

THE EFFECTS OF LOGGING ON TROPICAL FOREST UNGULATES

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Compared to the primates that have just been discussed, the information on the ecology of most forest dwelling, terrestrial mammals is sparse, often anecdotal, widely scattered in the literature, and supported by very few long-term studies. This chapter focuses on ungulates—a group of medium to large-sized terrestrial mammals, which includes elephants, odd-toed hoofed mammals (such as rhinos and tapirs), and even-toed hoofed mammals (such as cattle and antelopes). These mammals are:

- Important sources of subsistence animal protein for many peoples
- Central to the wild meat (bushmeat) trade in many parts of the world
- A source of opportunity for forest ecotourism
- Integral parts of forest ecosystem processes (e.g., seed dispersal)
- Major determinants of forest vegetation structure and composition

It is important, therefore, to review the effects of logging tropical forests on ungulate populations.

We begin with a review of the feeding habits and general ecology of ungulates to assess their reliance on relatively undisturbed closed-canopy forests, and their adaptability to the changes in forest structure and plant species composition that result from logging. Second, we examine reports of the effects of logging on these animals, or where these are unavailable, reports of the species' ability to live in human-altered forest habitats. Third, we describe two case studies that provide recent details on habitat change and its effects on ungulate populations in the forests of West Africa and northern Borneo. We close the chapter with a discussion of conservation, forest management, and research issues.

Intermediate categories (frugivore/browsers and browser/grazers) switch diets during the year according to variation in the availability of preferred items.

Bodmer (1990a) has shown that frugivorous ungulates are restricted to tropical forests, where round-the-year fruit availability is greatest, and have consistently small body sizes. Browsers—the most common group—show a wide range of body sizes in all habitat types, although they are often most abundant in forest edge and savannas. Pure grazers are absent from tropical forests, being most common in grasslands and savannas.

Medium- and Large-Sized Terrestrial Mammals (150–4,000 kg)

Elephants and Rhinos

African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephants (see photo 5-2) are the largest mammals to occupy tropical forests. The African elephant in particular has occupied a considerably wider range of habitats throughout sub-Saharan Africa than simply tropical forests. African elephants occupying tropical forests in the Congo Basin and West Africa show considerable differences in comparison to savanna elephants, including a smaller body size (some 2000–4000 kg), straighter tusks, and smaller group sizes (Merz 1986; Turkalo and Fay 1995). Asian elephants also live in habitats outside tropical forests, including bamboo forest, flood plain, and grassland habitats. They are of similar body size to the forest-dwelling African elephant, however, and live in small groups—but only the males have tusks (Sukumar 1989).

Both species of elephants have a simple stomach with microbial fermentation occurring in the caecum, which, together with their large body size, limits elephants to eating a large volume of low quality fibrous food that passes rapidly through the gut. African forest elephants are browser-frugivores, with a diet consisting almost entirely of woody plant tissues (bark, leaf and roots), fruits, and herbs (Alexandre 1978; Merz 1981; Short 1981; Lieberman et al. 1987; Dudley et al. 1992; White et al. 1993). In contrast, Asian elephants (and savanna elephants in Africa) are grazer-browsers, with a marked preference for (and nutritional dependence upon) grass in their diet—particularly in the wet season—with a switch to more browse in the dry season (Owen-Smith 1988; Sukumar 1989; Menon et al. 1997). Asian ele-



PHOTO 5-2 Forest elephant (*Loxodonta africana*) at a saline (PAN element 1, chapter 23). (L. White)

phants do well in swampy forests that are rich in palms, and in monsoon forests that have grass in the understory (Santiapillai and Jackson 1990). They are scarce in dense, evergreen primary forests unless they have access to open grassy areas, forest edge, and riverbanks.

The dietary differences between these two give rise to important predictions about the likely responses of elephants living in African and Asian tropical forests to different degrees of logging. In Africa, these browser-frugivores can both tolerate—and indeed prosper—in secondary forest (Barnes et al. 1991; White 1994c), including logged sites (Merz 1986; Struhsaker 1997). More elephants, therefore, are found in heavily logged forests (tree stem basal area harvested: 21 m³/ha) than in lightly logged (14 m³/ha) or unlogged forests in Kibale. Elephants are indeed an important factor in suppressing forest regeneration (Struhsaker 1997). The Asian elephant, a grazer noted as widespread outside forest habitats, showed an increase in population density in logged forests at one study area in Peninsular Malaysia (Olivier 1978). These large mammals tend to avoid current villages and roads, however (Barnes et al. 1991).

Two species of rhinoceros occupy tropical forests. Sumatran (*Dicerorhinus sumatrensis*) and Javan (*Rhinoceros sondaicus*) rhinos—weighing up to 800 kg and 1,400 kg, respectively—once occurred widely

throughout the tropical forests of southeast Asia, and were largely restricted to forest habitats. Where the two species lived sympatrically (throughout Sumatra and on the Malay Peninsula), there appears to have been a clear ecological separation between them. The Sumatran rhino occurred on higher and steeper ground and in undisturbed primary forests, while the Javan rhino occurred on lower, flatter ground and in disturbed secondary forests, forest edges, and transitional areas (Groves 1967; Borner 1979).

All rhinos, like elephants, are mid-gut fermenters with an enlarged caecum. The Sumatran rhino appears to be almost exclusively a browser—eating foliage and stems from plants in the understory of primary forest (Van Strien 1985)—while the Javan rhino also eats grasses and herbs in forest gaps. There are records, however, of rhinos eating fruits (Strickland 1967; Schenkel and Schenkel-Hulliger 1969; Borner 1979). Again, these dietary differences suggest differences in the response of these two species to logging.

Sumatran rhinos are relatively selective browsers that frequently use tree-fall gaps (Borner 1979). This species was abundant in regenerating thickets in abandoned transmigration schemes near the Way Kambas Reserve in Sumatra (J. MacKinnon, personal observation), and also relatively abundant in logged forests of the Dent Peninsula in Sabah—congregating in areas with natural salt sources (Davies and Payne 1982). Direct studies of its distribution in logged and unlogged areas inside and outside protected areas in Peninsular Malaysia, however, indicate that the species avoids areas where the primary forest habitat has been modified by commercial logging (Flynn 1978; Flynn and Abdullah 1984). In general, the Sumatran rhino appears to tolerate little human disturbance, despite their subsistence on forest gap vegetation in a variety of disturbed habitats. This once widespread species has suffered severe declines during the course of this century, both from wholesale loss of undisturbed habitats, and from over-hunting (Foose and van Strien 1997).

Observations on Javan rhinos (Amman 1985) indicate that they may be more adaptable to disturbed habitats. The only viable populations in Java and Vietnam are found in secondary forests following the Krakatau eruptions (Hoogerwerf 1970; Hommel 1987), and aerial herbicide spraying (Schaller et al. 1990), respectively. Their direct response to logging is unknown.

Tapirs

The South American and Mesoamerican tropical forests have not supported any mega-herbivores since humans caused the demise of the Pleistocene large mammal fauna (Diamond 1989; Burney 1993). Three species of tapir are now the continent's largest extant mammals living in tropical forests. The Brazilian or lowland tapirs (*Tapirus terrestris*), mountain tapirs (*T. pinchaque*) and Baird's tapirs (*T. bairdi*), attain body masses of 225–300 kg, 150 kg, and 150–300 kg, respectively. One slightly larger species of tapir—the Malayan (*T. indicus*), which weighs from 250–450 kg—occurs in southeast Asia. Like their closest living relatives—the rhinos—all tapirs are midgut fermenters.

The Brazilian or lowland tapir lives in forested and grassy habitats with permanent water, and is widespread over lowland areas. The mountain tapir lives at higher altitudes and can occur above the tree line. Baird's tapir lives in swampy or hill forests, while the Malayan tapir lives in a wide variety of habitat types, including primary rain forest. In these different habitats, tapirs feed on a diverse array of leaves, undergrowth, and forest-edge herbs, shrubs, and saplings. Tapirs also seek out a wide variety of fruits in different habitats—which can make up to 30 percent of their diet in some areas—and are very significant seed dispersers for different tree species (Matola 1974; Terwilliger 1978; Williams and Petrides 1980; Janzen 1982b; Bodmer 1990b; Rodrigues et al. 1993; Naranjo 1995; Downer 1996).

The generalist nature of most tapir diets suggests that these species will respond well to direct changes in their habitat following logging operations in tropical forests. Browser-frugivores like Baird's tapir, for example, appear to do well in secondary forests, including areas selectively logged (Fragoso 1991b). The Malay tapir has also been reported in logged forests, and has even been recorded as *common* in the logged and burned forests of the Way Kambas Reserve in Sumatra (FAO 1979).

Okapi

Among the large ruminants that occur in tropical forests, folivorous browsers are very unusual. The best example is the okapi (*Okapia johnstoni*), which occurs in the dense rain forest of the Democratic Republic of Congo (formerly Zaire). This giraffid reaches some 210–250 kg in body weight and almost exclusively selects high quality browse from species of shrubs and trees growing in the forest understory (Hart and Hart 1989).

persed fruits (with the exception of *Ficus*). Most have not been recorded in the diet of any ungulate. While overall tree density two years after logging is similar to unlogged forest, both the total number of fruiting trees and the density of those trees producing fruit eaten by mammals (i.e., in the 1–5 gm fruit size range) is considerably reduced: declines of 59 percent for mousedeer, 53 percent for muntjac, and 28 percent for bearded pig (Heydon 1994, and unpublished data). This situation was exacerbated by the seasonal nature of fruit production, which was more pronounced in the logged forest. It varied twice as much between peak and nadir months, leaving a more prolonged period when fruit supply was very scarce (Heydon and Bulloh 1997).

Terrestrial Mammal Abundance

The abundance of mammals in logged and unlogged forest was determined by night time transect surveying. Each of the ten transects was surveyed at monthly intervals between August and December of 1993 (total distances surveyed: 72 km in logged forest and 56 km in unlogged forest). The DISTANCE program (Laake et al. 1993) analyzed sighting data. Densities of sambar deer and the common muntjac were higher in logged forest (see table 5-6). Yellow muntjac and mouse deer densities were lower. For two species, the yellow muntjac (*M. atherodes*) and the mousedeer (*T. napu*), home ranges were also measured. In mousedeer, a three-fold difference in density between primary and 12-year-old logged forest was mirrored by a 2.7-fold increase in home range area (Ahmad 1994). For the yellow muntjac, home range mapping of this species in the same unlogged forest blocks generated a density of 4.6–6.1 animals per km² (Heydon 1994), similar to values from the transect surveys.

The large (i.e., elephant, banteng, and rhino) and nomadic (i.e., bearded pig) ungulate species were observed too infrequently (or not at all in the case of rhinos) to calculate densities using distance-sampling techniques (Buckland et al. 1993). Nevertheless, differences in encounter frequencies (including indirect signs) indicate higher densities of elephant (+380 percent) and banteng (only observed in logged forest) in logged areas, but lower densities of bearded pigs (-16 percent).

Finally, in conjunction with the above surveys, civet densities were also recorded in logged and unlogged forests. While civets are not ungulates, the response of these carnivore/omnivore mammals to log-

TABLE 5-6 Changes in Ungulate Densities (Individuals/km²) After Selective Logging in Danum Valley (after Heydon 1994; Heydon and Bulloh 1997)

Species	Unlogged Forest	Logged Forest	% Change
<i>Cervus unicolor</i> (Sambar deer)	0.2	2.2 (2-5 yr) 0.3 (12 yr)	+1000 +50
<i>Muntiacus atherodes</i> (Yellow muntjac)	4.9	2.2 (12 yr)	-55
<i>Muntiacus muntjac</i> (Common muntjac)	1.0	1.9 (12 yr)	+90
<i>Tragulus napu</i> (Greater mousedeer)	54.5	5.5 (2-5 yr) 16 (12 yr)	-90 -71
<i>Tragulus javanicus</i> (Lesser mousedeer)	30	10.3 (2-5 yr) 15 (12 yr)	-66 -50

ging is briefly noted in box 5-1, as there is virtually no information available on carnivore-logging interactions in the tropics.

Box 5-1 Civet densities in logged and unlogged forests of the Danum Valley in Sabah, Malaysia.

All civet species persisted in logged forests, as did the five felid species found in the Ulu Segama (M. Heydon, unpublished data). There were far fewer sightings of civets than ungulates, so data for all civet species were pooled during the Distance sampling analysis (see box table 5-1). The analysis showed that logging was associated with an 80 percent decline in the overall density of civets. Our results suggest that exclusively carnivorous species (e.g., *Hemigalus* and *Prionodon*) were disproportionately affected by logging, as compared to the omnivorous species (*Paradoxu-*

BOX TABLE 5-1 Densities of Civets (Individuals/km²) in Unlogged and Logged Forest in Danum Valley (after Heydon and Bulloh 1996)

Species	Unlogged Forest	Logged Forest	% Change
<i>Paradoxurus hermaphroditus</i>	5.6	1.4	-75
<i>Arctogalidia trivirgata</i>	1.1	P ^a	
<i>Arctictis binturong</i>	0.8	1.1	+38
<i>Paguma larvata</i>	P	P	
<i>Hemigalus derbyanus</i>	9.8	1.0	-90
<i>Cynogale bennettii</i>	P	P	

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THE CUTTING EDGE: CONSERVING WILDLIFE IN LOGGED TROPICAL FOREST

Robert A. Fimbel, Alejandro Grajal,
and John G. Robinson, editors



Columbia University Press
New York

2001

pp xxiv, 800^p