



Review Paper

## The Biotic Implications of Forest Fragmentation

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### Abstract

Forest fragmentation which is the process of breaking up of large forested areas into smaller pieces is a common phenomenon that occurs in the present times. A review of existing literature shows that fragmentation can exert even larger independent effects than forest loss. It gives rise to isolation and edge effects that affect both animal and plant populations. Significant impacts of forest fragmentation include reduction in species diversity and abundance, alterations in composition and demographic parameters of species and so on. Its effects propagate through the various pathways through the forest ecosystem, not only affecting particular plant or animal groups but also interspecific interactions. Through this review, the consequences of fragmentation on microclimate, flora, avian and mammalian fauna have been revealed, along with the inherent pathways. It very well shows how the impacts of the phenomenon encompass the entire forest ecosystem.

**Keywords:** Forest Fragmentation, Effects, Flora, Fauna.

### Introduction

Fragmentation of natural and semi-natural habitats is regarded as an important cause of the declines in biodiversity<sup>1,2</sup> and has led to investigations on habitat requirement of species<sup>3</sup>. During fragmentation, there is a decline in the average size of forest patches whereas there is an increment in the distance between patches increases, due to which the ratio of edge to interior increases<sup>4</sup>. It is resulted due to simultaneous decrease of forest area, increment of forest edge, and the sub-division of wide-spread forested areas into smaller non-contiguous fragments<sup>5</sup>. This can be caused by either natural or anthropogenic activities but forests fragmented due to anthropogenic reasons are more vulnerable to further degradation<sup>6</sup>. It is a serious threat to biodiversity<sup>7,8</sup> and has been coined as a separate problem from forest loss<sup>9</sup>.

Fragmentation has larger independent effect than forest loss<sup>10</sup>. It gives rise to isolation and edge effects that affect populations<sup>11</sup>. In fact, some of the important negative consequences of forest fragmentation include edge effects, elevated rates of predation and herbivory, and failure of metapopulation dynamics<sup>12</sup>. As a result of edge effects, there are alterations in plant and animal community composition and diversity<sup>13</sup>. Important consequences of forest fragmentation include reduction in species diversity and abundance, shifts in species composition and demographic parameters and reduction in genetic diversity<sup>14</sup>. The community health in forest fragments is also affected<sup>15</sup>. However, community responses towards fragmentation depend upon effects of area and edges and impacts arising due to position in the landscape<sup>16</sup>. Habitat

fragmentation is often stated to disrupt plant-animal interaction but very few studies have been devoted to this aspect<sup>17</sup>.

Thus, it is well understood that forest fragmentation which is a severe threat to biodiversity conservation, exerts a number of biotic consequences. The effects of forest fragmentation could further add to the same and could lead to further severe problems. Thus, there is a need to address the issue. However, much of the available information on fragmentation is biased<sup>18</sup>. A vivid appreciation of the phenomenon would lead to the development of proper management measures. Therefore, the present review, attempts to study the effects of forest fragmentation on flora and fauna. The review is likely to reveal the various mechanisms through which the issue brings about changes in the ecosystem as well as among different organisms. This would lead to a proper understanding of the problem as well as ecological consequences.

### Effects on Microclimate

Fragmentation brings about changes in environmental parameters<sup>19</sup>. It alters microclimates<sup>20</sup> and in this way can pose threat to number of plants that require certain set of microclimate for their favourable growth and regeneration e.g. orchids. Consequently, it results into local extinction of plant populations from habitat fragments<sup>21</sup>. Forest fragments have accelerated dynamics and this in turn induces changes in forest structure, floristic composition and microclimate and can affect disturbance-sensitive species<sup>22</sup>. Composition and population structure of regenerative plants in such fragments shift towards species-poor seedling community. Understorey species

(especially tree seedlings) are lost and this in turn, not only threatens rainforest biodiversity but also hampers forest regeneration<sup>23</sup>. Low abundance, requirement of large area, fluctuations in populations, low fecundity and dispersal ability, and needs for specialized habitat contribute to sensitivity of species towards the phenomenon<sup>24</sup>.

### Effects on flora

Fragmentation is likely to severely affect tree diversity<sup>25</sup>. However, different plant species respond differently to habitat fragmentation<sup>26</sup>. Fragmentation induces demographical and community changes in tree species present before disturbance<sup>27</sup> and also elevate the mortality rates of canopy trees<sup>28</sup>. Trees in fragments have also been frequently found to shed leaves due to physiological stress<sup>29</sup>.

Reduction in habitat and increase in the edges change the pattern of fruit consumption of birds and consequently plant fitness in forest fragments is affected<sup>30</sup>. In addition, species composition of seedlings is affected<sup>31</sup> and secondary species tend to increase at the expense of mature forest species. Pioneer species tend to be more abundant near fragment edges<sup>32</sup>. Low seedling density has also been observed in fragments and this is often correlated with reduced seed dispersal and increased seed predation<sup>33</sup>. Environmental changes due to fragmentation also affect plant recruitment and survival<sup>34</sup>. Seedling establishment is more likely to be affected by isolated fragments and creation of edges as compared to physiological processes<sup>35</sup>. Hence, seedling survivorship in fragments is highly suppressed and responsible factors are even likely to operate within the interiors of larger fragments<sup>36</sup>. Several studies have been done on changes in seed germination, predation, or dispersal in forest fragments<sup>37,38</sup>. Seed predation is found to be greater in fragments and forest edges<sup>39</sup> and pollination and seed dispersal are also hampered<sup>15</sup>. Disruption of pollination and seed dispersal mutualisms due to fragmentation has a threatening impact on neotropical forests<sup>40</sup>.

Fragmentation also affects pollination. However, the impacts of fragmentation differ among different animal flower visitors<sup>41</sup>. Fragmentation can lead to inbreeding depression which can have severe consequences on woody species whose pre fragmentation genetic neighborhoods might have involved plants scattered over a large area<sup>42</sup>. Another factor that affects seedling recruitment in fragments is grazing and trampling of seedlings and saplings by cattle in fragments, an issue which can constitute a severe short-term conservation problem<sup>15</sup>. When forest spatial patterns are altered, habitat quality and biodiversity in both tropical forests<sup>43</sup> and non-tropical forests<sup>44</sup> are affected. Disconnected forests tend to lose species but they do not gain species at the same rate. This occurs due to poor ability for colonisation of typical forest plant species because of dispersal limitation as well as disappearance of natural events of disturbance, which favours the dominance of certain competitive species in such forests<sup>45</sup>. In fact, it has been argued that Amazonian forest fragments would lose several

disturbance-sensitive tree species<sup>46</sup>.

### Effects on avian fauna

Many bird species in fragments recolonize themselves or undergo extinction<sup>47</sup>. In fact, understory insectivorous and large canopy frugivorous birds are more prone to extinction due to fragmentation<sup>48</sup>. Large interior-forest birds which are important seed dispersal agents vanish very rapidly due to forest fragmentation<sup>49</sup>. Forest fragmentation also exerts negative impacts on several woodland birds by elevating their vulnerability to predation and nest parasitism<sup>47</sup>.

The abundance of some birds in fragments decreases with their isolation from surrounding woodland whereas the reverse is found in case of some species<sup>50</sup>. Forest fragmentation has also been hypothesized to reduce nesting (reproductive) success of certain forest birds<sup>51</sup> by triggering nest predation and brood parasitism<sup>52</sup>. As fragmentation increases and there is greater intermixing with agricultural land, predation in small forest fragments also increases. But the response of all species is not the same<sup>53</sup>. Forest fragmentation also facilitates cowbird parasitism, decreases habitat heterogeneity, hampers dispersal between woodlots as well as increases nest predation and thereby harms neotropical migrants<sup>54</sup>.

### Effects on mammals

Forest fragmentation has been found to have severe consequences on mammals<sup>55</sup>. Frugivorous animals are a critical component of tropical forests because they cause the dispersal of seeds in a manner that enhances recruitment of seedlings<sup>56</sup>. Both frugivorous aves and primate species decline with decreasing fragment size and this in turn affects seed recruitment by decreasing seed dispersal<sup>57</sup>. Understory bats<sup>58</sup> also disappear quickly during habitat fragmentation. Extinction is greater in fragments in which habitat area is reduced and immigration among patches is limited<sup>59</sup>. Fragmentation can even alter animal population densities and the amplitude of population fluctuations, activity patterns of individual animals, and foraging ranges<sup>60</sup>. On the other hand Carrion and dung beetle fauna also changes due to forest fragmentation and its effects ramify through other related communities and ecosystem processes<sup>61</sup>.

Changes in plant-animal interactions due to fragmentation may be magnified into long-term effects on the integrity of reserves or other managed landscapes<sup>62</sup>. However, habitat generalists, and species that have greater population densities and can thrive in small home ranges survive well in fragmented regions<sup>63</sup>. Therefore, preservation of network of small forest patches can have great conservation value to the amphibians and reptiles<sup>64</sup>. On the other hand, as a result of fragmentation, accessibility to forest resources increases and this in turn also facilitates anthropogenic activities like, hunting<sup>65,66</sup>, subsistence and industrial logging<sup>67</sup> and plant harvesting<sup>68</sup> thereby threatening

survival and population of wild animals. Forest fragmentation also increases susceptibility to wildfire<sup>69</sup>. However, high quality forest fragments in terms of habitat, can play an important role in conserving plant species diversity, provided the forest management is appropriate<sup>70</sup>.

## Conclusion

It is understood that forest fragmentation takes place due to deforestation and disturbance and result into edge effects that extend into remaining forest areas<sup>71</sup>. It has a wide range of impacts that affects both flora and fauna. However, it is not easy to make comparisons among the consequences of fragmentation and habitat loss since both are intercorrelated<sup>72</sup>. Its effects vary according to different species and are realized at various levels. It is thus an eminent threat to biodiversity conservation. Small reductions in forests by narrow forest-dividing corridors can be helpful in protecting the abundances of forest-interior species<sup>73</sup>.

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