Effect of Habitat Fragmentation on Biodiversity

Akshayakumari. A.[1]*, Rashmitha. H.R.[2], and Nalina. S. J.[3]

[1]*Young Professional, NRLM Karnataka*
[2]*Dept. FBTI, COAS Iruvakki, KSNUAHS Shivamogga*
[3]*Technical Assistant, Tumukur ZP, KFD*

Corresponding Author
Akshayakumari. A
Email: akshaya141999@gmail.com

OPEN ACCESS

Keywords

Habitat fragmentation, Conservation biology, Island, Biodiversity.

How to cite this article:

Akshayakumari, A., Rashmitha, H. R., and Nalina, S. J., 2024. Effect of Habitat Fragmentation on Biodiversity. *Vigyan Varta* 5(11): 136-142.

ABSTRACT

When people ruin wildlife's natural habitats, it's referred to as habitat degradation. In conservation biology, habitat fragmentation is regarded as a major problem. This issue focuses on how human disturbances like land clearing and vegetation conversion from one type to another cause once-large, continuous habitat blocks to become less continuous. The observation that there are fewer species on islands than in comparable mainland locations is explained by the notion of island biogeography. Research on habitat fragmentation that is based on the island biogeography theory usually concentrates on the fragment's size and level of isolation. The effects of habitat fragmentation on the persistence of plant and animal populations, the makeup of communities, and ecosystem processes have been the subject of numerous ecological research. Both human activity and environmental processes, which operate on different time and spatial scales, contribute to fragmentation. While some species gain from fragmentation, other species are greatly endangered. Effective measures must therefore be taken to preserve biodiversity in fragmented settings.

INTRODUCTION

An ecological area inhabited by specific animals, plants, or other species is called a habitat. When people ruin wildlife's natural habitats, it's referred to as habitat degradation. The reduction of continuous habitat tracts to smaller, spatially discrete residual areas is known as habitat fragmentation, and habitat loss usually happens at the same time as habitat fragmentation (Wilson *et. al*., 2015). In conservation biology, habitat fragmentation is regarded as a major problem. This issue focuses on how human disturbances like land clearing and vegetation conversion from one type to another cause once-large, continuous habitat blocks to become less continuous. The division of a generally intact area of a single vegetation type into smaller units is the traditional definition of habitat fragmentation (Lord and Norton, 1990).

THEORY OF HABITAT FRAGMENTATION

The two key theoretical developments in community and population ecology to study fragmentation are: the Theory of Island Biogeography and the Theory of Metapopulation Dynamics.

Theory of Island Biogeography

In the context of habitat fragmentation, the Theory of Island Biogeography has focused primarily on the influences on habitat fragment size and isolation of species composition.

According to the island biogeography theory, which was first put forth by MacArthur and Wilson in 1967, the number of species that are found on an oceanic island depends on its size and distance from a mainland source of invading species. Landscape ecologists that investigate habitat fragmentation apply the island biogeography theory to the terrestrial islands formed by habitat fragmentation, even though it is clear that the idea was initially created to explain species composition on oceanic islands. (Fahrig, 2003). Habitat fragmentation research structured around the island biogeography theory typically focuses on the size of the fragment and the degree of isolation of the fragment.

The finding that there are fewer species on islands than in comparable mainland locations can be explained by the island biogeography theory (MacArthur and Wilson, 1967). According to this theory, species richness on islands is a balance between the rate at which new species are colonizing an island and the rate at which existing species are going extinct. Isolation from the mainland determines the rate of colonization, while island size mostly determines the rate of extinction. Smaller islands will have fewer species than larger islands of equivalent isolation, while islands of the same size that are farther away from a mainland source will have fewer species than those that are closer. This theory extends to mainland isolates and habitat fragments and a framework for studying the effects of habitat fragmentation. The theory that species richness and individual abundance will decrease with reduced patch size (Fahrig, 2003). The concept of isolation has also changed somewhat from distance to a mainland to distance between neighboring patches.

On oceanic islands, it aims to explain the species composition of animal communities. This idea specifically asserts that the number of species found on an oceanic island is determined by its size and distance from a mainland source of colonizing species. Large islands will have lower rates of extinction than tiny islands, while islands near a mainland will have higher immigration rates than islands farther away. Therefore, it is projected that there will be more species on large islands near continents than on small islands farther away. Island species reflect a dynamic balance between the loss of long-established species and the immigration of new colonizing species. The predictions of this hypothesis, which focuses on the species composition of oceanic islands, might hold true for the plant and animal groups that live on terrestrial islands (MacArthur and Wilson, 1967).

Theory of Metapopulation Dynamics

The Theory of Metapopulation Dynamics concept has focused attention on connectivity and interchange between spatially distributed populations. Metapopulation theory was originally conceived to describe and predict the population dynamics of species occupying naturally patchy habitats. A metapopulation is a set of spatially separated groups of conspecific individuals. In this model, local populations of organisms undergo periodic colonization and extinction, while the metapopulation as a whole persists indefinitely. Ecologists have directly applied the understanding of the oscillations of such naturally transient populations to predicting the persistence of species which occur in human-induced habitat fragments.

Like Island Biogeography Theory, this theory also focuses on local extinctions and colonization in the context of heterogeneous spatial pattern of habitat patches. It differs from island biogeography by the following points. It assumes a network of small patches with no mainland habitat and it considers population dynamics of only one species at a time (Hanski, 2002).

SPATIAL AND ECOLOGICAL ATTRIBUTES OF HABITAT FRAGMENTS

The effects of habitat fragmentation on the persistence of plant and animal populations, the makeup of communities, and ecosystem processes have been the subject of numerous ecological research. Numerous studies, for instance, link the number of plant or animal species found in fragments to specific fragment features, typically area, form, context, degree of isolation, or another indicator of habitat quality or variability. Although each of these characteristics influences ecological function alone, they may also work together to affect ecological processes. attributes independently, acknowledging that they are correlated (Fahrig, 2003).

The edge phenomenon: The biotic units that are so bounded are greatly influenced by the intensive interactions that frequently occur at edges. The phrase "edge effect" refers to a group of distinct events. It refers to the areas of a fragment that are impacted by outside factors, whereas the core habitat is the area that remains unaltered. The size, form, and composition of the surrounding landscape matrix all influence how much of a fragment is core habitat. Clearly, more light reaches plants at the perimeter of a forest fragment than in the center of the forest. At the woodland boundary, temperature rises and relative humidity falls as a result. Additionally, wind speeds are higher along the forest's border than inside. The light, moisture, temperature, and wind variations that are most noticeable at the fragment edge have the potential to drastically affect the plant and animal species that live there. Additionally, the edge's aspect or direction may have a major impact on how much the edge experiences these environmental changes.

Changes in the structure and makeup of the current plant communities are linked to variations in light, temperature, moisture, and wind along forest boundaries. The invasion of alien plant species may frequently be the cause of higher species richness along forest boundaries. Even though mortality rates at margins can be significantly greater than in fragment interiors, some animals seem to choose or prefer edges as acceptable reproductive habitat. Ecological trap is the term used to describe this situation. Compared to fragment interiors, edges support increased β-diversity.

Fragment size/area: Due in part to the modifications brought about by the establishment of habitat boundaries already mentioned, the size of a specific habitat fragment significantly affects the ecological processes taking place there. Smaller habitat fragments will have a higher percentage of edge habitat than bigger fragments because edge effects in a given habitat lead the distance between a habitat fragment's border and center to remain constant. A species' fall in population size and subsequent local extinction of those populations lead to a decline in species richness in limited habitat remnants. Population decrease brought on either directly by habitat loss or indirectly by altered interspecific interactions linked to edge effects and habitat isolation. The fraction of edge habitat declines and inner habitat increases with fragment size.

Fragment connectivity: Ecological dynamics within and between habitats are significantly influenced by landscape connectivity. It is anticipated that by preserving landscape connectedness, the preservation of vegetated corridors between otherwise isolated habitat remnants may mitigate the adverse consequences of habitat fragmentation. The term "corridor" typically refers to a linear landscape element made of native vegetation that connects areas of similar native vegetation in ecological studies of habitat fragmentation. Preventing soil erosion and preserving high water quality, in particular, depend heavily on the integrity of riparian corridors.

Vegetated corridors are predicted to facilitate the movement of plants and animals among habitat fragments, which may allow more species to exist and/or populations to persist longer than would be expected based solely on fragment size. Animal use of corridors may vary depending upon their foraging patterns, body size, home range size, degree of dietary specialization, mobility and social behaviour. movements via vegetated corridors might translate into population persistence and community composition of native habitats is not well understood. The existence of vegetated corridors between otherwise isolated habitat fragments may modify patterns of species richness and composition by increasing the effective size of the fragments. Thus, connected remnants would be predicted to maintain the attributes of continuous habitat, and support a greater biological diversity than completely isolated remnants.

Fragment shape: The degree to which edge effects penetrate (spread into) the interior of a discrete habitat fragment depends on its geometric shape. Thus, the quantity of interior area that remains in a specific habitat fragment is influenced by the interaction of size and form. The simplest way to characterize shape is to compute a habitat fragment's perimeter/area ratio. Compared to a rectangular piece of the same area, a square habitat fragment preserves a larger percentage of the interior habitat.

Fragment context: The degree and kind of interaction between a remnant of native habitat and the surrounding landscape will surely depend on the context in which it is located. Janzen's (1983) claim that no park is an island highlighted how human activity and the types of habitats around it affect the ecological integrity of places set aside for protection. The flow of nutrients and materials, as well as the persistence of plant and animal species in habitat fragments, may be significantly impacted by the kind, degree, and intensity of habitat type, land use, and human activity that are close to the fragments.

Other spatial features, such the size and shape of the fragments, will determine how important these nearby land uses are in relation to biological processes. There may be little chance of material and organism exchange between a segment of habitat and the matrix that surrounds it, making the boundary between the two areas comparatively impenetrable. On the other hand, if the boundary is extremely permeable, there will be many and frequent boundary crossings. The perimeter/area ratio and boundary permeability may have an impact on the magnitude and speed of flows across the boundary.

The supply and flow of nutrients, materials, and energy within habitat fragments, as well as between fragments and the surrounding landscape, will likely differ depending on the adjacent land-use or activity.

Fragment heterogeneity: The degree of habitat variability within isolated fragments has been determined to be one of the factors that contributes to the correlations between species composition and fragment spatial characteristics. Compared to small fragments, large fragments are more likely to have a wider range of soil types, more topographic variation, more microclimatic variation, and more habitat kinds.

Relatively varied, about equal-sized fragments typically support a higher number and diversity of species than more homogeneous ones. Compared to populations in more homogenous habitats, populations of plants or animals in varied habitat fragments can be less vulnerable to local extinction. For example, populations of bush crickets in Sweden were more likely to persist if they occurred in an area which contained several vegetation types than in an area which contained only a single or small number of vegetation types. This result was largely due to the existence of greater microclimatic variation in the more heterogeneous habitats, which allowed some individuals to persist even under severe weather conditions. In contrast, areas with little vegetational diversity exhibited little microclimatic variation; thus in severe weather, the cricket populations went extinct. This result suggests that maintenance or restoration of a high diversity of vegetation types within habitat remnants may be essential for long term population persistence. In addition to the size of the forest fragments, an analysis of forest birds in the temperate zone showed that the structural variety of the forest vegetation had a substantial impact on the species composition of the birds.

CAUSES OF HABITAT FRAGMENTATION

Fragmentation is caused by both natural forces and human activities, each acting over various time frames and spatial scales.

Fragmentation Due to Natural Causes

1. Over long-time frames (thousands or millions of years), landscapes are fragmented by geological forces (e.g., continental drift) and climate change (e.g., glaciations, changes in rainfall, sea level rise).

2. Over short periods (decades or months), natural disturbances, such as forest fires, volcanoes, floods, landslides, windstorms, tornadoes, hurricanes and earthquakes modify and fragment landscapes.

3. Also, landscapes are naturally fragmented by mountain ridges, canyons, rivers and lakes. Some ecosystems also commonly occur in discrete patches and are thus naturally fragmented. Natural processes create the habitat heterogeneity and landscape diversity upon which many species depend.

Fragmentation due to Human Activity

The most important and largest-scale cause of changes in the degree of fragmentation is anthropogenic habitat modification, with nearly all fragmentation indices being strongly correlated with the proportion of habitat loss in the landscape (Fahrig, 2003).

Humans have modified landscapes for thousands of years. Many human activities such as agriculture, settlement, resource extraction (e.g., mining, timber), industrial development (e.g. the construction of hydroelectric dams) alter and fragment landscapes. Of these activities, agriculture is the leading cause of ecosystem loss and fragmentation throughout the world today.

MANAGEMENT OF HABITAT FRAGMENTATION

Habitat fragmentation has a variety of impact on the environment and its organisms. Fragmentation benefits some species, and at the same time put other species at a great deal of risk. As a result, there is necessity to take effective actions to maintain biodiversity in fragmented landscapes.

Establishment of effective corridors: To preserve biological diversity in the face of habitat fragmentation, corridors must be included as a protective measure. Corridors are essential for controlling habitat fragmentation because they serve as conduits for connections between divided, fragmented regions. Corridors facilitate both individual immigration and emigration between patches as well as mobility between different sorts of patches, including feeding and breeding. Furthermore, if corridors are properly constructed, they can increase population viability in both isolated and fragmented areas.

Buffer zone: Buffer zones shield wilderness areas from development and human activity through carefully thought-out programs. By lessening the edge effect, it can raise the ratio of rare to common populations.

Sustainable Development: Since ecosystems are home to the majority of species diversity, one excellent approach to get started would be to support groups that work to conserve them. It is necessary to enact laws and regulations that distinguish and restrict the sustainable use of natural resources. Because certain areas would remain unaltered, biodiversity would be encouraged. Apart from that, legislation will provide plants and animals time to adjust appropriately in the event that alterations are implemented.

Raise awareness about biodiversity: We've suffered biodiversity loss in huge proportions over the last century. To help create a perspective about biodiversity, it should be taught at schools and colleges so that students know how we can preserve biodiversity and how everyone can contribute to it.

Habitat Restoration: Habitat conservation efforts are not only limited to reducing use of natural resources, but restoring of habitats should also be practiced for ones that have suffered degradation. Habitat restoration is achieved through continuous management, protection efforts and rebuilding of those areas. The goal here is to *return* **Biotic factors** (species richness, biological interactions among species) and **Abiotic factors** (soil health, water levels, air quality index) to make them as they were *before human interference*. Special consideration should be given to areas concentrated with high biodiversity. Such a place is known as a biodiversity hotspot.

Rebuild new habitats: It is easy to destroy natural habitats but are we willing to rebuild and replace what we have lost. Many areas can be **re-developed** where wildlife can be preserved by giving them a space to grow and adapt. Some conservationists argue wetland habitats should be favored in rebuilding habitats since they have been found to host as many as 20,000 species.

CONCLUSION:

Increased isolation of populations or species results in negative genetic effects, such as inbreeding depression (lower fertility and fecundity, higher natal mortality), decreased genetic diversity due to genetic drift and bottlenecks, and a higher risk of localized populations being exterminated or narrowly distributed species going extinct due to natural disasters like hurricanes, wildfires, or disease outbreaks. These are just a few of the negative effects of habitat fragmentation on wildlife populations and species; alters the type and quality of the food basis; modifies microclimates by adjusting temperature and moisture regimes; and changes the composition of habitat plants, frequently to invasive and weedy species; alters the flow of nutrients and energy and increases edge effect and modifies cover availability, bringing together species that could not otherwise interact and perhaps raising rates of competition, predation, and nest parasitism. Effective measures must therefore be taken to preserve biodiversity in fragmented settings.

REFERENCES

FAHRIG, L., 2003. Effects of habitat fragmentation on biodiversity. *Annu. Rev. Ecol. Evol. Syst.*, 34:487–515.

HANSKI, I., POYRY, J., PAKKALA, T. AND KUUSSAARI, M., 2002 Multiple equilibria in metapopulation dynamics. *Nature*, 377: 618-621.

LORD, J.M. AND NORTON, D.A., 1990. Scale and the spatial concept of fragmentation. *Conservation Biology*, 4(2), 197-202.

MACARTHUR, R.H. AND WILSON, E.O., 1967. The Theory of Island Biogeography. Princeton, NJ: Princeton University Press.

WILSON, M. C., CHEN, X. Y., RICHARD, T., CORLETT., RAPHAEL, K., DIDHAM. AND DING, P., 2015, Habitat fragmentation and biodiversity conservation: key findings and future challenges. *Landscape Ecol.*, 31, 219–227.