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Amur tiger (*Panthera tigris altaica*) conservation challenges and strategies in China

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China is effectively achieving the rapid recovery of the wild Amur tiger (*Panthera tigris altaica*) population and has a strong chance of reestablishing a sustainable population of over 300 individuals. However, to achieve more ambitious conservation goals, China needs to focus on enhancing the resilience of the population as it attempts to further increase its size, because only isolated, high-density populations are increasingly threatened by factors such as inbreeding, disease, and human-wildlife conflict. Successful conservation experiences and the application of AI and new monitoring technologies in tiger conservation provide excellent opportunities to address these issues. Based on the current conservation challenges faced by China, this article proposes future conservation efforts in several areas, including habitat restoration, prevention of inbreeding and disease, environmental pollution prevention, protection and community development, cross-border and interdisciplinary cooperation, and tiger conservation and carbon sequestration. We emphasize the need to promote a refined, efficient, intelligent, and community-friendly development in tiger conservation through new measures, such as tiger-friendly forest transformation, evaluating the potential impact of pollutants, developing “nonlethal pain stimulation deterrence” technology developed for human-tiger coexistence, applying AI, and combining tiger conservation with a carbon-neutrality plan.

KEYWORDS

Amur tiger, conservation strategies, human-tiger conflict, inbreeding pressure, tiger friendly forest transformation

1 Introduction

A recent study has shown that the current distribution of Amur tigers (*Panthera tigris altaica*) in China could support 310 individuals (Qi et al., 2021), indicating great potential for Amur tiger restoration in China. Tiger conservation in China is important for restoring the genetic diversity of tigers worldwide, as China historically had the largest number of tiger subspecies and still has the potential to restore the wild populations of four of these subspecies, i.e., the Amur tiger, the Bengal tiger (*Panthera tigris tigris*), the South China tiger (*Panthera tigris amoyensis*), and the Indochinese tiger (*Panthera tigris corbetti*). The Bengal tiger has frequently been recorded in recent years, and the Indochinese tiger was still present

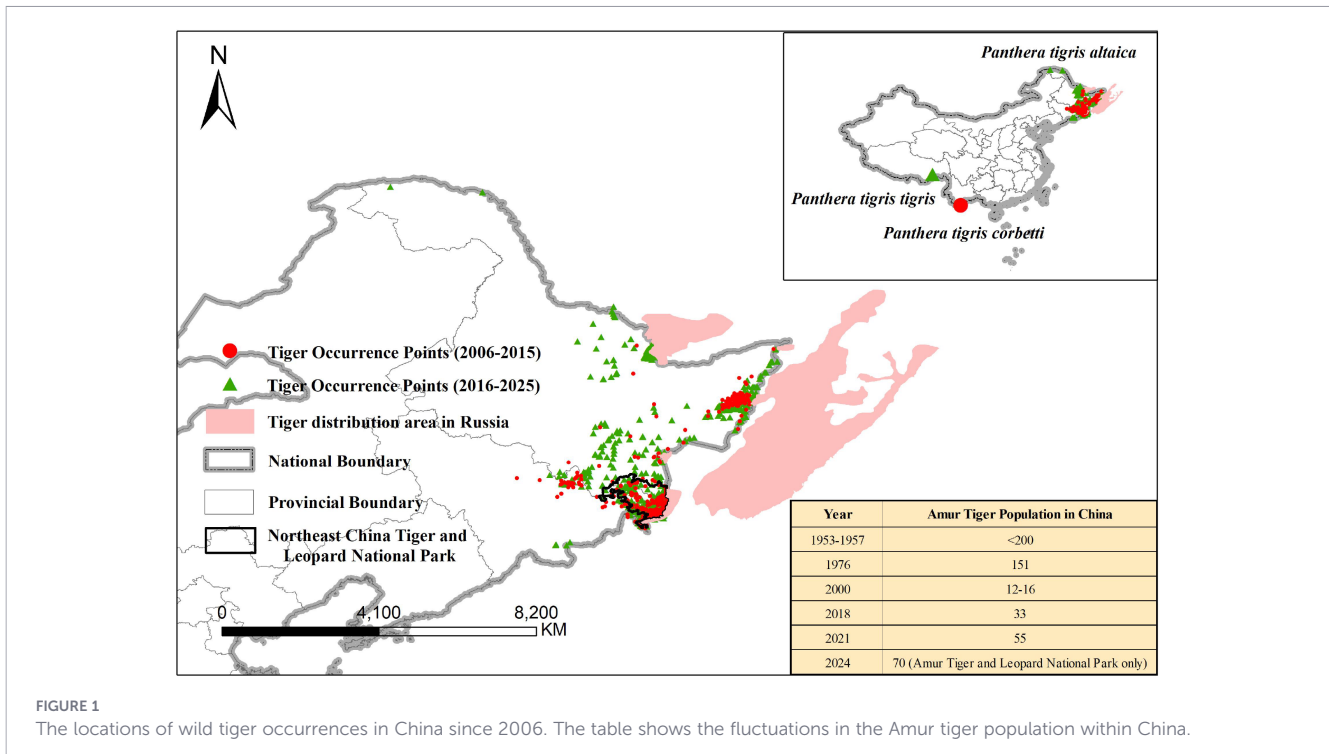


FIGURE 1
The locations of wild tiger occurrences in China since 2006. The table shows the fluctuations in the Amur tiger population within China.

in Xishuangbanna over a decade ago (Figure 1). China is still trying to rehabilitate a wild population of South China tigers by rewilding captive individuals. The Amur tiger is the subspecies that holds the greatest potential for rapid growth in China, with a current population of no less than 70 individuals (Forestry.gov.cn., 2024, Figure 1).

Numerous tiger conservation projects initiated by the Chinese government since the early 21st century, such as the Natural Forest Protection Project and the establishment of the Northeast China Tiger and Leopard National Park (NCTLNP), have been proven highly effective in Amur tiger population recovery (Jiang et al., 2017). However, some persistent protection challenges have not been properly resolved. For example, limitations imposed by habitat quality, fragmentation, and the unfavourable structure of prey resources still hinder population recovery. Additionally, serious inbreeding and loss of genetic diversity due to a small population and geographical isolation threaten the continuous recovery of the Amur tiger population and the establishment of other wild populations (Ning et al., 2022).

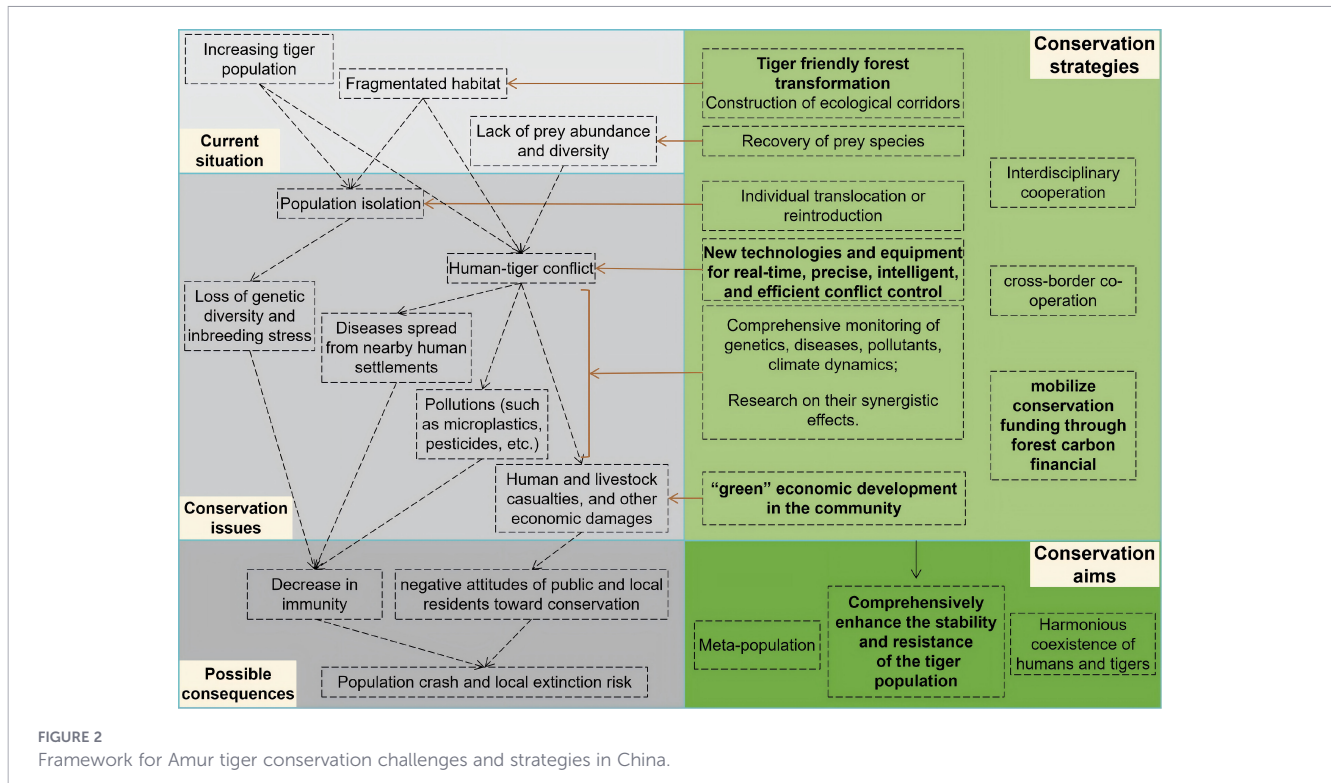
At the same time, the rapid recovery of tiger populations has also resulted in the emergence of many new conservation challenges. The most prominent one is the increasingly severe conflict between humans and tigers, which usually causes economic losses, human or tiger casualties, and public panic. Second, as an isolated, high-density population, tigers in the NCTLNP are not only facing more and more local, intensive intraspecific competition, but the risk of sudden collapse is also increasing under the combined effects of various factors, such as human interference, climate change, inbreeding depression, and disease (Ning et al., 2022; Qi et al., 2021). Meanwhile, some other populations face a high risk of local

extinction due to a lack of effective breeding females in Northeast China.

Thus, to achieve more ambitious conservation goals, China needs to focus on enhancing population resilience while trying to further restore population levels. Past successful experiences in Amur tiger conservation and the rapid development of new technologies, such as artificial intelligence (AI), have all provided excellent opportunities. Here, we list five key tasks and challenges that should be prioritized and hope they can provide useful guidance for realizing the sustainable survival of the Amur tiger in China (Figure 2).

2 Restore habitat quality and prey resources for tigers

Measures such as natural forest protection projects, complete hunting bans, and prohibitions of commercial logging in natural forests have effectively promoted the restoration of forests and wild animals. These are the main reasons for the reversal of the long-term decline of the Amur tiger population in China (Jiang et al., 2017). However, forest protection projects have also created large areas of pure, artificial forests. These forests, called “green deserts”, are usually not utilized by animals due to a lack of food sources. Currently, an increasing number of scholars and managers have realized the necessity of carrying out artificial transformations to improve this situation. Research has also shown that effective management strategies, such as creating gaps and optimizing the spatial arrangement of tree species, can significantly increase plant



diversity and biomass and enhance ecological functions such as carbon storage and litter decomposition (Beugnon et al., 2023; Dangal et al., 2017; Wang and Liu, 2011). Forest structure and productivity are two important factors influencing wild animal utilization (Verschuyl et al., 2008). More finely tuned habitat modifications to these large areas of artificial forests could make them accessible to ungulates, the main prey of the Amur tiger, by increasing biomass productivity and habitat heterogeneity. This would significantly contribute to increasing the total area and overall quality of tiger habitats. However, although the idea of enhancing tiger conservation through forest management was proposed long ago (Han et al., 2012), no systematic practices have been implemented so far. Here, we suggest that managers and researchers work together to conduct pilot experiments to determine the optimal renovation plans for different artificial forest types and guide restoration practices. At the same time, it is necessary to make adequate preparations in advance to avoid negative impacts on Amur tigers and other wild animals from strong human interference during large-scale forest modification. Adjusting the prey community structure is also part of advanced conservation efforts. Prey source recovery is not merely restoration in terms of population size. Low prey species richness would reduce the availability of total prey, and any population fluctuations of any one prey species will have a significant impact on the survival of tigers. For instance, in the Russian Far East, as wild boars are the only dominant prey species, when their population decreased significantly due to African swine fever, the survival of the Amur tigers was greatly affected (Aleksy et al., 2025). Thus, it is necessary

to pay close attention to the dynamics of prey species preferred by tigers, and efforts must be made to increase the diversity of prey species. In-depth theoretical research is also needed on the competitive relationships among predator species and the effects of top-down and bottom-up effects on prey species, which could guide the regulation of predator species abundance and diversity from a community perspective.

Habitat fragmentation is another important factor that limits the improvement of habitat quality. In China, the Amur tiger has re-habituated to four historical habitats with a total area of approximately 47,813 km², yet no single habitat patch could support a sustainable Amur tiger population of more than 83 breeding adult females (Qi et al., 2021). However, due to the isolation of these patches, the majority of Amur tigers in China are concentrated in the NCTLNP patch with an area of only 14,100 km² and cannot sustain a viable population (Wen et al., 2022). This, in turn, leads to various protection issues for local tiger populations, such as high intraspecific competition, inbreeding pressure, human-tiger conflicts, and so on. Only by establishing a meta-population that takes into account the existing habitat patches, along with the patches in Russia next to China, can the entire Amur tiger population enhance its ability to cope with various survival threats such as climate change, inbreeding, and diseases (Qi et al., 2021). Studies on the migration and diffusion patterns of tigers should be urgently conducted. Based on these studies, ecological corridors should be scientifically planned and constructed to promote individual dispersal among these habitat patches.

2 Focus on the effects of inbreeding, diseases, pollution, and their synergy on the survival of tigers

The continuous recovery of the Amur tiger and the establishment of a wild South China tiger population have always been among the issues of greatest concern due to inbreeding and loss of genetic diversity. Studies have shown the high degree of inbreeding in wild Amur tigers and its high correlation with parasite load, gut microbiota community structure, and pathogenic functions (Ning et al., 2022). Diseases are a more direct threat to the survival of tigers, as they not only directly kill individual tigers but may also lead to the collapse of local populations (Gilbert et al., 2020; Seimon et al., 2013). In addition, their interspecific spread through the food webs threatens the stability of entire mammal communities. An additional problem that wild animals in the Anthropocene era have to face is the pollution caused by human development, such as microplastics and pesticides. The latest research has shown that microplastics are widely present in the habitats of Amur tigers and have been transferred and accumulated along the food chain, resulting in microplastic content in the feces of Amur tigers being 2.26 times higher than in the soil (Huang et al., 2025).

Furthermore, all these factors may have a synergistic effect. Inbreeding and pollution may lead to a decline in an individual's resistance, thereby increasing the risk of disease infection and transmission (Ning et al., 2022). The elimination of individuals due to the disease may further reduce the genetic diversity of the local small tiger population through genetic drift. In addition, external factors such as habitat isolation and increased human-tiger conflicts will further promote the occurrences of inbreeding, epidemics, pollution, and their synergistic effects, exacerbating the situation.

Scientific monitoring and a comprehensive assessment of inbreeding, epidemics, pollution conditions, and their potential effects are necessary to cope with the possible collapse of the tiger population caused by these factors. If necessary, artificial intervention should be carried out to mitigate their exacerbation. This first requires enhancing the professional capabilities of park managers and front-line staff, so as to cover various aspects, such as genetics and diseases. Second, we recommend that some more ambitious conservation measures should be implemented when necessary, such as the cross-patch or cross-border translocation of Amur tigers, or even the re-wilding and reintroduction of captive individuals.

3 Control human-tiger conflicts and coordinate community development

Human-wildlife conflicts are becoming one of the biggest obstacles to wildlife conservation. As a large carnivore, the tiger's conflicts with humans can even lead to human injury or even death, causing greater fear and overt hostility. Effective and scientific conflict management is fundamental to the smooth progress of

any conservation efforts. This requires attention to every step of conflict management, including conflict monitoring and early warning systems, effective deterrence, and rescue operations. Early warning systems should be timely and accurate. Deterrence and rescue measures should be efficient and ensure the safety of both humans and animals.

The development of AI has provided significant assistance in solving these problems and has received widespread attention. Systems for human-wildlife conflict mitigation based on AI have been reported (Sabesh et al., 2025). The Northeast Tiger Leopard National Park has also made meaningful attempts at tiger monitoring with AI (Chinadaily.com.cn., 2020), and this system is currently playing a very important role in human-tiger conflict monitoring and in providing early warnings within the park. However, these systems still rely on traditional front-end monitoring equipment and deterrence methods. There have been no substantive changes in terms of monitoring comprehensiveness, data transmission efficiency, deterrence safety, or long-term effectiveness. Therefore, we suggest that park managers and researchers, while promoting the application of AI technology in Amur tiger conservation, actively explore new monitoring, transmission, deterrence technologies and equipment to enhance the real-time accuracy and intelligence of human-tiger conflict management. For instance, the development of new monitoring technologies such as vibrating optical fibers and unmanned aerial vehicles could help fill the gaps in monitoring coverage caused by the limited scope of camera traps. Real-time transmission technology based on 4G or satellite networks and AI technologies for species and individual identification are all necessary to ensure that the monitoring data can be utilized in a timely and accurate manner. Additionally, new deterrence technologies that are consistently effective and do not cause significant harm to wild, rare, and endangered animals, such as laser technology, pulse electric fences, and ultrasonic technology, which could be defined as "nonlethal pain stimulation deterrence", are crucial for reducing economic losses and the risk of casualties during human-tiger conflicts (Li et al., 2025; Ronning, 2016).

Local communities are at the forefront of conservation efforts, but are also the main victims of human-tiger conflicts. These often result in negative attitudes toward tigers among local residents, thereby reducing support for conservation practices. Therefore, scientific management of human-tiger conflicts must prioritize community management and protection of local interests. This includes many measures that have been proven to be effective, such as scientific livestock management, compensation schemes, and incentive programs (Pekor et al., 2026; Jamtsho, 2020; Goodrich, 2010). At the same time, we suggest that managers should actively promote a "green" economy that is compatible with conservation goals to increase local residents' incomes. For instance, international experiences have shown that managed hunting can generate income while also contributing to conservation efforts (Perco, 2020). China has already permitted the planned hunting of wild boars because of an overabundant wild boar population, but all the killed animals are currently subjected to safe disposal. It is entirely possible to develop this into a standardized hunting activity, and the idea of turning wild boar meat and skins into products and bringing

them to market could also be considered. In addition, it is necessary to actively explore some new models. For instance, domesticated sika deer (*Cervus nippon*) have been successfully reintroduced to the Lesser Khingan Mountains to restore prey sources for Amur tigers in the area. If these populations of sika deer could be utilized for the harvesting of antlers and tourism development, it would benefit both the Amur tigers' prey supply and the local economy through a scientific approach to animal management.

4 Promote cross-border and interdisciplinary joint protection and research

The habitat patches of the Amur tiger in both China and Russia are closely connected. The permanent restoration of the Amur tiger population and improvement of its genetic diversity, along with the handling of many sudden incidents encountered during the conservation practices, must rely on the close cooperation between these two countries. For instance, when Russia re-established a wild tiger population in the Jewish autonomous region by translocating rescued tigers to this area (Miquelle et al., 2016), the Chinese conservation team provided crucial support in monitoring the released individuals when they wandered into China. In addition, the first successful rescue and subsequent release of wild Amur tigers in China greatly benefited from the extensive practical experience of Russian experts (Chinadaily.com.cn, 2021). Furthermore, as top predators, tigers have a significant impact on the structure of the mammal community, but they are also constrained by bottom-up effects. Only through international cooperation can we get a thorough understanding of the ecological role of cross-border distributed tigers in mammal communities and entire ecosystems (Vitkalova et al., 2018), which is of great significance for guiding tiger conservation efforts through a bottom-up approach and enhancing regional biodiversity stability through tiger conservation.

Currently, we can observe an increasing number of practical, concrete cooperation projects and the establishment of a joint platform for long-term cooperation. This momentum needs to be sustained and strengthened. Transboundary protected areas are an effective measure for jointly protecting species that are distributed across borders (McCallum et al., 2015) and have been applied in other tiger habitats such as the transboundary landscape between India and the Royal Government of Bhutan (Borah, et al., 2012), but never in Amur tiger conservation. Based on the current distribution of Amur tigers, China and Russia should actively promote the establishment of cross-border protected areas, especially in the area of the Northeast Tiger and Leopard National Park and the Leopard Land National Park. We also suggest strengthening collaborative research and joint student training between scientific research institutions in China and Russia, including universities, as a key area for further enhancing protection cooperation. Scientific research teams provide crucial theoretical and technical support for conservation efforts and are also important participants in many conservation projects and the main source of technical personnel

for conservation management departments. Compared to joint protection actions, collaborative research and joint student training can achieve more in-depth technical communication and broader influence on protection policies.

Interdisciplinary cooperation has become a necessary prerequisite for the success of current conservation efforts. AI not only has advantages in efficiently processing massive monitoring data and designing protected area networks, but also promotes the application of new technologies, such as unmanned aerial vehicles and acoustic monitoring technology, in wildlife protection. However, realizing the application and promotion of AI and related technologies in tiger conservation requires collaborative efforts from experts in multiple disciplines, such as animal ecology, AI, and productization. Furthermore, we must take into account the increasing potential threats to the survival of the tiger population caused by the synergistic effects of inbreeding, pollution, diseases, and human-tiger conflicts. Therefore, experts in genetics, pollutants, diseases, sociology, and other relevant fields must enhance their collaborative efforts to jointly carry out relevant monitoring, research, prevention, and control. Even in human-tiger management, the involvement of experts from various fields, such as zoologists, sociologists, and economists, is necessary (Struebig et al., 2018). Whether the focus is cross-border joint protection or interdisciplinary cooperation, a dedicated institution or platform is needed to coordinate and oversee the process.

5 A combination of tiger conservation and a carbon neutrality plan should be an effective and groundbreaking conservation measure

One of the important goals that conservationists have been striving for is to fill the funding gap for conservation efforts by introducing a large amount of investment from the financial market. The biggest obstacle is that the ecological value cannot be verified using market-determined prices. Carbon storage and sequestration produced by species or ecosystems provide a breakthrough solution to this problem (Pollitt, 2019).

Research has shown the important role of wild animals in promoting carbon fluxes and carbon storage (Schmitz et al., 2018; Berzaghi et al., 2022). It was suggested that the ecological services of elephants in tropical Africa over the next 30 years would generate a carbon sink of 109 MtC, and it is worth about \$25.9 billion (Berzaghi et al., 2022). Tigers, as large carnivores, could influence the entire mammalian community and even the vegetation structure and renewal in forest ecosystems through direct and indirect trophic cascade effects, which would then affect the ecosystem's carbon cycling process. The spatial movement on the landscape scale of tigers and their prey could also regulate the spatial patterning of carbon sources and carbon sinks in the ecosystem. Current research focusing on the global range of tigers has shown that the presence of tigers is closely related to the carbon sequestration capacity of forests, providing a more direct link between tiger conservation and carbon sinks (Roberts et al., 2025). Another

study estimated that forests protected by tiger reserves established in India over the past 20 years are equivalent to offsetting over 1 million tons of carbon emissions. This has saved India over \$93 million in carbon reduction costs, which is more than a quarter of the annual budget allocated to the tiger reserves (Lamba et al., 2023). Clearly, these data would encourage more investments in tiger conservation. In 2010, the Global Tiger Recovery Program mentioned exploring and mobilizing tiger conservation funding through forest carbon financing. Although more and more evidence is proving the feasibility of this approach, there is still a lack of scalable and standardized methods for quantifying the carbon service value of tigers. Strengthening the research on the impact of tigers on the carbon cycle and on the differences in various forest types can help us better understand the ecological functions of tigers and find a feasible approach to attract large investments from financial markets, including national and global carbon markets.

China has the potential to restore the former abundance of tigers across large areas of the species' historic range and contribute significantly to global tiger population and habitat recovery. It is important to clearly understand the conservation challenges at different stages and promptly formulate targeted protection measures. At the same time, a long-term perspective is needed to focus more on enhancing population resilience in order to further increase population size.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding authors.

Ethics statement

This article does not involve animal experiments and adheres to animal ethical standards.

Author contributions

ZL: Conceptualization, Supervision, Writing – review & editing, Validation. QJ: Conceptualization, Visualization, Writing – review & editing, Validation, Writing – original draft. SS: Writing – review & editing, Data curation. WC: Writing – review & editing, Visualization, Validation, Data curation. AY: Resources, Validation, Writing – review & editing. GJ: Writing – review & editing, Validation, Conceptualization, Resources.

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The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

- Aleksey, Y. O., Sergey, A. K., and Victor, S. L. (2025). African swine fever effects on the northernmost Amur tiger (*Panthera tigris altaica*) subpopulation. *J. Wildl. Manage.* 89, e70039. doi: 10.1002/jwmg.70039
- Berzaghi, F., Chami, R., Cosimano, T., and Fullenkamp, C. (2022). Financing conservation by valuing carbon services produced by wild animals. *Proc. Natl. Acad. Sci. U.S.A.* 119, e2120426119. doi: 10.1073/pnas.2120426119
- Beugnon, R., Albert, G., Hähn, G., Yu, W., Haider, S., and Hättenschwiler, S. (2023). Improving forest ecosystem functions by optimizing tree species spatial arrangement. *Nat. Commun.* 16, 6286. doi: 10.1038/s41467-025-61389-7
- Borah, J., Wangchuk, D., Swargowari, A., Wangchuk, T., Sharma, T., Das, D., et al. (2012). *Tigers in indo-Bhutan Transboundary Manas Conservation Complex*. (New Delhi: Technical report).
- Chinadaily.com.cn (2020). *An Intelligent Integrated Monitoring System was put into Trial Operation in The Northeast Tiger and Leopard National Park*. Available online at: <https://cn.Chinadaily.com.cn/a/202001/17/WS5e217313a3107bb6b579a912.html> (Accessed April 4, 2026).
- Chinadaily.com.cn (2021). *Rare Siberian tiger released back into wild in NE China*. Available online at: <https://www.Chinadaily.com.cn/a/202105/18/WS60a3831ca31024ad0babfcc1.html> (Accessed April 4, 2026).
- Dangal, S. P., Das, A. K., and Paudel, S. K. (2017). Effectiveness of management interventions on forest carbon stock in planted forests in Nepal. *J. Environ. Manage.* 196, 511–517. doi: 10.1016/j.jenvman.2017.03.056
- Forestry.gov.cn (2024). *Reports on the Growth of Tiger and Leopard Populations in the Northeast Tiger and Leopard National Park*. Available online at: <https://www.forestry.gov.cn/c/www/lcdt/563334.jhtml> (Accessed March 14, 2026).
- Gilbert, M., Sulikhan, N., Uphyrkina, O., Goncharuk, M., Kerley, L., Castro, E. H., et al. (2020). Distemper, extinction, and vaccination of the Amur tiger. *Proc. Natl. Acad. Sci. U.S.A.* 117, 31954–31962. doi: 10.1073/pnas.2000153117
- Goodrich, J. M. (2010). Human-tiger conflict: A review and call for comprehensive plans. *Integr. Zool.* 5, 300–312. doi: 10.1111/j.1749-4877.2010.00218.x
- Han, X., Oliver, C. D., Ge, J., Guo, Q., and Kou, X. (2012). “Managing Forest Stand Structures to Enhance Conservation of the Amur Tiger (*Panthera tigris altaica*),” in *A Goal-Oriented Approach to Forest Landscape Restoration. World Forests*, vol. 16. Eds. J. Stanturf, P. Madsen and D. Lamb (Springer, Dordrecht).
- Huang, Z., Liu, D., Cheng, W., Zhang, W., He, Z., Huang, B., et al. (2025). Microplastics in the Amur tiger’s habitat: Occurrence, characteristics, and risk assessment. *J. Hazard. Mater.* 493, 138380. doi: 10.1016/j.jhazmat.2025.138380
- Jamtsho, Y. (2020). Human-tiger conflict: finding a middle path. (Bhutan: Jigme Dorji National Park, Department of Forests and Park Services). doi: 10.13140/RG.2.2.17381.42721
- Jiang, G., Wang, G., Marcel, H., Yu, Q., Jia, X., Guan, Y., et al. (2017). Land sharing and land sparing reveal social and ecological synergy in big cat conservation. *Biol. Conserv.* 211, 142–149. doi: 10.1016/j.biocon.2017.05.018
- Lamba, A., Teo, H. C., Sreekar, R., Zeng, Y., Carrasco, L. R., and Koh, L. P. (2023). Climate co-benefits of tiger conservation. *Nat. Ecol. Evol.* 7, 1104–1113. doi: 10.1038/s41559-023-02069-x
- Li, Z., Qi, J., Zhang, M., Roberts, N. J., Guan, Y., Li, G., et al. (2025). Optimal laser strike intensity to realize “Nonlethal pain stimulation deterrence” in human-Wildlife conflict management: wild boar as a case study. *Wildl. Lett.* 3, 194–202. doi: 10.1002/wll2.70016
- McCallum, J. W., Vasilijević, M., and Cuthill, I. (2015). Assessing the benefits of Transboundary Protected Areas: A questionnaire survey in the Americas and the Caribbean. *J. Environ. Manage.* 149, 245–252. doi: 10.1016/j.jenvman.2014.10.013
- Miquelle, D. G., Jiménez-Peréz, I. I., Lopez, G., Onorato, D., Rozhnov, V. V., Arenas, R., et al. (2016). Rescue and rehabilitation centers and reintroductions to the wild. In: *Snow Leopards: Biodiversity of the World: Conservation from Genes to Landscapes*. (Academic Press).
- Ning, Y., Roberts, N. J., Qi, J., Peng, Z., Long, Z., Zhou, S., et al. (2022). Inbreeding status and implications for Amur tigers. *Anim. Conserv.* 25, 521–531. doi: 10.1111/acv.12761
- Pekor, A., Jansson, I., Munka, O., Seki, W. O., Capper, S., Kissui, B., et al. (2026). Using incentive payments to promote human-carnivore coexistence. *Conserv. Biol.*, e70216. doi: 10.1111/cobi.70216
- Perco, F. (2020). “How hunting and wildlife conservation can coexist: review and case studies,” in *Problematic Wildlife II*. Eds. F. Angelici and L. Rossi (Springer, Cham).
- Pollitt, M. G. (2019). A global carbon market? *Front. Eng. Manage.* 6, 5–18. doi: 10.1007/s42524-019-0011-x
- Qi, J., Gu, J., Ning, Y., Dale, G. M., Marcel, H., Wen, D., et al. (2021). Integrated assessments call for establishing a sustainable meta-population of Amur tigers in northeast Asia. *Biol. Conserv.* 261, 109250. doi: 10.1016/j.biocon.2021.109250
- Roberts, N. J., Harihar, A., Zhou, X., She, W., and Jiang, G. (2025). Global tiger density linked with forest carbon stock, top-down and bottom-up. *Glob. Change Biol.* 31, e70191. doi: 10.1111/gcb.70191
- Ronning, D. J. (2016). Wildlife deterrence from hazards using high brightness ultraviolet light. *J. Chem. Chem. Eng.* 10, 109–119. doi: 10.17265/1934-7375/2016.03.001
- Sabesh, A. K. C., Kavin, K., and Elango, M. K. (2025). “AI-driven system design for human-animal conflict mitigation”, in: *9th International Conference on Electronics, Communication and Aerospace Technology (ICECA)*. (IEEE). doi: 10.1109/ICECA66444.2025.11382970
- Schmitz, O. J., Wilmers, C. C., Leroux, S. J., Doughty, C. E., Atwood, T. B., Galetti, M., et al. (2018). Animals and the zoogeography of the carbon cycle. *Science* 362, eaar3213. doi: 10.1126/science.aar3213
- Seimon, T. A., Miquelle, D. G., Chang, T. Y., Newton, A. L., Korotkova, I., Ivanchuk, G., et al. (2013). Canine distemper virus: an emerging disease in wild endangered Amur tigers (*panthera tigris altaica*). *mBio* 4, e00410-13. doi: 10.1128/mbio.00410-13
- Struebig, M. J., Linkie, M., Deere, N. J., Martyr, D. J., Millyanawati, B., Faulkner, S. C., et al. (2018). Addressing human-tiger conflict using socioecological information on tolerance and risk. *Nat. Commun.* 9, 3455. doi: 10.1038/s41467-018-05983-y
- Verschuyf, J. P., Hansen, A. J., Mcwethy, D. B., Sallabanks, R., and Hutto, R. L. (2008). Is the effect of forest structure on bird diversity modified by forest productivity? *Ecol. Appl.* 18, 1155–1170. doi: 10.1890/07-0839.1
- Vitkalova, A. V., Feng, L., Rybin, A. N., Gerber, B. D., Miquelle, D. G., Wang, T., et al. (2018). Transboundary cooperation improves endangered species monitoring and conservation actions: a case study of the global population of Amur leopards. *Conserv. Lett.* 11, e12574. doi: 10.1111/conl.12574
- Wang, G. L., and Liu, F. (2011). The influence of gap creation on the regeneration of pinus tabuliformis planted forest and its role in the near-natural cultivation strategy for planted forest management. *Forest. Ecol. Manage.* 262, 413–423. doi: 10.1016/j.foreco.2011.04.007
- Wen, D., Qi, J., Long, Z., Gu, J., Tian, Y., Roberts, N. J., et al. (2022). Conservation potentials and limitations of large carnivores in protected areas: A case study in Northeast China. *Conserv. Sci. Pract.* 4, e12693. doi: 10.1111/csp2.12693