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Co-existence of wildlife and pastoralism on extensive rangelands: competition or compatibility?

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Co-existence: a topical and timely issue?

Rangelands cover 69% of the world's agricultural land (FAOStats 2009) and around 40% of all global land surfaces, providing habitats for domestic livestock, wild plants and wild animals (du Toit et al. 2010).

Rangelands are therefore globally important and are some of the last, great wild lands. They are important for conservation as many of them continue to sustain wildlife outside of national parks but are under no formal protection. Amongst the millions of people also supported there, many are very poor and dependent on access to land for their livestock (Wrobel and Redford 2010, p. 2).

Over these large land areas, there are broad as well as quite intricate interactions between all the species, including humans. The rangelands are used by pastoralists,[a] primarily dependent on income from their livestock, principally reliant on grazing pastures, within extensive land use systems having low human and livestock population densities and using relatively low levels of inputs compared to other agricultural production systems (Robinson et al. 2011; Thornton et al. 2002).

Extensive livestock-keeping still dominates the terrestrial landscape, in areas where alternative forms of production are inhibited by limitations of climate and terrain, although that has not prevented other resource users (e.g. irrigated and rainfed cropping, housing development, mineral extraction) from expanding into the so-called marginal lands. Low land use pressure under pastoralism has allowed higher densities and diversities of wildlife, enabled to share the same areas as people and their livestock, as compared to other major land uses such as cropping and urbanization.

As global incomes rise, demand is accelerating for livestock products of meat and milk, leading to strong economic incentives to intensify livestock production in the rangelands (Steinfeld et al. 2010). The force of demand is accompanied by policy subsidies and private sector enterprises, as intensified livestock systems are frequently viewed as more modern, technically advanced and higher-yielding, compared to extensive pastoralism. These trends are increasing pressure on extensive pastures and rangelands, impacting both wildlife management and pastoralism, in high-income as well as low-income countries. But there are increasing concerns about the costs of intensive livestock production, which generates higher levels of green house gases compared to extensive pastoralism (FAO 2006; Herrero et al. 2011), as well as pollution, greater

worries about human and animal health (Gerber et al. 2010; Steinfeld et al. 2010; World Bank 2012) and calls to curtail demand for meat products because of health considerations in developed and developing countries.

The most enduring public images of extensive rangelands are of pasture land overgrazed by livestock, and therefore in environmental crisis, and threatening wildlife and biodiversity. In Africa and Asia, the popular narrative has been of expanding deserts, grazed by greedy herders with too many livestock, foretelling continuing cycles of famine, impoverishment and conflict (Niamir-Fuller 1999; Reynolds and Stafford-Smith 2002).

This narrative is however increasingly being challenged by researchers (Mortimore et al. 2009; Reynolds et al. 2007). In the late 1980s, some scientists concluded that it was drought (or climate more generally), not overgrazing, that controlled the number of livestock in the semi-arid tropical rangelands with a high degree of rainfall variability (Behnke et al. 1993; Ellis and Swift 1988; Homewood et al. 1987). These 'non-equilibrium' rangelands exhibit little feedback, or coupling, between livestock populations and vegetation (Vetter 2005; Homewood 2008). In the cold semi-desert rangelands of Asia, a pattern is found of climate-induced surges and crashes in livestock and wild antelope populations due to extreme winter weather events (Bekenov et al. 1998; Kerven 2004). It appeared that herders could stock as many animals as they want with little fear of long-term degradation or loss of rangeland productivity, *but* with the very certain peril of large-scale livestock losses from time to time.

Some scholars today support the notion that rangelands fall along a continuum extending from those driven mostly by grazing to those driven mostly by climate (Briske et al. 2003; Von Wehrden et al. 2012). In the non-equilibrium rangelands where livestock (and wildlife) numbers have been suppressed by regular climatic events, intensification of livestock production by addition of inputs - mainly cultivated fodder, fencing and large water points - can become environmentally unsustainable. As the natural controls on livestock populations are tempered by human interventions, intensification can lead to loss of plant diversity (Alkemade et al. 2012). Wildlife can be excluded by fencing and susceptible to disease exchange, disturbance and hunting at water points (Bekenov et al. 1998; McGahey 2011). Competition between wildlife and livestock is hard to define, and the evidence for the magnitude and type of competition is weak (Prins 2000; Young et al. 2005). Generally, therefore, the evidence that exists suggests that extensive livestock and wildlife are compatible in ways that intensified rangelands and wildlife are not (Reid et al. 2010).

Countries look to wildlife conservation as a means to increase GDP, increase foreign exchange earnings from tourism, provide public amenities and promote economic gain for local communities. Governments are also striving to meet their international obligations under multi-lateral environmental agreements, such as the Convention on Biological Diversity (CBD), Convention on Migratory Species (CMS), the United Nations Convention to Combat Desertification and Drought (UNCCD), and the Framework Convention on Climate Change (UNFCCC), and to implement projects and programmes funded among others through the Global Environment Facility. Concurrently, the intensification of livestock production will continue to heighten the struggle for and debate about rangeland control and use, raising questions as to how and under what circumstances wildlife and pastoralism can co-exist. In this Special Issue, contributors examine the relationships between pastoralism and wildlife from several angles, based on case studies from Argentina, Australia, China, East Africa, Kenya, Finland, Southern Africa, Tanzania, UK and USA.

The papers report results from investigations of biophysical interactions at the local and inter-species level, economic costs and benefits of wildlife and to people directly dependent on the rangelands, costs/benefits to wider society, issues of cultural values and heritage, preservation of endangered species and conflicts of values between social groups. Some of the papers take up and challenge the broader national and regional policies and programmes that have affected pastoralist practices and livelihoods, as well as conservation of biodiversity. Other papers consider the specific and often subtle relationships between groups of wild and domestic species. Overall, the papers showcase the dilemmas and alternative viewpoints on how the world's pastures and rangelands could be shared between domestic livestock and wild species.

This Special Issue has drawn from new, emerging and often grey literature with the aim of:

- Clarifying concepts and conceptual frameworks of competition and compatibility
- Highlighting policies, controversies and myths that may fuel conflict or misunderstanding between the various parties engaged in conservation, protection, economic development, scientific research and lobbying for wildlife or pastoralism
- Identifying gaps in research as a way forward

This Special Issue is topical because it presents new research and analysis with a view to moving the dialogue between those coming from a wildlife perspective and those from a livestock perspective to a higher, more productive level.

Competition and compatibility from different scales and perspectives

The various articles in this Special Issue focus on at least three types of competition and compatibility between wildlife and livestock:

- Productivity at the species level
- Productivity at the ecosystem level
- Socio-economic benefits and losses

Three conditions are necessary for competition to exist: (a) a shared resource (in space and time), (b) that this resource is limiting (c) and a negative influence of one user on resource availability for others. Competition for resources does not have to mean that resources are being used in the same spatial location at the same time; but competition can be displaced by time, especially in rangelands where resource availability is highly variable and resource users are highly mobile (Butt and Turner, this Issue).

The case for incompatibility was made starting with veterinary research, showing disease transfer as a major issue for both wildlife and livestock. But as vaccinations and use of veterinary medicine increased, the attention shifted to other forms of interaction (Prins 2000), sometimes framed as resource competition.

Negative interactions other than resource competition remain important. Pastoralists and wildlife compete (or damage) each other by passing diseases or killing or injuring each other. For example, just south of the Mara in Tanzania, pastoral dogs transmit rabies and canine distemper that kills lions in the Serengeti (Packer et al. 1999, Cleaveland et al. 2008), and wildebeest exclude livestock from nutritious short grass pasture for three

months during calving because they carry malignant catarrhal fever, which is deadly to cattle (McCabe et al. 1992). All over the world, pastoralists kill and poison carnivores that kill their livestock (e.g. Woodroffe and Ginsberg 1998; Maclennan et al. 2009). And, all over the world, carnivores and large herbivores (like buffalo, elephant) not only kill livestock but also can injure and kill people (e.g. Kangwana and ole Mako 2001; Moss 2001). Pastoralists and their livestock can also harass and exclude wild grazers and browsers around water points (and presumably salt licks) when they use them during the day (e.g., De Leeuw et al. 2001). This is important in predator-rich ecosystems where it is more dangerous for wildlife to drink at water points at night. And, as pastoralists settle, they can transform formerly open landscapes with soft boundaries into fragmented landscapes with harder boundaries like fences, farmland and denser settlements (Galvin et al. 2007).

But this story of competition between pastoralists, their livestock and wildlife is well told and well known. Some of it may be overstated or understated, depending on the stance of the author (Reid 2012; Butt and Turner, this issue). What is less known, and is pointed out by the authors in this volume, is that there are many opportunities, in the middle ground, for compatibility to occur and be enhanced. Are trade-offs inevitable? Must co-existence of wildlife and pastoralism result in less than optimal benefits to each form of land use, or will the combined benefits be higher than when the land is used for only one purpose - wildlife or pastoralism? These are some of the questions explored in the Special Issue papers.

It seems that the 'conservation business' is booming in East Africa; wildlife-based tourism remains a big earner for some, and some conservation NGOs can readily sell the idea to their northern support base without really knowing whether what they claim about the co-benefits of tourism for local people is true. Most (but not all) conservation NGOs do not wish to see their favourite 'win-win' solution (exclusion of pastoralists and/or strict limitations on their activities) be criticised. Some are genuinely trying to refine the model and the practice, and this set of papers aims to help that dialogue.

The concept of 'co-benefits' has an appeal to advocates representing opposing sides - whether to protect wildlife or pastoralists' livelihoods - as a condition for sustainable futures of rangelands. However, sceptics question whether the benefits are indeed balanced between wildlife and pastoralism or could be re-balanced to favour one sector more than another.

Productivity at the species level

Most of the research at the species level in this Special Issue focus on dietary competition or compatibility. Many of the articles in this Special Issue show that dietary compatibility does exist and that not all diets are competitive.

Nelson reports that in Tanzania, the herbivory impact of cattle is similar to that of zebras; they stimulate fresh growth that gazelles and other small mammals can selectively eat. The population of gazelles in Nairobi National Park fell after cattle were excluded, but rebounded when zebras were introduced. Riginos et al. find that in their research exclosures in Kenya, there is correlation between heavy grazing by cattle and increase in woody species but caution that this could also be a result of other factors such as fire suppression or climate change (increase in CO_2 in the atmosphere can stimulate woody species more). They also show that different types of wildlife/livestock combinations have different co-benefits, with elephants being the 'wild card' that benefits all.

Kearney et al. have found that short-duration intensive grazing by cattle on invasive buffel grass in Australia helps to control the grass and increase diversity of habitat for all. However, Bagchi et al. (this Issue, in press) report that in the Trans-Himalayas, livestock can have a more negative impact on plant species richness compared to wild graziers, especially in plant species-poor ecosystems.

In general, evidence is emerging that managing dietary compatibility is a key to achieving co-benefit to both wildlife and livestock. Furthermore, managing population densities and diversities can also be an appropriate management tool. Nelson makes the point that management of lion populations through hunting can increase the diversity of carnivores (wild dogs and cheetahs); Riginos et al. show that carnivores keep the population of rabbits and other small grazers down, thus benefiting livestock. Nelson also shows that the fencing of private ranches and large-scale farms in East Africa has been detrimental to both wildlife as well as pastoralism, thus suggesting that the two forms of land use have more in common than is sometimes assumed.

However, competition and compatibility at the species level goes beyond diets and population diversity. Butt and Turner, using data from East Africa, trace the divergent viewpoints on whether livestock compete with wildlife, facilitate or co-exist, and they propose a new conceptual framework at the species level, cautioning that we may be overestimating the impact of vegetative (dietary) competition between wildlife and livestock, since there are many other external factors that are more important in determining their respective well-being. Huntsinger et al. note from case studies in the western USA that management practices can have negative or positive impacts on wildlife and livestock (e.g. if a pond were fenced and 'cleaned', it would benefit neither livestock nor the local endangered salamander).

Therefore, competition and compatibility at the species level is complex and case-dependent. However, there is increasingly evidence-based research that shows more examples of compatibility than previously thought. Management of protected areas as well as management of extensive livestock production can find specific solutions for enhancing compatibility and win-win benefits for both livestock and wildlife.

Productivity at the ecosystem level

One of the more remarkable recent findings is that certain ecosystems are dependent on some form of grazing for their condition and maintenance. Thus, rangelands driven by grazing can have both negative impacts from grazing (degradation) and positive impacts (facilitation) Huntsinger et al. report that the removal of pastoral grazing, fire suppression, introduction of new species and curtailment of livestock mobility have all resulted in a decline in wildlife numbers and diversity, but an increase in land degradation. They remark that while co-evolution and co-dependence of ecosystems to ruminants may have taken a long time to occur, even in the last 200 years of livestock in the USA, the actions of livestock and their owners have created an ecosystem state change that will not revert 'back to a pristine state' with the departure of livestock - but to a third new state that will likely be less advantageous to wildlife. Short and Dwyer comment that 500 years of pastoral management in the UK has created mixed landscapes within which biological diversity has adapted. Notenbaert et al. cite research results showing that under-grazing can be just as detrimental to rangelands as overgrazing and

that biological diversity is higher just outside the boundary of parks in pastoral lands than inside the parks.

Huntsinger et al. also show that a pastoral land use in the USA is more compatible with wildlife conservation than other land uses. Nelson points to the injustice of parks and gazetted protected areas, where the wildlife are allowed to stray outside park boundaries (and pastoralists are not always compensated for damage caused by wildlife), while pastoralists' livestock are not allowed to stray into the parks.

Riginos et al. report that mobility of Kenyan pastoralists helps to create microhabitats that are of benefit to ecosystems - the transitions of temporary pastoral huts (*bomas*). They also find that compatibility can be enhanced through two types of actions in the East African savannah: (a) minimize herbivory competition during the dry season and (b) maintain or increase habitat heterogeneity through livestock and wildlife mobility.

Thus, compatibility between wildlife conservation and extensive livestock production appears even more relevant at the ecosystem level. Management decisions by conservationists and pastoralists can be aligned much more strongly especially through mobility and extensive production and conservation systems.

Climate change is expected to impact drylands in significant but varied ways. Barnes et al. (this Issue, in press), through a modelling exercise for Namibia, show that commercial fenced ranching systems and agriculture will be the most affected, whereas extensive pastoralism and mixed livestock plus wildlife operations would be most economically and ecologically viable. The conclusion is even more remarkable given that the economic analysis only looked at classic products (meat, milk, tourism) and did not add other ecosystem services that would have tipped the results even more in favour of extensive systems.

Socio-economic compatibility or competition

Because of the widely-held perception that wildlife and livestock always compete for resources, policy makers have frequently drawn the conclusion that conservation and pastoralism are incompatible and thus need to be segregated in land used. However, as many countries have adopted pro-poor policies, different approaches were developed over the years to allow livelihood extraction from protected areas. One can say that these approaches sought to maximize benefits to wildlife, while at the same time *preventing greater poverty* among pastoralists and farmers. Alternatively, attempting to maximize benefits to both can raise potential 'win-win' solutions, such as conservancies, sustainable tourism or sustainable extraction. In Burkina Faso, for example, a successful model being promoted through a GEF/UNEP-funded project has established community reserves, where transhumant pastoralists were allowed to use the rangeland through a fee, hunting concessions were given and wildlife were monitored and managed accordingly (UNEP/GEF 2009).

In this Special Issue, Lichtenstein and Carmanchahi describe the shearing of wild guanaco (camelids) as an additional income for pastoralists living around national parks of the Andes, thus providing incentives for sustainable use and respect of conservation policies and regulations. Foggin, writing about western China, argues that co-management of a national park between Tibetan pastoralists and government agencies is a long-term process of establishing understanding and cooperation between institutions and cultures that start from different points and have differing goals.

Child et al. promote a distinctive approach: that pastoralists should focus on wildlife conservation and production, as it is more lucrative than livestock production today in South Africa. They acknowledge, however, that this may not be the case everywhere because of different market forces and government policies. For example, in Kenya, the law states that all wildlife are state-owned, and therefore pastoralists cannot market off-take of wildlife.

In a criticism of the new 'win-win' paradigm, Homewood et al. conclude that revenue from wildlife and tourism to pastoral households in East Africa is not as high as is often claimed. Elite capture occurs, and also there are externalities to consider, e.g. when livestock are taken off newly-established conservancies, they are simply moved to communal rangelands. They note that the rhetoric of compatibility is over-stated and is promoted by conservationists, not pastoralist researchers. Furthermore, Nelson makes the point that the US $85 million annual revenue of tourism in Kenya cannot be attributed solely to the management of parks, because only 35% of wildlife use the park lands - the rest of the wildlife are found in pastoral and private game ranch lands. The government does not return the equivalent of 65% of this revenue to pastoralists. The findings of Homewood et al., Huntsinger et al. and Kearney et al. all point to lack of real and long-term incentives for pastoralists to engage in wildlife enterprises and conservation, due to skewed policies and subsidies, corruption, and red tape (depending on the country).

The evidence at the species and ecosystem level given in this Special Issue indicates a need to rethink the prevailing 'win-win' paradigm of today. We join our voice to Homewood et al. who ask why are we not looking at real 'win-win' strategies? Both migratory wildlife and livestock need large and non-fragmented land areas in order to remain mobile in rangelands with erratic and variable productivity. Dietary compatibility means that both benefit from some form of co-management. Ensuring that benefits are widely shared and incentives exist for pastoralists to engage in wildlife conservation will help to sustain a paradigm that promotes co-existence in a rapidly shrinking world.

Perhaps, as Heikkinen et al. suggest, the concept of 'ecosystem services' will be useful in bolstering an appreciation of compatibility between wildlife and pastoralism. As an illustration, they analyse a scenario of 'ecosystem engineering' where livestock production would not be for human consumption, but for predator consumption, thus increasing biological diversity in the ecosystems. The evidence of grazing-dependent ecosystems also lends itself to using this concept of ecosystem services. However, we should remain mindful of attempts to over monetize altruistic behaviour and common goods, as noted by Kearney et al.

Finally, Huntsinger et al., Short and Dwyer, as well as Notenbaert et al., all speak of the cultural values of pastoral mobility and that pastoralists see mobility as a practice necessary to efficiently exploit the rangelands, and a right that needs to be preserved. Huntsinger et al. comment that USA ranchers share many attributes of pastoralists elsewhere, including: strong identification with livestock husbandry as a way of life, distinct sub-cultures, and reciprocal social relations including sharing pastures at times of crisis. Short and Dwyer show that protection of the traditional culture as well as livestock breeds in pastoral regions of England are highly emotive issues. Combining this tremendous socio-cultural force with the economic and ecological imperatives for co-existence, points to a promising new direction for long-term sustainability.

Policy considerations

Policies can promote both competition and compatibility between wildlife and livestock, but perhaps the track record has been more evident on the former than the latter. The diversity of such impacts is illustrated by the different papers in this Special Issue.

Short and Dwyer discuss how wildlife-orientated schemes in the UK are distorting the farming system in a way that might not be in the long-term interest of wildlife. Intensive production of livestock (using mostly low lying land) is resulting in undergrazing in uplands and resultant increased fire, less watershed health, less biological diversity, and more gorse invasion. Also, agricultural biodiversity has decreased too, and uplands are being reserved for recreation. They also remark that in the 1970s and 1980s, the European Union Common Agricultural Programme (CAP) encouraged less hardier but higher-output breeds and higher densities of livestock, which led to land degradation - environmentalists then accused farmers of being 'degraders', rather than focusing on the negative incentives from the policy measures.

In some countries, pastoralists also consider that there is a perverse incentive created by policies: as soon as pastoral lands are successful in harbouring biodiversity, these lands attract higher regulation which in turn negatively impacts pastoralists, when conservationist policies follow the paradigm of segregated land use. This is documented by Huntsinger et al. for the western USA and Heikkinen et al. for northern Finland.

Kearney et al. make a case for greater involvement of the private sector (in this case, ranchers) in developed countries, noting that governments rarely have the resources to upscale conservation properly, and NGOs are too fragmented and competing for the same funding base. They further note that in a context where all rangelands are privatized (as in Australia), pastoralists need to be given authority over local conservation decisions, but with connectivity and accountability within a broader system of regulation and governance.

Promotion of eco-tourism and game ranching may be a suitable solution in a few cases, but large scale replication may pose both economic and ecological difficulties. Would these solutions eventually encourage a *neglect* of overall biological *diversity* in favour of an artificial (managed) ecosystem dominated by charismatic and photogenic species? This could be the danger from all of the pastoral conservancy approaches in the future; replacing pastoral systems with wild game ranches on a large scale may also have this unintended effect.

In the USA, the wildlife policy has drawn a lesson from carbon trading by allowing 'Conservation Banks', where a rancher can trade their 'non-impact' with others who have impact. However, Huntsinger et al. point out that if this were to be taken to its extreme, we would be left with only a few Banks that have viable populations, which then means a reduction in widespread genetic diversity. Their discussion shows how a scheme that can work on one 'global' output (such as carbon) cannot necessarily be transferred to another global output.

Policies aimed at both public and private sector incentives would gain from a greater understanding of the middle ground between the pure conservation wildlife and intensive livestock positions. Notenbaert et al. argue that governments who remain hostile to pastoralists can be convinced to change policies if the right information is given as to what,

where and when to invest. Huntsinger et al. show that faulty and incomplete science can lead to policy decisions that have negative impacts. Pastoralism in the western USA is on the decline, and this is raising concerns about changes in land use that will be less compatible with wildlife conservation. Recognition of the compatibility of the two could be the salvation of both. Foggin calls for a much closer integration of national and local government objectives for wildlife conservation combined with pastoralists' livelihood goals in western China. He portrays an example of how mutual trust between the various parties can be built up with time and can generate practical results of monitoring, protecting and gaining value from wildlife within pastoralists' landscapes.

Reconciling different viewpoints

Put starkly - and thus as stereotypes - there are at least five distinctive parties trying to be heard in the discussion. In no particular order of priority, there are (a) conservation ecologists, (b) social scientist researchers of pastoralism, (c) nature preservationists, (d) pastoral people's advocates. And - numerically the largest group of all - (e) pastoralists themselves, who of course do not speak with one 'voice' on the subject of wildlife. Groups (a) and (b) usually present themselves as objective scientists, seeking to uncover new facts, and prove or disprove old facts. Nevertheless, bias is often introduced, either intentionally or not. Groups (c) nature preservationists and (d) pastoral people's advocates, are typically more unequivocal that they act as lobbyists on behalf of their constituencies; for example, the Royal Society for the Protection of Birds (RSPB) or World Alliance for Mobile Indigenous Peoples (WAMIP). There is no question that in some parts of the world, there has been and continues to be active conflict over *control* and *management* of the lands in which pastoralists and wildlife co-habit. For instance, in the western USA, western China, northern Russia, and the game parks and tribal lands of east and southern Africa, these disagreements between parties supporting one 'camp' or the other have boiled over into anger and entrenched positions.

One of the causes of a division of views between development practitioners and social scientists on one side, and conservation biologists and ecologists on the other, lies in the deep and widespread disciplinary divide in teaching natural and social sciences within the Euro-American intellectual tradition. Members of the conservation science community may ridicule social scientists for romanticising the 'ecologically noble savage' untouched by western corruption; while at the same time, some social scientists are contemptuous of environmental scientists who, they believe, refuse to accept that people's activities are part of the natural ecology. Both positions suffer from having been brought up with a western philosophy of the separation of people and nature, a philosophy that was exported from Europe and European America to many places in the world during the colonial period (Peterson 2001). This notion of separation stands in sharp contrast to the philosophies of many of the indigenous cultures of the Americas, Asia, Latin America and Africa that were affected by these colonists: a view that people and nature are inseparable, mutually created and dependent. Christine Black, for example, emphasizes this idea in the title of her book *The Land is the Source of the Law* (Black 2011) from an Australian Aboriginal point of view. Practicing pastoralists, including those from European-based cultures, fall somewhere in this 'middle ground' between these two camps, acting to both conserve their environments and use them profitably but sustainably for the future, as many of the papers in this volume describe (Reid 2012).

In this middle view, pastoralists clearly recognize that their actions both compete with and are compatible with wildlife. Competition occurs when large numbers of wildlife remove large masses of growing forage in the lean season, as happens when wildlife avoid pastoral areas in the dry season of the Mara ecosystem of Kenya (Bhola et al. 2012). Borana pastoralists of Ethiopia recognize that heavy grazing by their cattle can 'overgraze' their pasture, promoting the spread of shrubs and reducing pasture productivity (Desta and Coppock 2004). Other east African pastoralists see clearly that some landscapes are more sensitive to grazing than others and carefully manage their grazing on the fragile landscapes (Oba and Kaitira 2006).

If we are to make progress in developing an evidence-based and integrated understanding of the complex relationships between pastoralists, their livestock, wildlife and the dynamic ecosystems on which they all depend, several things need to occur. First, pastoralists themselves need to be a much more prominent voice in this discussion because they not only see the complexity of the situation, but they also have legal ownership of or *de facto* use of rangelands and are most affected by what happens in these rangelands. Making progress will include highlighting pastoral interpretations of what is happening in rangelands and supporting their work to solve problems in these rangelands.

Second, it is important for those observers who see mostly competition or mostly compatibility to recognize that there is strong context-dependence, both between sites and dynamically in time and space within sites. And those who deny that pastoralist activities can sometimes compete with wildlife, even exterminating them, have to take off their rosy-coloured glasses. More productive may be a middle ground that all can occupy and discuss how to reduce competition at all levels (and address the costs of such a reduction to all concerned) and tip the balance towards compatibility. Researchers in any fields relevant to this issue (including a range of natural, social and interdisciplinary scientists) need to discuss all the evidence and negotiate what that evidence really means and then conduct new research together to find new spaces and directions to take this middle ground.

In the discussions on sustainable development occurring today, joining forces in the middle will carry more weight. Just as wildlife management will gain from association with extensive pastoralism, the reverse is also true. Extensive livestock production is under threat from policies that promote sedentarization and agricultural intensification. Joining forces will help both discourses.

Gaps in research

Understanding when and how competition occurs between wildlife and livestock can help governments, as well as local and international actors, to better understand its relative magnitude and importance (e.g. vegetative competition and factors such as disease transmission), and to design policies that will encourage compatibility between wildlife and pastoralism which depends on domestic animals.

- There is even less research focusing on the ecosystem level; research should focus not just on vegetative competition between ruminants (e.g. wild and domestic) or large herbivores (again, wild and domestic), but also on habitat and ecosystem benefits for other wildlife diversity (e.g. birds, insects, rodents, etc.).
- Documenting the extent to which natural rangeland environments have developed in tandem with grazing by domestic livestock. So many present-day landscapes that

have acquired enormous social, economic or nostalgic value and are therefore protected through state regulations - excluding or restricting pastoralists and their livestock - are in fact partly the result of millennia of grazing by livestock.

- Researching more ways to 'mix and match' wildlife and livestock for enhanced ecosystem services and livelihoods, exploiting the current enthusiasm at governmental and international levels for the ecosystem services paradigm, which brings with it new and substantial potential funding sources (such as the UK government's major Ecosystem Services for Poverty Alleviation programme).

Conclusion

Climatically unstable rangelands perhaps offer the most opportunity for integrating wildlife management with livestock to meet multiple goals: wildlife conservation, livelihoods support for pastoralists, and demand for livestock products generated with less intensification. The articles in this Special Issue underline that under stronger governance and regulatory co-management, integration can offer multiple and complementary income sources for the direct rangeland resource users - pastoralists and wildlife managers. There are examples of emerging success from Europe, South America, USA and Australia (see chapters in du Toit et al. 2010, especially Victurine and Curtin 2010). At the same time, co-existence of livestock and wildlife indirectly benefits global consumers of livestock products, as well as tourists, hunters, nature conservationists and governments, who all aspire to retain the wild in rangelands. If there is in fact an environmental ceiling on the extent to which rangeland intensification can be sustained, diversification incorporating wildlife management could become an effective economic supplement for pastoralists remaining in the rangelands (R. Behnke, personal communication 2012).

Several articles in this Special Issue show that land use change and new policies are recasting ranching and pastoralism from a threat into a key ally for conservation in the USA, Europe and Australia. Conservationists elsewhere have paid lip service to this in the past. Are they ready for a paradigm change? Are pastoralists ready to take up wildlife conservation as one more output and benefit from pastoralism?

Neither conservationists who focus purely on wildlife persistence, nor those who aim to boost production of rangelands for human benefit alone, have taken this challenge up strongly enough elsewhere in the world - though sharing land between predators and livestock remains a very fraught process in developed countries, e.g. in Europe and North America where government regulations require such co-existence. As paradigms shift - such as the rise of the ecosystem services concept to take equity issues into account, or the changing priorities of the multi-lateral environmental agreements which have moved from primarily conservation in their early days, to co-benefits and sustainable use - it is time for wildlife conservationists and pastoralists to focus on their shared needs and concerns. These two groups are natural allies, and the sooner they can join forces, the better will be the outcome for both people and wildlife, dependent on extensive rangelands for their wellbeing and continued existence.

Finally, this Special Issue argues strongly for bringing together the three elements of sustainability - social, economic and environmental - in line with the most recent findings of the Planet Under Pressure Conference (London, March 2012) and the UN Conference on Sustainable Development (Rio + 20).

Endnote

[a]Pastoralism covers production systems and livelihoods which are mainly dependent on livestock raised extensively, whether on communal or private pastures, with or without regular mobility. We now include in the definition of pastoralism the management of semi-wild animals, from the case studies in this Special Issue of reindeer in the Arctic and guanaco camelids in Argentina.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

MN-F inspired and developed the special theme of wildlife and pastoralism for this journal. CK and MN-F jointly solicited papers, arranged anonymous peer reviews and edited all papers accepted following reviews. RR contributed ideas and data on wildlife-pastoralist interactions, particularly in East Africa. EJM-G contributed insights and current information on the science and practice of conservation ecology. All authors read and approved the final manuscript.

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