

Habitat Fragmentation: Effects and Implications



Clearcuts and forest fragmentation, Willamette NF, Oregon.

From: Cascadia Wildland Project

URL: <http://www.cascwild.org/legacy/yourland.htm>

“Fragmentation has become a major subject of research and debate in conservation biology” (Meffe et al. 1997, p. 272)

Jabber M. Al-jabber

Spring 2003

Introduction of habitat fragmentation:

Fragmentation has been considered as one of the most major factors that lead to the decline of many wildlife species (Brittingham and Temple 1983, Yahner 1988, Winslow et al. 2000) because fragmentation tends to decrease population productivity (Robinson et al. 1995). Therefore, Meffe states that “fragmentation has become a major subject of research and debate in conservation biology” (Meffe et al. 1997, p. 272). Forest fragmentation usually occurs when large and continuous forests are divided into smaller patches as a result of road establishment, clearing for agriculture, and human development (Robinson et al. 1995, Meffe et al. 1997).

It is important to distinguish between fragmented and natural patchy landscapes. The latter has rich structures, including tree logs and various type of vegetation, whereas the fragmented landscape is a simple patch, trees with the same species and ages. In terms of a high number of edges, there is less appearance of edges in natural landscape due to structures similarities between adjacent patches. In contrast, edges appear to be very obvious in the fragmented landscape. Furthermore, species are at greater risk in the fragmented landscape than they are in the natural landscape (Meffe et al. 1997).

Definition of habitat fragmentation:

Generally, habitat fragmentation is an ecological process in which a large patch of habitat is divided into smaller patches of habitats. Usually, this process is caused by human activities (roads, agriculture, and logging). It also reduces the value of the landscape as habitat for many species (plants and animals). Fragmentation alters natural habitat in many ways, including reduction of patches' sizes, increment of

distances between similar patches, and increment of edges and predation (Brittingham and Temple 1983, Robinson et al. 1995).

Consequences of fragmentation effects:

Species vulnerable to fragmentation. Recognizing factors that might make a certain species vulnerable to extinction in habitat fragmentation is one of the most challenging issues in conservation biology. Although species vary in terms of vulnerability to predators in fragmented habitats, causes of vulnerability are poorly understood (Webb et al. 2002). Studies done by Sarre (1995) and Ranius and Hedin (2001) state that a low dispersal rate and range are reasons that lead to vulnerability of species to fragmentation (Sarre et al. 1995, Ranius and Hedin 2001). Generally, Webb et al. (2002) explains that habitat specific species are less in their ability to withstand the rapid changes and modifications in their habitats than those who are denoted as generalists species. Therefore, vulnerable species are likely to go extinct.

As stated, species differ from each other in respect to vulnerability. Several kinds of species are predicted to be most vulnerable to habitat fragmentation. These may include, but not restricted to, the following (Meffe et al. 1997):

- ❖ *Naturally rare species*: There are two main categories of naturally rare species, restricted geographic distribution (endemic species) and low population densities.
- ❖ *Wide-ranging species*: Large species often require large areas for their daily and seasonal movements. That is, these species need to travel through fragmented landscapes, facing hazard of road hunters.

- ❖ *Nonvagile species*: This refers to species that have low dispersal abilities. Usually, they do not travel far away from where they were born. Roads and clearcuts act as barriers in this situation.
- ❖ *Species with low fecundity*: Due to their low reproduction rates, some species, e.g., Neotropical migrant birds, cannot quickly rebuild their population when they encounter harsh environmental conditions such as fragmented landscapes.
- ❖ *Ground nesters*: Species that nest on or near ground are more vulnerable to predators than those who nest on or near top of trees.
- ❖ *Persecuted species*: Human activities, such as hunting and food gathering, are very obvious and higher in fragmented landscapes than in forested landscapes because they are easily seen by people.

Initial exclusion. Elimination of species is one of the most causes as a result of habitat fragmentation in an ecosystem. Species that are endemic to a specific habitat type in the landscape are likely to be excluded from their habitat range. For instance, if patches of a certain type are destroyed by fragmentation practices, species that require these patches are likely to be extinct (Meffe et al. 1997). Local extinctions are expected to be negatively correlated with the patch size as well as the amount of habitat in the landscape (Hames et al. 2001). Therefore, the more the habitats are destroyed, the more species are gone through extinction and/or elimination to elsewhere.

Barriers and isolation. Populations can become isolated within their patches when all of the surrounding habitats are destroyed. Removing these habitats make species migration into different adjacent patches difficult and dangerous. While some species require a single type of habitat to carry out their activities, there are many

species that need multiple seral stages to do their activities. Generally, species require a mix of different habitats for various activities e.g., food patches, roost sites, and breeding sites. If these habitats are not available, or even are separated by barriers from one another, species will be restricted to certain types of habitats and will be at high risk when there is no enough and large patches that encompass those species. For example, the Middle Spotted Woodpecker (*Dendrocopos medius*) occupies isolated forests with a low ability of dispersal. Its population in Sweden was somewhat stable between 1967 and 1974. Between 1975 and 1983, however, its population declined to extinction point. It is believed that the reasons for such a sharp decline are cold weather and reproductive failures (Meffe et al. 1997).

An important factor acting as barriers in fragmented landscape is road construction, where roads divide population into small fragments, exposing them to extinction (Meffe et al. 1997). Roads contribute directly to mortality of species when they disperse (Davies and Margules 1998). For instance, roads are seen as the largest threat to Florida panthers as well as many other large mammals in many areas (Fahrig et al. 1995 in Meffe et al. 1997). Like roads in landscapes, dams also act as barriers in aquatic ecosystem. Dams affect fish migration to upstream and seas. In aquatic ecosystem, the remaining populations are relatively small and isolated, leading to species extinction (Dodd 1990 in Meffe et al. 1997).

Crowding effects. Crowding occurs usually in the isolated fragments immediately after cutting takes place in the landscape (Schmiegelow et al. 1997). Logically, when a population is isolated by fragmentation into smaller patches, its intensity is likely to be high when time progresses, leading to congestion in the

population in the isolated patches (Debinski and Holt 2000). This is an ecological phenomenon known as *crowding of the ark* (Meffe et al. 1997). Such a phenomenon is especially dominant in small-mammal studies and is observed in birds and insects communities (Debinski and Holt 2000).

As a result of this phenomenon, a population collapse follows the crowding because of the limited place and the high intense competition among members of the same species on nutrient resources (Meffe et al. 1997).

Edge effects. Edges are considered one of the most destructive results of habitat fragmentation. To better understand such effects, it is imperative to provide a clear definition of what an edge means. The edge as defined by Yahner is “the junction of two different landscape elements (e.g. plant community type, successional stage, or land use” (Yahner 1988, p.334). That is, as a habitat becomes more fragmented into small patches, more of the habitat will end up adjacent to a different type of habitat. Moreover, the edge effect refers to several environmental changes such as diversity, abundance, and spatial distribution of wildlife communities (Yahner 1988).

Species that are attracted to nest near to edges are more vulnerable to predation and brood parasitism, especially by Brown-Headed Cowbirds (Meffe et al. 1997). For example, knowing that Brown-Headed Cowbirds prefer fragmented forests, they most often appear in agricultural and residential landscapes near edges rather than in interior and continuous and heavy forests. They appear in such areas because it is more difficult for the Brown-Headed Cowbirds to penetrate heavily forested landscapes. Being in fragmented landscapes makes it easy for them to forage and search for host species nests (Yahner and Mahan 1997, Muehter 2002). Brown-Headed Cowbirds are “a major

reason for the decline of forest birds in heavily fragmented landscapes” (Meffe et al. 1997, p. 295). Also, what makes such a decline worst is that many songbirds such as Warblers, Flycatchers, Tanagers, and Thrushes that nest close to forest edges lack the ability to cope the negative impact of the Brown-Headed Cowbirds parasitism (Coker and Capen 1995). The population rate of the Brown-Headed Cowbirds is observed to be higher in fragmented landscapes than it is in forested landscapes due to the availability of food resources (Wilcove 1985, Terborgh 1992, Coker and Capen 1995, Robinson et al. 1995, Ford et al. 2001, Robinson and Robinson 2001, Muehter 2002) regardless of the abundance of host species (Robinson et al. 1995). Therefore, the closer the host species are to the edges, the more likely they will severely suffer parasitism by the Brown-Headed Cowbirds (Goguen and Mathews 2000, Muehter 2002)

Climate changes. Fragmentation is considered as a factor that changes microclimate. During the day in a fragmented area, the soil surface absorbed most energy that comes from sun, warming the layer above it. This energy is radiated back during the night. As a result, evaporation, moisture and wind will be changed, which in turn will affect vegetation in the fragmented areas, creating their own microclimate. For example, temperature at a shaded place is lower that it is in an exposed place to sun and wind. Unlike fragmented areas, dense conifer forests, especially their canopies, tend to provide shade and break wind down. Such a microclimate for some species such as deer and elk is very important in providing what is known as “thermal cover” (Smith and Smith 2001).

In addition, soils can affect microclimate. Fragmented landscapes are more vulnerable to sunlight. Dry soils are likely to be poor conductivity and reflectivity, which

is the reason of the temperature coolness in dry sandy soils. In contrast, soils that have high conductivity will transfer most of the heat into the soils, affecting somehow organisms in soils (Smith and Smith 2001).

Changes in species composition. Meffe et al. (1997) mentions that there are several studies suggesting that species composition and abundance will change as fragmentation takes place in landscapes by losing those species that require large areas. In their study, Ford et al. (2001) suggest that reproductive success of birds nesting in the forests near an agricultural corridor is lower than in the forest interior. That is, songbirds reproduce more successfully in large forested areas as well as in old-growth forests (Brittingham and Temple 1983, Adler 1995). They are very infrequent in, or even absent from, small patches. For instance, birds in the wheatbelt of Western Australia have been lost in many small patches (Saunders 1989 in Meffe et al. 1997). This suggestion is also found in a study done by (Bernard et al. 2001). They compared bat species composition in three different locations in the Brazilian Amazon, continuous forest, fragmented forest, and continuous forest in two relatively well studied areas. They captured 17 to 42 species at each location. The highest number of species occurred at high abundance in the continuous forest, whereas it was the lowest in the fragmented forest (Bernard et al. 2001).

Another aspect related to habitat fragmentation is exotic species invasion. As far as habitat destruction, fragmentation increases the percentage of exotic species (Meffe et al. 1997). Having high reproduction and effective use of new habitats, exotic species can rapidly eliminate native species from their original habitats, where they impact “the environment, the economy, and human health.” Also, they might increase “predation

and competition, disease, habitat destruction, genetic stock alterations, and even extinction” for other species (U.S. Environmental Protection Agency).

Management and Implications:

As discussed earlier in this paper, 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.

Fragmentation vs. connectivity. Since fragmentation has an obvious negative influence on habitats and their species, it is very practical to avoid fragmentation and provide more connections in the environment. Undamaged habitats are likely to control and maintain a microclimate. However, sunlight, logging and other types of disturbance penetrate such habitats and change their microclimate. As a result, species in these habitats will be affected. Therefore, devoting conservation and protection, at least for endangered species, should be effectively taken into consideration. Efforts must be directed to identify these crucial species or group of species as well as the processes that affect them in the habitats if management plans are to be more effective (Noss 2001).

Establishment of effective corridors. Inclusion of corridors as a protection strategy in habitat fragmentation is imperative to maintain biological diversity (Rosenberg and Noon 1997). Corridors function as connection channels between separated fragmented patches (Magura et al. 2001, Noss 2001), so they are crucial in managing habitat fragmentation. Corridors serve two purposes: facilitating movement between various types of patches, including breeding, feeding and birthing; and

facilitating immigration and emigration of individuals among such patches (Meffe et al. 1997). Moreover, corridors can improve the population viability in both fragmented and isolated landscapes if they are appropriately designed (Meffe et al. 1997, Noss 2001).

Buffer zone. Through well-planned projects, buffer zones provide protection for wilderness from human activities and developments (Meffe et al. 1997). Martino (2001) lists several studies that discuss a buffer zone around a protected area. For example, He states that Barzetti (1993) explains that buffer zones are important for the protection of species with high mobility. Moreover, Martino talks about a study conducted by Götmark et al., which support the use of buffer zones to enhance the function of small patches in Sweden. Finally, buffer zones, as Shafer (1999) in Martino (2001) states, can increase the ratio of rare and common population by “softening the edge effect.”

Literature cited

- Adler, T. 1995. Think big to save birds on the edge. *Science News*, 147(13): 198-199.
- Bernard, E., Albernaz, A., and Magnusson, W. E. 2001. Bat species composition in three localities in the Amazon Basin. *Studies on Neotropical Fauna and Environment*, 36 (3): 177-184.
- Brittingham, M. C. and Temple S. A. 1983. Have cowbirds caused forest songbirds to decline? *BioScience*, 33(1): 31-35.
- Coker, D. R., and Capen, D. E. 1995. Landscape-level habitat use by Brown-Headed Cowbirds in Vermont. *Journal of Wildlife Management*, 59(4): 631-937.
- Davies, K. F., and Margules, C. R. 1998. Effects of habitat fragmentation on carabid beetles: Experimental evidence. *Journal of Animal Ecology*, 67(3): 460-472.
- Debinski, D. M., and Holt, R. D. 2000. A survey and overview of habitat fragmentation experiments. *Conservation Biology*, 14 (2): 342-355.
- Ford, M. B., Winslow, D. R., Whitehead, D. R. and Koukol, M. A. 2001. Reproductive success of forest-dependent songbirds near an agricultural corridor in south-central Indiana. *The Auk*, 118(4): 864-873.
- Goguen, C. B., and Mathews, N. E. 2000. Local gradients of cowbird abundance and parasitism relative to livestock grazing in a western landscape. *Conservation Biology*, 14(6): 1862-1869.
- Hames, R.S., Rosenberg, K. V., Lowe, J. D., and Dhondt, A. A. 2001. Site reoccupation in fragmented landscapes: testing predictions of metapopulation theory. *Journal of Animal Ecology*, 70(2): 182-190.
- Magura, T., Ködöböcz, V., and Tóthmérész, B. 2001. Effects of habitat fragmentation on carabids in forest patches. *Journal of Biogeography*, 28(1): 129-138.
- Martino, D. 2001. Buffer zones around protected areas: A brief literature review. *Electronic Green Journal*, NA(NA): NA.
- Meffe, G. K., Carroll, C. R., and contributors. 1997. Principles of conservation biology, 2nd ed. Sinauer Associate, Inc. Sunderland, MA.

- Muehter, V. 2002. Cowbirds and conservation. National Audubon Society. Available online: <http://www.audubon.org/bird/research>. Last visited: May 15, 2002.
- Noss, R. F. 2001. Beyond kyoto: Forest management in a time of rapid climate change. *Conservation Biology*, 15(3): 578-592.
- Ranius, T. and Hedin, J. 2001. The dispersal rate of a beetle, *Osmoderma eremita*, living in tree hollows. *Oecologia Berlin*, 126 (3): 363-370.
- Robinson, S. K. Robinson, W. D. 2001. Avian nesting success in selectively harvested north temperate deciduous forest. *Conservation Biology*, 15(6): 1763-1771.
- Robinson, S. K., Thompson, F. R. Donovan, T. M., Whitehead, D. R., and Faabrog, J. 1995. Regional forest fragmentation and the nesting success of migratory birds. *Science*, 267(5206): 1987-1990.
- Rosenberg, D. K., and Noon, B. R. 1997. Biological corridors: Form, function, and efficacy. *Bioscience*, 47(10): 677-688.
- Sarre, S. Smith, G. T., and Meyers, J. A. 1995. Persistence of two species of gecko (*Oedura reticulata* and *Gehyra variegata*) in remnant habitat. *Biological Conservation*, 71(1): 25-33.
- Schmiegelow, F. K., Machtans, C. S., and Hannon, S. J. 1997. Are boreal birds resilient to forest fragmentation? An experimental study of short-term community responses. *Ecology Washington D. C.*, 78 (6): 1914-1932.
- Smith, R. L., and Smith, T. M. 2001. Ecology and field biology, 6th ed. An imprint of Addison Wesley Longman, Inc. USA.
- Terborgh, J. 1992. Why american songbirds are vanishing. *Scientific American*, 266(5): 98-104.
- U.S. Environmental Protection Agency. ND. Exotic species. Available online: <http://www.epa.gov/bioindicators/aquatic/exotic.html>. Last updated on Wednesday, December 11, 2002. Last visited on April 13, 2003.
- Webb, J. K., Brook, B. W., and Shine, R. 2002. What makes a species vulnerable to extinction? Comparative life-history traits of two sympatric snakes. *Ecological Research*, 17(1): 59-67.
- Wilcove, D. 1985. Nest predation in forest tracts and the decline of migratory songbirds. *The Ecological Society of America*, 66(4): 1211-1214.

- Winslow, D. E., Whitehead, D. R. Whyte, C. F. Koukol, M. A., Greenberg, G. M., and Ford, T. B. 2000. Within-landscape variation in patterns of cowbirds parasitism in the forests of south-central Indiana. *Ecology and management of cowbirds and their hosts*. University of Texas Press, Austin. Pages 298-310.
- Yahner, R. H. 1988. Changes in wildlife communities near edges. *Conservation Biology* 2(4): 333-339.
- Yahner, R. H., and Mahan, C. G. 1997. Effects of logging roads on depredation of artificial ground nests in a forested landscape. *Wildlife Society Bulletin*, 25(1): 158-162.

