Settlements and plantations are sites of human–tiger interactions in Riau, Indonesia

Wivian Hui Yuan Neo, Muhammad I. Lubis and Janice Ser Huay Lee

Abstract Interactions between the Sumatran tiger *Panthera tigris sumatrae* and people (e.g. injury or loss of lives of people and tigers, evacuation of injured tigers, loss of livestock and sightings of tigers) can negatively affect the conservation of the subspecies. Land-use change in Sumatra has reduced habitat for tigers, forcing them into human-dominated landscapes and increasing the probability of interactions with people. Although the number of such interactions is high in South-east Asia, few studies have been published since 2000 and for Sumatra there is a lack of information regarding where these events occur. We collated data on human–tiger interactions in the province of Riau using web scraping of news sources published during 2010–2020, and mapped these data to village boundaries. We recorded 101 interaction events, with a total of 107 interactions, which we categorized into seven types (people injured or killed, livestock killed, sightings of tigers, tigers killed, injured or evacuated), in 78 villages. Most interactions with reported locations occurred close to settlements (35%), followed by in plantations (26%) and smallholdings (25%), with forests and forest edges comprising 14% of such events. Interactions were dominated by sightings of tigers, but severe interaction types (human death or injury and attacks on livestock) were also reported. The mean annual number of human–tiger interactions was 4.6 during 2011–2017 and 21.3 during 2017–2020. We highlight the need for mitigation and prevention, such as establishing conflict mitigation teams, improving animal husbandry practices, and providing training and education on human–tiger interactions focused in plantations and settlements.

Keywords Human–wildlife interaction, Indonesia, newspaper reports, *Panthera tigris sumatrae*, Riau, Sumatra, text mining, web scraping

Supplementary material for this article is available at doi.org/10.1017/S0030605322000667

Wivian Hui Yuan Neo (orcid.org/0000-0003-1705-3371) Asian School of the Environment, Nanyang Technological University, Singapore

Muhammad I. Lubis (orcid.org/0000-0003-0710-8076) and Janice Ser Huay Lee (Corresponding author, orcid.org/0000-0001-6368-6212, janicelee@ntu.edu.sg) Asian School of the Environment and Earth Observatory of Singapore, Nanyang Technological University, 62 Nanyang Drive, Singapore 637459

Received 31 October 2021. Revision requested 25 January 2022.
Accepted 18 May 2022. First published online 28 December 2022.

Negative interactions between people and tigers *Panthera tigris* on the island of Sumatra, Indonesia, have been documented for centuries. Such interactions include sightings of tigers, loss of livestock, injury or loss of lives of both people and tigers, and evacuation of tigers that have been injured near settlements in incidents unrelated to poaching (Nyhus et al., 2000; Boomgard, 2001; Campbell-Smith et al., 2012). The tiger is categorized as Endangered on the IUCN Red List (Goodrich et al., 2022). Following the extinctions of the Javan tiger *Panthera tigris sondaica* and the Bali tiger *Panthera tigris balica*, the Sumatran tiger *Panthera tigris sumatrae* is the only remaining subspecies of tiger endemic to Indonesia. Its numbers have declined significantly and populations have become increasingly fragmented (Luskin et al., 2017a). Rapid land-use change in Sumatra reduced the extent of forests from c. 161,000 to 121,000 km^2 during 2001–2019 (Gaveau et al., 2022), forcing tigers into human-dominated landscapes (Wibisono et al., 2011; Sunarto et al., 2013). The threat of tiger attacks on livestock and people has resulted in persecution of the tiger, threatening the conservation of this species (Nyhus & Tilson, 2004).

There are currently no publicly available, published datasets of human–tiger interactions in Sumatra. Earlier studies compiled information on human–tiger interactions in Sumatra, including interactions in the province of Riau, but data from 2010 onwards are needed (Nugraha & Sugardjito, 2009; Lubis et al., 2020). Riau used to be a stronghold for the Sumatran tiger and had one of the highest percentages of remaining forest cover (52%) in Sumatra (Nyhus & Tilson, 2004). But Riau was also one of the provinces with the highest number of fatal tiger attacks in Sumatra during 1978–1997 (Nyhus & Tilson, 2004). To address the lack of up-to-date information on human–tiger interactions in this province, which is being rapidly deforested, we compiled information on human–tiger interactions in Riau, and assessed where these events occurred, for 2010–2020. Our study area is the 89,913 km^2 province of Riau, which comprises 12 districts, 163 subdistricts and 1,737 villages. The major land-cover classes in 2017 were monoculture plantations (45% of the total land area), forests (18%), croplands (15%), shrubs (9%) and bare land (6%; Indonesian Ministry of Environment and Forestry, 2018b).

We collated data from online news reports for 2010–2020 using eight sources that reported news at the international, national and provincial levels (Supplementary Material 1, Supplementary Tables 1 & 2). For each news source we conducted a comprehensive search using the keywords *harimau*

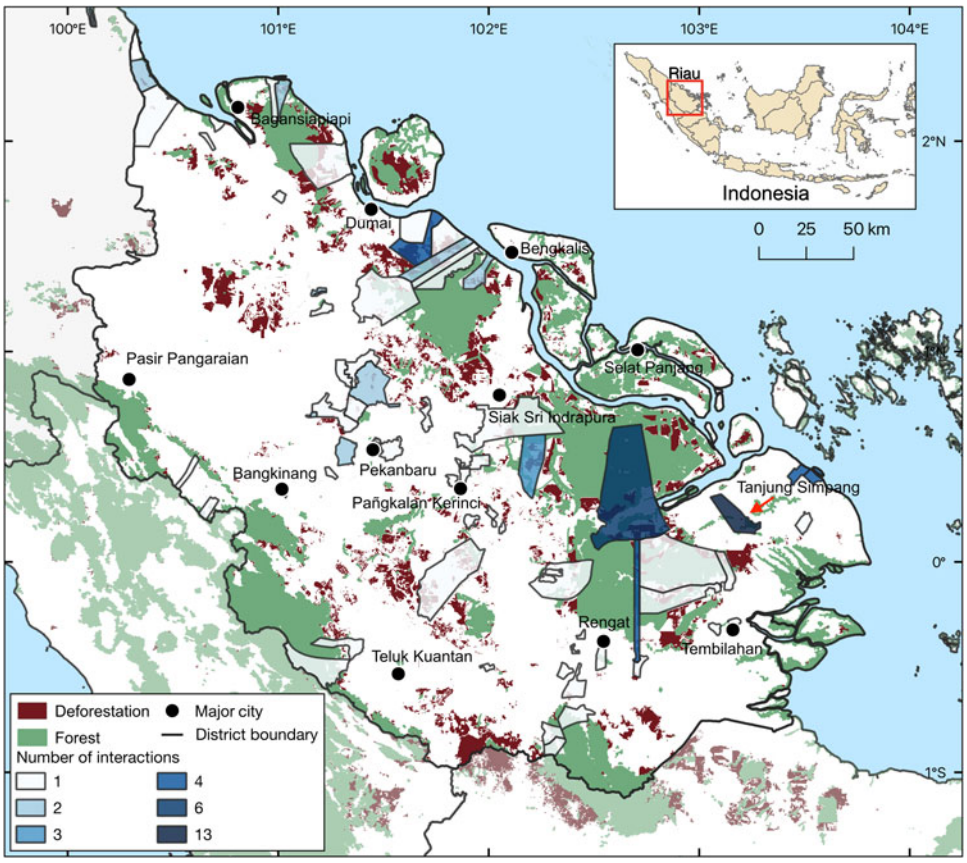

FIG. 1 The distribution of 101 human–tiger interactions in the province of Riau, Indonesia, during 2010–2020 (Table 1). Deforestation data for 2011–2020 and forest cover data for 2020 are from the Indonesian Ministry of Environment and Forestry (2018a). Tanjung Simpang village is identified in the figure by an arrow. (Readers of the printed journal are referred to the online article for a colour version of this figure.)

for tiger and *konflik manusia dan harimau* for human–tiger interactions, downloading all relevant articles published during 1 January 2010–31 December 2020. We conducted web scraping and text mining to derive this list of online news reports, using the packages *rvest* (Wickham & RStudio, 2021), *stringdist* (van der Loo et al., 2021), *corpus* (Huang et al., 2021) and *tidyverse* (Wickham et al., 2019) in *R 4.1.2* (R Core Team, 2021).

We obtained reports of a total of 454 individual human–tiger interactions from the eight news sources. After removing duplicates, we had information on 101 human–tiger interaction events, from which we obtained a total of 107 interactions, which we categorized into seven interaction types (one interaction event could consist of more than one interaction type). We based our definition of negative human–tiger interaction types on that of Goodrich (2010) and the Indonesian Government's definition of human–tiger conflict in Ministry of Environment and Forestry Law No. P.48/Menhut-II/2008 (Kholis et al., 2017). The latter defines human–tiger conflict as all interactions between people and tigers that result in negative effects on people, including their social life, economy, culture, and on the conservation of tigers or their environment. These include tigers present in human settlements, tigers attacking livestock, tigers attacking people, and tigers being hunted in retaliation. Our seven interaction types are: people injured, people killed, livestock killed, sightings of tigers, tigers killed, tigers injured and tigers evacuated (Supplementary Material 1, Supplementary Tables 1 & 2). For each interaction we recorded date of the article that reported the interaction, number of tigers involved, interaction type and location. We based the location of the interaction on the land use described in the report. When the reported number of tigers was unclear (e.g. 'a number of tigers' or 'several tigers') we recorded the number of tigers as 'NA'. We mapped human–tiger interactions to village administrative boundaries (Badan Pusat Statistik, 2017), the lowest-level administrative boundary in Indonesia, using *ArcGIS 10.8* (Esri, Redlands, USA).

We obtained records of 101 human–tiger interaction events in a total of 107 interactions published during 2010–2020 in 78 villages (4.5% of the total number of villages in the province) in Riau (Fig. 1). The majority of the interactions were tiger sightings (56), followed by attacks (19) in which tigers killed 34 animals. Seven tigers were reported killed, three injured and evacuated, and three otherwise evacuated. Eleven people were killed and nine people injured as a result of tiger attacks. Of the 101 interaction events, 77 reported the number of tigers involved, with most (81%) reporting a single tiger. The largest number of tigers reported in an interaction was five. Of the unique reports of human–tiger interactions, 100 (99%) reported the location of the interaction. The highest number of interactions

TABLE 1 Locations and numbers of seven human–tiger interaction types in the province of Riau, Indonesia, during 2010–2020 (Figs 1 & 2). Multiple locations could be reported for each interaction type and more than one interaction could occur at a location. Hence the combination of locations and interaction types results in a total number of 121.

Interaction type	Plantation	Forest	Forest edge	Settlement	Smallholding
Person injured	2	1	0	2	3
Person killed	5	2	0	1	3
Livestock killed	0	1	0	13	7
Sightings	18	5	3	22	16
Tiger evacuated	3	2	0	1	0
Tiger injured	1	2	0	0	0
Tiger killed	2	2	0	3	1
Total (%)	31 (26)	15 (12)	3 (2)	42 (35)	30 (25)

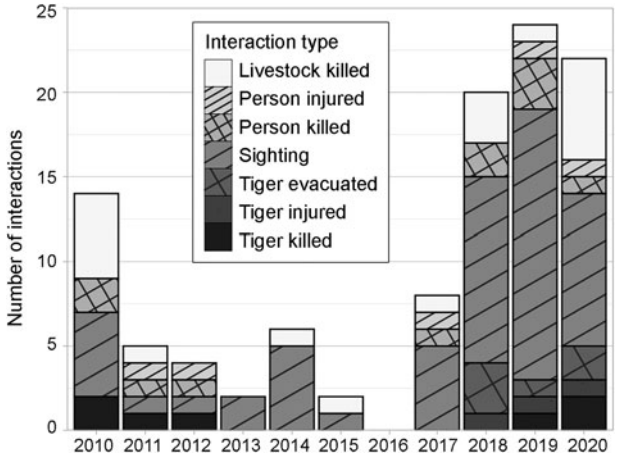

FIG. 2 Reports of the number of human–tiger interactions by type and per year in the province of Riau, Indonesia, published in eight news sources during 2010–2020 (Table 1).

occurred close to settlements (35%) followed by in plantations (26%) and smallholdings (25%; Table 1). Human–tiger interactions in the forest or at the forest edge comprised 14% of the reported events. Tiger sightings dominated human–tiger interactions in settlements, plantations and smallholdings. However, more interactions that resulted in people being injured or killed by tigers were reported in plantations and smallholdings (13) compared to settlements (three). The second most common interaction type reported in settlements and smallholdings was the killing of livestock.

The mean annual number of documented human–tiger interactions increased from 4.6 during 2011–2017 to 21.3 during 2017–2020, an increase of more than fourfold (Fig. 2). The village with the highest number of human–tiger interactions (n = 13, c. 13% of the total) was Tanjung Simpang, Pelangrian subdistrict, Indragiri Hilir district (Fig. 1). Interactions in this village resulted in six human deaths, one human injury, one livestock death, two evacuations of problem tigers and three tiger sightings.

The number of human–tiger interactions reported in our study was comparable to that reported previously around the Leuser Ecosystem (n = 148), which spans Aceh and North Sumatra, during 2008–2018 (Lubis et al., 2020). Our study and this previous study used a similar definition for human–tiger interactions. In Riau, the majority of human–tiger interactions occurred in settlements, plantations and smallholdings, indicating that human–tiger interactions occur with greater frequency at sites of high human activity and disturbance compared to in forests or at forest edges. This aligns with the results of similar studies elsewhere in Sumatra that found the probability of human–tiger interactions was higher in areas closer to settlements (Lubis et al., 2020) or in sites with intermediate disturbance such as multiple-use forests, and were low in sites with less disturbance such as protected areas (Nyhus & Tilson, 2004). The frequencies of human–tiger interactions in settlements, plantations and smallholdings in our study indicate there is a sharing of space and resources between people and tigers in Riau (Nyhus & Tilson, 2004; Maddox, 2010). The expansion of plantations and associated settlements into previously forested areas results in overlap between human land uses and the distribution of tigers (Wibisono et al., 2011). Although plantations are often dominated by monocultures such as oil palm, they can harbour generalist wildlife species such as wild pigs that are key prey species for tigers (Luskin et al., 2017b). Settlements may be sites with high numbers of human–tiger interactions because of the increased numbers of people in these areas, and potentially the availability of livestock as prey when wild prey populations have been depleted (Lubis et al., 2020).

Web scraping of online news sources is a cost-effective way to gather spatio-temporal information on human–wildlife interactions (Egri et al., 2021). However, the limitations of this approach include the inconsistent ways in which human–tiger interactions are reported across news sources, the bias in reporting that could arise as a result of more people or better telecommunication access, and some interaction types being considered more newsworthy than others (e.g. tiger sightings may be reported less than tiger evacuations). Given that our findings align with results from previous research (Lubis et al., 2020), we nevertheless

believe that our approach is useful and relevant to developing a spatio-temporal database of human–wildlife interactions.

The Sumatran tiger has been the subject of many conservation efforts (IUCN, 2021). It is important to document and monitor human–tiger interaction events to ensure these efforts do not unduly burden communities that live close to tigers (Nyhus et al., 2005), and so that the recovery of tiger populations is not undermined by retaliatory killings for the loss of livestock or of human lives (Inskip & Zimmermann, 2009). Although the greater number of human–tiger interactions in Riau during 2017–2020 comprises mostly tiger sightings, this is still a cause for concern given that every year at least one person is killed or injured and one tiger is killed, injured or evacuated. As with previous research (Lubis et al., 2020), we found that settlements, plantations and smallholdings are sites that should be targeted for prevention and mitigation efforts to reduce conflicts between people and tigers. These efforts include establishing conflict mitigation teams, improving animal husbandry practices, and providing training and education on human–tiger interactions. Our mapping of human–tiger interactions could contribute towards spatial prioritization for such mitigation and prevention efforts. Assessing the biophysical variables that drive human–tiger interactions and improving social tolerance for tigers in Riau (Struebig et al., 2018) are important future steps towards understanding and mitigating these events.

Acknowledgements We thank S. Smith, W.N. Lam, Y. Fatimah, L. Frias and A. Rege for their helpful comments. This research was supported by the Earth Observatory of Singapore via its funding from the National Research Foundation Singapore and the Singapore Ministry of Education under the Research Centres of Excellence initiative. This work comprises Earth Observatory of Singapore contribution number 454.

Author contributions Study design: all authors; data collection: WHYN, MIL; data processing and analysis: WHYN, MIL; writing: all authors.

Conflicts of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards and did not involve human subjects, experimentation with animals and/or collection of specimens.

Data availability The dataset is from the Data Repository of Nanyang Technological University (doi.org/10.21979/N9/WEJYID).

References

Badan Pusat Statistik (2017) *Peta Wilayah Kerja Statistik Tahun 2017*. Badan Pusat Statistik (Indonesian Bureau of Statistics), Jakarta, Indonesia.

Boomgard, P. (2001) *Frontiers of Fear: Tigers and People in the Malaya World, 1600–1950*. Oxford University Press, Oxford, UK.

Campbell-Smith, G., Sembiring, R. & Linkie, M. (2012) Evaluating the effectiveness of human–orangutan conflict mitigation strategies in Sumatra. *Journal of Applied Ecology*, 49, 367–375.

Egri, G., Han, X., Ma, Z. & Chakraborty, S. (2021) *Classifying and Analysing Human–Wildlife Conflicts in India using News Articles*. EasyChair Preprint no. 5898. easychair.org/publications/preprint/8nS7 [accessed 25 August 2021].

Gaveau, D.L.A., Locatelli, B., Salim, M.A., Husnayaen, Manurung, T., Descals, A. et al. (2022) Slowing deforestation in Indonesia follows declining oil palm expansion and lower oil prices. *PLOS ONE*, 17, e0266178.

Goodrich, J.M. (2010) Human–tiger conflict: a review and call for comprehensive plans. *Integrative Zoology*, 5, 300–312.

Goodrich, J., Wibisono, H., Miquelle, D., Lynam, A.J., Sanderson, E., Chapman, S. et al. (2022) *Panthera tigris*. In *The IUCN Red List of Threatened Species* 2022. dx.doi.org/10.2305/IUCN.UK.2022-1.RLTS.T15955A214862019.en.

Huang, L., Perry, P.O., Nielsen, F.Å., Porter, M., Boulton, R., The Regents of the University of California et al. (2021) *Text Corpus Analysis*. CRAN.R-project.org/package=corpus [accessed 25 February 2022].

Indonesian Ministry of Environment and Forestry (2018a) *Indonesia Report on REDD+ Performance, Directorate General of Climate Change*. Indonesian Ministry of Environment and Forestry, Jakarta, Indonesia.

Indonesian Ministry of Environment and Forestry (2018b) *The State of Indonesia's Forests 2018*. Indonesian Ministry of Environment and Forestry, Jakarta, Indonesia.

Inskip, C. & Zimmermann, A. (2009) Human–felid conflict: a review of patterns and priorities worldwide. *Oryx*, 43, 18–34.

IUCN (2021) *Saving the Sumatran Tiger*. iucn.org/theme/species/our-work/action-ground/integrated-tiger-habitat-conservation-programme/saving-sumatran-tiger [accessed 21 September 2021].

Kholis, M., Faisal, A., Widodo, F., Musabine, E., Hasiholan, W. & Kartika, E. (2017) *Pedoman Penanggulangan Konflik Manusi-Harimau. Direktorat Konservasi Keanekaragaman Hayati*. Ditjend KSDAE–KLHK, Jakarta, Indonesia.

Lubis, M.I., Pusparini, W., Prabowo, S.A., Marthy, W., Tarmizi, Andayani, N. & Linkie, M. (2020) Unraveling the complexity of human–tiger conflicts in the Leuser Ecosystem, Sumatra. *Animal Conservation*, 23, 741–749.

Luskin, M.S., Albert, W.R. & Tobler, M.W. (2017a) Sumatran tiger survival threatened by deforestation despite increasing densities in parks. *Nature Communications*, 8, 1783.

Luskin, M.S., Brashares, J.S., Ickes, K., Sun, I.-F., Fletcher, C., Wright, S.J. & Potts, M.D. (2017b) Cross-boundary subsidy cascades from oil palm degrade distant tropical forests. *Nature Communications*, 8, 2231.

Maddox, T. (2010) The claws of a dilemma: can big business contribute to tiger conservation in Indonesia? In *Tigers of the World: The Science, Politics and Conservation of Panthera tigris*, 2nd edition (eds R. Tilson & P. Nyhus), pp. 395–402. Academic Press, Cambridge, USA.

Nugraha, R.T. & Sugardjito, J. (2009) Assessment and management options of human–tiger conflicts in Kerinci Seblat National Park, Sumatra, Indonesia. *Mammal Study*, 34, 141–154.

Nyhus, P.J. & Tilson, R. (2004) Characterizing human–tiger conflict in Sumatra, Indonesia: implications for conservation. *Oryx*, 38, 68–74.

Nyhus, P.J., Osofsky, S.A., Ferraro, P., Madden, F. & Fischer, H. (2005) Bearing the costs of human–wildlife conflict: the challenges of compensation schemes. In *People and Wildlife, Conflict or Co-existence* (eds R. Woodroffe, S. Thirgood & A. Rabinowitz), pp. 107–121. Cambridge University Press, Cambridge, UK.

Nyhus, P.J., Tilson, R. & Sumianto (2000) Crop-raiding elephants and conservation implications at Way Kambas National Park, Sumatra, Indonesia. *Oryx*, 34, 262–274.

R Core Team (2021) *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.

Struebig, M.J., Linkie, M., Deere, N.J., Martyr, D.J., Millyanawati, B., Faulkner, S.C. et al. (2018) Addressing human–tiger conflict using socio-ecological information on tolerance and risk. *Nature Communications*, 9, 3455.

Sunarto, Kelly, M.J., Klenzendorf, S., Vaughan, M.R., Zulfahmi, Hutajulu, M.B. & Parakkasi, K. (2013) Threatened predator on the equator: multi-point abundance estimates of the tiger *Panthera tigris* in central Sumatra. *Oryx*, 47, 211–220.

van der Loo, M., van der Laan, J., R Core Team, Logan, N., Muir, C. & Gruber, J. (2021) *stringdist*: approximate string matching, fuzzy text search, and string distance functions. *The R Journal*, 6, 111–122.

Wibisono, H.T., Linkie, M., Guillera-Arroita, G., Smith, J.A., Sunarto, Pusparini, W. et al. (2011) Population status of a cryptic top predator: an island-wide assessment of tigers in Sumatran rainforests. *PLOS ONE*, 6, e25931.

Wickham, H. & RStudio (2021) *rvest*: easily harvest (scrape) web pages. CRAN.R-project.org/package=rvest [accessed 25 February 2022].

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L.D., François, R. et al. (2019) Welcome to the *tidyverse*. *Journal of Open Source Software*, 4, 1686.