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Ecological Doctors in Maasailand: Identifying Herding Best Practices to Improve Livestock Management and Reduce Carnivore Conflict

Kevin E. Jablonski[1,2]*, *John Merishi*[3], *Stephanie Dolrenry*[3] *and Leela Hazzah*[3]

[1] *Department of Forest and Rangeland Stewardship, Colorado State University, Fort Collins, CO, United States,* [2] *Center for Collaborative Conservation, Colorado State University, Fort Collins, CO, United States,* [3] *Lion Guardians, Nairobi, Kenya*

Ilkisonko Maasai pastoralists in the Amboseli ecosystem of southern Kenya earn livestock-based livelihoods in a difficult environment exacerbated by a range of challenges. In this setting, many stakeholders, including the Maasai themselves, have come to see traditional extensive pastoralism as essential to long-term social–ecological resilience. This includes the maintenance of communal land tenure, which protects both unfragmented landscapes and the cultural practices necessary to thrive therein. This land tenure system has also been well-documented to support diverse wildlife populations, including large carnivores such as the African lion. Lion Guardians is a conservation organization working on the group ranches of the Amboseli ecosystem to reduce human–lion conflict using culturally appropriate strategies, with a 13-year track record of reductions in lion killing as compared to other conflict mitigation approaches. However, in recent years, they have noted a marked increase in the amount of lost livestock. Lion Guardians' data indicate that untended livestock account for >80% of lion attacks, making them a primary driver of human–lion conflict in the ecosystem. In this paper, we present the results of a community-based qualitative study aimed at identifying the causes of lost livestock, in pursuit of win–win solutions for people and lions. Using an iterative multistage research process, we conducted interviews with more than 120 Maasai community members. Finding general agreement that lost livestock are a problem and that poor herding practices are the primary cause, we next sought to identify both herder and herder-mentor best practices. For this, we focused on the knowledge of elders and "master herders," those identified by their communities as especially adept and responsible herders. In creating these lists, we learned that herding best practices relevant to carnivore-conflict prevention are inseparable from those related to pasture management and livestock productivity and largely inseparable from traditional Maasai culture. This means that good herders, who have been called "ecological doctors," can support the vitality of not only plants and pastures but also lions, ecosystems, and entire human cultures.

Keywords: pastoralism, grazing management, African lion, human–wildlife conflict, Kenya, cattle, carnivore

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***Correspondence:**
Kevin E. Jablonski
kevin.jablonski@colostate.edu

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INTRODUCTION

Paralleling the situation of pastoralists in semiarid rangelands worldwide, Ilkisonko Maasai pastoralists in the Amboseli ecosystem of southern Kenya must navigate growing challenges to secure a livestock-based livelihood (BurnSilver and Mwangi, 2007; Reid et al., 2014; Galvin et al., 2015). These challenges include a highly variable climate, heterogeneous distribution of resources, conflict with wildlife, and population growth (Homewood et al., 2009). Additionally, for more than a century, Maasai across the region have been forced to adapt to repeated changes in government land tenure policy (including land seizure), misguided non-governmental organization interventions, incursions into communally held lands by outsiders, and, more recently, anthropogenic climate change (Fratkin and Mearns, 2003; Galvin, 2009; Bobadoye et al., 2016).

In this complex environment and amid growing sociocultural change, many pastoralists and affiliated stakeholders have come to see traditional extensive pastoralist culture as essential to long-term social–ecological resilience (Lesorogol, 2008; Groom and Western, 2013). This includes maintenance of communal land tenure as well as the associated preservation of unfragmented landscapes and the dynamic cultural practices necessary to thrive in them (Scoones and Graham, 1994). Apart from the inherent value of maintaining Maasai culture and the ecological value of maintaining pastoral mobility amid heterogeneously distributed forage, the protection of traditional extensive pastoral practices also holds promise to assist in maintaining viable wildlife populations outside of protected areas, including large carnivores such as the African lion (*Panthera leo* L.; Ellis and Swift, 1988; Boone and Hobbs, 2004; Mwebi, 2007; Groom and Western, 2013; Schuette et al., 2013).

This last assertion is perhaps counterintuitive. After all, lion killing resulting from depredation of livestock is one of the chief causes of the drastic and ongoing decline in lion populations across Africa (Woodroffe and Ginsberg, 1998; Ogada et al., 2003; Woodroffe and Frank, 2005; Hazzah et al., 2009). This has led many to conclude that the best way to conserve lion populations is to exclude pastoralists from vast areas in order to minimize interactions among livestock and lions (Packer et al., 2013).

However, historical and recent evidence indicate that a combination of effective livestock husbandry practices and culturally mediated tolerance can ensure the long-term viability of lion populations outside protected areas, a necessity if the species is to survive (Ogada et al., 2003; Hazzah et al., 2009; Dolrenry et al., 2014). We do not romanticize Maasai pastoralists or the challenges they face, which include overstocking of livestock and mismanagement of pasture resources. Nevertheless, we contend that traditional livestock husbandry practices, including herding, are not antithetical but instead essential to lion conservation in that they help prevent the vicious cycle of conflict that reduces tolerance and leads to lion killing.

Lion Guardians and Lost Livestock

Lion Guardians (LG) is a conservation organization working to enact culturally appropriate long-term solutions for people and lions to thrive together in the pastoral areas of East Africa. In the Amboseli ecosystem, the organization employs a team of more than 50 Maasai *ilmurran*, young warriors on whom their communities traditionally relied to kill problem lions, especially those that target livestock. Instead of hunting lions, these young men now work as "lion guardians" to monitor lions, mediate conflict, and serve as community liaisons. In combination with extensive community engagement by LG staff, this holistic approach has a lengthy record of significant reductions in lion killing compared to other conflict mitigation strategies (Hazzah et al., 2014). However, in the course of their work, LG staff, including many local Maasai, have identified one persistent cause of conflict that seems to be worsening despite their success—lost livestock.

Lost livestock leave the protection of the *boma* (night pen or *kraal*) with a herder in the morning but stray during the day and are often lost in the bush overnight. LG data show that lost livestock account for >80% of lion attacks on livestock in the Amboseli ecosystem, and the lion guardians have reported returning >15,000 lost livestock to owners each year. Lost livestock are also predated by other large carnivores such as spotted hyenas (*Crocuta crocuta* Erxleben), leopards (*Panthera pardus* L.), and cheetahs (*Acinonyx jubatus* Schreber). However, the reasons that Maasai herders lose livestock and how this might be prevented are poorly understood.

In this paper, we present the results of a qualitative study aimed at identifying community perceptions of causes and trends related to lost livestock in the Amboseli ecosystem. Our primary objective for the study was to seek solutions to the challenge of lost livestock in a way that provided value to both pastoralists and conservationists. We thus used the research process to identify management practices that could lead to win–win outcomes related to lost livestock. We ultimately came to focus on descriptions of herding best practices by elders and "master herders," those identified by their communities as being especially adept and responsible herders. By placing lessons from these experts in context with broader community perspectives, we were able to inform ongoing lion conservation efforts while focusing on outcomes of interest to Maasai research partners.

Fundamental to this work is the 13-year record of successful engagement and cooperation between Lion Guardians and the Ilkisonko Maasai communities of the Amboseli ecosystem and that most of the organization's staff are themselves Maasai. LG is embedded in the social–ecological landscape in which it operates, with a headquarters deep in the "bush" and a commitment to the local communities that extends well beyond lion conservation. Local Maasai were thus fundamentally engaged in the research, as well as within the iterative process wherein we continuously adapted our design to best meet the needs of the communities. Particularly, coauthor JM, an Ilkisonko Maasai from the Olgulului–Ololarashi Group Ranch, coled the design of the study and led or co-led as well as translated the interviews.

Study Area and Background

The study area was within the Amboseli ecosystem, a 5,975-km^2 region of semiarid grasslands and savannahs north of Mt. Kilimanjaro and west of the Chyulu Hills (**Figure 1**). Although

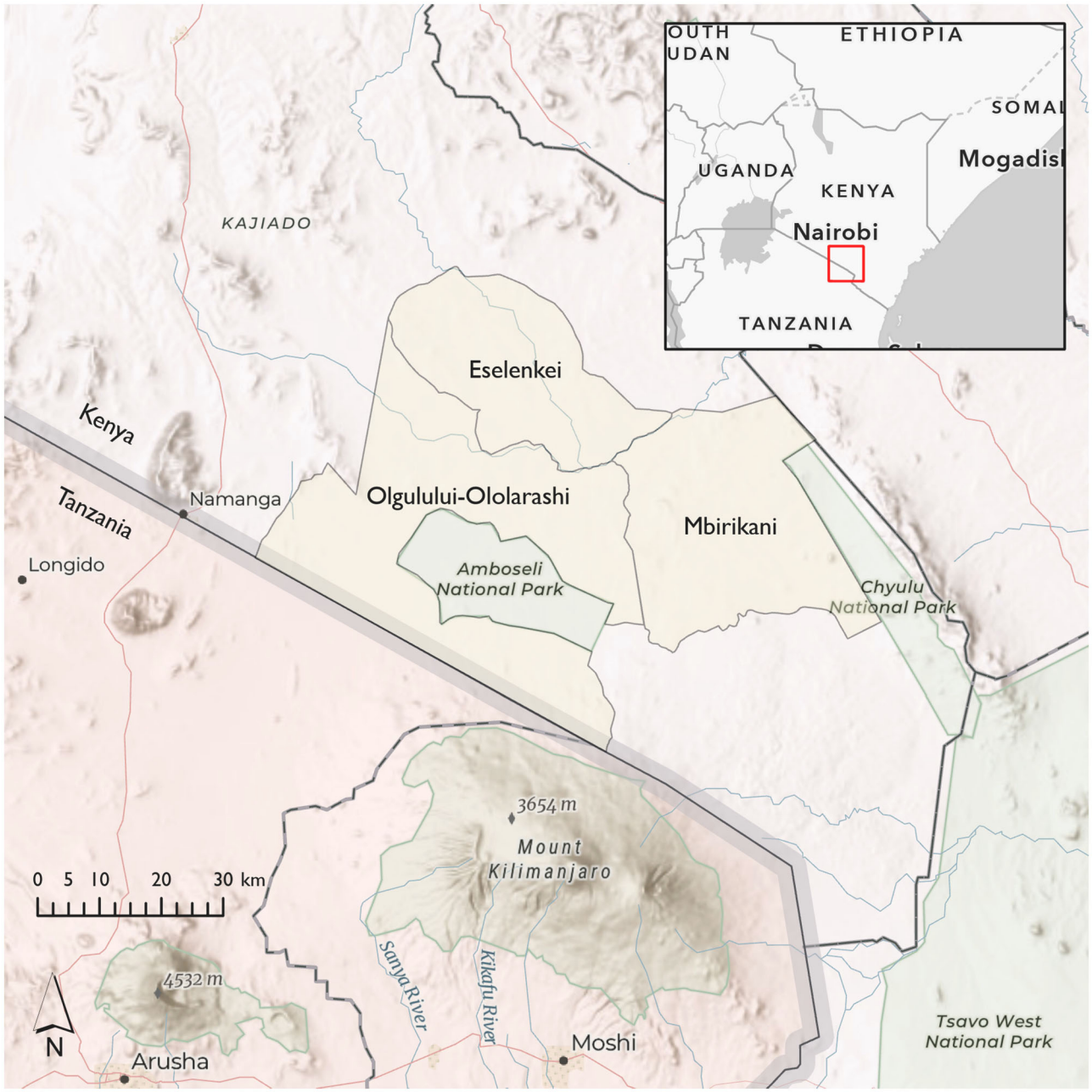

FIGURE 1 | Location of the study area, including the three Maasai group ranches.

Amboseli National Park is at the heart of the region, land tenure in the ecosystem is dominated by Maasai group ranches, which are communally owned and collectively managed. We focused our work on three of these group ranches: Eselenkei Group Ranch (748 km^2), Mbirikani Group Ranch (1,229 km^2), and Olgulului–Ololarashi Group Ranch (1,427 km^2) where LG has had a long-term presence, with guardian working territories covering most of the landscape.

An accurate human population count is difficult, as Kenyan national census boundaries do not overlap well with group ranch boundaries, but residents of the three group ranches likely number in excess of 30,000. Although income sources are increasingly diversifying, livestock such as cattle, sheep, and goats are the major livelihood source in the region, with an estimated 100,000 livestock spread across the three group ranches (BurnSilver, 2009; Hazzah et al., 2014). Nearly all livestock still rely on traditional pastoral extensive grazing for 100% of their feed, although some intensification has occurred in other aspects of livestock production, including the use of "improved" breeds and selling of animals (BurnSilver, 2009).

This extensive grazing is managed by herders, such that men and boys are responsible for cattle, which range further from the *boma*, and women and girls are responsible for sheep and goats, which stay close to home. The herder is responsible for watching over the herd from sunup to sundown, guiding them to good foraging areas and water and protecting them from predation or theft. Decisions about which areas are open to grazing and which are closed, as well as when herders can move cattle to temporary *bomas* to access forage located far from home, are made by elders. While open access (at least for other Ilkisonko Maasai) is the expectation for this decision making, it is subject to community-based negotiation, and resource use is carefully monitored and reported on by community members (Galaty, 1992). It is important to note that these livestock management practices are situated within a rapidly changing sociocultural landscape where economies, education, social networks, and land tenure are in flux (Homewood et al., 2009; Butt, 2015).

The group ranches also support diverse wildlife assemblages, including large herbivores such as zebra (*Equus quagga* Boddaert), wildebeest (*Connochaetes taurnius* Burchell), Thompson's gazelle (*Eudorcas thomsonii* Gunther), Grant's gazelle (*Nanger granti* Brooke), giraffe (*Giraffa camelopardalis* L.), and elephant (*Loxodonta africana* Blumenbach). Resident large carnivores include lion, spotted hyena, leopard, cheetah, black-backed jackal (*Canis mesomelas* Schreber), and the rare African wild dog (*Lycaon pictus* Temminck). Despite growing challenges, the continued coexistence of significant human, livestock, and wildlife populations makes the Amboseli ecosystem one of the world's great examples of conservation outside protected areas.

Maasai and lions interact within a complex cultural web of awe, fear, respect, and violence, wherein the lion is uniquely valued among all wildlife (Goldman et al., 2010). Although Maasai certainly resent and retaliate against lions that kill livestock, this is merely one aspect of a relationship that is continuously negotiated, across time and space with individual humans and lions, and mediated through social networks across Maasai communities (Hazzah et al., 2009; Goldman et al., 2010; Despret and Meuret, 2016; Dhee et al., 2019). It is thus important to recognize that lion killing by Maasai is motivated by diverse attitudes and experiences and is unlikely to ever be precipitated by a single livestock depredation event (Hazzah et al., 2017). Nonetheless, numerous studies have found a clear connection between livestock depredation by lions and lion killing by Maasai (Kissui, 2008; Ontiri et al., 2019).

METHODS

Throughout, this work was situated within a social–ecological framework wherein we sought to understand both social and ecological factors related to lost livestock in order to help "create beneficial feedback loops such that. . . ecological objectives are met in ways that benefit livestock operators and the broader society" (Hruska et al., 2017, p. 296). To do so, we used constructivist qualitative methods, which recognize human realities as complex and dynamic and acknowledge the researcher's role in constructing a story from data. Data collection was therefore iterative, interactive, and pragmatic, with analysis informing further data collection in cooperation with participants, with an aim toward thematic saturation (Saldaña, 2011; Denzin and Lincoln, 2018). We then used thematic analysis to encode responses in a collaborative process with research partners (Braun and Clarke, 2006).

We also structured the work to adhere to guidelines for responsible research practice with Indigenous communities (David-Chavez and Gavin, 2018). This means that the local Maasai were included in the decision to initiate the study; were continually engaged in study design, implementation, and analysis; and are leading the effort to appropriately disseminate results, among other important considerations. Overall, we worked to be non-extractive, with a focus on generating knowledge that will be useful to Maasai pastoralists rather than merely scientifically novel (Reid et al., 2016). At the same time, we approached the research participants as intelligent livestock producers with useful information that other livestock producers can learn from to improve their outcomes. This research was conducted with an exemption under Colorado State University IRB Protocol 204-18H.

Data Collection

We collected data in three stages. In all stages, participants were informed that participation was completely voluntary and anonymous and that the interview could be halted at any point. For LG staff, because of potential reluctance to criticize conservation groups in general and LG specifically, we took care to emphasize anonymity and address any questions or concerns. As is typical in Maasai culture, interviews were usually preceded by an often-lengthy conversation about families, weather, and recent events. Additionally, participants were encouraged to ask questions of the researchers. We kept detailed notes of all interviews in all stages. Some interviews were recorded but, on the advice of JM, this was often foregone when he determined that doing so might make participants reticent.

Stage 1 of data collection consisted of semistructured interviews of 21 LG staff in December of 2017 to build a baseline level of understanding about lost livestock trends and drivers, and to pilot and refine questions. Six of the interview subjects in this stage were English-speaking staff, three of whom are Maasai, while 15 were field-based lion guardians who did not speak English, were young men from all three group ranches, and were interviewed in groups of one to four. All lion guardians interviewed had experience tending livestock, and we believe their responses were generally more representative of the view of community members rather than conservation staff. Interviews lasted between ∼40 and 90 min, with an average of 1 h for individuals and slightly longer for groups.

The second stage of data collection used flexible, open-ended questionnaire-based interviews to learn more about lost livestock trends and drivers from a diverse set of 80 Maa-speaking Ilkisonko Maasai community members spread across the three group ranches. We interviewed participants individually and sought a range of ages and locations as well as gender diversity, with a target of 20–30 min per interview. This work was

TABLE 1 | Questions used in questionnaire-based interviews.

Question
1. Are lost livestock a problem in your area/community? Why or why not?
2. Are numbers of lost livestock increasing? Why or why not?
3. Why do livestock get lost?
4. Do certain types of herds lose livestock more often?
5. Do certain types of herders lose livestock more often?
6. What strategies are used (or could be used) to prevent lost livestock?
7. When livestock are discovered to be lost, what happens? Has this changed?
8. What strategies are used (or could be used) to find lost livestock?

completed in November of 2018. **Table 1** shows the questions included in the questionnaire.

Finally, using lessons learned from the first two stages of data collection, we conducted 12 semistructured interviews aimed at identifying herding best practices in January of 2019. All interview subjects were Ilkisonko Maasai community members with significant herding experience and knowledge, and most had been identified in stage 2 as excellent herders by other community members. In five interviews, only one respondent was present; in two, multiple people were present but only one responded to questions; and in five instances, there were multiple people that responded to questions, although a single respondent (usually the eldest male) led the responses with others occasionally contributing. These interviews lasted from 53 to 140 min.

All interviews were translated from Maa by a Maasai LG staff member (all but four by JM). For the semistructured interviews, KJ and JM collaborated to pose questions to participants, with JM translating and providing continual feedback and suggestions. For the questionnaire, KJ wrote the questions, JM translated them to Maa, and then a third Maa speaker translated them back to English to confirm that the interpretation in Maa was as desired. All quotations in this paper are translated from Maa.

Data Analysis

Thematic coding of responses followed a continuous iterative process whereby we developed initial general themes focused on our main questions and then examined the interview data in more depth, looking for additional themes, refining as we proceeded. For the semistructured interviews, we used these findings to improve or develop new questions as data collection proceeded, while the questionnaire remained consistent. We used the results from stage 1 to guide us in creating the questionnaire, both in further exploring areas where more information was needed and identifying new questions.

To analyze the questionnaire data, which were collected solely by JM, KJ, and JM jointly followed the coding process for each of the questions, together reviewing the results, identifying themes, and then iteratively refining those until we were satisfied that we had captured all relevant themes. For the semistructured interviews focused on herding best practices, we again followed the iterative coding process but with an *a priori* focus on identifying clear and actionable best practices. For example, while some participants identified national government policy changes as necessary, we did not focus on these. We also reviewed the results from the previous two stages to identify herding best practices. In the end, we were confident that, among our >120 participants, we had reached thematic saturation regarding lost livestock and herding best practices. The data collection and analysis process is illustrated in **Figure 2**.

RESULTS

Stage 1: Interviews of Lion Guardians Staff

A core question of the work was whether lost livestock are occurring more frequently across the region, as Lion Guardians' internal data indicate. Although the LG staff certainly had opinions about this (they generally felt that they are, although this was not uniform), we decided that there was too much potential intraorganizational bias to make conclusions about lost livestock trends from these interviews. Nevertheless, the findings from this stage exist within the context of increasing lost livestock, the reality of which we explored in more depth in stage 2 with community members.

As long-time observers of relationships among people, livestock, and wildlife in the region, both the Maasai and non-Maasai staff shared a wealth of knowledge about the causes of lost livestock conflict, noting that it has always been present. During this stage, we identified two core lost-livestock themes that would form the basis for the rest of the study, as well as several other factors that increase the likelihood of lost livestock, decrease the capacity to find them once lost, and increase the risk of predation of lost animals.

We also confirmed that although all livestock are important to Maasai livelihoods and all are predated by carnivores, cattle have the most social value and, because they graze farthest from home, are most likely to be predated when lost. As such, cattle and cattle herders were the dominant focus of the responses in all stages.

Declining Herder Skill and Dedication

The first of the core themes was that declining herder skill and dedication is causing an increase in lost livestock. Within this theme, we identified several driving factors for two main categories of herders: family herders and paid herders. Traditionally, family herders progress from children with responsibility over young sheep and goats to teens tending adult cattle, improving their herding skills and bush knowledge as they grow into skilled herders. Paid herders are usually adults from outside the family who are hired to tend to livestock.

Among family herders, many participants noted that children have always been "full of fun" and prone to distraction and thus prone to losing livestock. However, increased primary school attendance by children, which became compulsory in Kenya in 2003, has led to decreased interest in and knowledge about herding. Additionally, with adults seeking more diverse sources of income, they have less time to train the children that are available to herd. Several participants noted that children are no longer punished for bad herding as they once were.

With more children in school and increasingly uninterested in herding, participants noted that herds are frequently tended

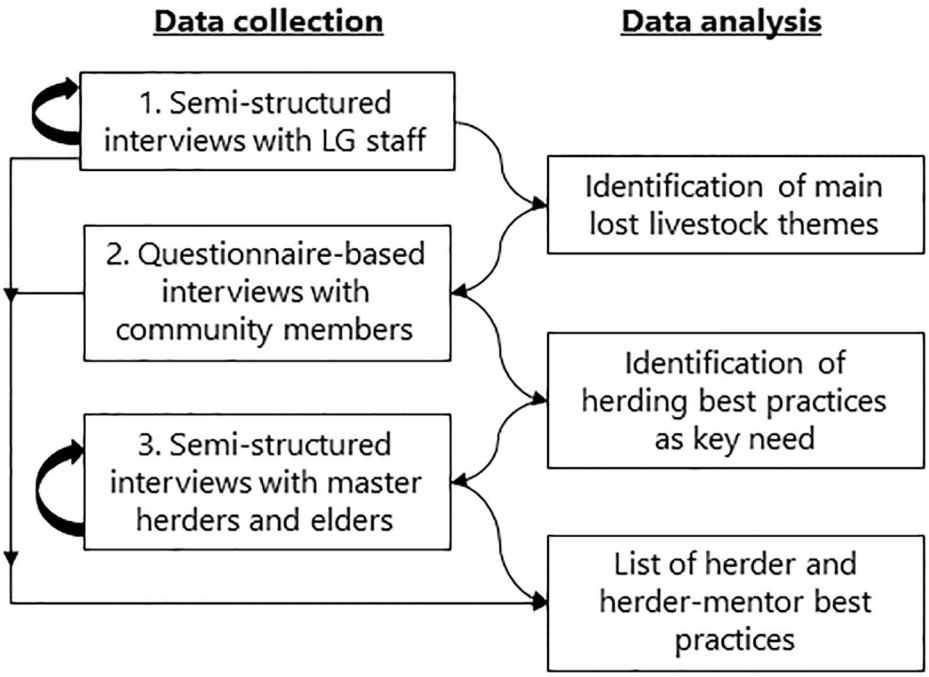

FIGURE 2 | The iterative data collection and analysis process, wherein each stage built upon what came before. Stages 1 and 3 were internally iterative, such that the conversation evolved as we proceeded. The data analysis column shows the key finding from each stage but is not comprehensive. All data collection stages informed the generation of herder and herder-mentor best practice lists.

by too few herders for the number of livestock and that young, inexperienced herders are often placed in charge of herds for which they are ill prepared. In the past, a large cattle herd may have been tended by an *ilmurran* warrior and two younger apprentice herders, while now, it is common to see a single young boy tending a large herd.

The alternative, when a family can afford it, is to hire a paid herder. However, with fewer children learning the trade and fewer viewing herding, which requires long days in the hot sun amid dangerous wildlife, as a desirable profession, good paid herders are increasingly scarce. Even when paid herders are available, many noted that it is difficult to evaluate their skill and dedication, especially if they are from outside the community. Dedication, which refers to the herder's personal devotion to the livestock and the family that depends on them, was frequently highlighted as especially important in both family and paid herders, and especially difficult to find in a paid herder. This was exacerbated by the tendency to pay herders poorly, perhaps in anticipation of poor performance.

Decreased Capacity to Search for and Find Lost Livestock

Because lost livestock have always been a challenge, and because livestock are so valued in Maasai society, the search for lost livestock is a well-known event in Maasai life. Traditionally, when a herder reported lost livestock, members of the community would rally to collectively search for them, with an elder perhaps performing *oenet*, a traditional practice intended to help guide lost livestock home. Participants consistently reported that it is increasingly difficult to mobilize community members and that *oenet* is now rarely practiced.

One reason that it is difficult to rally support to search for livestock is that *ilmurran* warriors, who used to be a "search army," are now less interested and available. Major causes of this include the declining interest in livestock and the bush noted above, as well as diversified livelihoods. However, several participants also noted that the legal prohibition on lion killing discourages warriors from joining a search, as searches no longer have the same potential to lead to a lion hunt, which can confer great prestige on a warrior who spears a lion.

Additional factors in the decreased capacity to search for and find lost livestock include fewer adults available to search and poor herders failing to note where the lost livestock were last seen. Of note regarding adult searchers is that several participants told us that there is a declining sense of community and so people are less willing to help look for livestock that they do not own. Lastly, a few participants noted that compensation from conservation organizations for livestock killed by predators may reduce the drive to search for lost livestock, although they stressed that this is only the case with sick or otherwise less-valued animals.

Other Factors

Several other potential factors were noted as contributing to lost livestock conflict but were viewed as less actionable by participants. For example, most noted that livestock are more likely to be lost in areas of dense vegetation and during times of

TABLE 2 | Profile of the 80 participants in the questionnaire-based interviews.

Group ranch	Count	Gender		Age		
		Male	Female	Min	Max	Mean
Eselenkei	24	21	3	18	76	38.6
Mbirikani	26	17	9	18	92	45.1
Olgulului–Ololarashi	30	23	7	24	80	41.3
Total	80	61	19	18	92	41.7

drought when livestock range farther from home and from the herder to find forage. However, participants saw these as cyclical and unavoidable causes of lost livestock. Carnivore abundance, distribution, and behavior were also identified as sources of conflict but were likewise seen as less tractable.

Finally, a few participants raised the issue of broad level herd and forage management as driving lost livestock. For one, overall livestock numbers have increased in the region, increasing the number of lost livestock. Participants also suggested that poor community-level enforcement of grazing restrictions means that herds and herders must travel farther to reach forage, increasing the likelihood of losing livestock. The effects of this poor management are exacerbated by drought.

Stage 2: Questionnaire Interviews of Community Members

To build upon and more broadly examine the findings from stage 1, we conducted questionnaire-based interviews with 80 Ilkisonko Maasai community members (**Table 2**) from across the three group ranches (**Figure 3**). Overall, 61 participants self-identified as men and 19 as women, with a minimum age of 18 and a maximum of 92.

Are Lost Livestock a Problem, and Are They Increasing?

For the question, "Are lost livestock a problem in your community?," 60 participants said that they are, while 20 said they are not. Responses were consistent across the different group ranches and for age and gender. For those that said lost livestock are a problem, reasons given ranged from their frequency of occurrence (60%) to the likelihood of lost animals being killed by predators (38%—note that more than one response was often given):

> *It is a big problem and predators are taking advantage of the situation. Most of the livestock that get lost are killed by predators. This is a big loss to pastoralists. (Older woman, Mbrikani GR)*

> *It is a big problem—livestock are reported lost daily across the village. (Middle-aged man, Eselenkei GR)*

For those who said that lost livestock are not a problem, the most common response was that they are not occurring frequently (35%), while many also noted that the problem varies according to either pasture availability (25%), vegetation density (20%), seasonal/drought conditions (20%), the availability (5%), and skill (10%) of herders, or the likelihood that predators will kill lost animals (10%), which they described as not currently problems in their area.

When asked if lost livestock are occurring more frequently in their area, 42 participants said yes while 38 said no. While responses were consistent across age and gender, 70% of participants from Olgulului–Ololarashi GR said they are increasing, much higher than on Eselenkei GR (46%) or Mbirikani GR (38%). Of those that said lost livestock are increasing, 50% said that this is due to a lack of adequate herders. Other reasons include declining herder skill and dedication (14%), failing to properly value livestock (12%), and a variety of environmental factors such as increasing drought and predator pressure.

> *Lost livestock are increasing because of the following reasons: In the past herding was done by livestock owners, nowadays it is done by paid herders. Most herds nowadays lack herders because of school and the lack of ability to pay herders. Also, there is a high presence of predators. (Older woman, Olgulului-Ololarashi GR)*

Of those that said lost livestock are not increasing over time, the most commonly given reason was that lost livestock occur cyclically due to forage heterogeneity (21%) or drought (18%) and so may rise and fall but, over the long run, have remained consistent. A few said that numbers have fallen over time due to an increased percentage of adults herding because children are in school (3%) or due to smaller herd sizes as livestock become less important (3%).

> *The numbers have been consistent over the years. The numbers are high during drought and somehow drop when rain comes and there is enough pasture. (Young man, Mbirikani GR)*

Overall, 44% of participants said that lost livestock are a problem and are increasing, 31% said they are a problem but not increasing, and 9% said they are increasing but not a problem in their community. This leaves only 13 of 80 participants (16%) who said that lost livestock are not a problem and are not increasing.

Why Do Livestock Get Lost?

Three questions focused on the causes of lost livestock, with prompting questions related to types of herds and types of herders that might lose livestock more frequently. The most common responses to the open-ended question related to herder skill and dedication (55%), with lack of herders (31%) also prominently noted. Other common responses related to heterogeneity in the distribution of forage and water causing livestock to wander (45%) and dense vegetation causing herders to lose track of some livestock (34%).

When prompted for the characteristics of herds that might lose animals more frequently, the most common response (40%) was that there are no consistent differences. Large herds (26%) were the most common affirmative response, with others mentioning herds of sheep and goats, herds of calves, and herds

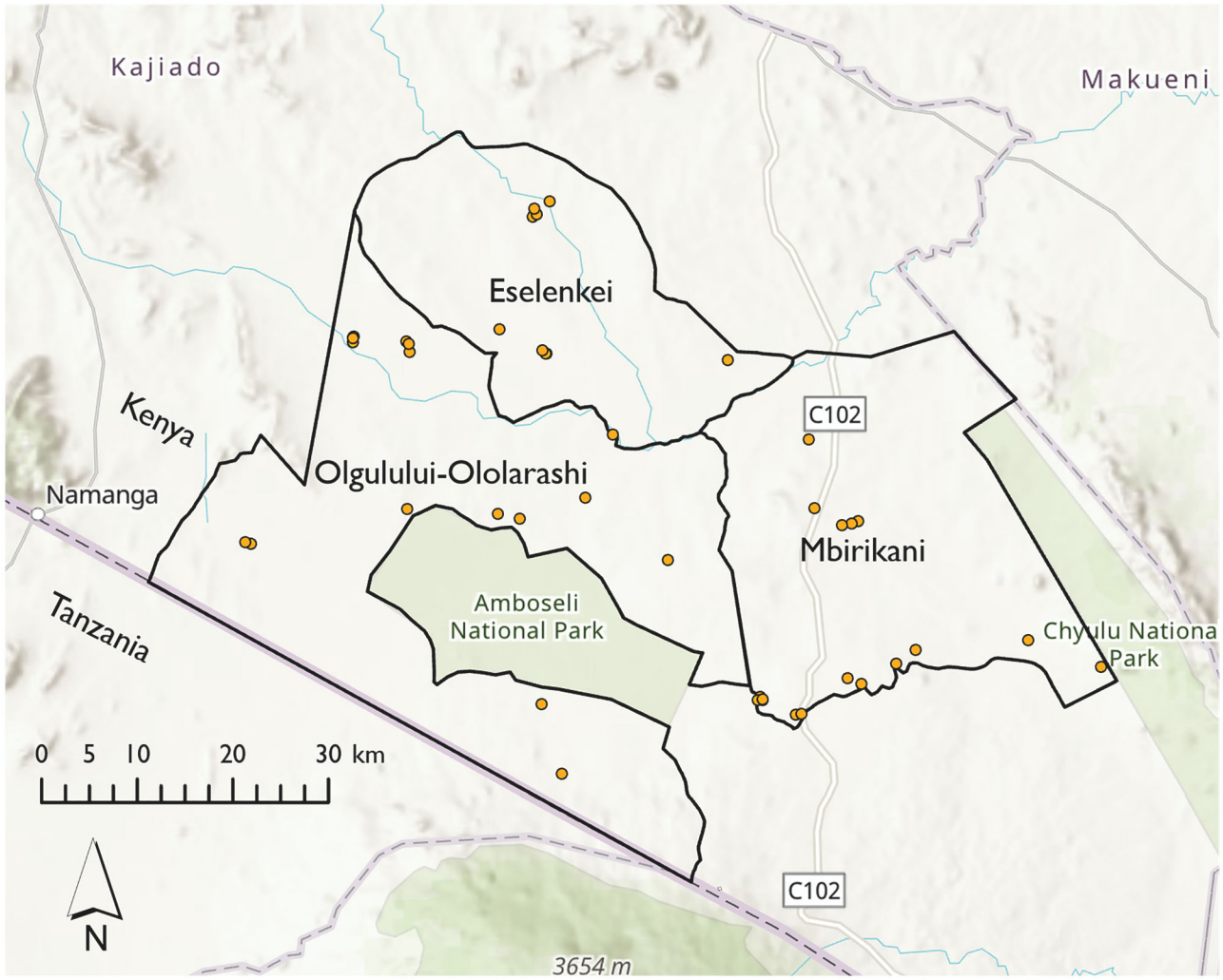

FIGURE 3 | Questionnaire participant locations. Note that multiple questionnaire interviews were often completed in a single location and that points do not necessarily mark the exact location that the person lives but rather where they were interviewed.

with many "rogue" livestock, those individual animals that have the tendency to lag or otherwise stray from the herd.

When prompted for the characteristics of herders that might lose animals more frequently, there was a broad range of opinions, with many participants sharing lengthy thoughts on the subject. The most common responses related to herders who were deemed "unreliable" (36%), did not value livestock (35%), or otherwise showed poor character.

> *Most paid herders are not good herders since there is no sense of ownership of the livestock. School children are not good herders either because they care more about books than livestock. They play while herding! (Middle-aged man, Eselenkei GR)*

Others noted that herders who have not received proper training (13%) and therefore lack skill (13%), those too young for the herd they have been assigned (15%), or those who are treated (4%) or paid (11%) poorly are most likely to lose livestock. Overall, 89% of participants reported that adult family members are always good herders, while only 13% said the same of paid herders or school children.

> *School children are not good herders because of school and lack of punishment. Most people no longer take time to mentor their children to be good herders. (Middle-aged woman, Eselenkei GR)*

How Can Lost Livestock Be Prevented?

We next asked about strategies that are used (or could be used) to prevent lost livestock. Reliable herders (41%) was the most common answer, with the related proper mentorship of herders (31%), adequate number of herders for the herd (21%), herders of the proper age (20%), and punishment of poor family herders (13%) also mentioned.

> *The owner must talk to the herder on how to be a responsible herder and, if needed, change their responsibility from a challenging*

herd to a less challenging herd, for example from herding cows to herding calves. Involve mature herders in herding. (Young man, Olgulului–Ololarashi GR)

Many participants also referenced specific best practices for herders. These include working with an elder to select areas with adequate forage and less dense shrubs and trees (28%), properly timing the grazing day to ensure the herd returns well before sunset (10%), using bells on animals, especially rogue livestock (6%), and proper pay for paid herders (4%).

Allow paid herders to have their own livestock in the herd. This increases their sense of ownership. Put bells on livestock to aid in identifying and also hearing livestock from afar or in dense brush. (Middle-aged man, Olgulului–Ololarashi GR)

Searching for Lost Livestock

Because owners are typically notified of lost livestock when a herder returns home in the late afternoon or dusk, the most common responses for what to do when this happens were to immediately mobilize neighbors to help (45%) and start searching as soon as possible (79%). *Oenet* was mentioned by 10% of participants. The main recommended strategy for searching for lost livestock was finding and following animal tracks (59%), which requires identifying the last point the lost animals were seen (19%). Others mentioned listening for bells (13%), strategically dividing the search team (10%), and prioritizing areas where predators are known to be (5%).

In response to the prompt of whether searching for lost livestock has changed, 45% were unsure, 29% said no, and 26% said that it has. Of those who felt that it has not changed, many noted that people still help when livestock are lost, with a few noting that mobile phones have made it easier. Of those that felt that it has changed, nine indicated that there has been a loss of communal feeling among the Maasai.

Nothing has changed since people are still united in the search for lost livestock. (Young man, Olgulului–Ololarashi GR)
Mobile phones have made mobilizing a search party easier. (Middle-aged man, Eselenkei GR)
People still help each other to search for lost livestock, However, sufficient notice is needed since people are busy these days. (Young man, Eselenkei GR)
In the past, livestock were considered property of the community. Thus, everyone participated in the search for the lost livestock in their village. Nowadays, things have changed. People don't want to help each other. Everyone is on their own. (Older woman, Mbirikani GR)

Stage 3: Identifying Herding Best Practices

The results from stages 1 and 2 made it clear that most pastoralists in the region see lost livestock as a problem in their community and that most see the main cause of lost livestock as poor herding practices. A slim majority felt that lost livestock have been increasing, and there was a consensus that, although the search for lost livestock has seen changes, it is not the main impediment to reducing lost livestock conflict.

As we discussed these issues with community members, it became clear that a large increase in school attendance in recent decades has led to a gap in the transmission of traditional herding knowledge. There is still a living generation of elders who learned to herd through a long apprenticeship, but many feel that the younger generations are not interested in learning what they know. We thus sought to document this knowledge to assist in its transmission and preservation.

During stage 2, we asked participants to identify any master herders in their area. In stage 3, we sought out these experts as well as elders with the reputation of having significant herding knowledge. The main question in these interviews was a "grand tour" question where we asked the respondent to walk us through a day in the life of a good herder. Using these interviews and our previously collected data, which often contained discussion of herding practices, we created a list of five herder best practices. Because we learned that mentorship of herders is also an essential element of a strong herding culture, we also created a list of five herder-mentor best practices.

Herder Best Practices

Practice 1: know your herd

As noted by Galaty (1989), Maasai pastoralists have a remarkable capacity to recognize individuals among herds of hundreds of cattle and, even more impressively, to identify a single missing animal among hundreds present. This is achieved through a system of symbolic organization of herds wherein "multiple dimensions of cultural classification provide for cognitive organization and redundancy" (Galaty, 1989). This is not a numerical count; in fact, one master herder told us that counting is taboo. We found this cognitive capacity to be alive and well in older generations but consistently lamented as lacking in younger generations.

Specifically, participants described using cattle matrilineal "houses," markings and colors, breeding status and health, and behavioral tendencies in naming and classifying animals. Many also described the need to continually update which animals are leaders and which are likely to lag, including those that might not usually lag but are sick or pregnant. If using bells, the animals they are placed on should be continually reviewed. The participants also noted that a good herder will know which animals are likely to be in the middle of the herd or at the side of the herd, as this knowledge may be useful at strategic moments, such as when moving through thick brush or away from a crowded watering location.

Practice 2: morning routine

The most frequently mentioned distinguishing feature of good herders was the tendency to awaken early and examine the herd immediately. Walking among the herd, the herder should mentally update animal health and reproductive status and clear up any concerns that may have arisen during the night. As in Galaty (1989), a few participants mentioned that concerns about missing or sick animals regularly arise in dreams.

Next, the herder should conduct the morning briefing with the herder-mentor. During this conversation, they will discuss the daily route, including areas with good forage, watering locations,

and potential challenges or threats. The master herders noted that a good herder will aim to arrive at the mid-day watering location slightly early, before the bulk of the local herds has arrived and created a risk of losing animals in the chaos. The herder and herder-mentor should also discuss which animals may present difficulty during the day and decide whether to leave any behind that may be too sick or likely to give birth.

> *A good herder wakes very early in the morning and, before he takes breakfast, he goes straight to the livestock and checks the status of each animal. He will observe which are sick, which are limping, and which might give birth. He can then go for his meal… Different seasons of year have their own rhythm. When things are green, herders need not be in a rush, but when it is dry the herder must get the animals out very early. (Master herder, Olgulului–Ololarashi GR)*

Practice 3: keep the herd close (physically and mentally)

The practices of a good herder in the field are complex, place based, and spatiotemporally dynamic (Meuret and Provenza, 2015). We cannot hope in this brief space to capture the range of place-specific practices that Maasai master herders use to find good forage, move animals efficiently and safely across varied terrain, avoid dangerous wildlife, and otherwise maintain healthy, well-fed livestock across the seasons. Instead, we focus on some key general practices.

All participants noted that herders must stay physically and, more importantly, mentally active throughout the day. Throughout this research, napping herders were objects of scorn and identified as regular sources of lost livestock. Other key behaviors are carrying a walking stick, whistling to keep livestock and wildlife aware of your presence and location, and shouting in densely vegetated areas to keep your livestock moving and alert.

The master herders noted that a good herder will continually and strategically reposition oneself in relation to the herd and its location on the landscape. This includes leading the herd through dense brush, pushing the herd from behind when leaving a crowded watering location, and staying toward the middle when moving through open areas. The herder should continually adjust the cohesion of the herd to keep them as close together as the forage resource will allow, recognizing that when forage is sparse, it may be necessary to allow them to spread out to find adequate nutrition.

Building on practice 1, herders should perform a herd check whenever arriving at pasture, ensuring that all livestock have arrived. Because the herd will then settle to graze, the herder can track down laggards before they become lost. Lastly, herders should always be wildlife aware, especially when moving the herd. Large carnivores, as well as elephants and Cape buffalo (*Syncerus caffer* Sparrman), present a threat to the herd and to the herder, and careful attention and strong bush skills can prevent most negative encounters.

> *A good herder is always passionate about herding and a good herder always values the livestock. While out in the bush, because you value your livestock and are passionate, you will use practices that ensure you keep a close eye on livestock, get to water on time, and find good pasture. (Master herder, Olgulului–Ololarashi GR)*

Practice 4: return early with full bellies

The strategic timing of leaving and returning was so frequently mentioned that it emerged as a best practice. The distance that a herd will travel during a day depends on many factors, including forage availability and proximity, water locations, and community grazing management. When forage is plentiful, many master herders noted that a herd can leave later in the morning and return earlier in the evening and still be adequately nourished. When there is a dearth of forage, particularly during drought, a herd may graze the whole day and not obtain enough food.

It is therefore essential for the herder to carefully consider the day's route and create a plan to obtain adequate forage for the animals while returning home when there is still plenty of daylight. This allows the herder and herder-mentor to identify any missing animals and begin a search before the danger of darkness sets in. However, there is an inherent tension between full bellies and an early return, and this practice will test the skill of the best herders and the knowledge of the best mentors, especially during drought.

Practice 5: evening routine

Just as it is important to start each day with herd assessment and route planning, it is important to end each day with another round of herd assessment as well as consideration of lessons learned from the day's activities. Most master herders stressed the necessity of the herder and herder-mentor reviewing the day together, including areas of good forage, route timing, and herd behavior, in preparation for the next day. They also stressed the importance of honest communication, as herders that are fearful of reprisal may not share all relevant information, making effective strategizing difficult.

As the day draws to a close, good herders will once again walk among the herd, observing animal health and behavior. If the herd has been carefully observed and kept close throughout the day, any lost animals should have already been noticed. However, participants did note that lost animals are occasionally identified at this point, and a search can still occur. If all animals are present and these five practices were followed, the herder can then rest well knowing that they have been good livestock stewards and set the stage for another productive day.

Herder-Mentor Best Practices

Practice 1: mentorship system

The biggest concern among elders was that a centuries-old traditional system for mentoring young herders is rapidly breaking down, despite livestock still being the most important component of Maasai livelihoods. In this system, children are taught to value livestock and their important role in Maasai culture. As a Maasai saying states, "You can't love the milk if you don't love the cow."

Young herders work with a mentor, often a parent but sometimes a sibling or relative, as they move through progressively more difficult assignments—baby sheep and goats to calves to adult sheep and goats to cows and bulls. Through a long apprenticeship they acquire the skills to know their herd and navigate the bush, developing into not only good herders but

respected community members. One master herder stressed to us that he had little formal education but was nonetheless one of the most respected members of his age set, which he attributed almost entirely to his skill as a herder.

The most important ingredient in this mentorship system is time. Good herding requires intimate knowledge of the changing environment across the seasons and years, the dynamics of livestock as individuals and groups, the personalities and behaviors of the local wildlife, and, ultimately, the proper place of the herd and herder in the world. These kinds of knowledge only emerge through a long conversation between child and elder, human, and environment. The elders despaired that this conversation is increasingly fractured and perhaps irrecoverable.

> *School-going children are losing their chance to learn herding, they only have a few days on weekends and holidays, and this is important but not enough. In the past, children spent lots of time with adults learning to herd. Now, my grandsons only know the classroom… The whole process is missing. The abarani [*those especially skilled at cattle recognition*] are gone. (Elder, Eselenkei GR)*

Practice 2: the right herder for the right herd

The master herders noted that the dearth of herders in the area is demonstrating the importance of placing the right herder with the right herd. In addition to properly correlating skill with herd type, participants indicated that herds should be properly sized. Although it was a matter of some disagreement, roughly 200 cows emerged as the maximum that is manageable by one good mature herder. Assistance with larger herds can be provided by younger apprentice herders under the tutelage of the mature herder.

Strategic splitting and mixing of herds was noted as one way to ensure proper herder coverage. For example, larger herds can be split into groups of older and younger cattle such that the older group is larger but equally manageable given the slower movements of the older animals. Other commonly noted elements of properly equipping a herder for the job were providing the herder with a mobile phone, purchasing bells for indicator animals, and properly rewarding paid herders, including with livestock of their own that can then be included in the herd.

Practice 3: morning routine

Because livelihoods are diversifying, many participants observed that herder-mentors are less engaged in the morning routine, as they have often already left the *boma*. However, their role in this routine is essential. One master herder shared that a beloved memory of his deceased father was when he would awaken as a young herder and find his father already walking among the herd in the gathering light, carefully checking each animal. Herder-mentors should walk through the herd with the herder, sharing what they see and listening to what the herder sees.

Discussion of the day's route is the most important part of the herder-mentor's morning routine. Based on the previous day's experiences, the two should walk through the plan for the current day. Many participants stressed that this conversation must be a two-way street wherein the herder-mentor trusts the herder to make decisions. Lastly, many noted that herder-mentors should walk out with herders as they leave the *boma*, observing the herd as they move and offering any final notes to the herder.

Practice 4: evening routine

The entire community becomes more active as the time approaches for the herds to return from the day's grazing. Herder-mentors should use this time to begin to walk out in the direction from which their herd will come, meeting the herders on their way in. Most importantly, the herder-mentor can use this time to learn from the herder if any individuals are missing and check the herd on their own. Walking in with the herd, the herder-mentor can see if bellies are full and ask the herder about the day while the events are still fresh in mind. Once the livestock are settled in the *boma*, the herder-mentor can check them again and then engage in a more leisurely conversation with the herder.

> *It is a routine that the livestock owners and elders should go into the bush and meet the livestock as they are coming home, the reason being that it gives you time to check the herd and respond if needed. Mostly it is just the senior elders who still do this, the younger ones are too busy with business errands. This is a big mistake, and they only realize animals are missing after it is too late… Maybe they only realize when they are in deep sleep, and they will not sleep well! (Elder, Olgulului–Ololarashi GR)*

Practice 5: respect grazing committees and other rules

Regulation of grazing is largely managed through local networks of elders. One such manifestation of this is the grazing committees, which are formally organized groups that meet to determine when and where herds can graze. This includes allowing herders to move to temporary *bomas*, granting permission for outsiders to graze in the area, and opening reserved areas to grazing. Many participants throughout the study noted that these formal committees are currently resurgent in the region and that they are increasingly involving younger community members, including herders, in their deliberations.

Herder-mentors should ensure that herders are aware of areas that are restricted for grazing and encourage them to observe and report on violations of these restrictions. Herder-mentors should provide input to the grazing committees and attend meetings when appropriate. Herders themselves, especially as they mature, can also provide input and may even be invited to join the committee itself, as had two of the master herders that we spoke with, to their great pleasure.

DISCUSSION

In this study, we aimed to capture the causes of and potential solutions to lost livestock, a social–ecological challenge that leads to damaged livelihoods and dead lions. Perhaps unsurprisingly, in the process, we learned that the challenge of lost livestock is

inseparable from the whole of Maasai livestock herding practices and, ultimately, traditional Maasai culture. As observed by Despret and Meuret (2016, p. 25–26), pastoralism is an endeavor that knits together ecology and cosmology into an unbreakable net, "forming a cosmoecology of multiple beings, gods, animals, humans, living, and dead, each bearing the consequences of the others' ways of living and dying." We should not be surprised that this holds true among the "people of the cattle," the Maasai.

We learned that working to prevent livestock–lion conflict by limiting lost livestock also requires us to assist in preserving traditional herding knowledge. Good herders lose fewer livestock but require a long-term intensive apprenticeship with their elders, as herding knowledge is fundamentally place based and ungeneralizable. As we have done here, we can potentially assist this knowledge transfer through the application of a "usable science" (Meiman et al., 2016), but this cannot take the place of a practical education in the particulars of place, people, and animals.

The alternative to herding is the model of commercial ranching practiced worldwide in which fences and other technologies take the place of herders. While these systems may be more effective at producing high-quality livestock products, they have also proved broadly devastating to pastoral peoples, large carnivores, and other wildlife (LaRocque, 2014). Meuret and Provenza (2014) describe herders as "ecological doctors," and we submit that their patients include not only plants but also lions, ecosystems, and entire cultures.

Throughout this work, we have been faced with the difficult reality that increased schooling, as Galaty (1989) observed, "is progressively altering the nature of the cognitive experiences of young Maasai, thus transforming the basis of knowledge on which pastoral practice has for so long rested." Clearly, this is not a new phenomenon, but our research suggests that the loss of the "cognitive concomitants of pastoralism" engendered by schooling is approaching a threshold among the Ilkisonko Maasai of the Amboseli ecosystem. Knowledge that has been developed and passed down across centuries is now being irretrievably lost with the death of every elder.

We are not in a position to judge the worthiness of schooling for Maasai children. However, we can encourage those that value lion conservation to also value good herding. As demonstrated by the work of Lion Guardians, there is great leverage in seeking conservation solutions that are embedded within pastoralist culture. We believe that supporting traditional herding practices presents a tremendous opportunity to demonstrate that there is no necessary paradox in seeking gains in both livestock-based livelihoods and lion populations.

Future work on Maasai herding practices should aim to grow our understanding of the fine-scale practices used by effective herders in the field. Because we did not target the transient population of paid herders and because they have growing importance in livestock management, the addition of their perspective on the questions we have asked would be instructive. Additionally, although we aimed to represent a broad range of perspectives, a study targeting Maasai women could shed important light on their all-important knowledge, especially as it relates to herding of sheep and goats. Lastly, young herders under the age of 18 were not included in this study due to privacy concerns, but their voices are certainly worth hearing.

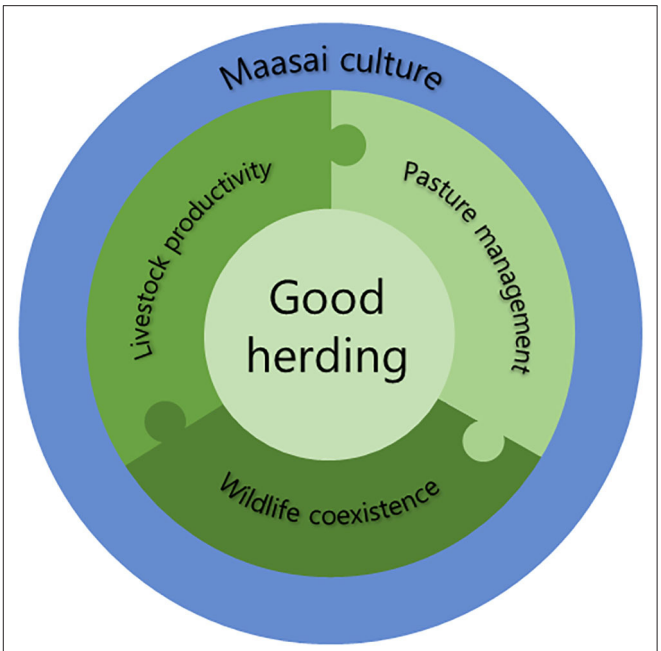

FIGURE 4 | Good herding simultaneously and synergistically achieves livestock productivity, effective pasture management, and wildlife coexistence. These outcomes are inextricably bound and are held together by traditional Maasai culture. At the same time, good herding also supports traditional Maasai culture by safeguarding livestock-based livelihoods and connecting the generations.

CONCLUSIONS

Lion Guardians data show that lost livestock are a significant driver of livestock–lion conflict in the Amboseli ecosystem of southern Kenya. In this study, we learned that a large majority of Ilkisonko Maasai pastoralists in the region see lost livestock as a problem in their communities because they occur frequently and are often the victims of attacks by large carnivores. Study participants were split on whether numbers are increasing, but there was broad agreement that poor herding practices are the main cause of lost livestock and that these practices are worsening over time as more children attend school and adults devote less time to mentoring and herding.

This leads eventually to a lack of well-trained mature herders, including those available to be hired by families lacking in-family herders. These paid herders present a challenge in that their skills as well as dedication to the family and the livestock are difficult to assess and often lacking. In anticipation of this, paid herders are typically underappreciated and poorly paid. Many suggested that better pay and other rewards for paid herders, which would aid in revalorizing the profession, would go a long way toward remedying the problem of lost livestock, but families appear to be caught in a dilemma in this regard.

Although some livestock will be lost and killed by carnivores even under the best circumstances, a strong traditional herding culture appears to be the best way to minimize conflict while maintaining the extensive land tenure system that allows for sustained coexistence with diverse wildlife (Hobbs et al., 2008; Groom and Western, 2013). Indeed, we find that each herder and herder-mentor best practice synergistically prevents lost livestock, improves pasture management, and maximizes livestock productivity.

This is a key point—attentive, thoughtful, and well-planned herding manages livestock such that they *simultaneously* find good forage, address collective management goals, and avoid wildlife conflict (**Figure 4**). These outcomes are inseparable from one another and from the traditional Maasai culture that both supports and is supported by herding. The alternatives, including land subdivision, sedentarization, and market-based commercial ranching, irrevocably sever these dependencies. In fact, we suggest that Western livestock sustainability efforts largely consist of attempts to stitch these multiple elements back together; good herding achieves this as a matter of course.

Lion Guardians, led by their Ilkisonko Maasai staff, is now implementing these findings within their collaborative, community-based model. The overarching goal of this work is to support a best practice herding culture on the group ranches in the Amboseli ecosystem. Key subgoals include improving the perception of herding and livestock among the youth, increasing the supply of verifiably skilled and dedicated paid herders, and creating opportunities for herders, elders, and others to discuss herding practices. Ultimately, the success of this effort will be found in the continuity of the dynamic cosmoecological balance that traditional Maasai culture strikes among people, livestock, and wildlife—which is to say, in the maintenance of resilience in the face of change.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Colorado State University IRB. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

All authors contributed to the conception and design of the study. KJ and JM collected and analyzed the data. KJ wrote the first draft of the manuscript and all authors contributed to manuscript revision, as well as read and approved the submitted version.

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