What is the Future for Wild, Large Herbivores in Human-Modified Agricultural Landscapes?

Author: Gordon, Iain J.

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What is the future for wild, large herbivores in human-modified agricultural landscapes?

Iain J. Gordon

Since the dawn of agriculture, people and wild animals have been in conflict because agricultural crops generally offer a rich food source for wild animals as well as for people. Large, wild herbivores compete for pasture resources with livestock and can act as reservoirs of livestock diseases. Furthermore, livestock form a concentrated and vulnerable food source for predators. As a result, humans have extirpated many native animal species from agricultural areas, either directly, or indirectly through modifications in habitat availability or structure resulting from land use changes. As human populations have expanded in developing countries they have caused loss in biodiversity and species extinctions, and will continue to do so. I review attempts to change the interaction between people and large herbivores from one that is primarily negative to one that is positive by increasing the benefits which individuals, communities and society derive from wild, large herbivores. My proposition is that, in developing countries, it is only by using this approach that wild, large herbivores have a chance of surviving outside areas specifically set aside for their protection. In the developed world the opposite trend will occur as people move into the cities causing human populations to decline in rural regions. As a consequence, wildlife habitat will increase and wild, large herbivores will come into conflict with humans, particularly in peri-urban areas rather than in rural areas as happens at present. This will lead to a change in public attitude from one that supports wildlife conservation to one that sees wild, large herbivores as a threat; again, with potential negative consequences for wildlife conservation.

Key words: human depopulation, land-use change, wildlife, wildlife-human conflict

Iain J. Gordon, Sustainable Ecosystems, CSIRO - Davies Laboratory, PMB PO Aitkenvale, Queensland 4814, Australia - e-mail: iain.gordon@csiro.au

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Large herbivores have provided food, fibre, draught and fertiliser for modern human populations for more than 500,000 years (Roth & Merz 1997). The early relationship between herbivores and humans was one of predator and prey, with humans obtaining most of their animal protein requirements from wild, large herbivores (Anderson 1985). As human populations grew and spread, human predation appears to have driven many species of large herbivore to extinction (Owen-Smith 1988, Wroe et al. 2004, Burney & Flannery 2005). With the advent of agriculture, and the increasing sedentarisation of human populations over the past 10,000 years, a more symbiotic relationship has formed between humans and their domesticated, large herbivore species (Clutton-Brock 1987, Roth & Merz 1997). However, only a few of the many potential large herbivore species (e.g. sheep *Ovis aries*, goats *Capra hircus*, cattle *Bos taurus* and *B. indicus*, yaks *B. gruinesis*, camels *Camelus* sp., water buffalo *Bubalus bubalis*, horses *Equus cabalus* and donkeys *E. asinus*) were domesticated (Clutton-Brock 1987, Roth & Merz 1997). Today, there are more than 3.3 billion cattle, sheep and goats across the planet and almost 100% of the meat consumed by humans, particularly in the developed world, comes from domestic species (including chickens; Millennium Assessment 2005). Domestic livestock now range over 80 million km^2 of the land mass of the developing world (Thornton et al. 2002) and the demand for livestock products is growing, again, particularly in developing countries (Bruinsma 2003).

With this increasing reliance on a few domestic forms of wild herbivores, the relationship between humans and wild, large herbivores (hereafter called wildlife) has changed (Hemmer 1990). No longer are wildlife a necessity for human survival, except in a few areas of developing countries where the impoverished have limited access to meat from domestic livestock, e.g. Timah et al. (2008). Wildlife has, however, become either a game species that is hunted for recreation (Roth & Merz 1997), or a pest that competes with humans for primary production, both directly through consuming agricultural crops and indirectly through consuming the vegetation needed to grow domestic livestock (Conover 2002). Wildlife is also a disease reservoir for domestic stock (Grootenhius 2000, Hudson et al. 2002) and even people (zoonoses; Beran 1994, Jones et al. 2008). This changed relationship has meant that wildlife is often persecuted or excluded from areas where humans live and farm, which either confines wildlife to areas which are too marginal for agriculture or, in places where there are no refuges away from areas taken over by agricultural production, may lead to extinction. Habitat change and depredation have resulted in approximately 84 of the 175 species of large herbivores alive at the end of the 20th century to be listed as Critically Endangered, Endangered or Vulnerable in the 2002 edition of the International Union for the Conservation of Nature's Red Data Book (IUCN 2002). On the Great Plains of North America, for example, the number of plains bison *Bison bison* was estimated at between 30 and 60 million before the 1800s when over-hunting began, causing a dramatic reduction in their numbers by the early twentieth century (Flores 1991). Nowadays, across most continents of the globe, wildlife lives at substantially reduced numbers within the bounds of protected areas such as national parks, and humans actively exclude them from agricultural areas. In Africa, over the past few decades, people have moved with their livestock into areas that once held large numbers of wildlife, and native large herbivore communities have suffered tremendous losses both in species richness and numbers due to poaching (Hilborn et al. 2006) and over-exploitation for meat (Wato et al. 2006).

With this as a background, I will argue in this paper that the interaction between people and wildlife is changing as we move into the 21st century. My thesis is that, in many parts of the developing world, the future for wildlife species is bleak unless there is a change in the relationship between wildlife and humans whereby wildlife has an economic value instead of being seen as a competitor for primary production or a carrier of diseases that affect livestock. On the other hand, in the developed world, the reduction in the amount of land used for agricultural production is leading to increased wildlife populations and increased negative interactions between people and wildlife, particularly in peri-urban areas. In these areas, there will have to be much stronger control of wildlife to ensure that it is kept at levels or in places where its negative impacts are minimised. In developing this line of reasoning, I will first describe the nature of the interactions between people and wildlife and then suggest ways forward for both research and management. I admit that my arguments run counter to a more generally held view that we have a moral or ethical obligation to protect wildlife species from harm because they exist (e.g. Ehrlich 2002). However, I believe that my argument is more pragmatic and reflects the real relationships between people and wildlife.

Competition for food

Indirect

Competition for pasture

Because domestic species are descended from wild herbivores and have similar physiologies and morphologies, they exploit similar niches (Clutton-Brock 1987, Hofmann 1989). Competition between the two groups generally occurs through modification of and combined use of the food base. At the dawn of agriculture this would have led to competition for native vegetation between domestic stock and wildlife, particularly in areas close to water or other key resources (Trash & Derry 1999) which probably attracted humans to settle these areas in the first place. However, with the domestication of grass and legume species and their subsequent agronomic development, competition for forage between livestock and wildlife increased on cultivated pastures. The drive for the development of fencing would have been not only to keep stock in but also to exclude wildlife from grazing cultivated pastures.

Whilst species such as deer (Cervidae) will consume pasture and silage (Putman & Moore 1998), with the extirpation of many wildlife species from agricultural areas, wildlife consumption of forage grown for livestock is not a major issue (except for rabbits *Oryctolagus cuniculus* in some pastoral systems in Europe and Australia; Kolb 1994, McLeod

2004). It is, however, still an issue in more extensive systems worldwide. For example, in the rangelands of Australia, which are the drivers of much of the agricultural economy, livestock production dominates and the major limitation to productivity is fodder supply, particularly in the dry phases of the annual or decadal cycle (Ash & Smith 2003). Native grazers, i.e. red kangaroos *Macropus rufus* and grey kangaroos *M. giganteus* and wallaroos *M. robustus*, are thought to compete with livestock for fodder (Edwards et al. 1996). Estimates suggest that more than A$15 million per annum is lost from livestock production due to competition for forage and more than A$16 million per annum is spent on repairing of fences damaged by macropads (McLeod 2004). As a consequence, more than five million kangaroos and wallaroos are culled per year to reduce this conflict. The extent to which this cull actually reduces competition is unknown (Pople & McLeod 2000). Generally, the extensive nature of these systems means that the only way of excluding wildlife is through fencing or culling, as the more intensive systems adopted to reduce crop raiding (see below) are not cost-effective to remove competition for pasture.

In places where potential competition for forage has lead to active persecution of many wildlife species or has lead to the demise of wildlife species because livestock are able to outcompete wildlife for scarce forage during lean times (often because of supplementation with additional fodder), wildlife species are generally doomed to local extinction. For example, Mishra et al. (2002) studied ungulate assemblages in the Indian Trans-Himalaya where seven species of wild ungulates have or had to live with five species of domestic stock. It was found that at least four species of the original assemblage of wild species were missing from the region and that this could be attributed to competitive exclusion by similar-sized domestic species. Competitive exclusion of wildlife by livestock is a world-wide concern and not only confined to the Himalaya (Wilson & Macleod 1991, du Toit & Cummings 1999).

Despite the many competitive interactions, facilitation of wildlife species by livestock has also been reported. Interestingly, these were mainly between a larger domestic grazer (notably cattle) and smaller medium-sized grazers such as red deer *Cervus elaphus* (Gordon 1988), wapiti *C. e. canadensis*, and between red deer and wild boar *Sus scrofa* (Kuiters et al. 2005). It may be that large domestic grazers play the role of a similar wild species, originally present in the system, notably the bison in North America and the extinct aurochs *Bos primigenius* in western Europe (Gordon et al. 1989).

Direct

Crop consumption

The development of agricultural crops more than 10,000 years ago has resulted in substantial changes in human society and in landscape structure. With the domestication of plant species has come human congregation into permanent settlements, rather than the hunter-gatherer lifestyles that had gone before. However, domestication of plant species also brought increased investments in time, infrastructure and natural resources (e.g. fertiliser and water) in order to increase production and secure food supplies. This concentration of food for humans also created high quality food resources for wildlife that lead to increased interaction for these resources between people and wildlife and the development of technologies (e.g. fencing and scarers) to keep wildlife off the crops. In a case study in Uganda (Naughton-Treves & Treves 2005), 5-10% of crops were damaged in some way by wildlife, and elephants *Loxodonta* spp. were the biggest (excuse the pun) culprits. In Malawi, crop loss to wildlife costs around US$58 million per annum (Deodatus 2000). In North America, white-tailed deer *Odocoileus virginianus* and mule deer *O. hemionus* cause more damage to crops, including orchards, than any other wildlife species. For example, in Wisconsin they cause crop damage amounting to more than US$34 million per year (WDNR 1994). This has lead to the use of odour and taste repellents to keep the deer away. These repellents include ones that give off an odour of predators (Conover 2002) or ones that are noxious to the taste (Conover 2002).

Disease

Again, because they come from the same evolutionary stock, livestock and wildlife harbour many of the same diseases. In livestock husbandry, modern medicine has led to the elimination of many of the diseases that historically cursed livestock; however, wildlife still act as a refuge for many diseases to the extent (Hudson et al. 2002) that, in certain areas of Africa, livestock production is still foregone because of Chagas disease carried between wildlife and livestock by the Tsetse fly (Kabayo 2002, Bowmann 2006). Nevertheless, these areas are relatively small as compared to the areas of the globe that are put

over to livestock production. In most of these areas, wildlife are actively excluded so that disease is not transferred from the wildlife reservoir. For example, in southern Africa fences have been established across a wildlife migration route in order to exclude the wildlife from areas where cattle are raised. The fences reduce the likelihood of cattle contracting foot-and-mouth disease from wildlife (Taylor & Martin 1987) which is important because southern Africa exports a substantial proportion of its livestock to the European Union. This has lead to wildlife being excluded from key resources, resulting in mass mortality. In the Kruger National Park, African buffalo *Syncerus cafer* are managed to reduce the likelihood of them transferring foot-and-mouth disease to cattle in the pastoral properties that border the Park (Caron et al. 2003). In Yellowstone National Park, USA, the highly endangered plains bison, which was on the verge of extinction because of hunting pressure, is now in effect caged into the Park, as it is persecuted outside the park because of fears that it will spread bruccilosis (Keiter 1997, Morris & Mcbeth 2003). This general fear of disease transfer in effect creates a spatial barrier between wildlife and livestock, and limits the opportunities for the utilisation of mixed livestock/wildlife systems (see below).

Interactions with infrastructure and transport

Wild, large herbivores are highly mobile and, with the expansion of infrastructure such as dams, power lines and transport networks, both road and rail, there is increasing interaction between wildlife and humans (Conover 2002). For example, in the USA there were more than 700,000 motor vehicle collisions with deer in 1991 (Conover et al. 1995) and in Wisconsin white-tailed deer alone cause more than US$92 million in damage to cars every year (WDNR 1994). This is only likely to increase as transport networks and vehicle traffic increase, and may even become the major cause of wildlife and human mortality in some regions (Seiler 2004).

Future for wildlife and people? A divide between the developed and developing world

Rural expansion in developing countries

The global human population has now passed the 6.5 billion mark with most of the global human

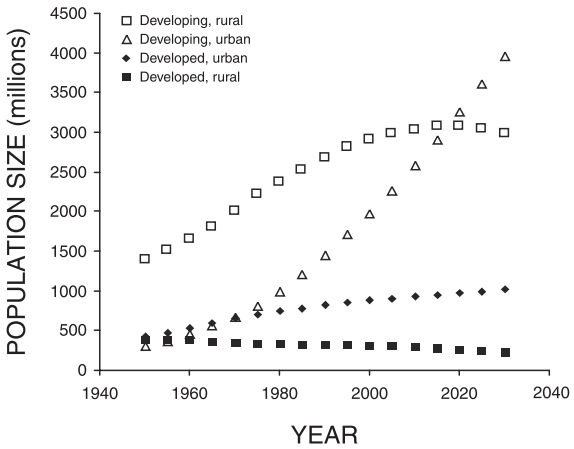

Figure 1. Actual and predicted changes in urban and rural human population sizes in developing (□, △) and developed (■, ◆) countries. Data Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat 2003, 2004.

population growth occurring in developing countries (Fig. 1). Whilst urban expansion in developing countries is the most dramatic trend, rural populations are also expanding, moving into areas which have not been farmed before (e.g. Amazon and southeastern Asia) or into areas which are marginal for agricultural production. As people move in with their livestock and crops, wildlife are extirpated as a consequence of habitat change or direct persecution. This is restricting wildlife populations into smaller and smaller areas and eventually may even mean that the only refuge for wildlife in developing countries will be in national parks. However, the area of national parks on a global level is unlikely to grow much beyond what it is today (Fig. 2) and many national parks will be too small to sustain

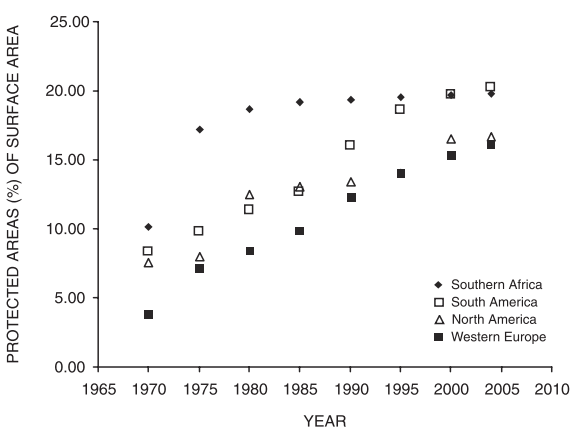

Figure 2. Changes in the area developed to National Parks in four different continents of the globe. Data Source: World Database of Protected Areas (data as of November 2007).

populations of large species of wildlife, especially predators. This will leave large proportions of wildlife populations living outside national parks, juxtaposed with people (Norton-Griffiths 1989, Blanc et al. 2003). If wildlife is to be supported outside national parks, living alongside people and agricultural production, rural people will have to change their perception of its role, from seeing wildlife as a competitor for food (direct or indirect) and a carrier of disease, to seeing it as an economic resource, even though livestock will remain the main source of animal protein. Of course this can only happen where wildlife is able to exist in human-modified landscapes. Where habitat change has been the cause of extirpation, wildlife species are unlikely to be able to survive.

Mixed livestock/wildlife systems

Ultimately, what may prove to be the most profitable are enterprises based on mixed livestock/wildlife systems, provided that issues of disease transmission can be addressed. In my view, there are two possible ways this could happen: encouraging wildlife onto land used by livestock and gaining economic return from that wildlife (e.g. trophy hunting and meat or tourism), or domestication/ranching of wildlife species within enclosed areas also used by livestock. In both cases this may require the development of specific disease control methods, for example vaccination against foot-and-mouth disease or the development of systems which limit the interaction between wildlife and livestock at particular times of year. Clearly this is easier to manage in domestication situations than where wildlife are free to come and go across the boundaries of the enterprise.

Where wildlife can move freely it does not respect enterprise boundaries, and wildlife exploitation under these circumstances could lead to the overexploitation of a common pool resource (the tragedy of the commons). Under these circumstances, wildlife will have to be managed as a common pool resource for the benefits of all stakeholders involved. In Africa, this has lead to the establishment of 'conservancies' where groups of graziers agree to cooperatively manage wildlife for their own mutual benefit (Hargreaves et al. 2004; http://www.africaguide.com/features/trvafmag/023.htm); occasionally this can lead to removal of stock and sole reliance on wildlife (http://www.africaguide.com/features/trvafmag/023.htm). An alternative approach, which was initiated in the 1980s in Zimbabwe and is now being adopted across many countries in Africa and the rest of the developing world, is the community-based wildlife management system (Bond 2001). The fundamental requirement of this approach is that the ownership and management of the wildlife resource is passed over to the local communities. This allows the communities to benefit from the use of wildlife and this benefit, usually financial, can be disbursed to the individual community members or may be used by the community for common projects (e.g. schools, clinics and roads). Wildlife and livestock can be managed within the same jurisdictional area, and wildlife is no longer seen as competing for the fodder that could be used to grow cattle. This community-based wildlife management approach is now being applied across Africa (Hulme & Murphree 2001) and the globe (IIED 1994).

Rural decline in developed countries

Many countries in the developed world have zero or even negative human population growth, however, this hides a dramatic change in the distribution of populations, with developed countries becoming much more urbanised as people move from the countryside into the city (see Fig. 1). This has resulted in swathes of abandoned farms (e.g. McDonald et al. 2000, Mottet et al. 2006), or reductions in agricultural intensity in the more marginal areas for agricultural production (Strijker 2005). This land use change, along with hunting regulations, the extirpation of large predators and other habitat changes such as those resulting from forestry practices, has largely benefited wildlife species (e.g. Milner et al. 2006). These changes have major consequences. For example, less and less people have a direct interaction with the countryside generally and wildlife in particular; the cities start spreading out, with suburbs in peri-urban areas taking over agricultural land as people make lifestyle decisions to live 'in the country'. Historically, the farmed landscape has acted as a buffer between the city and wildlife but with the abandonment of farmed land, or its conversion to lifestyle blocks, wildlife and people are now coming into direct contact on the margins of conurbations.

With the changes in the relationship occurring between people and the countryside and its wildlife come changes in attitudes to wildlife. Where wildlife does not pose a threat to people's livelihoods or lifestyles their attitude towards it may become more positive although, in many circumstances, attitudes become increasingly negative as urban people experience more interaction with wildlife (Evensen 2008).

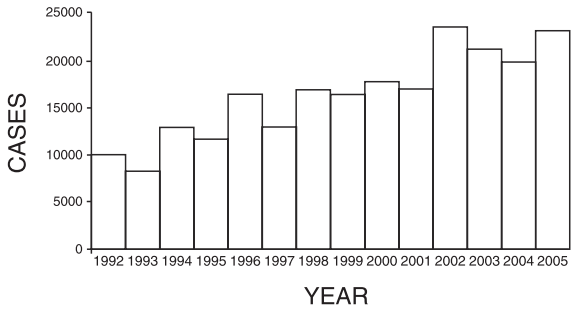

Figure 3. Changes in number of cases of Lyme's Disease reported in the USA. Data Source: USA Centers of Disease Control and Prevention Morbidity and Mortality weekly Report. Available at: http://www.cdc.gov/mmwr/

One example would be Lyme's disease. The disease, which is caused by the bacterium *Borrelia burgdorferi*, is transmitted by the bite of a tick *Ixodes dammini* and has intermediate hosts such as small mammals and deer. Almost unheard in the USA 15 years ago, nearly 20,000 cases were reported in 2005, the most recent full year for which there are records (Fig. 3). Interestingly, this has lead to calls to reduce deer densities in suburban areas although residents are unwilling to have animals killed, and would rather see the use of more sophisticated technologies such as immunosuppression of reproduction (Moulton & Saunderson 1999).

Conclusions

Wild, large herbivores and humans have had a long history of interaction. Initially this interaction was based on the provision of resources to meet human needs, but with the advent of domestication of animals and plants, this interaction changed to one of pest and competitor. This lead to dramatic decreases in the densities of wildlife species as habitats were fragmented and modified, and wildlife was extirpated from agricultural areas. This trend continues unabated in the developing world, with wildlife species being pushed into more and more marginal areas or only surviving in protected areas. Unless there is a change in the attitude of rural populations towards wildlife, through improved economic returns from activities such as harvesting, sport hunting or ecotourism, then wildlife in much of the developing world is doomed in the 21st century. Creation of this economic driver will require greater private or community ownership or use-rights for wildlife roaming within their lands. Therefore, the current research focus on autecological approaches to wildlife conservation is of limited value, and research in developing countries must instead focus on the ways in which value from wildlife can be brought to the rural inhabitants. Having said that, if the approach is to prove sustainable in the long term, community-based approaches to wildlife conservation through sustainable use will need to look at not only the livelihood benefits for humans but also the conservation benefits to wildlife species.

In developed countries, the rapid reduction of land devoted to agriculture and the increase in the human population in peri-urban areas that used to be agricultural, will lead to greater interactions between wildlife and urban populations. This will require research to focus on reducing the impacts of wildlife species on the welfare and well-being of urban populations. Research in behavioural ecology will need to provide a means of minimising the chances of wildlife spreading disease, coming in contact with transport systems and interfering with peoples' property. In developed countries, rather than increased private ownership or use-rights of wildlife, there is likely to be an increase in governmental (at all levels) engagement in the control and management of wildlife. This scenario will come into play as the urban majority demands restriction of the impacts of wildlife on their well-being, and as hunting impacts on wildlife populations decrease. This will mean bringing a greater proportion of wildlife into the public trust, in order to ensure societal objectives for its management are met (Geist et al. 2001, Prukop & Regan 2005), and the development of more sophisticated means of resolving conflicts between wildlife and people. In the end, there is likely to be a greater need for engineering solutions to these large herbivore-human problems in the developed world (Clevenger & Waltho 2005) because of the lack of enthusiasm for control through traditional culling methods.

Wild, large herbivores and humans have interacted for millennia and they will continue to do so. Let us hope, for the sake of both parties, that the relationship can be placed on a positive footing. If it does not, then it will be to the detriment of both parties in the long term.

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