Implications for Wildlife Populations

By Stanley A. Temple and David J. Flaspohler

The meeting of forest and field is an ecotone—the juxtaposition of two structurally and compositionally different ecosystems. Ecotones exist at several spatial scales, ranging from local-scale edges between patches of different habitat to continental-scale transitions between major biomes. The transitions between adjacent ecosystems may be gradual or abrupt. So-called inherent edges occur as a result of a variety of natural phenomena; induced edges are created by human activities (Thomas 1979).

Our focus will be on the abrupt, local edges of anthropogenic origin, especially the forest edges created by some forest management practices. Such forest edges generate complex interactions between species and communities associated with the adjacent ecosystems, usually a forest stand and an adjacent cleared area. These interspecific interactions can affect the characteristics of local wildlife populations in the vicinity of the forest edge, and the summed impacts over a landscape can affect the characteristics of an entire regional population.

Ecologists seeking to better understand the effects of forest edges on wildlife species have often studied
Creation of abrupt forest edges through application of even-aged management, as at this Oregon site, has long been known to have beneficial effects on game and other species that prefer ecotones, but the consequences for overall biological diversity can be damaging.

Edges: Beneficial or Harmful?
Ecologists have long been fascinated by phenomena associated with edges (Leopold 1933; MacArthur and MacArthur 1961; Odum 1971; Emlen 1973; Smith 1977). As a result, they have described a variety of "edge effects" (Lay 1938; Kendeigh 1946; Johnston 1947; Johnston and Odum 1956; Hagar 1960; Martin 1960; Hogstad 1967; Johnston 1970; Gates and Gysel 1978; Brittingham and Temple 1983; Johnson and Temple 1986). One of the earliest reported edge effects was increased diversity of species and density of individuals associated with forest edges. This phenomenon results from the unusual co-occurrence of several groups of species in the ecotones associated with forest edges. They include species that marginally occupy the ecotone but are primarily associated with one of the adjacent habitat types, species that occupy ecotones as their preferred habitat, and species that require both adjacent habitat types within their home range.

Based on a perception that edge effects were a positive phenomenon, wildlife managers, especially those who manage game species, have traditionally viewed the creation of forest edge as a habitat improvement (Yahnert 1988). In his seminal text Game Management, Aldo Leopold (1933) observed that certain game species could be found in greater abundance along habitat edges. Leopold’s specific reference to a few game species somehow was misinterpreted by subsequent generations of wildlife managers, who often generalized Leopold’s observation to imply that edges were good for all wildlife species. For example, in the third edition of Wildlife Management Techniques, published by the Wildlife Society, Yoakum and Dasmann (1971) provide a list of priorities for management of wildlife habitat. The list begins, “1. Develop as much edge as possible…”

Such a broad interpretation of a very specific phenomenon encouraged an alliance between wildlife managers and foresters. Intensive forest management generated lots of forest edges, which were viewed coincidentally as enhanced habitat for wildlife. We can call this seemingly win-win integration of forestry and wildlife management the beneficial edge paradigm. Even though Leopold and others recognized that there were also negative consequences of creating edges, few ecologists and even fewer resource managers questioned the paradigm until the late 1970s.

The first rumblings of change came from studies that looked at the effects of forest edges on nongame species, especially songbirds (Gates and Gysel 1978; Brittingham and Temple 1983). As more research accumulated, it became clear that many organisms were being negatively affected by the creation of forest edges and the fragmentation of forest habitat. For some bird species, negative edge effects included elevated rates of nest predation and brood parasitism by the brown-headed cowbird, which dramatically reduced avian productivity (Brittingham and Temple 1983;
As ecologists and resource managers began to understand the effects of forest edges on a broader range of species, a new paradigm surfaced: the harmful edge paradigm. While acknowledging the benefits for some species, this new view of forest edges emphasized the previously unmentioned deleterious consequences for many wildlife populations and biological diversity in general. During the 1980s and 1990s, these negative effects of forest edges became major conservation issues in situations where edge habitat had come to dominate whole landscapes (Robinson et al. 1995).

**Birds on the Edge**

At a local scale, forest edges can influence the composition of the bird community in a forest stand because they provide attractive habitat for some species but not others. Furthermore, each species that lives in edge habitat will have its fitness affected by the presence of the forest edge. Among the birds that live near forest edges, edge effects will promote the survival and reproductive success of some species and compromise the success of others. In general, the pattern is that edge specialists do well while forest-interior or open-habitat specialists fare poorly.

Abiotic and biotic conditions at the forest edge differ from those in the forest interior in many ways. Vegetation along the forest edge is exposed to increased light, allowing some plant species to grow faster and produce thicker foliage (Ranney et al. 1981). The vertical profile of vegetation along an edge is often more complex than under forest-interior conditions (Gates and Giffen 1991). The denser vegetation provides greater cover (Johnson et al. 1979) and possibly greater availability of insects (Helle and Mouna 1985). Some species, especially edge-habitat specialists, find these features attractive. However, these same features can also attract species that are normally adapted to forest-interior conditions, especially species normally associated with small tree-fall gaps (DeGraaf 1991).

Because forest edges often contain a high density of individuals and an unusual mixture of species from adjoining habitats, they bring species that are not normally associated with one another into contact. Interspecific interactions in the ecotones along forest edges can have negative consequences for edge-sensitive species—those whose fitness (i.e., survival and reproduction) suffers near forest edges.

Nest predation is the primary cause of nest failure for most forest bird species (Ricklefs 1969; Martin 1992). For this reason, it may play an important role in regulating populations at local and regional scales (George 1987; Sherry and Holmes 1992). Because many nest predators concentrate their search efforts near forest edges (Bider 1968; Angelstam 1986), studies that looked at nest success near forest edges often found that edge-sensitive birds incurred heavy nest losses to predators. Brood parasitism by brown-headed cowbirds can also cause heavy losses among some bird species. Many forest birds are particularly vulnerable because they have had little contact with cowbirds until anthropogenic habitat changes allowed cowbirds to leave their preferred habitat in grasslands and invade previously unfragmented landscapes (Mayfield 1965, 1977). Brittingham and Temple (1983) found that cowbird parasitism rates were higher near forest edges than in the forest interior.

At the regional scale, the negative effects for local populations of edge-sensitive species can add up when the ratio of forest edge to forest interior increases as a result of changes caused by forest management practices. A regional analysis of forests in the Midwest demonstrated that both nest predation and brood parasitism increased in fragmented landscapes dominated by forest edges relative to contiguous forest landscapes (Robinson et al. 1995). As the proportion of forest edge increases within a landscape, the regional status and viability of some species of edge-sensitive forest birds may be threatened (Temple and Cary 1988; Donovan et al. 1995, 1997). The problem is related to metapop-
ulation dynamics in which the forested habitat near forest edges becomes *sink habitat* where local bird populations are unable to maintain themselves because deaths exceed births (Temple and Cary 1988; Donovan et al. 1995). On the other hand, forest-interior habitats away from forest edges may serve as *source habitats* in which local populations produce a surplus because births exceed deaths. When the surplus from source habitats is sufficient to subsidize the local populations in sink habitat (the so-called rescue effect), the regional metapopulation can be maintained. But when sink habitat dominates, the subsidies will be inadequate and regional declines are inevitable (Temple 1991).

In the Midwest, for example, the regional importance of large, contiguous forest as source habitat has been highlighted (Temple and Cary 1988; Terborgh 1989; Robinson et al. 1995). Because of extreme habitat fragmentation in the southern Midwest, the source habitats in the northern Midwest may be essential to maintain regional metapopulations of forest-interior birds.

**New Management Prescriptions**

Today, wildlife ecologists, conservation biologists, landscape ecologists, ecosystem managers, and foresters find themselves at a juncture in which the two edge paradigms—beneficial and harmful—are competing for a dominant role in decisions on management of forested landscape. The shifts in management paradigms reveal as much about changing public values as they do about new discoveries regarding ecological relationships. The creation of forest edge does benefit certain game species that have been valued by segments of society for many decades. However, advances in our understanding of how forest edges affect other wildlife species parallels a broadening of public awareness and concern for biological diversity that goes beyond a desire to benefit a few favored species.

The simple prescription of "develop as much edge as possible" and the resulting alliance between game managers and forest managers is no longer tenable. Instead, forest managers must collaborate with wildlife ecologists, conservation biologists, landscape ecologists, and ecosystem managers to devise ways to minimize the negative impacts of forest edges on biological diversity by carefully planning the temporal and spatial patterns of forest edges across landscapes (Temple 1993).

Some of the emerging recommendations for forest managers that have been produced by this interdisciplinary reevaluation of forest edges can be summarized as follows:

- *In areas where anthropogenic forest fragmentation affects a large portion of the landscape, minimize the amount of edge created by forest management operations across a landscape. So much edge habitat is produced by human activities in general that it is forest-interior species that need more habitat in managed landscapes, not forest-edge species.*

- *Avoid creating edges in large, contiguous patches of forest that may be important source habitat for regional metapopulations of edge-sensitive species. It is usually quite obvious where the large forested landscapes exist. Those areas should be managed carefully to avoid converting source habitat to sink habitat.*

- *Where possible, create gradual edges rather than abrupt edges. Most forestry practices that create openings leave an abrupt edge with the unharvested portion of the forest. The application of selection techniques within the perimeter of a harvested stand creates a more gradual edge. It seems that at least some negative edge effects are worse along abrupt edges.*

- *Reforest openings created by logging as rapidly as possible so that the edge effects they produce are ephemeral. The longer a clearcut remains open, the longer the local edge effects persist. (In certain regions, however, concerns over the status of early-successional wildlife dictate that some forest openings be managed for these species; New England, for example, has areas where old field habitat has declined because of farm abandonment.)*

- *Where possible, use uneven-aged management, which creates little forest edge, rather than even-aged management, which tends to create much more forest edge. In general, the openings associated with even-aged management create more negative edge effects by providing a large patch of habitat for species that prefer nonforest conditions. Such species often create problems for edge-sensitive species inhabiting forest edges.*

- *Evaluate the ecological impacts of forest management in terms of biological diversity rather than a few favored species, like game species. Although such evaluations may necessitate working with a wider range of taxonomic specialists, this interdisciplinary approach will help ensure that forest management practices are truly sustainable.*

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