Wildlife health perceptions and monitoring in protected areas

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Introduction (under development)

Surveillance systems monitoring wildlife and livestock health in protected areas and fostering the early detection and timely communication of morbidity and mortality events are essential to track, prioritize threats, and activate contingency plans under high-risk scenarios for wildlife, human, and livestock health. However, effective surveillance systems involving wildlife are uncommon, especially in high-risk areas of pathogen emergence, such as the human-wildlife-livestock interfaces nearby protected areas. Logistical challenges associated with surveillance in locations hard to access exacerbate the task's difficulty.

Leveraging stakeholders already present at key interfaces is a potentially efficient strategy to establish baseline scanning wildlife health surveillance in these areas at a minimal cost (IUCN and EcoHealth Alliance 2022). Rangers and natural resource authorities (hereafter "rangers") are responsible for conservation and law enforcement in protected areas. On a global scale, rangers patrol thousands of square kilometers at critical wildlife-livestock-human interfaces where they can generate eyes-on-the-field health intelligence, detecting injured, sick, and dead animals; trigger investigations; and provide data for trend assessments (Montecino-Latorre et al. 2020; Kuisma et al. 2019).

Domestic animals…

However, to date there is little to no information about: i) the importance given to wildlife health in protected area conservation programs globally, ii) the extent rangers are mandated to record wildlife health during their patrols in protected areas, and iii) how wildlife health data are collected and the potential for comparability of measures across spatial units (if collected at all).

The "Spatial Monitoring and Reporting Tool" (SMART) is a suite of technological tools designed to manage protected areas. This suite is composed by SMART Desktop, a desktop computer software, SMART Mobile, a mobile device application, and SMART Connect, a server-based cloud. SMART was founded in 2011, and to-date it is currently use in more than one thousand protected areas in more than 70 countries distributed across the World.

We aimed to learn from protected area managers if: i) they consider wildlife health relevant from a One Health perspective, ii) dead, sick, or injured wildlife are observed in protected areas and recorded by rangers, iii) the presence and recording of domestic animals including dead, sick, or injured animals, and iv) health data is stored in SMART databases. We also asked for the current status of SMART in the protected areas. To accomplish this objective, we reached global distributed protected area managers belonging to the SMART user community through the SMART Partnership and request to complete an online survey.

perceptions regarding wildlife health and potential consequences of pathogen transmission among wildlife, domestic animals and people.

Methods

We developed a web-based questionnaire aimed at protected area managers. The survey had five sections. Under section 1, we asked managers to rank their overall agreement with the affirmations: “Wildlife health, including infectious and non-infectious diseases, is important to achieve the conservation goals of the protected areas where I work”, “Human or livestock pathogens can affect wildlife populations inhabiting the protected area I work in”, “Pathogens carried by wildlife inhabiting the protected area I work in can affect public health”, and “Pathogens carried by wildlife inhabiting the protected area I work in can affect livestock health”.

Under section 2, we requested managers to rank the overall frequency of encounters with dead, sick, or injured wildlife in protected areas and their documentation when found during patrols.

Under section 3, we asked managers to rank their agreement with the affirmation “Introduced domestic animals (e.g., dogs, cats, cattle, pigs, cats) are a concern for the conservation goals of the protected areas where I work”. We also assess the presence of domestic animals at these sites and their recording, including health status. Likert scales were used in sections 1 - 3, specifically in those questions involving rankings.

Under section 4, we asked about data storage practices.

Under section 5, we asked about the current state of SMART and its components.

An introductory webpage explained that the survey was voluntary, anonymous, aimed at protected area managers administering SMART data. The webpage also clarified that clicking the “Start the survey” button constituted consent. The survey was built on Google Forms, which has a translation tool. We provided a tutorial on translating it into the preferred language (https://sites.google.com/wcs.org/smarttorecordwildlifehealth/home). The survey was exempt from IRB review (ref #22-53 Wildlife Conservation Society Internal Review Board).

The survey was distributed globally to the SMART Community (SMART Community Forum users https://forum.smartconservationtools.org/) by the SMART Partnership via email in October 2022, and it remained open for three months. As the closing date approached, a reminder was sent to the SMART Community three weeks in advance.

Responses could represent a single or multiple protected areas. However, our analysis focused on responses representing one or two individual terrestrial protected areas to gain insights into specific local realities. Therefore, responses representing more than two protected areas were filtered out. The resulting dataset could have a specific protected area represented by single responses, by responses that included two protected areas, or a combination of both. We duplicated the responses that were representing two protected areas but left a single protected area for each one, so each row in the dataset implied a unique protected area. One of the responses representing the same protected area after this step were filtered out to leave a unique representation completion and consistency of answers, and respondent's alignment with the intended target audience of the survey.

The protected areas included in the responses were classified as marine or terrestrial based on the World Database on Protected Areas (https://www.protectedplanet.net/en/thematic-areas/wdpa?tab=WDPA). Marine protected areas were removed.

The questionnaire, survey data, data cleaning and filtering, and descriptive analysis scripts can be found at https://github.com/dmontecino/SMART_survey.

Results

General results

The total number of responses was 129.

Seven responses were removed because they included a given name instead of the protected area name and one response was removed because it did not have a protected area name. Twenty-four responses representing more than two protected areas were filtered out and other six were removed because they involved protected areas that were represented once already. Sixteen responses were removed because the respondent did not match the target audience.

The final dataset described below excluded four marine protected areas leading to the removal of another four responses, for a total of 76 protected areas represented by 71 answered surveys (66 responses representing a single protected area and 5 representing two protected areas) from 19 countries.

Section 1: Perceptions regarding wildlife health and potential consequences of pathogen transmission among wildlife, domestic animals and people

The ranking distribution with the overall agreement with the affirmations odf section is shown in Figure 1.

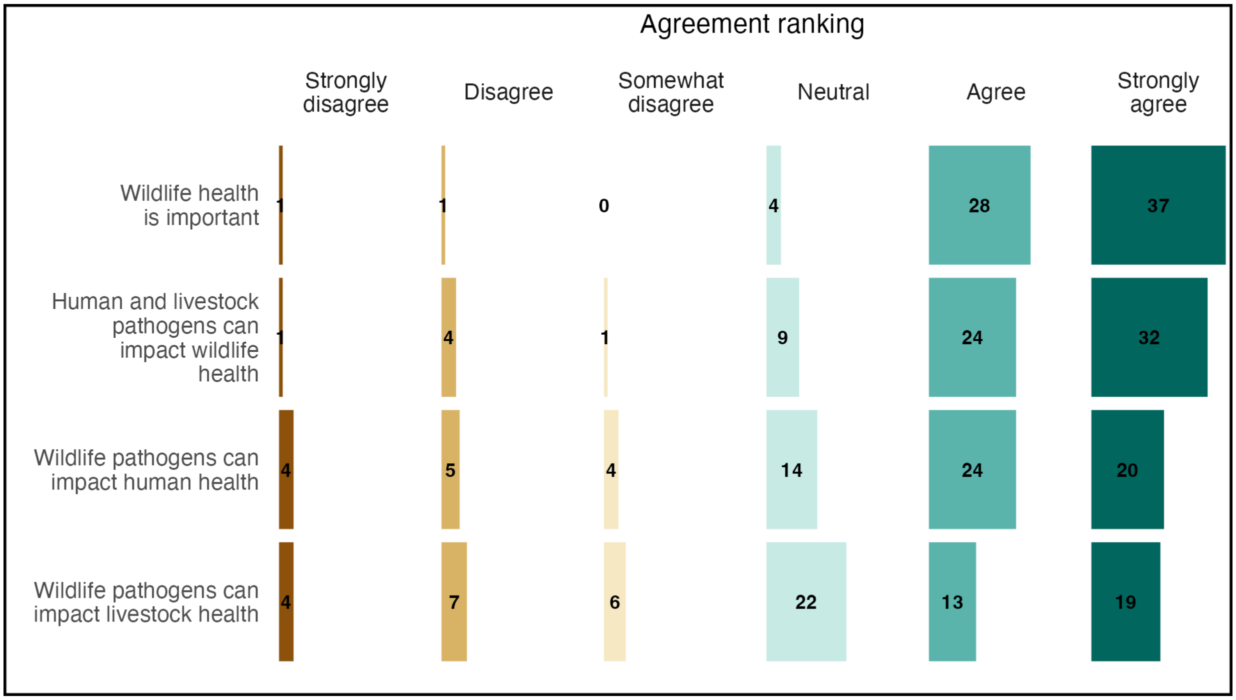


Figure 1: Distribution protected area managers responses regarding the importance of wildlife health to achieve the conservation goals of protected area(s) where they work in (row 1), human or livestock pathogens can affect wildlife populations inhabiting the protected area(s) where they work in (row 2), pathogens carried by wildlife inhabiting the protected area(s) where they work in can affect public health (row 3), and pathogens carried by wildlife inhabiting the protected area(s) where they work in can affect livestock health (row 4).

The most common ranking combination for the four affirmations was “Strongly agree” with the four affirmations (n=9; 12.7%), followed by “Agree” (n=4; 5.6% of the responses). Twenty-eight (39.44%) of the respondents answered either “Strongly agree” or “Agree” to the four affirmations. The ranking combinations and number of responses are provided in Appendix 1.

Section 2: Overall frequency of encounters with dead, sick, or injured wildlife in the protected areas and their documentation when found during patrols.

Fifty-six responses (78.9%) reported that either dead, sick, or injured wildlife found during patrols are recorded. Twenty out of the 71 respondents (28.2%) answered that dead wildlife found during patrols are not recorded as a specific category. Of this set, only three responses (15%) claimed that dead wildlife are "Never" encountered in the protected area(s). The overall distribution of responses across dead wildlife encountering frequency in the protected area(s) and recording when found during a patrol is shown in Figure 2.

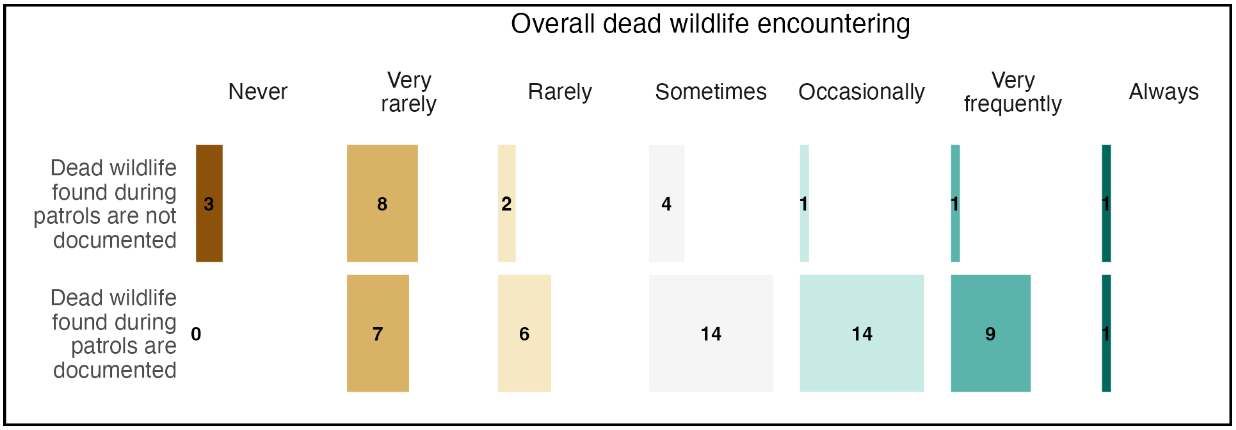


Figure 2: Distribution of protected area managers responses regarding the recording of dead wildlife found during ranger patrols as a specific category of animals across the overall encountering frequency with dead wildlife in the protected area(s) where they work in.

Forty-eight out of the 71 respondents (67.6%) answered that sick wildlife found during patrols are not recorded as a specific category. Of this set, only five responses (10.4%) claimed that sick and injured wildlife are "Never" encountered in the protected area(s). The overall distribution of responses across sick wildlife encountering frequency in the protected area(s) and recording when found during a patrol is shown in Figure 3.

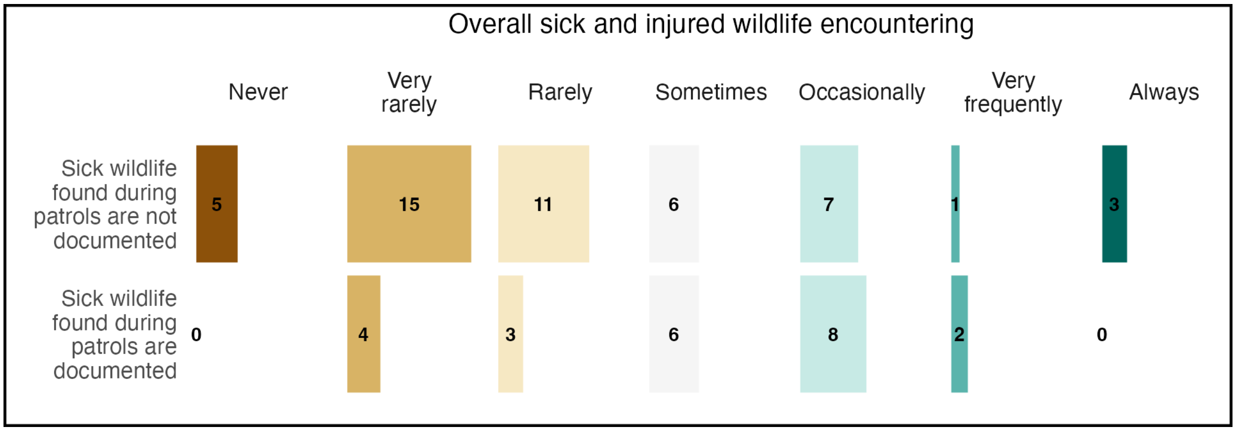


Figure 3: Distribution of protected area managers responses regarding the recording of sick wildlife found during ranger patrols as a specific category of animals across the overall encountering frequency with sick or injured wildlife in the protected area(s) where they work in.

Forty out of the 71 respondents (56.3%) answered that injured wildlife found during patrols are not recorded as a specific category. Of this set, only five responses (12.5%) claimed that sick and injured wildlife are "Never" encountered in the protected area(s). The overall distribution of responses across injured wildlife encountering frequency in the protected area(s) and recording when found during a patrol is shown in Figure 4.

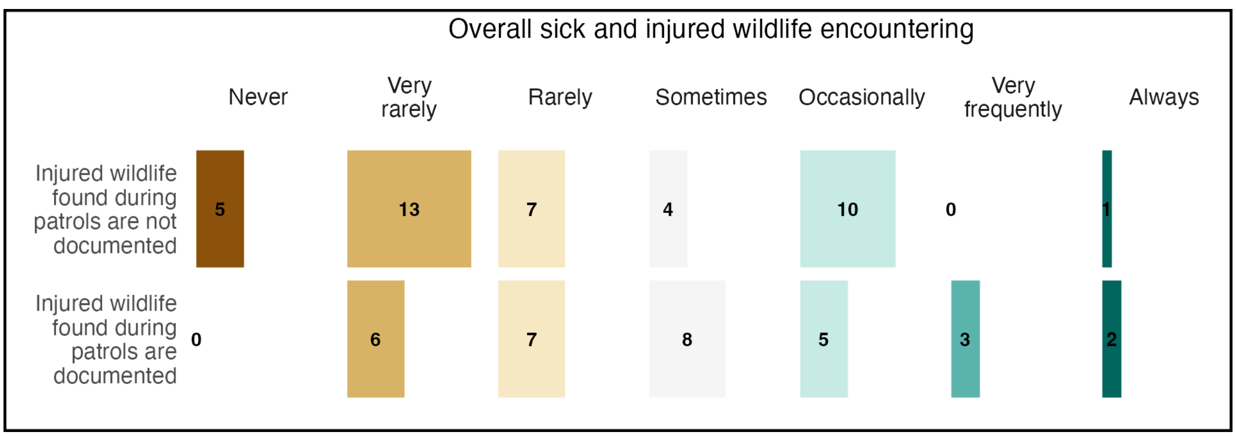


Figure 4: Distribution of protected area managers responses regarding the recording of injured wildlife found during ranger patrols as a specific category of animals across the overall encountering frequency with sick or injured wildlife in the protected area(s) where they work in.

The agreement of protected area managers with the assertion "Wildlife health, including infectious and non-infectious diseases, is important to achieve the conservation goals of the protected areas where I work" in the subgroup of responses reporting sick, injured, or dead wildlife sighting but no recording if found during patrols is shown in Figure 5.

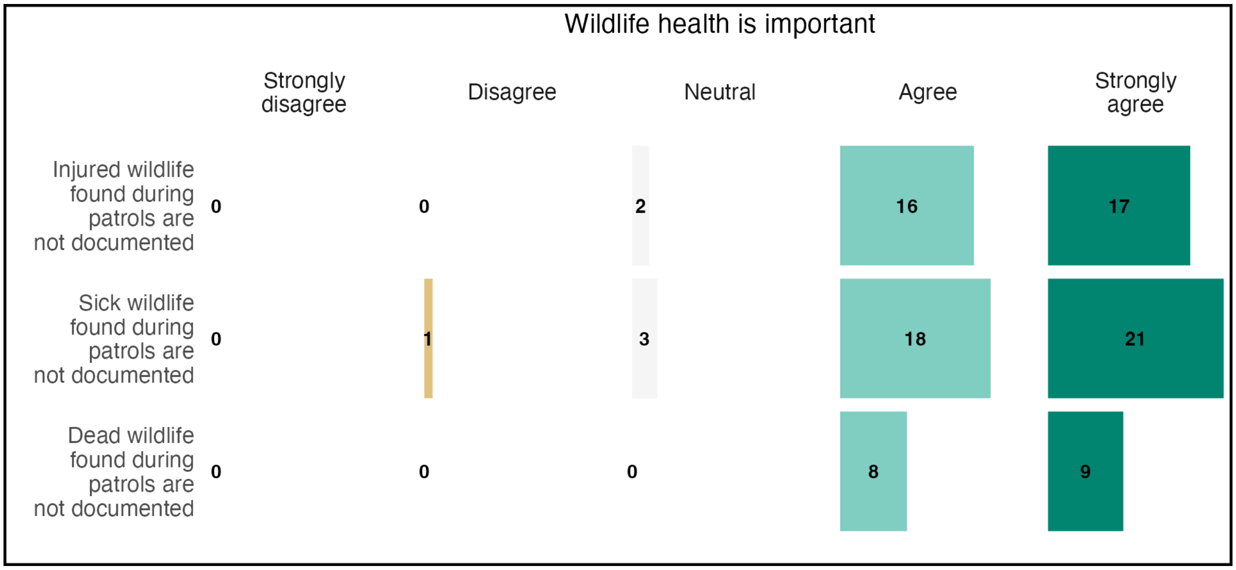


Figure 5: Distribution of the agreement regarding the importance of wildlife health to achieve the conservation goals of protected area(s) provided by managers of protected areas where sick, injured, or dead wildlife is observed with at least a minimal frequency but they are not recorded if found during patrols.

All 17 respondents in the subgroup with minimal observation of dead wildlife but no recording either "Agreed" or "Strongly agreed" with the statement. The percentages of respondents that either "Agreed" or "Strongly agreed" with the statement in the subgroups with minimal observation of sick or injured wildlife but no recording were 90.7 and 94.29%.

The methods to record either sick, injured, or dead wildlife found during a patrol (when registered): "Each animal is an individual observation", "Part of the full count of the species" (stratification of the animals of a specific species per health status), "Present/absent", and "Recorded in another way" were reported in 94.6, 51.8, 23.2, and 17.9% of the 56 responses that reported the recording of any of these wildlife health status categories when found during patrols. The distribution of the recording methods across healthy, sick, injured, or dead wildlife is shown in Figure 6.

Figure 6: Distribution of protected area managers responses regarding how healthy, sick, injured, and dead wildlife found during patrols are recorded.

The most common combination of methods to register either sick, injured, or dead wildlife was the recording of dead wildlife by itself with each dead individual as a unique observation (19.6% of the responses), followed by “Each animal is an individual observation” for the three health categories (10.7% of the responses). The number of responses per method used per health category are provided in Appendix 2.

The number of responses including specific data types collected across sick, injured, or dead wildlife (for the set of 56 responses reporting the recording of at least one of these categories) was 55, 51, 41, 37, 33, 30, 25, 21, 17 for the items Species, Photographs, Suspect cause, Sex, Condition, Age, Anomalies, Other. The distribution of the data items collected per each health status category is shown in Figure 7.

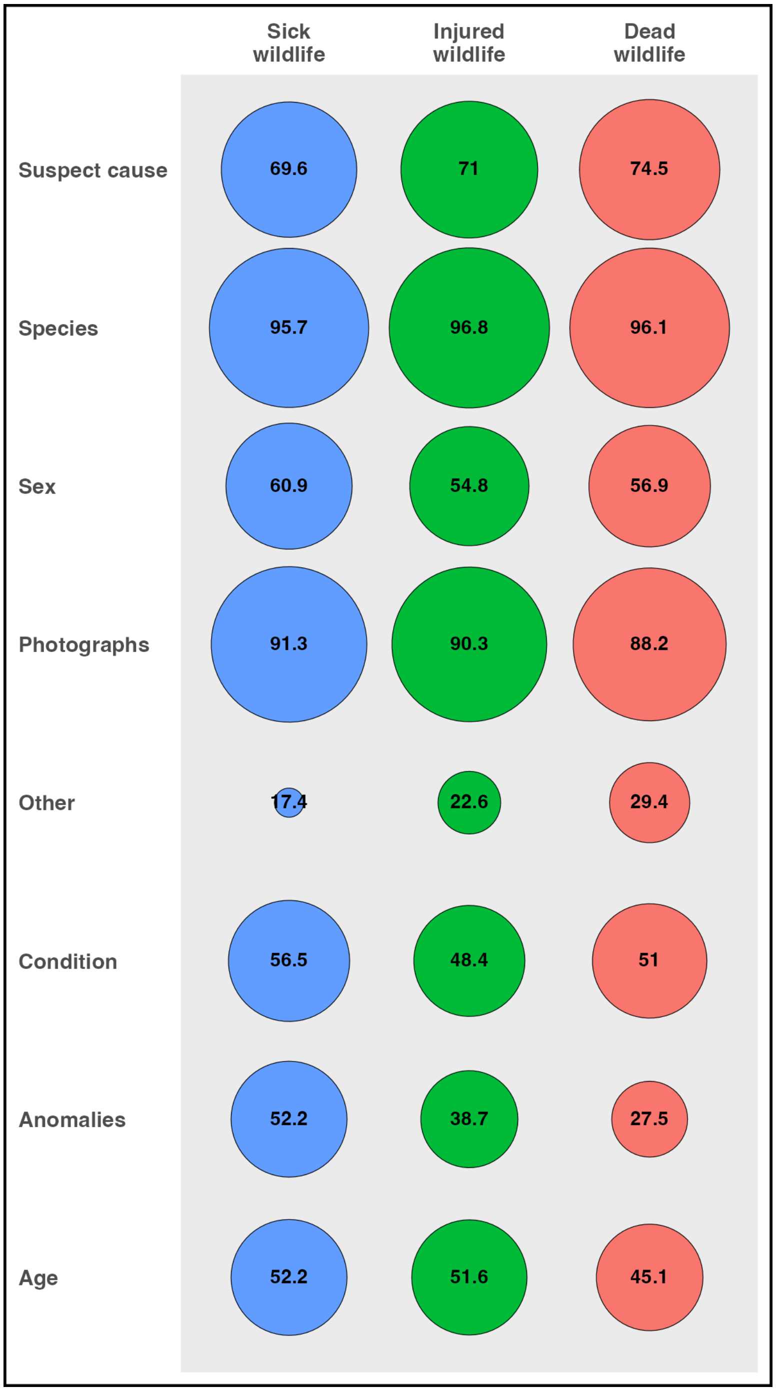


Figure 7: The recording of different data items across different categories of wildlife based on their health status. The size of the circles is proportional to the percentagez observed.

Section 3: Importance of introduced domestic animals for the conservation goals of the protected areas

Fifty managers responded that domestic animals are observed in the corresponding protected area(s; 70.4%). Thirty-five managers of this subset claimed that domestic animals are documented if observed during patrols (70%), but only 9 of these managers reported the recording of the health status of these animals. The distribution of manager responses across the overall ranking of domestic animals as a conservation concern, their documentation, and recording of their health status is shown in Figure 8.

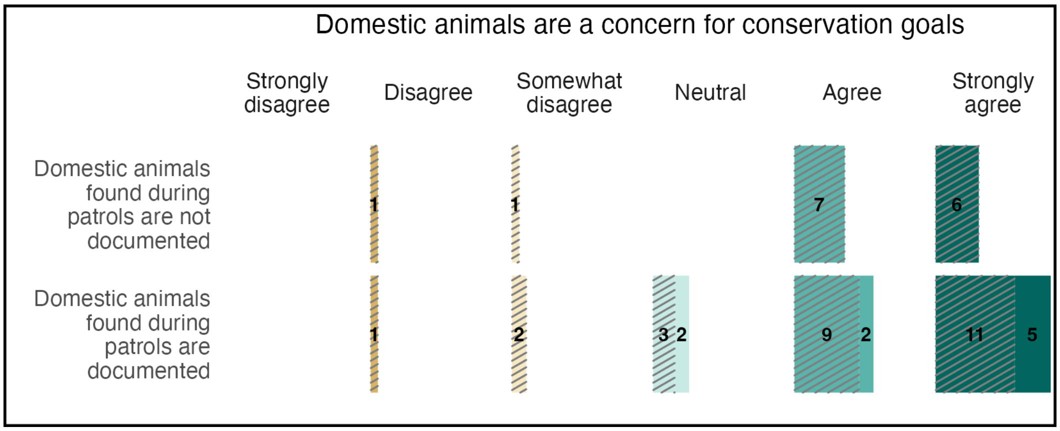


Figure 8: Distribution of protected area manager responses where domestic animals are observed regarding the recording of domestic animals found during ranger patrols across their overall agreement with domestic animals as a concern for conservation goals in protected areas. The dashed area of the polygons represent the subset of responses without health status of domestic animals recording. The responses included in this figure are those of managers that reported the presence of domestic animals in the corresponding protected area.

Section 4: Data storage practices

Health data storage in a SMART database across widlife health status category for the subset of responses reporting the recording of sick, injured, or dead wildlife is shown in Figure 9 (percentages). When sick, injured, or dead wildlife were recorded but their data was not stored in a SMART database ("None of these items are entered in a SMART database"), a range of options were employed instead, including paper forms, reports, and spreadsheets.

Figure 9: Health data storage practices with respect to the use of SMART in the subgroup of responses reporting the recording of dead, sick, and i injured wildlife across categories of wildlife health status. The size the circles is proportional to the percentages observed.

Thirty-one of the 35 managers (88.6%) reporting the recording of domestic animal sighted during patrols responded that this information was stored in a SMART database. All managers reporting the recording of health status in domestic animals responded that this information is stored in a SMART database.

Section 5: Current state of SMART components

Discussion

We developed a web-based questionnaire aimed at protected area managers around the globe to learn about their perceptions regarding wildlife health; the monitoring of dead, sick, and injured wildlife and domestic animals in protected areas; health data storage practices at these sites; and local status of SMART. We obtained 71 valid responses from protected area managers that involved 76 protected areas administered with the support of a SMART system version distributed in 19 countries. Responses from stakeholders strongly suggest that large amounts of valuable and syndromic no-cost data for One Health surveillance are being lost due to non-collection, non-standard recording, or inadequate management.

Managers usually considered wildlife health as relevant for conservation goals of protected areas and they understand that pathogens can be transmitted among wildlife, humans, and livestock and impact any of these groups. Several managers confirmed that dead, sick, or injured wildlife are observed at least "very rarely" but 25% to over 50% of them, depending on the wildlife health status category, reported non-recording of these animals when found during patrols. These contradictory answers could be explained by recent global pathogen-driven crises such as SARS-CoV-2, H5N1 Highly Pathogenic Avian Influenza (HPAI), Ebola Fever virus, and African Swine Fever virus that might have sensitized protected area managers by the time our survey was closed but before eventual new health-associated monitoring objectives could be planned and rolled-out in the represented conservation sites. Most valid responses (24; 33.8%) came from Peru where two major wildlife die-offs have recently occurred: H5N1 HPAI since November 2022 (Paulo citation), after the survey was closed, and the largest oil-spill in its history in January 2022, before the survey was opened. After excluding responses from this country, the distribution of perceptions regarding wildlife health and recording of dead, sick, or injured wildlife remain (Appendix 3), so neither of these die-offs or particular Peruvian responses explained the contradiction.

The subgroup of managers representing protected areas where sick, injured, or dead wildlife found during patrols are recorded provided several methodologies to register these animals (present/absent, individually, or grouped within a species) and they could be different within the same response depending on wildlife health status (e.g., sick versus dead wildlife). Specific information collected also varied across and within each wildlife group (demographic data, signs in animals, etc.) with only species and photographs being consistently recorded. Although harmonization of data is a foundational pillar of wildlife health surveillance systems (Lawson et al. 2021; Sleeman et al. 2012; Stephen et al. 2018; Merianos 2007; Worsley-Tonks et al. 2022; World Bank and Food and Agriculture O…; Pruvot et al. 2023; Machalaba et al. 2021; World Organisation for Animal Health …; World Organisation for Animal Health …; World Organisation for Animal Health …; World Organisation for Animal Health …; Stephen and Berezowski 2022; Ryser-Degiorgis 2013; Hayman et al. 2023; World Organisation for Animal Health …) these responses are not be surprising as data standards have been absent in wildlife disease monitoring historically and and globally (e.g., artois 2009 Machalaba, Heiderich, 2023). This scenario can seriously limit the value of health monitoring data from protected areas, hindering the generation of meaningful information, sharing, and timely health assessments within and across conservation sites or beyond.

Most managers "Agree" or "Strongly agree" with the affirmation "Introduced domestic animals (e.g., dogs, cats, cattle, pigs, cats) are a concern for the conservation goals of the protected areas where I work" and reported the presence of these animals in the protected area(s). Most responses also confirmed the recording of domestic animals but only a minority reported the registration of their health status. Wildlife can be impacted by domestic animals directly through predation, competition, inter-breeding, or disturbance and indirectly through land-use change (citation). Further, pathogen transmission from domestic animals to wildlife can seriously harm biodiversity conservation efforts. Documented evidence has shown that domestic animal sourced pathogens has led to the extinction of species and disrupted entire ecosystems.

Examples include Canine distemper and Pest du Petit Ruminants viruses, *Pastereulla multocida* or *Corynebacterium pseudotuberculosis*, *Sarcoptes scabiei* and many others (citations()). In a world with active encroachment into natural habitats, ubiquitous stressors for wildlife, and continuous disease emergence at human-wildlife-livestock interfaces, we encourage the categorization of domestic animals found in protected areas by health status.

SMART is available to support the management of protected areas represented in the responses; however, several managers responding that wildlife health is documented mentioned that, depending on the health status, this information was not managed using a SMART database. The alternatives mentioned almost guarantee information sparsity and the loss of wildlife health data. Adequate data management, including the use of appropriate databases, is another foundational pillar of wildlife health surveillance systems; however, most countries do not have such systems and flawed data governance remains a common pitfall in wildlife health. Consequently, these responses are also not surprising but it is important to remark that SMART databases are ready to support the adequate management of observational health data collected by rangers.

Currently, there are approximately 280,000 rangers worldwide their boots on the ground patrolling vast areas relevant for conservation and disease emergence and it is estimated that 1.5 million will be needed by 2030 to properly fulfill the goal to protect 30% of the planet. The current and projected number of rangers and their permanent boots on the ground and eyes on the field reveals the unique cost-effective potential of recruiting this army of "health sentinels" and address fundamental gaps in global health security. The presented responses to the survey indicate that managers recognize the relevance of health in achieving the conservation goals of protected areas and that rangers can detect non-healthy wildlife including dead animals as reported by previous experiences leveraging them in health surveillance. Ranger health data has supported risk assessments, establishment of trends, and serve as early warning systems for potential outbreaks without adding major burden to their duties.

However, to harness this approach, several findings in our survey must be reversed. First, the standardized documentation of dead, sick injured, and health animals is imperative. A clear definition of a health event for the "ranger audience" that encompasses wildlife and domestic animals stratified by health status, free-ranging or not, within a specified spatio-temporal unit must be established. The variables to be recorded from each event must also be defined and they should include environmental findings, photographs, species, health status, anomalies observed, and potential causes of disease, injury, or death among others whilst preventing any overload for rangers. Secondly, a database to guarantee the proper governance of ranger documented health events must be put in place. SMART is a sustainable and long-term developed technology designed for protected area management that can support the seamless standardized recording of health events by rangers (SMART Mobile), their real-time communication to managers (SMART Connect), and adequate health data governance (SMART Desktop). But SMART is already rolled-out in more than a thousand conservation areas in more than 120 countries. Therefore, SMART has the potential to help recruiting rangers into health surveillance under a common framework to document health events based on the same definition whilst supporting adequate data management.

The WildHealthNet initiative focuses on creating national surveillance networks and codifying their Standard Operation Procedures (Denstedt et al. 2021, Porco et al. 2023, Pruvot et al. 2023). Under WildHealthNet, rangers are explicitly included as health sentinels in protected areas capitalizing on contemporary SMART technology to support data management, ranger engagement, and the standardized recording of health events found in the field and it is a field tested model to reverse the current state of affairs regarding health data form rangers revealed by the responses to the survey. Rangers from Lao, Peru, and Guatemala have been integrated into health monitoring under this approach and rangers from Cambodia and Madagascar will be engaged during 2024.

Conclusions

The information collected through our survey suggests that: i) protected area managers tend to considered wildlife health as relevant for the conservation goals of protected areas and there is a general understanding from these stakeholders that pathogens can be transmitted among wildlife, humans, and livestock and impact any of these groups; ii) dead, sick, or injured wildlife might not be recorded if found during ranger patrols in protected areas; iii) dead, sick, and injured wildlife found in patrols and documented are recorded following different methodologies within and among protected areas; iv) domestic animals tend to be considered a concern for the conservation goals of protected areas by protected area managers, they are usually observed within their boundaries and recorded, but their health status is mostly not documented; v) health data collected from protected areas supported by SMART might not be properly managed as this information is either not stored or it is partially stored in a SMART database and the alternatives employed are not adequate. Consequently, large amounts of valuable syndromic non-cost data for health monitoring collected by rangers that could be included in One Health surveillance systems are currently been lost. With the right strategies, technology, and investments, rangers can play a crucial role in monitoring health.

Wildlife health is important	Human and livestock pathogens can impact wildlife health	Wildlife pathogens can impact human health	Wildlife pathogens can impact livestock health	Number of responses
Strongly agree	Strongly agree	Strongly agree	Strongly agree	9
Agree	Agree	Agree	Agree	4
Agree	Strongly agree	Neutral	Strongly agree	3
Strongly agree	Agree	Neutral	Neutral	3
Strongly agree	Agree	Strongly agree	Agree	3
Agree	Neutral	Neutral	Neutral	2
Agree	Strongly agree	Neutral	Agree	2
Strongly agree	Agree	Agree	Agree	2
Strongly agree	Agree	Strongly agree	Strongly agree	2
Strongly agree	Neutral	Neutral	Agree	2
Strongly agree	Strongly agree	Agree	Agree	2
Strongly agree	Strongly agree	Somewhat Disagree	Agree	2
Strongly agree	Strongly agree	Strongly disagree	Strongly disagree	2
Agree	Agree	Agree	Strongly agree	1
Agree	Agree	Neutral	Neutral	1
Agree	Agree	Somewhat Disagree	Agree	1
Agree	Agree	Somewhat Disagree	Somewhat Disagree	1
Agree	Agree	Strongly agree	Agree	1
Agree	Agree	Strongly agree	Strongly agree	1
Agree	Disagree	Disagree	Disagree	1
Agree	Disagree	Neutral	Agree	1
Agree	Disagree	Neutral	Neutral	1
Agree	Neutral	Disagree	Neutral	1
Agree	Neutral	Neutral	Agree	1
Agree	Neutral	Neutral	Disagree	1
Agree	Somewhat Disagree	Neutral	Disagree	1
Agree	Strongly agree	Agree	Somewhat Disagree	1
Agree	Strongly agree	Neutral	Neutral	1
Agree	Strongly agree	Somewhat Disagree	Disagree	1
Agree	Strongly agree	Strongly disagree	Strongly disagree	1
Disagree	Agree	Disagree	Strongly disagree	1
Neutral	Agree	Neutral	Neutral	1
Neutral	Neutral	Disagree	Neutral	1
Neutral	Strongly agree	Agree	Agree	1
Neutral	Strongly agree	Disagree	Neutral	1
Strongly agree	Agree	Agree	Strongly agree	1
Strongly agree	Agree	Strongly agree	Neutral	1
Strongly agree	Disagree	Strongly disagree	Strongly agree	1
Strongly agree	Neutral	Somewhat Disagree	Somewhat Disagree	1
Strongly agree	Strongly agree	Agree	Strongly agree	1
Strongly agree	Strongly agree	Disagree	Agree	1
Strongly agree	Strongly agree	Disagree	Disagree	1
Strongly agree	Strongly agree	Neutral	Strongly agree	1
Strongly agree	Strongly agree	Strongly agree	Agree	1
Strongly agree	Strongly agree	Strongly agree	Somewhat Disagree	1
Strongly disagree	Strongly disagree	Neutral	Neutral	1

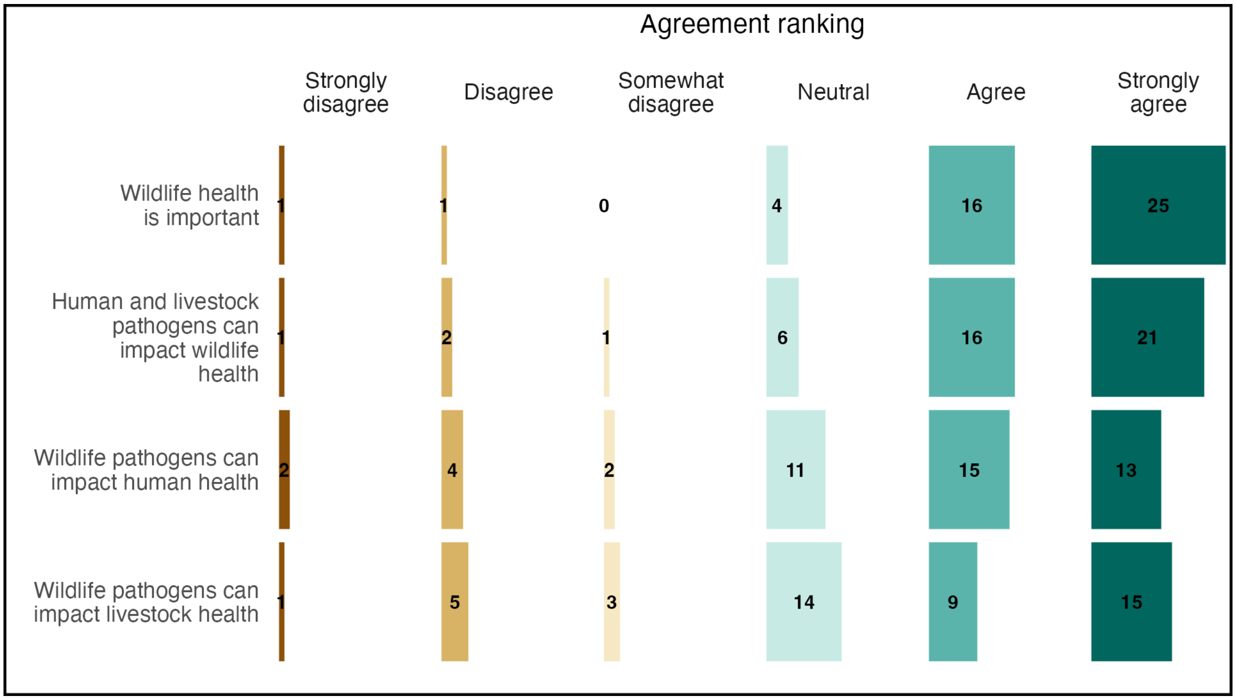
How sick wildlife is recorded	How injured wildlife is recorded	How dead wildlife is recorded	Number of responses
		Each animal is an individual observation	11
Each animal is an individual observation	Each animal is an individual observation	Each animal is an individual observation	6
		Recorded in another way	5
Part of the full count of the species	Part of the full count of the species	Part of the full count of the species	5
		Present/absent	3
	Each animal is an individual observation	Each animal is an individual observation	3
	Part of the full count of the species	Part of the full count of the species	3
	Present/absent	Present/absent	2
Each animal is an individual observation			2
Part of the full count of the species		Part of the full count of the species	2
Recorded in another way	Each animal is an individual observation	Each animal is an individual observation	2
		Part of the full count of the species	1
	Each animal is an individual observation	Present/absent	1
	Each animal is an individual observation	Recorded in another way	1
	Present/absent		1
	Present/absent	Each animal is an individual observation	1
	Recorded in another way	Each animal is an individual observation	1
Each animal is an individual observation		Each animal is an individual observation	1
Each animal is an individual observation	Each animal is an individual observation		1
Part of the full count of the species	Each animal is an individual observation	Each animal is an individual observation	1
Part of the full count of the species	Part of the full count of the species	Each animal is an individual observation	1
Present/absent	Present/absent	Present/absent	1
Recorded in another way	Each animal is an individual observation		1

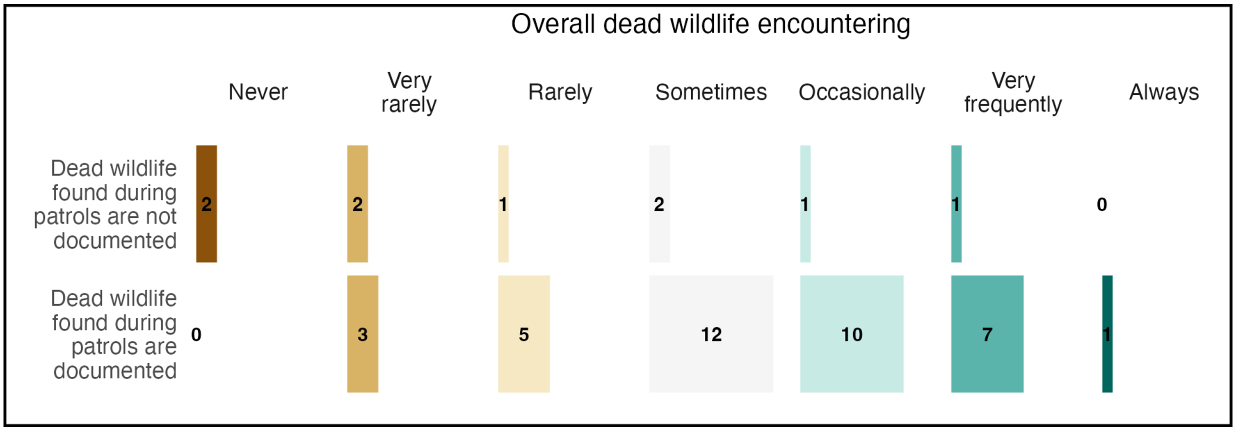
Appendices

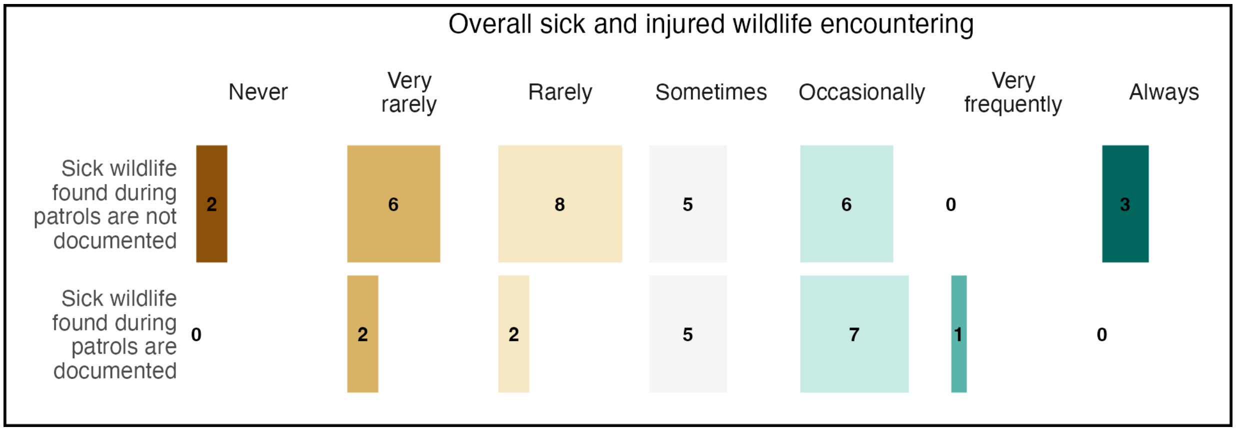
Appendix 1. Frequency of response combinations to the four affirmations of Section 1.

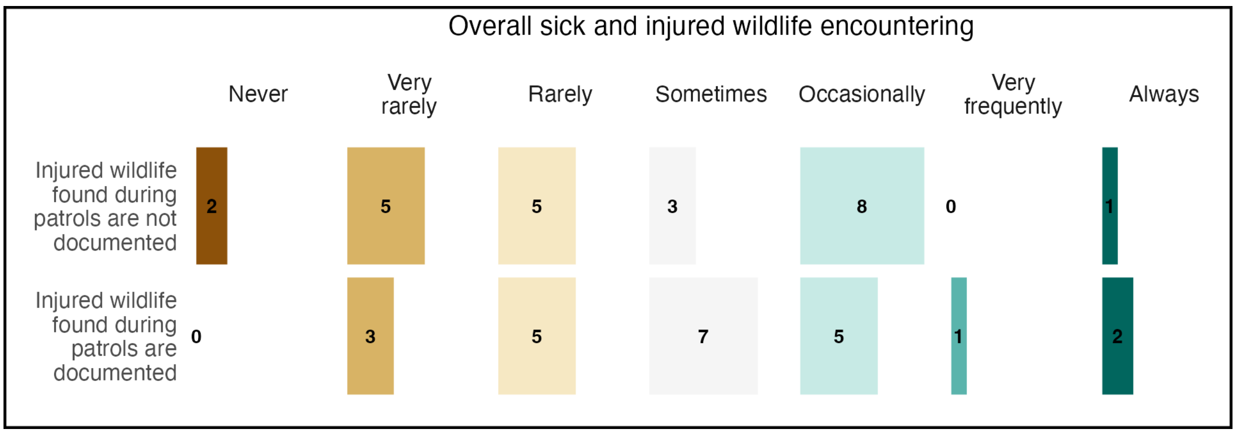
Appendix 2. Frequency of response combinations to the recording methods for sick, injured, and dead wildlife of Section 2. Cells without information means that the corresponding health categories were not recorded.

Appendix 3. Figures 1-4 exluding the responses from Peru.






Overall sick and injured wildlife encountering
Never
Very rarely
Rarely
Sometimes
Occasionally
Very frequently
Always
Sick wildlife found during patrols are not documented
2
6
8
5
6
0
3
Sick wildlife found during patrols are documented
0
2
2
5
7
1
0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8
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Injured wildlife found during patrols are documented
0
3
5
7
5
1
2