer sensitive areas such as riparian zones, promotes the conservation of aquatic systems, contributes to improved connectivity for wildlife and increases the ability of the matrix to support populations of species. The extent to which planners, decision-makers and practitioners are aware of these roles will determine the degree to which the matrix contributes positively or negatively to these functions (Malaysia Ministry of Natural Resources and Environment, 2009). There are five critical roles for the landscape matrix that relate specifically to conserving biodiversity; supporting populations of species; facilitating the movement of species; buffering sensitive areas and parts of the Protected Areas System ; maintaining the integrity of the aquatic system; and supporting ecosystem services. These five roles of the matrix are interrelated.

It is confirmed that resource management practices that maintain or improve the suitability of the matrix are fundamental to the conservation of biodiversity. Many studies have highlighted the importance of the matrix in agricultural areas, temperate forests, and tropical forests, such as through work on countryside biogeography. Many conservation biologists have largely overlooked the contribution of matrix and the habitat that it provides for biodiversity conservation (Franklin and Lindenmayer, 2009). Most conservation biologists have focused on such topics as retention of large patches of undisturbed habitat as reserves and intact habitat corridors as the primary strategy for providing for connectivity. Indeed, some biologists still assert that reserves are the only way to conserve biological diversity. In fact, approaches to matrix management have major implications for conservation biology as reserve design, metapopulation processes, extinction proneness, and connectivity and species persistence in human modified landscapes.

Supporting populations of species

The matrix can be managed to support broadly distributed populations of many species able to thrive or at least partly incorporate the matrix into their range. Some estimates suggest that more than half of all wild species exist principally outside Protected Areas, mostly in agricultural landscapes (Malaysia Ministry of Natural Resources and Environment, 2009). Such populations may, to a significant degree, supplement populations in the combined Protected Areas System, Permanent Forest Reserve (PA-PFR) and forest on state land - thus ensuring their survival. Species which survive in the matrix are also the ones most likely to be found in remnant patches and they may play a crucial role in reversing localized extinctions within forest fragments (Franklin *et al*, 2009).The matrix, the dominant component in the landscape, is the most extensive and connected landscape type, and it plays the dominant role in landscape functioning (Malaysia Ministry of Natural Resources and Environment, 2009). It also makes some facilitation to manage a habitat to provide what wildlife need in that area (Barnes, 2000).

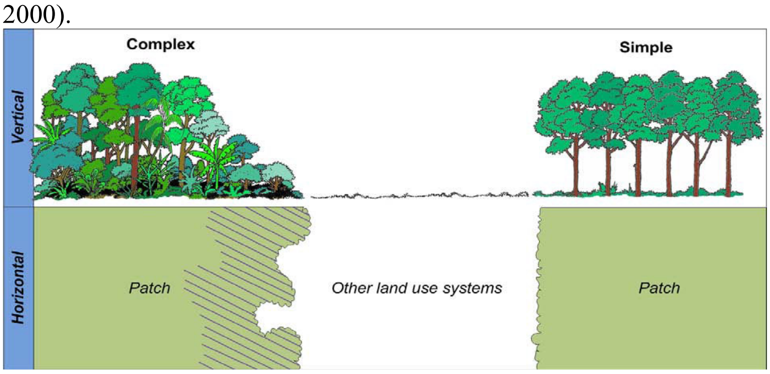

Fig 2; Low contrast edges (to the left) are richer in species than high contrast Borders (to the right)
Source: Malaysia Ministry of Natural Resources and Environment, 2009

The shape of patches significantly influences the amount of core area on which many species depend. Much habitat today falls within small to medium size patches and managing the matrix-to buffer edges can substantially increase their effective area within the matrix (Franklin *et al*, 2009). The intensity of the edge interactions between a patch and the surrounding matrix is typically directly related to their level of structural contrast. Most natural edges are curvilinear, complex and soft, and follow terrain features. However, humans tend to make straight, simple and hard edges ignoring natural topographic features. Matrix management strategies that reduce the contrast in structural and biophysical conditions between neighboring areas can therefore significantly reduce the intensity and depth of the edge effects (Malaysia Ministry of Natural Resources and Environment, 2009).

Facilitating the movement of species

Landscape connectivity should be maintained at multiple scales and for as wide a group of plant and animal species as possible. Facilitating ‘connectivity ‘and movement of species in the matrix may prevent populations of species from becoming isolated and fragmented. It may also allow populations to maintain or increase their demographic and genetic size, thereby enhancing chances of long-term survival (Malaysia Ministry of Natural Resources and Environment, 2009). For plants, connectivity allows for movement of spores, pollen and seeds, and thus species and populations. For animals connectivity is controlled by conditions such as appropriate vegetation cover or key structures (e.g. logs and dead trees).A matrix that provides a high degree of connectivity is critical since habitat loss, fragmentation of remnant vegetation, and increased isolation of patches are major reasons for the ongoing depletion of biodiversity. When resources and habitats are scattered in the landscape, individuals moving between patches adopt faster and straighter displacements than their usual slow and tortuous trajectories associated to resource searching particularly foraging associated movements (Baguette and Dyck, 2007).

Landscape matrix function concerns connectedness among the communities that make up the landscape, movements of organisms among the habitat patches that is, across the matrix, are of fundamental importance. These movements can be dispersal, within-home-range movements, or exploratory excursions. Longer-range movements is primarily dispersal, and those are the movements that is of most concern to conservation planners (Hilty *et al*, 2006).It may be useful to think of matrix surrounding a particular community patch as being on a gradient with respect to its traversability for a given species living in the patch (Wiens and Moss,2005). Permeability or traversability of matrix habitat will depend on a species’ access to the matrix (more about this later), the quality of the matrix with respect to survival and facility of movements, and the distance to neighboring patches (Franklin *et al*, 2009).

Buffering sensitive areas and parts of the Protected Areas System

In the development of comprehensive strategies for biodiversity conservation, identification and protection of sensitive ecologically important habitats within the matrix is paramount (Hilty *et al*, 2006; Malaysia Ministry of Natural Resources and Environment, 2009). Some of these habitats are widely distributed, such as streams and their associated riparian vegetation; and lakes and wetlands with associated coastal zones (Wiens and Moss, 2005). Others such as limestone hills, rock out-crops and caves may be important for species found nowhere else (i.e. 'endemics'). Particularly, forest landscape within matrix plays critical roles in maintaining ecologically sensitive areas which are core habitats for remnant species later developed to protected areas of biological species conservation centre (Kim and Weaver, 2009; Lindenmayer and Fischer, 2006).Such habitats may not be adequately represented in a Protected Area System but may constitute important small and medium sized reserves and Protected Area System embedded within the matrix. Proper matrix management may significantly increase their contributions to overall biodiversity conservation (Lindenmayer, 2009; Malaysia Ministry of Natural Resources and Environment, 2009).

Maintaining the integrity of the aquatic system

Kim and Weaver,(2009) argued that aquatic features of landscapes like rivers, wetlands, streams and lakes are critically important to biodiversity conservation and ecosystem processes. A very large proportion of biodiversity is associated with aquatic ecosystems. However, the status of aquatic systems is significantly influenced by neighboring land use practices. Even so, the habitat and functional relationship between spatially adjacent terrestrial and aquatic habitats have rarely received sufficient consideration in forest management and landscape planning. Adjacent terrestrial habitats such as riparian and coastal zones should be viewed as integral components of aquatic ecosystems because of the extensive functional relationship between adjacent terrestrial and aquatic communities of species (Malanson, 2002; Malaysia Ministry of Natural Resources and Environment, 2009).

Riparian Landscapes examines the ecological systems of streamside and floodplain areas from the perspective of landscape ecology. The specific spatial pattern of riparian vegetation is seen as a result of, and a control on, the ecological, geomorphological, and hydrological processes that operate along rivers. Riparian structures are controlled by the spatial dynamics of channels, flooding and soil moisture, and human impact. These dynamics are part of integrated cascades of water, sediment, nutrients and carbon, with the riparian zone acting as source, filter, and sink, to which animal and plant species respond through dispersal and invasion in ways that illuminate diversity, community structure and competition (Malanson, 2002).Maintaining and/or restoring the integrity of aquatic systems should also receive high priority for its bearing on coastal and marine diversity.

Riparian vegetation not only provides animals with movement corridors, it also stops surface 'run-off' from heavy rainfall events, preventing sediments and waterborne pollution from reaching the rivers (Malaysia Ministry of Natural Resources and Environment, 2009). Sediments and pollution are detrimental to freshwater biodiversity and have serious negative impacts on the status of marine resources (e.g. sediments shade corals and prevent them from re-establishing themselves, resulting in severely impoverished coral reef diversity, which also has an influence on offshore fishing).Linkages of different aquatic ecosystems is a good science basis, coupled with the bio-cultural nature of Earth systems has pivotal roles in conservation and management of biological species. This integration of the landscape and seascape bring a wider species needs (Bennette, 2003).

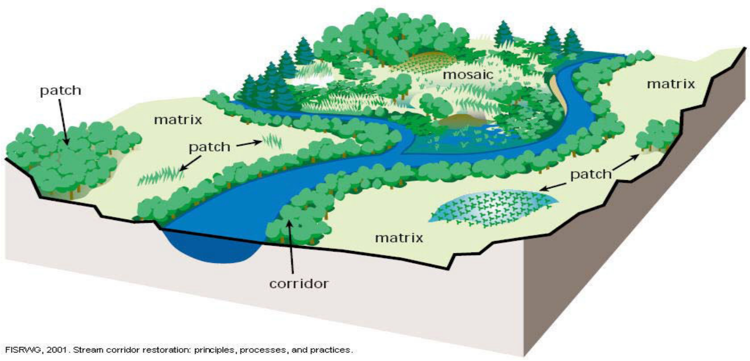

Fig.3. Patch-corridor-matrix model for restoration of river corridor
Source: FISRWH, 2001 Cited in Malaysia Ministry of Natural Resources and Environment, 2009

Support ecosystem services

The successful protection of biodiversity requires the preservation of adequate habitats and ecosystem functioning in the context of the entire landscape complex at various spatial and temporal scales. Particularly in light of future land use changes – which will increase further – and expected climate change, landscapes with high geomorphological heterogeneity are considered important (Walz, 2011). Therefore, in planning and nature conservation, the landscape level needs much more attention than has been the case to date. An understanding of the importance of the landscape matrix and an appropriate management are important for maintaining diversity (Malaysia Ministry of Natural Resources and Environment, 2009). Outside of protected areas, the management of traditional agricultural and forestry systems remains a key element of nature conservation. The consideration of the entire landscape matrix should also include the preservation or development of a functioning mosaic of interconnected habitats as an ecological network associated with areas of intermediate intensity cultivation (agriculture, settlement, etc.), with a minimum number or density of small-scale, semi-natural landscape elements (Lindenmayer, 2009) .

A conservative estimate is that the environment returns ecosystem services in the order of nearly twice the Gross National Product (as already referred to). In Malaysia, for instance, management practices and conditions in the Protected Areas, the Permanent Forest Reserve and the landscape matrix surrounding them determine the quality, quantity and sustainability of ecosystem services obtained. However, many elements of biodiversity need to be conserved within the landscape matrix to sustain long-term production of wood, potable water and other ecosystem products and services – this includes soil biodiversity. Losses of elements of forest biodiversity may impair essential ecosystem functions. Examples include organisms that play key roles in the decomposition of organic matter, pollination, seed dispersal, biological pest control, and the formation of associations between fungi and plants (i.e. mycorrhiza).Changes in biodiversity will also influence the long-term floristic composition and stand structure of forest habitat, which will have negative ramifications for the sustained production of commodities. Many of the components of biodiversity that play an important role in ecosystem processes are inconspicuous invertebrates (i.e. bugs) which have received little attention in conservation programmes (Walz, 2011).

Landscape matrix management is important for conserving ecosystem processes by emphasizing the importance of biodiversity in the matrix as well as conservation of genes, species, and populations for their own sake (Hilty *et al*, 2006). Beyond species diversity, genetic diversity within populations is also important because it allows continued adaptation to changing conditions through evolution, and ultimately, for the continued provision of ecosystem goods and services. Likewise, diversity among and between habitats, and at the landscape level, is also important in multiple ways for allowing adaptive processes to occur (Malaysia Ministry of Natural Resources and Environment, 2009).

High levels of diversity of landscape types, ecosystems, species and genetics provide higher adaptability to changing conditions, caused for instance by climate change (Sayer *et al*,2012).. As far as land/seascapes are concerned, the more diverse to keep them the more resilient they seem to become. Impaired ecosystem processes result in reduced production of goods and services in the matrix, and this has substantial social and economic costs for society. The outcome is a substantial contribution to rebuilding and maintaining the resilience of landscapes which benefits terrestrial, freshwater and marine systems (Malanson, 2002).

The Role of Corridors

Corridors are commonly used to connect fragments of wildlife habitat, yet the identification of conservation corridors typically neglects processes of habitat selection and movement for target organisms (Ament *et al*, 2014). Corridors are regions of the landscape that facilitate the flow or movement of individuals, genes, and ecological processes (Chetkiewicz *et al*, 2006; Srivastava and Tyagi, 2016). The concept of corridors as a conservation measure has been highly successful in catching the attention of planners, land managers and the community and a wide range of 'wildlife corridors', 'landscape linkages', 'dispersal corridors', 'green belts', 'greenways' and other forms of connecting features have been proposed, drawn into conservation plans, or are now under active construction or management.

These encompass a range of spatial scales and a variety of levels of sophistication – from artificial tunnels and underpasses that assist animals to move across local barriers such as roads and railway lines, to major tracts of undisturbed natural forest that link reserves at high and low elevations (Bennett, 2003).Habitat fragmentation resulting from increasing human activities in natural areas poses a great threat to the long-term conservation of biodiversity worldwide. Corridors play key contribution as a tool for maintaining viable populations of biota in fragmenting landscapes through enhancement of connectivity (Hilty *et al*, 2006).

Connectivity plays critical roles in capability of the landscape in facilitating species flux and is vital for protection of biological diversity in patchy environments. Landscape connectivity is viable in maintaining populations in space and time (Goulart.*et al*, 2015). Connectivity is a measure of the ability of organisms to move among separated patches of suitable habitat; it can be viewed at various spatial scales. A corridor is a narrow linear strip of land that differs in structure from the surrounding matrix and facilitates movement of species and process between habitats (Ament *et al*, 2014). Corridors may function differently within the landscape with respect to movement. Expansion of human land use has resulted in widespread loss and fragmentation of natural habitat, which could lead to the largest global extinction event in history. Corridors, routes that facilitate movement of organisms between habitat fragments, are increasingly being adopted as a tool to maintain and restore biodiversity (Hilty *et al*, 2006).

Corridors are effective in facilitating movement among patches of habitat, and then their effectiveness may be due to one of two mechanisms: increasing the probability of successful movements within the home range of an individual and increasing the movements of individuals among subpopulations through dispersal of young produced in the corridor (Cushman *et al*, 2013). If these mechanisms indeed contribute to the effectiveness of corridors, then the design of potential corridors and the means for their assessment need to be refined. Attention will need to be placed on individual movements between connected patches and the demography of populations within the linear patch, and on those populations that the linear patch is assumed to be connecting, rather than on simply the numbers of individuals observed within linear patches (Srivastava and Tyagi, 2016).

Future research of the efficacy of corridors will be most productive if conservation biologists and land managers focus on how corridor selectivity, survival costs, and movement rates of individuals vary among species with divergent evolutionary and life histories, in the conditions that are likely to persist in real landscapes (Rosenberg *et al*,1997). Corridors contribute much to connect isolated population and thereby reduce their extinction. Corridors are one means of achieving connectivity. They are any space identifiable by species using it that facilitates the movement of animals or plants over time between two or more patches of otherwise disjunct habitat.

Such movement may occur in a matter of minutes, hours, or over multiple generations of a species. Corridors may encompass altered or natural areas of vegetation and provide connectivity that allows biota to spread or move among habitat fragments through areas otherwise devoid of preferred habitat (Cushman *et al*, 2013). Landscape elements that function as corridors may also serve multiple other purposes, providing aesthetic amenities, ecosystem service values, cultural heritage protection, and recreational opportunities. Some landscape elements are unintentional corridors, providing connectivity for biota without being designated for that purpose. Corridors can be viewed over broad spatial and temporal scales (Cushman *et al*, 2013;Hilty *et al*, 2006).

Types of Corridors

Different kinds of landscape elements enhance connectivity (Cushman *et al*, 2013). Many elements serve as corridors that are not explicitly designed for the purpose, such as roadside vegetation, fencerows, and greenways. In other cases, corridors are purposely retained, maintained, and restored to facilitate landscape connectivity for individual species, groups of species, or entire ecological communities. Here emphasis is given to the potential of landscape elements to enhance connectivity (Hilty *et al*, 2006).

i. Unplanned Corridors

Landscape elements that enhance connectivity but exist for other reasons are de facto corridors. These provide different vegetative structures that enable biological diversity to survive through it (McAlpine *et al*, 2013). Fencerows, windbreaks, roadside vegetation, and ditches which are established for other purposes may serve to enhance connectivity (Hilty et al, 2006).Roadside corridors (vegetation strips along roads) mostly positive effects on connectivity for native biota. They provide habitat to both plants and animals and can act as a channel for movement among habitat patches. This is because availability of native plant species fosters the ability of roadside corridors to serve as habitat (Hilty *et al*, 2006). For instance, roadsides provide connectivity in Southern California, where revegetated highway rights-of-way enhance connectivity for native rodents and urban-adapted birds between habitat patches (Srivastava and Tyagi, 2016).

In agricultural landscapes, fencerows, unmanaged ditches, creeks production forests, and shelterbelts provide de facto corridors offering vertical vegetative structure that some species of plants and animals use to live in or travel through (MacDonald, 2003; DeClerck *et al*,2010). Similarly, vegetation along ditches and creeks is often left and can serve as both habitat and a conduit for species traveling among larger habitat patches. Shelterbelts, tree rows planted to prevent soil drift and hold snow on fields, are another element in agricultural landscapes used by some species of wildlife. For example, most movements of studied migratory bird species that breed in agricultural shelterbelts in North Dakota, for instance were found to occur in shelterbelts and between connected rather than unconnected sites. These vegetation structures within agricultural landscapes can function as movement corridors and even provide habitat for some species of wildlife (Hilty *et al*, 2006).

ii. Planned Corridors

According to Hilty *et al*, (2006) planned corridors are established purposively to enhance connectivity for biodiversity conservation. For instance, greenways provide open space systems or greenbelts that can potentially serve as connectivity. These are areas aimed to give different services like recreation, culture, and ecosystem services within developed landscape and other areas including cities, suburbs, and adjacent countryside. Trampling of vegetation, purposeful or inadvertent introduction of nonnative species, and wildlife harassment by pets are some examples of factors that may impair a greenway's connectivity value for biodiversity. Even so, greenways not explicitly focusing on conservation should be evaluated for their potential as corridors by providing habitat, acting as conduits, and even harboring source populations through restoration (McAlpine *et al*, 2013). The greenways offer recreational opportunities and some benefits for biodiversity conservation. One problem with these small urban natural areas is that they are often ecologically out of balance. They are sometimes linkages to rural and urban open spaces besides conservation of biological species (Cushman *et al*, 2013).

Some corridors focus solely and explicitly on ecological needs. They may buffer linear landscape elements of particular importance to biodiversity, such as riparian zones; conserve priority areas for individual species conservation; or promote community integrity across broad regions. In contrast to de facto corridors, these are often designed using scientific principles, biological surveys, and models to help determine landscape location (McAlpine *et al*, 2013). The major assumption in designating such corridors is that they will enhance conservation by promoting one or more connectivity goals (Sayer *et al*,2012).

Buffering Riparian Zones

Arguably one of the most important *landscape elements* for biodiversity is the riparian corridor (Malanson, 2002). Riparian corridors are made up of vegetation growing adjacent to creeks and rivers that are sometimes retained in human dominated landscapes. Riparian areas support a disproportionately large amount of biodiversity compared to other landscape elements, and conserving these sites can provide multiple natural resource benefits (Hilty *et al*, 2006). Vegetation strips along river systems also protect in stream biota by controlling erosion and providing shade to keep water temperatures cool. Retaining buffers along streams can benefit terrestrial biota as well (Cushman *et al*, 2013). For example, bird species richness and abundance appear to be greater where adequate riparian buffers are retained, according to studies of forests ranging from boreal forests in Sweden to riparian forests in California and Georgia. Buffer zones around wetlands and riparian habitats also have been found to be important for amphibian and reptile populations. Riparian buffers around lakes, rivers, and wetlands may be explicitly retained for conserving species, or they may be de facto, the result of policies such as those oriented toward water quality enhancement (Choowaew, 2007). Buffer zones around wetlands and riparian habitats also have been found to be important for amphibian and reptile populations .Riparian buffers around lakes, rivers, and wetlands may be explicitly retained for conserving species, or they may be de facto, the result of policies such as those oriented toward water quality enhancement (Hilty *et al*, 2006). Establishing and preserving vibrant riparian corridors is a good approach to conserving species, but conservation of riparian corridors alone is inadequate. First, landscape context is important, and corridors within a less intact landscape will be less effective. Second, creek and river corridors can lead wildlife into areas of human activity instead of to other habitat patches.

Corridors for Individual Species Conservation

The protection of specific landscape elements such as riparian areas, corridors may be mandated in individual species' management plans (Malanson, 2002). For example, dispersal corridors were proposed and identified through logging areas for spotted owls (*Strix occidentalis caurina*) in the U.S. Northwest. Similarly, an important part of the recovery of panthers (*Puma concolor coryi*) in Florida has been to identify and create safe corridors for them to move among remaining habitat fragments. This has involved both selecting specific locations such as road underpasses and conducting broad-scale landscape connectivity analyses. Road underpasses enhance connectivity and reduce panther deaths on roads because fencing inhibits road crossing and guides them to the underpasses in Florida for instance (Hilty *et al*, 2006).

Corridors that Enhance Community Integrity

Connectivity may be promoted to protect biotic community integrity or suites of species moving among parks or protected areas across large regions (Chetkiewicz *et al*, 2006).Corridors may be part of an ecological network that includes multiple core protected areas and corridors where connectivity minimizes the isolation of protected areas, such as in national parks. The long-term integrity of both these corridor projects is a challenge, as many people reside within the corridor boundaries and alter the natural habitat. However, these corridors may function for some species, especially if targeted restoration efforts are made and the resident human communities are engaged. Corridors can target some or all levels of biodiversity. Second, they occur at many different spatial scales. For example, some corridors may be a few meters or yards long to facilitate movement of smaller species, while others may span one or several countries to provide a conduit for biotic movements over a long time period .Third, corridors may provide connectivity for one species and not another due to species' different operational scales and habitat requirements. Finally, because the integrity of a community may affect individual species' survival, connectivity planning for entire communities should be considered where possible, rather than focusing on individual species (Hilty *et al*, 2006).

Types of wildlife movement facilitated by corridors

Wildlife corridors are important to link areas of crucial habitat and facilitate movement, thus reducing the negative impacts of fragmentation and allowing greater flexibility to adapt to stressors. Corridors are an important component of functional ecological networks (Hilty *et al*, 2006). The primary focus of corridor conservation is usually on supporting animal movement. Movements crucial to long-term viability of wildlife populations include daily foraging bouts among local resource patches, seasonal migrations between summer and winter ranges, once-in-a-lifetime dispersal events to seek new territories, and multi-generational range shifts in response to climate change (Ament *et al*, 2014). Wildlife use habitat corridors for different purposes, in different patterns, and at different scales, depending on the species (Cushman *et al*, 2013). One way to identify a corridor is by the species-specific needs and the movement function they provide; this is considered a fine-filter approach. An alternative coarse-filter approach is to define corridors based on integrity and continuity of landscape features or natural conditions, which requires the assumption that swaths of connected natural areas are likely to support movement of a variety of species. Different biodiversity scholars, for instance, Bennett, (2003), Hilty *et al*, (2006) and Ament *et al*, (2014) identified different types of wildlife movement facilitated by corridors as under.

Daily Travel

Daily travel is the continuous movement of individuals among primary habitat patches within home ranges. Many animals must move regularly among multiple habitat patches to obtain all the resources they need (this is also called station-keeping). Corridors among patches may be necessary for individuals to maintain sufficiently large home ranges when the distance they travel on a daily basis is larger than the patches of primary habitat available to them. Management of these corridors would be similar to how primary habitat areas are managed.

Migration

Migration is the predictable, periodic round-trip or cyclic movement of groups of individuals among discrete areas not used at other times of year. As environmental conditions, such as vegetation composition and productivity, snow cover, and water availability change seasonally, many species travel between seasonal home ranges to access the resources they need. Seasonal migration also facilitates access to breeding and spawning grounds for some species. Often, migratory animals follow the same routes year after year. An effective migration corridor must maintain the resources necessary at the right time of the year to support the focal species during its migration, but not its long-term occupancy, since the corridor is used primarily for travel from one place to another. Corridors should allow for rapid movement as necessary to accommodate the extent and pace of migration. Because migration corridors are not used year-round, human activities that may disturb the species need only be restricted during the migration period.

Dispersal

Dispersal is the movement of individuals that maintain genetic and demographic connectivity among populations. Dispersal is a function critical to both plants and animals. Movement of young adults from their maternal home range to establish territories of their own and find mates maintains healthy genetic and demographic diversity (DeFries *et al*, 2016). The different drivers of dispersal movements, compared to daily home range movements, may lead to different responses to the landscape. For example, young grizzly bears need to be able to move from one mountain range to another to establish their territory, but they don't need to use that route for anything but travel. Thus, dispersal corridors can be permeable to movement without needing to support long-term occupancy. The habitat quality of dispersal corridors generally doesn't need to be managed to support residency or reproduction, and management may instead focus on minimizing barriers to movement. Continuously occupied areas (e.g., by "corridor dwellers") are considered to be habitat, not corridors.

Future Movement

Future movement is the movement of individuals to and through areas expected to provide connectivity under future conditions (Kim and Weaver, 2009). Major disturbances such as fire, human development, and climate change may impact the quality and distribution of habitats and necessitate the movement of both plant and animal species (DeFries *et al*, 2016). When we can predict how disturbance will change patterns on the landscape (e.g., planning for roads or large-scale developments), we can better identify corridors that will support species' need to escape from the disturbance, to disperse, migrate, and move daily to continue to meet their habitat needs. In this case, management will require the prediction of areas expected to support movement under future change scenarios and protection for these areas from incompatible land uses.

Incidental Movement

Incidental movement is the fortuitous movement in areas primarily designed or managed to provide amenities to people (Franklin, 2018). Many corridors are intended to support multiple species. Multispecies corridors could be designed effectively by treating them as composites of multiple single-species corridors (DeFries *et al*, 2016). A coarse-filter, non-species-specific approach may also be useful for identifying broad areas of potential connectivity for multiple species. For example, some corridor designs are based primarily on landscape integrity and structural connectivity, the inclusiveness of umbrella species, or financial or social opportunity (e.g., least cost analysis). These landscape linkages are important to increase landscape connectivity, though they may or may not best meet the needs of individual species (Kim and Weaver, 2009). Multispecies approaches may be particularly well-suited in the context of extensive ecological networks of cores and corridors (e.g., the Pan-European Ecological Network, the Yellowstone to Yukon Conservation Initiative).

The Role of Patches

All biological resources must have access to areas where food, shelter, and mates can be found (Franklin, 2018). The size, composition, and spatial pattern of habitats that a species requires are all functions of diet, body-size, and the spatial and temporal patchiness of resource availability (Kettunen *et al*, 2007). Understanding the habitat requirements of a landscape species in time and space helps us to characterize the landscape that is biologically meaningful to that species (Tulloch *et al.*, 2016). By mapping the composition, quantity, and spatial configuration of habitat patches required by a healthy, functioning population of a landscape species, it is explicitly defined as the landscape necessary for its long-term survival, and thus determine the appropriate scale for conservation management. The theory of island biogeography has been the central tenet of conservation biology for several decades, a tenet in which continental landscapes are viewed islands of suitable habitat patches embedded in a matrix (i.e., surrounded by a sea) of unsuitable habitat. Patch size and isolation are predicted to be the critical variables in determining the efficacy of these habitat patches in preserving biological diversity (Franklin *et al*, 2009).

Most conservation biologists have focused on such topics as retention of large patches of undisturbed habitat as reserves and intact habitat corridors as the primary strategy for providing for connectivity. Indeed, some biologists still assert that reserves are the only way to conserve biological diversity. In fact, approaches to matrix management have major implications for such fundamental tenets of conservation biology as reserve design, metapopulation processes, extinction proneness, and connectivity and species persistence in human modified landscapes (Franklin *et al*, 2009).Several aspects of patches are important from an ecological perspective and affect landscape-level management decisions. The approach used most often in analyzing patch habitats is to think of them as islands (Barnes, 2000). Much of the current thinking about landscape patch management has its roots in the theory of island biogeography developed in 1967 by MacArthur and Wilson to explain the patterns of species diversity on oceanic islands. It has also proven useful and applicable to a variety of ecological situations because an island is simply defined as a patch or parcel of favorable habitat surrounded by unfavorable habitat. Just as wildlife disperse to oceanic islands, terrestrial wildlife and plants move between habitat islands.

The amount and arrangement of habitat is a fundamental determinant of biodiversity and ecosystem processes in a landscape. Biodiversity is expected to decline following habitat loss and isolation, potentially impeding ecosystem function (DeFries *et al*, 2016). But because greater isolation usually accompanies habitat loss, the effects of habitat amount and isolation can be confounded. Moreover, the type or quality of the intervening matrix habitat can mediate amount and isolation effects on biodiversity (Franklin, 2018). The benefit of patch isolation for biodiversity runs counter to that expected by island biogeography theory, suggesting that spatially dependent interspecific interactions, such as predation or competition, may override direct dispersal effects (Spiesman *et al*, 2018).Conservation activities in fragmented landscapes have largely focused on keeping remaining large patches intact, often disregarding the increasingly important role of smaller patches in the conservation of remaining vegetation. As habitat loss proceeds in fragmented landscapes, there is an increasing need to measure the relative contribution of all patches (large and small) to overall ecosystem persistence, in a way that helps deliver effective conservation strategies aimed at preventing the death of ecosystems (Tulloch *et al*,2016) .

One of the core messages of landscape ecology is that context—the surroundings of a landscape patch or place matters (DeFries *et al*,2016). How different habitats, cover types, or populations are arrayed over a landscape affects what is present and what happens at any particular place in the landscape. Much of the traditional focus of conservation, however, has been on protecting those particular places, places that have extraordinary conservation value. This approach is formalized in the notion of protected areas (Wiens, 2008). These areas—nature reserves, wildlife refuges, national parks, wilderness areas, and the like—are managed primarily to maintain or restore their natural values, usually under the aegis of a government agency, land trust, or conservation organization (Spiesman *et al*,2018). Landscapes are mosaics of places with different vegetation cover, ecological communities, and land uses (Franklin, 2018). These places, be they sharply bounded landscape elements (‘‘patches’’) or areas that grade into one another over gradients or ecotones (‘‘fuzzy patches’’), are interconnected both structurally and functionally.Conservation activities in fragmented landscapes have largely focused on keeping remaining large patches intact, often disregarding the increasingly important role of smaller patches in the conservation of remaining vegetation (Tulloch *et al.*, 2016). As habitat loss proceeds in fragmented landscapes, there is an increasing need to measure the relative contribution of all patches (large and small) to overall ecosystem persistence, in a way that helps deliver effective conservation strategies aimed at preventing the death of ecosystems by a thousand cuts.

Patches are units of land or habitat that are heterogeneous when compared to the whole (Barnes, 2000). They include four different types: disturbance, remnant, environmental resource, and introduced. Disturbance patches are either natural or artificial. They result from various activities, including agriculture, forestry, urbanization, and weather (i.e., tornados, hurricanes, ice storms, etc.). If left alone, a disturbance patch will eventually change until it combines with the matrix. Remnant patches result when humans alter the landscape in an area and then leave parcels of the old habitat behind. Remnant patches are generally more ecologically stable and persist longer than disturbance patches (Franklin, 2018). Environmental resource patches occur because of an environmental condition such as a wetland or cliff line. Introduced patches are ones in which people have brought in nonnative plants or animals or rearranged native species. Animals moving from one area to another can also bring in these nonnative elements (Spiesman *et al*,2018). Forested wildlife habitat in the landscape often occurs in patches within an agricultural landscape matrix. Managing wildlife at the landscape level is an attempt to unite habitat patches (through the use of corridors, specifically riparian forests or fencerow habitats) to allow native biodiversity to flourish across the complete range of environmental gradients or between ecosystems (Spiesman *et al*,2018). Viewed in another context, we do not necessarily have to connect habitat fragments, but rather direct our management to allow for the natural dispersal of wildlife (Barnes, 2000).

The effects of landscape change can be assessed for a single species or for multiple species simultaneously. Single-species investigations tend to be more detailed, and tend to demonstrate a reasonable grasp of the ecological processes that limit the distribution and abundance of a given species (Franklin, 2018). In contrast, investigations on multiple species often need to aggregate species into groups and may need to make several assumptions about how landscape patterns are related to a given group of species. A common, but problematic, assumption is that human-defined patches correspond to habitat for a group of species (Lindenmayer, 2009).Heterogeneity appears to be the predominant pattern in most landscapes, and increasing importance is attached to the role that it plays in determining ecological processes. A landscape contains heterogeneous characteristics that are expressed in discrete entities known as *patches,* which in turn make up a mosaic that is structurally and geographically distinct (Wu, 2015). The salient characteristics of these patches, such as dimensions, shape, type of vegetation, biological richness, abundance of organisms, and flow of nutrients, contribute to the organization and maintenance of the complexity of landscapes which play critical role in conservation of viable biological species (DeFries *et al*, ,2016).

Landscapes are typically composed of discrete elements termed as patches, which can be defined as relatively homogeneous areas that differ from their surroundings (Wu, 2015). In general, patches have discernable boundaries and distinct spatial properties that can be described compositionally by internal variables (e.g. the density, species composition and height of trees within a woodland patch) (Franklin, 2018). The arrangement and number of different patches creates heterogeneity within landscapes. This landscape heterogeneity, in particular the spatial distribution and arrangement of patches within landscapes (i.e**.** landscape pattern), is important because it affects interactions between/within species both within and between patches (Kettunen *et al*, 2007).From the perspective of biodiversity within landscapes, the maintenance of species and ecological functioning of landscapes is determined by what role patches play for different species (Spiesman *et al*, 2018). In this context, patches are defined in terms of the habitats and/or resources used by a species. Patches vary in the roles they play in a species' ecology, e.g. some patches might be used for foraging and some as breeding sites. The interstitial environment between patches is called the environmental or habitat matrix (Kettunen *et al*, 2007). Patches and the habitat matrix are species-specific, and therefore a forest patch for one species may be the habitat matrix for another. The spatial configuration of habitats within a landscape formed by patches arranged within a matrix is generally called a landscape mosaic (Franklin, 2018).

The existence of a species within a landscape is dependent on both the existence of adequate habitat/resource patches and the ability to move amongst them either for foraging, breeding or migration etc, or for dispersal and colonization (e.g. as individuals, seeds or spores). It is important that the area and quality of available patches fits the needs of the species in question (DeFries *et al*, 2016). In this context, the term habitat continuity is used to describe the permanent and long-term stock of all habitat requirements for a species within a given landscape or ecosystem. In addition, both the quality of the matrix and distribution of individual patches, in particular the distance between patches, plays an important role in enabling the movement of a species between patches (Hilty *et al*, 2006). In this context it is also to be noted that the patch and matrix quality are attributes that are strongly species specific, i.e. they are always to be defined according to the needs of individual species.

Patch size and connection between individual patches within landscapes also affect species population dynamics (Franklin, 2018). Population dynamics depend on interactions between individual and spatially separated populations of a species that, often as a result of the fragmentation, exist in discrete habitat patches (Spiesman *et al*, 2018). Rather than stable and homogeneous populations, species can therefore be seen as dynamic entities that are distributed unevenly across landscapes in habitats of varying quality (Singh, 2006). Small local populations of species inhabiting individual patches are generally considered vulnerable to extinction as a result of chance events etc. The minimum viable population size, i.e. the smallest size that an isolated population can be and survive in the long-term differs between species. However, if sufficient numbers of individuals from other local populations can recolonize empty habitat patches after extinctions then the species can continue to survive (Kettunen *et al*, 2007).

Conclusion

Present day conservation of biological species across the word requires an understanding of the heterogeneous landscapes. The landscape is composed of three elements namely patch, corridor and matrix. These three elements play their own critical contributions in conservation of biodiversity. Achieving global conservation goals requires that realizations, agreements, and directives be customized to reach all levels. Scaling up conservation across larger landscapes, as facilitated by most global conventions, involves cooperation at various levels. Landscape ecology incorporates conservation and human dimensions to create a sustainable and harmonized living environment. Landscape approaches seek to provide tools and concepts for allocating and managing land to achieve social, economic, and environmental objectives in areas where agriculture, mining, and other productive land uses compete with environmental and biodiversity goals. As a conclusion, a landscape based conservation of biodiversity is the most current technical approach to manage species extinction across landscapes. Therefore, approaches to conserving biological diversity should be developed at the local landscape level to support national implementation of the convention of biological diversity.

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