HUMAN–WILDLIFE COEXISTENCE

Supersizing sustainability in savannas

Increasing pressure for communities to conserve wildlife in mixtures with livestock faces scepticism about whether such management is sustainable. The study by Sitters et al. shows that wildlife–livestock coexistence may be sustainable, but only if megaherbivores are included.

Mark E. Ritchie

There are few more iconic scenes than the sight of great herds of large mammals amongst scattered flat-topped trees and tall grass in an African savanna. Such habitats are home to Earth's last populations of megaherbivores — large (>1,000 kg) plant-eating animals that include elephants, giraffes, rhinos and hippos. Conservation of these creatures is paramount to many, but there is considerable debate about how to achieve their long-term persistence. Writing in *Nature Sustainability*, Judith Sitters and colleagues[1] report that it may be possible for humans and their livestock to coexist and sustain productivity outside protected areas, but only if the animal menagerie includes megaherbivores.

Conservation of large mammals, and megaherbivores in particular, is typically achieved via protected areas that exclude humans. However, the long-term success of protected areas is uncertain, as these areas are increasingly recognized as the consequence of unjust removal of indigenous populations[2] and are vulnerable to human modification of habitat in surrounding areas even when effectively patrolled[3]. Mixing wildlife and livestock seems unsuccessful, as evidenced by widespread wildlife declines of 50–70% in Kenya at the same time livestock densities doubled[4]. Consequently, there is substantial interest in finding ways for communities to manage landscapes to support both wildlife and livestock.

The authors measured several indicators of savanna productivity in a twenty-year experiment established at the Mpala Research Centre, northwestern Laikipia County, Kenya. Using different types of fences, the experiment created areas that included six treatments: no large herbivores; only moderate densities of cattle; cattle mixed with smaller (<1,000 kg) wildlife; cattle mixed with all wildlife including megaherbivores; only smaller wild herbivores; and only wildlife of all sizes. They found that over the years, as expected[5,6], cattle alone or with smaller wild herbivores reduced potential soil fertility by transferring carbon and nitrogen from the plants they consumed across the landscape during the day to dung deposited in their corrals at night. This reduced the carbon and nitrogen found in the soil and was associated with plant forage of poorer nutritional quality. Surprisingly, when megaherbivores, mainly elephants, cohabited with cattle these negative effects were reversed, with soil carbon and nitrogen restored to levels found when cattle were absent. This result suggests that if humans, their livestock, and large herds of wildlife are to coexist, the megaherbivores must join the mix.

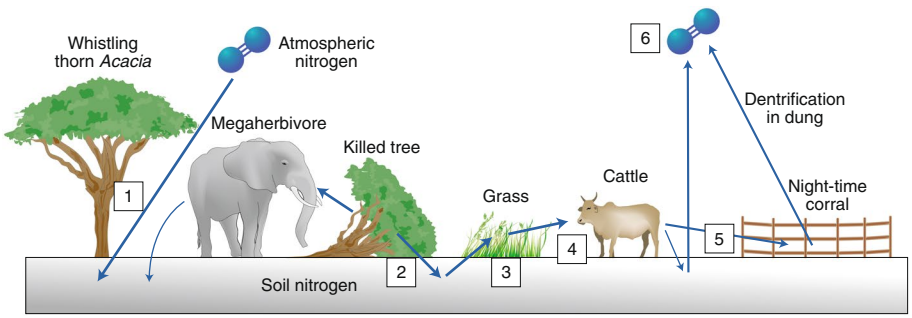

Fig. 1 | Illustration of the savanna nitrogen pump, as implied by the results of Sitters and colleagues. Atmospheric nitrogen (N_2) is fixed by tree symbiotic bacteria (1), cycled into soil N by megaherbivores killing trees (2), taken up by grass (3), eaten by cattle (4) and a portion is removed from the landscape to night-time corrals (5). Organic forms of N in dung and soil are converted to N_2 (6) by microbes, in a process called denitrification, to complete the cycle. Without megaherbivores, the cycle is interrupted and soil N and C outside corrals are depleted.

The specific ways that megaherbivores influenced soil carbon and nitrogen are still unclear, but Sitters et al. conjectured that most likely elephants knock down, kill and eat trees, and thus recycle tree carbon and nutrients back into the soil where they replace those transported by cattle to their night-time corrals. The dominant trees in the study, whistling thorn acacias (*Acacia drepanolobium*), are leguminous and have the potential to harvest nitrogen from the atmosphere through a symbiosis with root bacteria[7]. Elephants may therefore 'prime' a pump that transfers nitrogen from the atmosphere to trees, to soil, to forage plants and thence to livestock production (see Fig. 1). More work needs to be done to determine if this mechanism is indeed important, but the authors discuss and dismiss as unlikely other possible mechanisms.

The discovery that the presence of cattle and absence of megaherbivores reduced overall plant quality, measured as tissue nitrogen (N) and carbon to nitrogen (C/N) ratio, has potential implications for conservation of small wildlife as well. It is well known that smaller antelopes, such as impala (*Aepyceros melampus*), Grant's gazelles (*Gazella granti*) and oryx (*Oryx beisa*) depend more heavily on plant forage with high N and/or phosphorus (P) contents. The reduction in plant N and P associated with cattle without megaherbivores may reduce the abundance of these smaller wildlife species. Indeed, previous studies at the Mpala Centre[8] suggest that Grant's gazelles and oryx abundances were lower in the presence of cattle without megaherbivores.

Earlier work on savannas[5,9] at Mpala showed that the concentration of nutrients by livestock in corrals leaves patches of extremely fertile soil after corrals are abandoned and herders have moved elsewhere. These abandoned corrals sprout

trees and highly nutritious grasses that support a wide range of plant and animal diversity. What Sitters and colleagues discovered was that megaherbivores help keep nutrients in the soil so that the beneficial effects of livestock and people do not have to come at the expense of depleting soil in the surrounding landscape.

While the path to successfully mixing humans, livestock and wildlife is still unclear, this study shows the importance of including the full complement of large animal species in the plan. Even as they provide benefits, megaherbivores pose challenges as well, because they can raid crops, and, in the case of elephants, injure and kill people. Measures to minimize these conflicts will likely be needed for success in achieving wildlife–cattle mixtures. The study also shows that mixing wildlife and cattle works for moderate densities of cattle; it is unclear if such a system is sustainable at the higher livestock densities typically kept by pastoralist peoples in the African savanna. Nevertheless, studies such as that of Sitters et al. advance the knowledge base for finding future working solutions to conserving the iconic herds of Africa. ❐

Mark E. Ritchie
Department of Biology, Syracuse University, Syracuse, NY, USA.
e-mail: meritchi@syr.edu

Published online: 16 March 2020
https://doi.org/10.1038/s41893-020-0494-9

References

1. Sitters, J., Kimuyu, D. M., Young, T. P., Claeys, P. & Olde Venterink, H. *Nat. Sustain.* https://doi.org/10.1038/s41893-020-0490-0 (2020).
2. Taylor, B. *RCC Persp.* **1**, 117–122 (2014).
3. Veldhuis, M. P. et al. *Science* **363**, 1424–1428 (2019).
4. Ogutu, J. O. et al. *PLoS ONE* **11**, e0163249 (2016).
5. Soderstrom, B. & Reid, R. S. *Acta Oecol.* **36**, 184–190 (2010).
6. Augustine, D. J. *J. Appl. Ecol.* **40**, 137–149 (2003).
7. Fox-Dobbs, K., Doak, D. F., Brody, A. K. & Palmer, T. M. *Ecol. Appl.* **91**, 1296–1307 (2010).
8. Riginos, C. et al. *Pastoralism* **2**, 10 (2012).
9. Young, T. P., Partridge, N. & Macrae, A. *Ecol. Appl.* **5**, 97–108 (1995).

Competing interests

The author declares no competing interests.