Research

MULTI-DISCIPLINARY APPROACHES FOR MANAGING SHEEP AND WOLVES IN TUSCANY

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1. Introduction

Populations of large predatory species such as the wolf (*Canis lupus*), brown bear (*Ursus arctos*) and lynx (*Lynx lynx*) are recovering in Europe (Chapron et al., 2014). Increases in numbers and densities are associated with expansions of their ranges. Their presence has recently been reported in areas where they had been absent for decades (Boitani, 2018), often resulting in predation on livestock if this is not adequately protected (Naughton-Treves et al., 2003). Wolves, in particular, have shown a significant increase in their range in many European countries. In areas of recent wolf recolonisation, where prevention measures are not used, livestock quickly becomes vulnerable prey.

Compensation programmes for economic losses due to depredation are in place in most European countries (Fourli, 1999; Gervasi et al., submitted), but are commonly perceived as insufficient for mitigating the impact of large carnivores on livestock production (Bautista et al., 2019). Compensation schemes are often linked to the use of prevention measures (Fourli, 1999), even though the effectiveness of such tools has not been adequately assessed (Eklund et al., 2017). Moreover, an important social component appears to be systematically underestimated: the willingness of farmers to adopt prevention measures and their associated costs (Widman et al., 2019). In areas where large carnivores have always been present, the use of damage prevention measures to protect livestock is considered part of the farm productivity system. However, in areas of recent recolonisation, farmers may not be prepared to protect their animals and the inclusion of damage prevention measures in the husbandry system may imply modifications that significantly impact productivity (Widman et al., 2019).

In order to provide assistance to farmers and thus increase their tolerance of protected large carnivores in areas of recent recolonisation, the European Commission has funded a number of projects to support

A focus group with livestock breeders in Grosseto Province. *(Photo: LIFE MedWolf)*

the improvement of management practices (Salvatori and Mertens, 2012). Although a range of preventive measures have been used to decrease the impact of depredation, no single method fits all situations and approaches usually have to be adapted to local conditions (Shivik, 2006; Eklund et al., 2017).

In central Italy, wolves have increased in density and expanded their range to the lowlands, being increasingly reported in coastal areas (Galaverni et al., 2016; Lucchesi et al., 2019). The impacts of wolf predation on small-scale, semi-extensive farming systems have been increasing in the last decade and compensation programmes have proven unsatisfactory (Marino et al., 2016).

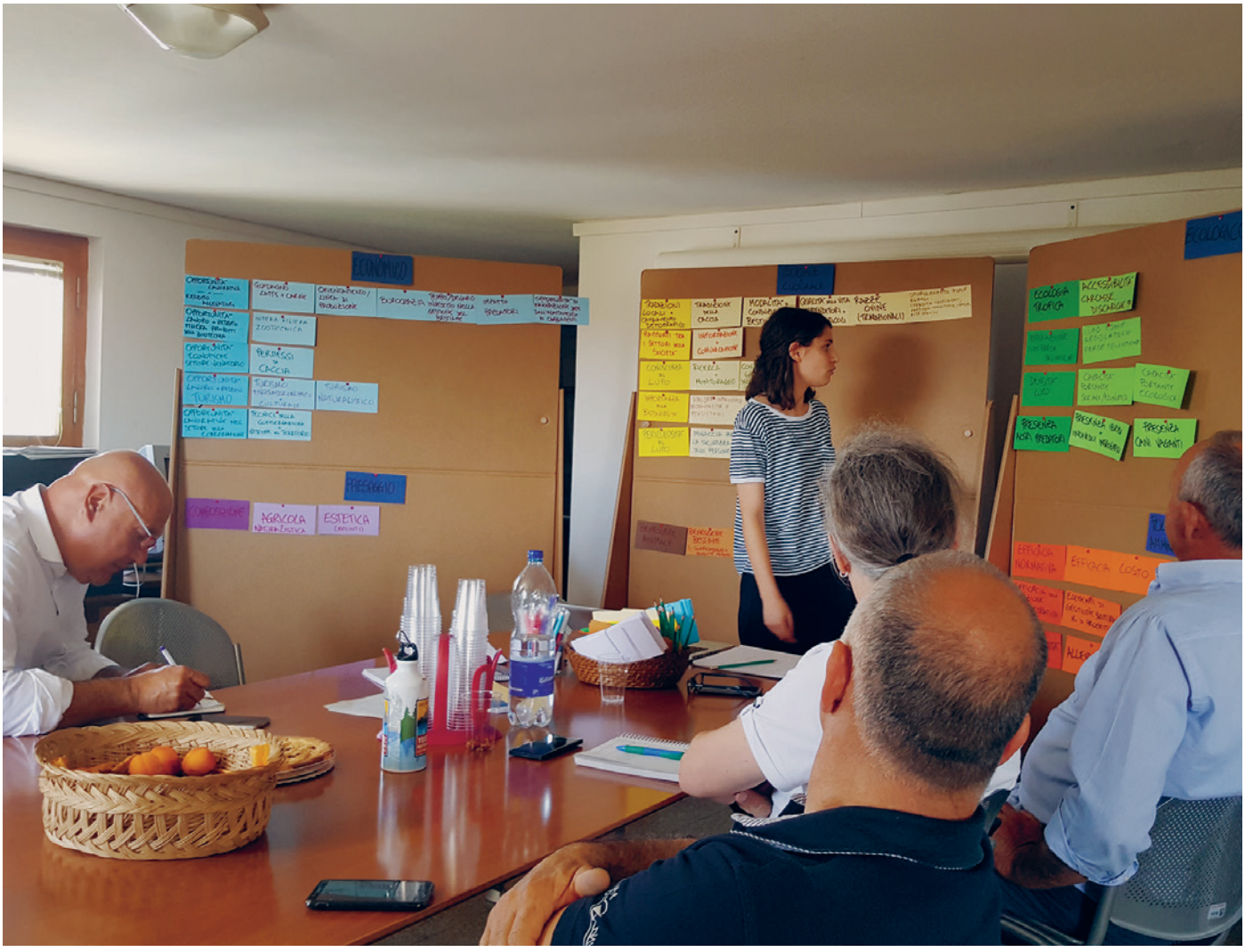
The coexistence of wolves and agricultural activities is a complex and challenging issue, made even more difficult to address as the extensive grazing sheep milk sector already faces serious market difficulties in many European countries. Sheep and goat production plays a marginal role in the agricultural economy of Italy, representing just over 1% of the total value of national agricultural production (ISMEA, 2018). The survival of livestock is, however, crucial for its social and environmental functions in specific areas where other productive activities would not be possible. The sheep milk supply chain at national and local levels is currently facing a market crisis, accentuated over the years by contingent health issues, economic-monetary factors, the decrease in domestic consumption and the collapse in exports for some varieties of cheese (ISMEA, 2020).

Among small-scale producers, the breeding phase is structurally the weakest step in this supply chain, in terms of both contractual relationships with the processing phase and exposure to market fluctuations, as it requires a considerable investment of energy and resources and is vulnerable to environmental and ecological factors, such as the presence of predators and availability of fodder. In Tuscany, there are several complex problems associated with the effects of climate change on the costs and availability of pasture and preserved fodder as well as on production performance, and with the overall market difficulties of products derived from sheep's milk (*pecorino*), culminating in the termination of numerous milk supply contracts by some important processing companies operating in the Region (ISMEA, 2019). It is against this backdrop that in recent decades Tuscan breeders have had to deal with the presence of the wolf and the impact it has on production. Tackling these issues effectively calls for a multi-actor, multi-sector approach developed in a multi-step mode, with each step envisaging consultation and information phases.

With the aim of decreasing the negative impacts of wolves on livestock farming, as part of the LIFE[1] Med-Wolf project (IEA, 2018) we implemented damage prevention measures in an area of central Italy where wolf density had recently increased and assessed: (1) the effectiveness of the implemented measures; and (2) the costs of their implementation at a model small-scale, extensive sheep farm. We anticipated that shared responsibility through participatory processes and active involvement of the affected party would increase the quality of implementation and the information needed to obtain results that could be used for guiding future management policies. We therefore organised a series of events targeting different audiences but made sure that results and planning were always shared with the farmers involved in the project.

2. Background: LIFE MedWolf project

The LIFE MedWolf[1] project, which ran from 2012 to 2017, aimed at mitigating the impact of the wolf on livestock production through the implementation of preventive measures as a tool to increase the tolerance of farmers for this species in two areas with a Mediterranean environment. The wolf is protected in both Italy and Portugal and its populations in these countries are expanding into areas where they have been absent for decades. The two project sites, the province of Grosseto in central Italy and the districts of Guarda and Castelo Branco in north-east Portugal, are dominated by semi-agricultural landscapes, where productive activities represent a significant share of the local economies. The presence of a top predator such as the wolf in these areas is associated with sig-



Application of Multi Criteria Decision Making approach with different stakeholders in Grosseto province. *(Photo: LIFE MedWolf)*

[1] http://www.medwolf.eu/

nificant impacts on farmers because common husbandry practices, such as extensive and semi-extensive grazing in small pastures, leave livestock vulnerable to predation.

The project aimed to share experience and knowledge of damage prevention measures from all over Europe and beyond; establish partnerships with the rural sector; empower selected holdings in management of entrepreneurial activities linked to damage prevention and livestock management; and optimise management efforts through identification of potential areas for expansion. To reach these objectives, several actions were implemented in order to: (1) train the local actors involved; (2) implement damage prevention measures following evidence-based criteria; and (3) assess the effectiveness of the implemented actions.

Each step was developed with an effort to adopt a participatory approach that empowered the different stakeholders, making them aware of their responsibilities. One of the major characteristics of the project in Grosseto was its shared responsibility approach, whereby project partners from environmental associations, agricultural unions and local authorities all received funds for the implementation of some actions and decisions were taken collectively. This was a novel approach, with intra-sectoral collaboration leading to agreement on what activities to implement or how to modify planned interventions.

Social aspects that contribute to conflict ought not to be underestimated and we therefore held many meetings and participatory events that were well-regarded by participants. In this article, we describe the stepwise process used in Grosseto and estimate the costs of adopting damage prevention measures in the province.

3. Study area: Grosseto

The province of Grosseto (mainland 4,479 km^2) is located in the southernmost part of Tuscany, central Italy (Fig. 1). The landscape consists largely of rolling hills at an average altitude of 235m (±225) above sea level. Around 54% of the province is used for agriculture, with mainly broad-leaved forests covering an additional 43%. The average human density is about 50 inhabitants/km^2 (ISTAT, 2013). Livestock production is an important economic activity: in 2013 there were an estimated 3,300 active livestock

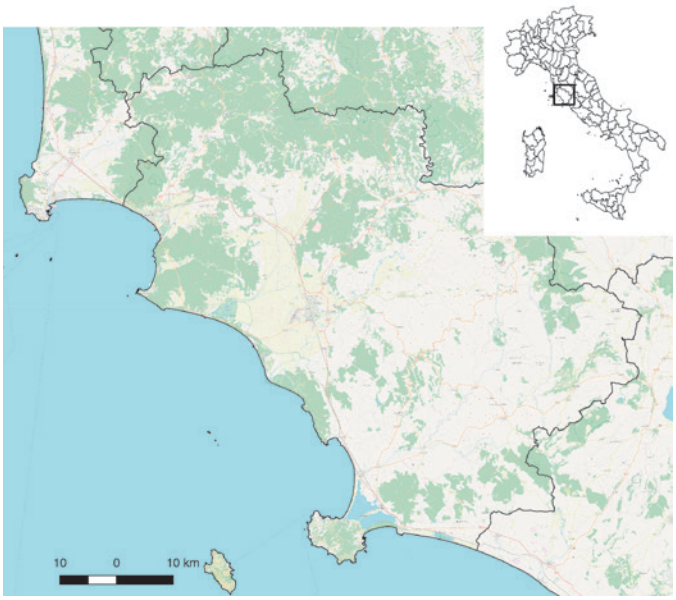


Fig. 1 The province of Grosseto, Italy.

owners (BDN, 2013). Sheep are by far the most numerous species of livestock in the province, with 48.1 head/km^2, followed by cattle (5.9 head/km^2), equines (1.2 head/km^2) and goats (0.54 head/km^2) (BDN, 2013). Reflecting the general trend of decline of the sheep breeding sector, the number of sheep owners has decreased by 3.6% (±1.1) and the number of sheep produced by 2.0% (±2.3) per annum since 2006 (BDN 2013).

Wolves began re-colonising Grosseto in the early 1980s (Boitani and Ciucci, 1993), having been nearly eradicated by the late 1960s (Cagnolaro et al., 1974, A survey in 2013–2014 estimated there to be a minimum of 13 packs in the area, while in 2017 the estimate rose to 22–24 packs (Ricci et al., 2018; Salvatori et al., 2019). They feed on locally abundant roe deer *(Capreolus capreolus)* and wild boar *(Sus scrofa)* as well as livestock, mostly sheep, which represent a secondary item in their diet (Bargagli, 2006).

4. Methods

The LIFE MedWolf project foresaw the implementation of damage prevention measures in Grosseto that had already been adopted in other parts of Italy and elsewhere in Europe (Salvatori and Mertens, 2012). The main tool were mobile electric fences at least 1.2m in height, which have proven effective in significantly reducing damage in different contexts of pasture grazing (Wam et al., 2004). The approach consisted of a series of steps to allow the implementation and evaluation of measures. In order to increase up-

take and empower interested stakeholders, we made the process flexible and included the possibility of modifying technical details (Fig. 2). The methodology for each step is described in detail below.

Step 1 Preliminary assessment

In order to define criteria for selecting beneficiaries of damage prevention measures, we analysed the context with regard to the dynamics (level and location) of wolf attacks on livestock. Data covering the period 2007–2013 were collected from administrative offices involved in damage compensation and assessment, such as the National Health Service Veterinaries, the provincial office for rural development, mayors and a local Consortium (step 1a).

To collect information on the perceptions and interests of farmers, we then organised a series of focus groups (step 1b). We also conducted a total of 150 face-to-face interviews (step 1c) with a random sample of 134 sheep owners with >50 head of sheep selected from a total of 1,094 sheep farms in the province, in proportion to their distribution at the

Fig. 2 Shared responsibility and contributions of different actors in each step of the LIFE MedWolf project implementation process in the province of Grosseto.

municipal scale, and 16 sheep owners who had declared recurrent damages (>6) during the period 2007–2012 (Ricci, 2013).

Step 2 Selection of beneficiaries

To have a longlist of potential beneficiaries to select from, and to make sure we were not imposing any interventions, we opened a call for expressions of interest in receiving damage prevention measures (step 2a). Criteria for selection were based on: location with respect to areas where damage in the previous five years was relatively frequent; number of head; and previous attacks suffered. A total of 201 expressions of interest were received and ranked according to the set criteria (step 2b). Starting with the highest ranking, farmers were visited individually by technicians with long-term experience of setting up damage prevention measures in order to assess their willingness to take part in the project and to decide together what could be the best solution for their husbandry system (step 2c).

Step 3 Assessment of most suitable measures:

As their successful implementation would be highly dependent on the capacity of farmers to include new measures in their current livestock management system, we opted for an approach that would allow them to be tailored to farmers' needs. To this aim, technicians evaluated the feasibility of implementing different measures (step 3a) – mobile electric fences, fixed fences and livestock guarding dogs (LGDs) – and interviewed potential beneficiaries, who were informed of the pros and cons of each measure, as well as providing their input for selecting the most suitable measures for each specific situation (step 3b). In order to include as many farmers as possible, support was limited to €2,500 per farm.

Step 4 Implementation of measures

Once the best suited measures were identified, project partners (farmers' unions) purchased the material needed (step 4a). All selected farmers agreed to contribute to the installation of the selected measures, with economic resources and/or with their own labour, and signed an agreement that implied a commitment to use and maintain in good condition the material received for at least five years after the project's end (step 4b).

Monitoring livestock guarding dog behaviour. *(Photo: L. Vilemi)*

Implementation of LGDs was supported through technical assistance (behavioural, health and sanitary aspects) until dogs reached 18–20 months of age and could be considered self-sufficient and worked independently. Technical assistance was also provided for fence construction and, if necessary, additional interventions were made to rectify unforeseen problems (step 4c). After implementation, farms were visited every six months to monitor correct use of the measures using a structured questionnaire for evaluating elements essential to their proper functionality (step 4d).

Step 5 Evaluation of effectiveness

The effectiveness of damage prevention measures was assessed by project staff using two complementary approaches: a before-after comparison and a treatment-control comparison (see Rigg et al., 2019 in *CDPnews* issue 18). For the former, data were collected through interviews and official statistics of damage suffered at farms that received prevention measures from the project only (step 5a), while the latter was performed through an experimental approach requiring the inclusion of a control sample of farms that did not receive prevention measures, located within 5 km of farms with project measures (step 5b). This buffer was considered to be within the size range of an average wolf pack's territory (Ricci et al., 2018).

A comparison of attacks suffered at 103 control and 50 treatment farms was made for the period from July 2016 to July 2017. Both treatment and control farms were visited after an attack in order to collect data that would allow the characterisation of circumstances in which it occurred. A structured questionnaire was used, with questions aimed at collecting information on the circumstances of attacks and any other attacks that had not been officially reported. We also interviewed farmers in order to assess the degree of satisfaction of those who had received damage prevention measures within the project (n = 62) and who had implemented them through other means (n = 101).

Checking use and status of installed fences. *(Photo: LIFE MedWolf)*

Step 6 Evaluation of costs

Through a shared approach among the various project partners, we identified the main effects of wolf presence[2] on farms (step 6a). In order to obtain information related to the main additional costs and/or losses, a questionnaire was prepared and tested at two farms before administering it to a sample of 20 farmers. This sample was selected taking into consideration a set of variables (location, flock size, membership of union organisation) as well as the willingness of farmers to participate in the survey (step 6b). Finally, a focus group of ten farmers was convened to evaluate the costs associated with the adoption of damage prevention measures at a typical farm in Grosseto (step 6c). Amortisation was calculated using reference values from the National Farming Data Network (FADN) managed by CREA.

Throughout its implementation, a series of meetings was organised to provide farmers with updates on how the project was progressing. In November 2017, a final symposium and a thematic meeting were organised to present the results to those farmers who took part in the project and to the general public in Grosseto and beyond. In April 2019, a thematic workshop on rural development programmes (RDPs) was also held as part of a training action where results of the project were presented.

5. Results

Step 1 Preliminary assessment

Data collected showed that most livestock holdings were managed in an extensive manner, often on rough terrain. Interviews revealed that most livestock owners were engaged in many other activities, as promoted by RDPs. Information gathered showed that dairy production is the main productive line in Grosseto, sheep flocks are split into different productive

[2] The need to identify a shared analysis path stems from the fact that it was decided not to use the data collection methodology of Farm Accountancy Data Network (FADN) because it would have been necessary to have an ex-ante situation (before the introduction of prevention measures) with which to compare the ex-post situation (following the introduction of prevention measures) and we had no funds available for technicians to collect such data at the selected farms.

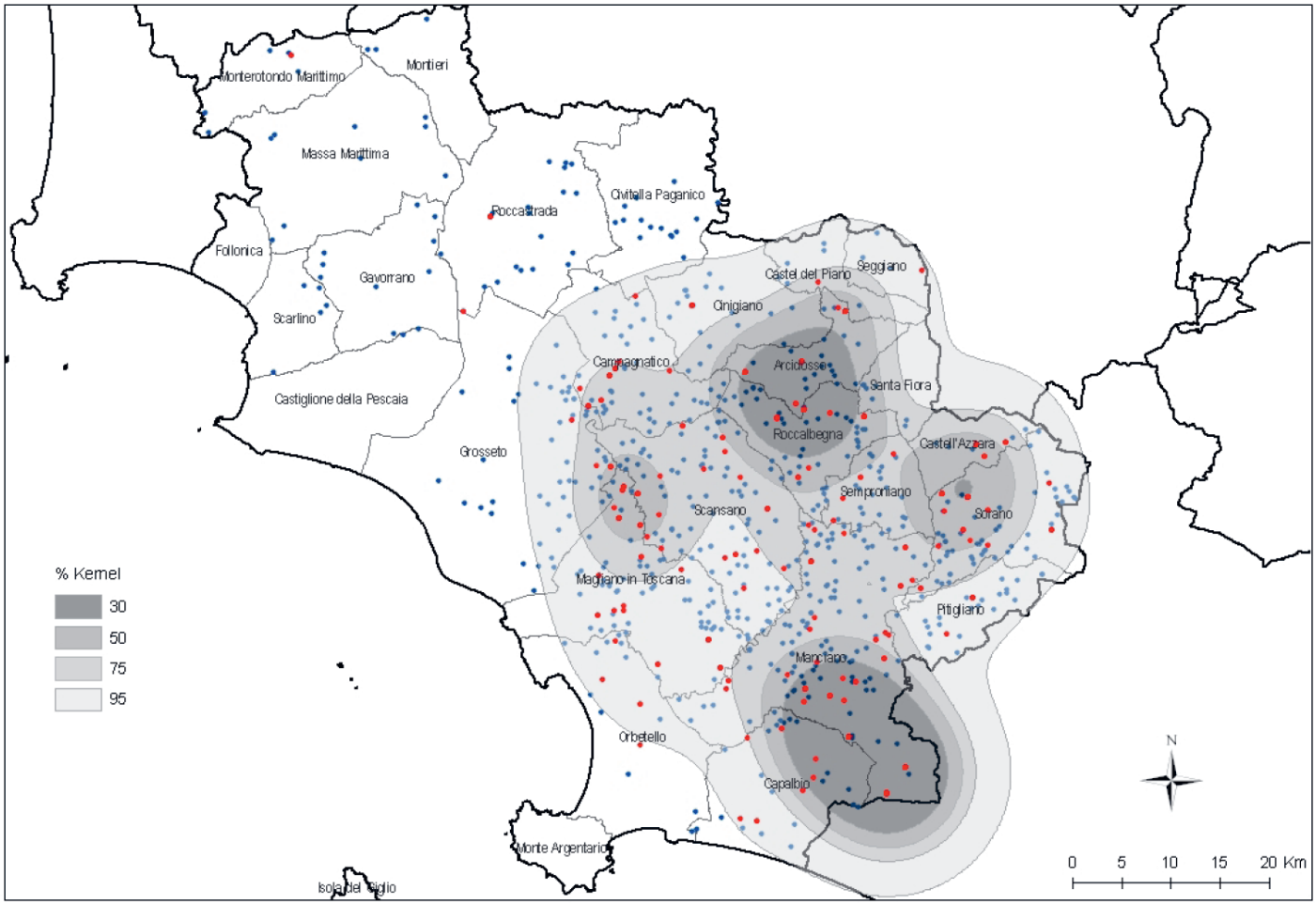


Fig. 3 Spatial distribution of farms that claimed compensation for damage by wolves (red dots) and farms with at least 50 sheep (blue dots) in the province of Grosseto. Grey shading shows the density of damage claims using Kernel Density Estimation.

groups and usually milked at the holding premises twice a day (76% of interviewees).

The landscape and terrain in Grosseto usually allowed grazing areas to be close enough to holdings for flocks to be returned to farms at night. However, most farms did not have appropriate night shelters for their sheep (97% of interviewees reported having 1 m high fences), thus farmers reported high levels of stress and difficulty to rest at night due to the perceived risk of attack (74% reported having suffered attacks at night, often not far from their holdings). Most interviewees (68%) expressed a willingness to receive damage prevention measures.

According to official damage statistics, attacks were mainly concentrated in the east and southeast of the province (Fig. 3). The damage compensation system at the time of our survey (in 2012–2013) was insurance-based, but our results showed that less than 4% of farmers in the province had insurance. This implies that damage often went unreported (Marino et al., 2016).

Step 2 Selection of beneficiaries

A total of 201 expressions of interest were received and a final ranked list was produced according to the set criteria. Visits were made to the 70 highest ranked farms, of whom only six declined the offer to be included in the project after having been fully informed of the conditions and responsibilities.

Step 3 Assessment of most suitable measure

During the preliminary assessment, most farmers had deemed mobile electric fences as unsuitable for their management systems. After consultation with interested farmers, we therefore opted for tools that were easiest to implement and did not require high levels of maintenance, such as fixed metal fences and fixed electric or mixed fences to be used as night shelters. The project also included the implementation of at least 20 LGDs in the area. We thus engaged in a consultation phase with the European Commission and asked permission to modify the planned activities

in their technical implementation and allow for construction of fixed night enclosures, which were more suitable for the project area, rather than mobile electric fences as originally planned.

Step 4 Implementation of measures

The resources available after obtaining permission from the European Commission allowed the project to provide 86 farms with fences, LGDs or both. A total of 79 fences and 54 LGDs were implemented (Table 1).

Table 1 Damage prevention measures implemented at 86 farms in the province of Grosseto through the LIFE MedWolf project.

No. of farms	No. of interventions
Fences	
59	69
LGDs	
19	39
Fences and LGDs	
8	10 fences, 15 LGDs
Total	
86	133 (79 fences + 54 LGDs)

Step 5 Evaluation of effectiveness

The before-after-control-impact (BACI) analysis found a significant decrease in damage suffered by farms (−47% attacks and −50% animals killed) after the adoption of prevention measures. We recorded a total of 139 depredation events between July 2016 and July 2017, 67% of them at control farms versus 33% at treatment farms. The difference between the two groups was greater if the temporal effect is considered: of 32 attacks that occurred at night, 81% occurred at control farms and only 19% at treatment farms (Fig. 4). Moreover, the number of animals killed per attack at night was significantly lower at treatment farms than at control ones (W = 2427, p-value = 0.0398).

Interviews to assess level of satisfaction revealed that fences were judged a valid tool to reduce depredation risk by 81% of respondents (n = 162), while LGDs were evaluated positively by 74% of interviewees. Notwithstanding this high rate of satisfaction, over 60% of interviewees reported that having damage prevention measures was associated with additional work for livestock management.

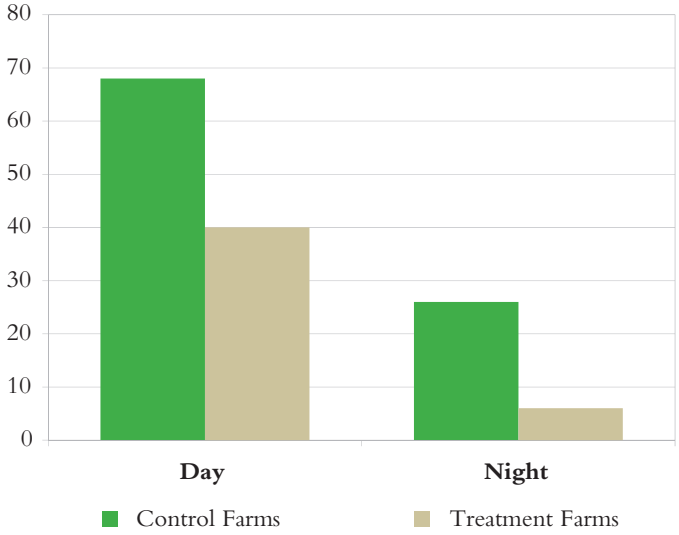


Fig. 4 Number of reported attacks on livestock by wolves at control and treatment farms during the survey period (n=139).

Step 6. Evaluation of costs

Interviews revealed great diversity not only among farms in terms of productive structure and husbandry, but also among farmers regarding their perceptions of wolf presence, of problems related to this, of the difficulties to be faced and of the adoption of different actions and solutions (the typology and use of damage prevention methods), with a variety of changes in management approaches and cost implications.

According to the findings of the focus group, a typical sheep farm in Grosseto was described as having the following general characteristics: family-run, with an average of one or at most two full time equivalent working units; relying primarily on owned land and secondarily rented, but also on other areas for grazing flocks; specialised in sheep breeding (especially dairy), with 300–400 head and selling milk to a processing cooperative; using part of the production for re-use and/or self-consumption; in addition to pastures and fodder, to a lesser extent there are also other productive activities (e.g. cereals, wine, olives), but rarely extra-agricultural activities; it uses the aid of the 1st pillar of the Common Agricultural Policy (CAP) but scarcely activates the investments measures offered by RDPs; for protection from wolves the use of three fences (with a total of 600 linear metres) and 7–8 LGDs (costs for maintenance and recovery) was considered adequate.

Interviews with farmers to assess perception and satisfaction. *(Photo: LIFE MedWolf)*

For a typical farm as described above, the estimate of costs for the adoption and maintenance of damage prevention measures such as fixed metal fences and LGDs ranged from 43 to 54 euros per head per year. It is important to note that 52% of the costs were due to the additional workload, represented mainly by family labour (Fig. 5).

Meetings and workshops were well-attended. Of the 86 farmers who received our damage prevention measures, at least 35 always attended the project meetings. The final international symposium had over 250 registered attendants. More than 25 farmers attended the thematic workshop on RDPs.

6. Discussion

The LIFE MedWolf project represented the first integrated attempt to respond to real problems that sheep farmers have to face as a consequence of wolf presence in a rural area of Tuscany. In order to maximise its effectiveness, we adopted the best available technical tools in conjunction with continuous consultation and participatory approaches. In particular, we focused on:

1. Identifying tailored solutions adapted to the diversity of characteristics and management systems of individual farms, stressing the ad-hoc approach and impossibility to adopt a one-size-fits-all solution imposed top-down;

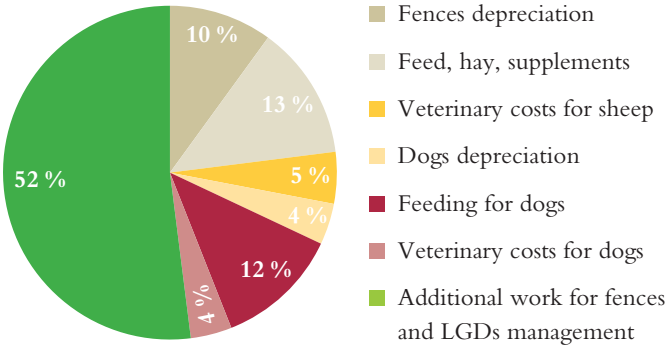


Fig. 5 Cost estimation for adoption and maintenance of damage prevention measures (three fences and 7-8 livestock guarding dogs) at a typical farm in Grosseto.

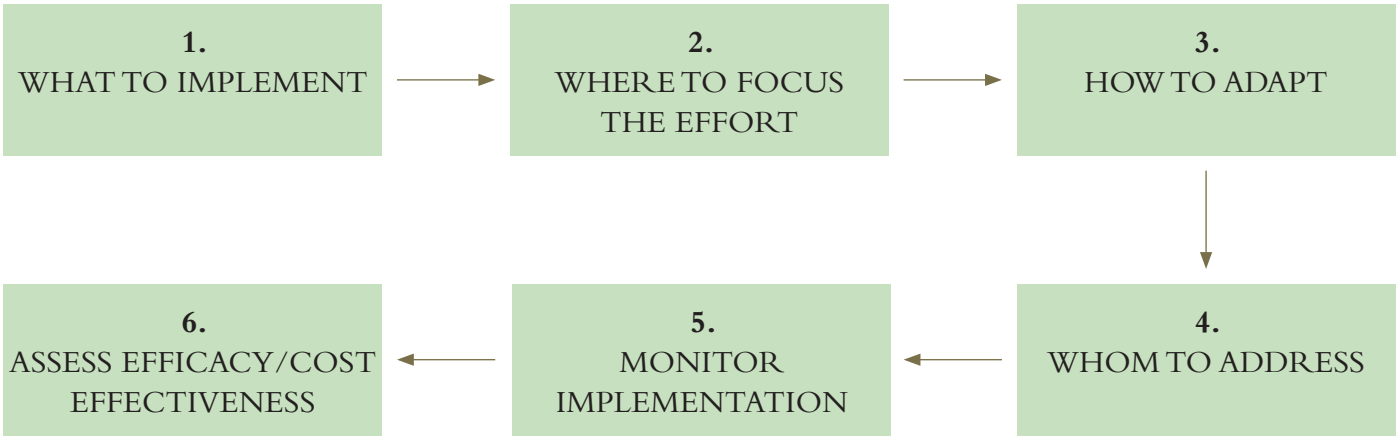


Fig. 6 Workflow adopted in the implementation of the LIFE MedWolf project in Grosseto, Italy.

2. Using a cost analysis methodology to estimate the economic impact of adopting measures to reduce livestock losses to wolf depredation.

For the damage prevention implementation phase, we deemed it fundamental to involve the interested parties at different levels (beneficiaries of damage prevention measures, farmers' unions and public authorities involved in carnivore damage management) from the early stages of project development, and to carefully plan each step of selection, implementation and evaluation as the local social context needed to be taken into account using robust evaluation of results.

Each step allowed identification of the most suitable solutions taking into account both environmental variability and productive characteristics of the farms involved (Fig. 6). This approach allowed a set of tailored solutions to be designed together with each individual farmer in order to meet their specific needs, thus optimising the damage prevention tools used. This process required a high level of flexibility, with the re-design of planned intervention approved by the European Commission and the request of over 50 modifications to the approved budget.

We also needed to hire specialist professionals who could satisfy individual requests in a relatively short time. For the cost estimate process, we started with a brainstorming session and progressed with a series of steps that involved sharing results and collaborative planning. Each step led to the development of reference conditions that were used to identify the most suitable working paths. We adapted the methodology to the situation at hand and modified what was originally planned. In fact, the interviews allowed us to record perceptions, opinions and attitudes that in part could have been predicted but which could have been underestimated or ignored, and revealed strong variation among farms (in structure and breeding typology), farmers (perceptions of the problem, actions taken and solutions adopted) and areas. Therefore, after the interview phase and the analysis of the information collected, we had sufficient information at hand to allow the design of adequate estimation methodology.

The importance of farmers' perceptions of the costs of damage prevention was ignored by many authors for decades but has recently been given more consideration. In southeast Brazil, for example, producers perceived the "unproductive" cost of sheepdogs similarly to the way they viewed taxes and followed a cyclical decision strategy, which basically depended on the purchase price of the sheepdog (Moral et al., 2016). Such an analysis was not originally planned within our project but was done at the direct request of farmers and their representative associations.

The cost composition results from Grosseto should stimulate an assessment of the long-term sustainability of the current productive system. Farms rely on an apparently unlimited workforce, but if the labour of family members were to be paid at market rates this would lead to a collapse of the production system. Furthermore, the damage prevention measures implemented were of a high standard and developed with the technical assistance of project staff, who also provided assistance for solving problems once they arose. Is such an approach sustainable for public administrations which should ensure long-term, large-

scale implementation? What resources can be made available for improvement and modification of husbandry systems necessary to allow the coexistence of protected predators and small-scale livestock breeding?

There are other questions relating to policy: what role do breeders play in providing support, i.e. could a system of amplification of positive experiences be included in the technical assistance that farmers might provide to each other? Is it possible to attach an economic value to a family workforce? Which standards must be used to design the extent of the support to be provided? What resources may be needed from administrations to ensure high quality standards? Would the introduction of standards in RDP funding conditions be feasible? All these questions remain open and should stimulate policy development with a special focus on the assessment of effectiveness with the long-term goal of improving living conditions for all.

Delivery of a new Maremma sheepdog pup by a Difesattiva technician. *(Photo: N. D'Apolito)*

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References

Bargagli L (2006). Analisi alimentare del lupo sul Monte Amiata. In: Lovari S, Sangiuliano A (eds) Il lupo sul Monte Amiata: progetto sui grandi canidi (lupo, cane) nel territorio dell'Amiata Grossetana e Senese. Comunità Montana Amiata Grossetano, Grosseto, pp 73–99 [In Italian].

Bautista C, Revilla E, Naves J, Albrecht J, Fernández N, et al. (2019). Large carnivore damage in Europe: Analysis of compensation and prevention programs. Biological Conservation 235(May), 308–316. doi: 10.1016/j.biocon.2019.04.019.

BDN (2013) Banca Dati Nazionale dell'Anagrafe Zootecnica istituita dal Ministero della Salute presso il CSN dell'Istituto BG. Caporale di Teramo. Updated 31 December 2013. http://statistiche.izs.it/portal/page?_pageid=73,12918&_dad=portal. Accessed 15 September 2015 [In Italian].

Boitani L (2018). *Canis lupus* (errata version published in 2019). The IUCN Red List of Threatened Species 2018. e.T3746A144226239. Downloaded on 15 July 2019.

Boitani L, Ciucci P (1993). Wolves in Italy: critical issues for their conservation. In: Promberger C, Schröder W, editors. Wolves in Europe: current status and perspectives. Munich Wildlife Society, Ettal, pp 75–90.

Cagnolaro L, Rosso D, Spagnesi M, Venturi B (1974). Inchiesta sulla distribuzione del lupo (*Canis lupus* L.) in Italia e nei cantoni Ticino e Grigioni (Svizzera). Ricerche di Biologia della Selvaggina 59 [In Italian].

Chapron G, Kaczensky P, Linnell JDC, Von Arx M, Huber D, et al. (2014). Recovery of large carnivores in Europe's modern human-dominated landscapes. Science 346(6216), 1517–1519. doi: 10.1126/science.1257553.

Eklund A, López-Bao JV, Tourani M, Chapron G, Frank J (2017). Limited evidence on the effectiveness of interventions to reduce livestock predation by large carnivores. Scientific Reports 7(1), 1–9. doi: 10.1038/s41598-017-02323-w.

Fourli M (1999) Compensation for damage caused by bears and wolves in the European Union. Experiences from LIFE-Nature projects. Report to Directorate General XI of the European Commission, Bruxelles, Belgium.

Galaverni M, Caniglia R, Fabbri E et al. (2016) One, no one, or one hundred thousand: how many wolves are there currently in Italy?. Mamm Res 61, 13–24. https://doi.org/10.1007/s13364-015-0247-8.

IEA (2018) LIFE+11 NAT/IT/069 MedWolf project Final Report. http://www.medwolf.eu/index.php/documenti.html?file=tl_files/MedWolf/redazione/download/ITALY/MEDWOLF_FINAL_REPORT.pdf.

ISMEA (2018). La competitività della filiera ovina in Italia, Dicembre [In Italian].

ISMEA (2019) Il mercato dei formaggi pecorini. Novembre [In Italian].

ISMEA (2020) Tendenze latte ovino, Giugno [In Italian].

Istat (2013). Bilancio demografico della popolazione residente per provincia e anno-dal 2011. http://www.istat.it/it/toscana/dati?q=get tablet err&datas e t=DCIS_POPORESBIL1&dim=63,2,3,0&lang=2&tr=0&te=1 [In Italian]

Lucchesi M, Fazzi P, Salvatori V, Ciucci P (2018) Monitoraggio della presenza del lupo nella Riserva Statale "Duna Feniglia". Istituto di Ecologia Applicata, Roma [In Italian].

Marino A, Braschi C, Ricci S, Salvatori V, Ciucci P (2016) Ex post and insurance-based compensation fail to increase tolerance for wolves in semi-agricultural landscapes of central Italy. European Journal of Wildlife Research. DOI: 10.1007/s10344-016-1001-5.

Moral RA, Azevedo FCC, Verdade LM (2016) The use of sheepdogs in sheep production in southeastern Brazil. Pastoralism 6, 18.

Naughton-Treves L, Grossberg R, Treves A (2003). Paying for tolerance: rural citizens' attitudes toward wolf depredation and compensation. Conservation Biology 17, 1500–1511.

Ricci S (2014). Ex-ante evaluation of livestock depredations in Province of Grosseto. LIFE MedWolf technical report for action A4. Istituto di Ecologia Applicata, Rome.

Ricci S, Salvatori V, Ciucci P (2018). Assessment of the efficacy of damage prevention structures and livestock guarding dogs in Province of Grosseto. LIFE MedWolf technical report for action D2. Istituto di Ecologia Applicata, Rome.

Rigg R, Ribeiro S, Colombo M, Luthi R, Mettler D, et al. (2019) Evaluation of prevention measures. Can assessment of damage prevention be standardised? Carnivore Damage Prevention News 18, 24-30.

Salvatori V, Mertens A (2012). Damage prevention methods in Europe: Experiences from LIFE Nature projects. Hystrix Italian Journal of Mammalogy. doi:10.4404/hystrix-23.1-4548.

Shivik JA (2006) Tools for the edge: what's new for conserving carnivores. BioScience 56, 253–259.

Widman M, Steen M, Olofsson K (2019) Indirect costs of sheep depredation by large carnivores in Sweden. Wildlife Soc. Bull. 43, 53-61.