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Effects of hurricanes on wildlife: implications and strategies for management

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9.1 INTRODUCTION

Hurricanes, also known as cyclones or typhoons, occur throughout the world and are common in at least six regions encompassing parts of the tropics, subtropics and temperate zone (Nalivkin, 1983). Although the frequency of hurricane occurrence may vary within a region, such storms may occur with sufficient frequency and destructive force (Figures 9.1 and 9.2) to be important factors in determining the structure and species composition of biotic communities (e.g. Wadsworth and Englerth, 1959; Odum, 1970; Doyle, 1981; Weaver, 1986; Crow, 1980). The importance of hurricanes in influencing ecosystems is consistent with the prevailing view that natural systems are largely organized by disturbance (Pickett and White, 1985; Denslow, 1987).

Recent hurricanes which have passed through the Caribbean, Middle America and the southeastern United States have provided an opportunity to study their effects on the local flora and fauna (for recent reviews see Bénito-Espinal and Bénito-Espinal, 1991; Finkl and Pilkey, 1991; Walker, 1991; Pimm *et al.*, 1994; Loope *et al.*, 1994; Smith *et al.*, 1994). Such studies are of particular interest to conservation biologists and managers because of the potential negative impact of catastrophic events on small populations (Ewens *et al.*, 1987). This concern for small isolated populations has increased as a result of habitat loss and fragmentation and is likely to continue increasing if the predicted destructive potential of hurricanes increases with increased global warming (Emanuel, 1987).

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Figure 9.1 Damage one week after Hurricane Hugo, Luquillo Experiment Forest, Puerto Rico, September 1989.

Figure 9.2 The cloud forest at Hardwar Gap, Jamaica, two months after the passage of Hurricane Gilbert in October 1988.

As summarized in our review of the effects of hurricanes on bird populations (Wiley and Wunderle, 1994), it has been demonstrated that hurricanes can have both direct and indirect effects on wildlife. For instance, the high winds and rainfall associated with hurricanes may result in direct mortality of some wildlife. However, after the storm the indirect effects may have even more profound and long-lasting influences on wildlife populations. These include loss of food supplies or foraging substrates; loss of nests and nest or roost sites; increased vulnerability to predation; microclimate changes; and increased conflict with humans. In the short term, before changes in plant succession, wildlife populations may respond to hurricane damage by shifting their diet, foraging sites or habitats, and reproductive patterns. In the long term, wildlife populations may respond to changes in plant succession as vegetation regenerates in storm-damaged old-growth forests.

Knowledge of the effects of hurricanes on wildlife populations and the response of wildlife to such storms is fundamental to the development of management strategies designed to reduce the vulnerability of endangered species. Therefore the purpose of this chapter is to summarize the effects of hurricanes on wildlife populations and the response of wildlife populations to hurricane effects. Here we concentrate on the adverse effects of hurricanes on terrestrial species in an effort to identify the characteristics which make certain populations vulnerable to hurricane damage. We describe the patterns of hurricane effects and responses without giving examples, at least for birds which we have previously reviewed in detail (Wiley and Wunderle, 1994). From these findings we offer some possible management strategies which might reduce the vulnerability of endangered species to hurricanes. Our intent is to stimulate both managers and researchers to devise management strategies that will reduce the vulnerability of endangered wildlife to hurricane damage.

9.2 DIRECT EFFECTS OF HURRICANES

It is often assumed that hurricane winds, rain and wave action directly cause wildlife mortality, although this has been difficult to document. The literature on wildlife mortality from hurricanes is sparse and occasionally contradictory (Cely, 1991). Accounts of avian mortality are confined primarily to waterbirds rather than landbirds, although their larger size could bias mortality surveys. High post-hurricane mortality has been documented for raccoons, rabbits and deer (Ensminger and Nichols, 1958) and for raccoons and rodents (Gunter and Eleuterius, 1971). We are unaware of any published accounts of mass mortality of amphibians and reptiles in the aftermath of hurricanes, although the small size of most species could make detection less likely.

Storms have been cited as responsible for affecting local movements of animals. Birds are particularly vulnerable to displacement by high winds and accounts of storm-displaced seabirds are common.

9.3 INDIRECT EFFECTS OF HURRICANES ON WILDLIFE

Given that hurricane winds strip flowers, fruits and seeds from plants, it is reasonable to expect that populations of nectarivores, frugivores and see-deaters are more likely to decline in the aftermath of a hurricane than insectivores or raptors. Indeed, several hurricane studies of birds have documented this pattern in sites with varying degrees of vegetation damage in a diversity of habitats. Many insectivore populations might be buffered from hurricane-induced food shortages by relying on a food source characterized by a high level of diversity, resiliency and turnover.

Whereas post-hurricane food loss can explain many population declines, factors such as changes in foliage distribution and vegetation structure can also affect certain species. This is particularly apparent in birds and reptiles (Reagan, 1991) that glean insects off the surfaces of leaves or stems which are vulnerable to hurricane impacts.

Nests, nesting sites, roosting sites and nesting material can be destroyed by high winds, rainfall or flooding. Species requiring large old trees for nesting or roosting are particularly susceptible to hurricane effects, as these trees are often most vulnerable to hurricane damage. Furthermore, wildlife that use storm-damaged old trees for nests or den sites run the risk of losing their nest den site in future storms.

Animals are likely to be more exposed to predators in defoliated habitats in the aftermath of hurricanes. Unfortunately, we are unaware of any published accounts supporting this probable event, possibly due to the difficulty of observing predation and assessing its impact on prey populations. However, raptors are certainly present and often quite visible after hurricanes and in some cases have not shown population declines after a hurricane.

Many forest-floor or understory species are accustomed to foraging in a dark forest understory and are likely to leave areas with reduced canopy cover. Whether these animals are responding directly to the absence of a canopy or to one of the secondary effects resulting from canopy loss (e.g. change in light level, microclimate, food supply, predator exposure, vegetation structure, etc.) is unknown.

Loss of the forest canopy can have profound effects on the microclimate of the forest understory. Higher temperatures and desiccation may stress organisms adapted to life in the shaded understory of a closed-canopy forest. Whereas microclimatic changes following a hurricane may affect some higher vertebrates, the effect is likely to be greatest upon ectotherms with limited dispersal abilities, such as some of the lower vertebrates (Reagan, 1991; Woolbright, 1991) and invertebrates (Willig and Camilo, 1991).

The negative effects of human activities on wildlife may increase in the aftermath of a major storm. For example, storm-weakened wildlife often provides a readily available and vulnerable source of protein for people who may be in need of food themselves. The tendency for wildlife to wander widely in search of food and cover in the aftermath of storms makes them even more vulnerable, particularly when they move into agricultural or residential areas (Craig *et al.*, 1994). Hurricanes may open primeval forests to human exploitation or increase the likelihood of human-caused fire damage. Opportunistic land settlement by subsistence farmers may encroach on woodlands, where forests have been blown down by hurricanes.

9.4 RESPONSE OF WILDLIFE POPULATIONS TO HURRICANE EFFECTS

One option for some species which have lost their main food source in the aftermath of a hurricane is to shift to another food source. Such post-hurricane diet shifts have been found in several species of bird and in at least one mammal (Spain and Heinsohn, 1973; Heinsohn and Spain, 1974).

If an animal's normal food supply or foraging site has been damaged or destroyed, it can be expected to shift its foraging location shortly after the storm's passage, well before plant successional changes occur. For some species this might involve a shift in foraging site within the same habitat, such as forest canopy-dwelling species foraging near the ground following canopy loss in the wake of a major storm. Other species may respond to hurricane damaged habitats by foraging more within the original home range or by expanding their home range size to forage over a greater area (Willig and Gannon, 1991). Additional foraging site shifts may involve movement into less damaged areas of the same habitat or movement into other nearby habitats, thus accounting for the post-hurricane appearance of some species in atypical habitats. Moreover, altitudinal movements or population shifts are likely in mountainous regions if high altitude sites are more severely damaged than lowland sites or because recovery rates of high altitude vegetation lag behind those of the lowlands.

Some animals breed normally in the aftermath of a hurricane in spite of substantial habitat damage, although the observed reproductive response can be variable. In some instances tropical birds may delay reproduction by several months. In a frog species the clutch size was reduced following a hurricane (Woolbright, 1991), while in rodents an increase in post-hurricane food supplies may have contributed to an increased reproductive output (Rao, 1980).

A major effect of hurricanes is the creation of early successional habitats, by increasing the number and size of forest openings. Second growth and edge species have responded to successional changes in the aftermath of hurricanes by moving into damaged forests where previously they had been rare or absent. Increased forest openings may enable avian brood parasites and some predators to invade extensive forest tracts which they would otherwise avoid. This could be particularly detrimental to the populations of some forest interior birds which have been shown to be highly sensitive to edge-dwelling brood parasites and predators (reviewed in Askins *et al.*, 1990).

In pre-settlement times, hurricanes were undoubtedly beneficial to wildlife diversity by creating early successional habitats in landscapes dominated by extensive forests. These storms create a patchwork or mosaic of communities which influences the abundance of particular species (Levin and Paine, 1974; Whitmore, 1974; Paine, 1979) and community diversity (Loucks, 1970; Connell, 1978; Huston, 1979). No doubt these disturbances provided habitat for edge and second growth species, which otherwise would have been uncommon or rare in those times. However, today most edge or second growth species have an adequate amount of habitat in contrast to species requiring mature forest or forest interior, which face the greatest risk of temporary habitat loss from hurricanes.

9.5 POTENTIAL MANAGEMENT STRATEGIES

Although the study of hurricane effects on wildlife populations is still in its infancy, recent studies suggest some promising management strategies to lessen the impact of hurricanes on wildlife populations in regions where cyclonic storms are expected. These strategies should focus on the stresses facing populations in the aftermath of storms, as a number of studies have indicated that the greatest stress of a hurricane on upland terrestrial wildlife populations occurs after its passage rather than during its impact. Here we list some potential management strategies, although some will require more research for specific sites or species.

1. The greater the geographic range and more widely dispersed a population, the less vulnerable it will be to a single hurricane strike. As suggested by Hooper *et al.* (1990) an effort should be made to ensure that populations of endangered species are uniformly dispersed within their geographic range.
2. Montane forest reserves require lowland forest reserves to which montane frugivores, seedeaters and nectarivores can migrate in the aftermath of a storm. Lowland vegetation, because of its rapid growth rate, can recover faster than montane vegetation and thus can serve as a refugium for montane species in the storm's aftermath (Wunderle *et al.*, 1992). Habitat corridors between montane and lowland reserves will facilitate altitudinal movement (Varty, 1991) and, in the aftermath of a hurricane, likely provide patches of undamaged vegetation.
3. Forest reserves on flat or level terrain should be as large as possible,

while reserves on mountainous or hilly terrain can be smaller. Topographic relief can affect the extent of hurricane damage to vegetation. Forests on level terrain are more likely to receive extensive damage, whereas hilly or mountainous terrain may have protected patches of undisturbed vegetation (e.g. Bellingham, 1991; Bellingham *et al.*, 1992; Wunderle *et al.*, 1992).

4. Encourage food plants with high recovery rates. Because many edge, gap or secondary successional plant species have high recovery rates in the aftermath of hurricanes, patches of these food plants should be available either within or near the reserve. For example, palms such as *Prestoea montana* and *Roystonea* spp. are important foods for West Indian parrots, as well as other frugivores, and often are less likely to be damaged than dicotyledons (Yih *et al.*, 1991; Frangi and Lugo, 1991; Francis and Gillespie, 1993). Palms should be encouraged throughout a range of altitudes and sites within a reserve, as emergency food supply for frugivorous and seedeating birds.
5. Encourage plants which are relatively resistant to hurricane damage. Tree species have been found to differ in their susceptibility to damage (reviewed in Brokaw and Walker, 1991; Francis and Gillespie, 1993) and the more resistant species provide valuable temporary cover and foraging substrate in the immediate aftermath of a storm. Consideration should be given to the possibility of ensuring that patches of resistant vegetation are available. For example, in South Carolina both bald cypress (*Taxodium distichum*) and live oak (*Quercus virginiana*) sustained relatively little hurricane damage in comparison with other species (Putz and Sharitz, 1991; Gresham *et al.*, 1991). On some sites, pines are more likely to suffer hurricane damage than nearby hardwoods (Boucher, 1990; Putz and Sharitz, 1991) but not always (Gresham *et al.*, 1991). We need to know if resistant vegetation can serve as temporary refugia in the immediate aftermath of hurricanes, even for species specialized on different habitat types.
6. Forest reserves and surrounding landscape should have a mixture of different age stands to ensure rapid replacement of hurricane-damaged old growth for wildlife requiring old growth forests. Second growth vegetation is more resistant to structural damage than old growth (reviewed in Brokaw and Walker, 1991) and therefore is likely to recover more quickly and ultimately provide old growth vegetation. Thus forest reserves consisting primarily of old growth forests will likely have a greater time lag for replacement following a hurricane than those forests with a mix of different aged stands.
7. It may be possible to 'hurricane-proof' forests by adjusting the density of trees in a stand, although the appropriate density is likely to vary with a variety of factors (reviewed in Tanner *et al.*, 1991). A direct relationship between pine stand density and hurricane survival suggested to Hooper

et al. (1990) that it might be possible to 'hurricane-proof' pine stands by having more densely stocked stands of pine than is currently practised. Although this may be appropriate for pine stands in South Carolina, for other forests it is unclear if comparatively high stem density makes forests more or less vulnerable to damage (Brokaw and Walker, 1991). The effect of stand density is not always obvious, as found by Reilly (1991) who observed that damage was greatest where neighboring trees were distant in two forest plots, but the reverse in a third. Recently thinned stands were more severely affected by a hurricane than unthinned stands on Puerto Rico, although age/size structure also influenced stand vulnerability (Wadsworth and Englerth, 1959). Finally, dense stands may be more susceptible to damage than open stands as observed after a hurricane in Massachusetts (Foster, 1988). Obviously no single management prescription will exist to 'hurricane-proof' forests by manipulating stand density, but management will depend upon a variety of factors including site, species and age composition.

8. Intensive post-hurricane management intervention may be necessary for some critically endangered species. Efforts concentrated on recovery of damaged or lost nest or roost sites have proven effective. For example, the repair of Puerto Rican parrot (*Amazona vittata*) nest cavities contributed to successful post-hurricane reproduction (Meyers *et al.*, 1993). Hand excavation of artificial woodpecker cavities to replace lost cavity trees is contributing to the post-hurricane recovery of the red-cockaded woodpecker, *Picoides borealis* (Hooper, personal communication). We are unaware of any attempts to provide food to endangered wildlife in the aftermath of hurricanes, and suspect that it might be ineffective for many species given the tendency for food-stressed wildlife to wander widely after hurricanes.

9.6 SUMMARY

Hurricanes, often known as typhoons or cyclones, are common in many parts of the world where their frequent occurrence can have both direct and indirect effects on wildlife. Direct effects include mortality from exposure to hurricane winds, rains and storm surges, and geographic displacement of individuals by storm winds. Indirect effects appear after the storm and include loss of food or foraging substrates; loss of nests, nest or roost sites; increased vulnerability to predation; change in microclimates; and increased conflict with humans. The short-term response of wildlife populations to hurricane damage, prior to changes in plant succession, includes shifts in diet, foraging sites or habitats, and reproductive responses. Wildlife populations may show long-term responses to changes in plant succession as second-growth vegetation increases in storm-damaged old-growth forests.

The greatest stress of a hurricane to most upland wildlife populations occurs after its passage rather than during its impact. Most important is the destruction of vegetation, which secondarily affects wildlife after the storm. Most vulnerable are animals which:

- have a diet of nectar, fruit, or seeds;
- nest, roost or forage on large old trees;
- require a closed forest canopy;
- have special microclimate requirements;
- live in a habitat with a slow recovery rate.

Small populations with these traits are at greatest risk to hurricane-induced extinction, particularly if they exist in small isolated habitat fragments. Recovery of wildlife populations from hurricane effects is partially dependent on the extent and degree of vegetation damage as well as its rate of recovery. Also, the reproductive rate of the remnant local population and recruitment from undisturbed habitat patches influence the rate at which wildlife populations recover from damage. Potential management strategies which might reduce impacts on endangered wildlife include:

- ensuring that populations are widely dispersed in their geographic range;
- maintenance of lowland reserves as post-hurricane refugia for montane species;
- encouraging food plants which are resistant to hurricane damage and/or have high recovery rates;
- adjusting the density of trees to 'hurricane-proof' a stand;
- post-hurricane intervention, which might include provision of artificial cavities for nesting or supplement feeding.

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