CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

Seventy-eighth meeting of the Standing Committee
Geneva (Switzerland), 3-8 February 2025

Species conservation and trade

Fauna

Elephants (Elephantidae spp.)

IMPLEMENTATION OF THE PRIORITY RECOMMENDATIONS FROM THE REVIEW OF THE ETIS PROGRAMME

1. This document has been submitted by the Secretariat.

2. At its 19th meeting (CoP19, Panama City, 2022) the Conference of the Parties adopted Decisions 19.94 to 19.96 on the *Implementation of the priority recommendations from the review of the ETIS programme,* as follows:

   Directed to the Secretariat

   19.94 *Subject to the availability of external funding, the Secretariat shall work with TRAFFIC to, in consultation with the MIKE and ETIS Technical Advisory Group (TAG) where required, implement the high and medium priority recommendations in Annex 3 to document CoP19 Doc. 21.*

   19.95 *The Secretariat shall report progress made with the implementation of the high and medium priority recommendations in Annex 3 to document CoP19 Doc. 21 and make any other recommendations emanating from the implementation to the Standing Committee.*

   Directed to the Standing Committee

   19.96 *The Standing Committee shall review the report provided by the Secretariat in accordance with Decision 19.95 and make recommendations to improve the ETIS system and the use of its results for consideration at the 20th meeting of the Conference the Parties.*

3. At CoP19, Parties agreed that 16 high priority recommendations and four medium priority recommendations from the review of the Elephant Trade Information System (ETIS) should be implemented, subject to the availability of external funding. The Secretariat appreciates the funding provided by the European Union and the Netherlands to support the implementation of the recommendations.

4. For ease of reference the Secretariat extracted the high and medium priority recommendations from Annex 3 of document CoP19 Doc. 21 on *Review of the ETIS programme* and included these in a table in Annex 1 to the present document. The table has been updated with information from TRAFFIC on the progress made to date.

5. With regards to the 16 high priority recommendations, five recommendations have been “implemented”; nine have been “partially implemented”, and two have been “not implemented”. With regard to the four medium priority recommendations, one has been “implemented” with three remaining recommendations as “not implemented”.

6. Below is a summary of the implementation status, as reported by the Secretariat. For recommendations where TRAFFIC provided detailed reports included in the Annexes to the present document, the Secretariat has made an assessment of the implementation status based on TRAFFIC's reports, the inputs received from the MIKE-ETIS Technical Advisory Group and reflected on challenges and further work that are deemed necessary.

Regarding priority recommendations reported as implemented

7. High priority recommendations 1, 5, 8, 19, 22 and medium priority recommendation 28 were implemented through amendments to Annex 1 to Resolution Conf. 10.10 (Rev. CoP19) on *Trade in elephant specimens* adopted at CoP19 and the development and implementation of the ETIS online system:

   a) ***Recommendation 1*** – Augment Annex 1 to include 'Data Governance' and introduce other minor refinements (implementation led by the CITES Secretariat in collaboration with TRAFFIC and TAG)

      Annex 1 to Resolution Conf. 10.10 (Rev. CoP19) was amended at CoP19 to include a section on *Data governance* (section 3 of Annex 1) that addresses recommendation 1. The Secretariat has initiated discussion with TRAFFIC on the implementation of the provisions in the Resolution relating to data governance matters with the aim to formalize it through a legal instrument as required in section 3 a) on *Oversight and accountability* in Annex 1 to Resolution Conf. 10.10 (Rev. CoP19). The Secretariat plans to conclude the discussion with TRAFFIC in 2025.

   b) ***Recommendation 5*** – define clear process (system and workflow) for confirmation and validation of Parties that are implicated in the illegal trade chain respectively; and ***Recommendation 8 –*** incorporation of ETIS Online notification-enabling data validation / confirmation flow (implementation led by TRAFFIC)

      i) The ETIS Online system facilitates the submission and validation of ETIS data. It also addresses amendments in Annex 1 to Resolution Conf. 10.10 (Rev. CoP19) adopted at CoP19, particularly in Section 2 (*Data scope*), which contains the following provision relating to data validation, addressing recommendations 5 and 8:

         Parties should validate seizure data relating to their country through ETIS Online or in response to a Notification to be issued by the Secretariat on an annual basis prior to the analysis of the data. TRAFFIC will include seizure data relating to their country in the analysis unless the Party indicates through ETIS Online or within the timeframe as specified in the Notification that the data should not be included.

      ii) Notifications to the Parties were issued in 2023 and 2024 as provided for in the Resolution (e.g. Notification to the Parties No. 2024/068), reminding Parties to validate data in ETIS relevant to them.

      iii) Challenges associated with the data validation process are reported on in Annex 2 to the present document (report prepared by TRAFFIC) and discussed in paragraphs 14 to 16 below.

   c) **Recommendation *19*** – determine the appropriateness of all data elements stored in the ETIS database both from a privacy policy and data ownership requirement perspective (implementation led by TRAFFIC and supported by the CITES Secretariat); and ***Recommendation 28 –*** modelling exploration of the impact of removing lower source grades (B and C) data from the trend analyses (implementation led by TRAFFIC in consultation with the Technical Advisory Group).

      i) In addition to the provisions in paragraph 27 g) of Resolution Conf. 10.10 (Rev. CoP19) that specifies data access and ownership, specific provisions relating to *Data ownership* and *Data stewardship* were also included in Section 3 (*Data governance*) in Annex 1 to Resolution Conf. 10.10 (Rev. CoP19) as part of the amendments adopted at CoP19.

      ii) In document SC77 Doc. 63.1 (Rev. 2) on *Report of the Secretariat on the implementation of Resolution Conf. 10.10 (Rev. CoP19)*, reporting was provided on the appropriateness of ETIS data (data submitted by Management Authorities (MAs) and data included from non- MA sources) and the impact of removing lower source grade data from the trend analysis. A quick review of data sources by Party and the modelling results excluding non-MA data suggest that non-MA data are the only source of information for 18 Parties, including one Party included in the CITES National

Ivory Action Plan (NIAP) process. Removing such data from the trend analyses could result in the loss of, at times, substantial information, changing the trend dynamics presented to Parties. Parties with a large proportion of non-MA data informing their ETIS analyses are encouraged to increase their engagement with ETIS, to regularly submit their seizure data and to validate existing and future non-MA data using the validation and confirmation process.

iii) The Secretariat notes that some of the outstanding data validation processes relate to data submitted by non-MA sources, some of which also result in duplicate record entries that must be reviewed and resolved by Parties. The data validation process is discussed in more detail in the report prepared by TRAFFIC in Annex 2 to the present document and in the Secretariat's analysis in paragraphs 12 to 17 below.

d) ***Recommendation 22*** – define a more efficient and effective ETIS user access management process (implementation led by TRAFFIC supported by the CITES Secretariat).

i) The ETIS Online system provides for efficient and effective ETIS user access. CITES Parties are regarded as *Data providers* to ETIS and can request an account, through the MA, to capture seizure records in the online system and access the respective Partys' records.

ii) This recommendation has been fully implemented.

Regarding priority recommendations reported as partially implemented

8. Although progress has been made with the implementation of recommendations relating to further exploratory analysis (see Annex 3 to the present document), some recommendations are partially implemented due to resource constraints.

a) ***Recommendation 2*** –CITES Secretariat to take on a more proactive role in helping TRAFFIC with data acquisition and as a mediator for concerns and issues raised by the Parties pertaining to data integrity, to facilitate data collection (implementation by the CITES Secretariat)

i) The Secretariat publishes annually Notifications to the Parties to remind Parties to submit ETIS data by 31 March each year and to validate ETIS data.

ii) The Secretariat is unable to implement this recommendation further, as it does not have sufficient resources to undertake additional tasks associated with data collection or with mediation of disputes raised by Parties regarding data integrity. Furthermore, the Secretariat is not placed to address concerns raised by Parties on the validation of non-MA data collected by TRAFFIC and is of the view that if a Party questions the validity of non-MA data it should be excluded from the ETIS analyses (see paragraphs 14 to 16 noting that this recommendation is linked to recommendations 5 and 8 on data validation). The Secretariat also highlights that in paragraph 4 of Annex 1 to Resolution Conf. 10.10 (Rev. CoP19), reporting on elephant specimen seizures or confiscations using the CITES Annual Illegal Trade Report is encouraged. The CITES Illegal Trade Database includes only data submitted by Parties, and following this approach could significantly reduce concerns about data integrity.

b) ***Recommendation 7*** – streamline and consolidate existing Standard Operating Procedures and methodology documentation for TRAFFIC's internal use and operations, and a refined version suitable for online publication outlining detail procedures and assumptions (implementation led by TRAFFIC)

i) Standard Operating Procedures and related documentation for internal use by TRAFFIC have been developed and are not publicly available.

ii) The Secretariat notes that the amendments to Annex 1 to Resolution Conf. 10.10 (Rev. CoP19) adopted at CoP19 include in Section 5 on *Information, data analysis and interpretation* a requirement that the statistical methodology, underlying code and supporting documentation, including how data is processed, bias-adjusted and then used in the ETIS analysis, be made available to all Parties. TRAFFIC has made detailed information relating to methodology and analysis available to CITES Parties (see document SC77 Doc. 63.1 (Rev. 2), Annex 1 to document SC78 Doc. 65.1 on *Report on the implementation of Resolution Conf. 10.10 (Rev. CoP19)* and Annex 2 and 3 to the present document) and continue to work towards the full implementation of this recommendation and the provisions contained in the Resolution. The Secretariat notes that the underlying code for the network analysis was shared with the TAG members but the code for all analyses done by TRAFFIC have not been made available to all Parties.

c) ***Recommendation 11*** – annual illegal trade report and ETIS report automated or manual reconciliation of data relating to elephant specimens (amendments to the relevant resolutions to facilitate the data reconciliation) (implementation led by CITES Secretariat); and ***Recommendation 13 –*** leverage synergies with other United Nations and global agencies from a resource and knowledge/expertise perspective (implementation led by the Secretariat).

   i) Amendments to paragraph 27 g) of Resolution Conf. 10.10 (Rev. CoP19) and paragraph 4 of Resolution Conf. 11.17 (Rev. CoP19) on *National reports* were adopted at CoP19 to facilitate the implementation of these recommendations and to allow for the sharing and exchange of seizure data relating to elephant specimens between the ETIS database managed by TRAFFIC in collaboration with the Secretariat and the CITES illegal trade database managed by UNODC on behalf of the Secretariat.

   ii) At the 77th meeting of the Standing Committee (SC77; Geneva, November 2023), the Committee Members noted the different reporting deadlines of ETIS and the CITES annual illegal trade reports in the aforementioned Resolutions, and expressed concerns that encouraging Parties to submit ivory seizures data within annual illegal trade reports could result in their failure to meet the ETIS reporting deadline, which is earlier (see summary record SC77 SR). Further concerns regarding potential inconsistencies between the two resolutions were raised. The Standing Committee established an intersessional working group with the mandate to review the provisions in the two Resolutions relating to exchange of information between the annual illegal trade report and ETIS, as well as the data elements to be reported in both as it relates to elephant specimens, and report to SC78. The report of the intersessional working group is contained in document SC78 Doc. 65.5 on *Exchange of information between the annual illegal trade report and the Elephant Trade Information System*. The recommendations contained in document SC78 Doc. 65.5 will assist in moving the implementation of these recommendations forward, but also highlights several matters that could benefit from further discussion.

d) ***Recommendation 17*** – financial resources needed to meet ETIS minimum requirements (implementation led by the CITES Secretariat and Parties) and ***Recommendation 18 –*** ensuring funding is available for future enhancements (implementation led by the CITES Secretariat with support from TRAFFIC).

   i) As highlighted in document SC78 Doc. 65.1, which includes information relating to the implementation of Decisions 19.35 to 19.37 on the *Financial and operational sustainability of the MIKE and ETIS programmes*, the MIKE programme has experienced a significant reduction in donor funding for period 2025-2029. While financial support for the ETIS programme has been maintained within this funding package, additional measures are needed to enhance cost-efficiency.

   ii) As highlighted in document SC78 Doc. 65.5, Parties may wish to consider the cost-efficiency of maintaining two separate databases (ETIS and the CITES Illegal Trade Database). It is important to note that reporting on annual illegal trade is mandatory, but not subject to compliance procedures. Data submitted by Parties in their annual illegal trade reports fulfil the reporting obligation to ETIS, since this data can be made available to ETIS by the Secretariat in accordance with paragraph 4 of Resolution Conf. 11.17 (Rev. CoP19) on *National reports*. As noted in document SC78 Doc. 38.1 on *Enforcement matters*, the Secretariat intends to highlight the budgetary implications and the importance of securing sustainable funding to maintain the CITES Illegal Trade Database during the 2026-2028 budget and work programme discussions at CoP20.

e) ***Recommendation 24*** – greater identification and testing of other covariates that could feature as independent country-specific variables for bias adjustment purposes or as explanatory factors to interpret and understand ETIS results more effectively, accompanied by supporting documentation (implementation led by TRAFFIC in consultation with the Technical Advisory Group); and ***Recommendation 29 –*** active engagement of the MIKE ETIS Technical Advisory Group (TAG) in the process (implementation led by CITES Secretariat in consultation with the TAG).

   i) In document SC77 Doc. 63.1 (Rev. 2), the Secretariat reported that progress has been made by TRAFFIC, noting that the launch of ETIS Online has changed the dynamics of the data collection processes. This also rendered some data collection definitions used in construction of the covariate outdated.

ii) The same document reported on how the new ETIS reporting covariate is constructed using a ratio of the total number of seizures reported from MA and non-MA sources as follows: MA/(MA + non-MA). This is similar to the methodologies to produce the covariate of Law Enforcement (LE) ratio that is used to bias-adjust seizure rates in the trend analyses models.

iii) Information on further developments in terms of these recommendations since SC77 is contained in the report prepared by TRAFFIC in Annex 3 to the present document and discussed in paragraphs 17 to 30.

f) ***Recommendation 25 –*** exploratory analysis with a view towards enhancing and improving the analytical framework for ETIS (implementation led by TRAFFIC in consultation with the TAG)

Annex 4 to the present document contains the exploratory analysis done by TRAFFIC in response to recommendation 25 and is further discussed in paragraphs 17 to 30.

Regarding priority recommendations reported as not implemented

9. Funding has been secured to implement the following two recommendations that have not been implemented to date. The Secretariat appreciates the support provided by The Netherlands to implement this recommendation:

a) ***Recommendation 15 –*** revisiting the terms of reference of the TAG and reasonable financial provisioning, including support for participation at CITES meetings by a limited number of members of the TAG; and

b) ***Recommendation 16 –*** feasibility assessment to evaluate the effectiveness / efficiency of alternative support mechanisms for ETIS.

10. With regards to ***Recommendation 15***, the Secretariat reminds the Standing Committee that the members of the TAG contribute to the work of MIKE and ETIS to ensure technical and practical soundness and scientific robustness on a *pro bono* basis. Subject to availability of funds, the Secretariat provides support to the operation of the TAG only in terms of organization of and participation of TAG members in TAG meetings. With reduced funding available for the implementation of MIKE and ETIS, the number of TAG meetings will be reduced, and the TAG will be required to focus on priority matters relating to MIKE and ETIS as mandated in Resolution Conf. 10.10 (Rev. CoP19). The Standing Committee and the Parties should take these into consideration when Parties make requests that includes the advice of TAG.

11. With regard to ***Recommendation 16***, the Secretariat will initiate the process to undertake the feasibility assessment with funding provided by the Netherlands. The Secretariat will take into consideration the outcomes of the discussion on document SC78 Doc. 65.5 on *Exchange of information between the Annual Illegal Trade Report and the Elephant Trade Information System* when it initiates the process.

12. ***Recommendation 27*** (exploration and incorporation of illegal trade patterns/trends in the overall analysis using multiple datasets in a single model) and ***Recommendation 32*** (thorough examination of the key drivers and their correlation in terms of elephant poaching and the illegal killing of elephant and illegal ivory trade) remain challenging to implement. Both recommendations involve accessing data from different monitoring systems [MIKE, ETIS, legal trade data (United Nations Environment Programme-World Conservation Monitoring Centre) and the African Elephant Database (survey data)] in a single model, or to carry out an integrated analysis using them. The Secretariat notes that the MIKE-ETIS TAG considered the feasibility of such a system at its 13th meeting (Nairobi, March 2016 – see TAG13_Minutes) and proposed a simpler level of integration, but indicated that further investigation / exploration is needed that will require targeted research funding. Although there have been improvements in MIKE, ETIS and population survey data quality, processes to collect, verify and manage the data and the analysis of the MIKE and ETIS data, the integration of these systems has not been explored further.

13. ***Recommendation 31*** (examination of the relationship between ivory stockpiles and illegal ivory trade) was delayed in order to allow adequate time for the Secretariat to develop a database to capture the ivory inventories submitted by Parties as required under paragraph 7 e) of Resolution Conf. 10.10 (Rev. CoP19). The Secretariat provides an update on the database development in document SC78 Doc. 54 on *Stocks*

and stockpiles (elephant ivory). The MIKE-ETIS TAG briefly discussed the implementation of this recommendation at its 20th meeting (TAG20; Nairobi, November 2024). The MIKE-ETIS TAG cautioned about the level of information to be shared in terms of the examination recommended and that a preliminary process should take into consideration the decisions adopted relating to the publication of stockpile information that specifies that only aggregated regional data should be shared.

<u>Data validation (Recommendations 2, 5 and 8)</u>

14. Annex 2 to the present document provides detailed information relating to the ETIS data validation process currently in place. Since the first Notification to the Parties on ETIS data validation was published in 2023, a total of 339 validation queries and amendments were received by TRAFFIC, of which 144 have been resolved.

15. TRAFFIC reports a number of key issues and challenges relating to the data validation process. Below is the Secretariat's brief summary of the issues, and an analysis of some of the issues:

    a) Lack of clarity expressed by Parties about their concerns relating to the seizure records: The MIKE-ETIS TAG considered information relating to the data validation process at TAG20 and requested the Secretariat and TRAFFIC to ensure alignment between the Notification to the Parties and the provision in the Resolution that states that (emphasis added by the Secretariat) "…TRAFFIC will include seizure data relating to their country in the analysis **unless the Party indicates through ETIS Online or within the timeframe as specified in the Notification that the data should not be included**". Parties should therefore be requested to indicate clearly whether the data should be included or not, rather than only raising inquiries relating to the data that in some cases remain unresolved.

    b) Inconsistency in the consideration of non-MA data: as noted above, the Secretariat is of the view that if a Party formally expresses its concern regarding the validity, data from non-MA sources should be excluded from the analysis without the need for further justification.

    c) Supporting documentation is not required when a seizure record is submitted, but Parties request supporting documentation to validate records (e.g. shipping documents).

    d) Inquiries from Parties relating to older records for which documentation may have become difficult to obtain.

    e) Lack of resolution regarding open inquiries, or resolution that have not been reported back to TRAFFIC: TRAFFIC, after consultation with the CITES Secretariat, has not included seizures with unresolved inquiries in the ETIS analysis as there are no specific provisions for unresolved data validation requests. The MIKE-ETIS TAG recommended that the possible implications associated with the unresolved inquiries for the ETIS analysis to CoP20 should be reflected on, because the data associated with these inquiries are not included in the analysis. Because the number of unresolved seizures is not as large compared to the total annual seizures reported, withholding the unresolved seizures data might not have an observable impact on the transaction index. However, it is noted that withholding the unresolved seizures data resulted in the removal of one Party from inclusion in the transaction index modelling. A mild effect is noted in the weight index results as some of the unresolved seizures can be of large weight, including the largest seizure ever reported to ETIS.

16. The MIKE-ETIS TAG recommended that the Secretariat and TRAFFIC inform the Standing Committee that there is a need to consider a protocol to manage the ETIS data validation process to address the issues and challenges as reflected in paragraph 15. A proposed draft protocol prepared by TRAFFIC and amended by the Secretariat is contained in Annex 2a to the present document.

<u>Trend Analysis (Recommendations 24 and 25)</u>

17. Annex 3 to the present document provides an update by TRAFFIC on improvements made on modelling methods by exploring the application of zero-inflated modelling of seizure numbers; smoothing of input modelling covariates; flexible trend modelling using splines; a revision of the weight class thresholds; and a revision of the weight estimation modelling. The MIKE-ETIS TAG considered these improvements and TRAFFIC implemented these in the trend analysis results presented in Annex 1 to document SC78 Doc. 65.1. Annex 3 to the present document includes two parts, with Part I providing an executive summary while Part II provides the technical details.

18. The Secretariat would like to highlight the following relating to the weight classes used in the presentation of the Transaction index and changes in the threshold for worked ivory:

   a) Since the ETIS report to CoP17, the Transaction Index has been presented in three weight classes of raw ivory (< 10 kg, 10 – 100 kg, and ≥ 100 kg), and two weight classes of worked ivory (< 10 kg Raw Ivory Equivalent (RIE) and ≥ 10 kg RIE). These categories aim to offer insights into the trends and characteristics of the global illegal ivory trade.

   b) The **raw ivory** thresholds are considered meaningful in capturing illegal trade, i.e., poaching activity in the small class, intermediate amalgamation of stocks in the medium class, and organized criminal activity in the large class of raw ivory, and that the distribution of weights in the raw ivory classes remains relatively stable over time.

   c) However, for **worked ivory**, recent patterns in seized weight show declining trends, such that over the years 2008 to 2023, approximately 94% were under 10 kg RIE (reported or estimated), with the majority (62%) also being under 1 kg. Therefore, the 10 kg threshold used for worked ivory may be too high. The fact that the large class of worked ivory contains significantly fewer seizures results in many more zero counts by country or territory and year. This data sparsity reduces the reliability of the trend models and makes it less likely for parameters to converge in this weight class. Therefore, TRAFFIC explored whether revising the weight classes can help address model-fitting issues caused by class imbalances while preserving relevance to the aspects and characteristics of the global ivory trade. Based on an exploration of seizure weights in ETIS data and after consultation with the MIKE-ETIS TAG and the CITES Secretariat, a new threshold of 1 kg for worked ivory was proposed. The TAG supported the implementation of the new 1 kg threshold to differentiate small and large worked ivory classes in the ETIS trend modelling and this was applied by TRAFFIC in the report contained in Annex 3 and in Annex 1 to document SC78 Doc. 65.1.

<u>Exploratory Analysis (Recommendation 25)</u>

19. Annex 4 to the present document provides a report by TRAFFIC on the exploratory analysis pursuant to Recommendation 25. TRAFFIC explored the application of network models to ETIS data in order to identify the Parties most affected by illegal ivory trade (Part I of Annex 4 includes a summary and Part II includes a technical report). TRAFFIC organized several consultation sessions with the MIKE-ETIS TAG on the work undertaken.

20. The network-based approaches that TRAFFIC outlines in Annex 4 to the present document facilitate the visualisation and quantification of key nodes (Parties or groups of Parties) and routes in the illegal ivory trade chain based on ETIS data collected under established CITES processes.

21. According to TRAFFIC, the key player algorithm allows the identification of Parties or territories best placed to disrupt the illegal ivory trade chain. Results from the network analysis highlight the heterogeneity in selecting the Parties to disrupt illegal trade in raw and worked ivory, potentially enabling more targeted objectives for NIAP Parties. Furthermore, TRAFFIC is of the view that the key player algorithm offers the advantage of quantifying the potential for illegal trade disruption, which could in theory allow the achievement rate of national or regional law enforcement and regulatory interventions to be measurable. The Secretariat however notes that this might be influenced by shifts in illegal trade trends and routes, as criminal networks respond to changes in law enforcement effectiveness, i.e. diverting illegal consignments through other countries when law enforcement in the country traditionally used is strengthened.

22. TRAFFIC indicates that one of the main considerations for applying analytical frameworks for the ETIS categorization of Parties is the prevalence of seizures with missing trade route information in ETIS-reported data (for full discussion see section "*Additional considerations"* in Part II). This also represents a limitation inherent to current ETIS analytical methods. To address these challenges, TRAFFIC proposes the use of network methods including bias-adjustment. Additional proposed improvements to the ETIS data collection procedures are outlined in Annex 1d to document SC78 Doc. 65.1.

23. The proposed network approaches provide a quantitative assessment of how Parties are affected by illegal ivory trade, thereby addressing concerns highlighted in the ETIS report to CoP19. TRAFFIC proposes this approach as a way forward for the ETIS categorization of the Parties, noting that incorporating the suggested network approach with outputs from existing methods (i.e. cluster analysis and heat maps) along with contextual data could create a holistic and quantifiable analytical framework for identifying Parties requiring attention under the NIAP.

24. The MIKE-ETIS TAG indicated that the network analyses constitute an interesting, data-based approach that provides spatial and temporal context alongside quantitative aspects. The TAG also noted that the input data is the same as the input variables used in the ETIS trend and cluster analyses and that the results are similar to those in the ETIS reports to CoP18 and CoP19. It further noted that the network analysis provides added quantitative dimensions of the ETIS data and that the different trends observed for raw and worked ivory could be useful for the Parties. However, the MIKE-ETIS TAG also recommended that a general note be included in the ETIS report for Parties to take a cautious approach to the interpretation of seizure data.

25. TRAFFIC was furthermore requested by the MIKE-ETIS TAG to clearly indicate assumptions and bias adjustments in the report, which are included in Annex 4b to the present document. Below is the Secretariat's review of the main assumptions made in TRAFFIC's analysis that merit further reflection in considering the proposed network analysis. The Secretariat added emphasis to the text (shown in bold) where it has concerns:

    A. *Assumptions inherent to all analyses of ETIS data*

    - ETIS data elements, including seizure year, quantity information, and trade route, are reported correctly by each Party[1].

    - Reported and bias-adjusted ETIS data are representative of illegal ivory trade patterns within and between Parties – NOTE: For the application of the route reporting rate bias-adjustment, it is noted that **the reported trade routes of a Party's seizures are assumed to be representative of their illegal ivory trade routes**[2].

    B. *Assumptions specific to the proposed network analyses of ETIS data: Practical assumptions in constructing the network*

    - If the reporting Party is not included (stated in the seizure record)[3] as the *country of discovery* in the otherwise reported trade route, the reporting Party is inserted into the trade route after any reported *country of transit* and prior to any reported *country of destination*.

    - If multiple origins or exports are reported without proportions, **the ivory weight of the seizure is split equally among the named origin or export Parties**.

    - If multiple *countries of transit* are reported, the trade route follows the order in which these countries or territories of transit are listed.

26. Although some explanations are provided in TRAFFIC's exploratory analysis (Annex 4), the rationale for the assumptions shown in bold is not entirely clear and may benefit from further elaboration. Additional clarity on why these assumptions are considered valid would help Parties' understanding of the process. The implications of these assumptions should also be explained in terms of how they might potentially influence the outcomes of the analysis.

27. The Secretariat is of the view that the ETIS trend and cluster analyses are sufficient to respond to the mandate for ETIS as contained in Resolution Conf. 10.10 (Rev. CoP19). The *Review of the ETIS Programme* carried out in the previous intersessional period as shown in document CoP19 Doc. 21 also confirmed that the ETIS analysis can support CITES processes and decision-making, such as the NIAP process.

28. The Secretariat therefore does not support using the network analysis to guide the ETIS report to be considered at CoP20 or to inform the ETIS categorization of Parties. Taking the following into consideration, the Secretariat is of the view that only the trend and cluster analyses should be used to prepare the report for CoP20:

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[1] *It is noted that through the ETIS data validation process (e.g., Notification No. 2024/068), Parties can review and validate data related to their Party.*

[2] *For the application of the route reporting rate bias-adjustment, it is noted that the reported trade routes of a Party's seizures are assumed to be representative of their illegal ivory trade routes. This is not a new assumption, because trade route characteristics have been informing the contextual interpretation of the cluster analysis results in the ETIS categorization of Parties since the ETIS report to CoP12.*

[3] *Text included by the Secretariat for clarification purposes.*

- the recommendations of the MIKE-ETIS TAG,
- the concerns regarding the assumptions highlighted in paragraphs 25 and 26 above,
- the lack of information and uncertainty related to trade route data,
- the activities of entities such as Customs and police working on these matters might later show that the assumptions used relating to trade routes were not correct and this would jeopardize the credibility of ETIS reports, and
- the results are similar to the cluster analysis conducted for the ETIS reports to CoP18 and CoP19.

29. Furthermore, the Secretariat prepared a document on the implementation of Decisions 19.97 to 19.98 on *ETIS categorization of Parties* (see document SC78 Doc. 65.3). This document prepared based on consultation with TRAFFIC and the MIKE-ETIS TAG sets out clear criteria to be used to identify Parties requiring attention.

30. The Standing Committee could consider inviting TRAFFIC to prepare and submit to the Secretariat an information document with the network analysis that could be published by the Secretariat at CoP20.

Conclusions

31. Progress has been made in the implementation of the priority recommendations from the ETIS review as contained in Annex 3 to document CoP19 Doc. 21. A number of recommendations have been addressed through amendments to Annex 1 and other provisions in Resolution Conf. 10.10 (Rev. CoP19). The Secretariat therefore proposes that new decisions consider focusing on the implementation of remaining high- and medium- priority recommendations. Accordingly, the Secretariat has prepared draft decisions for consideration by the Standing Committee contained in Annex 5 to the present document. These decisions, once adopted, would replace Decisions 19.94 to 19.96.

Recommendations

32. The Standing Committee is invited to:

    a) note the progress made with the implementation of the priority recommendations of the ETIS review, as well as the challenges identified;

    b) invite the Secretariat and TRAFFIC to formalize matters relating to data governance before CoP20, through an agreement as required in section 3 a) on *Oversight and accountability* in Annex 1 to Resolution Conf. 10.10 (Rev. CoP19);

    c) encourage TRAFFIC to prepare and make Standard Operating Procedures publicly available and to fully implement Section 5 on *Information, data analysis and interpretation* in Annex 1 to Resolution Conf. 10.10 (Rev. CoP19) that requires TRAFFIC to make the statistical methodology, underlying code and supporting documentation, including how data is processed, bias-adjusted and then used in the ETIS analysis, available to all Parties;

    d) review and agree the protocol for ETIS data validation as contained in Annex 2a to the present document;

    e) consider the application of network models to ETIS data carried out as exploratory analysis and as presented in Annex 4 to the present document and advise on the use of this analysis to inform the ETIS report to be considered at CoP20 and the categorization of Parties requiring attention in the NIAP process;

    f) review and agree to submit the draft decisions contained in **Annex 5** to the present document for consideration at CoP20; and

    g) agree to recommend the deletion of Decisions 19.94 to 19.96 on the *Implementation of the priority recommendations from the review of the ETIS programme* to CoP20.

HIGH AND MEDIUM PRIORITY RECOMMENDATIONS FROM THE ETIS REVIEW

Prioritization: Interpretation and timeframe

(red)	High	Recommendation to be implemented as a priority, subject to availability of external funding, either on ongoing basis or if additional work is required during the intersessional period between CoP19 and CoP20
(orange)	Medium	Recommendation to be implemented, subject to availability of external funding, before CoP21

Reviewers' Recommended Actions, Responsible Party and Anticipated Timeframes				Update on status and costing			
No.	**Reviewers' Recommended Actions**	**Responsible Party**	**Anticipated Timeframe[4]**	**Status**	**Priority**	**Nature of the cost and estimate (USD)**	**Funding Source**
Governance							
1	Augment Annex 1 to include 'Data Governance' and introduce other minor refinements	CITES Secretariat	-	**IMPLEMENTED** Data governance addressed in amendments to Annex 1 of Resolution Conf. 10.10 (Rev. CoP19).	High	-	-
2	CITES Secretariat to take on a more proactive role in helping TRAFFIC with data acquisition and as the mediator for concerns and issues raised by the Parties pertaining to data integrity, to facilitate timely data collection.	CITES Secretariat	Short term	**PARTIALLY IMPLEMENTED** The Secretariat publishes the Notification to the Parties relating to the submission of ETIS data as well as the ETIS data validation process agreed in Annex 1 of Resolution Conf. 10.10 (Rev. CoP19). The Secretariat does not have the capacity to mediate unresolved data enquiries. The challenges associated with the data	High	CITES Staff time (10% of P3 staff member - USD 7,500 per annum) TRAFFIC Staff time as part of operating	Donor funding

[4] *Anticipated timeframes in review report:*
Short term: up to one year, depending on available funding;
Medium term: three years (one CoP cycles), depending on available funding; and
Long term: up to six years (two CoP cycles), depending on available funding.

	Reviewers' Recommended Actions, Responsible Party and Anticipated Timeframes			Update on status and costing			
No.	**Reviewers' Recommended Actions**	**Responsible Party**	**Anticipated Timeframe[4]**	**Status**	**Priority**	**Nature of the cost and estimate (USD)**	**Funding Source**
				validation process is discussed in the present document.		budget to deliver ETIS	
Supporting Processes							
5	Define clear process (system + workflow) for confirmation and validation of Parties that are implicated in the trade chain respectively	TRAFFIC & Review Team Assistance	Short term	**IMPLEMENTED** See paragraphs 50 - 54 of Annex 2 of SC77 Doc. 63.1 (Rev. 2). Refer to challenges noted in the present document and the need for a protocol.	High	-	-
7	Streamline and consolidate existing SoPs & methodology documentation for TRAFFIC's internal use and operations, and a refined version suitable for online publication outlining detail procedures and assumptions	TRAFFIC	Short term Internal SoP online SoP: Subject to the availability of funding	**PARTIALLY IMPLEMENTED** Internal SoP developed; online SoP not publicly available.	High	One-time costs for a refined version of the SoP: ETIS Staff time – USD 10,000	Donor funded
8	Incorporation of ETIS Online notification-enabling data validation/confirmation workflow	TRAFFIC	Complete	**IMPLEMENTED** See paragraphs 50 – 54 of Annex 2 of SC77 Doc. 63.1 (Rev. 2).	High	-	Donor funded
11	Annual illegal trade report and ETIS report automated or manual reconciliation of data relating to elephant specimens and in parallel ensure that the responsible CITES Management Authority in each country enters and reconciles the data for elephant specimens for both reports. It is also recommended to make changes to Res Conf. 10.10 (Rev.	CITES Secretariat (in collaboration with UNODC)	Short term Subject to the availability of funding	**PARTIALLY IMPLEMENTED** See SC78 Doc. 65.5 (Exchange of information between the annual illegal trade report and the Elephant Trade Information System)	High	ETIS staff time to integrate databases:	Donor funded

	Reviewers' Recommended Actions, Responsible Party and Anticipated Timeframes			Update on status and costing			
No.	**Reviewers' Recommended Actions**	**Responsible Party**	**Anticipated Timeframe[4]**	**Status**	**Priority**	**Nature of the cost and estimate (USD)**	**Funding Source**
	CoP18) and Res Conf. 11.17 (Rev. CoP18) on National reports, in line with the proposed amendments in Annex N.						
Sustainability							
13	From a resource and knowledge/expertise perspective, leverage synergies with other UN and global agencies	CITES Secretariat	TBD	**PARTIALLY IMPLEMENTED** (linked to recommendation # 11)	High		
15	With the expanded responsibility for TAG and dependency outlined in this report, it would be prudent to revisit/adjust the TAG's ToRs and reasonable financial provisioning (i.e., 1-2 members to participate in CoP and SC)	CITES Secretariat	Short term	**NOT IMPLEMENTED** Funds identified to support limited number of TAG members attendance of CITES meetings, as appropriate.	High		Donor funded
16	Feasibility assessment to evaluate effectiveness / efficiency of alternative supporting mechanisms for ETIS (i.e., UNODC or CITES Secretariat supporting ETIS in place of TRAFFIC)	CITES Secretariat	Medium term, subject to the availability of funding	**NOT IMPLEMENTED** Funding secured – process to be initiated in 2025	Medium	USD 35,000	
17	With respect to the provision of financial resources to meet **minimum requirements** of ETIS to "keep the lights on"[5], Parties should be made aware of the implications of insufficient resources on core operations. A dedicated budget to cover these minimum requirements is required.	CITES Secretariat and CITES Parties	Short term	**PARTIALLY IMPLEMENTED** (see document SC78 Doc. 65.1 that includes information on the implementation of Decisions 19.35 to 19.37 on the Financial and operational sustainability of the MIKE and ETIS programmes)	High		Donor funded

[5] *To keep the lights on (i.e. continue supporting ETIS infrastructure and seizure data collection and cyclic analytics and reporting activity, without any further enhancements) there is a need for approximately USD 220k – 300k per annum, bearing in mind that CoP years are slightly more resource intensive. There is currently an estimated USD 200k shortfall in the budget for the 2020 - 2023 cycle.*

	Reviewers' Recommended Actions, Responsible Party and Anticipated Timeframes			Update on status and costing			
No.	**Reviewers' Recommended Actions**	**Responsible Party**	**Anticipated Timeframe[4]**	**Status**	**Priority**	**Nature of the cost and estimate (USD)**	**Funding Source**
18	For **any enhancements / improvements moving forward** there are two main requirements: i) change requests should be logged, costed and prioritized by the TAG and subsequently vetted by the Standing Committee to ensure the availability of funding, and upon approval, formal communication of planned changes to all ETIS stakeholders. Recognizing funding and capacity constraints, this should be undertaken on a "best effort" basis; ii) for the provisioning of additional funds for any improvements or enhancements for which there is insufficient funding, more emphasis should be placed on the private sector and philanthropic contributions. Moreover, to alleviate legal obstacles for the receipt of private sector contributions, a legal expert should be asked to propose (and set up) an appropriate legal framework for establishing an appropriate international fund; For **minimum funding requirements,** the following should be implemented: iii) a dedicated marketing campaign for ETIS, targeting the private sector (including technology firms) but leveraging messaging linked to the illegal killing of elephants (as opposed to illegal ivory trade) should be	CITES Secretariat with support from TRAFFIC	Medium term By CoP20 subject to the availability of funding	**PARTIALLY IMPLEMENTED** (see document SC78 Doc. 65.1 that includes information on the implementation of Decisions 19.35 to 19.37 on the Financial and operational sustainability of the MIKE and ETIS programmes)	High	-	

	Reviewers' Recommended Actions, Responsible Party and Anticipated Timeframes			Update on status and costing			
No.	**Reviewers' Recommended Actions**	**Responsible Party**	**Anticipated Timeframe[4]**	**Status**	**Priority**	**Nature of the cost and estimate (USD)**	**Funding Source**
	launched to promote non-traditional sources of funding. iv) An experienced consultant(s) should be recruited for the development and implementation of a Sustainable Financing Framework, resource mobilization, private sector engagement strategy, as well as establishing the required legal frameworks to operationalize preferred options.						
Data Governance							
19	It is recommended to determine the appropriateness of all data elements stored in ETIS database both from a privacy policy and data ownership requirement perspective	TRAFFIC / CITES Secretariat	Short term	**IMPLEMENTED** (Linked to recommendation 28. See report to SC77 – paragraphs 55 – 62 in Annex 2 of SC77 Doc. 63.1 Rev. 2)	High	-	
Data Management							
22	Define a more efficient and effective ETIS user access management process.	TRAFFIC / CITES Secretariat	Short term	**IMPLEMENTED**	HIgh	-	
Analytics Methodology							
24	Greater identification and testing of other covariates that could feature as independent country-specific variables for bias adjustment purposes or as explanatory factors to interpret and understand ETIS results more effectively, accompanied by supporting documentation for communication and reference by stakeholders.	TRAFFIC / TAG	Medium term For CoP20 Cycle, subject to the availability of funding	**PARTIALLY IMPLEMENTED** See report to SC77 – paragraphs 63 – 67 in Annex 2 of SC77 Doc. 63.1 (Rev. 2), and Annex to the present document.	High		Donor funded

	Reviewers' Recommended Actions, Responsible Party and Anticipated Timeframes			Update on status and costing			
No.	**Reviewers' Recommended Actions**	**Responsible Party**	**Anticipated Timeframe[4]**	**Status**	**Priority**	**Nature of the cost and estimate (USD)**	**Funding Source**
25	Further exploratory analysis with a view towards enhancing and improving the analytical framework for ETIS (in concert with recommendation 26)	TRAFFIC / TAG/ Research Consultancy	Medium term Subject to the availability of funding	**PARTIALLY IMPLEMENTED** (see Annexes 3 and 4 to present document)	High		Donor funded
27	Per Paragraph 27 of Resolution 10.10 (Rev CoP18) on *Trade in elephant specimens*, bring to a successful conclusion the exploration and incorporation of overall illegal trade patterns/trends in the overall analysis using the datasets held by the IUCN/SSC African Elephant Specialist Group's African Elephant Database (elephant numbers), MIKE (illegal killing) and ETIS (illegal trade) in a single model	ETIS/MIKE Supporting Team, CITES Secretariat / TAG / TRAFFIC	Medium term For CoP20 Cycle	**NOT IMPLEMENTED**	Medium	0	
28	Modelling exploration of the impact of removing lower source grades (B and C) data from trend analyses	TRAFFIC / TAG	Short term Noted as a planned activity for 2021 to be prioritized by TAG Subject to the availability of funding	**IMPLEMENTED** (Linked to recommendation 19. See report to SC77 – document SC77 Doc. 63.1 Rev. 2))	Medium		Donor funded
Analytics Interpretation							
29	Active engagement and involvement of the entire TAG in the overall interpretation and identification and fit-for purpose covariates and proxies before they are considered for the analysis, and refinement and validation of the analytics results and stakeholder	TAG / CITES Secretariat	Short term Immediate	**PARTIALLY IMPLEMENTED** Linked to recommendation 24. While the recommendation is partially implemented, engagement with the TAG and CITES Secretariat is taking place.	High	0	

	Reviewers' Recommended Actions, Responsible Party and Anticipated Timeframes			Update on status and costing			
No.	**Reviewers' Recommended Actions**	**Responsible Party**	**Anticipated Timeframe[4]**	**Status**	**Priority**	**Nature of the cost and estimate (USD)**	**Funding Source**
	communication of this important contribution and oversight.						
31	Examine the relationship between ivory stockpiles and illegal ivory trade needs.	TRAFFIC / TAG	Medium term For CoP20 Cycle Subject to the availability of funding	**NOT IMPLEMENTED** The Secretariat developed a database for the ivory inventories (see document SC78 Doc. 54 – this could facilitate the implementation of this recommendation)	High	Ivory stockpile database - CITES Secretariat (USD 25,000).	
32	Thoroughly examine the key drivers and their correlation in terms of elephant poaching and the illegal killing of elephant and illegal ivory trade. This activity can be undertaken in concert with recommendation 27 above	ETIS/ CITES Secretariat / TAG	Medium term Subject to the availability of funding	**NOT IMPLEMENTED**	Medium		Donor funded

Note: Detailed technical recommendations relating to data management and statistical analysis relevant to the implementation of the recommendations contained in the consolidated report of the review will be incorporated as appropriate.

ETIS DATA VALIDATION
(ETIS review recommendations 5 and 8)

1. This report has been prepared by TRAFFIC.

2. Annex 1 of Res. Conf. 10.10 (Rev. CoP19) states that:

   Parties should validate seizure data relating to their country through ETIS Online or in response to a Notification to be issued by the Secretariat on an annual basis prior to the analysis of the data. TRAFFIC will include seizure data relating to their country in the analysis unless the Party indicates through ETIS Online or within the timeframe as specified in the Notification that the data should not be included.

   The CITES Secretariat has to date issued two Notifications to the Parties relating to the *Validation of ETIS data* on 13 July 2023 (Notification No. 2023/082) and on 30 May 2024 (Notification No. 2024/068).

3. ETIS review recommendations # 5 and # 8 received relate to the ETIS data validation and confirmation processes and received high-priority. Recommendation # 5 called for the definition of a "… clear process (system + workflow) for confirmation and validation of Parties that are implicated in the trade chain", and recommendation # 8 called for the "Incorporation of ETIS Online notification-enabling data validation/confirmation workflow" (see Annex 1 to this document and CoP19 Doc. 21). These recommendations were implemented by TRAFFIC as detailed in the ETIS report to SC77 (SC77 Doc. 63.1 (Rev. 2)). The report also provided results on the first data validation cycle following the publication of Notification No. 2023/082. At the time, there were several outstanding unresolved inquiries[6] due to non-response by the Parties to the original inquiry or the follow-up emails by other Parties or ETIS staff; a large number of these inquiries remain unresolved (Table 1).

4. At SC77, TRAFFIC held a side event and presented the data validation procedures and engaged with Parties who had outstanding inquiries to encourage response and to reach a resolution. After SC77, one Party submitted 66 inquiries and an additional four were submitted by three other Parties; of these 70 inquiries in total, only 11 are resolved (Table 1).

5. The second ETIS Notification to the Parties on the *Validation of ETIS data* that was published on 30 May 2024 (Notification No. 2024/068) requested the Parties to validate their ETIS data by 27 June 2024. The second validation cycle resulted in 22 inquiries submitted by five Parties, of which only five inquiries have been resolved. An additional four inquiries were made by three Parties after the second validation cycle ended; of the latter, three inquiries directed at ETIS are resolved, whereas one inquiry directed at another Party remains unresolved or ETIS staff are not aware that a bilateral resolution was reached (Table 1).

6. Summarizing the outcome over the period since the first ETIS data collection cycle, a total of 285 non-MA records were approved by the MA of the Party that reportedly made the seizure. In accordance with Res. Conf. 10.10 (Rev. CoP19)[7], 560 non-MA records were included in the analysis as no inquiry was raised for these records in the periods specified by the data validation Notifications No. 2023/082 or 2024/068. Table 1 provides further detailed summaries on the outcomes of the data validation requests by cycle (1st cycle, between data validation cycles, or 2nd cycle), inquiry type (suggested amendments or implicated Party inquiry) and the current resolution status (resolved or unresolved).

7. While more Parties submitted a suggested amendment compared to the number of implicated Parties that submitted an inquiry (sample sizes in parentheses in Table 1), in total, more inquiries were made by

[6] *Inquiries here refer to any data validation function submitted by the Parties whether suggesting amendments on seizures reportedly made in country or territory, or inquiries on seizures that implicated the Party along the trade route.*

[7] *The Notifications on the Validation of ETIS data informed the Parties that, in accordance with Res. Conf. 10.10 (Rev. CoP19), TRAFFIC will include seizure data relating to a country in the analysis unless the Party indicates through ETIS Online or within the timeframe specified in the Notification that the data should not be included.*

implicated Parties (n = 199) compared to suggested amendments (n = 140)[8]. Of the 199 inquiries by implicated Party, the majority (n = 160) were directed to other Parties, and the majority of those (n = 142) remain unresolved or ETIS is not aware that a bilateral resolution has been reached. The remaining 39 inquiries were directed at ETIS for non-MA submitted data, and 35 of those remain unresolved, although ETIS has provided responses for clarification or additional information to the inquiring Party. Lastly, of the 140 responses suggesting amendment on already *Validated* or *To review* seizures[8] (all directed to ETIS), most (n = 122) are resolved, and for the remaining unresolved requests (n = 18) ETIS has provided responses for clarification or provided additional information to the inquiring Party.

8. Inquiries submitted by the Parties date back to the beginning of ETIS records more than three decades ago in 1989 (Figure 1). Depending on the year, the aggregated weight of the unresolved inquiries can be substantial and consists of up to 25% (Figure 1) of the total reported weight seized in the given year (see total weights seized in Figure 3 in document SC78 Doc. 65.1). It is noted that some of the required supporting information (e.g., forensic examination on specimens of small seized weight, waybill or bill of lading, and flight logs) are not a requirement for data inclusion into ETIS as specified in paragraph 2 of Annex 1 of Res. Conf. 10.10 (Rev. CoP19).

Table 1. Summary of ETIS data validation requests. *Suggest Amendment* refers to requests to suggest amendments to existing records whether originally submitted by the Party or collected by ETIS staff from non-Management Authority (non-MA) sources. *Inquiry on Implicated* refers to requests by implicated Parties along the trade chain and nationality of suspect, whereby requests were directed to other Parties (MA-submitted data) or ETIS staff (non-MA collected data). *1st cycle* refers to the first ETIS data validation cycle from 13 July 2023 to 3 August 2023, *2nd cycle* refers to the second data validation cycle from 30 May 2024 to 27 June 2024, and *Between cycles* refers to the period from 3 August 2023 to 29 May 2024. Overall totals are summarized for the shaded rows. Numbers in parentheses represent the number of Parties that submitted the data validation requests; the same Party(ies) may appear in multiple tallies.

Validation action[5]	Directed to[5]	Status	Data validation period			Overall Total
			1st cycle	Between cycles	2nd cycle	
Suggest Amendment	ETIS	Resolved	104 (9)	13 (7)	5 (4)	122
		Unresolved	-	16 (1)	2* (1)	18
Total Amendment			104	29	7	140
Inquiry on Implicated	ETIS	Resolved	4 (2)	-	-	4
		Unresolved	2 (2)	27 (2)	6 (1)	35
	Parties	Resolved	11 (1)	7 (1)	-	18
		Unresolved	8 (2)	125 (2)	9 (1)	142
Total Inquiry			25	159	15	199
Overall Total			129	188	22	339

* The two seizures in Unresolved status are awaiting documentation from the Party that submitted the inquiry in order to archive them as deleted records by MA request and therefore be considered as Resolved.

8 *It is noted that inquiries by implicated Parties are submitted when the Party did not make the seizure in country or territory but was implicated along the trade chain (Implicating records on ETIS Online). Implicating records may have been added to the database by other Parties' MA, or by ETIS staff if from non-MA sources; respectively, the data validation request would have been directed to the Parties or the ETIS. Suggested amendments can be made by the Party that reportedly made the seizure in country and the seizure records were previously considered as validated (Validated records on ETIS Online), or the seizure records have been added to the ETIS database by the ETIS staff from non-MA sources and were awaiting review (To Review records on ETIS Online). All suggested amendment requests were directed to ETIS staff.*

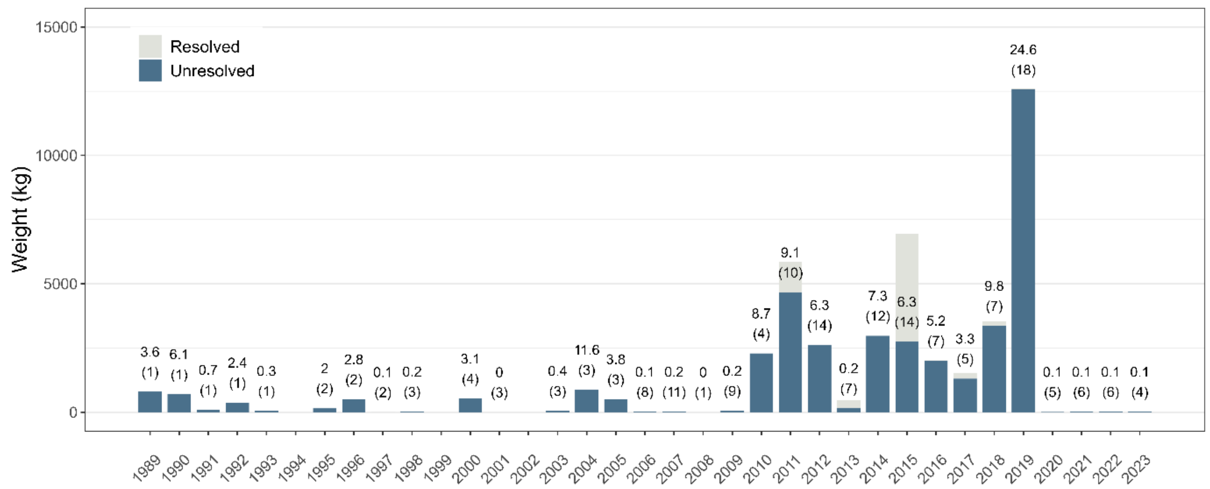

Figure 1. Total weights of seizures with inquiries. The total weight in kg is shown for unresolved (blue) and resolved (grey) inquiries submitted during two ETIS data validation cycles between 13 July 2023 and 27 June 2024. For seizures made each year, the total weight of unresolved inquires is displayed as a percentage of the total reported weight (Figure 3 in document SC78 Doc. 65.1). The numbers in parentheses indicate the number of seizures with unresolved inquiries; no labels (e.g., year 1994) indicate that no unresolved seizure inquiries exist for that year.

9. Based on the information provided the following key issues are highlighted:
   - **Ambiguity in the reason for the inquiry and lack of response when clarification is sought**. Some review requests provided ambiguous details on the inquiry, e.g., "no data" and "unverifiable" with no further guidance.

   - **Inconsistency when asking to delete non-MA records from the ETIS database.** Parties approved over 200 non-MA records, the majority in the first data collection cycle. However, after the second data collection cycle, ETIS received some statements that only data submitted by official channels of the CITES MA were to be used, at times from the same Party that previously approved non-MA records. In the Notification to the Parties, Parties are requested "to provide a justification if they request that the record be deleted from the ETIS database" (paragraph 7.a in Notification No. 2024/068 and Notification No. 2023/082).

   - **Request for documentation that is not required for submission of ETIS data or is difficult to obtain for older records.** Some of the documentation sought in the inquiries (e.g., shipping documents, forensic lab results) is not required for records to be added to the ETIS database as specified in paragraph 2.a of Annex 1 of Res. Conf. 10.10 (Rev. CoP19). While guidelines may differ nationally[9], official trade documents are not usually kept for more than a few years; therefore, it can be challenging and sometimes impossible to retrieve records for older seizure records.

   - **Lack of resolution on open inquiries.** While unresolved data issues only involve a very small number of Parties, these can have an impact on the analysis and results. At the time of writing, 53 unresolved inquiries are directed to ETIS and 142 are directed at the Parties (Table 1). While it is possible that some of the inquiries directed bilaterally at other Parties might have been resolved without informing ETIS, current mechanisms do not allow for ETIS or the CITES Secretariat to track the resolution outcome.

10. It is important to note that, while it is indicated in Res. Conf. 10.10 (Rev. CoP19) and the Notifications to the Parties on the *Validation of ETIS data* that "TRAFFIC will include seizure data relating to their country in the analysis unless the Party indicates through ETIS Online or within the timeframe as specified in the Notification that the data should not be included", TRAFFIC, after consultation with the CITES Secretariat, has not included seizures with unresolved inquiries in the ETIS analysis as there are no specific provisions for unresolved data validation requests.

11. Because the number of unresolved seizures is not as large compared to the total annual seizures reported, the impact of withholding the unresolved seizures data might not be as observable with the transaction index. However, it is noted that withholding the unresolved seizures data resulted in the removal of one

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9 *E.g., guidelines by the UK government and European Commission.*

Party from inclusion in the transaction index modelling. A mild effect is noted in the weight index results as some of the unresolved seizures can be of large weight, including the largest seizure ever reported to ETIS (Figure 2).

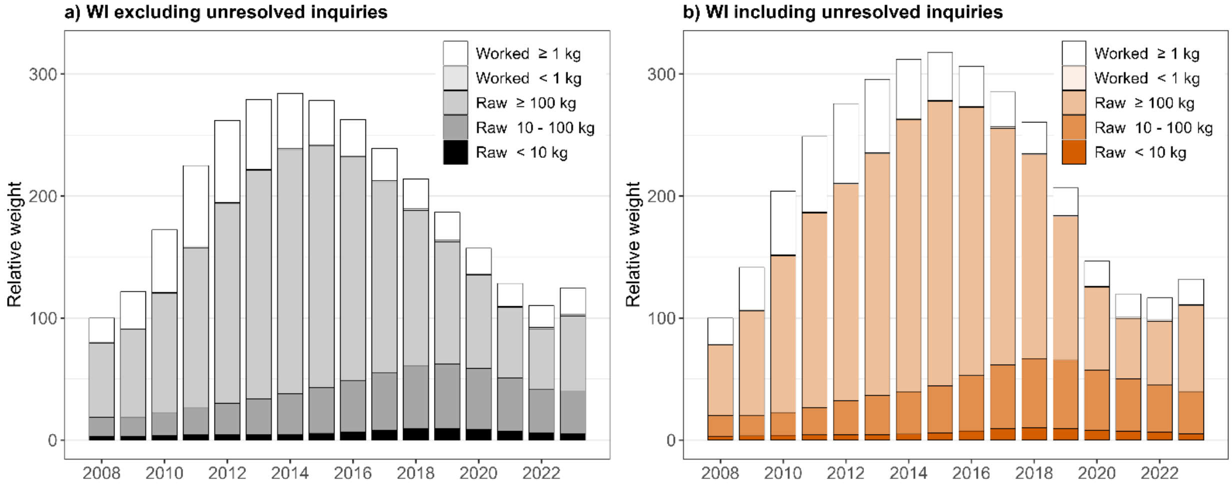

Figure 2. Weight Index trends by ivory type and weight classes. Weight Index median estimates are presented for models that (a) excluded and (b) included seizure records with unresolved review requests. Results are based on ETIS data downloaded from the database on 26 September 2024. Compared with the inclusion of seizures with unresolved inquiries (b), their exclusion (a) results in a reduction in the magnitude of the peak in relative WI (from > 300 to < 300); a slight shift in the peak to earlier years in the time series (from 2014 – 2016 to 2013 – 2015); and marginally different shape of the resulting WI trend in the latter years 2020 – 2023. The observed effects are expected as most of the weight excluded from the trend analysis was for seizures reportedly made in later years, including the seizure with the largest weight ever reported to ETIS (9.2 tonnes in 2019).

12. Due to the lack of responses by some Parties that submitted inquiries on most of their existing ETIS data, none of the data that implicated those Parties can be included in the analyses in the ETIS report to CoP20, which serves as the foundation to identify Parties requiring attention under NIAP. This also effectively penalizes Parties that have demonstrated substantial law enforcement effort in country, as their seizures will also be eliminated from ETIS analyses because a pending inquiry by an implicated Party is not being resolved.

13. At the 20th meeting of the MIKE-ETIS TAG, TRAFFIC consulted with the TAG and CITES Secretariat on how to best address issues of unresolved data validation to avoid negatively impacting the ETIS analysis results and the information provided to Parties for decisions-making at the CoP. Following the consultation, the TAG recommended that the Secretariat and TRAFFIC provide a report to the MIKE-ETIS Subgroup on the validation process to date; the unresolved inquiries with detailed breakdown and identifying potential implications for the CoP20 report; and the need to establish a protocol to guide the process to manage data validation. The TAG further invited the MIKE-ETIS Subgroup to provide guidance on how to proceed with unresolved inquiries in preparation of the ETIS report to CoP20 and invited the Secretariat to assist TRAFFIC with follow-up with three key Parties to attempt to resolve outstanding inquiries prior to SC78 and before the analysis for CoP20 is undertaken.

14. Annex 2a provides a suggested protocol for consideration by the MIKE-ETIS Subgroup on how to address ETIS data validation inquiries. This protocol builds on suggested revisions by the CITES Secretariat on an earlier version submitted by TRAFFIC to the MIKE-ETIS TAG. On the matter of resolving inquiries directed at TRAFFIC on non-MA data the TAG did not support revisions to the Resolution and suggested any protocol to be considered by the MIKE-ETIS Subgroup.

PROPOSED DRAFT PROTOCOL FOR ETIS DATA VALIDATION AS AMENDED BY THE SECRETARIAT

NOTE: The provision relating to data validation is contained in Section 2 c) in Annex 1 to Resolution Conf. 10.10 (Rev. CoP19) on *Trade in elephant specimens*:

Parties should validate seizure data relating to their country through ETIS Online or in response to a Notification to be issued by the Secretariat on an annual basis prior to the analysis of the data. TRAFFIC will include seizure data relating to their country in the analysis unless the Party indicates through ETIS Online or within the timeframe as specified in the Notification that the data should not be included.

The Secretariat would like to draw Parties attention to the provision above that states that a Party should indicate if seizure data **should not be included**. To make an informed decision relating to a specific seizure record / data, Parties may raise inquiries to obtain additional information. The draft protocol could assist in this regard.

The draft protocol aims to provide:

- a mechanism for Parties to submit inquiries and their responses using ETIS Online functionalities;
- further clarity on the information to be provided by Parties when submitting an inquiry relating to a seizure record;
- guidance for when records can be considered as 'grandfathered' into the ETIS database; and
- a process to resolve pending ETIS data validation inquiries to which Parties do not respond. It is proposed that this protocol be included as an Annex to the annual ETIS data validation Notification to the Parties.

DRAFT PROTOCOL FOR ETIS DATA VALIDATION

1. Submission of inquiries

   a) Parties should submit data validation inquiries using functionalities available on ETIS Online. If online access is not available to the Party, TRAFFIC staff can facilitate the submission of inquiries on behalf of Parties using a prepared Excel form template that is disseminated with the annual ETIS data validation Notification.

   b) In providing details for the inquiry, Parties should specify the information requested from the Management Authorities (MA) that submitted the record or the information requested from TRAFFIC if the data were collected by TRAFFIC staff from non-MA sources.

   c) If a Party is requesting the deletion of a record from the ETIS database, it is requested to provide a reason as to why the record should not be included / deleted if the record was submitted by another Party.

2. Records excluded from validation process

   Based on the data included in the ETIS analysis to identify Parties requiring attention under NIAP, records submitted for the period spanning the analysis prior to the last report to the meeting of the Conference of the Parties or the Standing Committee are considered "grandfathered in" for the next reporting cycle, meaning that only records submitted after the last CoP or SC analysis remain open for validation. The cut-off for validation of data will be linked to the inputs data for subsequent CoP or SC cycles.

3. Archiving resolved inquiries

   Once an inquiry is submitted as outlined in 1 above, Parties to which the inquiry is directed are requested to respond within the period specified in the Notification (currently three weeks) using functionalities in

ETIS Online, which will archive the response for future reference and record keeping purposes. TRAFFIC's ETIS staff will similarly respond to requests directed at data collected by ETIS also utilizing the same functionalities.

4. Timeframe to respond and status of records subject to inquiry

i. *MA-submitted data (Other Parties to respond to inquiry):*

When the inquiry is directed at another Party (owner of the data):

a) If owner of the data (Party that submitted the record) provides information relating to the record and the inquiring Party does not respond; the data will be included in the analysis;

b) If the owner of the data (Party that submitted the record) does not respond to the inquiry from another Party, the data will be excluded from the analysis until the matter is resolved bilaterally between the Parties.

ii. *Non-MA data (TRAFFIC to respond to inquiry):*

When the inquiry is directed at TRAFFIC (non-MA data) and TRAFFIC has provided all of the documentation and information at its disposal and followed up with the Party:

- If no response is received from the inquiring Party after one month of the relevant documentation and information at the disposal of TRAFFIC being provided to it, and after at least two written follow up attempts by TRAFFIC to which the enquiring Party does not respond, data could be included in the analysis.

- If the inquiring Party is not satisfied that the documentation and information at the disposal of TRAFFIC is sufficient to justify inclusion of the non-MA data, the data should not be included in the ETIS analyses and removed from the ETIS database.

ETIS TREND MODELLING DEVELOPMENT
Trend Analysis (Recommendation 24 and 25)

1. This report has been prepared by TRAFFIC.

2. ETIS review recommendation # 24 received a high-priority and was directed at TRAFFIC and the TAG and stated that "Greater identification and testing of other covariates that could feature as independent country-specific variables for bias adjustment purposes or as explanatory factors to interpret and continued with exploration of sample size corrections for the seizure rate covariate." Review recommendation # 25 also received a high priority and was directed at TRAFFIC, the TAG and a Research Consultancy, calling for "Further exploratory analysis with a view towards enhancing and improving the analytical framework for ETIS (in concert with recommendation 26[10])".

3. This Annex summarizes a year of trend modelling development to address review recommendations # 24 and # 25 that included four interim reports to the MIKE-ETIS TAG and the CITES Secretariat, three online statistical consultation meetings (held on 6 February 2024, 5 June 2024, and 13 August 2024) and consultation at the 20th meeting of the TAG held from 5 – 7 November 2024 in Nairobi, Kenya. Input from the TAG and the Secretariat were incorporated into methodology revisions to derive the analytical framework improvements to the ETIS trend analysis presented in this Annex, where Part I provides less-technical overall summary of key developments, while Part II provides a more comprehensive statistical technical discussion of each topic along with experimental results and figures. The R code associated with the final suggested models was provided to the TAG.

PART I – SUMMARY OF TREND ANALYSIS MODELLING IMPROVEMENTS

4. Several modelling developments were considered to address the issues of *i.* excess zeros in the input data for the ETIS trend models, *ii.* the large variability in ETIS data sample sizes and therefore in the values of the covariate used to model seizure rates for the bias-adjustment of ETIS data, *iii.* the sensitivity and peak-shifting of current polynomial trend models with an increase in the time-series data and/or outlier years' data, *iv.* the trends in the reportedly seized weight over time and their implication on weight class thresholds, and on *v.* the weight estimation models required when only number of pieces are reported to ETIS. The following sections address each issue, respectively, to improve on current modelling methods by exploring the application of *i.* zero-inflated modelling of seizure numbers; *ii.* smoothing of input modelling covariates; *iii.* flexible trend modelling using splines; *iv.* a revision of the weight class thresholds; and *v.* a revision of the weight estimation modelling. An overall conclusion is provided in paragraph 19.

i. Zero-inflated modelling

5. Zeros in the ETIS data arise through different mechanisms of reporting and non-reporting: some reflect actual reports by a Party of no seizures made in a given year, while others occur due to non-reporting. While both lead to zero data points, the first case is considered as a true zero that informs the ETIS trend analysis, whereas for the second case of non-reporting, it is unknown whether no seizures occurred and were not reported (true zeros), or if the Party has made seizures and did not report them to ETIS (false zeros). Some Parties do not report to ETIS regularly[11]; if no other non-Management Authority data exists, this results in a zero entry for those countries or territories and years in each ivory weight class (Figure 3 in Part II). Unaccounted for, false zeros can mislead the modelling of ETIS data and potentially mask higher levels of illegal ivory trade.

6. Two approaches to deal with the issue of false zeros were explored: the removal of non-reported zeros under the current negative binomial modelling approach, and the application of a zero-inflated negative binomial model. The latter approach consists of a mixture model that accounts for reported (true) zeros in the negative binomial component of the model which informs the trends, and non-reported (false) zeros through a purely zero component. Mixture probabilities are assigned to each component and are allowed to vary by country or territory and by ivory weight class to reflect differing reporting behaviours across Parties and seizure class types (small, medium and large raw ivory classes and small and large worked ivory classes). Both informative

[10] *Recommendation # 26 advises to "Streamline the 'R' scripts (+30) to enhance execution performance and minimize hands-on intervention".*

[11] *See Data Aggregates webpage on ETIS Online: https://etisonline.org/data-aggregates*

and uninformative priors were explored to estimate the mixture probabilities in the hierarchical Bayesian approach that is applied for the ETIS trend analysis. The impact of the zero-inflated model on the reporting rate used for the bias-adjustment was also explored (Figures 5 – 7 in Part II).

7. Removal of non-reported zeros had a large impact on the Transaction Indices (Figure 4 in Part II) and the reporting rate (Figure 6 in Part II) and showed poor model fit (Figure 1 in Annex 3c). The zero-inflated negative binomial model with uninformative, country- or territory- and ivory class-specific priors on the mixture probabilities performed better (Figure 1 in Annex 3c) and received the support of the MIKE-ETIS TAG statisticians following the second report submitted to the TAG on 6 April 2024.

ii. Smoothing of modelling covariates

8. The ETIS trend models employ a law enforcement (LE) ratio to serve as a proxy for law enforcement effectiveness and model the seizure rates that are used to bias-adjust ETIS data. The LE ratio is calculated for each country or territory and year as the ratio of the *Seizures-in* (seizures made in country) over the total of *Seizures-in* and *Seizures-out* (seizures that implicated the Party). Two main issues arise from the LE ratio calculation; *i.* the same LE ratio can be obtained regardless of sample size, e.g., an LE ratio of 0.5 can be obtained with one *Seizures-in* and one *Seizures-out* for the Party in question or from 100 *Seizures-in* and 100 *Seizures-out*, and *ii.* the yearly variation of the LE ratio can be substantial for Parties with low reported seizure involvements, e.g., the LE ratio might be zero one year followed by one the next year (Figure 8 in Part II).

9. To create a more stable covariate, exponential smoothing of seizure numbers was explored, allowing for an extended timeframe of data to inform the LE ratio. A country- or territory-specific smoothing parameter, estimated with an uninformative prior, was used to weigh past data, giving more recent data greater influence and applying greater smoothing for countries or territories with smaller sample sizes. However, results indicated large variability in the posterior distribution of the smoothing parameters (Figure 9 in Part II) and little effect on the overall trend model (Figure 10 in Part II).

10. It is noted that the Transaction Index is driven primarily by countries or territories that report many seizures, for which the derived LE ratios can be reliable proxies for law enforcement effectiveness. Therefore, adjustments aimed at improving the reliability of the LE ratio for under-represented countries or territories had minimal impact. Upon consultation with the MIKE-ETIS TAG and the CITES Secretariat, it was concluded that the explored adjustments made the LE ratio less intuitive without offering significant benefits, and the recommendation was not to implement smoothing of the LE ratio covariate in the ETIS modelling.

iii. Spline trend modelling

11. A polynomial regression is currently used for the non-linear modelling of ETIS trends. Since a single polynomial function is applied to model the trend across the entire range of data, the resulting fit is highly dependent across its time range. This means that as additional ETIS data are added and extend the time-series, polynomial trend results may vary by shifting peaks and influencing the overall shape of trends (Figure 11 in Part II). Furthermore, a single abnormal data year such as 2020[12] can influence the trend estimates far into the past and future. Finally, as currently applied, the polynomial model allows for limited flexibility, as the higher-order coefficients are kept constant across countries or territories and ivory weight classes.

12. Spline functions, which comprise of piecewise polynomial functions and therefore allow more localized modelling, can offer more flexible and stable trends. Implementing cubic splines with coefficients that are allowed to vary by country or territory and ivory class enabled the spline model to capture different trend dynamics across countries and territories more effectively. Regarding the implementation of the spline method, the number and placement of knot points (the endpoints of the polynomial segments) were discussed with the TAG and extensively explored. To avoid subjective decisions in knot placement, a process of statistical model averaging was proposed, whereby candidate models with increasing numbers of knots at uniform spacing were combined to construct an overall best-fitting model. The sensitivity of the models to the inclusion of additional years' data was further explored and showed good stability (Figure 13 in Part II).

13. The proposed spline models showed good performance compared to the polynomial model, including greater flexibility to capture recent peaks (Figure 1). It is noted that the peaks seen under the spline model in the classes of small raw and small worked ivory can be attributed to unusually high numbers of seizures reported in these classes by one Party over the years 2016 – 2018 (see also Figure 5 in document SC78 Doc. 65.1.).

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[12] *In which the effects of COVID-19 were felt globally and resulted in the reporting of less seizures to ETIS.*

The adjustment of the spline model to capture different trend dynamics across each country or territory allows this data to be reflected, whereas the polynomial model lacks this flexibility. Posterior predictive plots (Figure 1 in Annex 3a of this document) display the improved fit to the data under the spline model as compared to the polynomial model.

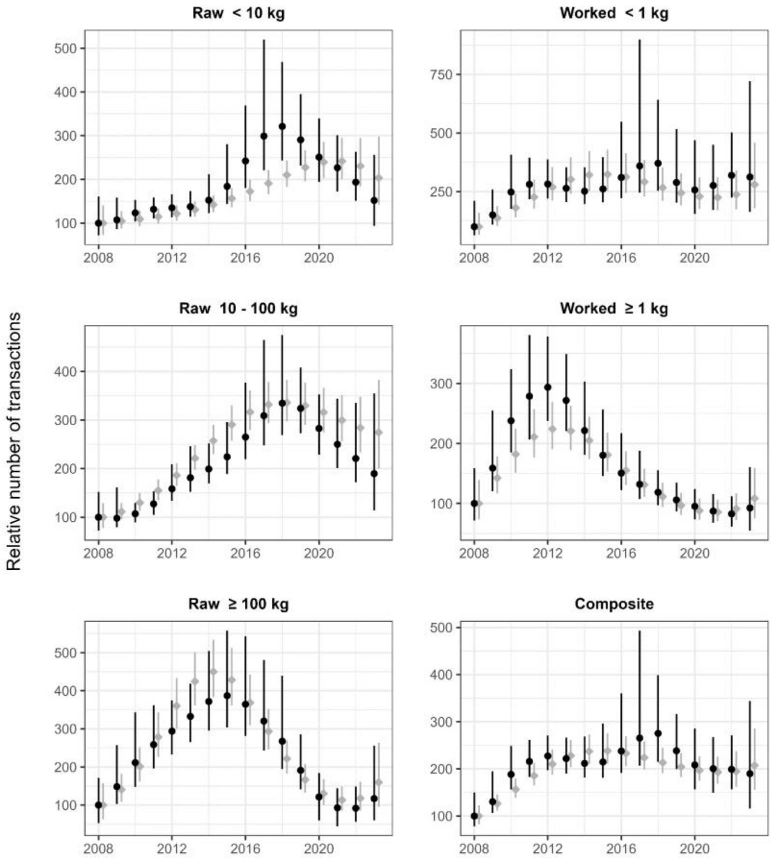

Figure 1. A comparison of Transaction Indices estimated with spline and polynomial modeling approaches. Comparisons are made across raw and worked ivory weight classes, and the composite index across all ivory types and weight classes, under the proposed spline modelling approach (black circles) and the previously used polynomial method (grey squares). Median estimates are shown with 90% quantile-based credible intervals. The previous method represents a 4th-degree polynomial model, chosen over higher-degree models based on marginal improvements seen to model fitting statistics including DIC, convergence diagnostics, and credible intervals. Factors including the input data, covariates, weight estimation modelling, and MCMC parameters were kept consistent to allow a fair comparison between alternative trend models. Results are based on data downloaded from the ETIS database on 26 September 2024.

iv. Weight classes of raw and worked ivory

14. Since the ETIS report to CoP17, the Transaction Index has been presented in three weight classes of raw ivory (< 10 kg, 10 – 100 kg, and ≥ 100 kg), and two weight classes of worked ivory (< 10 kg RIE and ≥ 10 kg RIE). These categories aim to offer insights into the trends and characteristics of the global illegal ivory trade. It was discussed with the MIKE-ETIS TAG and the CITES Secretariat that the raw ivory thresholds are considered meaningful in capturing illegal trade, i.e., poaching activity in the small class, intermediate amalgamation of stocks in the medium class, and organized criminal activity in the large class of raw ivory, and that the distribution of weights in the raw ivory classes remains relatively stable over time (Figure 16 in Part II). However, for worked ivory, recent patterns in seized weight show declining trends, such that over the years 2008 to 2023, approximately 94% were under 10 kg RIE (reported or estimated), with the majority (62%) also being under 1 kg (Figure 2). Therefore, the 10 kg threshold for worked ivory may be too high.

15. The fact that the large class of worked ivory contains significantly fewer seizures results in many more zero counts by country or territory and year (see Figure 3 in Part II). This data sparsity reduces the reliability of the trend models and makes it less likely for parameters to converge in this weight class. Therefore, it was explored whether revising the weight classes can help address model-fitting issues caused by class imbalances while preserving relevance to the aspects and characteristics of the global ivory trade.

16. Based on an exploration of seizure weights in ETIS data and after consultation with the MIKE-ETIS TAG and the CITES Secretariat, a new threshold of 1 kg for worked ivory was proposed. Trend models using the new 1 kg threshold supported the patterns observed in the data (Figure 2) in that the peak in the trend curve in the small worked ivory class was more recent under the 1 kg threshold (e.g., Figure 5 in document SC78 Doc. 65.1). The TAG supported the implementation of the new 1 kg threshold to differentiate small and large worked ivory classes in the ETIS trend modelling.

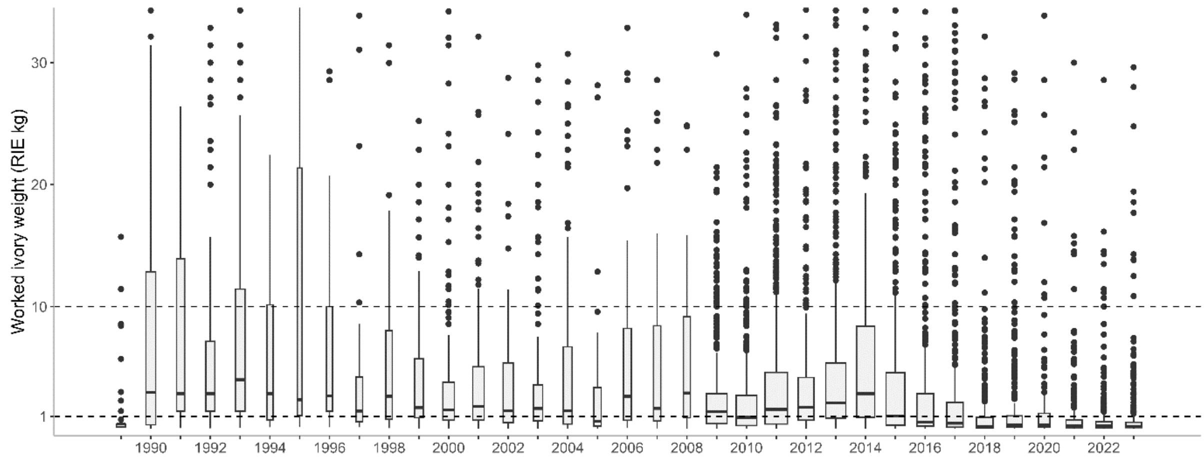

Figure 2. Distributions of reported weights over time. Boxplots showing the distribution of reported weights (Raw Ivory Equivalent[13]) over time for worked ivory seizures. The widths of the boxplots are proportional to the square root of the sample size, and the y-axis is truncated at the upper end to enhance the visibility of the central distributions.

v. Weight estimation

17. Weight estimation is a crucial step before conducting ETIS trend analysis, as it allows seizures for which weight information is missing to be assigned into the weight classes presented by the Transaction Index and included in the analysis. The existing weight estimation models for raw and worked ivory use polynomial regression based on the number of pieces, relying on seizure data since 1995 that report both weight and number of pieces to fit the models. This model has been used as a preparatory step in the ETIS analyses to CoP; however, given the trends in worked ivory weight discussed above, and large variability in reported weights for a given number of pieces (Figure 16 in Part II), alternative models were considered to improve the accuracy of the weight estimation.

18. Following advice from the MIKE-ETIS TAG, the subsequent modifications were explored for the weight estimation model: *i.* restricting the weight models' training data to more recent seizures made since 2008, which aligns with the timeframe of the trend analysis; *ii.* replacing the polynomial models with spline models; and *iii.* exploring the text in the Ivory comment field of each seizure record to assess whether it can lend additional information in refining the model estimation. For the latter, it was determined that keywords relating to jewellery can provide a useful indicator for the worked ivory weight estimation modelling (Figure 23 in Part II). Alongside this, the weight models have been adjusted through the restriction of the training data and the application of spline modelling as described in detail in Part II.

Conclusion

19. After a year of modelling development and following several interim reports and consultation meetings with the MIKE-ETIS TAG and the CITES Secretariat, the following developments were supported for the ETIS trend analysis: model averaging of zero-inflated negative binomial models with spline trends that are country- or territory- and year-specific, a 1 kg threshold to separate the worked ivory classes, and weight estimation modelling using spline regression and a jewellery keyword indicator incorporated into the weight model for worked ivory. Trend analysis results presented in document SC78 Doc 65.1. are based on the collective application of all supported model improvements.

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[13] *In the ETIS analysis, worked ivory weights are converted to Raw Ivory Equivalent (RIE) weights by dividing by a conversion factor of 0.7 to account for approximately 30% wastage when raw ivory is worked ([SC74 Doc. 68]() Annex 1c).*

PART II – TECHNICAL PAPER ON THE DEVELOPMENT OF TREND ANALYSIS MODELLING IMPROVEMENTS

Elephant Trade Information System (ETIS) methodology development – technical report

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Background

20. This report deals with technical aspects of the ETIS analysis methodology. Details of the previously established ETIS Transaction Index modelling framework can be found in Underwood, Burn, & Milliken (2013) and Burn & Underwood (2013). Briefly, the approach is to model y_{ikt}, the number of reported seizures made by country or territory *i* in ivory class *k* and year *t*, with a negative binomial distribution, with the aim to uncover the behaviour of an unknown quantity, λ_{ikt}, representing the expected number of unobserved transactions in country or territory *i*, ivory class *k*, and year *t*. This quantity is introduced by factorising the expectation of the negative binomial distribution in terms of λ_{ikt} and the seizure and reporting rates of the particular country or territory and year. For country or territory *i* and ivory class *k*, variation in λ_{ikt} over time is modelled via a polynomial trend on its log-transformed values. This framework is summarised as follows:

$$y_{ikt} \sim \text{NegBin}(p_{ikt}, r_k), \text{ where } 0 < p_{ikt} < 1 \text{ and } r_k \in \mathbb{Z}^+, \quad (1)$$

$$\text{E}(y_{ikt}) = \frac{r_k(1 - p_{ikt})}{p_{ikt}} = \lambda_{ikt}\varphi_{it}\vartheta_{it}, \text{ where } \lambda_{ikt} \geq 0, \text{ and } 0 \leq \varphi_{it}, \vartheta_{it} \leq 1, \quad (2)$$

$$\log(\lambda_{ikt}) = \alpha_{0ik} + \alpha_{1ik}\xi_1(t) + \sum_{j=2}^{p} \alpha_{jk}\xi_j(t)\,. \quad (3)$$

21. It is noted that the seizure rates, φ_{it}, and reporting rates, θ_{it}, vary across countries or territories and over time, but not across ivory classes. These are unobserved latent variables which are modelled linearly with their standardised predictors via a logit link function. In the trend equation, $\xi_j(t)$ represents the j^{th} order orthogonal polynomial term at year *t*. Only the coefficients of the intercept, α_{0ik}, and the linear trend, α_{1ik}, are allowed to vary across both country or territory and ivory class, while the higher-order coefficients remain constant across countries and territories. Where possible, parameters are modelled with non-informative priors, details of which are available in Burn & Underwood (2013). The model is fitted in a Bayesian framework using a Markov Chain Monte Carlo (MCMC) algorithm.

22. An external review of the ETIS statistical analysis has been conducted and suggested exploring improvements to the analytical framework of the models currently used to estimate ETIS trends. Several modelling developments were considered to address the issues of *i.* excess zeros in the input data for the ETIS trend models, *ii.* the large variability in ETIS data sample sizes and therefore in the values of the covariate used to model seizure rates for the bias-adjustment of ETIS data, *iii.* the sensitivity and peak-shifting of current polynomial trend models with an increase in the time-series data and/or outlier years' data, *iv.* the trends in the reportedly seized weight over time and their implication on weight class thresholds, and on *v.* the weight estimation models when only number of pieces are reported to ETIS.

23. The following sections respectively address each issue to improve on current modelling methods by exploring the application of *i.* zero-inflated modelling of seizure numbers; *ii.* smoothing of input modelling covariates; *iii.* flexible trend modelling using splines; *iv.* a revision of the weight class thresholds; and *v.* a revision of the weight estimation modelling. The developments explored and the conclusions of the technical consultations with the MIKE-ETIS TAG and the CITES Secretariat are discussed. Comparisons of proposed methods are at times compared to current modelling methods using data downloaded from the ETIS database on 27 July 2023; data were filtered to include seizures made during the years 2008 – 2021 inclusive, and thus represent a similar dataset to that used for the latest ETIS trend analysis published in CoP19 Inf. 33.

i. False zeros in seizure counts: zero-inflated modelling

24. For a given country or territory and ivory class, the reported seizure counts in the ETIS data often exhibit a high variance over time, and include many zeros. While the negative binomial model (equation (1)) can accommodate this overdispersion to some degree, zero-inflation has been explored as an additional component to the modelling of ETIS data.

Visualisation of zeros

25. The zeros occurring in ETIS seizure numbers can arise through two general mechanisms: reporting no seizures, if a Party's Management Authority (MA) reports to ETIS that no seizures were made for a given year (such zeros are hereafter referred to 0^{NSR}, or *true* zeros); and non-reporting, if a Party's MA fails to report to ETIS (hereafter referred to as 0^{NR}, or *false* zeros). Figure 3 depicts the distribution of zeros for every combination of country or territory (i), ivory class (k), and year (t) included in the trend analysis[14]. The greatest abundance of zeros is observed in the upper weight classes of raw and worked ivory, whereas the lowest occurrence is noted in the class of small worked ivory. In total, 63% of the data seen in Figure 3 are zero, with 4% labelled as 0^{NSR} (blue) and 37% labelled as 0^{NR} (red). A third category, 0^{R} (purple; 22% of the data in Figure 3), is introduced to denote zeros in a year for which a country has reported non-zero seizures to ETIS, but where the reported data did not cover all ivory classes (e.g., top left point in each panel: AE in 2008 reported only seizures of small worked ivory; zeros in the remaining ivory classes are labelled as 0^{R}). In general, it is not clear whether a 0^{R} data point implies reporting (equivalent to 0^{NSR}) or non-reporting (equivalent to 0^{NR}); these cases remain ambiguous.

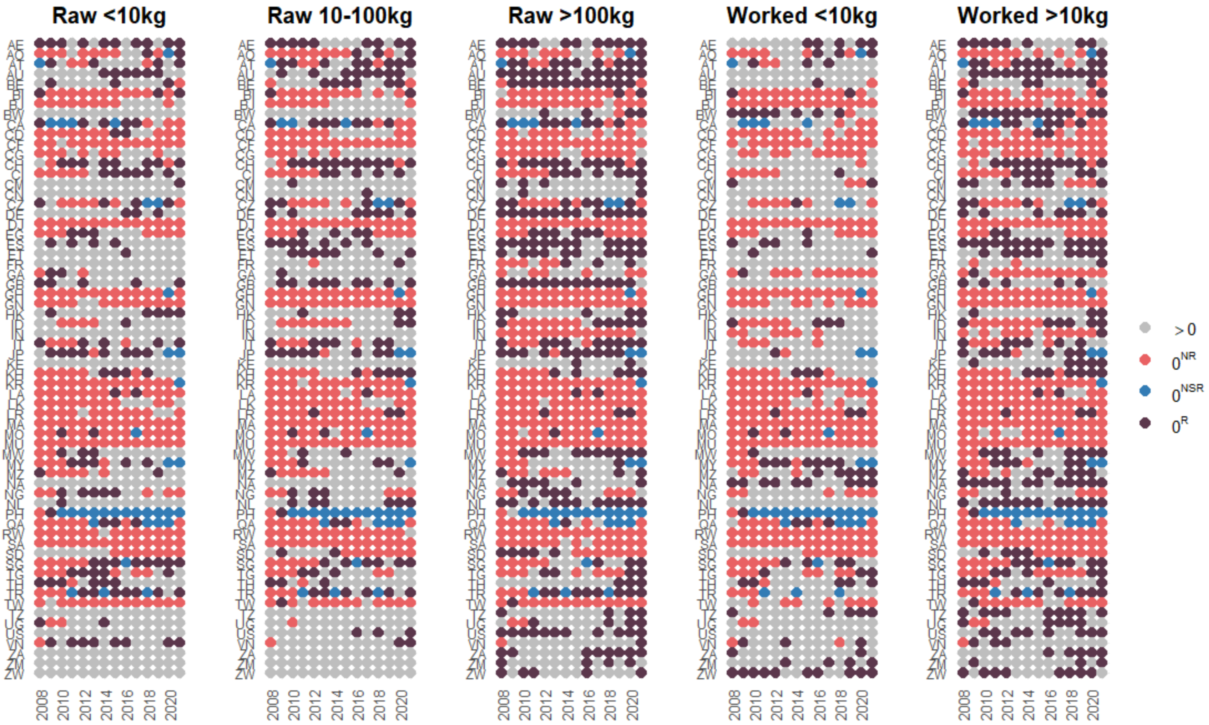

Figure 3. The distribution and classification of zeros included in the ETIS analysis. Each dot represents a data point, y_{ikt}, for a specific country or territory (i, y-axes, denoted by ISO alpha-2 codes[15]), ivory class (k, panels), and year (t, x-axes).

Zero-inflated modelling

26. To handle excessive zeros generated through two mechanisms, a zero-inflated model is introduced. Zero-inflated models comprise a mixture of two distributions, one of which generates only zeros (Cameron & Trivedi, 2013), and are often justified in the analysis of data in which excess zeros can emerge through a distinct mechanism. Retaining the negative binomial distribution of the current approach, and using π to represent the mixture proportion, a zero-inflated negative binomial model for y_{ikt} can be written as

[14] *Inclusion criteria considers the number and size of a country or territory's implicated seizures over the most recent 10-year period.*

[15] *Throughout this Annex, HK is used to refer to Hong Kong (SAR) of China.*

$$y_{ikt} \sim \begin{cases} \text{NegBin}(p_{ikt}, r_k) & \text{with probability } \pi, \\ 0 & \text{with probability } 1 - \pi. \end{cases}$$

27. Initial experiments with this approach used country- or territory-specific mixture proportions, π_i, with informative Beta priors constructed by tallying the number of years of 0^{NR} and non-0^{NR} data (as seen in Figure 3) for each country or territory.

28. Following a MIKE-ETIS TAG consultation, the following suggestions were made to assess the appropriateness and ramifications of the zero-inflated model: (i) to compare results with a negative binomial model in which non-reported zeros (0^{NR}) are treated as missing data and removed from analysis, and (ii) to assess the impact to the model's reporting rate. Investigations into these suggestions are presented below in addition to (iii) an exploration of the effects of zero-inflation parameterisation and prior distributions on reporting rate.

Removing 0^{NR} from analysis

29. Addressing the first suggestion by the TAG, 0^{NR} were considered as missing data and removed from the analysis using the former negative binomial model with 4th degree polynomial trends (hereafter referred to as the 0^{NR}-removed model). As a side note, it is worth recognizing that this approach precipitates issues in the use of the LE1 covariate for the seizure rate (see the following section, "*Smoothing of modelling covariates",* for further discussion of the LE1 covariate), which relies on seizure data with a one-year lag. Removing 0^{NR} points from the derivation of the LE1 covariate results in undefined LE ratios; in this exercise, these are replaced with zero in consistency with the current treatment of undefined (0/0) LE ratios.

30. Figure 4 shows the Transaction Indices (TIs) produced by the models under comparison. In the case of the 0^{NR}-removed model, it is noted that TI estimates of λ_{ikt} are generated for all *i*, *k*, *t*, including those for which the data, y_{ikt}, was removed. This occurs as the smooth trend equations on λ interpolate these points based on their fit to the remaining data. Since these remaining data contain a lower proportion of zeros (only those labelled as 0^{NSR} or 0^{R} in Figure 3), the TI estimates are higher under the 0^{NR}-removed model, most notably in the categories of large raw and worked ivory where the highest amount of 0^{NR}s occur. Posterior predictive distributions in Annex 3c show a poor fit under this model.

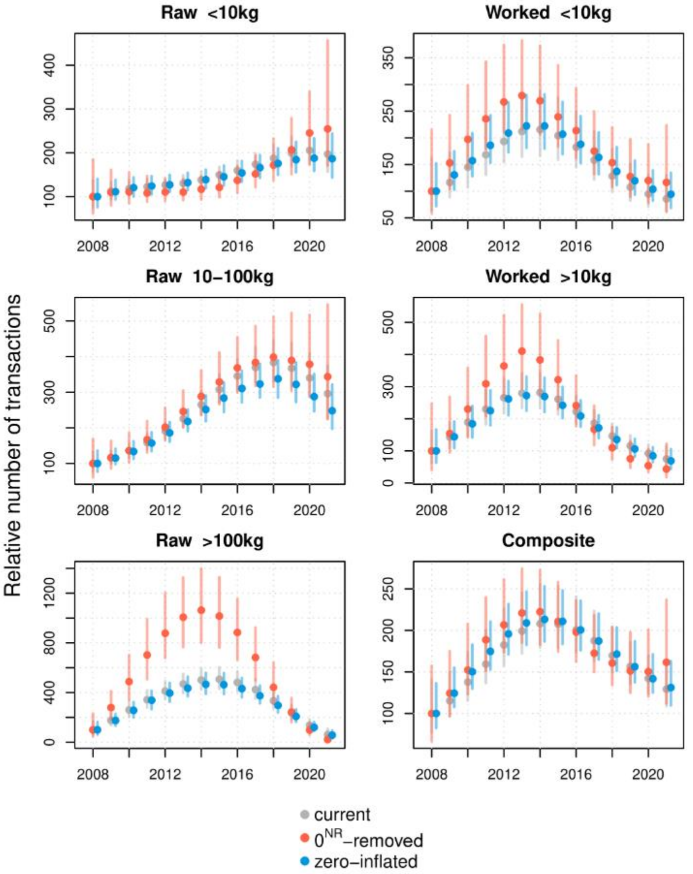

Figure 4. A comparison of Transaction Indices produced by the current ETIS model using 4th degree polynomial trends (current), the same model after removing 0^{NR} data (0^{NR}-removed), and a zero-inflated model using country- or territory-specific parameters with informative Beta priors (zero-inflated).

31. It is important to consider the meaning and implication of 0^{NR} points. Interpreting them as an absence of information supports removing them from the model. On the other hand, it might be likely that if a Party has no seizures to report, then nothing is reported. With this understanding, although a 0^{NR} provides imprecise information, it still holds value which should not be disregarded. A zero-inflated model retains 0^{NR}s and implicitly views them as either false zeros or true zeros, according to some probability. Conceptually, zero-inflation aims to integrate into the model the limitations inherent in the ETIS data and reporting processes. It seems reasonable to assume that a 0^{NR} is more likely to represent a true zero than a non-zero (proportionally, given the country and year context), although this assumption may hold stronger for some CITES Parties than others; parameterizing the zero-inflation by country can accommodate some of this variability.

Impact on reporting rate

32. The occurrence of 0^{NR} is an artefact of countries' reporting behaviour; however, a reporting rate already exists in the modelling framework. Therefore, following suggestions from the MIKE-ETIS TAG, the impacts on the reporting rate of treating 0^{NR} as a separate process were explored under the 0^{NR}-removed and zero-inflated models.

33. Figure 5 depicts the posterior distributions of the coefficients of the seizure and reporting rate covariates under the three models presented in Figure 4 (the current ETIS model, the 0^{NR}-removed model, and the zero-inflated model). Parameters b_1 and b_2 are used to model the seizure rate and parameters g_1 and g_2 are used to model reporting rate, where g_1 is the coefficient of the ETIS reporting covariate and g_2 is the coefficient of the CITES reporting score.

34. From examination of the posterior distributions of these parameters as well as those of the reporting rate (θ; Figure 6) by country and year, two insights emerge. Firstly, 0^{NR} data are valuable in informing the reporting rate; removing these data significantly altered the posterior distributions of g_1, g_2, and θ. This effect is most pronounced for g_1, the coefficient of the ETIS reporting covariate, since 0^{NR} data generate a

value of 0 for the ETIS reporting covariate. Hence, 0^{NR} data strongly influence the correlation between the ETIS reporting covariate and the observed data. Secondly, Figure 5 shows the coefficients of the reporting rate covariates under the zero-inflated model to be slightly reduced in comparison to the current model, although this translates to a small effect on the derived reporting rates seen in Figure 6. Nonetheless, some variability is removed from the reporting rate under the zero-inflated model; the following section explores the influence that the choice of prior distributions on π can have on this phenomenon.

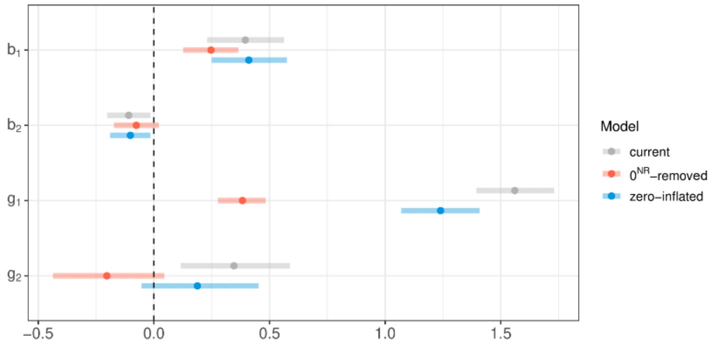

Figure 5. A comparison of the posterior distributions of the coefficients used to model the seizure and reporting rates. Medians are shown with 90% quantile-based intervals. The coefficients b_1 and b_2 model the seizure rate, while g_1 and g_2 model the reporting rate.

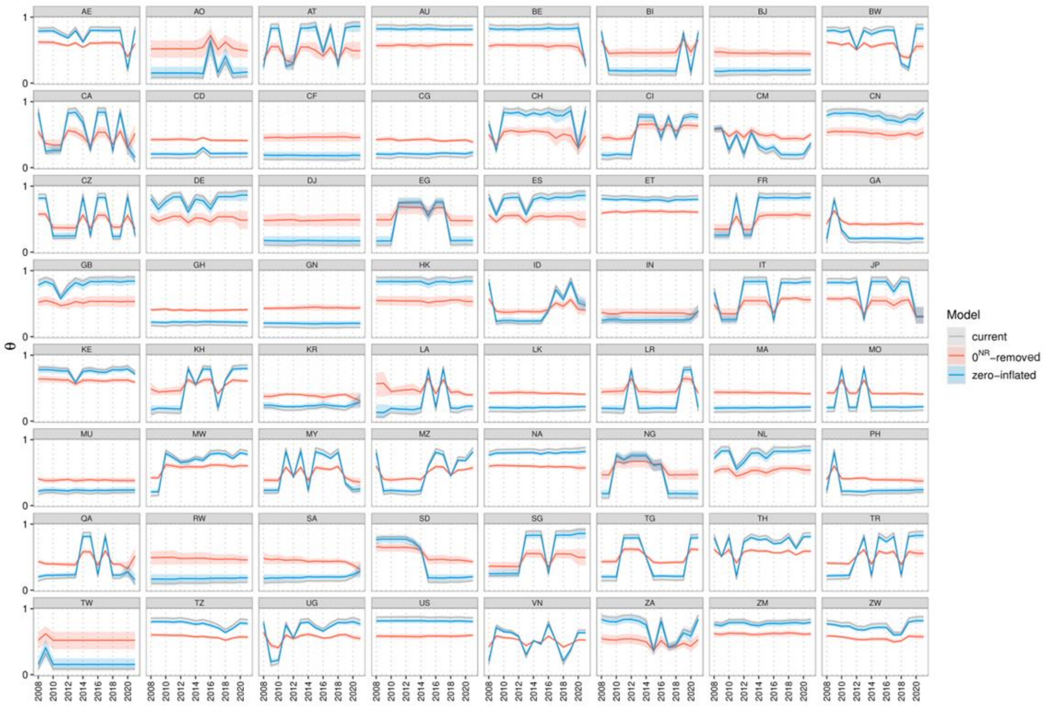

Figure 6. A comparison of the posterior distributions of the reporting rates (θ) by country and year. Medians are shown with 90% quantile-based intervals. The 0^{NR}-removed model shows the least variability in the reporting rates.

Zero-inflation parameterisation and prior distributions

35. Initially, informative prior distributions for π_i in the zero-inflated model were based on known proportions of reporting and non-reporting. In particular, let $\pi_i \sim$ Beta(α_i, β_i) and let $\alpha_i = 1 + r_i$ and $\beta_i = 1 + nr_i$ where r_i and nr_i denote the number of years for which data is and is not reported for country or territory i, respectively. Initialising the counts of α_i and β_i from 1 ensures that they are non-zero as required by the Beta distribution and implies the assignment of a non-informative Beta(1, 1) ~ Unif(0, 1) prior before any data examination. Under this strategy, a country or territory having a large prevalence of 0^{NR} data would immediately restrict the influence of its negative binomial component in the mixture model, which is where the reporting rate is learned, and the previous section revealed the importance of 0^{NR} data on the reporting rate. Alternatively, using non-informative priors should allow for a broader exploration of the negative binomial components and hence greater variability in the reporting rate to emerge. Furthermore, it was

evident from Figure 3 that the distribution of zeros varies substantially by ivory class; hence it may be reasonable to allow the model flexibility to estimate π_i separately for each ivory class (i.e., π_{ik}). This section reviews the choice of prior distributions in the zero-inflated model under three approaches: informative priors using reporting status ($\pi_i \sim \text{Beta}(\alpha_i, \beta_i)$) as previously employed, and two models with uninformative priors: the first of which accounts for variability by country or territory ($\pi_i \sim \text{Unif}(0, 1)$), and the second of which introduces further variability by ivory class ($\pi_{ik} \sim \text{Unif}(0, 1)$).

36. Figure 7 compares the posterior distributions of the coefficients for seizure and reporting rates under the three zero-inflation models. By comparing the effects on the reporting rate parameters, the model using informative priors appears to withdraw the most variability from the reporting rate. Introducing the ivory class-specific parameters with uninformative priors resulted in the least amount of variability lost compared to the current model. The posterior behaviour of π_{ik} in this model is displayed in Annex 3d and shows sensible fit to the data.

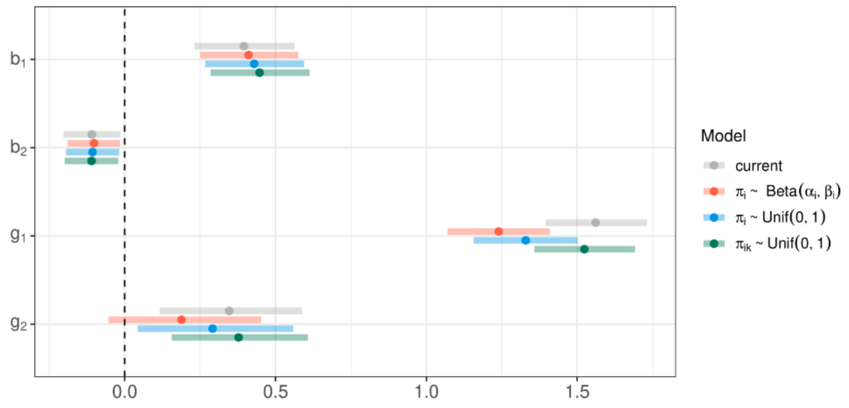

Figure 7. A comparison of the posterior distributions of the coefficients used to model the seizure and reporting rates under different zero-inflated models. Medians are shown with 90% quantile-based intervals. Three zero-inflated models using different prior distributions on π are compared against the current negative binomial model.

37. In general, justification for the ivory class-specific approach may point to a country or territory's likelihood of reporting being dependent on seizure size. Given that the ETIS model's reporting rate varies only by country or territory and year, and not by ivory class, allowing π_{ik} to vary by ivory class accounts for a different source of variability and provides distinction between the zero-inflation and reporting rate components of the model.

Summary

38. Removal of 0^{NR} data had a significant impact on the reporting rate and transaction indices, and showed poor model fit in the posterior predictive distributions. On the other hand, zero-inflated modelling retains 0^{NR} data, accounting for them in the modelling framework, and appears to avoid these issues. Consideration of the zero-inflation prior distributions showed that using informative Beta priors detracts variability from the model's reporting rate. Instead, using uninformative, country- or territory- and ivory class-specific priors retains this variability more effectively, and appears a justified approach. The proposed approach of using a zero-inflated negative binomial model with country- or territory- and ivory class-specific zero-inflation parameters with uninformative prior distributions has received the support of the MIKE-ETIS TAG.

ii. Smoothing of modelling covariates

39. An important aspect of the ETIS modelling is the bias-adjustment to seizure numbers brought by the seizure rates, φ_{it}, and reporting rates, θ_{it}, which vary by Party and year. Since these are unknown quantities, they are modelled from a collection of candidate proxy variables. One such variable which is found to be useful in modelling the seizure rate is the law enforcement (LE) ratio. This is a gauge of law enforcement effectiveness and is derived from the ETIS data by calculating the proportion of reported seizures made by a country in a given year out of all reported seizures that they had the opportunity to make. A potential modification of the LE ratio has been explored.

Sample size disparities

40. The LE ratio is defined by referring to *seizures in* and *seizures out*. We let (sz in)$_{it}$ denote the total number of seizures made *in* country or territory *i* and year *t*. That is, (sz in)$_{it}$ = $\sum_k y_{ikt}$. *Seizures out*, on the other hand, refer to seizures that are known to have originated in, exported from or transited through country or territory *i* without detection, later being seized and reported by a different country or territory. Denoting the number of these in year *t* by (sz out)$_{it}$, the LE ratio for country or territory *i* in year *t* can be expressed as

$$\text{LE}_{it} = \begin{cases} \frac{(\text{sz in})_{it}}{(\text{sz in})_{it} + (\text{sz out})_{it}} & \text{if } (\text{sz in})_{it} + (\text{sz out})_{it} > 0, \\ 0 & \text{otherwise.} \end{cases}$$

The LE ratio is therefore a proxy for law enforcement effort, as it aims to measure the proportion of reported seizure opportunities that a Party successfully makes. The one-year lagged LE ratio is used, hereafter referred to as LE1, such that a country or territory's seizure rate is inferred based on their law enforcement performance in the previous year.

41. Since it defines a proportion, the reliability and behaviour of the LE ratio depends significantly on the sample size of the total seizures *in* and *out*. Inevitably, some countries and territories play a more integral role in the illegal ivory trade than others, and therefore receive more data to inform their LE ratios. As an example, Figure 8 compares the seizure numbers and corresponding LE ratios for two Parties. Plotted are each year's seizure totals, and the LE1 covariate used in the analysis, which is calculated using the seizure totals of the previous year (i.e., lag-effect). High seizure numbers for the Party depicted in Figure 8a create reliable and consistent LE ratios, while low totals for the Party depicted in Figure 8b lead to erratic LE ratios with high variability. This highlights a possible limitation: the LE ratio itself conveys no information on its sample size. A ratio of 0.5 may equivalently result from 100/200 or from 1/2. The latter case, however, represents a much less reliable estimate of the law enforcement effectiveness.

42. The Party depicted in Figure 8b also reveals multiple years with an LE ratio of zero. For some of these years, *seizures out* were reported but no *seizures in* were reported, while for others, neither seizures *in* nor *out* were reported. Both cases lead to the same LE ratio, yet they represent different scenarios: the first implies poor law enforcement as measured by the LE ratio, while the second simply reflects a lack of information. In the ETIS data spanning 2008 - 2021 used in this exercise, 36% of the derived LE ratios are zero, with 25% resulting from the former scenario and 11% from the latter.

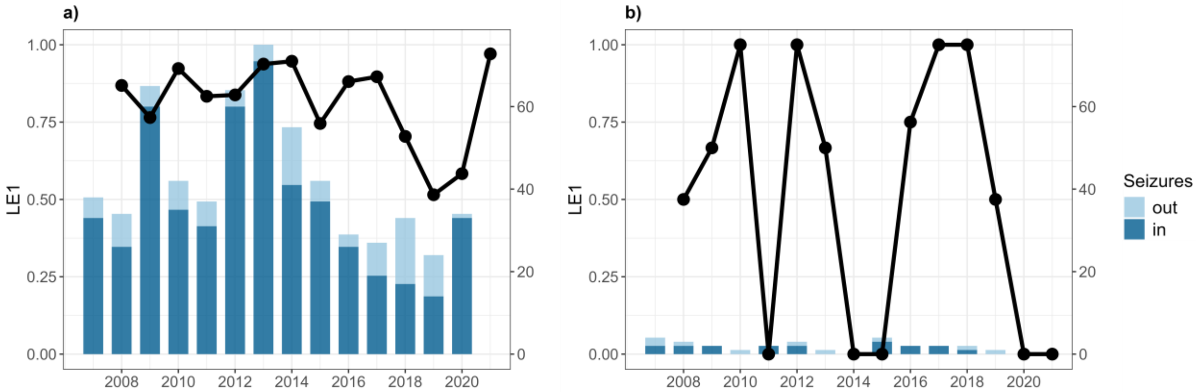

Figure 8. An illustration of the effect of seizure sample sizes on the LE ratio. The total seizures in and out (right-hand y-axes) and the corresponding LE1 covariates (left-hand y-axes) for a Party with consistent LE ratio (a) and one with more variable LE ratio (b). Note that the plotted LE1 values for a given year are based on the calculations of data from the previous year and are therefore offset by t + 1; for example, the LE1 covariate used to model 2021 data relies on the LE ratio of 2020 data, which in figure (a) consisted mostly of seizures in and therefore created a high LE1 covariate in 2021.

Exponential smoothing of seizure numbers

43. To approach the issues of small sample sizes and a lack of data feeding into the LE ratio, consideration is given to expanding its horizon beyond a single year. The modelling covariate currently used is LE1, the one-year lagged value of the LE ratio, which uses the assumption that a country's or territory's law enforcement effort is correlated from one year to the next. Extending this assumption, the two-year lagged seizure numbers can also, to a lesser extent, be informative of the current law enforcement environment, and similarly the three-year lagged values, and so on. Allowing more data to influence the LE ratio may improve its reliability as a proxy for law enforcement, and in particular help to avoid the currently common scenario in which both its numerator and denominator equal zero.

44. With this idea, the aim is to track a running average of the *seizures in* and the *seizures in* plus *seizures out* for each country or territory. A single exponential smoothing approach (Holt, 2004) provides a natural and computationally simple way to assign decreasing weights to past years' data. Labelling the initial year as t_0 and the subsequent years t_1, t_2, …, this can be constructed as follows:

$$
\begin{aligned}
s_{it_0} &= (\text{sz in})_{it_0}, \\
s_{it_j} &= \alpha_i(\text{sz in})_{it_j} + (1-\alpha_i)s_{i,t_{j-1}} \text{ for } j > 0, \\
z_{it_0} &= (\text{sz in})_{it_0} + (\text{sz out})_{it_0}, \\
z_{it_j} &= \alpha_i((\text{sz in})_{it_j} + (\text{sz out})_{it_j}) + (1-\alpha_i)z_{i,t_{j-1}} \text{ for } j > 0.
\end{aligned}
$$

Here, the variables s_{it} and z_{it} track smoothed averages of the *seizures in*, and the *seizures in* and *out*, respectively. In this way, larger seizure numbers in a particular year will carry forward more influence, while the weights assigned to the past years decrease exponentially. With these values, a smoothed LE ratio can be obtained as

$$
\widetilde{\text{LE}}_{it} = \begin{cases} \frac{s_{it}}{z_{it}} & \text{if } z_{it} > 0, \\ 0 & \text{otherwise.} \end{cases}
$$

The parameter $0 \le \alpha_i \le 1$ controls the proportional weight given to the current year's data. For example, setting $\alpha_i = 1$ places all weight on the current seizure numbers and exactly recovers the existing LE ratio for country or territory *i*. At the other extreme, using $\alpha_i = 0$ takes no account of the current data, with the result that the smoothed ratio is constant over time, $\widetilde{\text{LE}}_{it} = \widetilde{\text{LE}}_{it_0}$ for all t. Choosing $0 < \alpha_i < 1$ allows a balance to be found. Note that when $0 < \alpha_i < 1$, the smoothed LE ratio will only equal 0 if country or territory *i* reports no *seizures in* throughout the period from t_0 to t. For a year in which $(\text{sz in})_{it} + (\text{sz out})_{it} = 0$, the smoothed LE ratio inherits its value from the previous year: $\widetilde{\text{LE}}_{it} = \widetilde{\text{LE}}_{i,t-1}$. In this way, the protocol for dealing with an absence of data in the smoothed LE ratio is to revert to the most recent available data as opposed to assuming a value of zero.

45. In the following results, the smoothing parameter, α_i, is permitted to vary across countries and territories. This decision is made since the identified issues with the LE ratio stem from country or territory differences in the sample sizes of *seizures in* and *out*. Consequently, each country or territory's LE ratio can be expected to benefit from differing degrees of smoothing. Intuitively, countries or territories with low seizure numbers should benefit from a higher degree of smoothing (lower α_i), while countries or territories with high seizure numbers should require less smoothing (higher α_i). This prior intuition is difficult to quantify in distribution; therefore non-informative priors, $\alpha_i \sim \text{Unif}(0, 1)$, are assigned for each parameter.

Results

46. Fitting the model with a variably smoothed LE1 covariate leads to the posterior distributions of α_i depicted in Figure 9. These distributions are seen to be generally broad and often multimodal. Shown on the right of Figure 9 are the Parties with the largest or smallest mean value of α_i, and their smoothed LE1 values**.** In general, Parties with high seizure numbers resulted in a lower degree of smoothing, while Parties with lower seizure numbers received a higher degree of smoothing. However, it is noted also that the lower a country or territory's seizure numbers, the less impact they have on the overall model, meaning the less relevant their value of α_i. Parties with large enough seizure numbers to have a reasonable influence on the overall model, and displaying a particularly erratic LE ratio, are seen to have the highest degrees of smoothing.

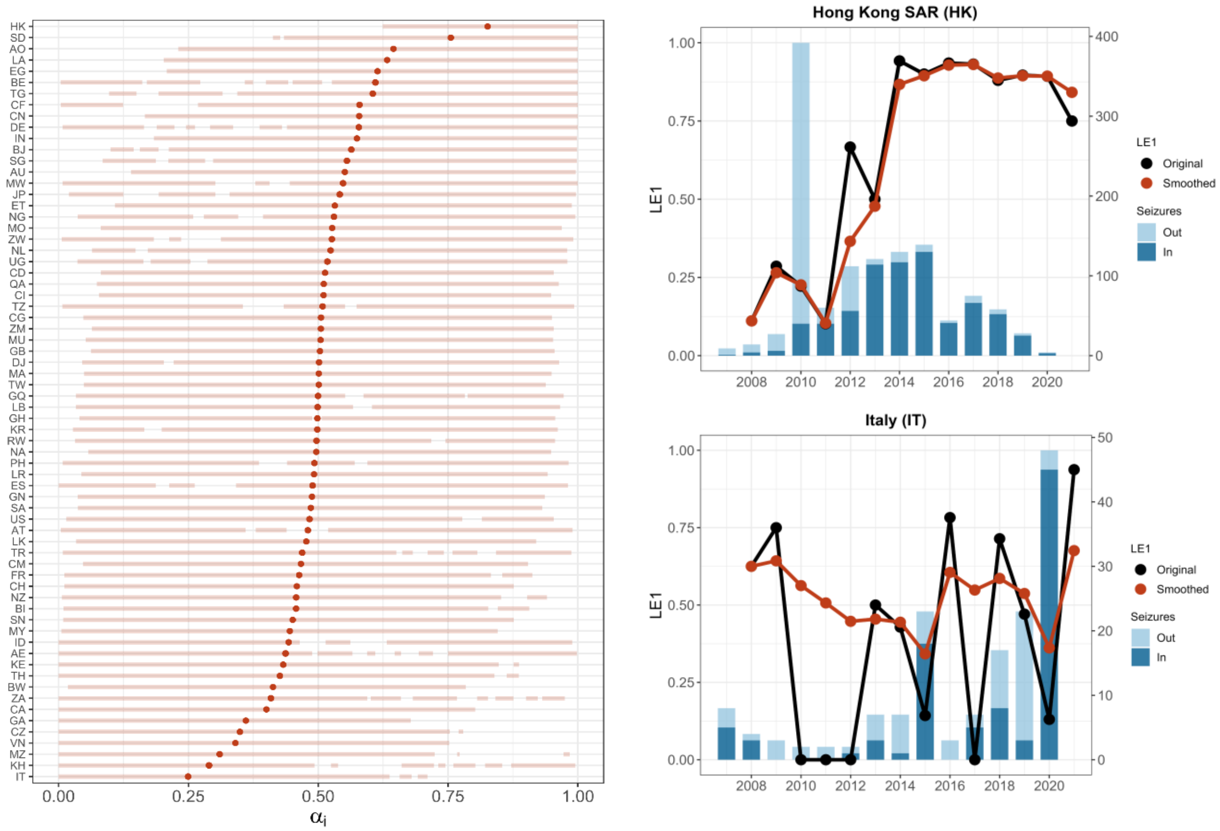

Figure 9. A comparison of the smoothing effect on the LE1 covariate for different countries and territories. Shown on the left are the means and 90% highest density regions of the posterior distributions of α_i for each country used in the analysis. The highest posterior mean is for Hong Kong SAR of China (α_i = 0.83), and the lowest is for Italy (α_i = 0.25). These countries or territories are shown on the right with their seizure numbers (right-hand y-axis) and original and smoothed LE1 ratios (left-hand y-axis) corresponding to their mean α_i. Note that the plotted LE1 values for a given year are based on the calculations of data from the previous year and are therefore offset by t + 1.

47. The large uncertainty in the posterior distributions of α_i in Figure 9 suggest that, in general, the model is not greatly affected by various degrees of smoothing being applied to the LE1 covariates. This conclusion is reinforced by Figure 10, which shows little influence on the Transaction Index when LE1 smoothing is introduced.

Summary

48. This section explored potential issues with the use of the LE ratio as a reliable proxy for law enforcement effort. These issues arise from the often small or zero totals of *seizures in* and *out* for single country- or territory-years, which can create highly variable and misleading ratios. The proposed approach to mitigate this issue involved an exponential smoothing of the seizure numbers to allow data from past years to influence the LE ratio with diminishing weight. However, results suggest that this adjustment has little overall affect. In reality, the LE1 covariate is a small component of the model, and its potential issues apply mainly to countries or territories which have low seizure numbers and make a small contribution to the overall Transaction Index (TI). Instead, the TI is driven by countries or territories which report many seizures, and for which the derived LE ratios can be assumed to be reliable proxies for law enforcement effectiveness. For this reason, adjustments aimed to improve the LE1 covariate for under-represented countries or territories may be seen as low impact and low priority. The adjustment explored in this section makes the LE ratio less intuitive while not providing clear benefits. This conclusion was supported by the MIKE-ETIS TAG, and this development will not be implemented in the ETIS modelling.

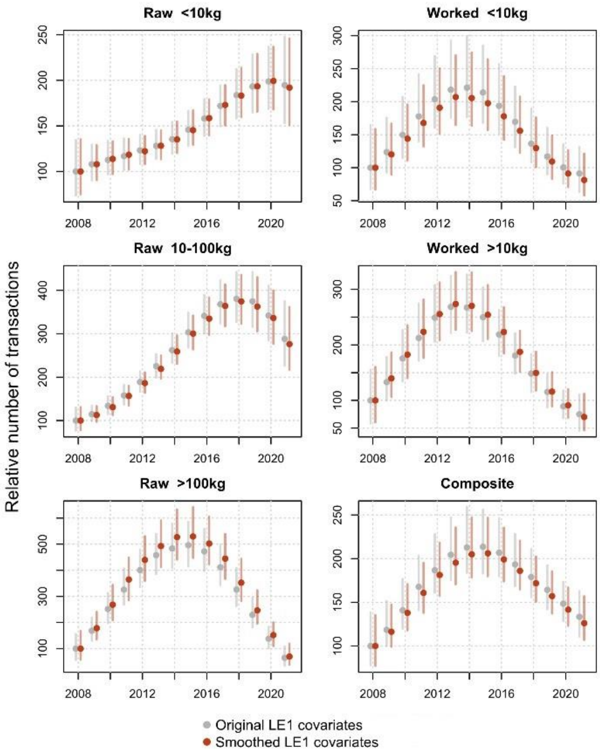

Figure 10. A comparison of Transaction Indices with (red) and without (grey) exponential smoothing in the LE1 covariate.

iii. Trend smoothing with spline regression

49. In the previously established ETIS model, smoothness in the Transaction Index (TI) trends over time was implemented by fitting a polynomial function of *t* to log(λ_{ikt}). Limitations of the polynomial method have been explored, leading to the development of an alternative approach using spline regression.

Properties of a polynomial trend

50. Polynomial regression allows for modelling the trend in seizure numbers over time with a non-linear relationship. However, as a global regression technique, it applies a single function to model the trend across the entire range of data. As a consequence for the TI, this results in a fit which is highly dependent across its time range, meaning that the data from a single year can influence the trend estimates far into the past and future.

51. The ETIS trend analysis is conducted every one to two years to present updated trends to the CITES Parties. Therefore, the non-robustness of the polynomial trend model can be problematic, as the inclusion of additional years of data can affect estimates of the historical trend. This phenomenon is demonstrated in Figure 11, which shows two separate model outputs using the polynomial trend, the first using data from 2008 to 2019, and the second updated to include the additional years of 2020 and 2021. The data and bias-adjustment covariates spanning 2008 to 2019 are identical across the two implementations, and every other aspect of the models are also kept consistent. However, the addition of new data covering 2020 and 2021 is seen to affect the trend prior to 2019. The deviation is notable in the category of small worked ivory, in which the peak of the TI appears to shift. This category contributes the highest number of total seizures in the ETIS records, and thus also drives the composite TI.

52. Another potential drawback of the polynomial modelling approach is its limited flexibility in capturing different trend dynamics across countries and territories. In the trend equation (equation (3)), the coefficients for the first two polynomial terms (the intercept and linear trend) are allowed to vary by country or territory and ivory class, but the coefficients for the higher-order terms are held constant across all countries and territories. While this simplification aims to maintain model parsimony and may be justified by the relatively smaller contribution of the higher-order terms, it limits the model's ability to capture more nuanced differences in the seizure trends of individual countries and territories.

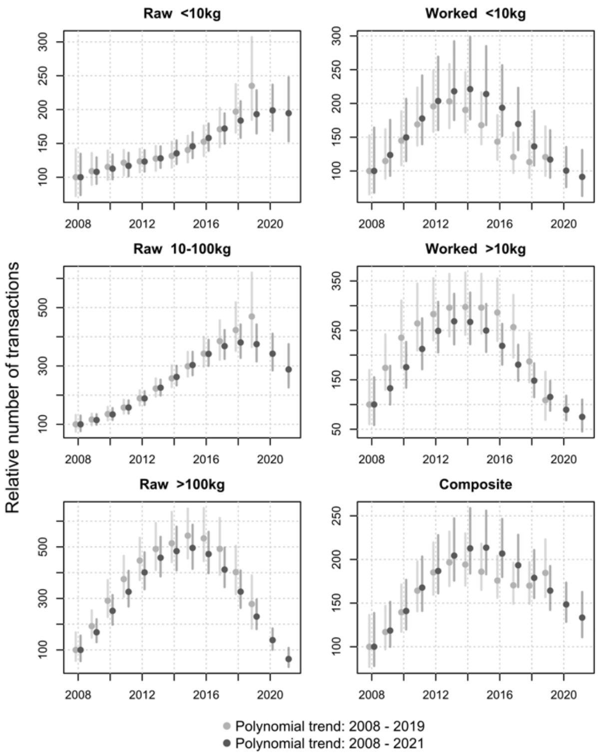

Figure 11. A comparison of Transaction Indices with the addition of extra years' data when using a polynomial trend model.

Spline regression

53. The limitations of the polynomial trend equation discussed above could be addressed to some extent by moving to spline regression. Splines, which can be understood as piecewise polynomial functions, segment the data with a series of *knot* points and fit separate polynomial functions to the data within each segment. This allows for greater flexibility in capturing localised trends and is often preferred over polynomial regression for this reason (Hastie, Tibshirani, & Friedman, 2009). The polynomials within each segment of a spline function are not independent, since they are constrained to join smoothly at the knot points to produce an overall smooth function. However, compared to a single polynomial, the influence of data points on the fitted curve in different segments is less direct. As a consequence, splines can provide more localised TI trend modelling, and therefore offer greater stability of the historical trend when incorporating additional data in updated analyses. The remainder of this section outlines the technical set-up and implementation of a spline regression approach for TI modelling.

Model set-up

54. A common representation of a spline function is through a linear combination of B-spline basis functions (De Boor, A Practical Guide to Splines, 1978). These basis functions form a set of localised functions, each of which takes non-zero values only over a limited range of the data. A spline of degree d with K knot points requires $d+K+1$ B-spline basis functions, $\{B_c(t)\}$. Under this representation, a spline trend on the values of $\log(\lambda_{ikt})$ can take the form

$$\log(\lambda_{ikt}) = \sum_{c=1}^{d+K+1} \alpha_{ikc} B_c(t).$$

This equation represents a spline model for every country or territory, i, and ivory class, k. The sharing of coefficients across countries, as occurs in the existing polynomial model, is less natural here. Although this results in a larger number of parameters, maintaining separate coefficients allows for the flexibility to fit independent trend models for each country or territory.

55. Maintaining consistency with the framework of the previous polynomial model, the set-up of the coefficient parameters is as follows. For country or territory i, let $\boldsymbol{\alpha}_{ic} \sim \text{MVN}(\boldsymbol{\mu}_c, \boldsymbol{\Omega}_c)$ denote the coefficients of $B_c(t)$ in the trend for each ivory class, and let $\boldsymbol{\mu}_c \sim \text{MVN}(\mathbf{0}, 10^4\boldsymbol{I})$. The covariance matrices, $\boldsymbol{\Omega}_c$, account for correlated

trends among the ivory classes, and are modelled as $\boldsymbol{\Omega}_c^{-1} \sim$ Wishart($\boldsymbol{R}_c$, 5), where the diagonal scale matrices, $\boldsymbol{R}_c$, reflect prior variance estimations from the data.

56. The B-spline basis functions, $\{B_c(t)\}$, are uniquely defined by the Cox-de Boor recursion formula (De Boor, 1972), depending on two key factors: the spline degree and the knot vector. These represent structural choices in the creation of a spline function. The spline degree indicates the degree of the polynomial components, while the knot vector determines the number and placement of the knot points. In practice, cubic splines with degree d = 3 are often preferred, with the added flexibility brought by the piecewise fit precluding the need to use higher-order polynomials (Hastie, Tibshirani, & Friedman, 2009). The number and placement of knots remains a choice; consultation with the MIKE-ETIS TAG recommended exploring different options for the number and frequency of knots while being mindful of the potential for overfitting.

Knot placement

57. A common recommendation when applying spline models is to use a uniform knot vector, in which the knot points are equally spaced (De Boor, A Practical Guide to Splines, 1978). This approach is generally appropriate unless there is a specific need for additional flexibility in a particular region. In the context of ETIS trend modelling, the equally spaced discrete-year data points seem to support the selection of a uniform knot vector. However, following the suggestion by the MIKE-ETIS TAG statisticians, the choice of knot placements is explored by comparing two approaches: (1) placing knots with regular spacing along the time series - e.g., placing 3 knots at 2011.25, 2014.5, and 2017.75 for the time series spanning 2008 to 2021 (*Uniform vectors* in Table 1); and (2) placing knots at specific years with a fixed frequency - e.g., placing 3 knots every 4 years at 2012, 2016, and 2020 (*Specific years* in Table 1). Table 1 shows the results of information criteria (see Annex 3b for details) for each *Uniform vectors* and *Specific years* model considered, and Figure 12 shows the TI for the first three of these models under each approach (see Annex 3e for TIs from the rest of the models (Figure 1 in Annex 3e), as well as posterior predictive distributions from all models (Figure 2 in Annex 3e)).

Table 1. Information criteria for spline models with increasing knot frequency under the Uniform vectors and Specific years approaches.

Model	Placement approach	No. of knots	Knot values (years)	Mean deviance	DIC	WAIC	LOOIC
Uniform vectors		1	2014.5	9733	11172	10394	10528
		2	2012.33, 2016.67	9615	11349	10375	10560
		3	2011.25, 2014.5, 2017.75	9545	11411	10365	10583
		4	2010.6, 2013.2, 2015.8, 2018.4	9491	11760	10380	10651
		5	2010.17, 2012.33, 2014.5, 2016.67, 2018.83	9414	12001	10368	10687
		6	2009.86, 2011.71, 2013.57, 2015.43, 2017.29, 2019.14	9411	12391	10429	10804
Specific years	Every 7 years	1	2015	9735	11129	10397	10528
	Every 6 years	2	2014, 2020	9727	11549	10451	10628
	Every 5 years	2	2013, 2018	9656	11582	10412	10598
	Every 4 years	3	2012, 2016, 2020	9563	11417	10367	10589
	Every 3 years	4	2011, 2014, 2017, 2020	9469	11819	10357	10631
	Every 2 years	6	2010, 2012, 2014, 2016, 2018, 2020	9424	12437	10424	10789

58. Examining model outputs (including posterior predictive plots in Annex 3e) and diagnostics suggests that: (1) increasing frequency of knots can lead to overfitting, (2) across both approaches, there was little variation in the overall Transaction Index trends, with the exception of models for which a knot fell on the year 2020 (an abnormal year of ETIS data due to the impacts of the COVID-19 pandemic). It is noted that a knot on the year 2020 results in the final spline segment involving only two points, which may be insufficient for the flexibility of a cubic polynomial. Four points are required to uniquely fit a cubic polynomial; based on this, it is suggested to ensure at least four points, including knot points, comprise each segment. For example, for the time series beginning in 2008, the first knot should come after 2010 to ensure three data points and a knot comprise the first segment. Under both approaches, this rule would exclude the 6-knot model from consideration, while under the specific years approach, knots at 2020 would often be removed.

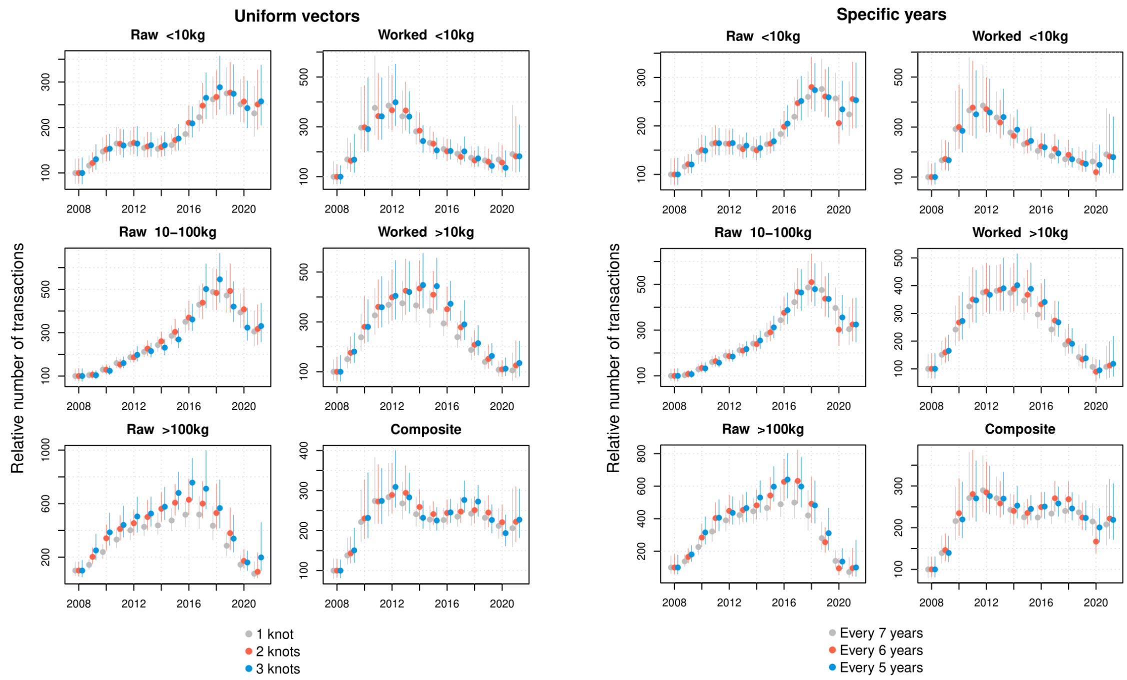

Figure 12. A comparison of Transaction Indices from spline models with various knot placements. Left: the first three of the Uniform vectors models listed in Table A1. Right: the first three of the Specific years models listed in Table A1.

Model averaging

59. The issue of final model selection concerning the number of knots remains. Several factors including MCMC convergence diagnostics, credible intervals, posterior predictive checks, and information criteria should be considered; however, the use of model averaging is explored as a way to avoid subjective decisions and mitigate biases produced by the knot placements of an individual model.

60. The use of model averaging recognises uncertainty in the identification of a single most appropriate model. From the collection of models M_1, M_2, …, M_J, the distribution of a quantity of interest in the averaged model, $\bar{M}$, is a convex linear combination ($w_j \geq 0$ and $\sum_j w_j = 1$) of the corresponding distributions of the individual models:

$$p(\cdot\,|\bar{M}) = \sum_{j=1}^{J} w_j\, p(\cdot\,|M_j).$$

The model weights, w_1, w_2, …, w_J, can equivalently be interpreted as probabilities. To implement model averaging, n samples from the averaged model's posterior distributions can be obtained by drawing nw_j samples from the posteriors of each model, M_j. Various methods to derive appropriate model weights have been considered in the literature (see for example Dormann, Calabrese, Guillera-Arroita, & others (2018)).

61. Importantly, model averaging can eliminate the need for the analyst to make a subjective decision selecting a single knot placement, thus making the model-fitting process more objective. Moving away from using a single model, uniform vectors become a more sensible choice than the non-uniform vectors of the 'specific years' approach. The model weights assigned to the five uniform vector models in consideration (given the rule suggested above) under three approaches to model averaging are shown in Table 2. This includes a psuedo-BMA approach using $w_j \propto \exp\{-½\text{LOOIC}_j\}$, the same approach using Bayesian bootstrap sampling (referred to as pseudo-BMA+), and a stacking of posterior predictive distributions to maximise the log pointwise predictive density. Further details of these approaches can be found in Annex 3f. Briefly, each method estimates the expected log pointwise predictive density of the models; the pseudo-BMA (and pseudo-BMA+) weights directly reflect the LOOIC comparison, while stacking is designed for predictive accuracy. As such, the former two methods concentrate weight on the one-knot model (Table 2), while stacking appears to draw useful features (i.e., knot placements) from a more diverse collection of models. Pseudo-BMA is understood to be sensitive to the model set, while stacking provides a more robust approach; its solution depends only on the space spanned by the candidate models. Stacking is concluded as the appropriate version of Bayesian model averaging in the case when the true data generating model

is not specified (Yao, Vehtari, Simpson, & Gelman, 2018), and is thus the method adopted for the ETIS modelling.

Table 2. Model averaging weights, under three methods, for the uniform vectors spline models with varying numbers of knots.

Model	No. of knots	LOOIC	Weights Pseudo-BMA	Pseudo-BMA+	Stacking
Cubic spline with uniform vectors	1	10528	1	0.896	0.673
	2	10560	0	0.091	0
	3	10583	0	0.013	0.060
	4	10651	0	0	0
	5	10687	0	0	0.267

Summary

62. Spline functions have been introduced as an alternative to polynomials for modelling the trends in log(λ_{ikt}) over time, offering the potential to address the existing limitations in the polynomial trends, particularly in terms of stability and flexibility. The proposed approach involves using cubic splines with ivory class and country- or territory-specific coefficients to allow greater flexibility in modelling trends.

63. Uniform knot vectors are chosen as the strategy for knot placement. However, to avoid subjective decisions in selecting a single model, statistical model averaging is applied across a collection of candidate models with varying numbers of knots. To discourage overfitting and ensure that the data can support the chosen models, a guideline is introduced requiring each knot segment to contain at least four points, including endpoints (knots). This provides a practical stopping rule on the number of models to be considered for model averaging, dependent on the length of the analysis period.

64. Stability of the TI trend was discussed with the TAG as an advantage of the splines over the previous polynomials. To demonstrate this, Figure 13 shows the TI from the model-averaged spline models when using data up to 2019 compared to the full time series up to 2021, and shows consistent trends (compare this with the polynomial models seen in Figure 11). For the time series ending in 2019, the permissible 1- to 4-knot models received weights of 0.738, 0.163, 0, and 0.098, respectively.

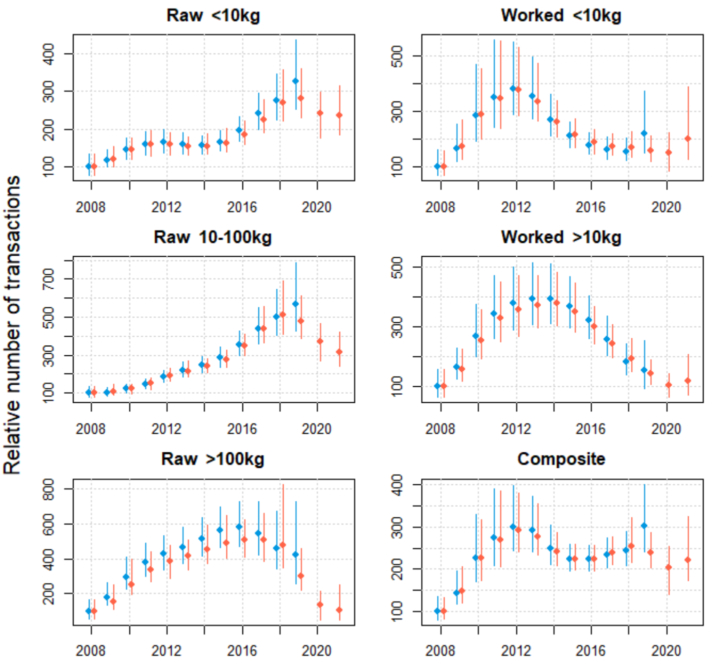

Figure 13. A comparison of Transaction Indices with the addition of extra years' data when using averaged spline models.

iv. Revision of ivory weight classes

65. The Transaction Index (TI) is divided into weight classes of raw and worked ivory to provide insights into more specific trends in the global ivory trade. However, there are clear imbalances in terms of the number

of seizures across these classes. For example, in the latest ETIS data for the years 2008 – 2023 (downloaded on 26 September 2024), the small (< 10 kg), medium (10 – 100 kg), and large (≥ 100 kg) raw ivory classes included approximately 49%, 44%, and 7% of the raw ivory seizures in the analysis, respectively. Meanwhile, the small (< 10 kg) and large (≥ 10 kg) worked ivory classes included approximately 94% and 6% of the worked ivory seizures, respectively. The large classes of raw and worked ivory contain significantly fewer seizures and, accordingly, exhibit many more zero counts by country or territory and year (see Figure 3). This data sparsity reduces the reliability of the trend models and makes it less likely for parameters to converge in these classes.

66. Revising the weight classes is considered as a means to address model-fitting issues caused by class imbalances while preserving relevance to the aspects and characteristics of the global ivory trade. In the raw ivory categories, the current thresholds of < 10 kg, 10 – 100 kg, and > 100 kg may, respectively, reflect seizures of one or two pieces or tusks from small poaching incidents, seizures of multiple pieces that may indicate the consolidation into larger illegal stocks, and large-scale operations often linked to organized crime. Despite the smaller proportion of raw ivory seizures in the largest weight class, these interpretations are meaningful and offer limited scope for an adjustment of the class thresholds. For worked ivory, however, the 10 kg threshold represents a relatively large seizure, especially in light of trends showing that the reported weights of worked ivory seizures appear to have decreased over time (see Figure 14). Through the 1990s, the central spread of worked ivory weights often fell between 1 kg and 10 kg. Since the early 2000s, however, these distributions have centered more towards 1 kg, and over the past six years in particular, the central distribution has consistently fallen below 1 kg. These patterns perhaps reflect trends which see worked ivory items of smaller size and an increase in global travel and seizures of small worked items transferred in personal luggage.

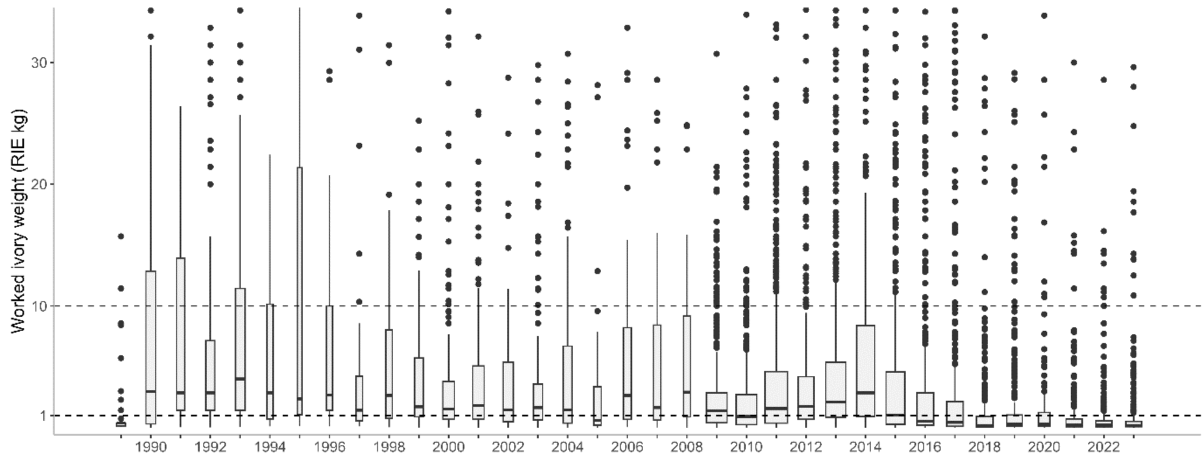

Figure 14. The distribution of reported weights (Raw Ivory Equivalent[16]) over time for worked ivory seizures. The widths of the boxplots are proportional to the square root of the sample size, and the y-axis is truncated at the upper end to enhance the visibility of the central distributions.

Summary

67. To respond to observed trends in the reported weights of worked ivory seizures, it is proposed to reduce the class threshold for worked ivory from 10 kg to 1 kg. This adjustment received the support of the MIKE-ETIS TAG. For the latest ETIS trend model (see document SC78 Doc 65.1), Figure 15 shows the distribution of seizure weights used in the analysis, with both the previous and proposed worked ivory weight thresholds indicated. The adjustment appears to be better supported by the data and enhances the interpretation of the small weight class as reflecting seizures of individual worked items such as jewellery and ornaments.

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[16] *In the ETIS analysis, worked ivory weights are converted to Raw Ivory Equivalent (RIE) weights by dividing by a conversion factor of 0.7 to account for approximately 30% wastage when raw ivory is worked (SC74 Doc. 68 Annex 1c).*

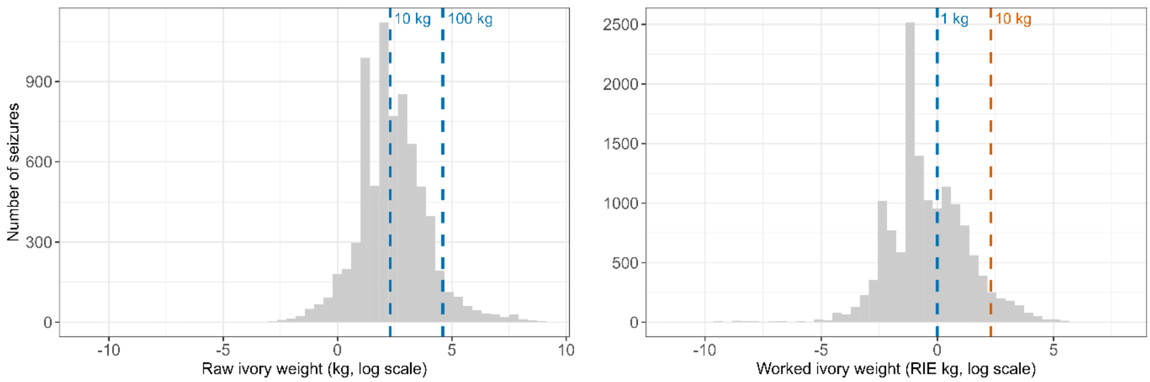

Figure 15. The distributions of seizure weights used in analysis. Histograms show the raw (left) and worked (right) seizure weights (reported and estimated) for the data covering 2008 – 2023 used in the latest ETIS trend analysis, with the previous (orange) and proposed (blue) class thresholds marked. No change is proposed to the raw ivory thresholds.

v. Weight estimation modelling

68. In the ETIS database, quantity information, whether the weight or the number of pieces, is required for an ivory seizure to be considered valid for analysis. Of these, weight is crucial as it is used to summarize the total amount seized (see for example Figure 3, SC78 Doc 65.1) and to categorize seizures into the raw and worked ivory weight classes displayed in the Transaction Index (TI). However, many seizure records do not provide weight information, requiring instead the use of a weight estimation model.

69. The weight estimation model uses records (of seizures made from 1996 onwards) that provide both the number of pieces and the weight as a training data set to develop a model that estimates the weight for records that provide only the number of pieces. The previously used weight estimation model applies a polynomial regression on the log-transformed number of pieces, with a Box-Cox transformation of the target weight variable. The degree of the polynomial is selected to minimize the Akaike Information Criterion (AIC), and separate models are fitted for raw and worked ivory.

70. Initial explorations considered whether seizure year should be included as a continuous variable in the weight estimation models, given suggestions that tusk size and worked piece sizes may have varied over time. The boxplots in Figure 16 show the yearly distributions of weight per piece for seizures of raw and worked ivory that reported both quantities, i.e., the weight estimation models' training sets. The raw ivory seizures show a consistent weight-per-piece distribution over time, whereas the worked ivory seizures display noticeably lower distributions over the past decade.

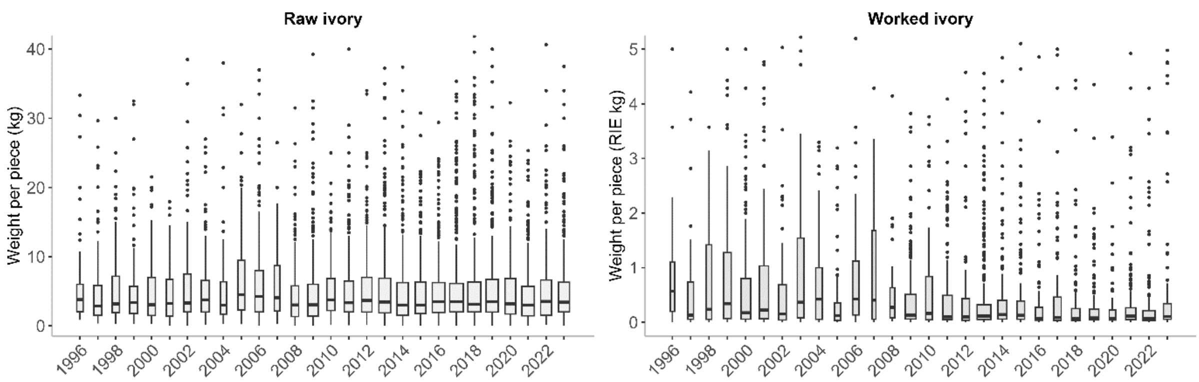

Figure 16. The distributions of weight per piece over time. Boxplots include seizures of raw (left) and worked (right) ivory reporting both quantities, thus serving as a training set for the weight estimation models. The widths of the boxplots are proportional to the square root of the sample size, and the y-axes are truncated at the upper end to enhance visibility.

Trends in weight reporting over time

71. Concerns arose through discussion with the MIKE-ETIS TAG that the time-varying patterns seen in the data may equally reflect reporting biases in the training set. The trends in the quantity reporting behaviours

(only pieces, only weight, and both) over time for seizures of raw and worked ivory are shown in Figure 17. Records with *Only pieces* reported (orange bars) represent records requiring weight estimation, while records with *Both* pieces and weight quantities reported (grey bars) represent training data for the weight models. Figure 17 suggests that Parties report both quantities (grey) more often for raw ivory compared to worked ivory, and that seizures of worked ivory greatly increased after 2008[17], with the proportion of seizures reporting weight also improving with this increase. Further possible reporting biases in the ETIS data are investigated:

Reporting differences by Party

72. Figure 18 provides a breakdown of quantity reporting for raw and worked seizures by a sample of Parties. For raw ivory, few Parties (with more orange bars) primarily report only weight as the seized quantity of ivory, while other Parties (with more blue bars) primarily report the number of pieces; other Parties report both (grey bars), and the reporting patterns can change over time as evident in the examples plotted in Figure 18. Similar trends and variations are observed in the reporting of quantity information for worked ivory, suggesting there is little consistency in the reporting practices of various Parties over time (see also document SC78 Doc 65.1). Therefore, the varying temporal patterns that emerge in the weight models' training data may not reflect genuine changes in the global weight-pieces relationship.

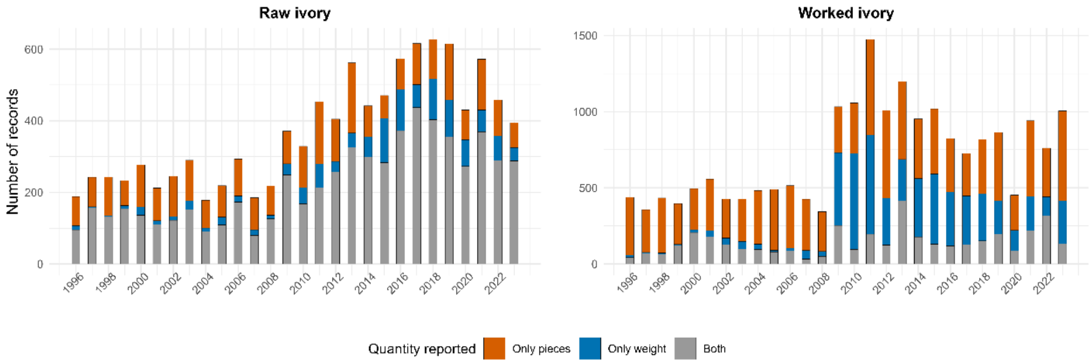

Figure 17. Trends in quantity reporting over time. Numbers of seizures reporting only pieces (orange), only weight (blue), and both pieces and weight (grey) for raw (left) and worked (right) ivory. An increase is noted in the numbers being reported since 2008[17], most notably in worked ivory.

Figure 18. Trends in quantity reporting over time for a sample of individual Parties. Numbers of seizure records for raw (left) and worked (right) ivory, with breakdown by country or territory, year, and quantity reporting. Displayed are the 15 countries or territories with the highest total number of seizures for raw or worked ivory since 1996. Note the differing scales on the y-axes.

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17 *It is noted that 2008 marks the one-off sale of ivory from Botswana, Namibia, South Africa and Zimbabwe to China and Japan (https://cites.org/eng/news/pr/2008/080716_ivory.shtml)*

Reporting differences by quantity element

73. Additionally, boxplots in Figure 19 explore the possibility of differences in quantities reported over time for seizures that report only number of pieces (the estimation set; orange boxplots), only weight seized (blue boxplots), or both quantity elements (the training set; grey boxplots). In the top row, records reporting both weight and pieces appear to contain generally greater numbers of pieces than records which only report pieces. This perhaps suggests an under-representation of small-piece seizures in the training data for both raw and worked ivory. The corresponding comparison of weight with records which only report weight (bottom row) is less clear, with possible variations in the relationship over time. In general, however, the boxplot comparisons in Figure 19 indicate that the training data is not necessarily representative in terms of weight and pieces quantities.

74. Given the reporting behaviour and quantity patterns apparent in the training data, caution should be taken if including time as a continuous predictor variable. Furthermore, the distinct change in reporting behaviour since 2008[17] (see Figures 16 and 17) perhaps points to an appropriate shorter time period for the training set. The current and recent ETIS analyses have included data since 2008 (see ETIS reports to SC74 and CoP19); hence, with less need to estimate seizure weights pre-2008, the weight estimation training sets can reasonably be restricted to exclude these records.

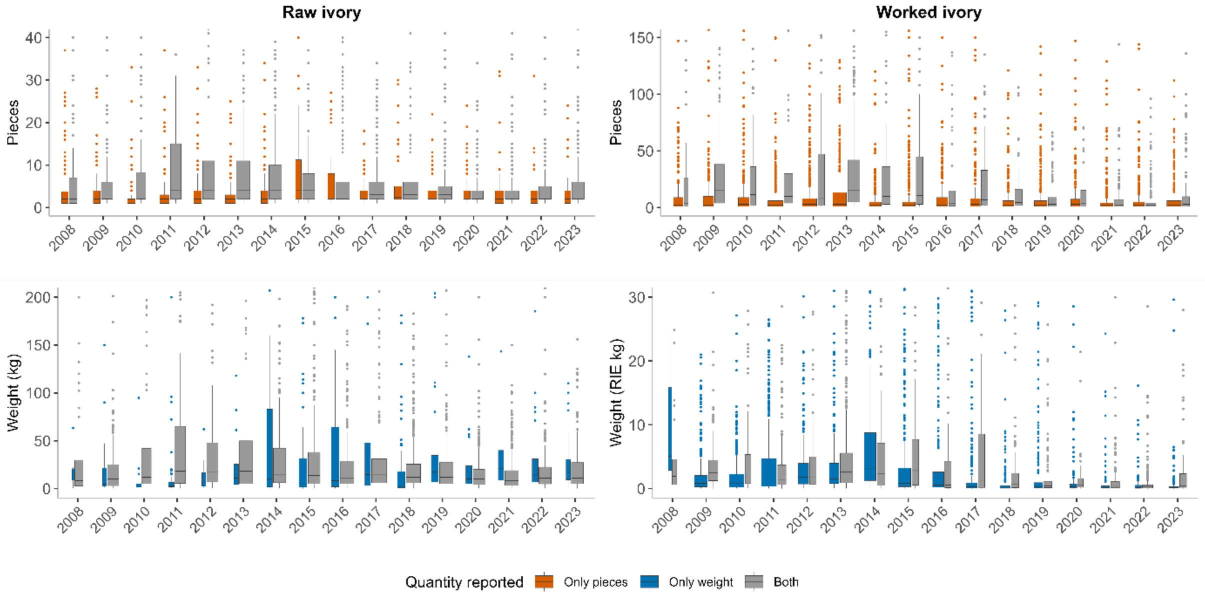


Figure 19. Distributions of quantity information for seizures reporting only pieces, only weight, or both pieces and weight. Top row: boxplots comparing the distributions of the number of pieces between seizures reporting only pieces (orange) and seizures reporting both pieces and weight (grey) over time since 2008. Bottom row: boxplots comparing the distributions of weight between seizures reporting only weight (blue) and seizures reporting both pieces and weight (grey) over time. The comparisons are separated for raw ivory (left) and worked ivory (right). Boxplot widths are proportional to the square root of the sample size, and the y-axes are truncated at the upper end to enhance visibility of the boxplots.

Exploring the utility of keyword predictors

75. The distributions shown in Figure 16 revealed large variability in seizure weight per piece, largely due to the fact that a reported number of pieces may refer to anything from whole tusks to cut or worked pieces of various sizes. This distinction is not explicitly available, though analysis of a free text *ivory comment* field can sometimes offer insights. The ivory comment is an optional field in the ETIS database which allows data providers to give a written description of the seized ivory. Figure 20 summarizes the reporting of ivory comments for raw and worked seizures, showing generally good reporting rates, particularly for worked seizures. However, the contents of the ivory comment field, in terms of the keywords used, may be subject to changes in reporting habits over time; Party-specific biases, as seen in other aspects of the data, are likely to again be present.

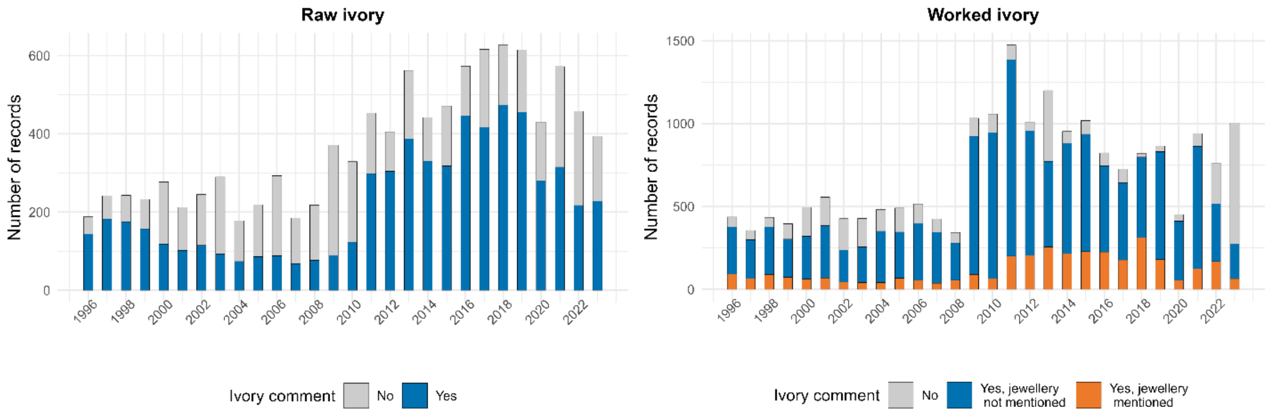


Figure 20. Trends in ivory comment reporting over time. Numbers of seizures reporting an ivory comment (blue) for raw (left) and worked (right) seizures over time. For worked seizures reporting an ivory comment, the number of seizures indicating jewellery in the ivory comment field are also shown.

76. The word clouds in Figure 21 illustrate the relative frequency of keywords appearing in the ivory comment fields for raw and worked seizures. Raw seizures frequently mention whole or cut pieces of tusks, while worked seizures often describe products, carvings, and jewellery. Binary variables, indicating the presence or absence of particular keywords in a seizure's ivory comment field, were explored to assess their potential predictive value for the weight estimation models.

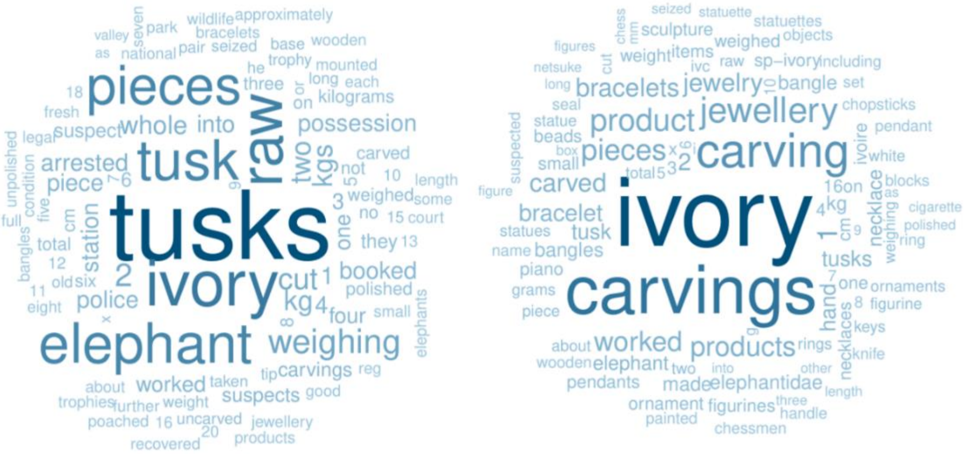


Figure 21. Word clouds for ivory comment reporting. Word clouds show the relative frequency of words appearing in the 'ivory comment' field of ETIS seizure records for raw (left) and worked (right) ivory. Common connective words have been removed.

77. Exploring the prediction value of keywords suggested that keywords were not especially meaningful or relevant as predictors for raw ivory. However, for worked ivory, which can range from large carvings to small ornaments and jewellery, the ivory comment is often more informative. To understand the potential for keywords to be used as predictors for worked ivory weight modelling, the weight-per-piece behaviour with and without particular keywords was further explored. The most discriminative keywords found related to jewellery; Figure 22 shows boxplots of the weight-per-piece distribution over time for worked seizures with jewellery mentioned (orange) or not mentioned (blue) in the ivory comments since 2008[18]. Among worked seizures with both weight and pieces reported, the jewellery indicator often accompanies seizures with lower weights per piece. Factoring also its reasonably consistent reporting behaviour throughout the recent period since 2008 (Figure A18; orange bars), jewellery may represent a useful (and interpretable) predictor for worked ivory weights.

[18] *Based on keyword frequencies, the jewellery indicator is positive if the ivory comment contains any of the following words: "jewellery", "jewelry", "bracelet", "necklace", "bangle", "ring", "earring", or "pendant".*

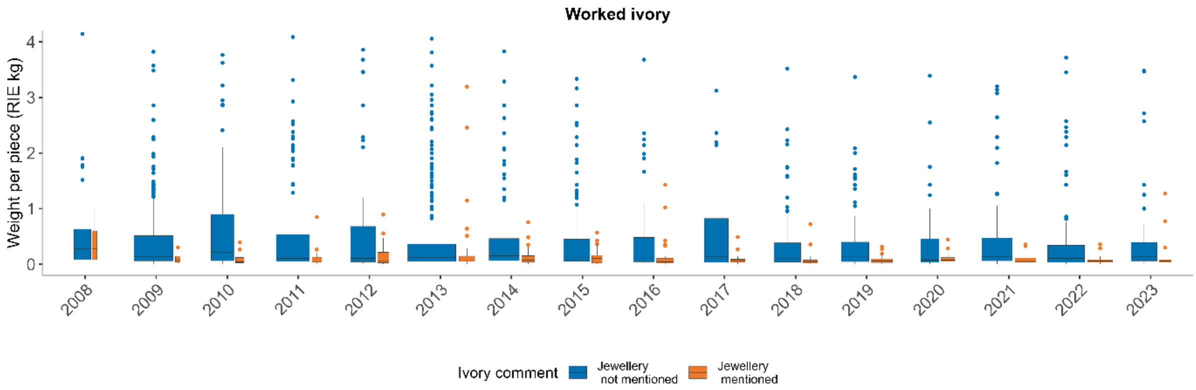


Figure 22. A comparison of the distributions of weight per piece for worked ivory when jewellery is and is not identified in the ivory comment. Boxplots include worked ivory seizures reporting both weight and number of pieces since 2008, grouped according to whether their ivory comment includes jewellery keywords (orange) or not (blue). The latter case includes seizures reporting no ivory comment. Boxplot widths are proportional to the square root of the sample size, and the y-axis is truncated to remove more extreme outliers and display the boxplot comparison.

Weight models

78. To fit the weight models, a variety of statistical and machine learning regression and classification methods were explored, although the differences in results were minimal. Following consultation with the MIKE-ETIS TAG, it was agreed to replace the previously used polynomial models with cubic spline models. To aid consistency in the weight estimation across analyses, the TAG recommended selecting the knots once and not revisiting this decision with each analysis. Experiments revealed that this choice had little impact on results, although three knots were selected to allow sufficient flexibility to the models' fit. Rather than using uniform knot vectors which would be subject to change with additional data, fixed knot points have been selected (see Figure 23 for details). Additionally, natural spline functions have been applied to enforce linearity beyond the range of the data and avoid potentially unrealistic weight estimates if extrapolation is required.

79. The model for raw ivory seizures is expressed as follows:

$$y_i = \mu + \sum_{c=1}^{6} \beta_c B_c(x_i) + \varepsilon_i,$$

where x_i denotes log(pieces + 1) for the i^{th} seizure, and $\{B_c()\}_c$ represent the set of B-spline basis functions (without intercept). To encourage a normal error distribution, the target variable, y_i, is obtained after applying a Box-Cox transformation to the seizure weight, w_i:

$$y_i = \begin{cases} (w_i{}^{\lambda} - 1)/\lambda & if\ \lambda \neq 0 \\ \log(w_i) & if\ \lambda = 0 \end{cases},$$

where the exponent, λ, is estimated via maximum likelihood. When back-transforming the predictions of $\hat{y}_i$ to the weight in kg, $\hat{w}_i$, a bias-correction term can be applied to account for the skewed residual distribution created by the direct back-transformation (Hyndman, 2018):

$$\hat{w}_i = \begin{cases} (\lambda\hat{y}_i + 1)^{1/\lambda}\left[1 + \dfrac{\sigma_i{}^2(1-\lambda)}{2(\lambda\hat{y}_i + 1)^2}\right] & if\ \lambda \neq 0, \\ \exp(\hat{y}_i)\left[1 + \dfrac{\sigma_i{}^2}{2}\right] & if\ \lambda = 0, \end{cases}$$

where σ_i^2 is the local prediction variance.

80. For worked ivory, the model includes a binary factor variable indicating whether jewellery keywords are detected in the ivory comment field:

$$y_i = \mu + \sum_{c=1}^{6} \beta_c B_c(x_i) + \gamma z_i + \varepsilon_i,$$

where $z_i = 1$ if the ivory comment of the seizure *i* contains a jewellery keyword[18], and zero otherwise. The fitted models are shown in Figure 23. Across both raw and worked models, the adjustments to the weight estimation models have reduced the cross-validated mean squared error by around 25%.

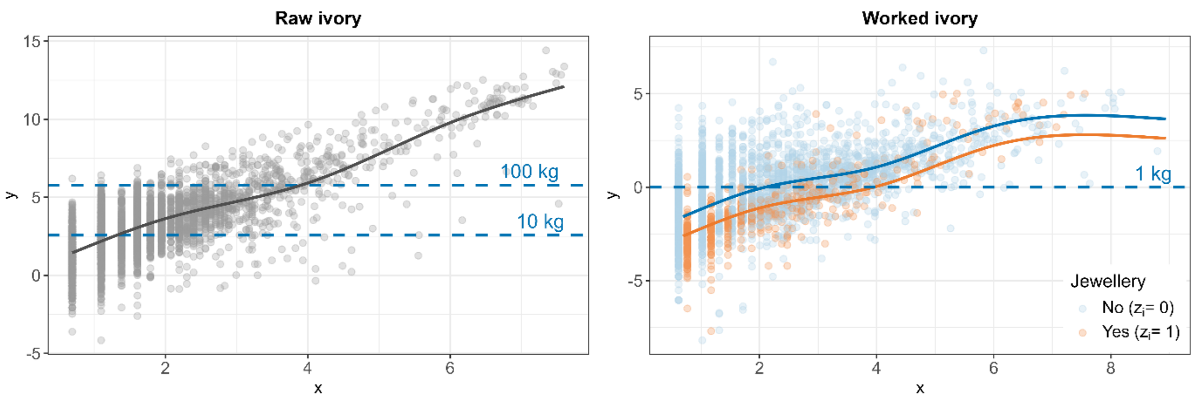


Figure 23. A visualisation of the fitted weight estimation models for raw and worked ivory. Weight estimation models for raw and worked ivory seizures, fitted using natural cubic splines with knot points at x = 2, 4, and 6. Some x-shift has been applied to the groups in the right-hand figure to more clearly display overlapping colours.

Summary

81. Following thorough experimentation and consultation with the MIKE-ETIS TAG, various adjustments have been made to the weight estimation models used in the ETIS analysis. The key adjustments are as follows: (1) the training set has been limited to seizures from 2008 onwards to align with the current range of the trend analysis and in response to observed changes in seizure and reporting practices since that time; (2) natural cubic splines with fixed knots at x = 2, 4, and 6, have replaced the previously used polynomials, where the degree was selected based on AIC; and (3) the weight model for worked ivory now includes an indicator variable for whether jewellery is mentioned in the ivory comment, based on a set of keywords. These modifications received the support of the MIKE-ETIS TAG.

Acknowledgements

TRAFFIC would like to thank the MIKE-ETIS TAG and the CITES Secretariat, as well as Professor Rachel McCrea of University of Lancaster and Dr. Fiona Underwood for providing valuable feedback to improve the methods development presented in this report.

References

Burn, R. W., & Underwood, F. M. (2013). *A new statistical modelling framework to interpret ivory seizures data.* The University of Reading.

Burnham, K. P., & Anderson, D. R. (2002). *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach.* Springer.

Cameron, A. C., & Trivedi, P. K. (2013). *Regression Analysis of Count Data* (2nd ed.). Cambridge University Press.

De Boor, C. (1972). On Calculating with B-Splines. *Journal of Approximation Theory, 6*(1), 50-62.

De Boor, C. (1978). *A Practical Guide to Splines.* Springer-verlag New York.

Dormann, C. F., Calabrese, J. M., Guillera-Arroita, G., & others. (2018). Model averaging in ecology: A review of Bayesian, information-theoretic, and tactical approaches for predictive inference. *Ecological Monographs, 88*(4), 485-504.

Gelfand, A. E., Dey, D. K., & Chang, H. (1992). Model determination using predictive distributions with implementation via sampling-based methods. *Bayesian Statistics, 4*, 147-167.

Hastie, T., Tibshirani, R., & Friedman, J. H. (2009). *The Elements of Statistical Learning: Data Mining, Inference, and Prediction* (2nd ed.). Springer.

Hoeting, J. A., Madigan, D., Raftery, A. E., & Volinsky, C. T. (1999). Bayesian model averaging: a tutorial. *Statistical Science, 14*(4), 382-417.

Holt, C. C. (2004). Forecasting Seasonals and Trends by Exponentially Weighted Moving Averages. *International Journal of Forecasting, 20*(1), 5-10.

Hyndman, R. J. (2018). *Forecasting: principles and practice (3rd Ed.).* OTexts.

Le, T., & Clarke, B. (2017). A Bayes interpretation of stacking for M-complete and M-open settings. *Bayesian Analysis, 12*(3), 807-829.

Plummer, M. (2008). Penalized loss functions for Bayesian model comparison. *Biostatistics, 9*(3), 523-539.

Quintero, A., & Lesaffre, E. (2018). Comparing hierarchical models via the marginalized deviance information criterion. *Statistics in Medicine, 37*(16), 2440-2454.

Rubin, D. B. (1981). The bayesian bootstrap. *The Annals of Statistics*, 130-134.

Spiegelhalter, D. J., Best, N. G., Carlin, B. P., & Van Der Linde, A. (2002). Bayesian measures of model complexity and fit. *Journal of the Royal Statistical Society Series B: Statistical Methodology, 64*(4), 583-639.

Spiegelhalter, D. J., Best, N. G., Carlin, B. P., & Van Der Linde, A. (2014). The deviance information criterion: 12 years on. *Journal of the Royal Statistical Society Series B: Statistical Methodology, 76*(3), 485-493.

Underwood, F. M., Burn, R. W., & Milliken, T. (2013). Dissecting the Illegal Ivory Trade: An Analysis of Ivory Seizures Data. *PLOS One, 8*(10), e76539.

Vehtari, A., Gelman, A., & Gabry, J. (2017). Practical Bayesian model evaluation using leave-one-out cross-validation and WAIC. *Statistics and Computing, 27*, 1413-1432.

Vehtari, A., Simpson, D., Gelman, A., Yao, Y., & Gabry, J. (2015). Pareto smoothed importance sampling. *arXiv preprint arXiv:1507.02646*.

Watanabe, S. (2009). *Algebraic Geometry and Statistical Learning Theory.* Cambridge University Press.

Watanabe, S., & Opper, M. (2010). Asymptotic equivalence of Bayes cross validation and widely applicable information criterion in singular learning theory. *Journal of Machine Learning Research, 11*(12).

Wolpert, D. H. (1992). Stacked generalization. *Neural Networks, 5*(2), 241-259.

Yao, Y., Vehtari, A., Simpson, D., & Gelman, A. (2018). Using stacking to average Bayesian predictive distributions (with discussion). *Bayesian Analysis, 13*(3), 917-1007.

Posterior predictive distributions for the ETIS data comparing polynomial and spline modelling methods

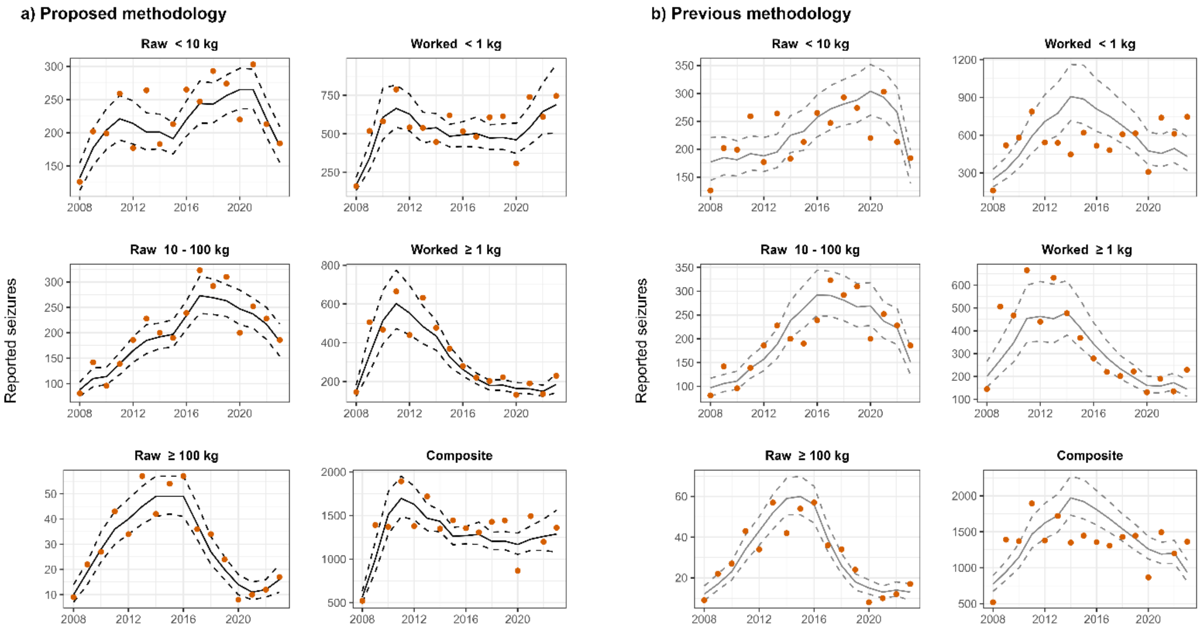


Figure 1. A comparison of posterior predictive distributions of y_{ikt} between models using the proposed and previous methodology. The posterior predictive distributions in each ivory class are summed over countries and territories under a) the proposed model-averaged spline model, and b) the previous 4th degree polynomial model. The solid and dashed lines show the median and central 50% quantile-based intervals of the predictive distributions, while the orange points indicate the observed data.

An overview of information criteria for ETIS model comparison

1. The deviance information criteria (DIC) was introduced by Spiegelhalter, Best, Carlin, & Van Der Linde (2002) as measure of model comparison for Bayesian models, and has previously been used to aid the ETIS model development and model selection (Underwood, Burn, & Milliken, 2013). DIC combines an estimate of deviance (model fit; (-2) times log-likelihood) with an estimate of the *effective number of parameters* (model complexity). Given the data, $\boldsymbol{y} = (y_1, y_2, \ldots, y_n)$, and model parameters, $\boldsymbol{\theta}$, DIC can be written as follows:

$$\text{DIC} = -2\sum_{i=1}^{n} \log p(y_i|\bar{\boldsymbol{\theta}}) + 2p_D,$$

where p represents the model likelihood, $\bar{\theta}$ represents a point estimator (typically the posterior mean) of the model parameters' posterior distribution, and p_D estimates the effective number of parameters. An estimate for p_D was suggested by Spiegelhalter, Best, Carlin, & Van Der Linde (2002) as the difference between the posterior mean deviance and the deviance at the posterior means, although this is exposed as a poor approximation unless $p_D << n$ (Plummer, 2008).

2. The use of a point estimator of the posterior expectation makes the DIC unsuited to complex, non-Gaussian posterior densities. There are also concerns with its use for hierarchical and latent variable models (Quintero & Lesaffre, 2018). In such settings, the DIC calculation may derive the likelihood conditioned on the latent variables, or equivalently at the *wrong* level of the hierarchical structure, such that the model's uncertainty is not fully represented (see also references to *model focus* in Spiegelhalter, Best, Carlin, & Van Der Linde (2002)). However, while the ETIS model can be described as a hierarchical latent variable model (with the Transaction Index, seizure rate and reporting rate constituting latent variables), its representation as such is purely structural; the latent variables can be algebraically ignored and are not treated as model parameters in a conditional likelihood. Nevertheless, the DIC is not a justified Bayesian approach, with its view partially limited to posterior expectations rather than full distributions.

3. The widely applicable information criteria (WAIC, Watanabe (2009)) is seen as an improvement on DIC for Bayesian models. Rather than using point estimates, WAIC uses the full posterior distribution of model parameters:

$$\text{WAIC} = -2\sum_{i=1}^{n} \log \mathbb{E}_{\boldsymbol{\theta}|\boldsymbol{y}}[p(y_i|\boldsymbol{\theta})] + 2p_w.$$

The estimate used by WAIC of the effective number of parameters, p_w, is calculated as the sum (over data points) of the variance (over posterior samples) of the pointwise log-likelihood. This summation provides a more stable estimate than that of p_D used by DIC, although it becomes unreliable as the individual pointwise variances increase (a 'reliability' threshold of 0.4 is identified by Vehtari, Gelman, & Gabry (2017)).

4. Watanabe & Opper (2010) showed WAIC to be asymptotically equivalent to the Bayesian leave-one-out cross validation (LOOCV) estimate of the log predictive density. The latter can be expressed as

$$\text{LOOCV} = \sum_{i=1}^{n} \log \mathbb{E}_{\boldsymbol{\theta}|y_{-i}}[p(y_i|\boldsymbol{\theta})],$$

where $\mathbb{E}_{\boldsymbol{\theta}|y_{-i}}$ represents the expectation under the model parameters' posterior distribution when the model is fitted with the i^{th} data point removed. Direct calculation of LOOCV requires fitting the model n times, and is thus generally infeasible. However, it can be approximated using importance sampling (Gelfand, Dey, & Chang, 1992), replacing the unknown density, $\theta|\boldsymbol{y}_{-i}$, with the full posterior density, $\theta|\boldsymbol{y}$. To cope with the often large variance (over posterior samples) of importance weights for each pointwise density in this approximation, Vehtari, Simpson, Gelman, Yao, & Gabry (2015) introduce a method of Pareto-smoothed importance sampling (PSIS). This allows for stable estimates by fitting Pareto distributions to the upper tail of the importance weights, with the estimated Pareto shape parameters providing a diagnostic indicator as to the reliability of the approximations (good performance is suggested up to a threshold of 0.7). The PSIS estimate of LOOCV is multiplied by (-2) to place it on the conventional scale of deviance and produce the information criteria denoted as LOOIC throughout this document. Both WAIC and LOOIC estimate pointwise predictive density by evaluating the log-likelihood at the posterior simulations of the parameter values, and both are asymptotically equivalent to (-2 times) Bayesian LOOCV. However, Vehtari, Gelman, & Gabry (2017) show LOOIC to be a more robust approximation in the finite case, particularly when dealing with weak priors or influential observations.

Posterior predictive distributions for the current and 0^{NR}-removed models, and zero-inflated models with different prior distributions on the zero-inflation parameter, π

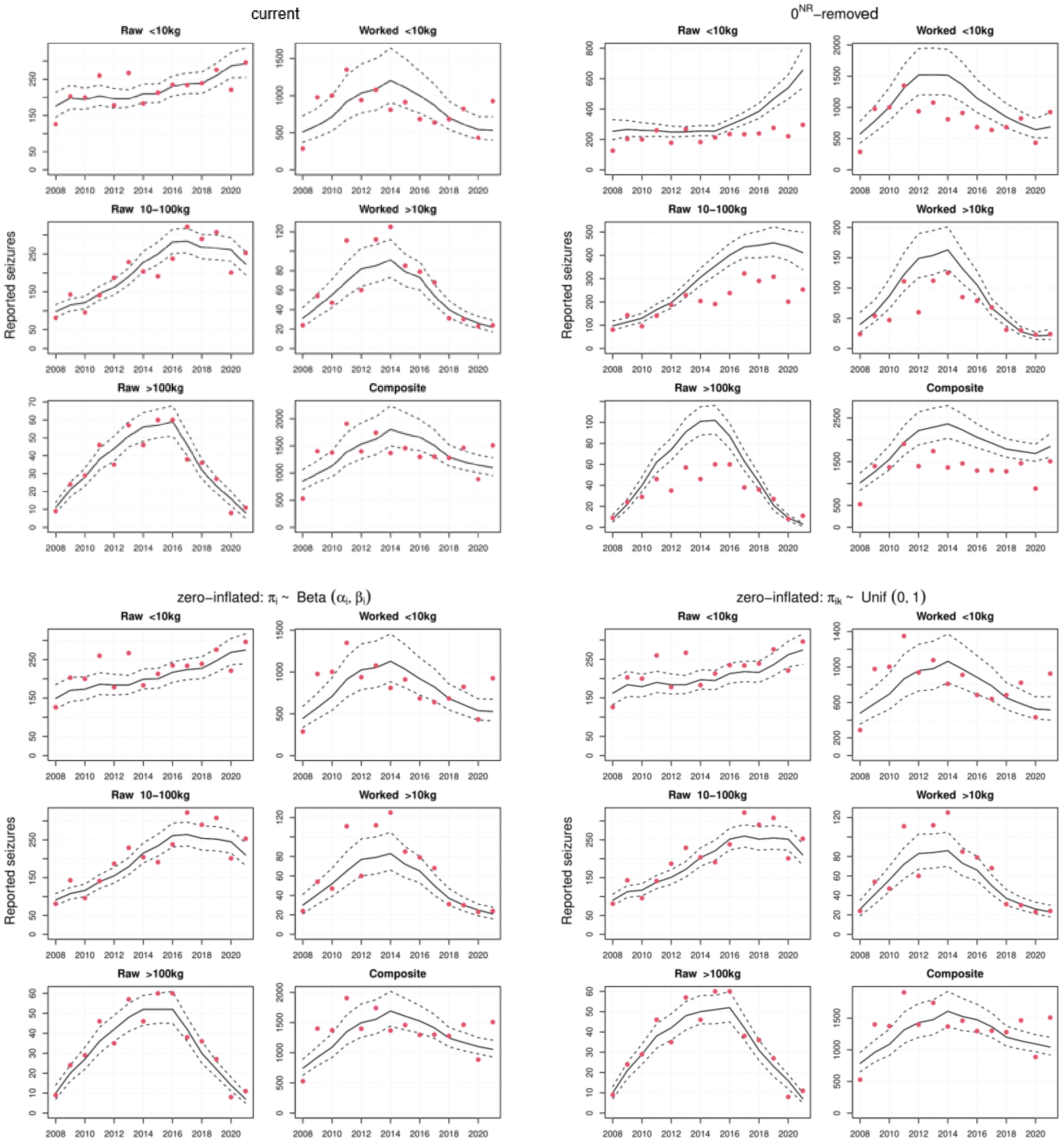


Figure 1. A comparison of posterior predictive distributions of y_{ikt} under different models, summed over countries and territories. The solid and dashed lines show the median and central 50% intervals of the predictive distributions, while the red points indicate the observed data. For the 0^{NR}-removal model (top left), predictions are not simulated for the removed y_{ikt}, yet the predictive distributions still overestimate the data. The baseline model for comparison (current) is a 4^{th} degree polynomial model.

<u>Posterior distributions for the zero-inflation parameter, π_{ik}, by country or territory and ivory class</u>

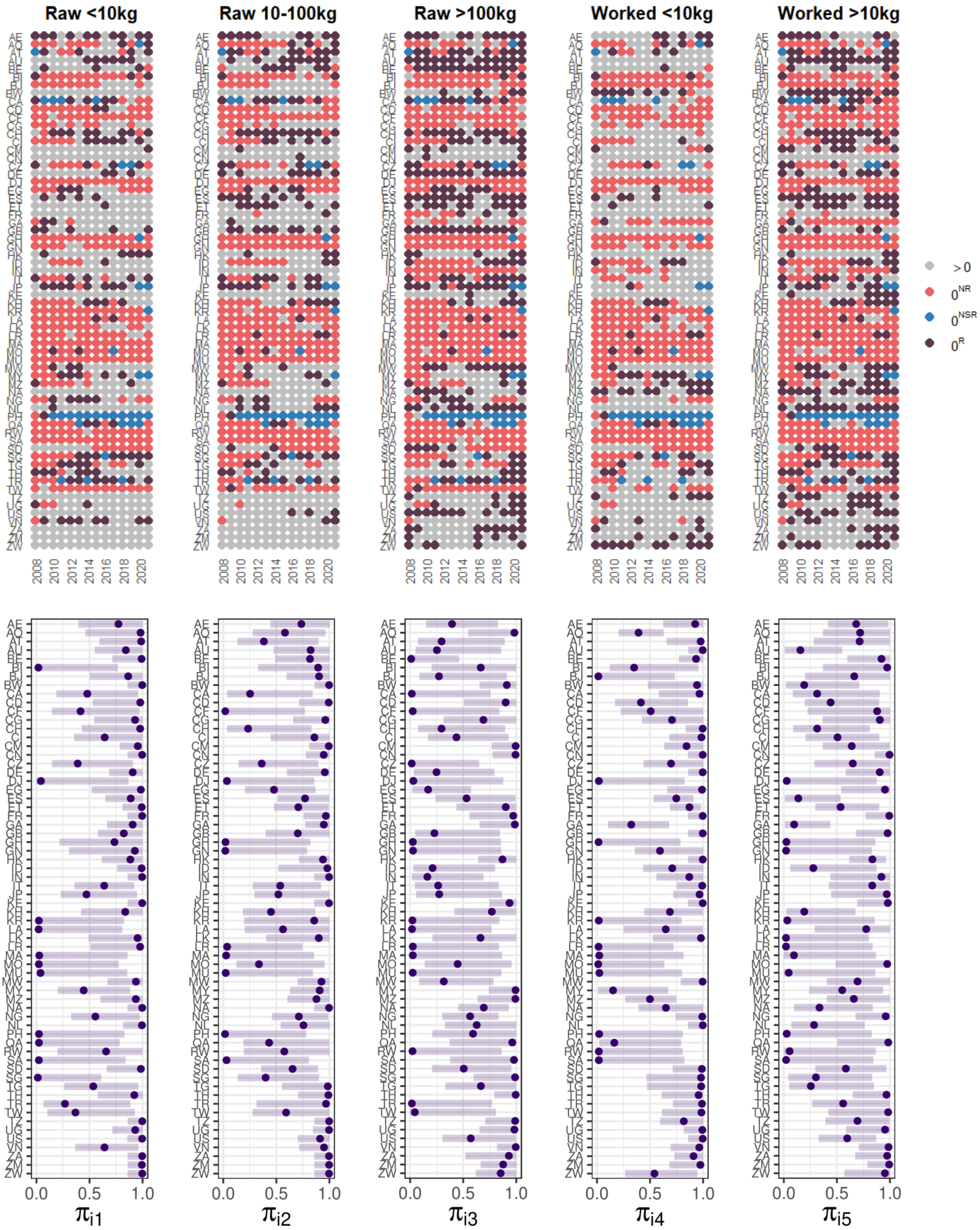


Figure 1. Posterior distributions for the zero-inflation parameter. Top: a visualization of the zeros occurring for each country or territory, ivory class, and year in the data used in analysis (this is a repeat of Figure 4 in Annex 3). Bottom: posterior distributions (maximum a posteriori estimates and 90% highest density credible intervals) for the parameters, π_{ik}, in the country- (or territory-) and ivory class-specific zero-inflated model (using prior distributions π_{ik} ~ Unif(0, 1)). The distributions of π_{ik} can be seen to reflect the proportion of zeros across years for each country or territory and ivory class (lower values of π_{ik} imply a greater proportion of zeros).

Transaction Indices and posterior predictive distributions for spline models under the *Uniform vectors* and *Specific years* approaches to knot placement

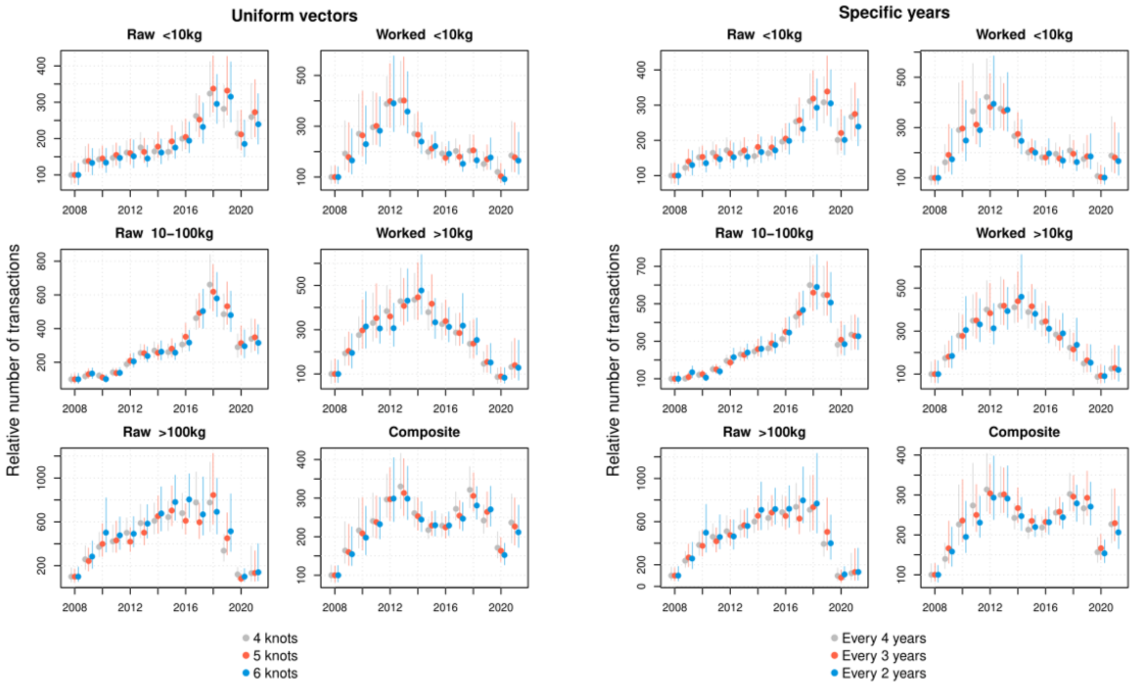
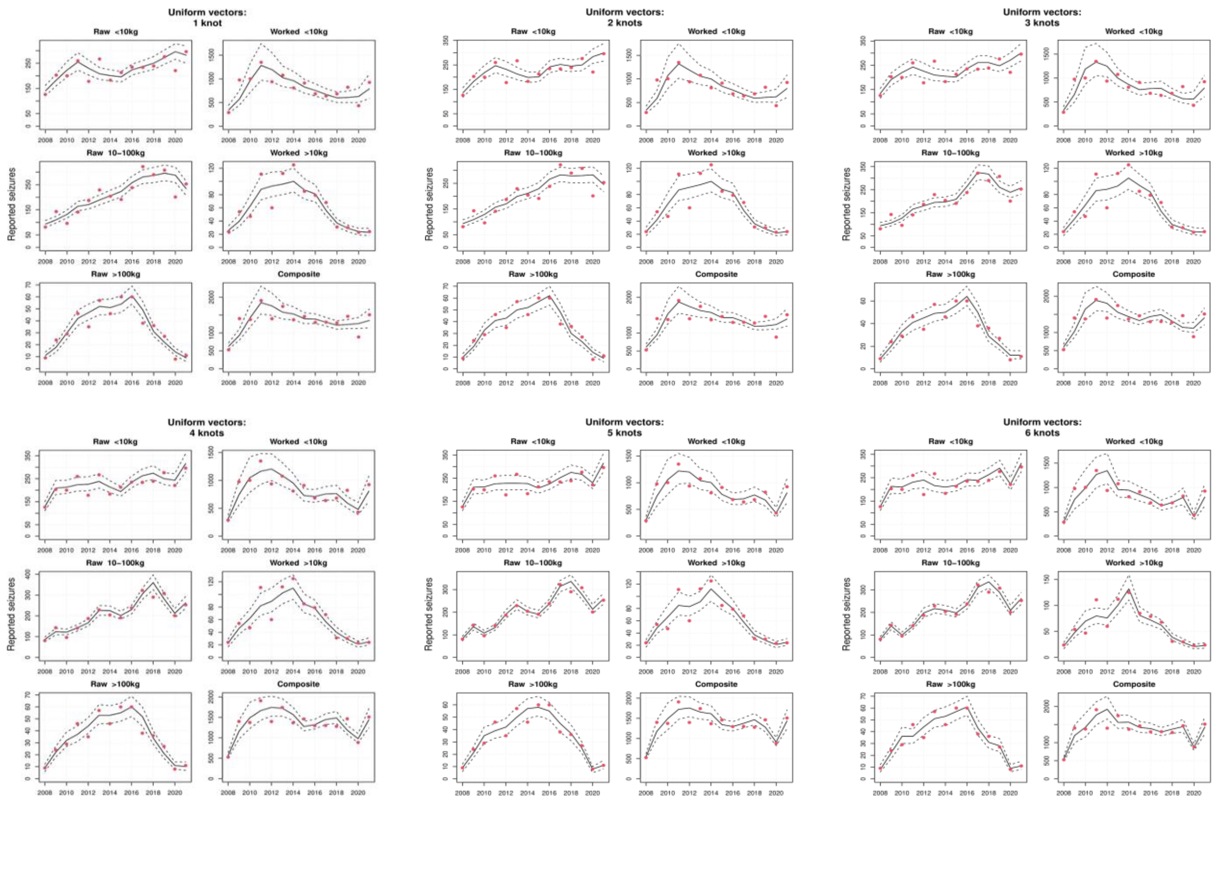


Figure 1. Transaction Indices for the latter three spline models under each knot placement approach in Table 1 of Annex 3 (Uniform vectors; left, and Specific years; right).



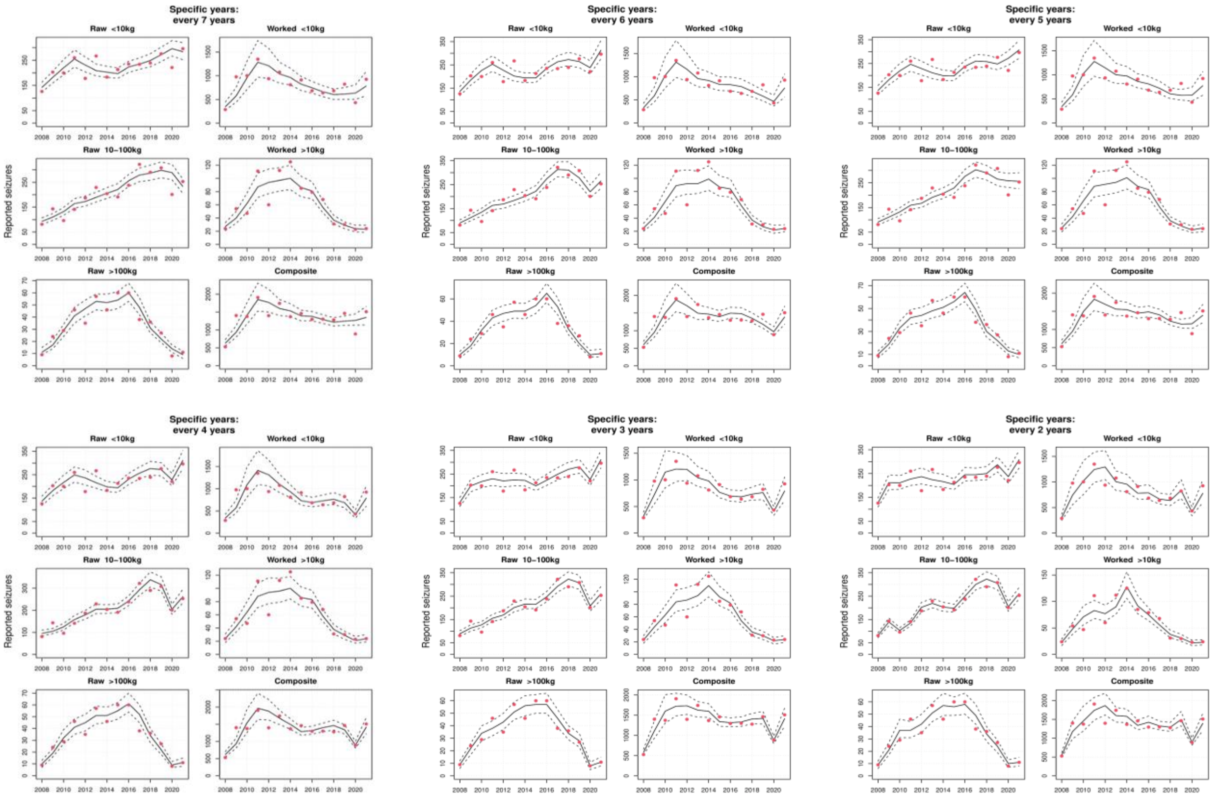


Figure 2. Posterior predictive distributions of y_{ikt} summed over countries and territories under spline models with the Uniform vectors (top two rows) and Specific years (bottom two rows) approaches to knot placement (see Table 1 in Annex 3 for the exact knot placements of each model). The solid and dashed lines show the median and central 50% intervals of the predictive distributions, while the red points indicate the observed data.

An overview of methods for Bayesian model averaging

1. The framework for drawing inference from an averaged model, $\bar{M}$, can be written as follows:

$$p(\cdot\,|\bar{M}) = \sum_{j=1}^{J} w_j\, p(\cdot\,|M_j),$$

where w_1, w_2, …, w_J denote the model weights ($w_j \geq 0$ and $\sum_j w_j = 1$) assigned to the individual models M_1, M_2, …, M_J. This represents a distribution from the model ensemble, with each model, M_j, contributing to the overall distribution according to its weight, w_j.

2. In the framework of Bayesian Model Averaging (BMA, Hoeting, Madigan, Raftery, & Volinsky (1999)), models are assigned weights based on their posterior probabilities: $w_j \propto p(\boldsymbol{y}\,|M_j)p(M_j)$, where $p(\boldsymbol{y}\,|M_j)$ is the likelihood of M_j, integrated over the model's parameters. However, BMA is theoretically flawed when the true data-generating process is not among the candidate models. Alternatively, Akaike's Information Criterion (AIC) is commonly used to construct model weights of the form $w_j \propto \exp\{-½\text{AIC}_j\}$ (Burnham & Anderson, 2002). More recently, WAIC and LOOIC (see Annex 3b) have been applied to derive similar weights in a Bayesian setting; these methods are often referred to as pseudo-BMA. Yao, Vehtari, Simpson, & Gelman (2018) mitigate uncertainty in the finite sample LOOIC approximations behind a pseudo-BMA weighting by applying a Bayesian bootstrap (Rubin, 1981), which has the effect of regularising the model weights away from the extremes of zero and one (this method is referred to as pseudo-BMA+ in Table 2).

3. Both BMA and pseudo-BMA ultimately converge towards selecting a single best model as the data grows. An alternative approach to model averaging, known as stacking (Wolpert, 1992), aims to find the linear combination of models that optimises the overall predictive distribution. Originally developed for averaging point estimates, stacking was generalised by Le & Clarke (2017) to combine predictive distributions, and Yao, Vehtari, Simpson, & Gelman (2018) extend the framework to general optimality criteria. When maximising the log pointwise predictive density, stacking weights can be expressed as

$$\underset{w_1,\dots,w_J}{\operatorname{argmax}} \sum_{i=1}^{n} \log \sum_{j=1}^{J} w_j p\left(y_i \middle| M_j, y_{-i}\right),$$

where $p(y_i\,|M_j, \boldsymbol{y}_{-i})$ is the leave-one-out predictive density for the model M_j, approximated using Pareto-smoothed importance sampling (Vehtari, Simpson, Gelman, Yao, & Gabry, 2015). This is the method of model averaging used in the ETIS trend analysis, fuller details of which can be found in Yao, Vehtari, Simpson, & Gelman (2018).

APPLICATION OF NETWORK ANALYSIS METHODS TO ETIS DATA
(ETIS review recommendation 25)

1. This Annex has been prepared by TRAFFIC.

2. ETIS review recommendation # 25 received a high priority, was directed at TRAFFIC and the TAG and a Research Consultancy and called for "Further exploratory analysis with a view towards enhancing and improving the analytical framework for ETIS (in concert with recommendation 26[19])". This Annex summarizes the exploration of application of network models to ETIS data in order to identify Parties most affected by illegal ivory trade.

3. The process of identifying Parties affected by the illegal ivory trade has been conducted since CoP12 using an agglomerative hierarchical cluster analysis of ETIS data (see document SC78 Doc. 65.3, Annex 1). The cluster analysis broadly differentiates countries and territories by their levels of illegal ivory trade based on number of seizures and seized weight derived from the ETIS trend analysis results. Parties are identified as being in NIAP Categories A, B or C based on supporting information summarized from ETIS data including the volume of illegally traded ivory and the extent of trade links, and additional external supporting information e.g., effective governance (Corruption Perceptions Index) or prevalence of organized crime (Organized Crime Index).

4. In the report to CoP19 and following consultation with the MIKE-ETIS TAG and the CITES Secretariat, it was recognized that "… *more refinements might be made in future assignment of Parties under the NIAP process to Category C, as well as Categories A and B, as better definitions are developed by the Parties as to what most affected, markedly affected, and affected mean in terms of quantifiable illegal trade characteristics*" (CoP19 Doc. 66.6). At CoP19, Parties also adopted Decision 19.97 which states that the CITES Secretariat shall, in consultation with the MIKE-ETIS Technical Advisory Group and TRAFFIC, develop draft criteria for the categorization of Parties based on the ETIS analysis and seizure data relating to elephant specimens submitted to TRAFFIC, and submit the draft criteria to the 78th meeting of the Standing Committee for consideration. The CITES Secretariat requested TRAFFIC to prepare a report on past and current methodologies of ETIS categorization of the Parties (see document SC78 Doc. 65.3, Annex 1) and develop an improved analysis as part of the implementation of ETIS review recommendations to improve the analytical framework (recommendation # 25 in Annex 3 of CoP19 Doc. 21).

5. Key is the derivation of quantifiable metrics and data-driven evidence to inform the identification of Parties that are affected by illegal ivory trade and to further estimate the possible effect these Parties have on the wider illegal ivory trade network. Quantitative methods may also provide a tool to set targeted NIAP objectives and evaluate their achievement and, in line with the objectives of the ETIS programme set in Res. Conf. 10.10 (Rev. CoP19), assess the effect of measures taken by Parties under the auspices of CITES.

6. The modelling framework was developed in collaboration with researchers at the Conservation Research Institute at the University of Cambridge and was presented to the MIKE-ETIS TAG and the CITES Secretariat in an interim report, two online statistical consultation meetings (held on 5 June 2024, and 13 August 2024), and the 20th meeting of the TAG held from 5 – 7 November 2024 in Nairobi, Kenya. The TAG indicated that the network analyses is an interesting data-based approach that provides spatial and temporal context and quantitative aspects; noted that the input data is the same as the input variables used in the ETIS trend and cluster analysis and that the results shows similar results as the cluster analysis done for the ETIS reports to CoP18 and CoP19[20]; it further noted that the network analysis provides added quantitative dimensions of the ETIS data and that the different trends observed for raw and worked ivory could be useful for the Parties.

7. Input from the TAG and the Secretariat were incorporated into methodology revisions to derive the analytical framework improvements to the ETIS trend analysis presented in this Annex. Part I of this Annex provides less-technical overall summary of key developments, while Part II provides a more comprehensive statistical

[19] *Recommendation # 26 advises to "Streamline the 'R' scripts (+30) to enhance execution performance and minimize hands-on intervention".*

[20] *It also recommended as a general rule, that Parties should have a cautious approach to the interpretation of seizure data, which is the case with any ETIS analysis.*

technical discussion of each topic along with experimental results and figures. The R code associated with the final suggested models was provided to the TAG.

PART I – SUMMARY OF NETWORK ANALYSIS MODELLING DEVELOPMENT

8. The following aspects of the analytical framework of network models were explored and are presented in this Annex: *i.* procedures and considerations in the construction of illegal ivory trade networks using ETIS data, *ii.* proposed methods of key player identification and the use of disruption metrics to identify most affected Parties and based on pre-determined, or optimal, disruption of illegal ivory trade, and *iii.* a comparison of current and proposed methodologies using data presented at CoP19. Part II describes in detail the derivation and adaptation of network statistical methods for the application to ETIS data. Annex 4b summarizes the assumptions made in the analyses of ETIS data, including those which are specific to the proposed network analysis. Annex 4f provides additional comparisons with CoP18 data. The R code associated with the final suggested methods was provided to the TAG. Finally, interactive versions of network maps presented here can be explored at https://etisonline.org/network-maps.

Constructing the illegal ivory trade network

9. The illegal ivory trade is inherently a trade *network* with Parties reported as origin, export, re-export and destination country or territory along the trade chain, where Parties may often occupy different roles depending on whether they are range or non-range States. Cumulatively this creates an interconnected trade network in which the presence of illegal ivory in one Party often depends on its trade through another Party or Parties. This is crucial, as enforcement or policy action that might be implemented by Parties through regulatory actions such as the NIAP processes can extend to have wider impacts beyond the individual Parties. With this understanding, the modelling of ETIS data as a trade network can allow a fuller representation of the intricacies and connected nature of the global illegal ivory trade for a more effective law enforcement implementation and decision-making by the Parties.

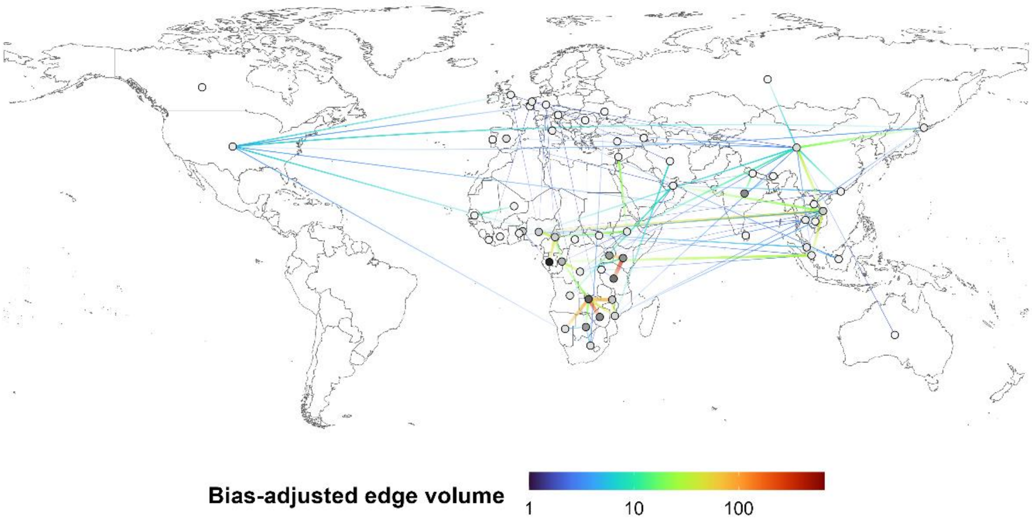
10. The *country of discovery* (or country or territory of seizure) is a minimum required field to add a record to the ETIS database (paragraph 2.a of Annex 1 of Res. Conf. 10.10. (Rev. CoP19)). Additional trade route information, although not considered as a minimum requirement, is essential not only to understand illegal ivory trade networks but also to inform the current ETIS trend modelling in terms of bias-adjustment seizure rate covariates (i.e., in constructing the law enforcement ratio covariate). However, it is noted that only around 50% of seizure records reported to ETIS include a full or partial trade chain route beyond the country of discovery. While some of this may be explained as relating to seizures made in range States for which no unreported route exists, a significant proportion can be attributed to cases in which an existing trade route was either unknown or unreported. Further exploration of the trade route reporting behaviour reveals substantial variation in Parties reporting patterns over time (Figure 1 in Annex 1a to document SC78 Doc. 65.1).

11. The missing trade routes in ETIS records, if not accounted for, can introduce biases in a network analysis of ETIS data. Approaches to address the issue of missing routes that were explored with the MIKE-ETIS TAG and the CITES Secretariat include: 1) the removal of seizures with no reported trade route from the analysis; 2) the inclusion of seizures with no trade route as a self-loop link in the network without bias-adjustment; and 3) a bias-adjustment approach where, similar to the reporting and seizure rates of the ETIS trends analysis, a route-reporting rate is calculated to bias-adjust trade volume based on the reported trade routes (see additional details in Part II). While the removal of seizures with no trade route from the ETIS analysis had substantial impacts on network structure and results (Annex 4d), the network results with and without the route reporting rate bias-adjustment were highly comparable. For the sake of brevity, only results with the bias-adjustment are shown in Part I; a full set of results are provided in Part II.

12. Similar to the input data type used by current methodologies and the cluster analysis, two input variables were considered to calculate the networks trade volume: the number of transactions (also referred to as *transactions network*) and weight of seized ivory (also referred to as *weight network*). To allow comparison to CoP19 results, the networks were constructed based on trend analysis results from the CoP19 reporting

period (2018 – 2020)[21]. Figures 1 and 2 show the transactions and weight networks for raw ivory (Figure 1) and worked ivory (Figure 2). The strength of trade links based on the bias-adjusted volume (or *edge weight* indicated as lines) between Parties (or network *nodes* represented as circles) are depicted such that redder (and thicker) lines indicate edge weight with higher volume compared to bluer (and thinner) lines, and darker-coloured nodes indicate nodes with higher volume compared to lighter-coloured nodes.

A. Raw ivory transactions network



B. Raw ivory weight network

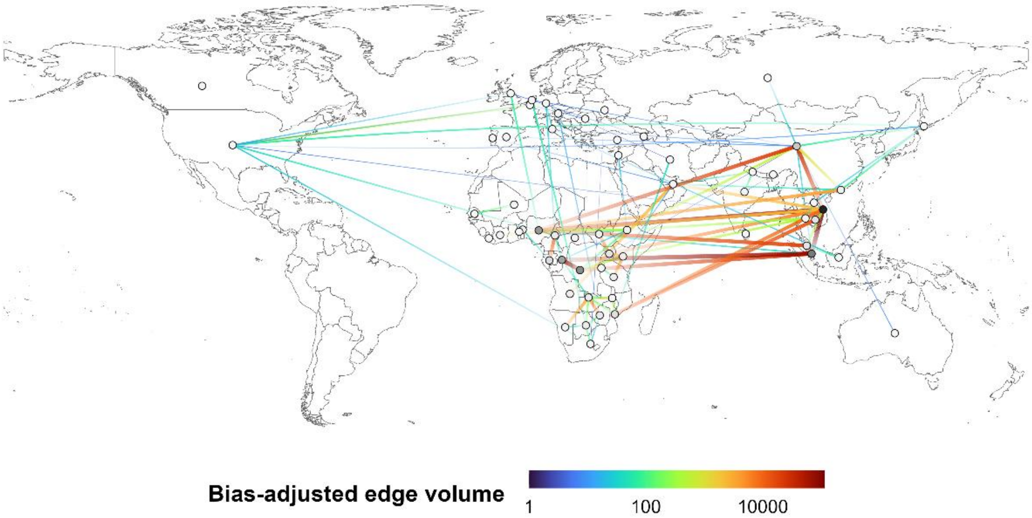
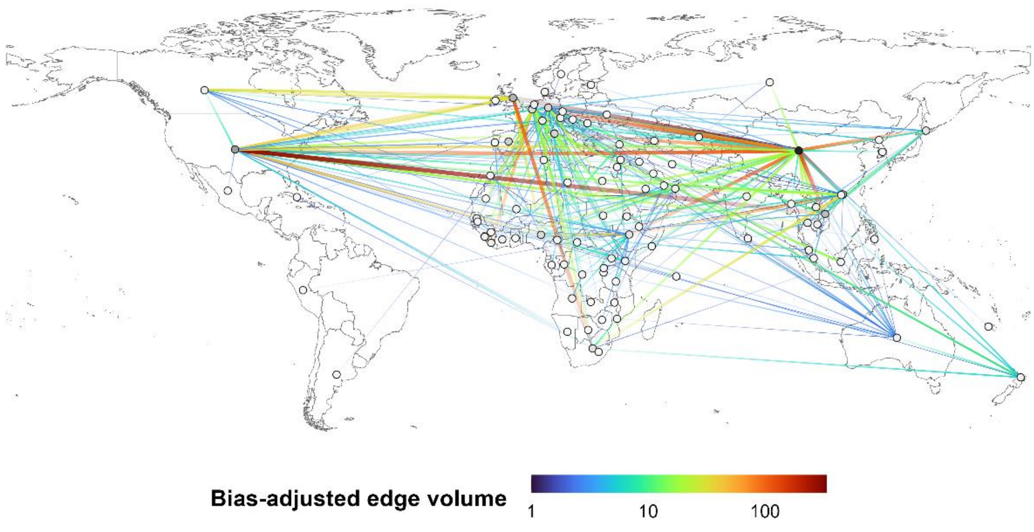


Figure 1. Illegal raw ivory networks for the CoP19 reporting period of ETIS data (2018-2020). Networks are based on the bias-adjusted volume of raw ivory moving between countries and territories and are constructed separately based on the number of transactions (top) and the weight (bottom). The colour and thickness of the edges denote the relative strength of the trade links (using a separate log scale for each map), with the direction of travel indicated by the transparency of the edge moving from fainter to darker. The shading of nodes indicates the proportion of the total network volume that each country or territory encounters, with the darker shading indicating proportionately greater involvement in the global trade. For interactive versions of these maps, visit https://etisonline.org/network-maps.

21 *Additional networks were constructed for the CoP18 reporting period (2015 – 2017) with properly bias-adjusted data based on CoP18 trend analysis, and are presented in Annex 4f.*

A. Worked ivory transactions network



B. Worked ivory weight network

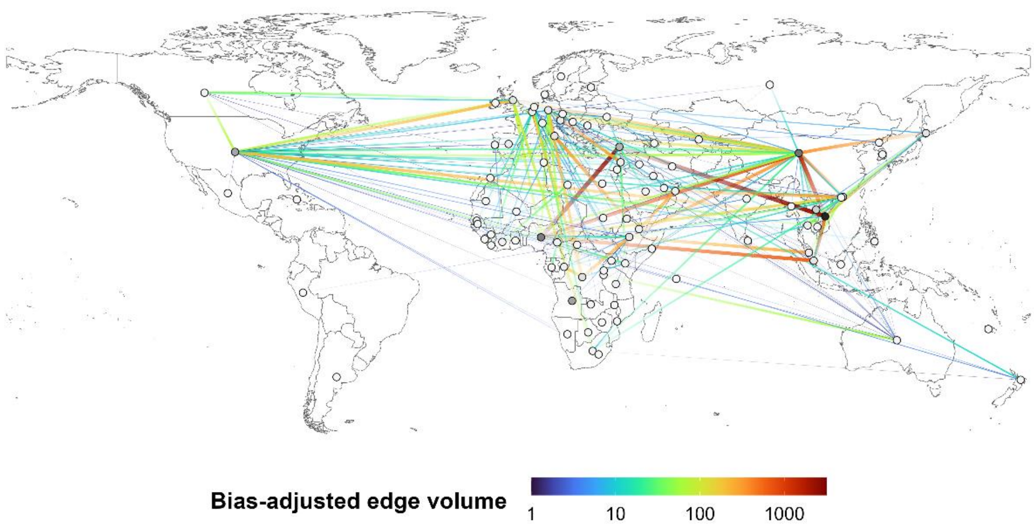


Figure 2. Illegal worked ivory networks for the CoP19 reporting period of ETIS data (2018-2020). Networks are based on the bias-adjusted volume of worked ivory moving between countries and territories and are constructed separately based on the number of transactions (top) and the weight (bottom). The colour and thickness of the edges denote the relative strength of the trade links (using a separate log scale for each map), with the direction of travel indicated by the transparency of the edge moving from fainter to darker. The shading of nodes indicates the proportion of the total network volume that each country or territory encounters, with the darker shading indicating proportionately greater involvement in the global trade. For interactive versions of these maps, visit https://etisonline.org/network-maps.

13. Beyond the immediate visual illustration of ETIS data and the interconnectedness of Parties affected by the illegal ivory trade, examination of constructed illegal ivory networks depicted in Figures 1 and 2 provides the following two general insights:

- Within ivory type (i.e., raw or worked), networks constructed based on transactions or weight input data can provide differing inferences on most affected Parties and prominent trade links. This difference was more pronounced for raw ivory networks, where a few seizures of very large weight (e.g., totalling several tonnes of seized ivory) may carry the majority of the trade volume, and where the transaction network of raw ivory highlighted the trade links between African range Parties as more prominent, while the weight network highlighted links between African and Asian Parties (Figure 1).

- Considering the same input variable (i.e., transactions or weight), general differences are noted between networks constructed for raw and worked ivory types. For example, for the number of transactions and compared with raw ivory networks (Figure 1A), worked ivory networks had more diverse trade links and included more prominent links between non-range Parties (Figure 2A).

Identification of Parties requiring attention using key player approach

14. Various network centrality measures exist to quantify the importance of individual nodes (Parties) and edges (trade links) in the network structure (e.g., Tables 1 and 2 in Part II). However, when considered in isolation, the identification of key Parties based on individual centrality scores overlooks the connected nature of the network and the potential redundancy when, for example, intervening actions are being taken in two highly important but connected nodes. A key player approach in network modelling allows for a more optimal identification of important nodes that might arise from different regions of the network but that collectively provide broader disruption impact across the network. This key player algorithm is well-established among network analyses of health and criminal networks and works to identify groups of nodes which have the potential to collectively achieve the greatest disruption to the network.

15. Applying the key player approach iteratively to ETIS data, while each time increasing the number of Parties that can be identified as most affected, allows for multiple key player solutions based on group size. A network disruption metric can be calculated for each specific key player group by calculating the proportion of the network volume that will be disrupted if these key players are removed, and results can be plotted as *disruption curves* (Figure 3). Predefined thresholds of disruption (e.g., 75% or 90% reduction in illegally traded ivory; dashed lines in Figure 3) can be used to identify an optimal solution of key players. An alternative optimal solution can balance the number of Parties identified with the most pronounced slope change based on the disruption curves (solid lines in Figure 3). Uncertainty in the selection of key players can be further explored via the construction of multiple networks based on the posterior distribution of trend analysis results, thus yielding a percentage disruption range that a Party or group of Parties might achieve given the multiple iterations and key player solutions.

16. Here, both key player optimization approaches with uncertainty estimation were considered to identify Parties most affected by illegal ivory trade (similar to Category A, or *most affected*, and B, *markedly affected*, Parties under the NIAP process). Additionally, an approach to identify Parties who are important to watch (similar to Category C, or *affected* Parties) was developed. For the latter, examining changes in Parties' relative importance metrics between CoP periods provided insights to emerging trends. Top Parties with increasing trends were identified as important to watch (Figure 4, dashed orange lines), while Parties with decreasing relative importance to the network were also identified (Figure 4, solid blue lines); the latter might consist of Parties that have successfully implemented NIAP actions or other measures under the auspices of CITES, in line with the objectives to the ETIS programme to assess linkages to CITES actions taken by the Parties (see additional discussion in Part II).

17. Results of the key player approach suggested that while some key Parties consistently emerged across the different network types (i.e., transaction or weight based networks, for raw or worked ivory), distinct sets of Parties were also identified (Table 3 in Part II and Annex 4d). Thus, network analyses can provide a more tailored approach to identify Parties requiring attention by illegal ivory type, and can be used to develop more targeted NIAP objectives and law enforcement efforts that are focused for example, on poaching reduction if a range State Party is identified based on raw ivory key player results, or on behavior change if a consumer Party is identified based on worked ivory key player results.

Evaluation of key player approach with current methodologies

18. In comparing the current analytical framework used in ETIS report to CoP19 with the results of the identification of Parties based on network modelling approaches, it was evident that current approaches fall short in achieving maximum optimal illegal ivory network disruption (note asterisks fall below disruption curve in Figure 3). However, this effect was less pronounced for raw ivory. This suggests that, under current methods that consider raw and worked ivory collectively, the identification of Category A Parties might be more likely to identify countries or territories with prominent seizures of raw ivory. Use of the

network analysis methodology might result in a more balanced identification approach that also includes more prominent illegal trade in worked ivory.

19. In general, there was congruency in the Parties identified as requiring attention under NIAP Category A and B and Parties identified as key players in network analysis results. However, several exceptions emerged. For example, one Party was identified with current methodologies as a Category A Party but was not identified with the network approach. An explanation is related to the redundancy in trade links between this Party and the other Parties already identified as key players. Additionally, other Parties that were identified in the key player approach for raw (e.g., few range Parties) and worked ivory (e.g., non-range Parties in North America, Europe and Asia) were not identified in the CoP19 report. This is likely because unlike current methods, the network analysis collectively considered all trade links including seizures made in country.

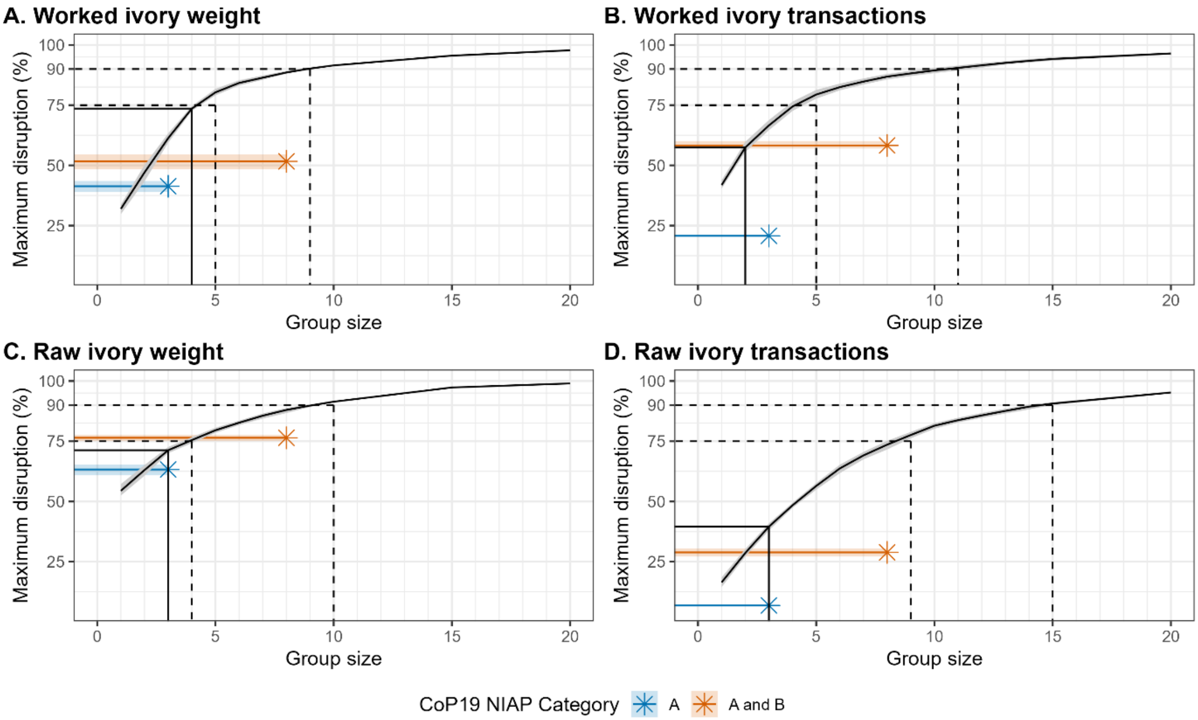


Figure 3. Network disruption as a function of key player selection. Curves show the maximum disruption of the illegal ivory trade networks as a function of key player group size for networks constructed based on the bias-adjusted weight volume (left column) or number of transactions (right column) of worked ivory (top row) and raw ivory (bottom row). Data were summarised for the CoP19 reporting period and are compared to the identification of Parties requiring attention under the NIAP process as Category A (blue asterisk) and Categories A and B (orange asterisk) as reported on in the ETIS report to CoP19 (CoP19 Doc. 66.6). Disruption curves are based on the most common selection of nodes of each group size from 100 randomly sampled posterior bias-adjusted networks where median disruption across the 100 networks is plotted with a shaded 90% quantile interval (grey; note that due to the high consistency across posterior networks this interval is often very narrow). Solid black lines represent group selection based on an optimization procedure to balance the trade-off between group size and maximum disruption (the group size at which the rate of increase in maximum disruption slows the most). Dashed lines show group size based on pre-selected disruption thresholds of 75% and 90%.

20. In terms of emerging trends, while the network methods did not highlight the country identified as Category C in the ETIS report to CoP19, other range and non-range Parties which were not identified in the CoP19 report were identified as having increasing trends with the network methods (Figure 4). It is important to state that increasing seizure trends can also result from increased enforcement levels. Therefore, similar to current methods, results should be interpreted with contextual supportive information that provides broader understanding on the governance, enforcement and legislation efforts by the identified Parties. Finally, it is noted that a few range Parties that previously completed their NIAP and exited the process were highlighted as having declining trends, which could possibly be attributed to the continued success of the CITES-implemented programme and national efforts by the Parties (Figure 4). It is therefore possible to use the proposed analysis of declining trends for the continued evaluation of Parties that are participating, are requesting to exit, or have recently exited the NIAP process.

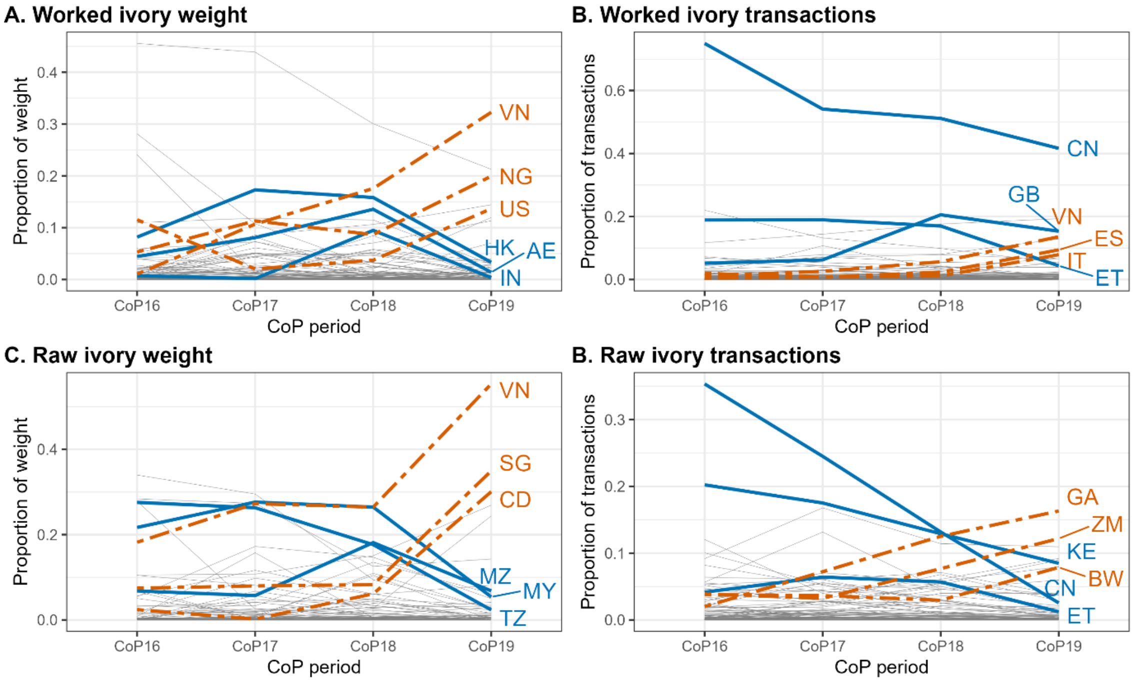


Figure 4. Emerging trends in Parties' proportionate roles in worked and raw ivory trade flows for networks constructed based on the bias-adjusted weight volume (left column) or number of transactions (right column) of worked ivory (top row) and raw ivory (bottom row). Networks are constructed from seizures data within each CoP period from CoP16 to CoP19, and Parties' proportionate roles in the networks are tracked over time. The highlighted lines indicate the top three Parties with increasing (dashed orange lines) and decreasing (solid blue lines) trends between the most recent CoP periods. Note that the summed period proportions can exceed one as multiple countries will be involved in the same ivory shipments.

Conclusion

21. The network-based approaches outlined here facilitate the visualisation and quantification of key nodes (Parties or groups of Parties) and routes (trade links) in the illegal ivory trade network based on ETIS data collected under established CITES processes. The key player algorithm itself allows the identification of countries or territories most ideally placed to disrupt the illegal ivory trade network. Network analysis results highlight the heterogeneity in selecting key players to disrupt raw and worked ivory, which may provide for more targeted objectives for Parties participating under NIAP. Furthermore, the benefits of the key player approach include the ability to quantify the potential for illegal trade disruption (e.g., "effectively achieving NIAP objectives in these x identified Parties has the potential to disrupt xx% of all estimated illegal ivory weight in the network"), which can conceivably be linked to percent achievement of national or regional law enforcement and regulatory interventions.

22. A main consideration in the application of analytical frameworks for the ETIS categorization of the Parties is the prevalence of seizures with missing trade routes in ETIS reported data (for full discussion see the section "*Additional considerations*" in Part II), which is also a limitation inherent to existing methods of ETIS analyses. The proposed network methods address such data reporting issues by bias-adjustment, and additional improvements to the ETIS data collection procedures are suggested in Annex 1d to document SC78 Doc 65.1. Network approaches provide a quantitative assessment of how Parties are affected by illegal ivory trade, thereby addressing the concerns highlighted in the ETIS report to CoP19 and providing a way forward for the ETIS categorization of the Parties as requested by the Standing Committee in Decision 19.97 (see document SC78 Doc. 65.3). Incorporating the suggested network approach with outputs from existing methods (cluster analysis and heat map) along with contextual data could provide a holistic yet quantifiable analytical framework for the use of ETIS data in the identification of Parties requiring attention under NIAP.

PART II – TECHNICAL PAPER ON THE DEVELOPMENT OF NETWORK ANALYTICAL FRAMEWORK TO ETIS DATA

Proposed network methodology for the ETIS categorization of Parties – technical report

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Background

23. Annex 3 of Resolution Conf. 10.10 (Rev. CoP19) on Guidelines to the National Ivory Action Plans Process states that: '*The foundation for identifying Parties to participate in the National Ivory Action Plan (NIAP) Process, is the ETIS report submitted to each meeting of the Conference of the Parties (CoP) under this Resolution.'* Since the ETIS report to CoP12 (CoP12 Doc. 34.1), Parties that have been identified as important to, or affected by, illegal ivory trade and were invited to develop and implement action plans for the control of trade in African elephant ivory (e.g., Decision 13.26). The process later expanded to non-range State Parties and was formalized as part of the NIAP process that was added as Annex 3 to Res. Conf. 10.10 (Rev. CoP17). Further developments of NIAP guidelines post-CoP17 resulted in the current naming and categorization of the Parties as most affected (Category A), markedly affected (Category B), and affected (Category C) based on criteria suggested by the Secretariat (SC69 Doc. 29.3). Hence since the ETIS report to CoP18, the ETIS report has informed the identification of Parties as requiring attention under the three NIAP categories using ETIS data and methodologies described in Annex 1 to document SC78 Doc. 65.3.

24. To inform the process of identifying Parties affected by the illegal ivory trade, an initial step is to summarize the ETIS data by grouping Parties with similar levels of illegal trade characteristics. Since CoP12, this initial step has been achieved using an agglomerative hierarchical cluster analysis (See Annex 1a, adopted from CoP19 Doc. 66.6); this method broadly differentiates countries and territories by their levels of illegal ivory trade based on number of seizures and seized weight. Starting with the CoP16 ETIS report, input variables to the cluster analysis were derived from bias-adjusted data from the ETIS trend analyses (CoP16 Doc. 53.2.2 (Rev. 1)). Once highly affected Parties were characterized according to their ETIS data, a second step was to assess whether these Parties should be identified as NIAP Categories A, B or C. This assessment was made by considering contextual information, including data on Parties' law enforcement efforts (e.g., law enforcement ratio based on ETIS data and notable arrests), governance (e.g., Corruption Perceptions Index), organized crime (e.g., Organized Crime Index) and other reports and peer-reviewed papers on ivory-trade, related legislation, and notable law enforcement actions (e.g., Part IV of CoP19 Doc. 66.6). Annex 1 to document SC78 Doc. 65.3 details the previous procedures and criteria used to recommend Parties into NIAP Categories.

25. Following TRAFFIC's consultation with the MIKE-ETIS TAG and the CITES Secretariat in the preparation of the ETIS report to CoP19, it was recognized that "*more refinements might be made in future assignment of Parties under the NIAP process to Category C, as well as Categories A and B, as better definitions are developed by the Parties as to what most affected, markedly affected, and affected mean in terms of quantifiable illegal trade characteristics*" (CoP19 Doc. 66.6). Consequently and in line with the ETIS review recommendations to improve the analytical framework of ETIS (recommendation # 25 in CoP19 Doc. 21), the Parties adopted Decision 19.97 directing the Secretariat, in consultation with the MIKE-ETIS Technical Advisory Group and TRAFFIC, to "*develop draft criteria for the categorization of Parties based on the ETIS analysis and seizure data relating to elephant specimens submitted to TRAFFIC; and submit the draft criteria to the 78th meeting of the Standing Committee for consideration*." Previous ETIS analyses qualitatively used trend analysis results and additional contextual information to inform the identification of Parties requiring attention under NIAP but did not derive holistically quantifiable metrics regarding why Parties have been identified and what possible disruption measures taken by those Parties under the auspices of CITES will have on the wider illegal ivory trade network. This document suggests

improvements to the analytical framework of the ETIS analyses and considers the potential application of network-based methods to ETIS data to informing the identification of Parties affected by illegal ivory trade.

Rationale for the application of network models to ETIS data

26. The illegal trade of ivory involves multistep trade chains which can include origin, export/re-export, transit and destination countries or territories. Enforcement or policy action that might be implemented by Parties through regulatory actions such the NIAP process can have wider impacts beyond the individual Party. The existing ETIS analysis to categorize Parties focuses on each Party separately and is therefore less efficient in quantifying how action by highly affected Parties (e.g., NIAP Category A or B) may alter the wider structure of the interconnected illegal ivory trade chain. Presenting ETIS data in the context of a trade network highlights the connectedness of illegal ivory trade chains and conforms to the Parties' recognition that "*the illegal trade in elephant specimens is an international problem which requires all elephant range States and transit and consumer States to take urgent and concerted efforts to combat it*" (Res. Conf. 10.10 (Rev. CoP19)). It also exemplifies the different roles Parties may play in the illegal ivory trade network and, under processes such as the NIAP, allows for the identification of affected key players and trade links, promoting multi-lateral collaboration and more effective interventions to disrupt illegal trade.

Brief background to network terminology

27. The interconnected nature of global illegal ivory trade chains can be viewed and analysed as a network, where Parties are considered as *nodes* and measures of illegal ivory trade volume are represented as *edges* linking these nodes. Node importance can be summarised as centrality metrics that measure the interconnectedness of a given node (Landherr et al., 2010); for example, the *degree in* metric simply sums the number of connections of a given node (or a Party in the case of ETIS), whereas *closeness* assesses the average length of the shortest path between the node and all other nodes in the network (or illegal ivory trade in the case of ETIS). Such metrics can be extended to include *edge weights* that place a value on the connections between nodes (e.g., the total ivory weight illegally traded or the number of seizures related to that illegal ivory trade link).

28. In most conventional network analyses, edge weights are often applied as a measure of distance where, two nodes that have a high distance are considered as less connected than two nodes with a short distance. However, for application to ETIS data, the inverse interpretation could be considered as nodes connected by higher volume of illegal ivory trade are likely more closely connected in terms of the illicit trade network. Thus, a conventional interpretation of common network centrality metrics can be easily applied to ETIS data by using inverse edge weights for metrics that interpret edges as distance.

Key player identification

29. A drawback to network centrality measures is that they focus on the individually most voluminous or most central nodes (or Parties), which is similar to the current ETIS analysis framework in the categorization of the Parties and can be inefficient given redundancy in the illegal ivory trade network. For example, identifying the top two most central nodes may be largely redundant if those nodes have a high tie strength (shared edge volume) and share many edge connections. In such cases, a more optimal approach would be to identify a node from a different region of the network with a high centrality score that augments, but not replicates, those of the first identified node. This complexity increases as more nodes are identified and the effects ripple through the network.

30. A solution to the issue of redundancy in the identification of nodes by their order of individual importance is provided in the *key player* methodology, which algorithmically identifies the most central *group* of nodes from a network (Borgatti, 2006). The key player approach has two dominant paradigms. Firstly, the Key Player Problem/Positive (KPP-Pos) aims to maximise the dissemination of information through a network. The KPP-Pos has practical applications in a public health context, for example, where a health agency needs to identify an optimal subset of the population to seed the dissemination of behavioural changes or new practices. Secondly, the Key Player Problem/Negative (KPP-Neg) identifies the group of nodes that would result in a residual network with the least possible cohesion (maximises fragmentation); again in a public health context this paradigm has application in identifying key nodes to most efficiently contain a pandemic. For criminal networks, KPP-Neg has the most relevance as it seeks to maximise the disruption

of the network; it is therefore the most relevant key player paradigm to apply to ETIS data and the categorization of the Parties.

31. The key player problem (KPP-Neg) has previously been applied to illicit wildlife trade networks (Patel et al., 2015), finding that acting in a small number of well-connected nodes can lead to high levels of potential network disruption. It is noted that authors did not perform any bias-adjustment of the illegal trade data, and this is an extension that can be applied to ETIS data given current modelling framework. Bias-adjustment is especially important if nodes (or Parties) are compared to each other, as reporting rates of data as well as seizure rates can vary by Party and overtime; such bias-adjustment methodology has been implemented in ETIS trend analyses since CoP16.

32. This technical paper proposes the development of a modelling framework to apply network methodology to bias-adjusted ETIS data to quantitatively identify key groups of Parties with a high group-level influence over the wider illegal ivory trade network, and subsequently to utilise this and other network-based inference to strengthen the identification of Parties affected by the illegal ivory trade. As such the suggested methodology improvements aim to address ETIS review recommendations to improve the analytical framework, and inform the development of criteria for the ETIS categorization of the Parties.

METHODS

Constructing the network

Input ETIS data

33. The analyses presented here are based on the data used in the ETIS report to CoP19 (CoP19 Doc 66.6), which allows comparisons between the previous and proposed analytical methods. Following the established ETIS methodology (Annex 1c of SC74 Doc. 68), missing seizure weights were estimated from the reported number of pieces, and all worked ivory weights were converted to their Raw Ivory Equivalent (RIE) to account for wastage in carving. All seizure records were adjusted based on mean country-, or territory-, and year-specific seizure and reporting rate parameters obtained from the trend analysis modelling (see methodologies Underwood et al. 2013 and Annex 1c of SC74 Doc. 68). For the CoP19 report, this was composed of 30,259 seizure records, of which 16,753 were included in the analysis.

34. The *country of discovery* (or country or territory of seizure) is a minimum required field to add a record to the ETIS database (paragraph 2.a of Annex 1 of Res. Conf. 10.10. (Rev. CoP19)). While reporting countries or territories in the rest of the trade chain route is not considered as minimum requirement, it is nonetheless essential to inform the trend modelling in terms of bias-adjustment seizure rate covariates (i.e., in constructing the law enforcement ratio covariate) and the qualitative synthesizing of illegal ivory trade chain data to inform the categorization of the Parties (e.g., through the assessment of the number of trade links a Party might have). Therefore, regardless of the application of network modelling to ETIS data, the use of any data elements in ETIS analyses (e.g., trade chain or quantities seized) assumes that each Party reports the data correctly[22]. Additionally, as implicitly inferred in any ETIS analyses, bias-adjusted ETIS data is assumed to be representative of the illegal ivory trade patterns as this is the best available information to infer illegal trade trends and affected Parties. These underlying assumptions have been used since the first analysis of ETIS data in the report to the Parties at CoP12 and are implicit also for the network methodologies proposed here. A list of the assumptions applied in the modelling of ETIS data can be found in Annex 4b.

35. With the above in mind, the reported trade chain data was used to construct the illegal ivory networks. When multiple origin or exports were given, the edge-weight was assigned based on the proportions reported in the data or, if no proportions were given, the weight was split equally between all named origin/export countries. Where multiple transit countries are named in a seizure record, it was assumed that the route passes through the countries or territories in the order given. This aligns with the reporting protocol and was confirmed by checking a subset of seizure records in detail. A list of the assumptions applied in the application of the network analysis methodology can be found in Annex 4b.

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[22] *It is noted that through the ETIS data validation process (e.g., Notification No. 2024/068) Parties can review and validate data related to their Party including their position on the trade chain route.*

36. Similar to the input of the trend analysis results that inform the identification of Parties requiring attention under NIAP (by also conducting a cluster analysis), the total number of seizures and reported weight that were used to represent the network edge weight were bias-adjusted using country- and year-specific parameters for reporting and seizure rates as obtained from the ETIS trend analyses. Hereafter, and unless otherwise specified, referring to trade volumes or network input data refers to the bias-adjusted data using already published ETIS methodologies. The section below expands on the bias-adjustment approach to address the issues of missing trade routes in the data.

Bias-adjustment for missing trade routes

37. In examining the raw input ETIS data, it was observed that 47% (n = 7,822) of seizure records provide only the country of discovery without a trade route. The remaining 53% of records include a full or partial trade chain route, progressing from the origin to the export to the transit and then to the destination country or territory (see Annex 1a to document SC78 Doc. 65.1). This underreporting is not unique to trade data and has been reported for quantity elements of the ETIS data where on average, 34% of the ETIS records included in analysis have both the number of pieces and total weight reported (Annex 1a to document SC78 Doc. 65.1).

38. Three plausible explanations were considered as to why no trade route was reported for the 7,822 records:

- The discovery country or territory was the range State from which the ivory originated. In this case, the ivory was most likely seized before it could be moved out of the country or territory. Thus, there is no unreported trade chain. Similarly, in a small number of cases, the ivory could be destined for markets within the origin range States.

- The ivory was seized in a country or territory further along the trade chain (export, transit or destination) but the prior route was either not known or not reported. Missing route information means that countries or territories that are involved in the illegal trade but not reported in trade chains are underrepresented in all subsequent analyses.

- A less common occurrence may be that the ivory was seized in a country or territory due to a specific domestic law breach (e.g., mislabelling, lack of certification) but had originally entered the country or territory legally. This likely affects only a small number of cases and the identification and discrimination of such cases has not been attempted to date.

39. Two potential approaches were considered to address issues presented by the missing route information:

- *Apply no bias-adjustments for missing routes* – Records that report only the discovery country remain in the network with no further adjustment. These then represent self-loops in the network, i.e., the route goes from Party X to Party X. This has significant implications, as while the discovery country itself may be represented fairly in subsequent analyses, other countries or territories who in fact had a role in that movement of ivory will be underrepresented, thus underestimating their role in the wider trade network. This approach is equivalent to how the existing ETIS analyses handles missing routes, although it leads to biases since Parties differ in their route-reporting habits.

- *Missing trade route bias-adjustment* – An alternative approach is to apply bias-adjustment procedures similar to the reporting and seizure rates and to calculate a route-reporting rate (RRR) based on the volume of ivory trade (weight or transactions) that a Party reports with and without a trade route. Similar to the ETIS trend analysis, this can then be applied to proportionately adjust the reported volume of ivory trade discovered by a given country or territory. The RRR is therefore derived per discovery country *i*, and per time period *p* (in this case per CoP reporting period), as the volume (ivory weight or number of transactions) reported by country or territory *i* during period *p* with a trade route, $V^r_{i,p}$, divided by the total volume reported by country or territory *i* during period *p* for all seizures with or without reported trade route, $V_{i,p}$:

$$RRR_{i,p} = \frac{V^r_{i,p}}{V_{i,p}}$$

This bias-adjustment can then be applied to adjust the seizure records with known routes reported by country or territory *i*. Let $s^r_{i,p,j}$ denote the total volume (ivory weight or number of transactions) of the j^{th} seizure reported by country or territory *i* during period *p* which includes a trade route. Then its route-reporting bias-adjusted volume is given by:

$$\tilde{s}^r_{i,p,j} = \frac{s^r_{i,p,j}}{RRR_{i,p}}$$

This bias correction is only applied to ivory quantities associated with the known routes of the discovery country (see worked example in Annex 4c) and was applied to nodes with at least five seizures with a known route; for discovery countries with less than five routes reported, seizures without a route were retained as self-loops. This is to ensure that bias-adjustment doesn't include routes that have occurred particularly infrequently, e.g. if a range country mostly makes seizures in country with no subsequent route, but in a one-off seizure ivory was seized further down the trade chain implicating that country or territory.

40. It is noted that the missing trade route bias-adjustment approach impacts transit and/or destination countries where an illegal consignment never passed through or reached. This is not unique to the bias-adjustment methods described here and is inherent in the ETIS data and analysis as onward trade chains and Parties' roles along the chain are considered as contextual information to inform categorization of the Parties. There is a compelling argument to be made that this approach correctly captures the illegal ivory trade *flow* from start to finish; even if a consignment never reached its transit or destination, it was illegally intended to happen, thereby implicating the Parties further along the trade flow. Additionally, bias-adjustment places the focus on the flow of the commodity rather than the Parties that had contact with the ivory, the latter being difficult to reliably ascertain as a shipment may pass through a transit country or territory without that country having the legal right or opportunity to seize.

41. An important feature of the no route-reporting rate (RRR) bias-adjustment and the RRR bias-adjustment is that no new transactions or weight are introduced into the network (no double counting); hence for a given time period under analysis, the total bias-adjusted ivory weight and number of transactions moving through the network remains constant regardless of the method. An alternative approach suggested during the consultation with the MIKE-ETIS TAG and the CITES Secretariat was to fully remove records with no trade route from the analyses. The full details and exploration of this approach and its output is given and discussed in Annex 4d of this report.

Identification of Parties requiring attention using key player approach

Key player identification metric

42. As discussed previously, the key player problem can be focused on identifying the optimum group of nodes to *fragment* a network (KPP-Neg). Here, the classic approach to fragmenting a network is adapted using a greedy search algorithm to select seed nodes and iteratively swap nodes to assess increases in fragmentation (An & Liu, 2016). The algorithm itself is highly versatile as it works to optimise by the function that is defined as the fragmentation metric.

43. The classical fragmentation metric approach from graph theory considers edges as a measure of distance between nodes (e.g., larger edge values indicate that nodes are less well connected). As previously mentioned, this could theoretically be modified to use the inverse ivory volumes to denote the tie strength of nodes. This method assumes that it is easier to move between nodes with a high weight or number of transactions:

$$F = 1 - \frac{2\sum_{ij\neq k}\frac{1}{d_{ij}}}{n(n-1)},$$

where d_{ij} is the geodesic distance of the inverse edge weight for nodes *i* and *j* (high-weight edges are "closer"[23] than low-weight edges) after node *k* is removed. Thus, the higher the value of *F* (ranging from 0 to 1), the more fragmented the network becomes as illegal activity must utilise rarer, lower-weight edges to reach the same nodes. This approach is common in network analyses in which the edge between nodes has an intuitive distance or tie strength interpretation.

44. Proposed here is a second, more directly applicable, fragmentation metric based on the proportion of total network volume that flows through a particular node and that can be disrupted. This provides a more intuitive metric to quantitively identify key players requiring attention to disrupt the flow of illegal ivory trade. Here, W_n represents the *total network volume*, or the total volume of ivory present in the network for any given time period. Similarly, *k* represents a node (or a group of nodes), and W_k denotes the volume of *k,* which is defined as the total ivory volume discovered within *k* without any external trade route plus the total ivory volume flowing into and out of *k* (avoiding double counting volume related to seizures that both entered and exited). Thus, W_k can be viewed as the total volume of ivory that a given *k* node(s) interact with. The proposed disruption metric, D_k, gives the *proportion of total ivory flowing through the network* that would be removed by removing node(s) *k*:

$$D_k = \frac{W_k}{W_n}.$$

The special case of this when *k* represents a single node is hereafter termed the *individual node volume*.

45. It is worth noting that while the classical fragmentation method removes only the target nodes to recalculate the metric to be optimized, the proposed disruption metric also accounts for edges further along the trade routes. Thus, when a group of nodes is removed, *all* edge contributions from seizures involving those nodes are also removed.

Selection of key players that require attention

46. Here, the disruption metric D_k is optimised via the key player algorithm applied with groups of two to 20 nodes at a time. Results can be plotted as the percent disruption of the network as a function of the key player group size (see Figure 7 under Results and Discussion). Naturally, as group size increases, the maximum disruption increases, though at a diminishing rate as more of the network becomes disrupted. While a disruption score of 100% is desired to completely stop illegal ivory trade flows, it is likely unrealistic to achieve. Alternatively, one can determine the group size as the number of key players to remove in order to achieve a specific threshold of network disruption (e.g., 75% or 90%). However, a more informed guideline may be to effectively balance the trade-off between group size and disruption by finding the group size at which the gradient of the key player line decreases the most, i.e., the group size at which the rate of increase in the maximum disruption falls the fastest.

47. Here, both the threshold method as well as the optimal trade-off method were implemented to select a group size of key players that require attention and maximize disruption of the network. The key Parties selected were then identified – i.e., the Parties that would achieve a network disruption of 75% or 90% of the illegal ivory trade, or the Parties that were identified based on the balanced trade-off solution (that may achieve less than 75% or 90%). To incorporate uncertainty, the analysis was repeated 100 times, each time applying different seizure and reporting rate bias-adjusting parameters from their posterior distributions from the ETIS trend analyses. This created a 'posterior distribution' of bias-adjusted networks, each with its selection of key Parties for the three approaches (75% or 90% disruption thresholds method and optimal trade-off method). Results were summarized based on the group combinations that were most frequently selected across the 100 iterations and reported as the range of percent disruption for the selected group of key Parties based on the 100 network iterations.

Evaluation of key player approach alongside current methodologies

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[23] *It is stressed that the distance is not based on geographic distance but rather on the relative magnitude of the edge weight considered, i.e., total volume of trade by weight or by number of transactions.*

48. Methods to identify Parties requiring attention under NIAP using the key player approach were compared to current methodologies and the Parties reported as NIAP Categories A (*most affected*) and B (*markedly affected*) and C (*affected*) in the ETIS reports to CoP. As described above and detailed in Annex 1 to document SC78 Doc. 65.3, current methodologies rely on identification of Parties with similar high and low illegal trade characteristics where Parties belonging to high-value clusters and that have "…higher overall illegal trade activity within country, but also higher large-scale illegal trade activities that occurred in the country undetected…" are considered as requiring attention under NIAP Categories A and B. Further differentiation of Category A and B Parties considers the scale of the Party's seizure data and its location along the trade chain, such that Parties with more small-scale seizures made in country were assigned a Category B, and Parties which had more large-scale seizures in which the illegal trade chain implicated the country were assigned to Category A (CoP19 Doc. 66.6). Here, results from the key player approach are compared with Parties previously identified as Category A and B.

49. In previous ETIS reports to CoP, the analyses also identified Category C (*affected*) Parties which exhibited emerging trends in illegal ivory trade and are important to watch. Here, a similar approach was used by evaluating any rapid or unusual increases in the relative importance of Parties to the illegal trade network over analysis time periods that correspond to CITES CoPs. This approach can be extended to also examine Parties with decreasing trends, which may result from regulatory intervention by Parties implementing CITES Decisions or processes. Implementing such analysis is in line with the objectives of the ETIS programme as specified in paragraph 27.a.ii of Res. Conf. 10.10 (Rev. CoP19) to assess "…*whether and to what extent observed trends are related to measures concerning elephants and trade in elephant specimens taken under the auspices of CITES."*

50. Since the data analysed for CoP19 ranged from 2018 – 2020 and included the unusual effects of COVID19, comparisons to evaluate new and current analytical methods were repeated using the CoP18 data (CoP18 Doc. 69.3 (Rev. 1)). However, for brevity, only the results of the comparison to CoP19 data are presented and discussed in this Annex; comparisons to CoP18 data are included in Annex 4f. Additionally, for the sake of brevity and because threshold results were highly nested (e.g., Table 3 and Annex 4e), the current methodologies are discussed only in comparison to the 75% threshold and trade-off approaches to identify key players (see previous section for details).

RESULTS AND DISCUSSION

Construction of illegal ivory trade networks

51. The following presents worked and raw ivory trade flows for the CoP19 reporting period for both transactions-based and weight-based networks, with the two different approaches for dealing with missing route reporting: no bias-adjustment and route reporting rate (RRR) bias-adjustment (hereafter respectively referred to as no RRR-adjustment and RRR-adjustment). It is noted that results are largely consistent across no RRR-adjustment and RRR-adjustment approaches in terms of the network structure (Figure 5 for worked ivory and Figure 6 for raw ivory) and the dominant network nodes (Table 1 for worked ivory and Table 2 for raw ivory). However, considering different edge weight input data (i.e., number of transactions or weight) results in different identification of key network features and key players for both worked and raw ivory. Finally, it is worth highlighting that some of the most dominant nodes and edges, regardless of route adjustment approach, are self-loops, especially with the no RRR-adjustment approach. This is commonly the case for the more typical origin/export countries since almost all seizures they discover have no subsequent route; therefore, these countries often don't have enough routes to apply the RRR bias-adjustment. The following provides additional breakdown of the results for worked and raw ivory flows.

Worked ivory trade flows

52. *Worked ivory transaction flows* were similar across the two bias-adjustment approaches (Figure 5) where China was involved in 33-42% of all transactions in the network (represented as a proportion of total network volume; Table 1). The next most affected nodes by number of worked ivory transactions were the United States of America, United Kingdom, Viet Nam and France (albeit at a far smaller scale, 11-19%). Most key trade routes for the no RRR-adjustment network were self-loops (Table 1), this is a product of 1) range countries seizing the ivory hence no subsequent routes were reported and 2) targeted enforcement action in specific countries e.g., *Operation Thunder*. For the RRR-adjustment network, besides the self-

loop of Spain, key trade routes highlighted included Viet Nam to the United States of America, and four routes to China from United Kingdom, Viet Nam, Belgium, and Hong Kong SAR of China.

53. *Worked ivory weight flows* were also similar across the two bias-adjustment approaches in terms of the most affected nodes and trade links, but it identified different Parties as the most important compared to the results based on the transactions network (Figure 5 and Table 1). Important nodes consisted of Viet Nam accounting for roughly 30% of the overall trade volume, followed by China and Nigeria each accounting for roughly 20% of the overall trade. In terms of the most affected trade links, the top edge in both analyses was a self-loop by Angola, followed by direct flows from Nigeria to Türkiye and Türkiye to Viet Nam (Table 1).

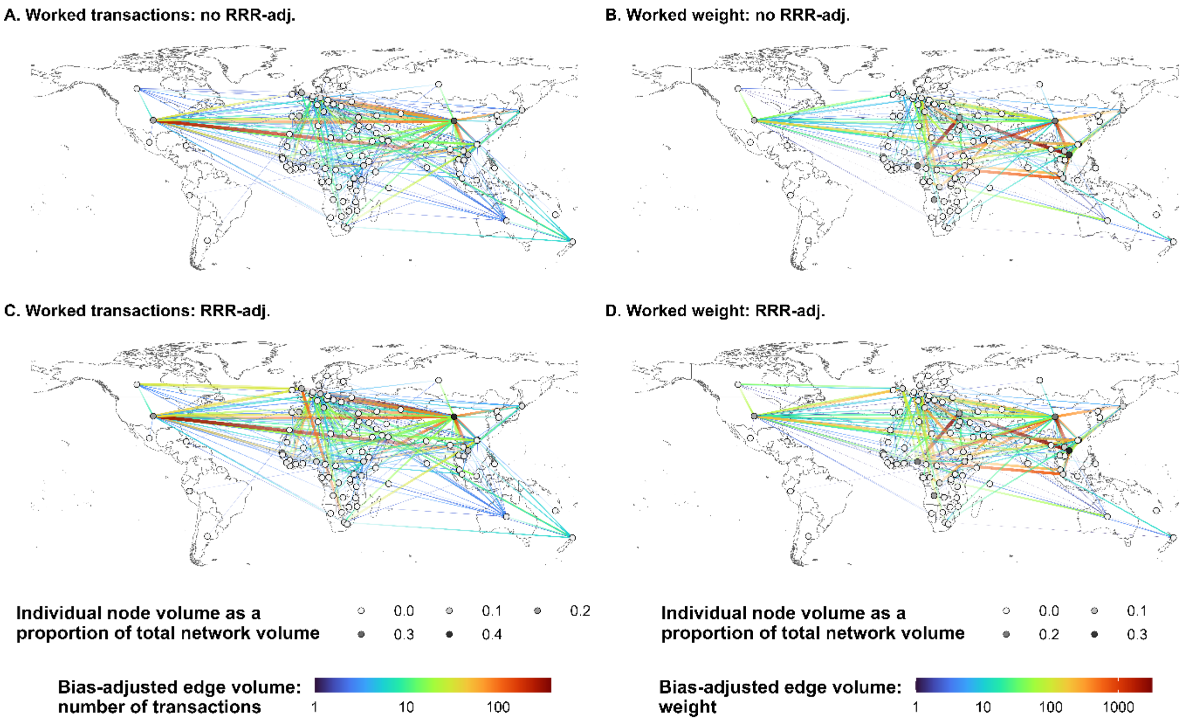

Figure 5. Illegal worked ivory networks for the CoP19 reporting period of ETIS data (2018-2020). Networks were constructed with (bottom panels) and without (top panels) route reporting rates (RRR) bias-adjustment. The left panels show transaction-based networks and the right panels show weight-based networks. Edges are coloured based on their log scaled relative volume (using a separate scale for the left panels and the right panels), and nodes are coloured by individual node volume as a proportion of total network volume.

Table 1. Most affected Parties and trade links to the illegal worked ivory network. The top five Parties (nodes) and top five trade links (edges) most affected by the flow of illegally traded worked ivory for ETIS data analysed for the CoP19 reporting period**.** Node and edges are ranked by their volume as a proportion of total network volume. Proportions summed across all nodes or edges equal more than 1 due to redundancy in the network and the same ivory passing through multiple nodes. A proportion of e.g., 0.2 denotes that the node or route is involved in 20% of all transactions or weight that occurred in the ETIS data analysed for CoP19.

	No RRR adjustment		**RRR adjustment**	
	Important node	Important edges	Important node	Important edges
Transactions network	CN (0.33)	GB to GB (0.1)	CN (0.42)	GB to CN (0.08)
	US (0.17)	FR to FR (0.09)	US (0.19)	ES to ES (0.08)
	GB (0.14)	ES to ES (0.08)	GB (0.15)	VN to US (0.07)
	FR (0.12)	VN to US (0.06)	VN (0.14)	BE to CN (0.04)
	VN (0.11)	CN to CN (0.05)	FR (0.13)	HK to CN (0.03)
Weight network	VN (0.30)	AO to AO (0.14)	VN (0.32)	AO to AO (0.14)
	CN (0.20)	NG to TR (0.12)	CN (0.21)	NG to TR (0.12)
	NG (0.19)	TR to VN (0.12)	NG (0.20)	TR to VN (0.12)
	AO (0.14)	VN to VN (0.09)	AO (0.14)	US to FR (0.10)
	TR (0.12)	LA to LA (0.06)	US (0.14)	VN to VN (0.09)

Raw ivory trade flows

54. *Raw ivory transaction flows* for the no RRR-adjustment and RRR-adjustment networks indicate that the most important nodes are all African and Asian elephant range States including Gabon, India, Botswana, Zambia, Zimbabwe, Tanzania and Kenya (Table 2). However, the percentage of single top most affected node (i.e., individual node volume as a percent of total network volume) is smaller (7% – 16%) than the top most affected nodes of the worked network (11% – 42%). Similar to the worked ivory analysis, all most affected edges were self-loops for the no-RRR networks, and most were also self-loops for the RRR-adjusted network except one trade link between Tanzania and Botswana (Table 2).

55. Results for the *raw ivory weight flows* were identical regardless of the RRR-adjustment approach, with Viet Nam being particularly important to the network as it is involved in the flow of 55% of all raw ivory by weight. Singapore, Democratic Republic of the Congo, Nigeria, and Congo similarly being involved in the flow of 22% – 35% of all raw ivory in the network by weight. Multiple high raw ivory weight routes emerge between Africa and Asia (Congo to Singapore, Nigeria to Viet Nam) as well as within Africa (Democratic Republic of the Congo to Congo) and within Asia (Singapore to Viet Nam and Viet Nam to China (Figure 6, Table 2)).

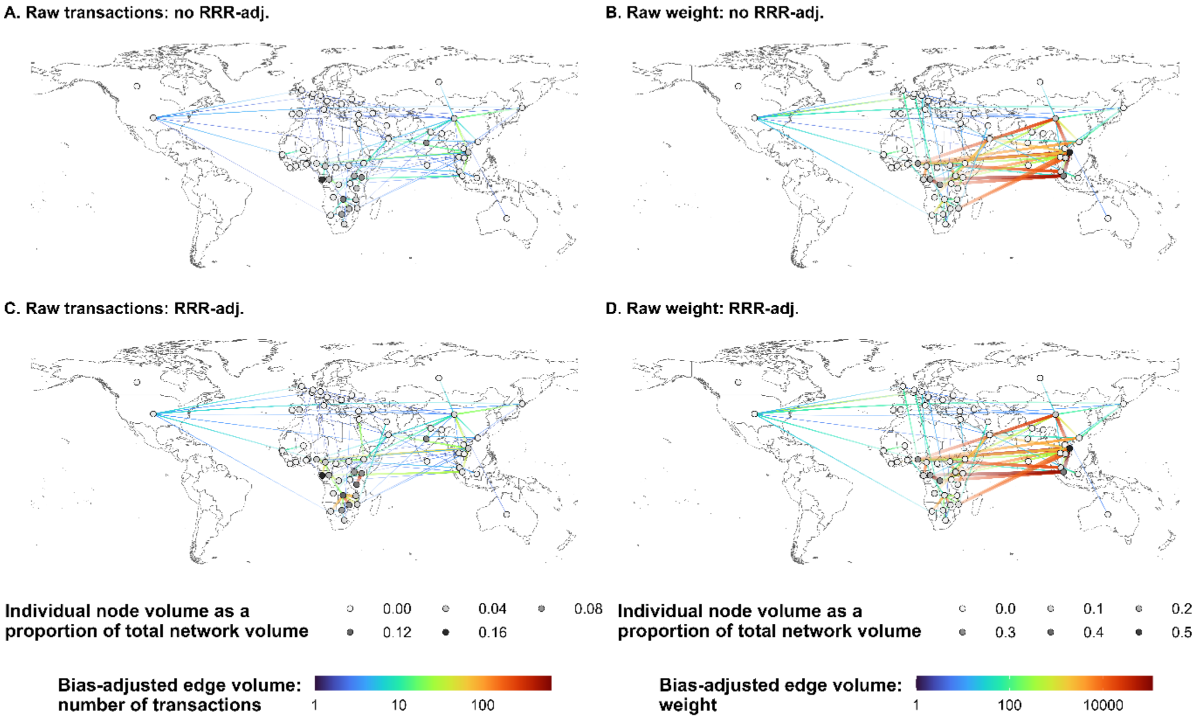

Figure 6. Illegal raw ivory networks for the CoP19 reporting period of ETIS data (2018-2020). Networks were constructed with (bottom panels) and without (top panels) route reporting rates (RRR) bias-adjustment. The left panels show transaction-based networks and the right panels show weight-based networks. Edges are coloured based on their log scaled relative volume (using a separate scale for the left panels and the right panels), and nodes are coloured by individual node volume as a proportion of total network volume.

Table 2. Most affected Parties and trade links to the illegal raw ivory network. The top five Parties (nodes) and top five trade links (edges) most affected by the flow of illegally traded raw ivory for ETIS data analysed for the CoP19 reporting period**.** Nodes and edges are ranked by their volume as a proportion of total network volume. Proportions summed across all nodes or edges equal more than 1 due to redundancy in the network and the same ivory passing through multiple nodes. A proportion of e.g., 0.2 denotes that the node or route is involved in 20% of all transactions or weight that occurred in the ETIS data analysed for CoP19.

	No RRR adjustment		**RRR adjustment**	
	Important node	Important edges	Important node	Important edges
Transactions network	GA (0.15)	GA to GA (0.15)	GA (0.16)	GA to GA (0.15)
	ZM (0.10)	ZM to ZM (0.09)	ZM (0.12)	IN to IN (0.09)
	IN (0.09)	IN to IN (0.09)	TZ (0.11)	BW to BW (0.07)
	KE (0.08)	KE to KE (0.08)	ZW (0.09)	TZ to KE (0.07)
	BW (0.07)	BW to BW (0.07)	IN (0.09)	UG to UG (0.06)
Weight network	VN (0.55)	SG to VN (0.32)	VN (0.55)	SG to VN (0.35)
	SG (0.32)	CD to CG (0.20)	SG (0.35)	CD to CG (0.23)
	CD (0.27)	CG to SG (0.20)	CD (0.30)	CG to SG (0.23)
	NG (0.25)	NG to VN (0.12)	NG (0.27)	NG to VN (0.14)
	CG (0.22)	VN to CN (0.08)	CG (0.24)	VN to CN (0.08)

Identification of Parties requiring attention using key player approach

56. Table 3 and Figure 7 show the key player results for the weight-based illegal trade network (see Annex 4e for the results of the transaction-based networks and no RRR bias-adjustments, which are not discussed in detail for brevity). Incorporating uncertainty by running the key player algorithm on 100 posterior networks highlighted a generally very high degree of agreement between the Parties selected for maximum disruption at each group size (Table 3). In a small number of cases, there is uncertainty in the selection of key players across the posterior distribution of networks, e.g., the results for the raw ivory network where VN and NG, and VN and GA were equally identified (probability of 0.5). However, all three Parties were identified with full agreement across the posterior network distribution for the group size of three. Detailed results of the Parties selected to achieve a 75% or 90% disruptions (threshold approach) or selected based on optimizing the trade-off of diminishing percent disruption gain as selected group size increased (trade-off approach) are discussed in the following section and compared against the current methodologies to identify Parties requiring attention under NIAP.

Table 3. Parties included in the most frequent key player selection. The table shows the groups of Parties selected with the highest probabilities based on 100 randomly sampled posterior bias-adjusted networks, and their disruption ranges (90% quantile interval) across these 100 networks. Results are displayed for networks constructed based on the weight volume of worked and raw ivory with a route reporting rate (RRR) bias-adjustment approach (RRR-adj.) for data informing the ETIS report to CoP19 (CoP19 Doc. 66.6). Light grey shading highlights the Parties selected to achieve at least 75% disruption of the illegal ivory networks based the median disruption values (not shown here, but enclosed in 90% quantile interval); similarly, dark grey shading highlights the Parties selected to achieve 90% network disruption and the * denotes the groups selected based on the optimization procedure. Equivalent results from the networks without a route reporting rate bias-adjustment and for transaction-based networks can be found in Annex 4e.

Type	Group size	Key players	Probability	Disruption % (90% quantile interval)
Raw	1	VN	1	[52, 57]
	2	VN, NG	0.5[24]	[61, 65]
	3*	VN, NG, GA	1	[70, 73]
	4	VN, NG, GA, MZ	0.54	[74, 77]
	5	VN, NG, GA, MZ, ZW	1	[78, 81]
	6	VN, NG, GA, MZ, ZW, UG	0.80	[82, 84]
	7	VN, NG, GA, MZ, ZW, UG, BW	0.97	[84, 87]
	8	VN, NG, GA, MZ, ZW, UG, BW, TZ	0.85	[87, 89]
	9	VN, NG, GA, MZ, ZW, UG, BW, TZ, AO	0.55	[89, 90]
	10	VN, NG, GA, MZ, ZW, UG, BW, TZ, AO, BJ	0.52	[91, 92]
Worked	1	VN	1	[30, 34]
	2	VN, AO	0.57	[43, 50]
	3	VN, AO, CN,	0.74	[59, 63]
	4*	VN, AO, CN, US	1	[73, 75]
	5	VN, AO, CN, US, LA	1	[79, 82]
	6	VN, AO, CN, US, LA, CD	1	[83, 85]
	7	VN, AO, CN, US, LA, CD, IT	0.61	[86, 87]
	8	VN, AO, CN, US, LA, CD, IT, AT	0.99	[88, 89]
	9	VN, AO, CN, US, LA, CD, IT, AT, ES	0.92	[90, 91]

[24] *The pair VN, GA also obtained probability 0.5, although had a lower median disruption score across the 100 networks.*

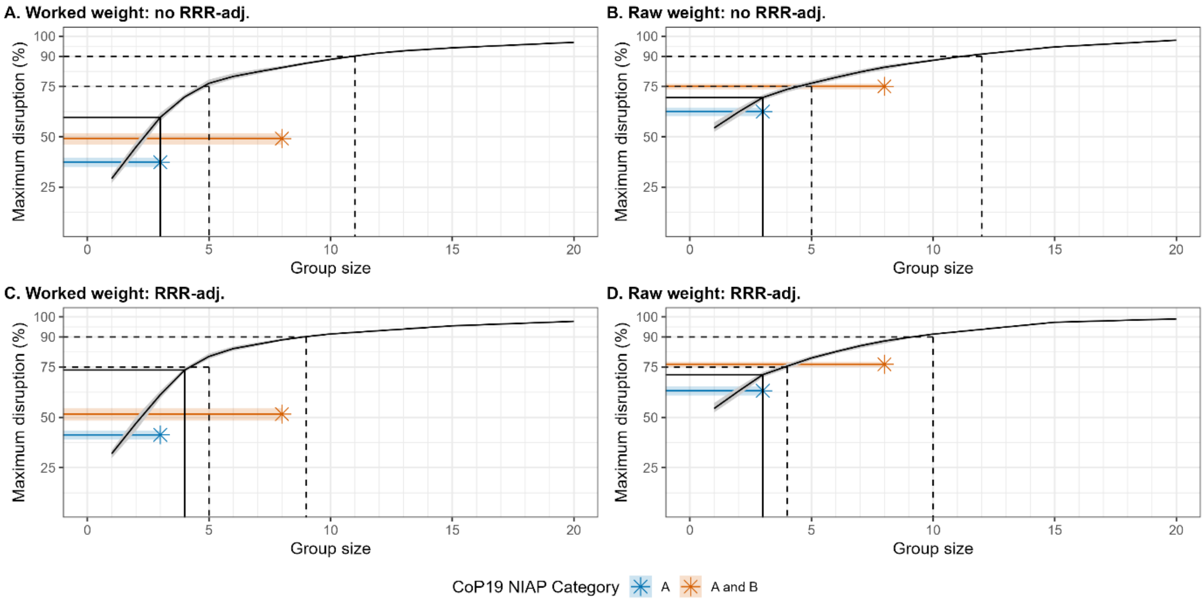

Figure 7. Network disruption as a function of key player selection. Curves show the maximum disruption of the illegal ivory trade networks as a function of key player group size for networks constructed based on weight volume of worked (left column) and raw ivory (right column) and with (RRR-adj.) or without (no RRR-adj.) a route reporting rate (RRR) bias-adjustment approach. Data were summarised for the CoP19 reporting period and are compared to the identification of Parties requiring attention under the NIAP process as Category A (red asterisk) and Categories A and B (orange asterisk) as reported on in the ETIS report to CoP19 (CoP19 Doc. 66.6). Disruption curves are based on the most common selection of nodes of each group size from 100 randomly sampled posterior bias-adjusted networks where median disruption across the 100 networks is plotted with a shaded 90% quantile interval (grey; note that due to the high consistency across posterior networks this interval is often very narrow). Solid black lines represent group selection based on an optimization procedure to balance the trade-off between group size and maximum disruption (the group size at which the rate of increase in maximum disruption slows the most). Dashed lines show group size based on pre-selected disruption thresholds of 75% and 90%.

Evaluation of key player approach with current methodologies

57. A first step in comparing the key player approach with the current methodologies is to calculate the potential disruption that could arise by removing from the network the Parties previously recommended as NIAP Category A (red asterisk, Figure 7) and Categories A and B (orange asterisk, Figure 7). The Parties identified as requiring attention as NIAP Category A (Nigeria, Democratic Republic of Congo and Viet Nam) resulted in network disruption of around 7-20% for transaction-based networks, and 35-65% for weight-based networks depending on the network under consideration (i.e., worked or raw ivory, and with or without bias-adjustment; Figure 7, Table 3, and Annex 4e). In general, when considering key player disruption curves, the percent disruption for NIAP Category A Parties was always smaller than the disruption based on an equivalent group size of Parties identified as requiring attention under the key players approach (Figure 7 and Annex 4e). Similar patterns were observed when considering the percent disruption for all Parties identified as requiring attention under NIAP in Categories A *and* B.

58. Compared to the CoP19 NIAP Category A Parties of Nigeria, Democratic Republic of Congo and Viet Nam that were identified with current methodologies, the proposed key player 75% threshold approach identified Viet Nam, Nigeria and Gabon based on raw ivory weight-based network results, and Viet Nam, Angola, China and United States of America based on the worked ivory results (Table 3). The Democratic Republic of Congo was not selected under the key player approach until a group size of six for worked ivory. Exploring the network input data suggests this is likely because while the Democratic Republic of Congo were implicated in a number of very large weight seizures (3,446 kg, 8,795 kg and 9,104 kg of raw ivory), this seizure transitioned via Singapore to Viet Nam and thus their volume is already 'accounted for' in the key player solution by removing Viet Nam.

59. The potential additional disruption achieved by including the five Category B Parties (Gabon, China, Malaysia, Mozambique and Cambodia) identified in the CoP19 report contributed little to disrupt the

network further for worked ivory, but resulted in better disruption to the raw ivory networks (Figure 7 and Annex 4e). This may suggest that current methodologies of ETIS categorization of the Parties might be focused more on raw ivory seizures and could benefit from consideration of raw and worked ivory separately. Treating raw and worked ivory networks separately can result in more targeted law enforcement and regulatory action targeting supply and demand aspects of the trade-chain and promoting multi-lateral collaborations that are focused on reducing illegal trade in specific ivory commodities.

Identifying emerging trends of key players over time

60. Figure 8 presents results for relative importance trends across CoP reporting periods based on Parties' relative importance in the network (defined as the Parties' node volume as a proportion of the total network volume). Similarly to the interpretation of results in Tables 1 and 2, a value of 0.2 indicates that the Party is involved in 20% all of the illegal ivory trade volume, the latter calculated by number of transactions or weight. Results are shown for worked (Figure 8.A-D) and raw (Figure 8.E-H) networks constructed based on the no RRR or RRR-adjusted approaches described above.

61. Results indicate that the Parties with the greatest increase in worked ivory between CoP18 and CoP19 are Viet Nam, Spain and Italy for transactions-based networks, and Viet Nam, Nigeria and the United States of America for weight-based networks (Figure 8.A-D). The Parties with the greatest increase in raw ivory between CoP18 and CoP19 are Gabon, Zambia and Botswana for transactions-based networks, and Viet Nam, Singapore and the Democratic Republic of the Congo for weight-based networks (Figure 8.E-H). The Parties identified using the key player approach do not include South Sudan which was identified as Category C in the CoP19 report. However, the Parties identified with emerging trends were also identified as most affected in the key players in this report (Viet Nam, Nigeria, Gabon; Table 3), while others were identified as requiring attention in earlier ETIS reports to CoP (United States of America, Singapore). Zambia's and Botswana's emerging trends present an interesting new consideration for their contribution to the illegal ivory trade, and results are in line with the heat map based on the cluster analysis results reported at CoP19 (Figure 1 in Annex 4a of this document).

62. The highlighted declines in Figure 8 were previously discussed in the narrative that accompanied the discussion of contextual information used to identify Parties requiring attention under NIAP but were never presented quantitatively as shown here. For example, it was discussed that legislative and enforcement efforts might have resulted in decreased demand in China, and therefore decreased illegal activity, which seem supported by the results from the transaction-based network results presented in Figure 8; however, caution must be applied when interpreting these results, as they should be considered in the context of the Parties reporting patterns to ETIS (see Figure 1 in Annex 1a to document SC78 Doc. 65.1). It is interesting to further note that Parties that previously completed their NIAP and exited the process (Kenya, Ethiopia, Uganda, Tanzania) are highlighted as having declining trends, possibly attributed to the continued success of CITES-implemented programmes and national efforts. It is possible to use the emerging declining trend analysis presented here for the continued evaluation of Parties that are participating (e.g., Mozambique), are requesting to exit (e.g., Malaysia), or have recently exited the NIAP process.

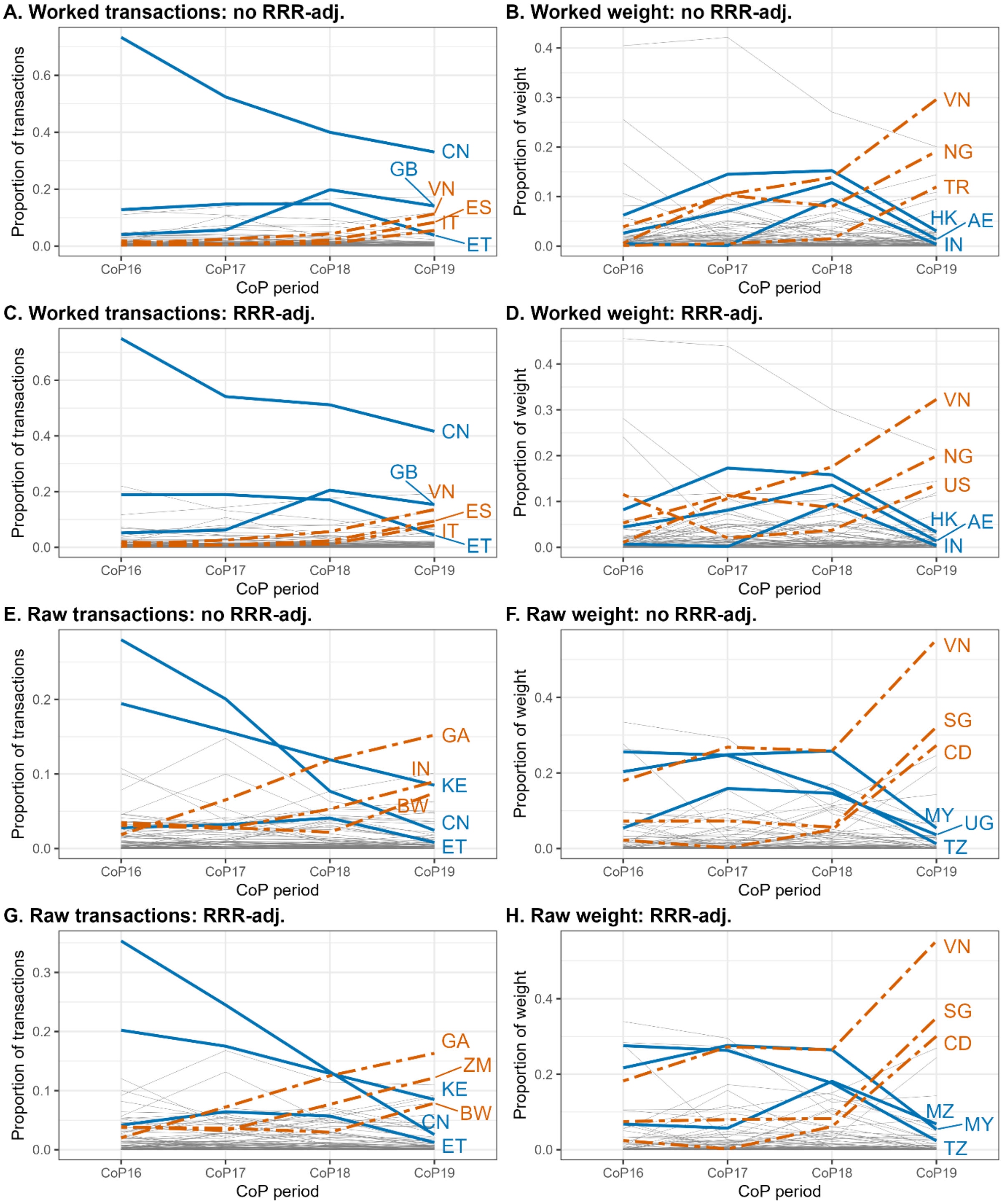

Figure A4. Emerging trends in Parties' proportionate roles in worked and raw ivory trade flows. Panels A – D consist of results for worked ivory networks, while panels E – H consist of results for raw ivory networks. The left column shows results for networks based on the number of transactions and the right column shows results for networks based on ivory weight. Panels in top and third rows show results for networks with no trade route reporting rate (RRR) bias-adjustment (no RRR-adj.), while the second and bottom rows show results for networks with RRR adjustment (RRR-adj.). Orange and blue lines indicate the top three Parties with increasing (orange; dashed) and decreasing (blue) trends from the previous to current CoP periods. Note that the summed period proportions can exceed one as multiple countries will be involved in multiple shared shipments.

Additional considerations

63. There are several considerations for the application of network approaches to ETIS data. Firstly, as reported here and in Annex 1a to document SC78 Doc. 65.1, an average of 53% of the data reported to ETIS include partial or full trade route data. Two approaches presented here (no route-reporting rate (RRR)

bias-adjustment and RRR adjustment) resulted in almost identical results suggesting inferences regarding the network remain relatively robust regardless of how missing routes are addressed. While inference remains similar, it should be noted that the no RRR-adjustment risks biasing the weight or transaction inferences towards range Parties. Additionally, in the case of non-range (more typical consumer countries) Parties with poor route reporting, it adds nothing to an understanding of how ivory came to be seized in that country. In contrast, adjusting for route reporting allows better inference of the flows of ivory and allowing better and more complete understanding of illegal ivory supply and demand flows.

64. A second consideration relates to the fact that potentially few large weight seizures might be driving the observed results of weight-based networks. Such was the case for raw ivory where the record-setting seizures made in 2019 involved few Parties (Viet Nam, Singapore and the Democratic Republic of the Congo). However, this is also the case for the current more qualitative methodology used in the CoP reports, whereby very large seizures receive increased attention. While this is warranted as these seizures indicate the presence of large-scale organized crime, it may be just as important to target also Parties with many smaller illegal ivory transactions. By also considering the outputs from the transaction-based network, a more holistic approach can be achieved in identifying Parties requiring attention.

65. A third consideration relates to the group size selection approaches presented here. Because it is not feasible to engage all Parties or achieve 100% disruption of the illegal networks, there is a need to highlight a few Parties as requiring attention. An agreement could be reached by the Parties as to what constitutes an accepted threshold of disruption to use in such analyses and to direct future analyses. It will also force the debate as to what is an acceptable background rate of illegal ivory trade that, perhaps with further analysis, will not negatively impact the conservation of elephants. Alternatively, several thresholds can be explored and presented to the Parties for most transparent decision-making.

66. While the implementation of the network analysis is computationally intensive, especially in applying the uncertainty analyses, this is already the case with the existing trend analyses of ETIS data, and TRAFFIC has established the capacity to deliver such rigorous analyses. Most importantly, while the underlying algorithms might be complex, the spatial and graphical presentation of the results of the network analyses is intuitive and easily interpretable by non-technical experts in a way previous analyses have not been.

CONCLUSION

67. The network-based approaches outlined here facilitate the visualisation and quantification of key nodes (Parties or groups of Parties) and routes (trade links) in the illegal ivory trade network based on ETIS data collected under established CITES processes. The key player algorithm itself allows the identification of countries or territories most ideally placed to disrupt the illegal ivory trade network. Compared to previously identified Parties, it was found that while some key players were similarly identified, others were newly highlighted, based on a more quantifiable analytical framework and inference. Network analysis results also highlighted the heterogeneity in selecting key players to disrupt raw and worked ivory, which may provide for more targeted objectives for Parties participating under NIAP. The benefits of the key player approach include the ability to quantify the potential for illegal trade disruption (e.g., "effectively achieving NIAP objectives in these x identified Parties has the potential to disrupt xx% of all estimated illegal ivory weight in the network"), which can conceivably be linked to percent achievement of national or regional law enforcement and regulatory interventions.

68. Current ETIS categorization of the Parties include a summary of cluster group characteristics and identification of specific Parties requiring attention under NIAP. The currently implemented methodology has facilitated the easier visualisation and interpretation of patterns across Parties in the type of characteristics their seizure activity groups them into. However, the cluster analysis does not provide a quantitative method to evaluate the Parties' role in the wider and interconnected movement of illegal ivory through the network or understand the relative potential impact of any increased action by the Party. Such analyses are done qualitatively, and thus result in less efficient network disruption solutions compared to the key player approach. By supplementing the current clustering analysis with the network analysis, the identification of Parties can also include key trade routes, thus provide a data-driven recommendation of where enforcement has the greatest potential for multi-lateral efforts by the Parties to disrupt the criminal network. With the additional output derived from the construction of networks using ETIS data (e.g., emerging trends and thresholds of network disruptions), such recommendation can inform the goals and

objectives of CITES Decision and NIAP plans, as well as the achievement of NIAPs and other actions implemented by the Parties under the auspices of CITES.

ACKNOWLEDGEMENTS

TRAFFIC would like to thank the MIKE-ETIS TAG and the CITES Secretariat, as well as Professor Rachel McCrea of University of Lancaster and Dr. Fiona Underwood for providing valuable feedback to improve the methods development presented in this report.

REFERENCES

An, W., & Liu, Y.-H. (2016). keyplayer: An R Package for Locating Key Players in Social Networks. *The R Journal*, *8*(1), 257. https://doi.org/10.32614/RJ-2016-018

Borgatti, S. P. (2006). Identifying sets of key players in a social network. Computational and Mathematical Organization Theory, 12(1), 21–34. https://doi.org/10.1007/s10588-006-7084-x

CITES. (2022). *CoP19 Doc. 66.6. Report on the elephant trade information system (ETIS). Prepared for the Nineteenth meeting of the Conference of the Parties Panama City (Panama), 14 – 25 November 2022.*

Landherr, A., Friedl, B., & Heidemann, J. (2010). A Critical Review of Centrality Measures in Social Networks. *Business & Information Systems Engineering*, *2*(6), 371–385. https://doi.org/10.1007/s12599-010-0127-3

Patel, N. G., Rorres, C., Joly, D. O., Brownstein, J. S., Boston, R., Levy, M. Z., & Smith, G. (2015). Quantitative methods of identifying the key nodes in the illegal wildlife trade network. *Proceedings of the National Academy of Sciences of the United States of America*, *112*(26), 7948–7953. https://doi.org/10.1073/pnas.1500862112

Example output of the ETIS analysis to identify Parties requiring attention in the ETIS report to CoP19 (CoP19 Doc. 66.6)

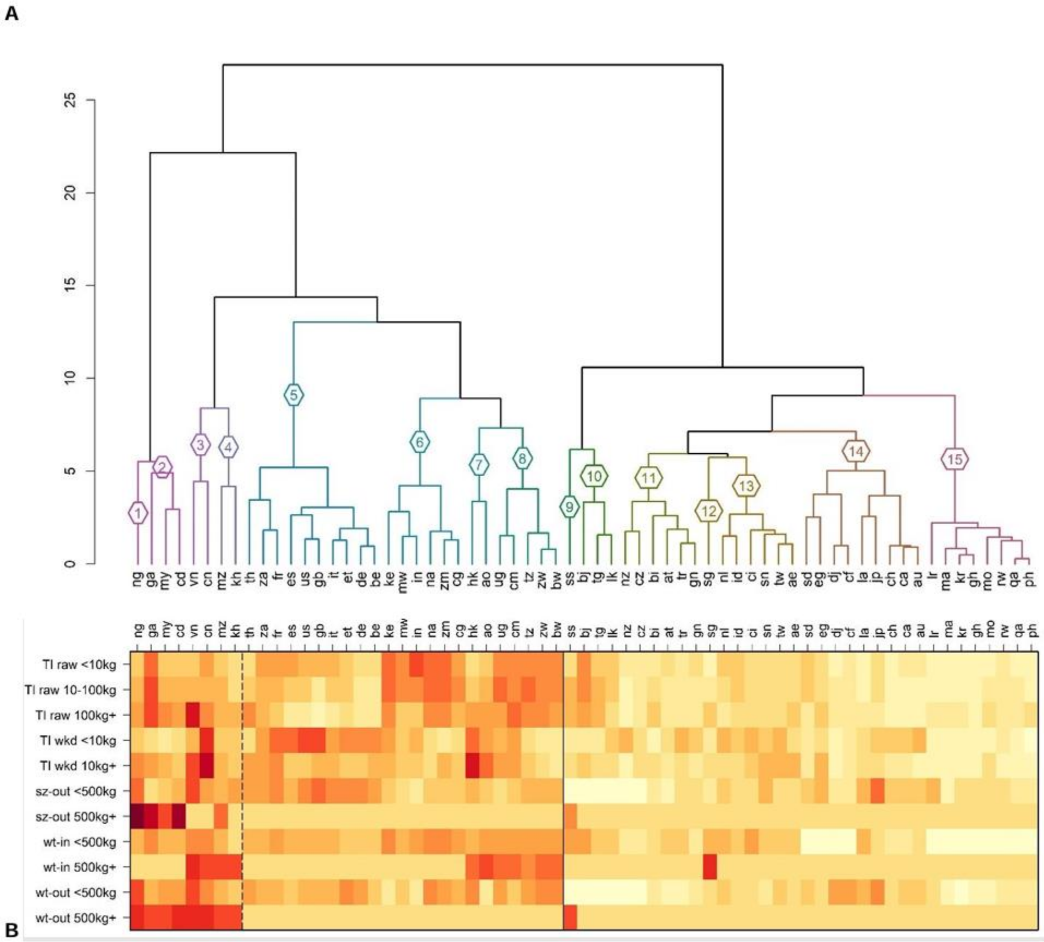

Figure 1. Example of previous cluster analysis taken directly from CoP19 Doc. 66.6, p. 9 - Cluster analysis results and input variables. A) A dendrogram delineating the clusters based on 11 input variables representing measures of illegal ivory trade in 65 countries or territories from 2018 - 2020. Clusters are numbered sequentially from left to right on the dendrogram but have no bearing on cluster ranking. B) A heat-map ranking of standardized, log-transformed values (darker colour = higher values).

Assumptions required in the proposed application of network analysis methods to ETIS data

This Annex lists the assumptions made in the proposed application of network analyses to ETIS data. These are separated into the following categories:

Assumptions inherent to all analyses of ETIS data

- ETIS data elements, including seizure year, quantity information, and trade route, are reported correctly by each Party[25].
- Reported and bias-adjusted ETIS data are representative of illegal ivory trade patterns within and between Parties - For the application of the route reporting rate bias-adjustment, it is noted that the reported trade routes of a Party's seizures are assumed to be representative of their illegal ivory trade routes[26].

Assumptions specific to network analyses of ETIS data

Practical assumptions in constructing the network

- If the reporting Party is not included as the *country of discovery* in the otherwise reported trade route, the reporting Party is inserted into the trade route after any reported *country of transit* and prior to any reported *country of destination*.
- If multiple origins or exports are reported without proportions, the ivory weight of the seizure is split equally among the named origin or export Parties.
- If multiple *countries of transit* are reported, the trade route follows the order in which these countries or territories of transit are listed.

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25 It is noted that through the ETIS data validation process (e.g., Notification No. 2024/068), Parties can review and validate data related to their Party.

26 For the application of the route reporting rate bias-adjustment, it is noted that the reported trade routes of a Party's seizures are assumed to be representative of their illegal ivory trade routes. This is not a new assumption, because trade route characteristics have been informing the contextual interpretation of the cluster analysis results in the ETIS categorization of Parties since the ETIS report to CoP12.

Worked example of bias-adjustment using the route reporting rate (RRR)

Table 1. Route reporting rate. A simplified example of the full route reporting bias-adjustment in which Country B discovers three seizures, and the route is not reported for the third.

From	To	Discovery	Weight	RRR	Adjusted weight
A	B	B	60	(60+40)/(60+40+10) = 10/11	60/(10/11) = 66
C	B	B	40	10/11	40/(10/11) = 44
-	-	B	10	10/11	
		Total	110		110

<u>Exploration of a removal approach for seizure records without reported trade route</u>

1. Additional analysis was suggested during consultation with the MIKE-ETIS TAG to fully remove seizure observations with missing trade route information. This drew from common practice in the ecological literature that data with missing observations are removed prior to analysis. If the observations (seizures) with missing route information are distributed randomly across the network (e.g. any country is as likely as any other to not report a route in a given period), then this approach may be optimal as it removes any potential bias that could be introduced in trying to correct or infer the missing route data. However, if the missing trade route data are not randomly distributed across the Parties, then this process risks omitting or masking true trends in the network.

2. Removing input data for seizures without a trade route resulted in a reduction of 90% in the mean bias-adjusted transaction volume and 34% in the mean bias-adjusted weight volume for raw ivory networks, and reductions of 49% and 53% in the mean bias-adjusted transaction and weight volume, respectively, for worked ivory networks. While these constitute a substantial removal of data, some aspects of the results remain consistent, e.g., the rising role of VN in raw ivory weight, notable key differences also emerge (Figure 1 and Table 1 of this Annex 4c compared to Figures 1 and 2 and Table 3 of Annex 4).

3. Overall, while aspects of the inference remain consistent despite the much-reduced state of the network, this cannot be guaranteed to always be the case. Route reporting rates vary between Parties whereby many range countries do not report routes (as there is no route to report) and certain notable consumer Parties across Southeast and central Asia likewise have low route reporting rates time (see Figure 1 in Annex 1a to document SC78 Doc. 65.1). Removing these seizure records may further bias the network resulting in less ideal approximation of the illegal ivory trade. This conclusion was supported by the TAG at its 20th meeting; alternative approaches are suggested in Annex 4.

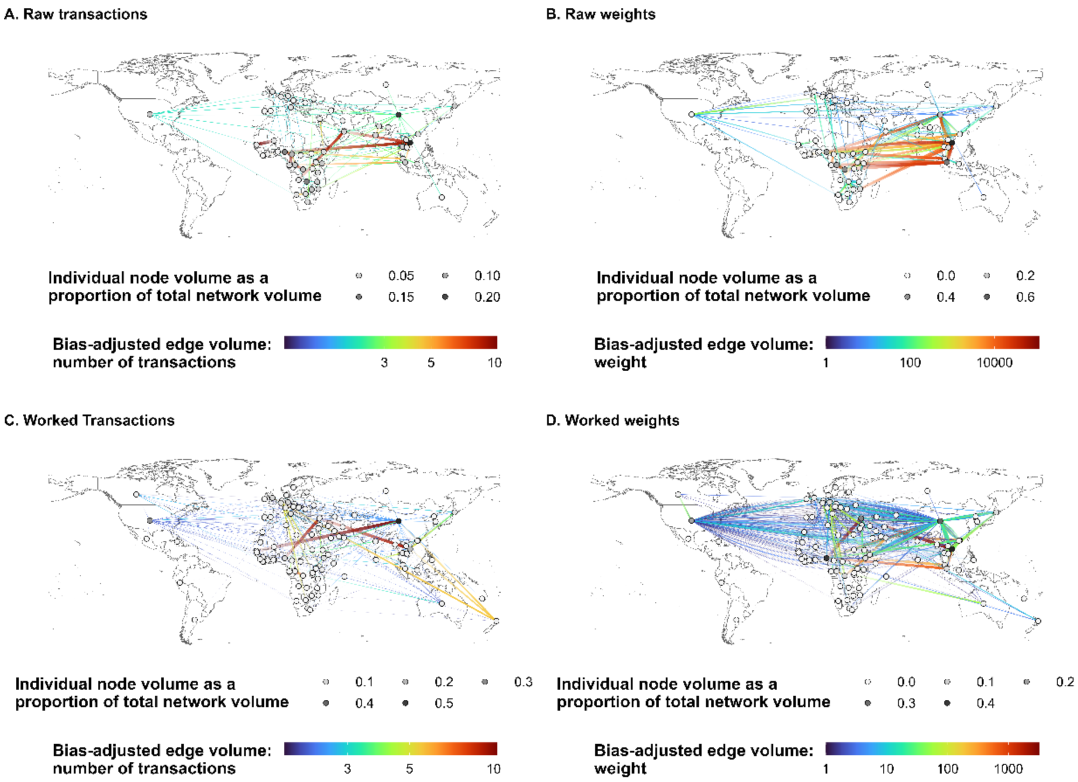

Figure 1. Raw and worked ivory trade flows for the CoP19 reporting period (2018-2020) when seizures with missing trade routes are removed from analysis. Results are shown for networks constructed based on the bias-adjusted number of transactions (left column) or weight volume (right column) of raw ivory (top row) and worked ivory (bottom row). Edges are coloured based on their relative volume (note the separate log scales for each map) and nodes are coloured by individual node volume as a proportion of total network volume.

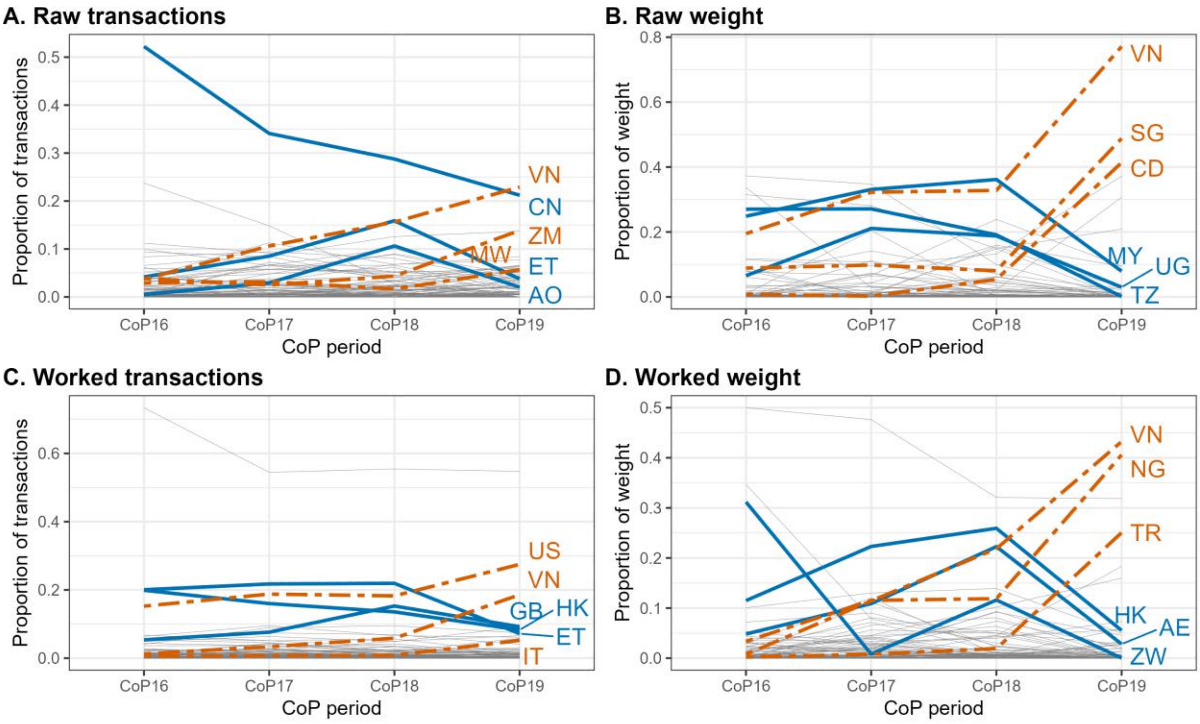

Figure 2. Emerging trends in Parties' proportionate roles in raw and worked ivory trade flows when seizures with missing trade routes are removed from analysis. Results are shown for networks constructed based on the bias-adjusted number of transactions (left column) or weight volume (right column) of raw ivory (top row) and worked ivory (bottom row). Networks are constructed from seizures data within each CoP period from CoP16 to CoP19, and Parties' proportionate roles in the networks are tracked over time. The highlighted lines indicate the top three Parties with increasing (dashed orange lines) and decreasing (solid blue lines) trends between the most recent CoP periods. Note that the summed period proportions can exceed one as multiple countries will be involved in multiple shared shipments.

Table 1. Parties included in the key player selection. Results are displayed for networks constructed based on the weight volume of raw and worked ivory.

Type	Group size	Key players	Disruption %
Raw	1	VN	77
	2	VN, NG	88
	3	VN, NG, MZ	94
	4	VN, NG, GA, MZ	97
	5	ZM, VN, NG, GA, MZ	98
	6	CN, ZM, VN, NG, GA, MZ	99
	7	CN, ZM, VN, KE, NG, GA, MZ	99
	8	CN, ZM, VN, FR, KE, NG, CM, MZ	99
	9	CN, ZM, VN, FR, KE, NG, CM, MZ, US	99
	10	CN, ZM, VN, ZA, FR, KE, NG, CM, MZ, US	99
Worked	1	VN	43
	2	CN, VN	66
	3	CN, VN, US	82
	4	CN, VN, CD, US	89
	5	CN, VN, HK, CD, US	92
	6	CN, VN, HK, CD, US, JP	94
	7	CN, VN, HK, DE, CD, US, JP	96
	8	CN, VN, HK, DE, CD, US, JP, IT	70
	9	CN, VN, HK, DE, CD, AU, US, JP, IT	97
	10	CN, VN, HK, DE, CM, CD, AU, US, JP, IT	98

Additional key player results for weight-based networks with no RRR-adjustment and transaction-based networks with both RRR-adjustment approaches

Key player results for the weight-based networks with no route reporting rate (RRR) bias-adjustment

Table 1. Parties included in the most frequent key player selection. The table shows the groups of Parties selected with the highest probabilities based on 100 randomly sampled posterior bias-adjusted networks, and their disruption ranges (90% quantile interval) across these 100 networks. Results are displayed for networks constructed based on the weight volume of worked and raw ivory with no route reporting rate (RRR) bias-adjustment (no RRR-adj.) for data informing the ETIS report to CoP19 (CoP19 Doc. 66.6). Light grey shading highlights the Parties selected to achieve at least 75% disruption of the illegal ivory networks based the median disruption values (not shown here, but enclosed in the 90% quantile interval); similarly, dark grey shading highlights the Parties selected to achieve 90% network disruption and the * denotes the groups selected based on the optimization procedure.

Type	Group size	Key players	Probability	Disruption % (90% quantile interval)
Raw	1	VN	1	[52, 57]
	2	VN, NG	0.62	[60, 64]
	3*	VN, NG, GA	1	[68, 71]
	4	VN, NG, GA, MZ	1	[72, 75]
	5	VN, NG, GA, MZ, ZW	0.71	[75, 88]
	6	VN, NG, GA, MZ, ZW, BW	0.78	[78, 81]
	7	VN, NG, GA, MZ, ZW, BW, KE	0.93	[81, 83]
	8	VN, NG, GA, MZ, ZW, BW, KE, ZM	0.85	[83, 86]
	9	VN, NG, GA, MZ, ZW, BW, KE, ZM, AO	0.50	[86, 87]
	10	VN, NG, GA, MZ, ZW, BW, KE, ZM, AO, BJ	0.45	[88, 89]
	11	VN, NG, GA, MZ, ZW, BW, KE, ZM, AO, BJ, UG	0.78	[89, 90]
	12	VN, NG, GA, MZ, ZW, BW, KE, ZM, AO, BJ, UG, CG	0.79	[91, 92]
Worked	1	VN	1	[27, 31]
	2	VN, CN	0.56	[42, 47]
	3*	VN, CN, AO	0.91	[58, 62]
	4	VN, CN, AO, FR	0.99	[69, 71]
	5	VN, CN, AO, FR, LA	1	[75, 78]
	6	VN, CN, AO, FR, LA, CD	1	[79, 82]
	7	VN, CN, AO, FR, LA, CD, GB	0.43	[81, 84]
	8	VN, CN, AO, FR, LA, CD, GB, AT	0.33	[84, 85]
	9	VN, CN, AO, FR, LA, CD, GB, AT, IT	0.68	[86, 87]
	10	VN, CN, AO, FR, LA, CD, GB, AT, IT, US	0.68	[88, 89]
	11	VN, CN, AO, FR, LA, CD, GB, AT, IT, US, HK	0.97	[90, 91]

Key player results for transactions-based networks

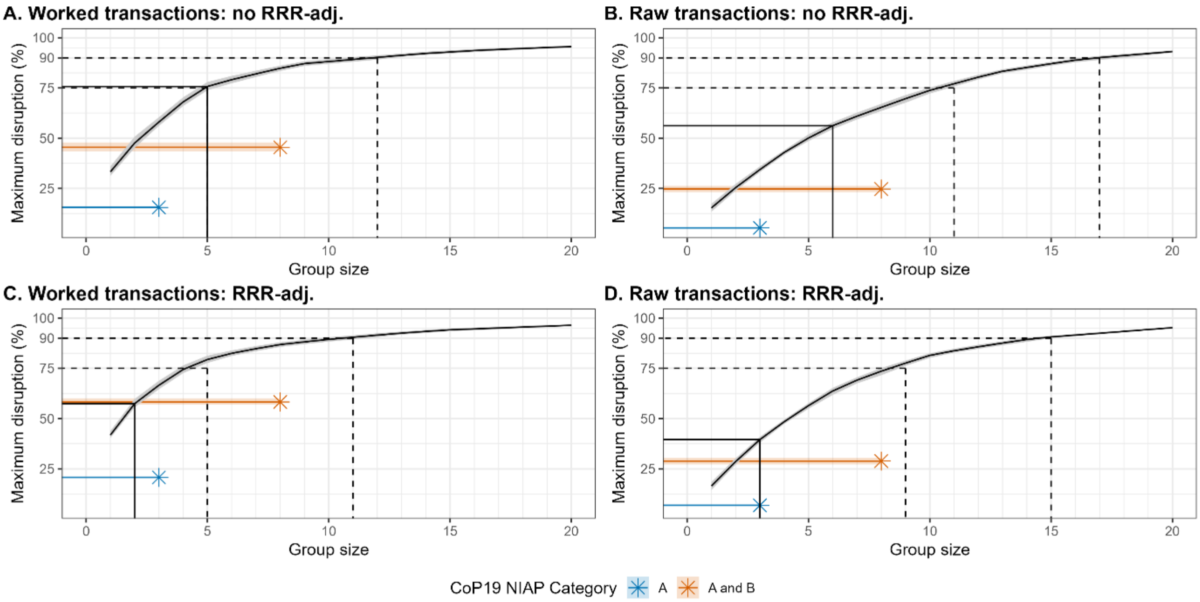

Figure 2. Network disruption as a function of key player group size. Curves show the maximum disruption of the illegal ivory trade networks as a function of key player group size for networks constructed based on transaction index of worked (left column) and raw (right column) ivory and with (RRR-adj.) or without (no RRR-adj.) a route reporting rate (RRR) bias-adjustment approach. Data were summarised for the CoP19 reporting period and are compared to the identification of Parties requiring attention under the NIAP process as Category A (red asterisk) and Categories A and B (orange asterisk) as reported on in the ETIS report to CoP19 (CoP19 Doc. 66.6). Disruption curves are based on the most common selection of nodes of each group size from 100 randomly sampled posterior bias-adjusted networks where median disruption across the 100 networks is plotted with a shaded 90% quantile interval (grey; note that due to the high consistency across posterior networks this interval is often very narrow). Solid black lines represent group selection based on an optimization procedure to balance the trade-off between group size and maximum disruption (the group size at which the rate of increase in maximum disruption slows the most). Dashed lines show group size based on pre-selected disruption thresholds of 75% and 90%.

Table 2. Parties included in the most frequent key player selection. The table shows the groups of Parties selected based on the mean bias-adjusted transactions-based networks for raw and worked ivory, and their disruption ranges (90% quantile interval) across 100 posterior networks. Results are displayed for networks constructed with and without a route reporting rate (RRR) bias-adjustment approach (RRR-adj.) for data informing the ETIS report to CoP19 (CoP19 Doc. 66.6). Light grey shading highlights the Parties selected to achieve at least 75% disruption of the illegal ivory networks based the median disruption values (not shown here, but enclosed in 90% quantile interval); similarly, dark grey shading highlights the Parties selected to achieve 90% network disruption and the * denotes the groups selected based on the optimization procedure.

Adjustment method	Type	Group size	Key players	Disruption % (90% quantile interval)
RRR-adj.	Raw	1	GA	[14, 18]
		2	GA, ZM	[27, 30]
		3*	GA, ZM, TZ	[38, 41]
		4	GA, ZM, TZ, IN	[47, 49]
		5	GA, ZM, TZ, IN, UG	[55, 58]
		6	GA, ZM, TZ, IN, UG, BW	[62, 65]
		7	GA, ZM, TZ, IN, UG, BW, CG	[67, 71]
		8	GA, ZM, TZ, IN, UG, BW, CG, ZW	[72, 75]
		9	GA, ZM, TZ, IN, UG, BW, CG, ZW, BJ	[76, 79]
		10	GA, ZM, TZ, IN, UG, BW, CG, ZW, BJ, NG	[80, 83]
		11	GA, ZM, TZ, IN, UG, BW, CG, ZW, BJ, NG, CN	[83, 85]
		12	GA, ZM, TZ, IN, UG, BW, CG, ZW, BJ, NG, CN, ZA	[85, 87]
		13	GA, ZM, TZ, IN, UG, BW, CG, ZW, BJ, NG, CN, ZA, MZ	[87, 88]
		14	GA, ZM, TZ, IN, UG, BW, CG, ZW, BJ, NG, CN, ZA, MZ, ES	[88, 90]
		15	GA, ZM, TZ, IN, UG, BW, CG, ZW, BJ, NG, CN, ZA, MZ, ES, AO	[90, 91]
	Worked	1	CN	[40, 44]
		2*	CN, US	[56, 60]
		3	CN, US, FR	[65, 69]
		4	CN, US, FR, ES	[73, 77]
		5	CN, US, FR, ES, GB	[78, 81]
		6	CN, US, FR, ES, GB, VN	[81, 84]
		7	CN, US, FR, ES, GB, VN, DE	[84, 86]
		8	CN, US, FR, ES, GB, VN, DE, IT	[86, 88]
		9	CN, US, FR, ES, GB, VN, DE, IT, BE	[87, 89]
		10	CN, US, FR, ES, GB, VN, DE, IT, BE, ZA	[88, 90]
		11	CN, US, FR, ES, GB, VN, DE, IT, BE, ZA, IN	[89, 91]
No RRR-adj.	Raw	1	GA	[13, 17]
		2	GA, ZM	[24, 27]
		3	GA, ZM, IN	[33, 36]
		4	GA, ZM, IN, KE	[42, 44]
		5	GA, ZM, IN, KE, BW	[49, 52]
		6*	GA, ZM, IN, KE, BW, UG	[55, 58]
		7	GA, ZM, IN, KE, BW, UG, CG	[59, 63]
		8	GA, ZM, IN, KE, BW, UG, CG, ZW	[64, 67]
		9	GA, ZM, IN, KE, BW, UG, CG, ZW, TZ	[68, 71]
		10	GA, ZM, IN, KE, BW, UG, CG, ZW, TZ, BJ	[72, 75]
		11	GA, ZM, IN, KE, BW, UG, CG, ZW, TZ, BJ, VN	[76, 78]
		12	GA, ZM, IN, KE, BW, UG, CG, ZW, TZ, BJ, VN, CM	[79, 82]
		13	GA, ZM, IN, KE, BW, UG, CG, ZW, TZ, BJ, VN, CM, MW	[82, 84]
		14	GA, ZM, IN, KE, BW, UG, CG, ZW, TZ, BJ, VN, CM, MW, ZA	[84, 86]
		15	GA, ZM, IN, KE, BW, UG, CG, ZW, TZ, BJ, VN, CM, MW, ZA, CN	[86, 88]
		16	GA, ZM, IN, KE, BW, UG, CG, ZW, TZ, BJ, VN, CM, MW, ZA, CN, ES	[88, 90]
		17	GA, ZM, IN, KE, BW, UG, CG, ZW, TZ, BJ, VN, CM, MW, ZA, CN, ES, FR	[89, 91]
	Worked	1	CN	[31, 36]
		2	CN, US	[45, 51]
		3	CN, US, GB	[56, 60]
		4	CN, US, GB, FR	[66, 70]
		5*	CN, US, GB, FR, ES	[74, 78]
		6	CN, US, GB, FR, ES, IT	[77, 81]
		7	CN, US, GB, FR, ES, IT, VN	[80, 84]
		8	CN, US, GB, FR, ES, IT, VN, BE	[83, 86]
		9	CN, US, GB, FR, ES, IT, VN, BE, DE	[86, 88]
		10	CN, US, GB, FR, ES, IT, VN, BE, DE, IN	[87, 89]
		11	CN, US, GB, FR, ES, IT, VN, BE, DE, IN, NL	[88, 90]
		12	CN, US, GB, FR, ES, IT, VN, BE, DE, IN, NL, UG	[89, 91]

<u>Comparing key player results under all analyses options to the ETIS report to CoP18</u>

1. This Annex considers the key player results of the proposed network analysis when applied to the data that was used to inform the ETIS report to CoP18. For comparison, the ETIS cluster analysis presented in CoP18 Doc. 69.3 regarded the following Parties as Category A (most affected) and Category B (markedly affected):

   - Category A: Malaysia (MY), Mozambique (MZ), Nigeria (NG), Viet Nam (VN)
   - Category B: China (CN), Hong Kong SAR of China (HK), Kenya (KE), United Republic of Tanzania (TZ), Uganda (UG)

Weight-based networks

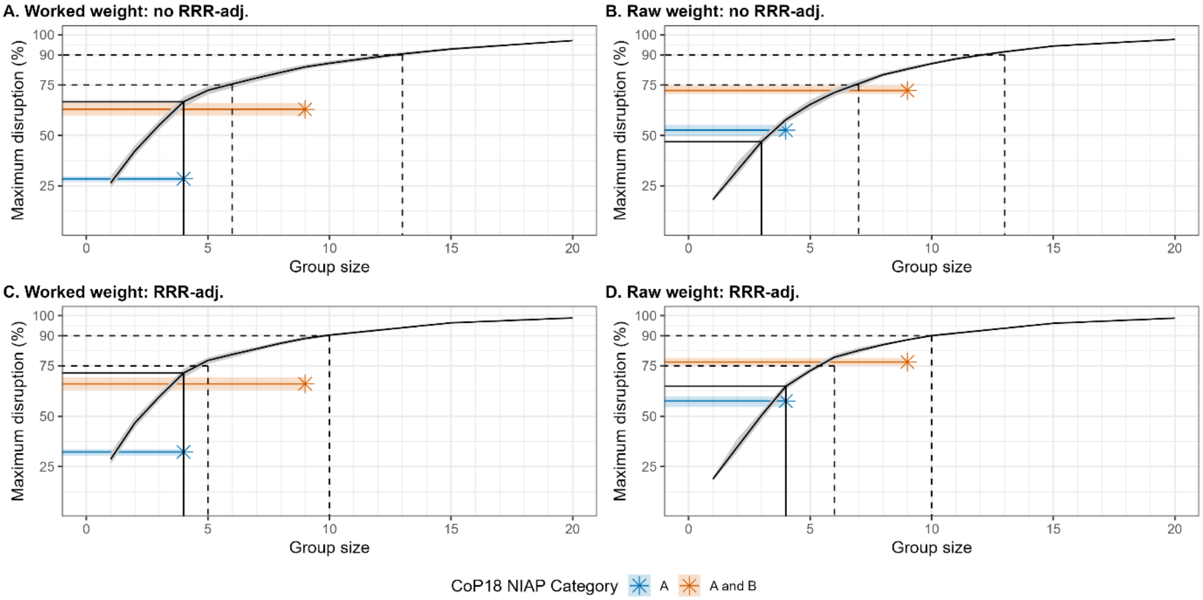

Figure 1. Network disruption as a function of key player group size. Curves show the maximum disruption of the illegal ivory trade networks as a function of key player group size for networks constructed based on weight volume of worked (left column) and raw (right column) ivory and with (RRR-adj.) or without (no RRR-adj.) a route reporting rate (RRR) bias-adjustment approach. Data were summarised for the CoP18 reporting period and are compared to the identification of Parties requiring attention under the NIAP process as Category A (red asterisk) and Categories A and B (orange asterisk) as reported on in the ETIS report to CoP18 (CoP18 Doc. 69.3). Disruption curves are based on the most common selection of nodes of each group size from 100 randomly sampled posterior bias-adjusted networks where median disruption across the 100 networks is plotted with a shaded 90% quantile interval (grey; note that due to the high consistency across posterior networks this interval is often very narrow). Solid black lines represent group selection based on an optimization procedure to balance the trade-off between group size and maximum disruption (the group size at which the rate of increase in maximum disruption slows the most). Dashed lines show group size based on pre-selected disruption thresholds of 75% and 90%.

Table 1. Parties included in the most frequent key player selection. The table shows the groups of Parties selected with the highest probabilities based on 100 randomly sampled posterior bias-adjusted networks, and their disruption ranges (90% quantile interval) across these 100 networks. Results are displayed for networks constructed based on the weight volume of worked and raw ivory with and without a route reporting rate (RRR) bias-adjustment approach (RRR-adj.) for data informing the ETIS report to CoP18 (CoP18 Doc. 69.3). Light grey shading highlights the Parties selected to achieve at least 75% disruption of the illegal ivory networks based the median disruption values (not shown here, but enclosed in 90% quantile interval); similarly, dark grey shading highlights the Parties selected to achieve 90% network disruption and the * denotes the groups selected based on the optimization procedure.

Adjustment method	Type	Group size	Key players	Probability	Disruption % (90% quantile interval)
RRR-adj.	Raw	1	MY	0.71	[18, 20]
		2	MY, TZ	0.59	[32, 39]
		3	MY, TZ, NG	0.40	[48, 53]
		4*	MY, TZ, NG, MZ	1	[63, 67]
		5	MY, TZ, NG, MZ, CD	0.85	[72, 74]
		6	MY, TZ, NG, MZ, CD, VN	1	[78, 81]
		7	MY, TZ, NG, MZ, CD, VN, GA	0.71	[81, 84]
		8	MY, TZ, NG, MZ, CD, VN, GA, ZM	0.85	[85, 86]
		9	MY, TZ, NG, MZ, CD, VN, GA, ZM, UG	0.74	[88, 89]
		10	MY, TZ, NG, MZ, VN, GA, ZM, UG, CN, CG	0.50	[89, 91]
	Worked	1	CN	1	[26, 32]
		2	CN, VN	0.98	[44, 49]
		3	CN, VN, IN	0.69	[58, 62]
		4*	CN, VN, IN, HK	1	[69, 74]
		5	CN, VN, IN, HK, AO	1	[76, 79]
		6	CN, VN, IN, HK, AO, GB	0.65	[79, 82]
		7	CN, VN, IN, HK, AO, GB, NG	0.55	[82, 85]
		8	CN, VN, IN, HK, AO, GB, NG, ZM	0.92	[85, 87]
		9	CN, VN, IN, HK, AO, GB, NG, ZM, MY	0.55	[88, 90]
		10	CN, VN, IN, HK, AO, GB, NG, ZM, ZW, CD	0.42	[90, 91]
No RRR-adj.	Raw	1	MY	0.79	[17, 19]
		2	MY, TZ	0.44	[30, 37]
		3*	MY, TZ, MZ	0.83	[45, 49]
		4	MY, TZ, MZ, NG	0.97	[56, 59]
		5	MY, TZ, MZ, NG, VN	0.88	[63, 68]
		6	MY, TZ, MZ, NG, VN, CD	0.93	[70, 73]
		7	MY, TZ, MZ, NG, VN, CD, CM	0.47	[74, 77]
		8	MY, TZ, MZ, NG, VN, CD, CM, ZM	0.80	[79, 81]
		9	MY, TZ, MZ, NG, VN, CD, CM, ZM, GA	0.52	[82, 84]
		10	MY, TZ, MZ, NG, VN, CD, CM, ZM, GA, UG	0.75	[85, 86]
		11	MY, TZ, MZ, NG, VN, CM, ZM, GA, UG, CN, CG	0.64	[87, 89]
		12	MY, TZ, MZ, NG, VN, CM, ZM, GA, UG, CN, CD, TH	0.64	[89, 91]
		13	MY, TZ, MZ, NG, VN, CM, ZM, GA, UG, CN, CD, TH, ZW	0.42	[91, 92]
	Worked	1	CN	1	[24, 30]
		2	CN, VN	0.96	[40, 45]
		3	CN, VN, IN	0.78	[53, 57]
		4*	CN, VN, IN, HK	1	[64, 69]
		5	CN, VN, IN, HK, AO	1	[70, 74]
		6	CN, VN, IN, HK, AO, MY	0.50	[74, 77]
		7	CN, VN, IN, HK, AO, MY, GB	0.63	[77, 80]
		8	CN, VN, IN, HK, AO, MY, GB, ZM	0.54	[80, 83]
		9	CN, VN, IN, HK, AO, MY, GB, ZM, NG	0.95	[83, 85]
		10	CN, VN, IN, HK, AO, MY, GB, ZM, NG, FR	0.74	[85, 87]
		11	CN, VN, IN, HK, AO, MY, GB, ZM, NG, FR, AE	0.45	[86, 89]
		12	CN, VN, IN, HK, AO, MY, GB, ZM, NG, FR, AE, US	0.79	[88, 90]
		13	CN, VN, IN, HK, AO, MY, GB, ZM, NG, FR, AE, US, KE	0.79	[90, 90]

Transactions-based network

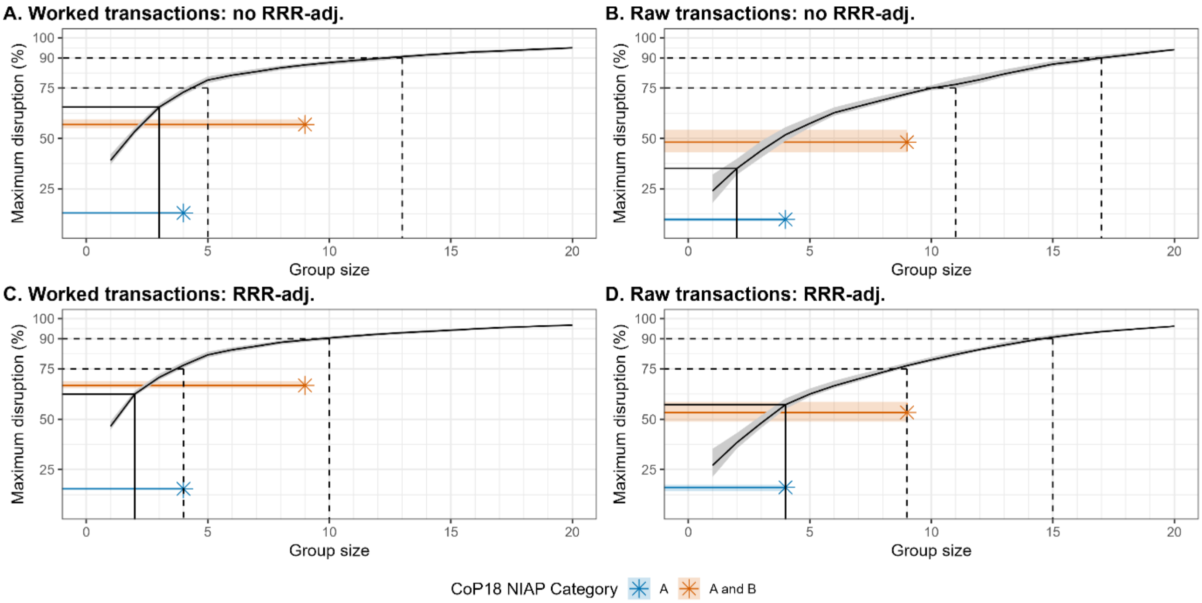

Figure 2. Network disruption as a function of key player group size. Curves show the maximum disruption of the illegal ivory trade networks as a function of key player group size for networks constructed based on transaction index of worked (left column) and raw (right column) ivory and with (RRR-adj.) or without (no RRR-adj.) a route reporting rate (RRR) bias-adjustment approach. Data were summarised for the CoP18 reporting period and are compared to the identification of Parties requiring attention under the NIAP process as Category A (red asterisk) and Categories A and B (orange asterisk) as reported on in the ETIS report to CoP18 (CoP18 Doc. 69.3). Disruption curves are based on the most common selection of nodes of each group size from 100 randomly sampled posterior bias-adjusted networks where median disruption across the 100 networks is plotted with a shaded 90% quantile interval (grey; note that due to the high consistency across posterior networks this interval is often very narrow). Solid black lines represent group selection based on an optimization procedure to balance the trade-off between group size and maximum disruption (the group size at which the rate of increase in maximum disruption slows the most). Dashed lines show group size based on pre-selected disruption thresholds of 75% and 90%.

Table 2. Parties included in the most frequent key player selection. The table shows the groups of Parties selected based on the mean bias-adjusted transactions-based networks for raw and worked ivory, and their disruption ranges (90% quantile interval) across 100 posterior networks. Results are displayed for networks constructed with and without a route reporting rate (RRR) bias-adjustment approach (RRR-adj.) for data informing the ETIS report to CoP18 (CoP18 Doc. 69.3). Light grey shading highlights the Parties selected to achieve at least 75% disruption of the illegal ivory networks based the median disruption values (not shown here, but enclosed in 90% quantile interval); similarly, dark grey shading highlights the Parties selected to achieve 90% network disruption and the * denotes the groups selected based on the optimization procedure.

Adjustment method	Type	Group size	Key players	Disruption % (90% quantile interval)
RRR-adj.	Raw	1	TZ	[21, 35]
		2	TZ, ZM	[35, 43]
		3	TZ, ZM, CN	[46, 52]
		4*	TZ, ZM, CN, GA	[55, 60]
		5	TZ, ZM, CN, GA, IN	[61, 65]
		6	TZ, ZM, CN, GA, IN, NG	[65, 69]
		7	TZ, ZM, CN, GA, IN, NG, CG	[69, 72]
		8	TZ, ZM, CN, GA, IN, NG, CG, ZW	[72, 75]
		9	TZ, ZM, CN, GA, IN, NG, CG, ZW, KE	[76, 78]
		10	TZ, ZM, CN, GA, IN, NG, CG, ZW, KE, ET	[78, 81]
		11	TZ, ZM, CN, GA, IN, NG, CG, ZW, KE, ET, BJ	[81, 84]
		12	TZ, ZM, CN, GA, IN, NG, CG, ZW, KE, BJ, VN, MW	[84, 86]
		13	TZ, ZM, CN, GA, IN, NG, CG, ZW, KE, BJ, VN, MW, TG	[86, 88]
		14	TZ, ZM, CN, GA, IN, NG, CG, ZW, KE, BJ, VN, MW, TG, CD	[88, 90]
		15	TZ, ZM, CN, GA, IN, NG, CG, ZW, BJ, MW, TG, CD, UG, MZ, AO	[90, 92]
	Worked	1	CN	[45, 49]
		2*	CN, US	[62, 64]
		3	CN, US, HK	[70, 73]
		4	CN, US, HK, FR	[76, 78]
		5	CN, US, HK, FR, GB	[81, 84]
		6	CN, US, HK, FR, GB, TH	[83, 86]
		7	CN, US, HK, FR, GB, TH, VN	[85, 87]
		8	CN, US, HK, FR, GB, TH, VN, TZ	[87, 89]
		9	CN, US, HK, FR, GB, TH, VN, TZ, AU	[88, 90]
		10	CN, US, HK, FR, GB, TH, VN, TZ, AU, DE	[89, 91]
No RRR-adj.	Raw	1	TZ	[18, 32]
		2*	TZ, ZM	[32, 40]
		3	TZ, ZM, GA	[40, 49]
		4	TZ, ZM, GA, KE	[49, 56]
		5	TZ, ZM, GA, KE, CN	[55, 61]
		6	TZ, ZM, GA, KE, CN, IN	[61, 65]
		7	TZ, ZM, GA, KE, CN, IN, CG	[64, 68]
		8	TZ, ZM, GA, KE, CN, IN, CG, NG	[68, 71]
		9	TZ, ZM, GA, KE, CN, IN, CG, NG, ZW	[71, 74]
		10	TZ, ZM, GA, KE, CN, IN, CG, NG, ZW, UG	[74, 76]
		11	TZ, ZM, GA, KE, CN, IN, CG, ZW, CM, TG, BJ	[75, 79]
		12	TZ, ZM, GA, KE, CN, IN, CG, ZW, CM, TG, BJ, VN	[77, 82]
		13	TZ, ZM, GA, KE, CN, IN, CG, ZW, CM, TG, BJ, VN, UG	[81, 84]
		14	TZ, ZM, GA, KE, CN, IN, CG, ZW, CM, TG, BJ, VN, UG, NG	[83, 86]
		15	TZ, ZM, GA, KE, CN, IN, CG, ZW, CM, TG, BJ, VN, UG, NG, MW	[86, 88]
		16	TZ, ZM, GA, KE, CN, IN, CG, ZW, CM, TG, BJ, UG, NG, MW, ZA, AO	[87, 90]
		17	TZ, ZM, GA, KE, CN, IN, CG, ZW, CM, TG, BJ, UG, NG, MW, ZA, TH, VN	[89, 91]
	Worked	1	CN	[37, 42]
		2	CN, US	[52, 55]
		3*	CN, US, GB	[64, 67]
		4	CN, US, GB, HK	[72, 75]
		5	CN, US, GB, HK, FR	[77, 81]
		6	CN, US, GB, HK, FR, TH	[80, 83]
		7	CN, US, GB, HK, FR, TH, VN	[82, 85]
		8	CN, US, GB, HK, FR, TH, VN, TZ	[84, 86]
		9	CN, US, GB, HK, FR, TH, VN, TZ, CM	[85, 87]
		10	CN, US, GB, HK, FR, TH, VN, TZ, CM, AU	[86, 89]
		11	CN, US, GB, HK, FR, TH, VN, TZ, CM, AU, DE	[88, 90]
		12	CN, US, GB, HK, FR, TH, VN, TZ, CM, AU, DE, NL	[89, 91]
		13	CN, US, GB, HK, FR, TH, VN, TZ, CM, AU, DE, NL, IN	[90, 91]

DRAFT DECISIONS ON THE *IMPLEMENTATION OF THE ETIS REVIEW RECOMMENDATIONS* PROPOSED FOR CONSIDERATION BY THE STANDING COMMITTEE

Directed to the Secretariat

20.AA Subject to the availability of external funding, the Secretariat shall:

a) finalize the feasibility assessment for alternative support mechanisms for the Elephant Trade Information System (ETIS);

b) review the terms of reference of the MIKE-ETIS Technical Advisory Group and propose amendments, as appropriate;

c) in consultation with TRAFFIC and the MIKE and ETIS Technical Advisory Group (TAG):

i) identify and test covariates that could feature as country specific variables for bias-adjustment purposes or as explanatory factors to further enhance the interpretation of the ETIS results better and improve the understanding of the ETIS results;

ii) explore the feasibility of an integrated analysis using the Monitoring of Illegal Killing of Elephants (MIKE), ETIS and African Elephant Database data; and

iii) examine the relationship between ivory stockpiles and illegal ivory trade based on aggregated stockpile data; and

d) report on the implementation of paragraph a) to c) and make recommendations as necessary to the Standing Committee.

Directed to the Standing Committee

20.BB The Standing Committee shall review the report provided by the Secretariat and make recommendations, as necessary, for consideration at the 21st meeting of the Conference the Parties.