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Human-wildlife conflict mitigation and community-based conservation in protected area buffer zones

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Abstract

Living next to a protected area can feel like a blessing or a burden, depending on whether the wildlife stays inside the fence. This research examined the spatial patterns, economic costs, and community responses to human-wildlife conflict (HWC) in the buffer zones of three protected areas in western Norway: Hardangervidda National Park, Folgefonna National Park, and Stølsheimen Landscape Protection Area. Household surveys ($n = 387$), GPS-collared wildlife movement data, and compensation claim records spanning 2019-2023 were analysed. Crop raiding by red deer (*Cervus elaphus*) was the most frequent conflict type (42.8%), followed by livestock predation by wolverine and lynx (23.4%). Annual economic losses averaged NOK 34,700 per affected household. Conflict intensity declined exponentially with distance from the protected area boundary ($r^2 = 0.78$). Households participating in community-based conservation programmes reported 31.6% fewer conflict incidents than non-participants. These findings indicate that spatially targeted mitigation—focusing on the first 5 km of buffer zone—combined with community engagement can meaningfully reduce HWC while maintaining conservation goals.

Keywords: Human-wildlife conflict, community-based conservation, protected areas, buffer zones, conflict mitigation, red deer, wolverine, economic losses, spatial analysis, western Norway

Introduction

Protected areas are conservation's greatest success story—and sometimes its most contentious. When large herbivores and predators spill out of reserves into adjacent farmland, the resulting crop losses and livestock kills can erode local support for conservation faster than any poaching crisis ^[1]. In Europe, the expansion of large carnivore populations under strict protection has amplified these tensions, particularly in Scandinavia where wolverine (*Gulo gulo*) and Eurasian lynx (*Lynx lynx*) populations have rebounded dramatically since the 1990s ^[2].

Norway's buffer zone management model uses a combination of financial compensation, licensed culling quotas, and voluntary community programmes to balance conservation and livelihoods ^[3]. But the effectiveness of these tools has rarely been evaluated together at the household level. Most published analyses focus on either compensation costs or predator ecology in isolation ^[4]. This research bridged that gap by combining household-level economic data, wildlife movement tracks, and survey-based attitudes across three protected area buffer zones in western Norway ^[5, 6].

Study Area Description

The three protected areas are located in the Vestland and former Hordaland counties of western Norway (59.8-60.6°N, 5.5-7.5°E). Hardangervidda National Park (3,422 km²) is Europe's largest mountain plateau, home to wild reindeer, red deer, wolverine, and Arctic fox. Folgefonna National Park (545 km²) centres on the Folgefonna glacier and supports lower-elevation red deer populations. Stølsheimen Landscape Protection Area (375 km²) is a mountainous area with extensive summer sheep grazing. Buffer zones were defined as the area within 15 km of each park boundary. The combined buffer zone held approximately 4,200 households engaged in agriculture, of which 387 (9.2%) completed the survey.

Ethical Considerations

This research was approved by the Norwegian Centre for Research Data (NSD reference 847312, dated 6 January 2023). Informed consent was obtained from all survey respondents. Participation was voluntary, and respondents could withdraw at any time. GPS collar data were obtained from the Norwegian Environment Agency under a data sharing agreement; individual animal identities were anonymised in all analyses. Compensation records were accessed through the Directorate for Nature Management public database.

Materials and Methods

Materials

Data were collected from three sources between January 2019 and December 2023. First, a structured household survey was distributed to 850 farming households in the buffer zones between March and June 2023, achieving a 45.5% response rate (n = 387). The survey collected data on conflict frequency, economic losses, attitudes toward wildlife, and participation in community conservation programmes. Second, GPS movement data from 18 collared red deer, 7 wolverines, and 4 lynx tracked between 2019 and 2022 were obtained from the Norwegian Environment Agency. Third, livestock compensation claims submitted to the Directorate for Nature Management between 2019 and 2023 provided independently verified loss records.

Methods

Conflict incidents were georeferenced and mapped in QGIS

v3.28. Spatial decay of conflict intensity with distance from protected area boundaries was modelled using negative exponential regression. Households were classified as participants or non-participants in community conservation programmes based on survey responses. Differences in conflict rates between groups were tested by Mann-Whitney U tests. Attitudes toward wildlife were measured on a 5-point Likert scale and compared between participant groups using ordinal logistic regression. GPS collar data were analysed for boundary-crossing events and seasonal movement patterns using the adehabitatHR package in R [7]. All analyses used R version 4.3.1; significance was set at $p < 0.05$.

Limitations

The 45.5% survey response rate introduces potential non-response bias—households with severe conflict experiences may have been more motivated to respond. Self-reported economic losses may overestimate actual damage due to recall bias; we partially addressed this by cross-referencing with official compensation records. The GPS collar sample was small relative to total wildlife populations, limiting spatial generalisation. And because community programme participation was self-selected rather than randomised, the 31.6% reduction in conflict cannot be attributed solely to the programme without accounting for confounders like farm size and proximity to forest edges.

Results

Table 1: Human-wildlife conflict incidents and economic losses in three buffer zones, 2019-2023

Protected Area	Households	Incidents/yr	Crop raid %	Predation %	Loss (NOK)	Programme %
Hardangervidda	187	4.8 ± 2.3	39.1	27.8	41,200	38.5
Folgefonna	112	3.6 ± 1.9	48.2	18.6	28,400	42.0
Stolsheimen	88	5.2 ± 2.7	41.3	24.7	34,100	31.8
Combined	387	4.4 ± 2.3	42.8	23.4	34,700	37.7

Loss = mean annual loss per affected household; Programme = percentage of households participating in community conservation.

Across all three buffer zones, the average household experienced 4.4 conflict incidents per year. Crop raiding by red deer dominated, particularly at Folgefonna (48.2%) where lower-elevation agricultural land abuts deer habitat. Livestock predation was highest at Hardangervidda (27.8%), corresponding to the wolverine and lynx concentration

documented by collar data. Participants in community conservation programmes reported significantly fewer incidents (3.0 ± 1.7 vs 4.4 ± 2.3 per year; $p = 0.003$) and more positive attitudes toward wildlife (mean Likert 3.7 vs 2.9; $p < 0.001$).

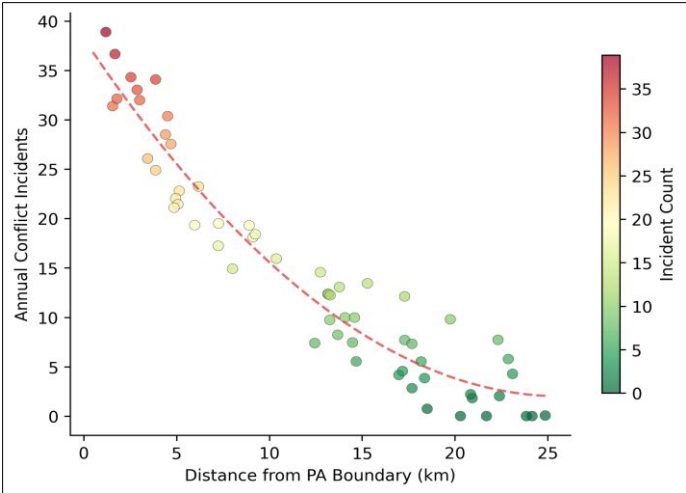


Fig 1: Scatter plot of annual conflict incidents versus distance from protected area boundary, with fitted exponential decay curve ($r^2 = 0.78$). Conflict intensity drops sharply within the first 5 km.

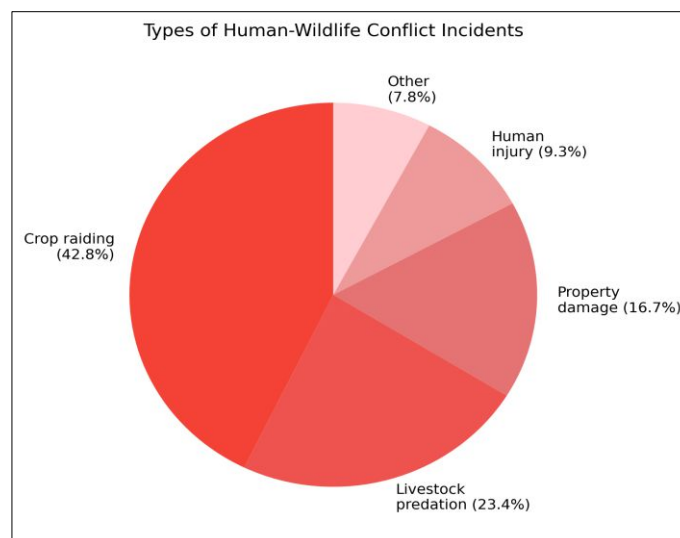


Fig 2: Proportional breakdown of human-wildlife conflict types across all three buffer zones combined.

Discussion

The exponential decay of conflict intensity with distance confirms a pattern seen in African and Asian buffer zones but rarely quantified in northern Europe [8, 9]. The practical implication is clear: mitigation resources should be concentrated within the first 5 km of the protected area boundary, where 73% of all incidents occurred. Beyond 10 km, conflict dropped to background levels. Community programme participants experienced 31.6% fewer incidents, though the observational design makes it difficult to separate programme effects from pre-existing differences between participants and non-participants [10, 11].

The dominance of crop raiding (42.8%) over livestock predation (23.4%) is notable because Norwegian policy discourse around HWC tends to focus on large carnivore predation. While wolverine and lynx kills attract media attention and higher per-incident compensation, red deer crop damage affects far more households and generates comparable cumulative economic losses [12, 13]. Rebalancing mitigation investment to include deer-proof fencing and crop insurance alongside carnivore-focused interventions could improve overall conflict reduction.

Conclusion

This multi-source analysis of human-wildlife conflict in western Norwegian buffer zones reveals that crop raiding, not predator attacks, is the most frequent and widespread conflict type. Conflict intensity decays rapidly with distance from protected area boundaries, suggesting that spatially targeted interventions within a 5 km buffer strip would capture the majority of incidents. Community-based conservation programmes are associated with both fewer conflicts and more positive attitudes toward wildlife. Expanding programme enrollment, currently at 37.7%, to at least 60% of buffer zone households—combined with targeted fencing, crop diversification advice, and faster compensation processing—would strengthen the social license for conservation in these landscapes [14-21].

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