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REGISTERED REPORT STAGE 1: STUDY DESIGN

What is the evidence that counter-wildlife crime interventions are effective for conserving African, Asian and Latin American wildlife directly threatened by exploitation? A systematic map protocol

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Abstract

1. Human activities are driving a global biodiversity crisis. In response, a broad range of conservation actions have been implemented. With finite resources available, and a rapidly narrowing window, the scientific and policy communities have acknowledged the need to better understand the effectiveness of interventions for conserving threatened species.
2. Given the recent emphasis on the use of counter wildlife crime interventions (i.e. those that directly protect wildlife from illegal harvest, detect and sanction rule-breakers, and interdict and control illegal wildlife commodities), there is a clear need to summarize the available evidence on biological and threat reduction outcomes of such actions to help make evidence-informed management and funding decisions.
3. Here, we present a protocol for a systematic map that will collate the existing body of literature addressing the effectiveness of counter-wildlife crime interventions for protecting targeted species. Our focus will be on select species or species groups directly threatened by exploitation (i.e. illegal harming whether by harvest as a resource or for control/persecution) and native to Africa, Asia and Latin America, which are regions that have experienced significant wildlife populations declines.
4. The systematic map will aim to capture available evidence found in commercially published and grey literature. We will search for the literature using four publication databases, Google Scholar, 36 specialist websites and databases and sources identified through a call for evidence among relevant networks. Eligibility screening will be conducted at two stages: (1) title and abstract and (2) full text. Relevant information from included papers will be extracted and entered into a searchable, coded database (MS-Excel).

5. Narrative synthesis and descriptive statistics will describe the key characteristics of the relevant evidence base (e.g. geographic location, species, interventions, direct threats, outcomes and study designs). Using visual heat maps, we will identify key knowledge gaps warranting further research and clusters of evidence that could serve as topics for future systematic reviews.
6. The resulting map will guide further exploration on evaluating the effectiveness of counter-wildlife crime interventions, and aid in building an evidence base that supports both management and funding decisions to ensure efficient use of limited resources and maximal conservation benefits.

KEYWORDS
evidence map, evidence synthesis, evidence-based conservation, human–wildlife conflict, law enforcement, patrols, poaching, wildlife trade

1 | INTRODUCTION

Human activities are driving a global biodiversity crisis. The list of threatened species and ecosystems continues to grow globally with an unprecedented rate of extinction indicating that a sixth mass extinction is occurring (Ceballos et al., 2015). The Living Planet Index, which measures abundance levels of wild vertebrate species, shows a persistent negative global trend of a 68% decline between 1970 and 2016 (WWF, 2020). African, Asian, and South American species are at elevated extinction risk, which is expected to intensify considerably in coming years due to human population growth and economic development (Di Marco et al., 2014; Tilman et al., 2017). Substantial biodiversity loss in these regions has already had devastating impacts on species and ecosystems (Maisels et al., 2013; Ogada et al., 2016; Scheele et al., 2019; Namkhan et al., 2021). Biodiversity loss also negatively impacts human well-being through the loss of crucial ecosystem services, such as crop pollination and water purification, as well as providing food security and livelihoods for hundreds of millions of people (Ceballos et al., 2015; Ripple et al., 2016).

There are many direct threats leading to these species declines, but one of the main drivers of biodiversity decline (second to habitat loss) is direct exploitation (Diaz et al., 2019). Illegal exploitation of species from unsustainable logging, hunting, fishing, and gathering of wild plant and animal species to meet subsistence needs and consumer demand in domestic and international markets for food, medicine, ornaments, pets, and status symbols is causing significant population declines and driving several species towards extinction (e.g. helmeted hornbills: Beastall et al., 2016; songbirds such as the Straw-headed bulbul: Bergin et al., 2018; pangolins: Challender et al., 2014; also see IUCN, 2021). In a recent meta-analysis on the impacts of wildlife trade on terrestrial species, Morton et al. (2021) found that overall, species declined in abundance by 62% where wildlife trade occurs, with local species extirpations observed in 16% of the cases, and declines increasing with threat status.

Furthermore, threats rarely occur in isolation, with the cumulative effect of co-occurring threats often far exceeding that of individual threats (Brook et al., 2008). For example, deforestation and collection for the trade of forest-dependent birds led to significantly higher population decline, and the number of species threatened with extinction nearly doubled, when assessed together compared to separately (Symes et al., 2018). Moreover, the expansion of road networks, often accompanied by logging activities, increases opportunities for harvesting and hunting by increasing accessibility to previously unexploited areas and relatively isolated populations (Benitez-Lopez et al., 2017; Clements et al., 2014). Habitat loss, human encroachment, and agricultural and livestock expansion are common co-occurring threats (Ripple et al., 2016).

These threats also increase the risk of human–wildlife conflicts and consequently retaliatory killings (Gross et al., 2021). Retaliatory killings are one of the most serious threats to wildlife in Africa, causing significant population declines among elephants and several carnivore species, and has, combined with poaching for trade, devastated lion populations in East Africa (Ogada, 2014). Felines, especially large-bodied species, are especially threatened, with over 75% of all species affected, primarily due to competition for space and food (Inskip & Zimmerman, 2009). In addition, the potential monetary gain from some high-value species is thought to exacerbate retaliatory killings as it provides further motivation to kill (e.g. jaguars in Venezuela: Jedrzejewski et al., 2017) and research suggests that human–wildlife conflict killings feed into the illegal trade (e.g. snow leopards: Nowell et al., 2016).

To address the exploitation of species, a range of conservation interventions have been implemented to directly protect target wildlife from illegal harvest/persecution, detect and sanction rule-breakers, and interdict and control illegal wildlife commodities; here, referred to as counter-wildlife crime (CWC) interventions. Most CWC interventions are performed or implemented by actors with the authority to arrest, prosecute, and/or sanction alleged crimes, for example rangers and prosecutors (here referred to as 'law enforcement

interventions', and include criminal justice interventions like prosecuting and sanctioning wildlife crime). Law enforcement interventions have been a principal approach and afforded higher levels of attention, international commitment, and funding in recent years (Challender & MacMillan, 2014; Wright et al., 2016). The purpose is to reduce opportunities and incentives to harvest while increasing the risk of detection and capture, as well as impose stricter legal penalties and more successful conviction rates (Cooney et al., 2017; Duffy, 2014). The goal with stricter legal penalties and convictions is achieving deterrence, although this is rarely tested (Wilson & Boratto, 2020). Interventions include, for example, on-site management and restricting harvest through anti-poaching actions, discouraging non-compliance, raising awareness of, or enforcing compliance with existing laws and policies (Barichievy et al., 2017; Kablan et al., 2019), and intelligence-gathering and surveillance (Astaras et al., 2020; Critchlow et al., 2017). Law enforcement interventions are less commonly employed to reduce threats of human–wildlife conflicts (van Eeden et al., 2018). However, imposing penalties alongside other management actions are used to further disincentivize farmers to kill problem animals (e.g. through formal agreements that stipulate compensation to farmers for lost livestock and impose fines for hunting/killing infractions) (Hazzah et al., 2014).

Some CWC interventions are performed by actors without law enforcement authority, for example civil society, industry (here referred to as 'non-law enforcement interventions', for example actions supporting offender rehabilitation through counseling or education programmes, or some actions making people aware of the illegality and/or penalties associated with the transfer of illegal wildlife products), and further still, in some situations, are performed collaboratively by both law and non-law enforcement actors (e.g. CWC interventions implemented by both law enforcement rangers and eco-guards or community liaisons). While law enforcement strategies such as patrols are often necessary to protect wildlife against harmful activities (Moore et al., 2018), engaging local communities is valued as an important supplement or replacement for law enforcement-based efforts (Cooney et al., 2017; Roe & Booker, 2019).

Given the gravity of the threats, finite resources available, and a rapidly narrowing window to reverse the dramatic declines (Ceballos et al., 2015), there is a growing recognition of the need for efficient use of conservation expenditure by prioritizing conservation efforts based on the best available evidence (Lynch & Blumstein, 2020; Sutherland et al., 2004; van Eeden et al., 2018). Conservation efforts need to address multifaceted threats that take place in inherently complex socio-ecological systems, where determining causality and confounding factors is difficult (Mascia et al., 2017; Sutherland et al., 2021). Much of the evidence is not formally documented or readily accessible to policy and other decision makers (Mossaz et al., 2015; but see Conservation Evidence; https://www.conservationevidence.com/). Assessing the effectiveness of conservation interventions is further impeded by the lack of studies that compare among interventions (but see, e.g., Chaves et al., 2018) or employ rigorous evaluation methods (but see, e.g., Jayachandran et al., 2017). Consequently, in the absence of inference-based evidence, anecdotal evidence is frequently used to support the selection of conservation interventions, which can lead to misguided use of resources and potentially ineffective actions (McKinnon et al., 2016; Sutherland et al., 2004).

Previous efforts to describe and/or synthesize the evidence base on the effectiveness of interventions have primarily focused on other non-CWC conservation actions (e.g., impacts of protected areas: Ban et al., 2019; Geldmann et al., 2013; Gill et al., 2019; Pullin et al., 2013, human well-being impacts of in situ conservation interventions: Eales et al., 2021; McKinnon et al., 2016), alternative livelihood projects: Roe et al., 2015, community-based conservation: Brooks et al., 2013; Galvin et al., 2018; Roe & Booker, 2019, and demand reduction initiatives: Verissimo & Wan, 2019). Comparatively, there have been limited evidence synthesis activities on evaluating the impacts of CWC interventions. Kurland et al. (2017) provided an exploratory commentary of wildlife crime as it relates to crime science, having identified within the conservation literature the mechanisms and techniques akin to those found within situational crime prevention, and discussing their reported effectiveness. Delpech et al. (2021) provided a more thorough review, assessing the effectiveness of measures implemented for the situational prevention of crimes against terrestrial species (wild and domesticated). Our proposed map will be complementary to these previous efforts; however, it will not be duplicative as we will use a different intervention framework focusing on a select group of interventions implemented across the wildlife crime continuum often used in the criminal justice toolset (see *Intervention framework development* below for further details). Additionally, our search will be more recent and therefore capture new evidence (although Delpech et al., 2021, was recently published, the searches were performed in 2016). Lastly, our map will take a systematic approach with a more robust and comprehensive search string that will allow for the identification of new evidence, and a more transparent searching and screening strategy following the Collaboration for Environmental Evidence (CEE) guidelines for evidence synthesis (CEE, 2018). The proposed map will collate and describe the available evidence base evaluating the effectiveness of CWC interventions on biological and threat reduction outcomes for species or species groups native to regions that have experienced the largest population declines (i.e. Africa, Asia and Latin America; WWF, 2020). These regions also experience high levels of human–wildlife conflicts and are wildlife trade hotspots (Inskip & Zimmerman, 2009; Scheffers et al., 2019). With this map, we will also identify evidence clusters (subsets of evidence that may be suitable for secondary research), and evidence gaps (topics that are underrepresented in the evidence base that require future primary research); two mapping functions that are necessary first steps to help make evidence-informed decisions (both management and funding related) and drive more effective actions.

1.1 | Topic identification and stakeholder involvement

The U.S. Fish & Wildlife Service (USFWS) is interested in trying to answer the question 'What is the evidence that CWC interventions are effective for conserving African, Asian, and Latin American wildlife

directly threatened by exploitation and human–wildlife conflicts?'. Staff from the USFWS and the Canadian Centre for Evidence-Based Conservation (CEBC) collaborated to develop this question in the context of the plant and animal species targeted by the agency's international grant programmes and law enforcement activities. The aim of this project is to better understand and help build the evidence base that supports grant-making programmes and decisions and to shed light on a topic of increasing policy relevance and attention. Although USFWS initiated the collaboration, this question is of broader relevance as governments and non-governmental organizations (NGOs) worldwide with a focus on nature conservation routinely make decisions about investment of limited resources with goals of having maximal conservation benefit (Brockington & Scholfield, 2010; Waldron et al., 2013).

Due to the wide scope of such a review, and diversity of CWC interventions, the potential set of studies to consider will be quite heterogeneous. Therefore, prior to undertaking a comprehensive and quantitative synthesis, we propose to address this research need using a systematic map methodology. Systematic maps are a form of evidence synthesis that aims to provide an accurate description of the evidence base relating to a particular question. Although procedurally similar to a systematic review, systematic maps do not aim to provide a quantitative or qualitative answer to a particular question, but instead, an overview of research that has been undertaken (Haddaway et al., 2016; James et al., 2016).

During the formulation of the systematic map question, evidence synthesis specialists from the CEBC (i.e. the review team) established and consulted an advisory team made up of 12 stakeholders and scientific experts. The advisory team consists of wildlife biologists, conservation scientists and criminologists from the USA, Central Africa, México, Indonesia, South East Asia, and the Netherlands who have research and on-the-ground experience related to wildlife crime, conservation criminology and conservation management. The advisory team includes academics (three members; University of Maryland, Florida International University, Universidad Nacional Autónoma de México), staff from USFWS affiliated with the International Affairs Program (three members) and the Office of Law Enforcement (one member), and researchers from the Wildlife Conservation Society (two members), Panthera (two members), and the Netherlands Institute for the Study of Crime and Law Enforcement (one member). The role of the advisory team is crucial to many aspects of the systematic mapping exercise, including suggestions of search terms, generation of the benchmark list, suggestions for specialist websites to search, and development of the inclusion criteria for article screening and metadata extraction strategy. The advisory team will continue to participate in this systematic map through to completion and will be invaluable for helping to acquire grey literature on this subject.

1.2 | Intervention framework development

During early stages of question formulation, we initially considered including all conservation actions outlined in the International Union for Conservation of Nature (IUCN) and Conservation Measures Partnership's (CMP) Conservation Actions Classification framework v2.0 (Salafsky et al., 2008; CMP, 2016), with a much broader goal of collating the evidence base of studies that evaluate the effectiveness of law enforcement and related conservations actions for conserving African, Asian and Latin American wildlife. The IUCN–CMP framework identifies three conservation action types (i.e. highest level groupings known as level 0 actions): (a) target restoration/stress reduction actions, (b) behavioural change/threat reduction actions and (c) enabling condition actions. Within these three action types are 10 conservation action categories (i.e. level 1 actions): (1) land/water management, (2) species management, (3) awareness raising, (4) law enforcement and prosecution, (5) livelihood, economic, and moral incentives, (6) conservation designation and planning, (7) legal and policy frameworks, (8) research and monitoring, (9) education and training and (10) institutional development. After an initial scoping exercise including all conservation actions, however (see Supporting Information 1), we concluded that the evidence base was too large to attempt such an exercise (> 100,000 search results). Therefore, we narrowed the scope of the mapping exercise to focus on CWC interventions only.

For the purpose of our mapping exercise, we adapted the IUCN–CMP framework in three primary ways following input and feedback from our advisory team to better represent and focus on CWC interventions and to distinguish between those that are performed by actors with and/or without law enforcement authority. First, we moved away from the level 1 category name 'law enforcement and prosecution' and reconceived it to 'counter-wildlife crime interventions'. This modification was made because some level 3 interventions listed under the existing IUCN–CMP 'law enforcement and prosecution' category could be performed by actors with and/or without law enforcement authority, which could be misleading given the existing level 1 category name. For example, patrolling for wildlife poachers could be performed by patrol teams with a legal mandate to arrest, or alternatively by NGO teams, or community guardians that do not have authority to arrest. Therefore, to distinguish between law enforcement and non-law enforcement CWC interventions, each CWC intervention evaluated within a given article will be identified (i.e. coded) as being (i) a law enforcement CWC intervention, that is performed or implemented by actors with law enforcement authority (here, including criminal justice interventions like prosecuting and sanctioning wildlife crime), (ii) a non-law enforcement CWC intervention, that is performed or implemented by actors without law enforcement authority (including but not limited to civil society and industry) or (iii) a combination of both (i) and (ii).

Second, in the existing IUCN–CMP framework, certain interventions that would fall under the 'law enforcement and prosecution' level 1 category (as well as our reconceived 'counter-wildlife crime interventions' category) could be considered more related to enabling condition actions (i.e. actions to create the conditions necessary for other interventions to succeed) rather than behaviour change/threat reduction actions, yet all would be categorized as the latter given the existing classification hierarchy including level 0 action types (e.g. informant networks – more of enabling condition action in that information derived from a given human source serves the purpose of informing the nature of the intervention to reduce the focal wildlife crime

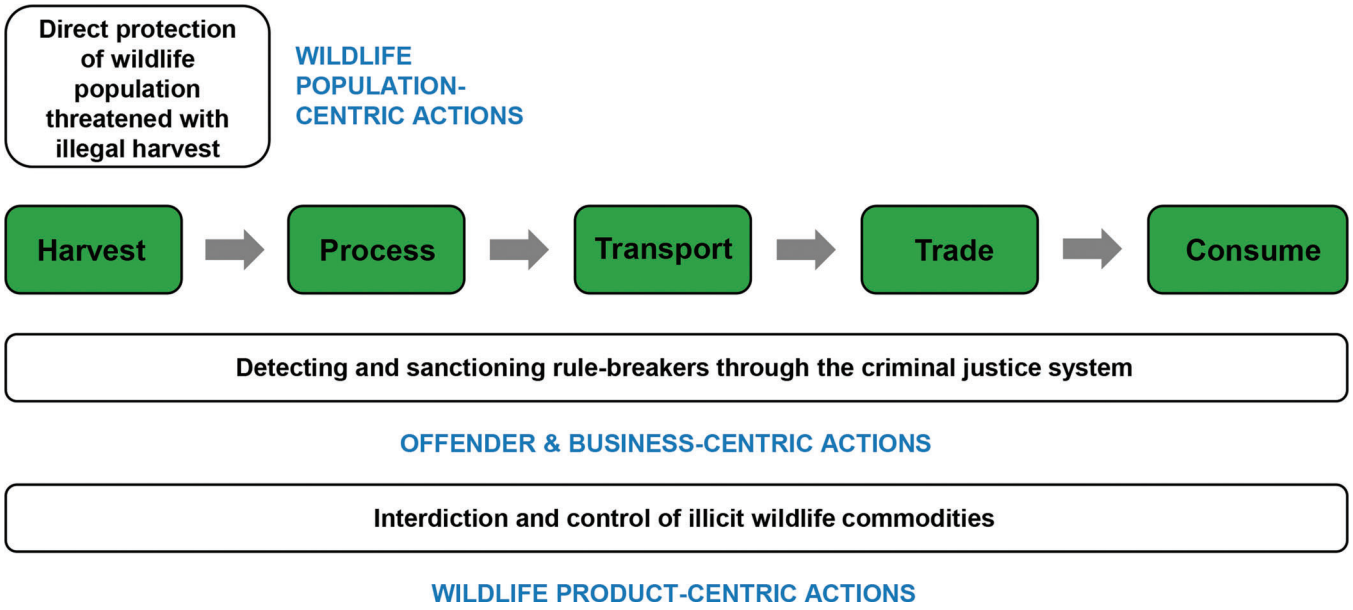

FIGURE 1 The three broad groups of CWC interventions implemented to address wildlife crimes and where these interventions fall along the wildlife-crime continuum. Modified from Lemieux & Pickles (2020)

problem). Therefore, we removed the existing level 0 conservation action types so that CWC interventions include a mixture of action types (for instance, target centric action type, e.g. direct guarding of wildlife; behaviour change/threat reduction action type, e.g. sanctioning at time of encounter with an offender, rehabilitation, detection and confiscation of wildlife products; enabling condition action type: e.g. intelligence, information sharing and analysis). Information on conservation action types will be captured in our mapping exercise during data coding; however, this information would be extracted for the lowest level intervention subcategories (level 2 or 3 actions), allowing for more flexibility in our revised classifications framework.

Lastly, within this reconceived CWC interventions category, we (after much input and feedback from our advisory team) modified the existing IUCN–CMP level 2 categories into three broad groups: (1) wildlife population-centric actions: aimed to prevent the loss of target wildlife species from its habitat by illegal activities by directly protecting wildlife; (2) offender and business-centric actions: focused specifically on individual offenders and businesses by detecting and sanctioning rule-breakers through the criminal justice system; and (3) wildlife product-centric actions: aimed to target illegal wildlife products and its removal from circulation by interdiction and control of illicit wildlife commodities. These groups were developed to be more in line with existing functional divisions of work in countering wildlife crime, and relatedly, where along the wildlife-crime continuum, a CWC intervention would be implemented (see Figure 1).

2 | OBJECTIVE OF THE PROTOCOL

The objective of the proposed systematic map is to provide a collated summary of the existing body of literature addressing the effectiveness of CWC interventions for conserving African, Asian and Latin American wildlife directly threatened by exploitation (here, including illegal harming of wild animals and plants whether by harvest as a resource or for control/persecution). Through this mapping exercise, we will describe the quantity and key characteristics of the available evidence, as well as identify evidence clusters (subsets of evidence that may be suitable for secondary research), and evidence gaps (topics that are underrepresented in the evidence base that require future primary research).

2.1 | Question(s)

The primary question that this proposed systematic map seeks to address is as follows: What is the evidence that CWC interventions are effective for conserving African, Asian and Latin American wildlife directly threatened by exploitation?

Specifically, we aim to address the following research questions:

1. What are the frequency and types of CWC interventions used either alone, or in combination with other CWCs or with other non-CWC conservation interventions for conserving wildlife directly threatened by exploitation, for which evidence on effectiveness exists?
2. What is the frequency and types of CWC interventions performed by actors with law enforcement authority, non-law enforcement authority, or both?
3. What are the key characteristics of the evidence base addressing the effectiveness of CWC interventions in terms of geographical locations, species or species groups, outcome measures, study designs and monitoring/assessment methods?

4. What are the evidence clusters and gaps in the evidence base? And can we assess qualitatively or quantitatively the effectiveness of interventions for any identified evidence cluster?

2.2 | Components of the primary question

Subject (population): Wild animal and plant species, and species groups native to Africa, Asia or Latin America targeted by USFWS international activities (i.e. financial assistance programmes, Office of Law Enforcement, Migratory Bird Program, and international wildlife trade programme).

Intervention/exposure: Establishment, adoption or implementation of any CWC intervention, either alone or in combination, for conserving animals and plants directly threatened by exploitation (e.g. wildlife collection, harvest, process, transport, trade, consumption), including human–wildlife conflicts (e.g. pest control, retaliatory killings). When a CWC intervention is applied, it will be assumed the threat is illegal.

Comparator: The absence of intervention either between sites and/or over time or comparison with another intervention or alternative levels of the same intervention. However, no studies will be excluded based on the presence or absence of a comparator.

Outcomes: Measures of change in biological outcomes (i.e. overall status of the relevant population/species of concern, e.g., abundance, biomass) and threat reduction outcomes (i.e. indicators of reduced threats for target species, e.g., poaching incidents, wildlife crime/trade levels).

3 | MATERIALS AND METHODS

The proposed systematic map will follow, as closely as possible, the guidelines provided by CEE (2018), and conform to ROSES reporting standards (i.e. detailed forms for ensuring evidence syntheses report their methods to the highest possible standards; see Haddaway et al., 2018) (see Supporting Information 2).

3.1 | Searching for articles

The systematic map will be based on literature searches (i.e. commercially published and grey literature) using four publication databases, one web-based search engine, and 36 specialist websites and online databases, as described in more detail below. Reference sections of relevant reviews identified from this mapping exercise will be hand-searched to evaluate relevant titles that may not be found using the search strategy. We will issue a call for evidence to target sources of grey literature through relevant mailing lists and social media. The call for evidence will also be distributed by the advisory team to relevant networks and colleagues.

3.1.1 | Search string

A list of potentially relevant English search terms was developed in consultation with the advisory team and broken into three components: the population (population), intervention (interventions and direct threats) and outcome. The review team then developed a set of search strings that were modified and refined iteratively through a scoping exercise using Web of Science Core Collections (WoSCC) and Scopus which evaluated the sensitivity of the search terms and associated wildcards (Table 1; Supporting Information 1). The comprehensiveness of the search string was tested using a list of benchmark papers (Supporting Information 1) that were identified as relevant for this map by the advisory team.

3.1.2 | Searches

Four bibliographic databases (i.e. ISI Web of Science Core Collections, Scopus, ProQuest Dissertations & Theses Global, Science.gov) will be searched using Carleton University's institutional subscriptions. No language, date or document type restrictions will be applied during the search. We will also conduct a search in Google Scholar using three simplified search strings to search for additional commercially published and grey literature (see Supporting Information 1). Based on a scoping exercise, the top 200 search results for each search string (sorted by relevance) will be exported for screening in Excel (see Supporting Information 1). To ensure the inclusion of a wide range of sources and materials, the websites and portals of organizations and databases relevant to the topic will be searched using their built-in search facilities using simplified English search term combinations. For each specialist website and online database, the top 30 search results for each simplified search string, sorted by relevance, will be screened for inclusion. After consulting with our advisory team, the list of websites and online databases was narrowed to the following:

1. African Wildlife Foundation: www.awf.org
2. bioRxiv: https://www.biorxiv.org/
3. C4ADS: https://c4ads.org/
4. Conservation Criminology: www.conservationcriminology.com
5. Darwin Initiative: www.darwininitiative.org.uk
6. EAGLE Network: https://www.eagle-enforcement.org/
7. Foreign, Commonwealth & Development Office (FCDO): https://www.gov.uk/government/organisations/foreign-commonwealth-development-office
8. International Impact Initiative (3ie): www.3ieimpact.org
9. International Institute for Environment and Development (IIED): www.iied.org
10. International Union for Conservation of Nature (IUCN): www.iucn.org
11. Interpol: https://www.interpol.int/
12. Netherlands Institute for the Study of Crime and Law Enforcement (NSCR): www.nscr.nl
13. Open Grey: www.opengrey.eu
14. Open Science Framework (OSF): https://osf.io/
15. Oxford Martin Programme on the Illegal Wildlife Trade: https://www.oxfordmartin.ox.ac.uk/illegal-wildlife-trade/
16. Panthera: www.panthera.org
17. People Not Poaching: https://www.peoplenotpoaching.org/

TABLE 1 Proposed search string for the execution of the searches optimized for Web of Science Core Collection

Component	Search string
Population	TS = ((Wildlife OR Fauna OR Animal$ OR Mammal$ OR Flora OR "Endangered species" OR "Threatened species" OR "Vulnerable species" OR Ornamental OR Pet$ OR Timber OR Elephant* OR Rhino* OR Antelope$ OR Gazell* OR Tiger$ OR Lion$ OR Panther$ OR Leopard$ OR Cheetah$ OR Ocelot$ OR Jaguar$ OR Pangolin$ OR Anteater$ OR "Ant eater$" OR Giraff* OR Okapi$ OR Primate$ OR Ape OR Apes OR Gorilla$ OR Chimpanzee$ OR Orangutan$ OR Gibbon$ OR Parrot$ OR Macaw$ OR Duck$ OR Geese OR Swan$ OR Shorebird$ OR Songbird$ OR Passeri* OR Vulture$ OR Hornbill$ OR Hummingbird$ OR Turtle$ OR Tortoise$ OR Crocod* OR Boa$ OR Python$ OR Chameleon$ OR Gecko$ OR "Monitor lizard$" OR "Girdle-tail lizard$" OR Totuava OR Cyca* OR Succulent$ OR Spurge$ OR Cactus OR Cacti OR Aloe$ OR "Elephant truck$" OR Mahogan* OR Rosewood$ OR Ivory OR Bushmeat$) NOT (Rhinovirus* OR Rhinoplast*))
	AND
Intervention	TS = ((Enforcement OR Prosecut* OR "Anti-poaching" OR Surveil* OR Patrol* OR Guard* OR Ranger$ OR Informant$ OR Informer$ OR Intelligence OR Law$ OR Compliance OR Arrest$ OR Interdict* OR Convict* OR Trial$ OR Seiz* OR Confiscat* OR "Snare removal*" OR Detain OR Sanction* OR Incarcerat* OR "Trap removal" OR Evict* OR "Threat$ reduction" OR "Conservation action$" OR "Conservation intervention$" OR "Conservation measure$" OR "Community based" OR "Biodiversity conservation" OR Outreach OR Awareness OR Campaign$ OR "Public service announcement$" OR Advocacy OR "Social media" OR "Electronic media") NOT ("Artificial intelligence"))
	AND
Direct threats (Intervention qualifier)	TS = (("Biological resource use" OR "Consumptive use$" OR "Non-consumptive use$" OR "Wildlife collect*" OR "Animal collect*"OR "Wildlife kill*" OR "Animal kill*" OR "Wildlife consum*" OR "Animal consum*"OR Hunting OR Trade$ OR Poach* OR Traffic* OR Harvest* OR Trapping OR Snaring OR Logg* OR Clearcut* OR "Clear-cut*" OR Forestry OR "Plant collect*" OR "Wood collect*" OR "Firewood collect*" OR "Egg collect*" OR "Human-wildlife conflict" OR "Crop raid*" OR "Retaliatory kill*" OR "Fear kill*" OR "Human mortalit*" OR "Livestock predation" OR "Problem animal" OR "Predator control*" OR Persecution OR "Animal control*" OR "Pest control*" OR Poison* OR "Accidental mortality" OR Bycatch OR "Illegal activit*" OR "Prohibited activit*" OR "Unlawful activit*" OR "Human activit*" OR Threat$ OR "Source$ of stress" OR "Wildlife crime$") NOT ("Trade-off$" OR Tradeoff$))
	AND
Outcomes	TS = ("Population size$" OR "Relative size" OR Abundance$ OR Densit* OR Biomass OR Status OR Presence$ OR Distribution OR Range$ OR Occupanc* OR Detect* OR Recovery OR Progress OR Protect* OR Reproducti* OR Migration OR Behavior$ OR Behaviour$ OR "Genetic diversity" OR Fecundity OR "Age structure" OR "Size structure" OR Recruitment OR Trial$ OR Convict* OR "Law suit$" OR Arrest* OR Seiz* OR Violat* OR Poach* OR Carcass OR Carcasses OR "Market price" OR "Demand reduction" OR "Biotic response" OR "Biological response" OR "Conservation target" OR Biodiversity OR "Ecological response" OR Impact OR Effectiveness OR Effective OR Efficacy OR "Direct measure$" OR "Threat reduction measure$")

18. Poverty and Conservation Learning Group: http://povertyandconservation.info
19. Problem-Oriented Policing Centre at Arizona State University: www.popcenter.org
20. Rutgers University Gray Literature Database: njlaw.rutgers.edu/cj/gray/search.php
21. Save the Elephants: http://savetheelephants.org
22. Spatial Monitoring And Reporting Tool (SMART): https://smartconservationtools.org/
23. The Convention on Biological Diversity (CBD): www.cbd.int
24. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): www.cites.org
25. TRAFFIC, the wildlife trade monitoring network: www.traffic.org
26. U.S. Fish & Wildlife Service: https://www.fws.gov
27. UN Office on Drugs and Crime (UNODC): https://www.unodc.org/
28. United Nations Environment Programme – World Conservation Monitoring Centre (UNEP-WCMC): www.unep-wcmc.org
29. United States Agency for International Development (USAID): www.usaid.org
30. Wildlife Conservation Society (WCS): https://www.wcs.org/
31. World customs organization: http://www.wcoomd.org/
32. World Trade Organization (WTO): www.wto.org
33. Worldwide Fund for Nature Conservation (WWF): www.panda.org

For select online databases anticipated to contain highly relevant evidence (referred here as *open evidence resources*, listed and denoted with an asterisk below), all search results, sorted by relevance, for each simplified search string will be screened for inclusion; however, if the reviewer notices that the level of relevance of each article significantly declines before screening all articles, the reviewer will stop screening (as per suggested by Livoreil et al., 2017).

34 CEE Evidence Synthesis Library*: https://environmentalevidence.org/completed-reviews/
35 Conservation Evidence*: www.conservationevidence.com
36 The CEE Database of Evidence Reviews (CEEDER)*: https://environmentalevidence.org/ceeder/

To supplement the above searches, the bibliographies of any relevant review article (i.e. not containing primary empirical data) identified during screening stages will also be manually searched for any additional relevant articles that were not already captured. Authors of any unpublished references will be contacted to request access to the full article. Additionally, a call for grey literature will be circulated via professional networks and professional association distribution lists (e.g. IUCN Green Criminology Specialist Working Group) to solicit articles for inclusion in this systematic map. The review team will also use social media and email to alert the community of this systematic map and to reach out to recognized experts and practitioners for further recommendations and provision of relevant unpublished material, with no date or language restrictions.

3.1.3 | Search record database

All articles found by databases will be exported into EPPI-Reviewer Web (https://eppi.ioe.ac.uk/EPPIReviewer-Web/home) as a single database. Duplicates will then be identified and merged. Articles from Google Scholar will be exported directly into Excel, where duplicates will be removed prior to screening.

3.2 | Article screening and study eligibility criteria

3.2.1 | Screening process

Articles will be screened at two stages: (1) title and abstract and (2) full text. Documents found through databases and search engines will be screened at title and abstract. Based on an initial scoping exercise, we anticipate a very large number of search results (> 30,000) and therefore intend to use machine learning in EPPI-Reviewer to increase screening efficiency. To support title and abstract screening, we will use priority screening which uses machine learning to sort articles by relevance and promotes early identification of relevant articles. Before screening begins, two or more reviewers using a random subset of 1% of database articles or 1000 abstracts (whichever is larger) will undertake a consistency check. To ensure consistent and repeatable decisions, a Kappa score of ≥0.6 (which indicates substantial agreement between reviewers) will need to be achieved prior to any further screening being conducted. The results of the consistency checks will be compared between reviewers, and all discrepancies will be discussed to understand why an inclusion/exclusion decision was made. Revisions to the inclusion criteria will be made as necessary. Articles found through calls for evidence or from the reference sections of review articles will be screened at full text but will not be included in consistency checks. A set of articles screened by at least two reviewers will be used as a training set for the machine learning technology, after which screening will continue with a single reviewer screening each article. While machine learning technologies are still under development, EPPI-Reviewer's priority screening has been shown to effectively reduce the screening burden by up to 60% (Tsou et al., 2020). Although we intend to use priority screening to increase title and abstract screening efficiency, all articles found through databases and search engines searches will be screened by at least one reviewer.

A similar process will be repeated prior to screening articles at full text, that is two or more reviewers using a subset of 1% or 25 articles (whichever is larger) of all articles that were included at title and abstract, will undertake a consistency check and a Kappa score of ≥0.6 will be required before any further screening is conducted. If the reviewer is uncertain whether to include an article at any screening stage, they will tend towards inclusion to the next stage. If there is further doubt, the review team will discuss those articles as a group and come to a decision. Justification for inclusion or exclusion will be recorded, and a list of studies rejected in full text will be provided in an additional file together with the reason for exclusion. Digital media will be screened, when they are available online without the need for purchasing the media or having specialized pay-for-use software to view it. The Interlibrary Loans program at Carleton University will be used to acquire hard or digital, full-text copies of any articles that are included once the title and abstract screening has occurred. Reviewers will not screen studies (at title and abstract or full text) for which they are an author.

3.2.2 | Eligibility criteria

The following predefined criteria will be used when assessing the relevance and deciding on inclusion or exclusion of articles.

Eligible populations

Wild animal and plant species and species groups native to Africa, Asia or Latin America are targeted by USFWS international activities (Table 2). While not comprehensive of all the species involved in USFWS international assistance, this species list is representative of the taxonomic groups targeted by the international activities of the agency's financial assistance programmes, Office of Law Enforcement, Migratory Bird Program, and international wildlife trade programme. For the purposes of this exercise, Latin America will include all the Americas south of the United States (i.e. South America, Caribbean, Central America including Mexico).

Eligible interventions

Any CWC intervention established, adopted or implemented to prevent the loss of target wildlife, discourage non-compliance, raising awareness of or enforce compliance with existing laws and policies at all levels performed by actors with and/or without the authority to arrest, prosecute and/or sanction alleged wildlife crimes. We propose three broad groups of CWC interventions primarily implemented to address direct threats: (1) wildlife population-centric actions; (2) offender and business-centric actions; and (3) wildlife product-centric actions (Table 3; Figure 1). Eligible articles will include an evaluation of a single CWC intervention, combinations of CWC interventions, or the combination of one or more CWC interventions and one or more non-CWC conservation

TABLE 2 The species and species groups native to Africa, Asia or Latin America targeted by USFWS international activities

Species group	Order	Family name[a]	Example species
African and Asian elephants	Proboscidea	Elephantidae	*Loxodonta africana*, *Loxodonta cyclotis*, *Elephas maximus*
African and Asian rhinos	Perissodactyla	Rhinocerotidae	*Diceros bicornis*, *Ceratotherium simum*, *Rhinoceros unicornis*, *Rhinoceros sondaicus*, *Dicerorhinus sumatrensis*
Bovids	Cetartiodactyla	Bovidae	*Saiga tatarica*, *Oryx dammah*, *Addax nasomaculatus*, *Nanger dama*
Felids	Carnivora	Felidae	*Panthera tigris*, *Panthera leo*, *Panthera onca*, *Panthera uncia*, *Acinonyx jubatus*, *Panthera pardus*, *Leopardus pardalis*
Pangolins	Pholidota	Manidae	*Phataginus tricuspis*, *Phataginus tetradactyla*, *Smutsia gigantea*, *Smutsia temminckii*, *Manis pentadactyla*, *Manis crassicaudata*, *Manis javanica*, *Manis culionensis*
Giraffes and Okapi	Cetartiodactyla	Giraffidae	*Giraffa camelopardalis*, *Okapia johnstoni*
Parrots	Psittaciformes	Psittacidae	*Psittacus erithacu*, *Ara macao*
Ducks, Geese and Swans	Anseriformes	Anatidae	*Anas bernieri*, *Asarcornis scutulata*, *Dendrocygna autumnalis*, *Rhodonessa caryophyllacea*
Shorebirds	Charadriiformes	Charadriidae	*Charadrius melodus*
		Scolopacidae	*Calidris pygmaea*, *Calidris subruficollis*
Songbirds and other passerines	Passeriformes	Estrildidae	*Lonchura oryzivora*, *Erythrura prasina*, *Lonchura fuscans*
		Muscicapidae	*Kittacincla malabarica*, *Myophonus castaneus*
		Pycnonotidae	*Pycnonotus zeylanicus*, *Rubigula dispar*
		Sturnidae	*Acridotheres melanopterus*, *Rhabdornis rabori*
		Zosteropidae	*Zosterops* spp., *Dasycrotapha speciosa*
		Leiotrichidae	*Leiothrix argentauris*, *Garrulax nuchalis*
		Corvidae	*Cissa thalassina*, *Urocissa xanthomelana*
		Thraupidae	*Sporophila beltoni*, *Charitospiza eucosma*
		Thamnophilidae	*Cercomacra carbonaria*, *Terenura sicki*
		Turdidae	*Geokichla interpres*, *Zoothera major*
		Furnariidae	*Synallaxis kollari*, *Cinclodes aricomae*
		Tyrannidae	*Calyptura cristata*, *Platyrinchus leucoryphus*
Old World vultures	Accipitriformes	Accipitridae: sub-family Gypinae[a]	*Necrosyrtes monachus*, *Gyps himalayensis*
		Accipitridae: sub-family Gypaetinae[a]	*Gypaetus barbatus*, *Neophron percnopterus*
Hornbills	Bucerotiformes	Bucerotidae	*Rhinoplax vigil*, *Rhyticeros subruficollis*, *Aceros nipalensis*
Hummingbirds	Apodiformes	Trochilidae	*Amazilia luciae*, *Archilochus alexandri*
Primates	Primates	Hominidae (non-human)	*Gorilla beringei*, *Gorilla gorilla*, *Pan troglodytes*, *Pan paniscus*, *Pongo abelii*, *Pongo pygmaeus*, *Pongo tapanuliensis*
		Hylobatidae	*Symphalangus syndactylus*, *Hylobates agilis*, *Nomascus siki*
		Callitrichidae	*Callithrix penicillata*, *Saguinus midas*, *Leontopithecus rosalia*, *Mico rondoni*
		Cebidae	*Cebus olivaceus*, *Sapajus nigritus*, *Saimiri ustus*
		Aotidae	*Aotus* spp.
		Pitheciidae	*Callicebus coimbrai*, *Cacajao melanocephalus*, *Pithecia chrysocephala*
		Atelidae	*Alouatta coibensis*, *Ateles fusciceps*, *Lagothrix lagotricha*
Turtles and Tortoises	Testudines	Cheloniidae	*Chelonia mydas*, *Caretta caretta*, *Lepidochelys kempii*, *Lepidochelys olivacea*, *Eretmochelys imbricata*, *Natator depressus*
		Chelydridae	*Chelydra rossignonii*, *Chelydra acutirostris*
		Dermochelyidae	*Dermochelys coriacea*

(Continues)

TABLE 2 (Continued)

Species group	Order	Family name[a]	Example species
		Dermatemydidae	*Dermatemys mawii*
		Emydidae	*Terrapene coahuila*
		Geoemydidae	*Cuora trifasciata*, *Cyclemys gemeli*
		Kinosternidae	*Kinosternon angustipons*, *Staurotypus triporcatus*, *Claudius angustatus*
		Pelomedusidae	*Pelomedusa galeata*, *Pelusios niger*
		Platysternidae	*Platysternon megacephalum*
		Podocnemididae	*Erymnochelys madagascariensis*, *Peltocephalus dumerilianus*
		Testudinidae	*Chelonoidis chilensis*, *Homopus femoralis*, *Kinixys natalensis*
		Trionychidae	*Chitra chitra*, *Lissemys punctata*
Crocodiles	Crocodylia	Crocodylidae	*Crocodylus niloticus*, *Crocodylus mindorensis*, *Osteolaemus tetraspis*
		Alligatoridae	*Alligator sinensis*, *Caiman yacare*, *Caiman crocodius*, *Caiman latirostris*, *Melanosuchus niger*, *Paleosuchus palpebrosus*, *Paleosuchus trigonatus*
		Gavialidae	*Gavialis gangeticus*
Boas	Squamata	Boidae	*Boa constrictor*, *Sanzinia madagascariensis*
Pythons	Squamata	Pythonidae	*Python regius*, *Python bivittatus*
Chameleons	Squamata	Chamaeleonidae	*Furcifer pardalis*, *Bradypodion caeruleogula*
Typical geckos	Squamata	Gekkonidae	Gekko gecko, *Phelsuma ocellata*
Monitor lizards	Squamata	Varanidae	*Varanus* spp.
Girdle-tail lizards	Squamata	Cordylidae	*Hemicordylus capensis*, *Ouroborus cataphractus*, *Smaug giganteus*
Cycads	Cycadales	Cycadaceae	*Cycas* spp.
		Stangeriaceae	*Stangeria eriopus*
		Zamiaceae	*Ceratozamia fuscoviridis*, *Encephalartos altensteinii*
Succulents	Malpighiales	Euphorbiaceae	*Euphorbia* spp.
Cactus	Caryophyllales	Cactaceae	*Parodia tenuicylindrica*, *Hylocereus setaceus*, *Browningia candelaris*
Aloes	Liliales	Liliaceae	*Aloe* spp.
Elephant trunks	Gentianales	Apocynaceae	*Pachypodium* spp.
Mahoganies	Sapindales	Meliaceae	*Swietenia humilis*, *Swietenia macrophylla*, *Swietenia mahagoni*, *Khaya* spp., *Toona* spp., *Cedrela* spp.
Rosewoods	Fabales	Fabaceae/ Leguminosae	*Dalbergia* spp.

[a]Taxonomic level species or species groups will be considered for eligibility.

interventions. Non-CWC conservation interventions, when combined with CWC intervention(s) will be identified and coded drawing upon the IUCN and CMP Conservation Actions Classification v2.0 (Salafsky et al., 2008; CMP, 2016), and include the following (level 1 action) categories: (i) protected area management, (ii) land/water management, (iii) species management, (iv) livelihood, economic, and moral incentives, (v) conservation designation and planning, (vi) legal and policy frameworks, (vii) research and monitoring, (viii) education and training, and (ix) institutional development. Articles that only implement non-CWC conservation intervention(s) (i.e. any intervention from categories (i)–(ix) above, with no CWC interventions) to conserve wildlife will be excluded. Note, non-CWC intervention category numbers do not align with those used in the IUCN–CMP Action classification because we consider 'law enforcement & prosecution' and 'awareness raising' in our CWC interventions and added a different category 'protected area management' to categorize those studies that look at protected area management in general.

Eligible direct threats (i.e. wildlife crimes) will include various forms of exploitation, broadly defined as the collection, harvest, or killing of terrestrial animals or animal products, plants, or trees for a resource or control/persecution reasons, that is human–wildlife conflicts (see Table 4). Although the word 'crime' implies illegal activities, and that is indeed the focus of our mapping exercise, we anticipate that not all papers will clearly identify a threat as being legal/illegal. Furthermore, legality varies across geographical locals, and over time with changes in legislation (see 't Sas-Rolfes et al., 2019). Therefore, we will assume that if a CWC intervention is applied, the threat was considered illegal. We will not include activities that are clearly identified as legal but may

TABLE 3 Eligible CWC interventions

Interventions	Definition	Examples
Wildlife population-centric actions		
1.1 Direct protection of wildlife threatened with illegal harvest	Actions aiming to prevent loss of target wildlife species from its habitat by illegal harvesters (not specifically to detect and arrest a harvester).	
Discouraging and/or removing opportunity structures used by harvesters to enter, extract wildlife products and leave with the product through…		
1.1.1 Direct guarding of wildlife or key features	Actions dissuading attempts to harvest by physical presence of the guardian.	For example, camping at locations of a nesting bird, camping on beaches during turtle egg laying to dissuade egg theft, directly following individual rhinos
1.1.2 Removal/destruction/control of traps, weapons, tools and infrastructure used by wildlife criminals	Actions removing from circulation a device or tool that will either directly kill/catch or facilitate that process.	Removal/destruction of traps and harvester tools and infrastructure (e.g. snare sweeps to collect abandoned wire used to make a snare, destruction of poacher hides or conveyances) Weapons amnesty (e.g. firearms are exchanged for farming tools)
1.1.3 Control of entry and exit points	Actions discouraging illegal harvesters attempting to enter the species' protected habitat.	For example, guard posts and checkpoints
1.1.4 Surveillance	Actions gaining information of what is going on where inside a protected area to inform protection strategies and immediate responses to illegal harvesting incursions.	Informant Drone/poacher camp/gunshot detector/geosensor Patrol team Tourists, workers informing through some form of hotline
1.1.5 Interception of illegal harvest attempt	Actions confronting illegal harvesters making an attempted incursion (ideally prior to extraction of resource). Here, actions result in a push out of the harvesting team, but no actual sanctioning occurs (cases of detention of individual harvesters, would fall under 1.2 below).	For example, a coast guard patrol vessel intercepting an illegal trawler in a marine protected area
Offender and business-centric actions		
1.2 Detection & Sanction of Rule-Breakers Through the Criminal Justice System	Actions focusing on individual offenders and businesses at whatever stage of the wildlife crime continuum.	
Reducing, deterring and/or incapacitating illegal behaviours of offenders and businesses through…		
1.2.1 Intelligence	Actions supporting wildlife investigations, that is research and analysis.	Tip lines Pre-enforcement action plans – deter illegal activity Target exploitation (def.: building out threat profile) Link analysis (def.: identifying network of individuals or businesses) Financial/asset analysis Timeline structure Telephone (toll analysis) Imagery interpretation Trend analysis Short- and long-term collection requirements (identifying gaps in information and addressing them to strengthen law enforcement cases) Shipping or database alerts

(Continues)

TABLE 3 (Continued)

Interventions	Definition	Examples
1.2.2 Sanctioning at time of encounter with the offender	Actions focusing on the immediate sanctioning of an offender at the time of encounter.	Detain
		Arrest
		Confiscate items
		Formal warning
		Verbal warning
		Spot fine (e.g. fines for angling without a correct permit)
		Eviction (e.g. removal of illegal land squatters)
1.2.3 Prosecuting and trying of alleged crimes	Actions building prosecution cases and trying suspects in court.	For example, holding trials for alleged lawbreakers
1.2.4 Sanctioning following prosecution and sentencing of an offender	Actions focusing on sanctions following offender prosecution.	Incarceration
		Financial penalty
		Forfeiture of assets (e.g. conveyances used in commission of a crime such as vessels, vehicles)
		Freezing of bank account (e.g. use of anti-money laundering acts to prevent profiting from crime)
		Repatriate (in cases of foreign criminals)
		Closure of business (e.g. restaurant repeatedly selling bushmeat, businesses acting as shell companies or legal fronts)
		Removal of benefits (e.g. conservation credits, vouchers for health clinic, government benefits)
		Job loss
1.2.5 Individual communications	Actions (communication related) supporting individual offender and potential offender compliance.	Verbal communication about legality (e.g. during customs screening or in-person investigations)
		Targeted communication with repeat offenders
		Letters to individuals and businesses (e.g. letters sent from U.S. Customs and Border Protection to potential offenders about federal laws and regulations)
1.2.6 Rehabilitation	Actions supporting offender rehabilitation.	For example, counseling programmes, educational programmes
Wildlife product-centric actions		
1.3 Interdiction and control of illicit wildlife commodities	Actions targeting the wildlife product itself and the transfer of that product from person to person, place to place at whatever stage of the wildlife crime continuum.	
Detecting, disrupting and securing the post-harvest supply chain of wildlife products by…		
1.3.1 Information analysis and sharing	Actions using information to support interdiction investigations of wildlife and wildlife products.	Hotspot and trade analysis
		Sharing information within and among law enforcement agencies (coordination)
		CITES species identification guides
		Training videos to improve identification and detection of wildlife contraband

(Continues)

TABLE 3 (Continued)

Interventions	Definition	Examples
1.3.2 Detecting and confiscating illegal wildlife products	Actions detecting and confiscating illegal wildlife products.	Inspection Inspection using various tools to enhance procedures to detect, and then confiscate illegal products (e.g. detection dogs, thermo guns, x-ray machines)
1.3.3 Disposition and/or destructing seized illegal wildlife products	Actions controlling, disposing and/or destructing illicit wildlife commodities after detection to remove them from circulation.	Disposition of illegal products to remove them from circulation (e.g. returning to the country of origin or place of transit, burning products) Management of stockpiled specimens (e.g. ivory, horns, timber)
Reducing the trafficking of illegal wildlife products by…		
1.3.4 Awareness raising related to the transfer of illegal wildlife products	Actions making people aware of the illegality and/or penalties associated with illegal harvest, transit, trade, purchase and/or consumption of illicit wildlife products.	Media (e.g. reported, and electronic) Public service announcements (e.g. voice announcements at transit hubs on the legal status of wildlife trade) Displays (e.g. CITES exhibits at airports, poster or billboard campaigns) Person-to-person engagement (e.g. info booth)

TABLE 4 Eligible direct threats resulting in the need for CWC interventions

Threat category[a]	Problem	Definition
Exploitation	Hunting and collecting terrestrial animals	Killing or collecting terrestrial wild animals or animal products for commercial, recreation, subsistence, research, medicinal or cultural purposes; includes wild animal trade. Includes a collection of turtle eggs, and/or the harvest of female nesting turtles on land.[b]
	Gathering terrestrial plants	Collecting or harvesting plants, and other non-timber/non-animal products for commercial, recreation, subsistence, medicinal, research or cultural purposes.
	Logging and wood harvest	Harvesting trees and other woody vegetation for timber, fiber, or fuel, including site preparation and other forestry management practices.
Human–wildlife conflict	Human–wildlife conflict	Threats from human and wildlife interactions that result in negative impacts on humans and wildlife, including crop raiding, disease transmission, retaliatory and fear of killing wild animals for control/persecution, human mortalities caused by wild animals, livestock predation, and problem animals.

[a]Adapted from the Arizona State University Centre for Problem-Oriented Policing's Taxonomy of Wilderness Problems (https://popcenter.asu.edu/content/resources) and IUCN–CMP Conservation Actions Classification v2.0 (CMP, 2016).
[b]Excludes fishing and harvesting aquatic animals; however, includes bycatch otherwise.

nevertheless be associated with unsustainable harvesting; even though these remain issues of conservation concern, here, our focus will be on threats that are both associated with overexploitation of wildlife and identified as illegal or assumed so by implementation of a CWC intervention. Our selection and definitions of eligible wildlife crimes will primarily draw from the Arizona State University Centre for Problem-Oriented Policing's (POP) Taxonomy of Wilderness Problems (https://popcenter.asu.edu/content/resources) and partly from the CMP Direct Threat Classification (CMP, 2016 v2.0). Note, further subcategorization of wildlife crimes will be made as the review progresses drawing from the taxonomies of the POP centre and the IUCN–CMP level 2 and 3 threats. Studies that focus on fishing or harvesting aquatic animals and plants will be excluded; however, bycatch will be included otherwise.

Eligible comparators

Where present, the absence of intervention either between sites and/or over time, or comparison with another intervention or

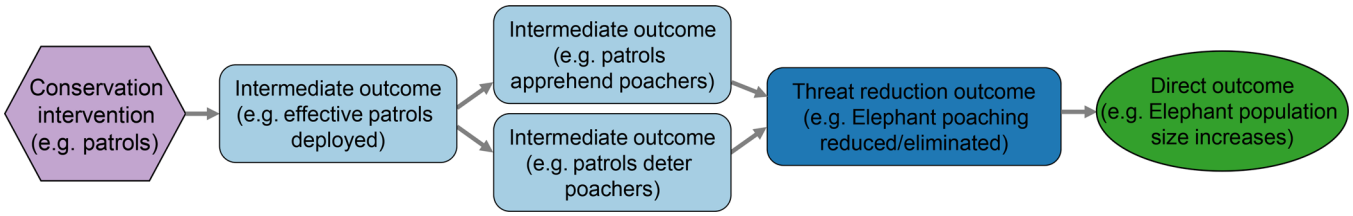

FIGURE 2 Simplified example theory of change diagram depicting direct and indirect (intermediate and threat reduction outcomes) outcomes from a CWC intervention. Modified from Muir and Byler (2014)

alternative levels of the same intervention. However, no studies will be excluded based on the presence or absence of a comparator.

Eligible outcomes

To address the question of whether CWC interventions are effective for conserving wildlife threatened by human activities, a direct measure (i.e. ultimate conservation target) would be required (i.e. a measured potential change in a biological outcome at the population and species levels including, for example abundance, biomass, health, reproduction). Often, however, more indirect measures (i.e. intermediate or threat reduction outcomes) are used as indicators of a potential or perceived change in population/species outcomes. Intermediate outcomes are results that show progress towards expected outcomes and that can be used as the basis for taking corrective management steps and building accountability, whereas threat reduction outcomes are outcomes that the intervention is trying to achieve in terms of reducing critical threats for target species/habitats (Muir & Byler, 2014) (see Figure 2 for a simplified example of a theory of change diagram but also see Muir and Byler, 2014, and the Conservation Actions & Measures Library, (https://www.miradishare.org/ux/program/cmp-conservationaction?nav1=caml-projects, for further generic theory of change examples). In general, indirect measures provide limited information as to whether an intervention is effective in conserving wildlife; however, they can provide information on whether the intervention is on the right path to reaching the ultimate conservation target (Sosnowski et al., 2021). To our knowledge, there is currently no available source that clearly and comprehensively distinguishes between intermediate and threat reduction indicators for evaluating wildlife crime interventions. Therefore, based on input from the advisory team and at the request of USFWS stakeholders, we will include any article that documents a change in biological outcomes and take an inclusive approach when considering the eligibility of indirect indicators (see Table 5 for a list of eligible outcomes). Here, for indirect indicators, we will focus on clear threat reduction outcomes (e.g. metrics related to poaching incidence: number of poached animals; changes in wildlife crime levels: number of wildlife products available for sale at markets) as well as other threat and/or intermediate indicators (e.g. presence of patrols deter poachers evaluated by comparisons of the number of poachers; incidence of illegal activity detected by CWC interventions evaluated by comparisons of the number of snares, gunshot shells, etc.). Part of this mapping exercise will include a description of the existing evidence base with respect to the different types of outcomes, including limitations therein (e.g. the number of confiscated wildlife products or arrests is commonly assumed to provide a measure of wildlife crime, when it can instead reflect enforcement effort). Our selection and definitions of relevant biological outcomes will primarily draw from Brooks et al. (2020), and for indirect indicators from a combination of sources (e.g. Muir & Byler, 2014; Sosnowski et al., 2021, Conservation Actions & Measures Library, https://www.miradishare.org/ux/program/cmp-conservationaction?nav1=caml-projects). Based on feedback from the advisory team, it was decided that intermediate outcomes farther removed from ultimate conservation targets, will not be eligible for inclusion. These include indicators related to (1) intervention effort (e.g. total days or distance patrolled) and (2) awareness, attitudes or knowledge outcomes (e.g. percentage of people that indicate they will consume less bushmeat, change in attitudes towards poaching, number of rangers trained in new techniques, number of poachers employed as rangers/scouts). If during article screening, the reviewer is uncertain whether to include an article at any screening stage based on the type of indirect outcome evaluated, they will tend towards inclusion to the next stage. If there is further doubt, the review team will discuss those articles as a group, including the advisory team when necessary, and come to a decision. Justification for inclusion or exclusion will be explained and recorded. Furthermore, articles reporting ecological outcomes (e.g. outcomes focusing on change in ecosystem processes and conditions, or community conditions), and evolutionary phenomena and processes will be excluded. We acknowledge as others have previously, the importance of conservation interventions striving for not only biological but also human well-being objectives (e.g. Biedenweg & Gross-Camp, 2018; Kaplan-Hallam & Bennett, 2018). Due to the already wide scope of this mapping exercise, articles that only report on human well-being outcomes will also be excluded; however, during data extraction, we will identify and describe articles that in addition to reporting on relevant direct and/or indirect measures, provide measures of human well-being outcomes (see *Data coding strategy* below).

Eligible types of study designs

We recognize that study designs included in this map will likely not fit the typical before/after (BA), control/impact (CI), or before/after/control/impact (BACI) designs. It is anticipated that some studies will include post-treatment (PT) designs (i.e. a single post-treatment monitoring period or a temporal correlation design using multiple post-treatment monitoring periods without true before data) and impact only (I-only) designs (i.e. no control site). Therefore, all study designs will be included in the systematic map and the type of

TABLE 5 Definitions and example indicators of eligible direct and indirect outcomes

Outcome type	Outcome category	Definition	Example metrics
Direct	Biological	Outcomes focusing on change in populations of individuals or populations within species.	Measures of a potential change in abundance/density (e.g. number of individuals per unit area), biomass (e.g. animal or plant dry mass per unit area), age/size structure (e.g. length/weight/age distributions of individuals in a population), reproduction (e.g. fecundity, number of offspring/reproductive individuals), recruitment (e.g. number of individuals that have joined a population over some time period), behaviour (e.g. time spent feeding/hiding), species range/spatial extent (e.g. expansion or contraction of a species range limit and/or extent), dispersal (e.g. migration and/or connectivity patterns), connectivity (e.g. measures of a degree to which populations are interacting), body condition (e.g. incidence of disease, incidence of target or bycatch species injury by traps), adaptability (e.g. genetic diversity).
Indirect	Threat reduction	Indicators focused on reducing critical threats for target species/habitats	Measures of a potential change in poaching incidents (e.g. number or percentage of illegally killed/poached animals/nests), wildlife crime/trade levels in focal area(s) (e.g. number of wildlife products available for sale in markets, number of poached items in checkpoints/transport points, number or weight of wildlife contraband confiscated).
			Also considered, measures of potential change in other threat and/or intermediate indicators: number of poachers apprehended by law enforcement patrols, number or catch per unit effort of poacher camps, incidents of detected poaching or other illegal activities (e.g. gunshot shells, gunshots, snares, traps), key informant estimates of poaching rates, change in efficacy of patrols that are informed by local 'tip-offs', behavioural change related to demand/ consumption (e.g. demand metrics including but not limited to number of people purchasing/consuming target species, change in market price), number of arrests of large-scale wildlife traffickers resulting from project's investigations and/or operations support, number or percentage of wildlife traffickers who have been arrested that are successfully prosecuted, appropriately sentenced, and serve or complete jail terms and/or pay fines, number or percentage of legal efforts undermined by corruption

study design will be coded. Theoretical modeling studies will also be included. Understanding what study design types exist in the literature for these types of interventions will be insightful for understanding the potential for future quantitative analysis. Reviews and policy discussions will be excluded; however, as noted above, bibliographies of relevant reviews will be cross-checked to identify additional articles.

Language

Only English-language literature will be included during the screening stage.

3.3 | Study validity assessment

Given the broad objective and scope of this systematic map, the validity of individual studies will not be appraised. Meta-data on aspects of study setting and design will be extracted from included studies to provide a very basic overview of the robustness and relevance of the evidence. However, the primary purpose of extracting this meta-data would be to aid future more in-depth critical appraisal and synthesis of studies on sub-topics of interest identified from this systematic map exercise.

3.4 | Data coding strategy

Coding and data extraction will be conducted following full-text screening. The following main categories of descriptive data will be extracted: (1) bibliographic information; (2) geographical location (e.g. country, latitude/longitude); (3) species (or species group) information; (4) study design and comparator information; (5) intervention details (e.g. CWC intervention type, actor(s) implementing CWC intervention [law enforcement actors, non-law enforcement actors, both], whether a CWC intervention was combined with a non-CWC intervention); (6) direct threat information; (7) outcome details (e.g. outcome category: biological, threat reduction, intermediate; and subcategories within: e.g. abundance, biomass, behaviour, poaching incidents, wildlife crime/trade levels, evidence of illegal activities, incidence of offender arrests; whether human well-being outcomes were also measured [Y/N], and if Y, which human well-being outcomes); (9) monitoring/assessment method details. Coding options within these key

variables will be compiled in a partly iterative process, expanding the range of options as they are encountered during scoping and extraction. To ensure that data are being extracted in a consistent and repeatable manner, the review team's extracted data from a random subset of articles (approximately 5% of articles included at full text) will be included in a consistency check before full meta-data extraction proceeds. All coding decisions will be reviewed by the review team, and any discrepancies will be reconciled and clarified before allowing data extraction to continue.

3.5 | Study mapping and presentation

There will be two main outputs from this systematic map: (1) a written narrative synthesis and (2) a searchable, coded database (MS-Excel). Descriptive statistics will be used to describe the overall amount (e.g. number of articles, number of studies) and key characteristics (e.g. geographic locations, species, interventions, wildlife crimes, outcome measures, study designs and monitoring/assessment methods) of evidence available. Key knowledge gaps (areas that are under-represented in the evidence base and could warrant further research) and knowledge clusters (areas of evidence that are well-represented and could potentially be good topics for future systematic reviews) will be identified using visual heat maps. The narrative synthesis will aim to be as visual as possible, summarizing information in tables and figures.

4 | DISCUSSION

The ultimate goal of this systematic map is to identify, collate and describe the information that exists on the effectiveness of CWC interventions. Understanding what actions have been evaluated, for which species/species groups, the study designs used, and what outcome metrics are commonly reported in the literature will help guide further exploration on evaluating the effectiveness of these interventions. Furthermore, information gathered from this mapping exercise will help build the evidence base that supports USFWS grant-making programmes and decisions and to shed light on a topic of increasing policy relevance and attention. More broadly, the results from this mapping exercise can also serve to support various governments and NGOs with a focus on nature conservation who routinely make decisions about investment of limited resources with goals of having maximal conservation benefit.

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AUTHORS' CONTRIBUTIONS

TR, JJT, JRB, MJM, JRBM, AP, WYL, RSAP and SJC conceived the ideas and designed methodologies. TR and SLAO led the writing of the manuscript. JJT, JRB, MJM, JRBM, AP, WYL, RSAP and SJC provided comments and revisions. All authors contributed critically to the drafts and gave final approval for publication.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

PEER REVIEW

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DATA AVAILABILITY STATEMENT

This article does not contain data. Once the study (i.e. systematic map) will be complete, a publicly accessible online version of the systematic map and a queryable database will also be developed.

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SUPPORTING INFORMATION

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