BOOK REVIEWS

Rhinos of the World: Ecology, conservation and management

(Eds.). Mario Milleti, Bibhab Talukdar and David Balfour

Reviewed by Sam M Ferreira, Daniel Stiles, Hilloljyoti Singha, Jonathan Spencer, Deba K Dutta, Keryn Emslie, Inov Sectionov, Suzannah Goss

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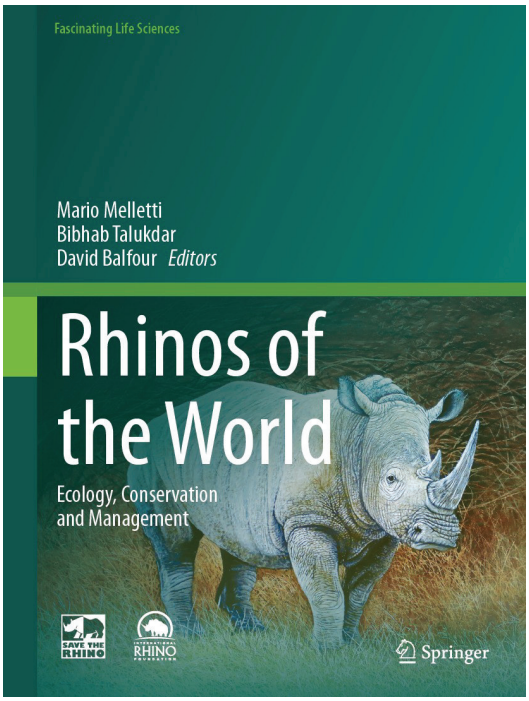

Figure 1. Front cover (https://link.springer.com/book/10.1007/978-3-031-67169-2)

Chapter 1/Phylogeny and systematics of the extant rhinoceros

Authors: Yoshan Moodley, Jan Robovský

Reviewed by Sam M Ferreira

The first chapter of the 16-chapter book on *Rhinos of the World* (under the sub-section 'Systematics and Evolution') provides a multi-scalar analysis of rhinoceros evolution, spanning extinct taxa to population-level divergence within extant species. It critically evaluates the influence of morphological traits, mtDNA (which often overestimates divergence), and nuclear DNA (with limited variability), revealing how these tools shaped competing phylogenetic hypotheses—namely, the horn, geographic, and radial models. Whole-genome sequencing emerges as a transformative approach, resolving inconsistencies, affirming a geographical model of divergence from a common ancestor ~36 million years ago, and clarifying mtDNA/nDNA discordance via secondary contact. The genomic data also inform estimates of ancient effective population sizes based on heterozygosity, of particular relevance given the fragmented and constrained population structures of modern-day rhino species.

While the chapter offers a robust synthesis of phylogenetic insights, several areas present opportunities for further development. Integrating ecological and demographic processes—such as dispersal dynamics and local adaptation—could

enhance understanding of the mechanisms driving gene flow and shaping genetic structure. Additionally, many of the studies cited are based on limited sample sizes, which may not fully capture variability within populations or geographic patterns of diversity. Expanding sampling frameworks could strengthen the resolution of phylogenetic analyses. Finally, rather than emphasizing fixed, historical genetic structures, conservation strategies may benefit from a more flexible perspective that accounts for evolutionary potential and ecological responsiveness to the context of ongoing environmental change and disturbance.

The chapter concludes with a forward-looking recommendation: to move beyond rigid subspecies classifications and adopt more dynamic frameworks, such as evolutionarily significant units (ESUs) and management units, informed by historical gene flow and adaptive potential.

Chapter 2/Evolution and fossil record of Old World Rhinocerotidae

Authors: Pierre-Olivier Antoine, Damien Becker, Luca Pandolfi, Denis Geraads

Reviewed by Sam M Ferreira

The second chapter in *Rhinos of the World* offers a comprehensive synthesis of the evolutionary history of Old World Rhinocerotidae, tracing the lineage over 40 million years through dramatic climatic and biogeographical shifts. It highlights a remarkable radiation of rhinoceros species across epochs, with hundreds of genera emerging and disappearing, often in response to global environmental changes that unfolded at far slower rates than today's accelerating anthropogenic shifts. The chapter captures the Miocene as a peak of rhino diversity, followed by a stark contraction in both generic and specific richness during the Pliocene–Pleistocene. Notably, all surviving members are of the subtribe Rhinocerotina and possess nasal horns, while hornless lineages have vanished—marking a morphological legacy that survived severe attrition.

Asian fossil records provide relatively clear evolutionary trajectories, unlike the more fragmented African evidence. The chapter also candidly acknowledges the phylogenetic uncertainties that challenge fossil-based reconstructions, especially where taxa are defined from incomplete or geographically sparse materials. Despite these gaps, the review effectively outlines the deep-time patterns that shaped modern rhinoceros diversity.

The transition from the Pleistocene to the Holocene was pivotal, ushering in not only climatic instability but also the onset of direct human pressures. Anthropogenic pressures have intensified into the present, resulting in the precipitous decline of all five extant species and several subspecies. With northern white rhinos (NWR), western black, and northern Javan rhinos effectively lost, the chapter concludes with an urgent, sobering reflection: how much longer can the last wild representatives of this once-thriving 40-million-year-old lineage survive?

Chapter 3/Southern white rhino *Ceratotherium simum simum* (Burchell, 1817) Northern white rhino *Ceratotherium simum cottoni* (Lydekker, 1908)

Authors: Adrian M Shrader, Richard Emslie, Kes Hillman-Smith, Petra Kretzschmar, Courtney Marneweck, Mario Melletti, Norman Owen-Smith, Kees Rookmaaker, Kerry Slater

Reviewed by Daniel Stiles

The third chapter under the subsection 'Species Accounts' covers various aspects of the biology and natural history of the southern white rhino (*Ceratotherium simum simum*) and NWR (*Ceratotherium simum cottoni*), including names, taxonomy, subspecies and their distribution, descriptive notes, habitat, movements and home range, activity patterns, feeding ecology, reproduction and growth, behaviour, and status in the wild and in captivity. The chapter also includes a distribution map (Fig. 3.1; however the map fails to show the historical range of the NWR). There are also several photos of the species and a list of key literature.

An interesting tidbit from the taxonomic discussion was the fact that the question of whether the NWR and southern white rhinos (SWR) are separate species or

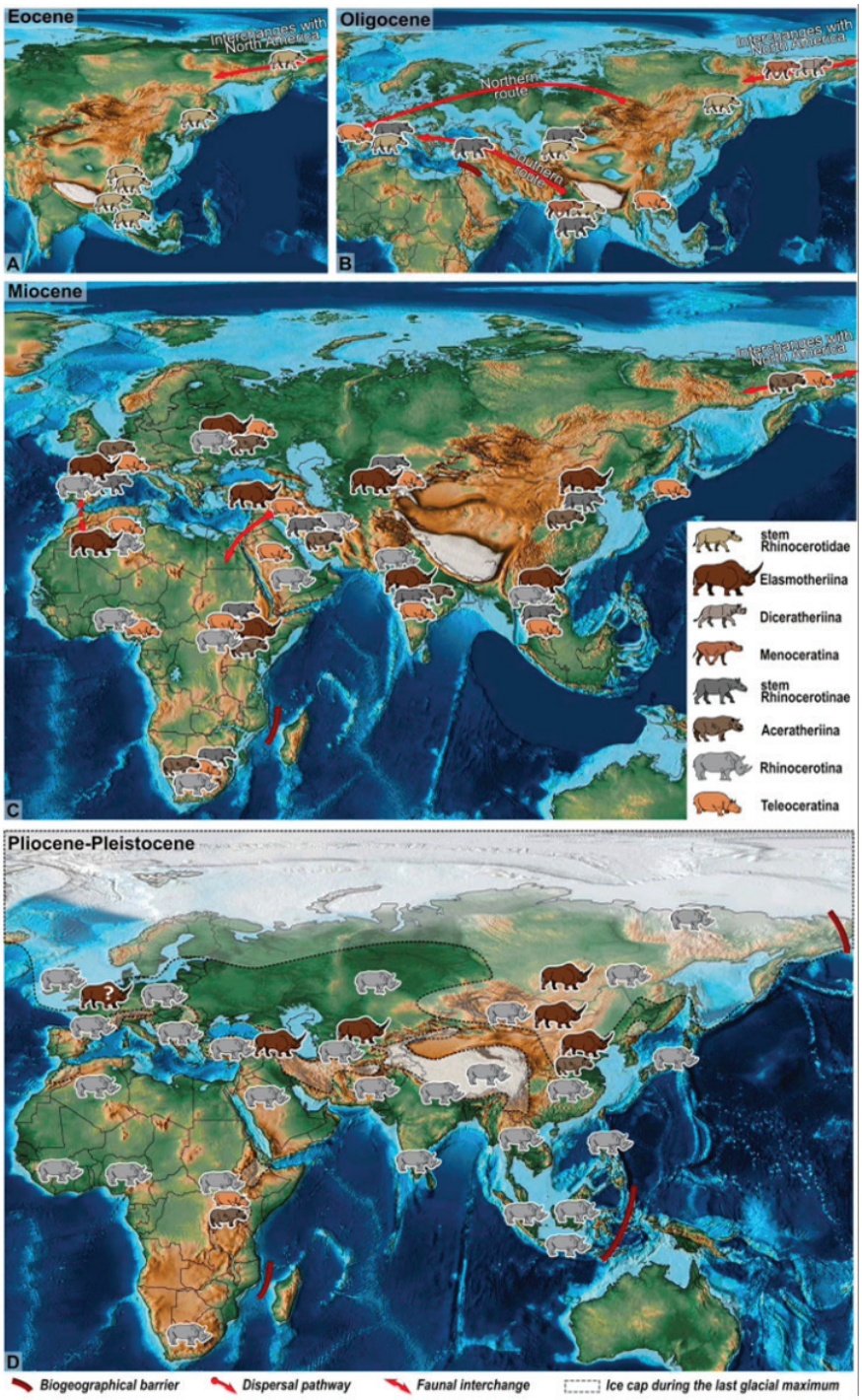

Figure 2. (Fig. 2.2) Historical paleobiogeography of rhinocerotids in the Old World, over (a) Eocene; (b) Oligocene; (c) Miocene, and (d) Pliocene-Pleistocene (c) PaleoAtlas for GPlates and the paleoData plotter programme.
Scotese CR. 2021. An Atlas of Phanerozoic Paleogeographic Maps: The Seas Come In and the Seas Go Out. *Annual Review of Earth and Planetary Sciences* 49 (1): 679–728. https://doi.org/10.1146/annurev-earth-081320-064052

subspecies, is still open. Recent genetic studies show that the differences between the NWR and SWR are greater than the differences found between any black rhino subspecies. In addition, it is not known whether the subspecies can interbreed and produce fertile offspring, which is one of the distinguishing features of the biological or taxonomic species concept. It is not difficult to tell them apart; the NWR is distinguished by the fringe of hair around the ears, which the SWR does not have.

The distribution map is quite dated, from 2012, and therefore does not include the more recent translocations of SWR from Zimbabwe to the DRC. The map also does not show the white rhinos in Angola and Rwanda as reported by the International Rhino Foundation, although these countries are listed under the 'Status in the Wild' section. The chapter would have benefitted from a table showing the population estimates by country at three or four points in time in order to clearly see the trends.

The authors categorize the last two remaining NWR as living in the wild. Having spent four years based at Ol Pejeta Conservancy in Kenya, where they are located and visited them on numerous occasions, I would consider them better viewed as living in captivity. They are under close, constant surveillance by conservancy rangers and live in a fenced enclosure within the electrically fenced conservancy.

Fig. 2 Dame Valerie Jane Morris Goodall (3 April 1934–1 October 2025) at Ol Pejeta Conservancy with Sudan, the last male NWR, before he died © Dan Stiles

Chapter 4/Black rhino *Diceros bicornis* (Linnaeus, 1758)

Authors: Adrian M Shrader, Keryn Adcock, Rob Brett, Charles Dewhurst, Vanessa Duthé, Richard Kock, Marietjie Landman, Peter R Law, Roan D Plotz, JA Shaw

Reviewed by Sam M Ferreira

Chapter 4, in this sub-section on 'Species Accounts', presents a richly detailed and scientifically grounded account of the biology, behaviour, and conservation status of the black rhinoceros, (*Diceros bicornis*). Far beyond a guidebook summary, this chapter synthesises an impressive array of literature, covering taxonomy, morphology, habitat use, dietary preferences, reproductive traits, and socio-ecological dynamics. It tracks the species' historical distribution and current range contraction, contextualising the population collapse of the 1970s–1980s and the subsequent recovery efforts. Notably, the chapter revisits subspecies designations, incorporating recent genetic and biogeographic data to support nine evolutionary lineages, seven of which persist.

The authors highlight black rhinos as ecologically generalist browsers with complex behavioural traits, such as conspecific recognition, home range fidelity, and sex-biased anti-predator responses. These observations are embedded in practical implications for translocation, habitat suitability, and ex situ conservation, offering both a retrospective and forward-looking perspective on black rhino management.

However, three caveats deserve consideration to deepen the analysis. Firstly, while the revised subspecies units are biologically defensible, they are not yet formally recognised by global conservation bodies such as the IUCN. This creates potential mismatches in policy, especially under CITES trade mechanisms. Such challenges could be overcome through emerging paradigms in dynamic ecological management, particularly those promoting dispersal and connectivity between neighbouring populations

to mimic historical gene flow. Finally, insights from evolutionary theory, such as functional heterogeneity in resource use or the Trivers-Willard hypothesis on reproductive strategies, could enhance interpretations of demographic variability and life-history trade-offs.

In sum, this chapter offers a valuable scientific foundation for black rhino conservation. As pressures from poaching, habitat fragmentation, and climate change continue to mount, advancing science and adaptive management remain essential tools to safeguard this keystone browser and preserve its irreplaceable evolutionary legacy.

Chapter 5/ Greater one-horned rhino *Rhinoceros unicornis* (Linnaeus, 1758)

Authors: Bibhab K Talukdar, Deba K Dutta, Kanchan Thapa, Anwaruddin Choudhury

Reviewed by Hilloljyoti Singha

Under the series of 'Fascinating Life Sciences' by Springer Nature, this fifth of the 16 chapters, 'Greater One-Horned Rhino (*Rhinoceros unicornis* (Linnaeus, 1758) is authored by several greater one-horned rhino experts. This chapter provides an account drawing on up-to-date data covering every detail of the greater one-horned rhino (GOH) as found presently in India and Nepal.

According to the authors, due to its large body size and high mobility, the swimming prowess helped this primitive species adapt in floodplains. The historical range of the GOH rhino has been vividly depicted in historical records, from references in the *Chandogya Upanishad* of 900 BC to modern research papers. The historical documents mentioned are fascinating and important, found in various archives and sources, and have been well-researched by the authors. The authors also discuss the primary reasons for the decline of the species in its former range of distribution.

The current and recent past distribution and population trends have also been adequately described. The authors present the GOH rhino population trends of India and Nepal from 1900 to 2023 (Fig. 5.2). The latest population data (2021–2022) for the GOH rhino in the protected areas (PA) of India and Nepal are presented in Table 5.1.

Each rhino inhabiting PA has been described with its own specific history, conservation challenges and prospects with the landscape. The land cover map of each PA in India and Nepal along with the population trends of the last few decades, are consistent elements of this chapter.

The field experiences, coupled with the authors' knowledge of the GOH rhino, are evident, and the habitats, activities and behaviour of the rhinos are well described. They have reviewed works by different authors and also drawn on their own research. For example, the home range of GOH rhinos has been studied by several researchers, and the authors conclude that the expansion and contraction of home ranges depend on the unique factors of each habitat, with adult male rhinos experiencing the largest proportion. The daily activity patterns, including feeding ecology, are also found to differ in different rhino habitats, and are influenced by their surroundings and anthropogenic factors, as the authors have studied from various literature. However, it is recognized that research on the diseases affecting GOH rhinos caused by parasites has been limited.

From this chapter, readers will learn that GOH rhinos have the lowest reproductive rate among the terrestrial herbivores. Although breeding has been observed to occur 'throughout the year', it was not mentioned whether the flood season has had any impact on breeding success or not. Stated to be crepuscular, GOH rhinos are active at dawn and dusk, and the authors have described their behaviour and association with other species in the same habitat. However, defecating in a particular place and creating a dung pile (or midden), is one of the unique characteristics of the species, which should have been elaborated upon more. Similarly, the description of the animal's morphology and the status of the species should have been presented at the beginning of this chapter. Interestingly, the authors note that the body length of the GOH rhino is 160–200 cm, whereas elsewhere it has been mentioned as 310–380 cm. These differing measurements may pertain to captured GOH rhinos that have either been translocated or rescued. For clarification, the accurate range for the body length of the GOH rhino is established as 160–380 cm.

The conservation challenges, including habitat

management, recurring floods, invasive plant species and negative rhino-human interactions, have been addressed through community-based anti-poaching efforts. The topics of modern technologies combating poaching, reintroduction and rhinos in captivity have also been covered. However, crime related to rhino poaching has not been given adequate mention, perhaps due to a lack of space. Indeed, this topic could be an independent chapter of the book, on its own.

The chapter is well-illustrated with excellent and rare photographs that depict both the species and its habitat. Figures, tables and an absence of scientific jargon have definitely made this readable and will be enjoyable for non-expert readers also.

Chapter 6/review: Javan rhinoceros, *Rhinoceros sondaicus* (Desmarest, 1822)

Authors: Steve Wilson, Kees Rookmaaker, Adhi Rachmat Hariyadi, Inov Sectionov, David M Leslie, Barney Long, Sunarto Sunarto, Mahmat Rahmat, Rois Mahmud

Reviewed by Jonathan Spencer MBE

Chapter 6 presents a comprehensive account of the biology, natural history, ecology, behaviour and conservation status of the Javan Rhino (*Rhinoceros sondaicus*), starting with its common name, a reflection of its relict status on the Island of Java rather than its once far wider distribution across the islands of the Sunda archipelago and of mainland Southeast Asia. The chapter does not flinch from identifying the gaps in knowledge and where these have been extrapolated by comparison with the closely related GOH Rhino (*Rhinoceros unicornis*). The chapter synthesises the available information from an array of literature on topics such as taxonomy, morphology, habitat use, dietary preferences, reproductive and population biology and behaviour. It also explores the characteristics of the vegetation of habitats found at its last remaining global location within the Ujung Kulon National Park (NP) in Indonesia. Additionally, the chapter describes how vegetation and other features—notably wallows and access to minerals from sea spray—influence rhino behaviour and distribution. Like the similar but unrelated Sumatran rhino (*Dicerorhinus sumatrensis*), the Javan rhino is clearly a creature most at home in disturbed secondary forest rich in its favoured food plants, and not at its most optimal in mature, undisturbed forest.

The chapter tracks the historical distribution and current range contraction of the species, highlighting its protracted decline in both distribution and abundance throughout the 19th and 20th centuries. However, there has been recovery in Java, attributed to successful conservation efforts that have increased the Ujung Kulon NP population from approximately 25 individuals to around 75 today (almost certainly a considerable overestimation, see review Chapter 13); it is nevertheless a precariously low number, especially given that only some 30% or so are believed to be in breeding condition. This situation is believed to have arisen from a combination of factors, including ageing, probable genetic constraints and competition for resources among potentially competing fertile females. Much of the habitat within the Park is maturing forest, not well suited to support rhinoceros, which favour early successional forest following natural disturbance, coastal forest enriched with salt spray and its associated minerals, as well as ready access to wallows for regulating their body temperature. The authors advocate both the establishment of a second population of Javan rhinos on conservation grounds and the enhancement of breeding opportunities of individuals remaining in Ujong Kulon NP. Deciding on suitable areas must therefore involve careful consideration of the extent and character of potential reintroduction sites, which could look very different from those where rhinos have persisted into the 20th and 21st centuries.

Threats to the long-term future of the Javan rhinoceros include outbreaks of disease, notably those spread by livestock from nearby villages, and potential natural disasters include volcanic eruptions and tsunamis. The Ujong Kulon NP is only 55 kilometres from the very active Anak Krakatoa. The authors advocate establishing both a captive breeding population (none are in captivity at present) and at least one (and ideally far more) captive breeding units in both this chapter and in chapter 13. Control of poaching and forest incursions has been partially achieved, allowing for the 20th century recovery of the remaining Javan rhinos in Indonesia and the time is now ripe for a further recovery phase and the

consolidation of successes to date.

The authors highlight Javan rhinos as a species exhibiting resilience and potential for recovery, but with complex demands for sufficient space, appropriate vegetation and nutrition and access to key landscape features such as wallows and mineral salts. The studies collated in the chapter make clear, though, that such conditions are not necessarily confined to forests similar in character to its last surviving refuge in Ujung Kulon NP. Many other forest types and geographies might be suitable if social and other conditions are met. In summary, this chapter offers an invaluable scientific foundation for the conservation and recovery of the Javan rhino in the face of continued pressures from climate change and natural disasters, alongside the more optimistic opportunities offered by both increasing interest in nature conservation and ecosystem recovery and the recovery and "rewilding" of logged-over and secondary forests.

Chapter 7/ Sumatran Rhinoceros *Dicerorhinus sumatrensis* (Fischer, 1814)

Authors: Francesco Nardelli, Ellen Dierenfeld, Rasmus W Havmøller, Nan Schaffer, Terri Roth

Reviewed by Deba K Dutta

The Sumatran rhinoceros (*Dicerorhinus sumatrensis*), the smallest and most ancient of the five critically endangered rhino species, has long been a symbol of evolutionary resilience and conservation despair. Chapter 7 marks a comprehensive chapter in the book, and is a compelling, authoritative, and deeply reflective piece that not only explores the biology, taxonomy and ecology of the species but also critically examines the trajectory of its conservation.

The chapter begins with the Sumatran rhino's historical distribution and ecological niche, and details that the species was once widespread across Southeast Asia, from the foothills of the eastern Himalayas down to Borneo. It outlines key biological traits of the species, such as its habitat in dense tropical forests, its solitary nature, and its diet as a selective browser. The chapter also describes the elusive behaviour and rare vocalizations that make field study especially challenging. These biological insights are essential, but the true strength of this chapter lies in its systematic exploration of conservation challenges.

A central theme running through the chapter is the decline into what conservationists now describe as an "extinction vortex." The species' population has plummeted to fewer than 80 individuals scattered across a few isolated pockets in Sumatra and Borneo, and the majority of subpopulations consist of fewer than 10 individuals. The authors make clear that the causes of this crisis are multifactorial: continued habitat fragmentation, human encroachment, poaching, and, importantly, the failure of early ex situ efforts in the 1980s and 1990s.

Rather than avoiding criticism, the chapter candidly accounts for how poorly coordinated captive breeding initiatives, particularly those outside the rhino's native range, failed to produce viable offspring and contributed to the continued decline of the species. This degree of introspection is rare in conservation literature and adds substantial value to the book.

The chapter offers an insightful overview of more recent and promising conservation strategies. The Sumatran Rhino Rescue project, for example, has become a flagship effort that integrates habitat protection, targeted capture of isolated individuals, and a science-driven breeding programme. The authors emphasise the important breakthroughs in reproductive science, such as the use of assisted reproductive technologies (ART), including artificial insemination and in vitro fertilization. They also highlight the central role of institutions like the Sumatran Rhino Sanctuary in Way Kambas, which has successfully produced calves, (five have been born between 2012 and 2022), through captive breeding.

Furthermore, the chapter addresses the socio-political dynamics of conservation. It underscores the importance of involving Indonesian government institutions, conservation NGOs, and international partners in a coordinated framework. The authors emphasise that long-term funding, political will, and continued public engagement are as critical as the science itself in ensuring any chance of success.

One of the chapter's most valuable contributions is its advocacy for adaptive management and transparency. It presents a roadmap that other conservation programmes, especially those involving critically endangered

megafauna, could follow. The discussion is steeped in lessons learned—not just about what to do, but also what not to repeat. The need for early collaboration between field biologists, reproductive specialists, and local stakeholders is stressed, as is the imperative to build mechanisms for honest performance evaluation.

In conclusion, this chapter is a cornerstone for anyone committed to the conservation of rhinos or endangered species in a more general sense. Its blend of ecological detail, historical reflection, and forward-looking strategy makes it informative and inspiring. It brings to light the hard truth that saving the Sumatran rhino is no longer just a matter of protecting habitat or stopping poachers—it is a multifaceted, race-against-time endeavour that must combine cutting-edge science, institutional humility, and global solidarity.

Chapter 8/ Significant developments and major trends in rhino conservation in Africa

Authors: Peter S Goodman, David Balfour, Dave Cooper, Richard H Emslie, Keryn Adcock

Reviewed by Sam M Ferreira

This chapter offers a comprehensive and insightful review of the evolution of rhino conservation efforts across Africa. It highlights the increasing importance of partnerships, particularly those involving public-private collaboration and community engagement. It aligns well with the insight from the CITES report of 2021 that populations managed through such cooperative models often showed the most positive performance trends, underscoring the value of shared stewardship in achieving conservation outcomes.

The chapter further documents technical progress in population management, including refinements in immobilisation protocols, spatial planning for range expansion, and the broader use of genetic and surveillance technologies. These innovations, supported by evolving national strategies and greater coordination among stakeholders, reflect an adaptive and maturing conservation framework.

While the chapter succeeds in capturing major advances, there are additional dimensions which could enhance future discourse. For instance, performance assessments have often emphasised maximising population growth at individual sites, frequently guided by concepts like ecological carrying capacity (ECC). Although widely used, these concepts are challenging to define consistently, especially given ecological variability across landscapes and seasons. Similarly, removal-based management models have provided operational flexibility but differ from naturally occurring regulatory processes such as delayed reproduction, age-specific mortality, and dispersal behaviour. Natural population regulatory processes, however, can result in higher rhino mortalities and lower birth rates that represent challenges when authorities seek to maximize growth, especially for populations recovering.

Another area worth exploring further is the application of spatial population ecology, particularly metapopulation theory. This approach supports the idea that not all populations will grow simultaneously, and that persistence across fragmented habitats may rely on functional connectivity, small subpopulations, and dynamic dispersal. Such perspectives could enrich current strategies, including how founder success is defined over time and how conservation value is attributed across sites.

Overall, the chapter provides a solid platform for integrating emerging ecological insights into established conservation practice, shaping a future where rhino populations are managed not only for growth, but also for their broader socio-ecological roles within resilient and interconnected landscapes.

Chapter 9/ White rhino: contrasting conservation outcomes of two subspecies

Authors: David Balfour, Kes Hillman-Smith, Herbert HT Prins, Thomas B Hildebrandt, Jan Stejskal, Susanne Holtze, Kees Rookmaaker, Sam M Ferreira

Reviewed by Keryn Emslie

Chapter 9 covers the white rhino numerical histories and the impact of humans and conservation interventions and events in the different African range States,

allowing the reader to understand the contrasting fates of the NWR and SWR subspecies. It draws out key lessons for restoring and maintaining the white rhino species' demographic viability, keystone ecological role and socio-economic benefits in Africa's ecosystems and human communities.

Three of the chapter authors (Hillman: NWR, Ferriera and Balfour: SWR, mainly in South Africa) have extensive experience in rhino conservation at the field and coordination and planning level. Holtze, Hildebrand and Stejskal provide their expertise in zoo-based and assisted rhino reproduction. Prins is top researcher in wildlife ecology, and Rookmaker has highly detailed extensive knowledge of documented historical rhino reports. The listings of author affiliations and names of TB Hildebrandt, K Rookmaaker and J Stejskal are misplaced in the first page layout.

The chapter introduction summarises the evolutionary origins of the two white rhino subspecies, and their changing distributions and numbers in central and southern Africa respectively. Further details of historical records and uncertainties of their ranges and numbers are then described, up to c. 1960. At that time NWR numbered 2–3,000, but the SWR was very close to extinction.

Indiscriminate killing and expansion of European settlement are given as the main cases of the pre-'60s declines of both subspecies. There are very sparse details on these two important drivers of rhino decline, which have complex political, economic and social ramifications to this day in most African rhino range States, and human settlement/encroachment still impacts rhino conservation.

Histories after 1960 emphasize factors affecting populations in each country, and the local and international conservation actions and strategies employed. The information is interesting, building a vivid picture of just how complex white rhino conservation efforts and challenges have been.

For NWR, civil unrest, armed conflict, and widespread poaching in range States (DRC, Sudan, Uganda) caused significant declines, leading to functional extinction in the wild by 2008, despite brief periods of effective protection and population growth in Garamba NP. The last two individuals remain in Kenya. For SWR, the population in the Hluhluwe–Corridor–Umfolozi Complex expanded under secure conditions. With the entire SWR global population at this one site, major translocation efforts began in the 1960s, successfully restocking areas across southern Africa, mainly into Zimbabwe, former Swaziland (Eswatini), Namibia, and later introduced to Kenya. Global numbers grew to over 20,000 by 2015.

Widespread poaching resurged in c.2006, again causing continental declines, with a small uptick to 16,801 SWR by late 2022. Social instability and poor governance were prime factors in white rhino declines, but few details are given. (The Fig. 9.8 caption is confusing and omits the Garamba NWR population).

Translocations to private land also occurred, many with low founder numbers and potential for genetic issues. (Not mentioned: breeding females became more valuable than males leading to ongoing genetic exchange between these populations). More recently, concerns are expressed around the intensification of SWR into smaller areas in response to poaching, and a desire by some owners to engage in the rhino horn trade. (The mention of the Platinum Rhino operation doesn't do justice to the achievements of that endeavour of protecting several hundred SWR and breeding over 1,000 calves during a massive regional poaching crisis.)

In summary, these are the key strategic insights and underlying requirements for success described in chapter 9. The core insight is the vastly different outcomes: the NWR have become functionally extinct, while the SWR have recovered successfully from very low numbers to "Least Threatened" on the IUCN Red List. The ability and vision to translocate sufficient numbers of rhinos to many new areas was key to rescuing the SWR. The interdependence of rhino and human security is a key insight. Periods of decline for both subspecies are consistently linked to human–human conflict and/or high levels of corruption. Regional, country and local-level security and citizens' safety from crime and corruption are essential for successful rhino conservation. Good governance in the wider human societies provides contexts where rhinos can thrive.

Partnerships between the State, private and communities, with devolved decision-making to local participants, do better than State management alone, especially where the regional landscapes are safe and

secure. The private sector typically provides critical funding, expertise and technical resources, while the State offers legitimacy, legal mandates, and streamlines administration processes like permitting. Additionally, international and national policies, laws, and conservation planning frameworks enhance legitimacy and legal authority, providing a broader perspective.

The NWR subspecies persistence is dependent on "biorescue" efforts. However, the continued ecological role of rhinos in NWR ecosystems may be achieved with the ecological equivalent SWR to replace the role of the functionally extinct taxon. (However, the NWR is a larger-bodied animal than SWR and may be better-adapted to cope nutritionally and physically with extreme long-grass, low nutrient environments of high rainfall NWR range areas. The SWR introduction to Garamba NP will be an interesting test.)

Chapter 10/ Black rhinoceros: contrasting conservation actions and outcomes across the continent

Authors: JA Shaw, K Adcock, R Amin, N Anderson, N Banasiak, P Beytell, R Brett, R du Toit, RH Emslie, J Flamand, L Kariuki, C Khayale, JR Muntifering, B Okita-Ouma

Reviewed by Sam M Ferreira

The chapter presents a thorough and balanced account of black rhinoceros (*Diceros bicornis*) conservation efforts across Africa. It highlights the diversity of strategies employed in different regions and the valuable progress made in recovering this critically endangered species. A notable theme is the increasing use of integrated approaches, especially in southern Africa, where structured coordination, translocations, and custodianship initiatives have supported population growth and range expansion.

While these different approaches have stabilised numbers, metapopulation structures are often applied without fully integrating ecological processes that influence their long-term function. For example, dynamics such as natural dispersal, asynchronous growth, and the demographic contribution of smaller populations receive limited emphasis. Including these dimensions more explicitly may help strengthen future conservation planning.

The use of growth targets, such as aiming for annual increases greater than 5% or establishing founder groups of around 20 individuals, has provided practical guidance. Sites vary in vegetation suitability for rhino and rainfall. Black rhino populations can grow at around 8% per annum, and 5% is a minimum target that is achievable, except when external events impact the rhinos or the site.

However, the ecological underpinnings of such benchmarks vary by context. More attention to species-specific life history traits, such as age-specific survival, delayed age at first reproduction, and sex-biased adolescent dispersal—could help refine population expectations and guide adaptive decision-making. In many countries, most populations are closely monitored, and most individuals are known to a sufficient degree of detail, including their life history parameters and behaviour patterns, which are used to make decisions.

The chapter closes by encouraging continued learning and collaboration across regions. By aligning emerging ecological understanding with on-the-ground practice, conservation efforts can remain responsive and resilient.

Chapter 11/The recovery of the greater one-horned rhinoceros in India and Nepal

Authors: Bibhab K Talukdar, Shant Raj Jnawali, Bishen Singh Bonal, Anindya Swargowari, Amit Sharma, Deba K Dutta, Naresh Subedi, Ganesh Pant

Reviewed by Jonathan Spencer MBE

The remarkable 20th century conservation success achieved by the nations of India and Nepal in rescuing the GOH or Indian rhinoceros from extinction is comprehensively described in chapter 11. The chapter provides a detailed account of the history of the challenges and conservation actions taken throughout the 20th century to the present day. It charts the growth in GOH rhinoceros numbers, which dropped to a low of some 200 animals in the early 1900s to the current high of over 4,000 individuals, along with a few hundred (250–300) held and managed

in captivity. Past threats to the species and the actions adopted to address them are carefully and thoroughly explored, highlighting the importance of international and interstate cooperation.

Conservation measures successfully enacted in both countries have included the gazetting of land as PAs and NPs, the implementation of tough anti-poaching measures and engagement with local communities and other government agencies. In both countries, the rhinos have slowly become a source of national pride. Such actions have been extended in more recent years to reintroductions and translocations between important rhinoceros habitats within the Indian and Nepalese national park series.

The critical role of frontline staff, supported by forest officers, community engagement, fostering a sense of stewardship, innovative approaches and robust approaches to illegal poaching and habitat encroachment are presented as key components to successful rhino conservation, the basis of which was timely and effective action in the first quarter of the 20th century by committed and key individuals in India, notably in the State of Assam, and effective Royal legislation in Nepal. The critical roles of the Chitwan NP in Nepal and the Kaziranga NP in India are clearly demonstrated.

The later challenges of socio-political unrest and subsequent exposure to rampant poaching are also unflinchingly explored. Additionally, the threats from development, invasive plant species and climate change are also fully examined, as are the future potential uses of new technology, habitat expansion and population growth through translocation. Translocations are now seen as a well-established and key tool in the conservation of the GOH rhino, in mitigating genetic isolation or addressing losses due to past social upheaval. Numbers are now such that individual rhinos are occasionally found wandering into other PAs and unprotected lands. The unusual challenge of conservation success—the increase in numbers within PAs leading to intraspecies conflict and nutritional stress—is addressed and identified as offereing positive opportunities for further range expansion through the export of individuals from areas at carrying capacity for this species. An Indian government target of expanding the area occupied by the rhinos by 5% by 2030 is discussed.

Lessons for all concerned with rhinoceros conservation and translocations are presented in detail, with accounts of techniques and veterinary considerations, critical post-translocation monitoring needs and protocols, logistical needs, security and communications are covered in depth. The complex teams required to deliver successful outcomes are well described and supported in graphical form.

The chapter presents a 20th century conservation success story that addressed a dire situation and goes on to explore the challenging road ahead, with potential success rooted in further international cooperation, individual and institutional commitment and widely shared expertise. The chapter is well illustrated with maps and well-presented data and effectively captures the successful history of the conservation of this rare, iconic and enigmatic species "from the brink of extinction to a symbol of resilience and successful conservation effort".

Chapter 12/The Sumatran rhinoceros: what went wrong and how to move forward

Authors: John Payne, Karen K Dixon, Sukianto Lusli, Zainal Zahari Zainuddin, Mochamad Indrawan, K Yoganand, Kees Rookmaaker, Nan E Schaffer, Ahmad Zafir Abdul Wahab, Petra Kretzschmar, Rasmus W Havmøller, Muhammad Agil

Reviewed by Inov Sectionov

This chapter provides a detailed history of the Sumatran rhino, tracing its evolution to the present day. Based on morphological and genetic evidence, the Sumatran rhinoceros is believed to be closely related to the extinct woolly rhinoceros *Coelodonta antiquitatis* and *Stephanorhinus*, with the split between their last common ancestors estimated to be around 9.5 million years ago. (See chapters 1 and 2).

The authors explore historical perspectives, as well as internal and external challenges to conserving the Sumatran rhino. This includes examining the political commitment of the countries that harbour the Sumatran rhino and the initiatives aimed at preventing its extinction. The chapter raises important questions, perceptions and assumptions regarding securing the Sumatran rhino into the future.

The chapter also introduces several idioms and

terminologies that may interest both experts and the general public. For example, it discusses an agreement focused on preserving a reservoir of genetic diversity by using animals classified as 'doomed' in their current habitats. However, these 'doomed' rhinos (IUCN Species Survival Commission 1984) were not redefined in any subsequent discussions, which might confuse some readers regarding the rescue efforts to capture certain Sumatran rhinos from the wild and relocate them to the breeding sanctuary in Indonesia, specifically at Way Kambas NP.

The chapter highlights an important issue: "Although not all individual rhinos marked as 'doomed' are affected, the entire programme faces significant risks. Many potential breeding animals remain in the forest, while a large percentage of captured rhinos are either too old, injured, or infertile to contribute their genetic material without human assistance and the use of assisted reproductive technologies."

The section on reproductive problems in both wild and captive populations for the Sumatran rhino is clearly explained. It highlights that the reproductive potential of the Sumatran rhino differs significantly from that of other rhino species, increasing the challenges of conserving this species. The chapter discusses several examples of unsuccessful breeding programmes for the Sumatran rhino, noting that only one relatively young pair Emi and Ipuh, brought together at the Cincinnati Zoo, successfully mated and eventually produced offspring. This is from 40 Sumatran rhinos captured for the captive breeding programme between April 1984 and November 1995. This success was attributed to human intervention and intensive management.

The Government of Indonesia (GoI) protects the Sumatran rhino under Indonesian regulations, and a similar protection measure was likely in place in Malaysia when the Sumatran rhino still existed there. Most of the programmes for Sumatran rhino conservation originated from collaborations with NGOs and national and international agencies. However, the chapter does not clearly outline the government's contributions to the Sumatran rhino conservation efforts, such as the Indonesian rhino strategy and action plan (1994, 2007–2017), the emergency action plan and the small progress made in the last decade. Including the achievements, however minor, would have better highlighted the GoI's commitment to Sumatran rhino conservation.

The combination of habitat loss, poaching for horn and slow reproduction rates have severely reduced the population of this species, leaving it in great and imminent peril. Additionally, various factors affecting the Sumatran rhinos' vulnerability, such as the dire and negative impact of human activities (over three centuries), further threaten its survival. Many lowland forests on Sumatra Island, which serve as the primary habitat for this species, have been lost due to land conversion for agriculture, even in PAs such as national parks. This situation heightens the risk of declining distribution and numbers of Sumatran rhinos, and the real possibility of extinction cannot be avoided. Preserving the Sumatran rhino, one of only five surviving rhino species, will pose significant challenges for many years to come.

Chapter 13/Conservation of the Javan rhinoceros: lessons from Indonesia

Authors: Barney Long, Indra Exploitasia, Rois Mahmud, Kurnia O Khairani, Inov Sectionov, Asep Y Firdaus, Desy S Chandradewi, Drajat D Hartono, Haerudin R Sadjudin, Yusep Hardiana, Sarah M Brook, Steven G Wilson

Reviewed by Suzannah Goss

This chapter, like the other fifteen, is authored authoritatively by experts who have worked in ecology, conservation and rhino management for many years, if not decades.

The Javan (and Sumatran) rhinos have survived for 55 million years, enduring ice ages, earthquakes and meteor strikes. However, primarily due to anthropogenic impacts, *Rhinoceros sondaicus* is now listed as Critically Endangered (on the IUCN Red List). The authors paint a more optimistic picture than the situation currently warrants.

The chapter provides an overview of the last two populations of Javan rhinos, which have followed markedly different paths over the past thirty years. The Vietnamese population, decimated by poaching sometime between 2007 and 2010, is only briefly discussed. The Indonesian population had been growing modestly until a recent surge in poaching.

The last remaining population inhabits just a small area, the Ujung Kulon NP, located on the far tip of the Java peninsula.

While the authors highlight the necessary strategies to save the fourth smallest (in both size and population, estimated at 50) of the extant rhinos, newer data suggest that the situation is more precarious. (The Sumatran rhino has the smallest population at a perilously low 34–47 individuals). Due to the challenging terrain, Javan rhinos remain the least studied among all rhinoceros species; consequently, researchers rely heavily on camera traps and faecal samples to assess the health and behaviour of these animals.

> However, the chapter does not reflect recent findings: in 2023, scientists and conservation organizations expressed concerns about the accuracy of population figures for Javan rhinos following the discovery that camera traps had failed to detect numerous individuals over three years. The chapter still insists that the number is higher, 77 individuals (KLHK 2022). The sharp decline in rhino numbers stems from the poaching crisis of 2019–2023. The case came to light on 29 May 2023, when missing camera traps and a noticeable drop in rhino activity prompted an investigation. Footage from other cameras revealed armed individuals tracking rhinos inside the Park. Police traced the crime to two poaching gangs. whose testimonies confirmed that 26 rhinos had been killed over five years—a 33% loss of the global Javan rhino population. Targeting males with larger horns has also skewed the sex ratio and reduced the number of breeding males available.

The chapter examines several constraints on recovery; which help galvanise funds for strategic and urgent, tailored action. One major risks is that with only one wild population and no captive ex situ breeding programme, an eruption of nearby Anak Krakatoa occur (in an area prone to earthquakes and tsunamis), could wipe out the species overnight.

Disease transmission poses an additional threat. Water buffalo in the vicinity are carriers of anthrax/haemorrhagic septicaemia, and may have contributed to past Javan rhino mortalities. The authors explain that a well-managed domestic buffalo vaccination programme would minimise the risk. Another challenge is the ECC of the Ujung Kulon NP, which is overstretched, however, any relocation is highly risky. The chapter explains that a hypothetical newly created second population of five females and three males, (the scenario which performs the best in modelling) shows a lower extinction risk, higher population size over the longer term and lower inbreeding accumulation. (The loss of genetic diversity leads to genetic "bottlenecking" or inbreeding depression).

Other conservation interventions are less risky, such as the removal of the Arenga palm, which is not a food plant for rhinos and reduces the light due to over-shading, impeding the growth of the understory, and essential legumes that the Javan rhino feeds on.

Enhancing security is another strategy that could be strengthened. Nonetheless, rural, potentially rugged Park boundaries mean that law enforcement cannot be equally present in all places at all times. In some areas, this lack of security still places the species at risk from poachers. The communities living around the Ujung Kulon NP (and its rhinos) have benefitted from community-led environmental awareness programmes such as the Sustainable Livelihood Assessment method, and conservation is increasingly a key consideration in community discussions and decision-making. These initiatives involve residents as stakeholders, engaging them in activities related to security and monitoring.

The chapter's final section presents the continued survival of the Ujung Kulon population as a success, outlining the complex challenges ahead—especially tackling poaching and sustaining the teamwork, planning, and commitment needed to secure the Javan rhino's future. But is this outlook too optimistic? One hopes not, though the situation remains undeniably precarious.

Chapter 14/Ex Situ conservation and management of rhinoceros

Authors: Friederike von Houwald, Gina M Ferrie, Susie Ellis, Nan Schaffer, Mark Pilgrim, Lars Versteege, Adam Eyres

Reviewed by Sam M Ferreira

The chapter provides a well-structured synthesis of the role of ex situ conservation activity in supporting the long-term survival of all rhinoceros species. The chapter highlights the history and development of zoological and conservation breeding programmes across the globe, noting the increased alignment with IUCN's One Plan Approach. This integration emphasises the value of linking in situ and ex situ strategies to build resilient conservation systems. Key institutional networks, such as the European Association of Zoos and Aquaria (EAZA), the American Species Survival Plan (SSP), and partnerships with IUCN Specialist Groups, are presented as foundational pillars of this coordinated effort.

A major theme emerging from the chapter is the positioning of ex situ populations as insurance or assurance populations. These captive populations are seen as safeguards against catastrophic loss in the wild. This function is most critical for the most imperilled species—such as the northern white, Javan, and Sumatran rhinos—where wild populations are either functionally extinct or remain at critically low levels. A stronger prioritisation of ex situ resources towards these species could maximise conservation returns.

The chapter also outlines the broader value of ex situ facilities, beyond demographic support. These include educational outreach, public awareness, fundraising, and the advancement of scientific research. Zoos and breeding centres serve as platforms for engaging global audiences and building conservation literacy. In addition, controlled environments allow for behavioural and physiological research that is not easily achievable in the wild, contributing important data to species management.

One important opportunity not fully explored in the chapter is the potential for ex situ populations to serve as integral nodes within metapopulation frameworks. Expanding on the One Plan Approach, these facilities could be better incorporated into structured metapopulation strategies that span wild, semi-wild, and captive contexts. Furthermore, ex situ programmes offer unique access to develop and apply assisted reproductive technologies (ART), such as in vitro fertilisation and stem cell techniques. These tools hold particular promise for recovering functionally extinct or severely threatened species, including the northern white, Javan, and Sumatran rhinos.

Some caution should be taken seriously. Despite the improvements for white rhinos, there remain challenges linked to some husbandry practices at zoos. For instance, practices of browsing and mixed feeding in these facilities often link to reduced breeding.

In summary, the chapter effectively underscores the multifaceted role of ex situ conservation. As technologies and partnerships evolve, these efforts can make increasingly strategic contributions to species recovery within an integrated conservation framework.

Chapter 15/ The impact of poaching on rhino conservation

Authors: Michael 't Sas-Rolfes, Julian Rademeyer, Lucy Vigne, Richard Emslie, Michael Knight, Jamie Gaymer, Bibhab K Talukdar

Reviewed by Jonathan Spencer

The most significant impact on rhinoceros populations over the 20th and 21st centuries—and still the biggest threat to their conservation and recovery—is poaching for their horns. Chapter 15 reflects on the history of human exploitation of rhinos and provides a comprehensive account of the rhino poaching in Africa and Asia during these two centuries. Two distinct waves of poaching are recognized, the first began in the 1970s, and continued well into the 1990s. This was followed by a lull and then a resurgence of poaching activity in the present century, peaking in 2015. The illegal killing of rhinos continues to pose a significant threat to all rhinoceros populations. However, the Sumatran rhino has become so scarce and dispersed in Indonesia that poaching is no longer the most immediate threat it faces.

The nature of poaching is explored in depth, from the concept of poaching as a social construct, to the contested views over rights to benefit from rhinos and the various methods used in the illegal killing of rhinos and the development of increasingly sophisticated techniques. The influence of social and political conditions that drive market demand for rhino horns is examined, along with the significant risks and penalties associated with poaching rhinos, which in

many African range States can be severe. The chapter goes on to explore the considerable variation in national strategies to combat poaching and the extent of corruption within both government and related organisations, with South Africa and its agencies and safari operators coming under particular scrutiny.

Strategies adopted to address poaching are reviewed, covering the importance of legal frameworks, law enforcement, policing of PAs and the crucial role of gaining local community support. It also discusses the drastic measure of dehorning rhinos. The availability of weapons and equipment varies significantly between countries, and the influence of political unrest, social upheaval and poverty play a critical role in determining the persistence of poaching across the two continents. The effectiveness and impact of these and other strategies are assessed in detail. The appalling statistics regarding the decline of rhinoceros populations in PAs across both continents highlight the grisly nature of the poaching operations.

The adverse impact of rhino poaching on surviving populations and their conservation is also covered in detail. Two species have been driven to the brink of extinction, and several subspecies have suffered actual extinction, with the ongoing impact of population fragmentation, risks of inbreeding in wild populations (and the captive populations ultimately derived from them). Additionally, the costs associated with rhino conservation have significantly increased, making it prohibitively expensive for all but the best-funded range States and conservation organisations to manage effectively.

The overall conclusion of Chapter 15 is that the future of rhino conservation must continue to address poaching for the foreseeable future. Effective conservation will rely heavily on anti-poaching measures and on sustaining funding sources that support these initiatives, especially if consumer demand for rhino horn products persists at its current high levels. The ongoing, and often selfless, dedication of wildlife department staff and enforcement agencies will remain critical, as will continued financial support from sponsors and the general public.

Chapter 16/The impact of rhino Horn trafficking on Conservation

Authors: Lucy Vigne, Michael 't Sas-Rolfes, Tom Milliken, Julian Rademeyer, Bibhab K Talukdar

Reviewed by Daniel Stiles

This 16th and final chapter in *Rhinos of the World* presents a meticulously detailed history of the killing of rhinos and the trafficking of their horn, mainly to eastern Asia and, up until the early 1990s, Yemen. As a proportion of its total population, the five African and Asian rhino species have been poached since the 1970s and are probably the most poached animals in the world. Demand for the horn for use in traditional medicine and carved ornaments rose precipitously between 1970 and 2015, after which demand, prices and poaching rates began to fall rapidly.

The chapter delves into the highly controversial topic of conservation strategies—which approach is most effective in mitigating poaching and trafficking, legal trade or total prohibition, along with stockpile destruction? The authors recognise the complexity of economic dynamics, demand drivers, changing consumer preferences and the increase in corruption and the creation of transnational organised crime networks, all of which interact to influence poaching and trafficking rates. They discuss the effectiveness of various strategies, such as demand reduction campaigns and the use of substitutes, including growing genetically modified "rhino" horn. What is not discussed are the sources of the rhino horn entering trade, i.e. the relative proportion of wild rhinos poached for their horn versus released stockpile horn.

The chapter presents a great deal of data, including prices, numbers of rhino poached, horns entering trade, horns seized and market survey results and is generously endowed with data tables and colour photographs. A weakness, however, is that the mass of data is not analyzed to present a clear trend that rhino poaching rates and prices have fallen significantly since their peak in the years 2010–2015, and does not offer explanations of why that may be. The authors also do not discuss evidence that increasing quantities of stockpiled rhino horn entered the trade chain from at least 2019, and probably earlier, both from intended leakages and thefts, reducing the need to poach.

Despite reduced rates of poaching, the authors conclude that "Rhino horn trafficking remains the single greatest challenge to rhino conservation and a significant drain on scarce financial resources for the biodiversity conservation sector in rhino range states." They also believe that there may be a role for "carefully imple¬mented legal use and specific trade allowances" in future rhino conservation strategies.

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