Rhino poaching may cause atypical trophic cascades

Current anthropogenic pressures drive the widespread loss of apex consumers where the effects of their removal from a system may cascade through lower trophic levels, with unanticipated impacts (Estes *et al.* 2011; Ripple *et al.* 2014). Similarly, the observed global decline in large herbivores has complex outcomes for ecosystem functioning (Ripple *et al.* 2015). Key to predicting and understanding the consequences of declines in both these guilds has been the concept of ecological cascades. Thus, hypothesizing ecological pathways and species' interactions is an important first step in forecasting ecological responses to changes in the abundance and distribution of both apex predators and large herbivores.

We raise the question of whether the recent surge in poaching of white rhinoceros (*Ceratotherium simum*) and, to a lesser extent, the less abundant black rhinoceros (*Diceros bicornis*) in the Kruger National Park, South Africa, is providing the ingredients for an atypical cascade – one in which the mechanisms include an artificial enhancement rather than reduction of apex predators (Figure 1). We further hypothesize that this atypical trophic cascade could act synergistically with another anthropogenic pressure, the related poaching of lions (*Panthera leo*) for body parts coveted by rhino poachers, and subsistence poaching of wild meat in the adjoining Limpopo National Park, Mozambique, leading to the creation of an "ecological trap" (where species mistakenly respond to environmental cues that no longer match habitat quality) for an endangered species.

In Kruger National Park poachers have slaughtered 1670 rhinos over the past 3 years (2012–2014) (http://bit.ly/1PELXMm), taking the horns and leaving the (~1900-kg) carcasses. As a mega-herbivore not normally predated upon (Owen-Smith 1988), adult rhinos have negligible trophic interactions with lions or spotted hyenas (*Crocuta crocuta*) (Clements *et al.* 2014). However, both these apex-predator species readily scavenge (Estes 1992), are able to open pachyderm carcasses (White and Diedrich 2012), and can take advantage of this rich resource subsidy. Predator abundance is positively correlated with prey resources (Carbone and Gittleman 2002), and lion pride sizes are known to increase incrementally following resource augmentations (Packer *et al.* 2005). Because carcass occurrence has been predictable on the landscape and has been steadily increasing (currently about two per day) (www.environment.gov.za), this increase in food resources may likely lead to an increase in predator numbers (Oro *et al.* 2013; Ripple *et al.* 2013). This hypothesis is in line with the findings that the provision of trophy-hunted elephant (*Loxodonta africana*) carcasses in Botswana represented a substantial and valuable resource for spotted hyena (Cozzi *et al.* 2015), changing their foraging behavior and possible clan sizes.

A numerical increase in the abundance of lions and hyenas in Kruger may have widespread and undesirable impacts on predator-limited prey species. For example, higher numbers of lions in Kruger may imperil the park's small population of roan antelopes (*Hippotragus equinus*) already restricted to low numbers due to predation pressure (McLoughlin and Owen-Smith 2003). Additionally, increasing numbers of lions and hyenas in Kruger could enhance intraguild competition. Competitively inferior predators, including endangered African wild dogs (*Lycaon pictus*) (Creel and Creel 1996) and cheetahs (*Acinonyx jubatus*) (Durant 1998), may no longer be able to find sufficient competition refugia in the park.

The rhino poachers entering Kruger largely come from communities within the adjoining Limpopo National Park (Oosthuizen 2014). Local superstition dictates that carrying a body part from a lion will provide a hunter with luck on a dangerous hunt, including the ability to avoid capture by rangers (Els 2002). The killing of lions, for the local demand for body parts, threatens the population of lions in Limpopo (Everatt 2015).

This link between rhino poaching and lion poaching suggests that an increase in the perceived risk to rhino poachers, from intensifying anti-rhino-poaching efforts in Kruger, could lead to increased pressure on Limpopo's lion population. Furthermore, reduced lion densities in Limpopo may make the landscape appear more attractive to African wild dogs seeking refugia from the (already) higher lion densities encountered in Kruger (van der Meer *et al.* 2014). Unfortunately, African wild dogs are particularly vulnerable to mortality from snares set for herbivores (Becker *et al.* 2013), and illegal snaring for bushmeat is widespread and common in Limpopo (Everatt *et al.* 2014). It is therefore reasonable to predict that a greater disparity in the density of lions between Kruger and Limpopo, combined with the high threat of snares in Limpopo, could result in an ecological trap that will be detrimental to the region's African wild dogs.

Moreover, the loss of primary consumers, whose massive body size typically safeguards them from predation (Clements *et al.* 2014), may also induce trophic cascades. For instance, the removal of white rhinos from the Kruger ecosystem leads to the loss of "grazing lawns", areas of short grass (roughly 4 m^2) maintained by rhinos but potentially benefiting insects, birds, small mammals, and ungulates (Ripple *et al.* 2015). The reduction of rhino-maintained short grass areas also coincides with changes in fire regimes, with larger, hotter fires occurring where rhinos have been removed. These intense fires increase the homogenous nature of the savanna, creating a positive feedback

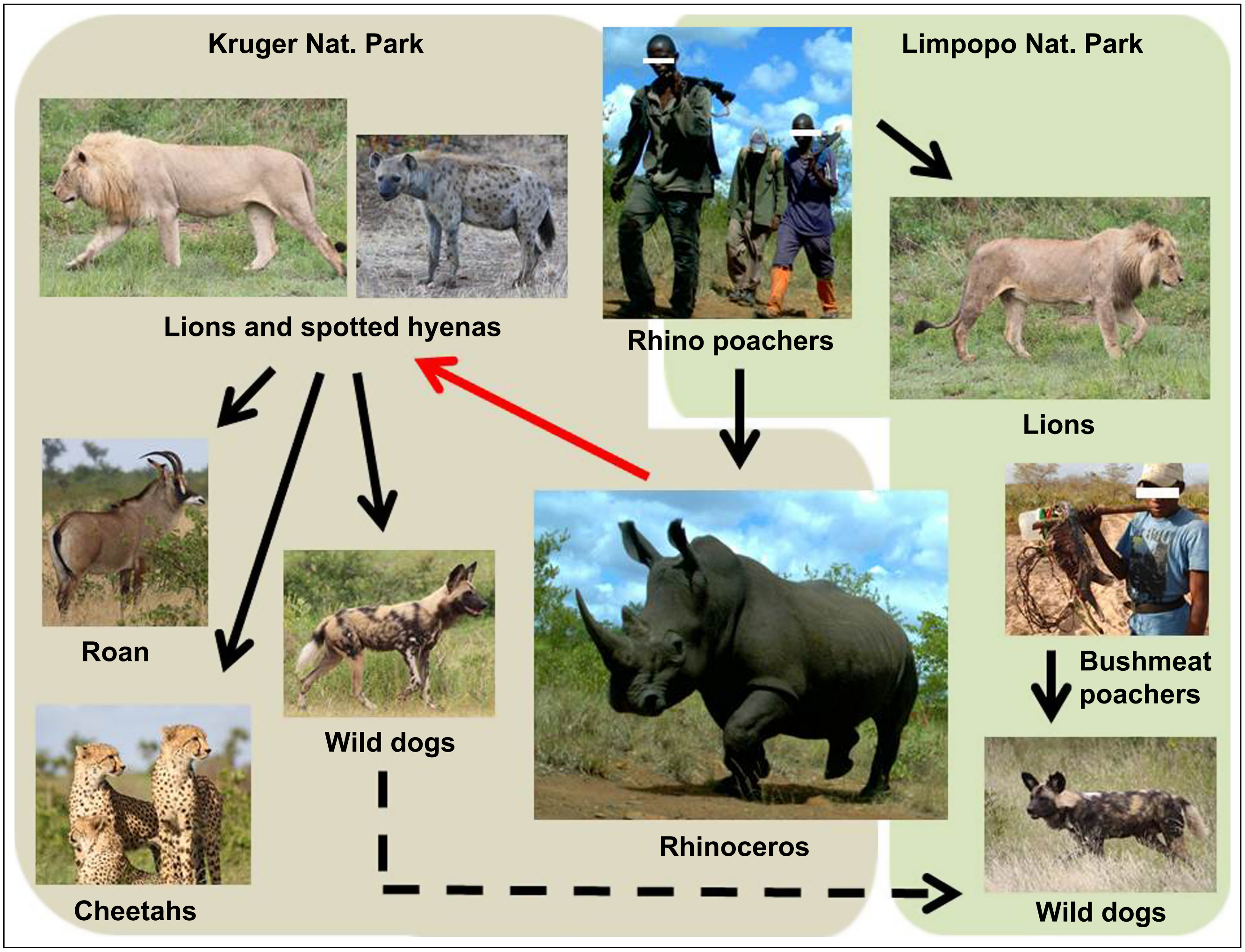

Figure 1. *Conceptual diagram showing a hypothetical atypical trophic cascade induced by rhino poaching in the Kruger National Park, South Africa. Poachers decrease abundance (black arrow) of mega-herbivores (www.environment.gov.za), leaving carcasses that provide a resource subsidy, supporting an increase in abundance (red arrow) of apex predators (lions and spotted hyenas) in Kruger (Carbone and Gittleman 2002; Packer* et al. *2005). Increased apex predators in Kruger suppress (black arrows) competitively inferior, endangered African wild dogs (Creel and Creel 1996) and cheetah (Durant 1998) and predator-limited roan antelope (McLoughlin and Owen-Smith 2003). Simultaneously, lions are killed in adjoining Limpopo Park (black arrow) to acquire body parts coveted by rhino poachers (Els 2002; Everatt 2015). African wild dogs select habitat (dashed arrow) with lower lion densities (van der Meer* et al. *2014), moving from Kruger to Limpopo, where they then suffer high mortalities (black arrow) in snares set for bushmeat (Becker* et al. *2013). Other important pathways not shown include the indirect effects following the loss of the rhinos, including the loss of rhino-maintained "grazing lawns": a distinct micro-habitat that could support species of birds and lizards and encourage smaller grazers, and that alters fire patterns (Cromsigt and te Beest 2014).*

loop toward a fire-dominated system (Cromsigt and te Beest 2014).

The current rhino poaching crisis of Kruger has the ingredients for widespread ecological degradation. We suggest the possible pathways of atypical trophic cascades originating with the increases, rather than loss, of apex predators, and the associated loss of mega-herbivores. We hypothesize that such cascades could result not only in the loss of other populations of endangered species but also in changes in vegetation structure and fire regimes; in addition, these cascades may interact with the actions of local poachers to create an ecological trap for an endangered species.

Although we describe untested hypotheses in this letter, each pathway has been observed and the predicted end results are important enough to justify prudence among natural resource managers tasked with mitigating the impacts of poaching as well as further investigations by ecologists into unanticipated dynamics in systems affected by poaching.

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The moral basis for conservation – reflections on Dickman *et al.*

Dickman *et al.* (2015; *Front Ecol Environ* **13[6]**: 325–31) suggested that "moral relativism" and "misguided respect" for cultural practices impede biological conservation. They favor a world in which conservation scientists armed with universal norms will more readily implement their solutions without the consent of local stakeholders. While we acknowledge their concerns, their vision, however tentative, appears misguided. Here we highlight some objections.

The authors suggest their interventions are justified by universal values and scientific rationality. But society also protects cultural diversity and human rights on the basis of philosophy and universal values (Maffi 2005; Elliott 2014). Sen, whose non-relativist views were mentioned, actually proposed universal human capacities and freedoms that he wanted to see protected, not undermined, though he acknowledged these principles do not readily yield a practical means to make choices by calculation (Sen 1988). Human rights related to conservation actions enjoy widespread, often legal, recognition (Elliott 2014) and have motivated various international agreements (eg www.unccd.int, http://undesadspd.org, www.cbd.int, and www.ilo.org). "Free, prior, and informed consent" is a principle emphasized in these agreements and others (Hanna and Vanclay 2013).

Dickman *et al.* fail to recognize that conservation serves a plurality of people and principles. Furthermore, conservation represents one set of societal goals among many; choices are necessary to allocate resources and manage trade-offs. The challenge is how to reconcile competing values and human rights.

We propose that the route to legitimacy lies in respecting democratic and legal principles. Such principles acknowledge different views and perspectives. Scientists should draw on their knowledge to inform choices, but scientific utility is no excuse for tyranny by scientists (Sheil and Meijaard 2010). The ends and means of science represent one subset of the ends and means of society as a whole.

Relativism takes many forms. In conservation, "relativism" emphasizes inclusive and respectful approaches. This is a guiding principle, not a fundamental doctrine. Such relativism reflects the diversity of perspectives that occur even within science.

Scientific views are seldom monolithic. Applied science is often controversial, even among scientists, and normative assessments differ (Vedeld 1994). Perceptions, framing, and preferred outcomes vary among stakeholders, including sci-

