Incorporating geographic context into coyote and wolf livestock depredation research

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SHORT TITLE: Geographic context

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Applying research results to new locations and situations can be confounded by differences in the geographic context between the original and the applied study sites. Replication studies and meta-analyses may be similarly hindered. We investigated how often canid management research reports (e.g., journal articles, conference proceedings) included information on historical/current lethal control, alternative prey availability, landscape features, seasonal, and settlement characteristics. We included experimental research published between 1970 and 2018, focusing on livestock depredations by wolves and coyotes in North America. Reporting on contextual factors was highly variable; seasonal context was included in 83% of research findings; human settlement characteristics were reported in only 8%. Contextual information was more common in journal versus grey literature, and in reports with academic versus government affiliated primary authors. Discussions of the effects of contextual factors on livestock depredation mitigation strategies also were underdeveloped. Yet, geographic context of research is vital; it can alter animal behaviour and reduce the efficacy of applied mitigation. We suggest reporting guidelines to improve comparisons and meta-analysis opportunities, which may enhance comparisons and management decision making.

Keywords: canid, predator management, reporting standards, generalizability, replicability

Key Messages:

- Research context has not been reported consistently, yet it influences animal behaviour and the generalizability of results

- Context details are reported more often in journal than grey literature, and by academic versus government affiliated authors
- We suggest guidelines for more consistent reporting of context

Introduction

Geography explores the often complex relationships between the physical environment (including plants, animals, and landforms) and social activities (including humans and infrastructure) (Hartshorne 1939; Lave et al. 2014). Geography aims to understand patterns and process, but also seeks solutions. The management and mitigation (i.e., reduction) of livestock depredations by wild animals exemplifies a geographic challenge in which understanding the contextual precursors to successful management can have tangible consequences for people and wildlife (e.g., loss of income and animal life). Recognizing that geographic context drives emergent spatial phenomena, coupled with contemporary calls for synthesis in nature-human research (e.g., Lave et al. 2014), we investigate whether livestock depredation management research publications include geographic context of a study area. We are interested in this because failure to provide contextual details likely will have negative consequences on how the research is applied, replicated, generalized, and synthesized (Cook et al. 2017; Kedron et al. 2021), resulting in loss of animal life, economic loss, and emotional suffering for humans.

We are not aware of other research to date that evaluates the reporting of context in wild canid management publications. Graham et al. (2005) criticized studies on predator-prey relationships for not including characteristics like prey availability and loss. In evaluating context however, we argue there is a need for more inclusive consideration of factors. Some authors have defined geographic context as a summary term describing area-level factors (Chum et al. 2015). Others used context as a synonym for location (e.g., Meegaskumbura et al. 2019; Cano Guervos et al. 2020) or spatial extent (Kwan 2012). We take a more holistic approach: one that understands livestock depredation occurs within a complex system that changes across space (e.g., terrain), time, and place (e.g., impact of culture). For instance, anthropogenic linear features (e.g., roads, fences), animals (e.g., livestock, dogs), and objects (e.g., light-sound devices, poison bait/traps) can influence predators whether people are present or absent.

Recognizing the need for measurable metrics that can be consistently applied in the future, we returned to past livestock depredation and ecological work (e.g., Muhly et al. 2010). We identified five key factors that we believe most influence the effectiveness of livestock depredation mitigation strategies: alternative prey; landscape; seasonal; historical/current lethal control; and settlement characteristics. Our rationale for each of these contextual factors is described subsequently.

The contextual factors

The abundance of alternative prey has been found to influence predator behavior towards food sources and the strategies people implement to mitigate livestock depredations. Alternative prey in a study area have been found to influence black bear (*Ursus americanus*) food searching behaviours (Johnson et al. 2015), large felid livestock depredations, (Hiller et al. 2015; Khorozyan et al. 2015), and wolf (*Canis lupus*)-livestock conflict in Europe (Meriggi and Lovari 1996; Gula 2008; Imbert et al. 2016). Domestic animals can be an attractant, drawing in carnivores, and can sometimes be consumed as prey due to proximity and chance. Thus, domestic and wild animals in-situ were included as a contextual factor, due to the potential to alter how canids interact with livestock, people, and mitigation strategies.

Wolf depredation of livestock has been related to the physical attributes of the landscape (Edge et al. 2011) and vegetation features (Imbert et al. 2016). As these characteristics have the potential to influence a predator's response to mitigation strategies too, we included physical landscape attributes as a contextual factor of interest.

Predator behaviour changes seasonally. For instance, coyote (*Canis latrans*) breeding seasons may increase reliance on livestock (Boitani et al. 2004; Sillero-Zubiri and Switzer 2004; Blejwas et al. 2006). Snow depth influences coyote activity budgets (Gese et al. 1996) and may encourage the use of easily accessible food sources, such as livestock. Thus, some seasonal conditions may shift predator consumption of livestock and wild prey. As such, we include seasonal information because the potential effects on livestock depredation could increase predator exposure to mitigation strategies and, in turn, increase habituation rates.

While the above contextual factors have focused on space and time, culture also can constrain values, beliefs, and actions, which play a role in integrated systems (Goudie 2017). The term 'place' describes the unique meaning of a geographic location and is often culturally entrained. We believe metrics of 'place' affect coyote and wolf management and livestock depredation. For instance, the cultural landscape (e.g., entraining attitudes) of where predator presence is believed to be inappropriate (Alexander and Draper 2021) or a biosecurity threat (Collard 2012) can manifest as lethal predator control (e.g., trapping, shooting). Control activities can result in negative, unintended changes to predator behaviour across generations and space (Kitchen et al. 2000; Sillero-Zubiri et al. 2004). For example, past and current lethal control efforts can shape bold and shy behavioral traits in coyotes (Darrow and Shivik 2009). If control efforts select against bold individuals, the population of coyotes may be less likely to investigate novel objects and to interact with mitigation strategies, affecting mitigation success. Bold individuals also are thought to habituate to stimuli faster than shy individuals (Darrow and Shivik 2009), reducing the long term effectiveness of mitigation efforts. As the possible behavioural consequences of lethal control (stemming from culture) may affect the generalizability and efficacy of mitigation strategies, we included this metric in our analysis.

Next, we included human-built (i.e., settlement) features on the landscape, such as roads and residences, because these affect species survival and behaviour, such as movement rates (Alexander 2008). Roads also may increase predator access to livestock (Edge et al. 2011). Boldness (Darrow and Shivik 2009) may increase tolerance of anthropogenic features, which in turn, could increase the likelihood of human-related predator deaths (e.g., hunting from vehicles, vehicle collisions).

Lastly, we acknowledge that contextual factors can interact with each other and with the agency of human and non-human animals leading to emergent phenomenon with unexpected consequences (Urbanik 2012; Lave et al. 2014). For instance, the availability of wild alternative prey can be affected by human settlement (Coon et al. 2019). Similarly, non-human animals can respond in different ways to changes in the landscape (e.g., deforestation, roads, hunting) associated with agricultural development.

Research generalizability and replicability

Research results that are presented without full discussion of context can be misinterpreted or misapplied to other contexts, with negative consequences. For instance, fladry (i.e., flags attached to string hung across an area) could be deemed ineffective at decreasing livestock depredations and abandoned completely, despite the research results being confounded by the effects of dense vegetation on the visibility of the fladry or the prevalence of bold predators in the area. Yet, fladry used with consideration of the contextual factors might save animal lives. Further, without knowledge of context it is difficult to replicate (e.g., Open Science Collaboration 2015) or synthesize (e.g., meta-analyses; Konno et al. 2020b) research, possibly leading to a failure in the scientific process and loss of meaningful contributions.

Graham et al. (2005) focused on research about predator-prey relationships, but otherwise the presence of these contextual factors in livestock depredation research related to coyotes and wolves in North America remains uninvestigated. We included literature about both canid species in our analysis, given their shared life-histories and behaviours (Crabtree and Sheldon 1999; Wang et al. 2004). This research was from Canada and the United States (US) due to shared environmental, social, legislative, and economic conditions. This also increased our sample size. We examined how frequently researchers reported contextual factors amongst publication types and authorship affiliations. We also detailed instances where the potential effects of context were included in analyses and discussions. To facilitate mitigation research application and effectiveness in the future, we provide suggested guidelines for reporting context in canid-livestock depredation research.

Methods

Documents on livestock depredation mitigation strategies for coyotes and wolves ranged nearly 50 years (1970-2018) and were assembled from journals and grey literature (e.g., conference proceedings, research reports, theses, periodicals). Document procurement began with searches of titles and abstracts on Google Scholar and Science Direct. Search terms that we used included livestock depredation/conflict and mitigation methods (e.g., lethal, non-lethal), strategies (e.g., scare device, taste aversion, trapping, aerial shooting), and species (wolf, coyote). We manually screened documents and included only those where the research was applicable to mitigating livestock depredation by wolves or coyotes in Canada and the US and removed documents that did not include methods and results.

Grey literature documents were located through search engines and conference-specific internet records and hard copies retrieved through university resources. We focused on well-known annual conferences, particularly the Vertebrate Pest Conference, the Eastern Wildlife Damage Control Conference, and the Wildlife Damage Management Conference. Citations in each document helped identify additional documents for analysis. When a document was not locatable online, the authors' university library was used to retrieve it, when possible.

Document processing and analysis

We use the term 'research finding' to refer to each result from a research effort. Some research documents included multiple results, and we counted each as a research finding. Individual research findings included a single experimental design, predator species, and mitigation strategy as often as possible. For instance, multiple experiments with differing designs or samples, but using a single mitigation strategy could be reported in one document. We considered each of these experiments to be an independent research finding. Research findings also were recorded by predator species type (i.e., coyote and wolf) if the distinction was clear. Using individual research findings helped avoid issues arising from contextual information being reported for one research finding and not another within a single document.

We coded each research finding by literature type, author affiliation, experimental design, and experimental circumstances (Table 1). We identified 88 research findings in 74 documents. Each research finding was the result of quasi or controlled experimental design and was conducted in a field setting. We evaluated each document to determine which of the five contextual factors (i.e., historical/current lethal control, alternative prey availability, landscape features, seasonal, and settlement characteristics) were reported for each research finding (Table 2). Then, we determined the frequency at which research findings included information for each contextual factor (i.e., number of research findings reporting a factor divided by total number of research findings). Although the qualitative attributes (e.g., level of detail) of each contextual factor is important for future studies, we did not include this in this analysis due to our scope. We also recorded whether the effects of the contextual factors were reported.

Results

Our results are divided into two main sections: 1) the frequency of research findings that reported each contextual factor; and 2) research findings that proposed, investigated, or attributed a result to one of the contextual factors. Given that habituation is related to exposure, which is likely related to how often a predator takes livestock, the second section also includes research findings that reported relationships between the contextual factors and livestock depredations.

Frequency of reporting contextual factor information

We observed a wide range in the reporting frequency for each contextual factor (Table 3). Of the 88 field-based experimental research findings, 83% included seasonal information, 58% information on historical or concurrent lethal control, and 64% ecosystem related information. Only 28% reported information on other prey available in the area, while information on human dwellings and roads were least common at 8% and 11%, respectively.

Few differences were found in the frequency of reporting contextual factors between academic and government authored research findings (Table 3). Distance to roads showed the largest difference between author affiliations at 14.7% (academic authors: 17.4%; government authors: 2.7%). Only alternative prey information was reported at a higher frequency by government affiliated authors (29.7%) than academically affiliated authors (26.1%). Academic authors reported the five contextual factors an average of 5.6% more often than did government affiliated authors.

All five contextual factors were reported an average of 16% more often in journal than grey literature (Table 3). The reporting of landscape information showed the largest difference between the literature types at 23.5% (journals 34.6% vs grey literature 11.1%). Seasonal information showed the second largest reporting difference at 22.9% (journals 92.3% vs grey literature 69.4%). Alternative prey information had the least variability in being reported between journal and grey literature with a 5.8% difference. Settlement related information was reported least often, with no grey literature reporting distance to residences.

Effects of contextual factors

The frequencies presented above do not indicate whether the contextual factors were included in the analysis or discussion. A hypothetical research finding could report that a study area was 40% dense forest and 60% open pasture without including that information in analyses of a light and sound device. Below, we present the remaining results in summary form by author, describing cases where an actual or potential effect of a contextual factor on a mitigation strategy or livestock depredations was discussed. We organized the section by each of the five contextual factors noted previously.

Historical/concurrent lethal control. Future behavioral responses of predators were often the focus of discussions around past or current lethal control. Beasom and Gober (1977) reported that the efficacy of m-44 cyanide devices may have been reduced by other devices removing coyotes in the first month of the study and predators learning to avoid the devices. Mettler and Shivik (2007) proposed that intense lethal control may select for neophobic individuals, especially if the control methods were more effective against bold individuals. Davidson-Nelson and Gehring (2010) speculated that opportunistic shooting would not lead to as high a degree of neophobia as intensive trapping. Sacks et al. (1999) conceded that several decades of trapping prior to their study may have made trapping more difficult if coyotes in the area learned to avoid traps. In contrast, Pfeifer and Goos (1982) raised the possibility that hunting may lead to predators with a strong phobia of non-lethal deterrents that use rifle-like noises to scare predators away.

Alternative prey. Only three research findings discussed the effect of alternative prey characteristics. Lance et al. (2010) reported a negative relationship between time since last feeding and time until habituation to a fladry barrier in captive wolves. Bradley et al. (2005) reported that translocation was ineffective in their studies because the new areas lacked alternative prey which increased the likelihood the wolves would take livestock. Bradley and Pletscher (2005) evaluated husbandry techniques, such as carcass removal, and found no relationship with livestock depredations; however, livestock depredations were associated with the presence of elk, an alternative prey. This relationship was similar to the relationship between elk density and livestock depredations reported by Muhly et al. (2010).

Landscape. Six research findings discussed the effectiveness of mitigation strategies with regards to the landscape characteristics of the experimental area. Clark (1976) found no differences in the effectiveness of sodium cyanide traps compared with traditional trapping and shooting across four areas with differing landscape characteristics. Yet, Faller (1975) reported differences in both lamb losses and weight gain among five ranches with differing topography. Bjorge (1983) attributed increased livestock losses in one of two study areas to less intensive management and greater forest cover. Similarly, DeCesare et al. (2018) discussed selective removal and reported that the highest number of livestock losses were in areas with around 50% forest cover. Robel et al. (1981) investigated relationships between livestock depredations and a variety of producer and pasture characteristics; the highest livestock losses occurred on flat topography and second highest losses were in areas with the roughest topography. Franklin and Powell (1994) reported that llamas were equally effective at reducing livestock depredations in open and covered habitats.

Season. Beasom and Gober (1977) attributed the negative results of their study that used m-44 cyanide devices, in part, to the deployment of the devices in fall and winter rather than during the seasons used by other studies. This is an important consideration, as wolf depredation patterns change with season and location (Musiani et al. 2005). Seasons with lambing have higher monthly depredation rates regardless of mitigation strategies; Robel et al. (1981) reported that producers who lambed in the fall had reduced losses than producers who lambed in the Spring or throughout the year. Investigations have reported that the shortest times between livestock depredations occurred during pup-rearing season (Blejwas et al. 2002).

Human Settlement. Reported and suspected effects of distance to human settlement on the effectiveness of depredation mitigation strategies were mixed. A radio activated guard device was effective at protecting cattle but not at keeping predators away from a carcass dump that was located closer to people (Breck et al. 2002). Robel et al. (1981) found that rates of livestock depredation by coyotes differed based on distance to nearest town but not on how far the pasture was from a residence. Mech et al. (2000) reported that although animals were lost close to residences, chronic losses were associated with greater distance from residences. Similarly, Muhly et al. (2010) reported that distance to roads and buildings was related to livestock depredation by wolves. Although the distance of a study area to roads was reported in some research findings, the effect of that distance on the effectiveness of a mitigation strategy was not discussed.

Discussion

Geographic context includes a location's unique space, time, and place characteristics and these factors are known to influence biotic factors (including human activity) on the landscape. We expected the influence of geographic context to be considered in canid livestock depredation management research. We focused on historical/concurrent lethal control, alternative prey, landscape, seasonal, and settlement characteristics as contextual factors with potential influence on mitigating livestock depredation by coyotes and wolves. We found these contextual factors were reported inconsistently in research findings and rarely discussed or included in analysis. This makes generalizing these results to new situations and conducting meta-analyses difficult (Cook et al. 2017).

We observed that research findings with academically affiliated primary authors were more likely to have described contextual factors, except in the case of alternative prey. We expect this finding may be related to government researchers being pre-disposed to considering other wildlife due to their responsibilities managing a variety of wildlife. Journal research findings were more likely to have included contextual factor descriptions than grey literature. Notably, the metric distance to residences was only reported in journal research findings. Seasonal information was the most frequently reported contextual factor in both journal and grey literature research findings. These literature type results could be due to the peer review process and journals having more extensive requirements than grey literature for the reporting of research details. The differences in the reporting of contextual factors between literature types and affiliation types may be artefacts of academic authors being more likely to publish in journal literature than government affiliated authors.

Comparing how seasonal and historical/concurrent lethal control metrics were reported showed the varying levels of specificity used to describe contextual factors. Seasonal information often was written explicitly (e.g., trials took place June to August) while descriptions of historical/concurrent lethal control were sometimes nonspecific (e.g., other control activities were suspended). This leads to an inability to evaluate the research in context and could create bias in these primary studies that makes replication and inclusion in meta-analyses difficult (Konno et al. 2020a). Notably, the potential effect of lethal control on the effectiveness of mitigation strategies was discussed in the 1970s (Beasom and Gober 1977) and we found little consideration of the idea in the following decades.

The effect of settlement, landscape, and alternative prey characteristics on strategies to mitigate livestock depredation were difficult to evaluate. The effects of settlement characteristics were variable, but this factor was reported least frequently. Increased rates of depredations were associated inconsistently with increased distance from residences or towns with limited consideration given to the effect that distance may have on the effectiveness of mitigation strategies. No research findings explored the potential effects of distance to roads, even though the information was reported at similar frequencies as distance to residences. The settlement information is expected to be important to generalizing and replicating canid management research as humans can influence predator behavior (Kitchen et al. 2000; Frank and Woodroffe 2001; Sillero-Zubiri et al. 2004). Although landscape characteristics were mentioned in research findings, evaluations of the effectiveness of mitigation strategies rarely included the information. Analyses that included landscape often focused on the association between landscape and depredation rates; only two research findings included evaluations of the effect of landscape characteristics on mitigation strategies and reported no confounding effect. The effects of alternative prey on anti-depredation strategies were inconclusive as we did not believe the past research provided enough information to draw conclusions; one research finding used captive predators (Lance et al. 2010), another finding evaluated translocation (Bradley et al. 2005), and a third finding was correlational in nature (Bradley and Pletscher 2005). We did not find evidence of how the type of alternative prey in an area may influence the effectiveness of mitigation strategies even though available food types may influence predator behaviour (Bowen 1981; Toweill and Anthony 1988; Lukasik and Alexander 2012).

Overall, these contextual factors, and any potential synergistic effects, have been reported and discussed inconsistently in the literature. Management research is used by many parties, including producers who may be harmed financially by implementing an ineffective depredation mitigation strategy that did not account for the effect of geographic context. A hypothetical producer may implement a light-sound device (e.g., Linhart et al. 1984) to protect their livestock based upon a controlled experiment; this producer may be financially harmed if the hypothetical researchers did not account for contextual differences between the control and experimental areas (e.g., device visibility, prey density, past lethal control). Inclusion of the contextual factors then, can allow producers to draw more appropriate conclusions. Similar issues may arise around replication of the original research or meta-analyses and reviews that compare across primary research studies. Standardizing how experimental field research and associated contextual factors are reported should help ameliorate some inefficiencies.

Research reporting guidelines

Canid management research is expected to benefit from field studies due to behavioural differences between captive and wild animals (e.g., Birkett and Newton-Fisher 2011; Benson-Amram et al. 2013). Field research has limitations as "it appears that in some years certain ecological factors may influence levels of predation on domestic sheep more than do predator control efforts" (Beasom and Gober 1977, p. 49). Other disciplines must consider confounding factors, and interactions between those factors, on the results of research. For example, medical researchers are expected to follow the Consolidated Standards of Reporting Trials (CONSORT). That checklist of information to include within reports arose because of inadequate and inconsistent reporting of randomized controlled trials (Moher et al. 2010; CONSORT 2019).

We believe canid management research, and other ecological investigations, can benefit from standardized research reporting guidelines that include geographic context. The role of bias in literature reviews, meta-analyses, and the associated primary studies was acknowledged by the Collaboration for Environmental Evidence (CEE; Haddaway et al. 2015; Haddaway et al. 2018; Konno et al. 2020a). The CEE approach requires aspects of literature reviews be defined a-priori and for potential bias in the primary studies to be assessed.

To address this need, we created a preliminary set of guidelines for reporting field-based depredation research that we believe would align with and benefit the goals of the CEE (Table 4). These guidelines focus on the methods and study area while providing basic criteria for the title, abstract, results, and discussion.

Beyond the typical methods-related information (e.g., sample size), the guidelines include the reporting of the contextual factors described earlier in our paper. We do not specify descriptors (e.g., shrubland, grassland) for the contextual factors currently included in the guidelines to allow researchers to describe their study area without a-priori categories.

Researchers could also include additional contextual factors based on their experience and in-situ knowledge.

The guidelines for results and discussion focus on the replicability, applicability, and generalizability of livestock mitigation research by encouraging researchers to identify how context may have biased their conclusions. Although we hope researchers will include contextual information in all future analyses, we understand this may not occur immediately given entrenched practice. For researchers choosing to include contextual factors in their analyses, the methods will depend on the research and contextual information available. We expect simple descriptions of geographic context, as were used here, would likely be included as variables in linear models. However, consideration of geographic context in the research design phase would allow for more complex geographic contextual data (e.g., terrain layers, locations of deadstock, human activities, and predator sightings) to be collected. More advanced spatial techniques, such as geographically weighted regression (Brunsdon et al. 1996), then can be used with this detailed information. Our guidelines also suggest researchers state why their study was concluded, due to the potential implications for application and replication of the research. For instance, producers withdrawing due to low perceived effectiveness.

The inclusion of geographic context acknowledges the intricacies inherent to replication and meta-analyses in geography (Kedron et al. 2021; Waters 2021) and could help identify patterns associated with effective implementations of depredation management strategies. We hope that adherence to guidelines might increase over time, making research replication, review, and application more effective and efficient. Finally, we offer our guidelines as a framework that might enhance research by accommodating new perspectives (e.g., animal welfare), knowledge (e.g., additional contextual factors), and research topics (e.g., ungulate management).

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Table 1
Descriptions of the four Research Characteristics and sub-sequent categories assigned to each experimental research finding on mitigating coyote and wolf livestock depredation published between 1970 and 2018.

Research Characteristic	Description of Characteristic	Categories
Experimental Circumstances	The environment the research was conducted in.	Field (e.g., experiment conducted on a grazing area) Captive (e.g., experiment conducted at a field station)
Experimental Design	The design of the research reported in the research finding.	Quasi-Experiment (e.g., livestock losses in previous years compared to current year after a strategy was implemented) Controlled Experiment (e.g., livestock losses at one location with a strategy implemented compared to another location without the strategy implemented)
Author/PI Affiliation	Affiliation of the author of contact or Principal Investigator (PI) on a document or (if author of contact or PI were not delineated) the affiliation of first author.	Academic (e.g., University of Colorado) Government (e.g., Wildlife Services)
Literature Type	Location of the document that contained the research finding.	Journal (e.g., Conservation Biology) Grey (e.g., conference proceedings, research reports, theses, periodicals)

Table 2. Questions used by the authors for determining whether the five types of geographic information were reported in each research finding on mitigating livestock depredation by wolves and coyotes in North America.

Contextual Factor	Associated Question
Historical/concurrent lethal control	Did the authors report whether lethal control had been used in the study area prior to the research or while the research was being conducted?
Alternative prey	Did the authors report what alternative domestic or wild prey were in the study area and the abundance of that prey?
Landscape	Did the authors report the landscapes features (e.g., mountainous, grasslands) or ecosystem characteristics (e.g., type/height of vegetation) of the study area?
Season	Did the authors report information on what season or time of year the research was conducted in?
Settlement	Did the authors report information on the distance of the study location from roads or human settlements?

Table 3
The frequency that contextual factors were reported in field-based experimental research findings on mitigating coyote and wolf livestock depredation and sub-analyses comparing academic to government authored research findings and journal to grey literature research findings.

Contextual Factor	% of Research Findings (n= 88)	% of Academic Research Findings (n= 46)	% of Government Research Findings (n= 37)	% Difference Between Academic and Government Research Findings[a]	% of Journal Research Findings (n= 52)	% of Grey Literature Research Findings (n= 36)	% Difference Between Journal and Grey Literature Research Findings[b]
Historical/Concurrent Lethal Control	58	58.7	56.8	1.9	63.5	50	13.5
Alternative Prey	28.4	26.1	29.7	-3.6	30.8	25	5.8
Landscape[c]	25/63.6	30.4 / 67.4	18.9 / 62.2	11.5 / 5.2	34.6 / 71.2	11.1 / 52.8	23.5 / 18.4
Season	83	84.8	78.4	6.4	92.3	69.4	22.9
Settlement[d]	11.4/8	17.4 / 8.7	2.7 / 5.4	14.7 / 3.3	17.3 / 13.5	2.8 / 0	14.5 / 13.5
Range Across Factors	8-83	8.7 - 84.8	2.7 - 78.4	-	13.5 - 92.3	0 - 69.4	-

[a] =Academic−Government
[b]=Journal−Grey
[c]Landscape information / Ecosystem information
[d]Distance to roads / Distance to residences

Table 4
Guidelines for reporting research on managing canid livestock depredation to ensure all applicable information is provided to the reader.

Title/Abstract		Specific mention of quasi or controlled experiment in title.
		Specific mention of strategy tested, general experimental design, and results with contextual information in abstract.
Methods	Experimental Design	Description of experimental design (e.g., quasi, controlled) and the process of determining groups.
	Intervention/Strategy	Indication of which management strategy was evaluated, if applicable.
	Outcome Measure	Description of the dependent variable (e.g., livestock depredations, predator behavior).
	Sample Information	Description of sample (e.g., packs, predators, pastures, farms) and recruitment methods (e.g., phone, referrals from government agents).
	Sample Location	Description of sample location and scale (e.g., local group, multiple states).
	Context: Historical/Current Lethal Control	Description of concurrent or prior lethal control, hunting, etc. in the study area.
	Context: Other Prey Available in the Area	Description of other prey available in the area, their population levels (i.e., density), and whether the prey are spatially separated from the livestock.
	Context: Landscape/Ecosystem Information	Description of the landscape/ecosystem (e.g., distance to dense vegetation and tree cover, terrain roughness) of the sample locations.
	Context: Settlement Characteristics	Report the distances of the sample sites to roads and residences.
	Temporal Scale Research	Description of study time frame (e.g., months, seasons, years).
	Analysis Strategy	Description of statistical tests used to evaluate differences or other criteria used to judge effectiveness.
Results	Outcome	Description of the outcome of the experiment or estimate of effectiveness.
	Trial Conclusion	Description of why the experiment was concluded (e.g., pre-planned time frame, increased predation, producers no longer participating).
	Effect of contextual variables	Description of confounding contextual effects if analyzed or potential effects if not analyzed.
Discussion	Interpretation	Description of conclusions drawn from methods and results.
	Generalizability	Indication whether results are generalizable to broader research, other locations, depredation mitigation strategies, etc.
	Limitations	Description of the primary limitations of the experiment and whether generalizability could have been affected by not including contextual factors in the analysis (if applicable).